The Land Conservancy
OF SAN LUIS OBISPO COUNTY

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September 1st, 2010

Re: Santa Rosa Creek Watershed Conservation Plan Final Release

To All Interested Parties:

The Land Conservancy of San Luis Obispo County is pleased to announce the release of the ***Santa Rosa Creek Watershed Conservation Plan***. This plan was funded in 2007 through a grant awarded by the California State Coastal Conservancy for a total cost of $81,000.

The purpose of the Plan was to:

- Compile and summarize existing data regarding land use, water resources, sensitive habitat, and fisheries to inform future and ongoing studies (such as the *Santa Rosa Creek Watershed Management Plan* funded by the California Department of Fish and Game).
- Identify and prioritize conservation projects informed by erosion modeling and spatial analysis.
- Recommend land restoration techniques and practices which improve habitat for steelhead and other sensitive species of flora and fauna in Santa Rosa Creek.

The specific intent of the project is to guide the efforts of The Land Conservancy and other conservation professionals working with willing landowners and funding entities to complete priority voluntary conservation projects in the watershed.

The Land Conservancy and the California Coastal Conservancy hope that practitioners find the plan useful as they undertake efforts to protect this relatively pristine watershed and to support the family farmers and ranchers that steward the land.

For additional information, or to obtain a digital copy of the plan, please contact me at (805) 544-9096 or Tim Duff, Project Manager with the California State Coastal Conservancy, at (510) 286-3826.

Best Wishes,

Kaila Dettman
Deputy Director

Local People. Local Land.

Santa Rosa Creek
Watershed Conservation Plan

Prepared for

California Coastal Conservancy

by

The Land Conservancy of San Luis Obispo County

August 2010

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The Santa Rosa Creek Watershed Conservation Plan was made possible with funding provided by the California Coastal Conservancy and guidance from the Technical Advisory Committee.

Technical Advisory Committee Agencies/Organizations:
California Coastal Conservancy
California Department of Fish and Game
Natural Resources Conservation Services
Upper Salinas Las Tables Resource Conservation District
Cambria Community Services District
San Luis Obispo County Farm Bureau
Central Coast Salmon Enhancement
Friends of Fiscalini Ranch
Greenspace - The Cambria Land Trust
Land Conservancy of San Luis Obispo County

ACKNOWLEDGMENTS

The Land Conservancy wishes to acknowledge the following individuals who offered their time, resources, and expertise to assist the development of the Santa Rosa Creek Watershed Conservation Plan.

Cambria Community Services District-who provided an extensive list of published resources for watershed conservation and restoration in the Santa Rosa Creek Watershed.

Bobby Jo Close, County of San Luis Obispo-who supplied valuable spatial data which informed nearly all areas of the Conservation Plan.

Joy Fitzhugh, San Luis Obispo County Farm Bureau-whose working knowledge provided an overview of historic and present activities in the watershed.

D.J. Funk, Upper Salinas Las Tables Resource Conservation District-who provided road erosion information which assisted in upland erosion analysis.

Brent Hallock, California Polytechnic State University-who brought a wealth of knowledge and experience in erosion assessments which guided the RUSLE2 erosion study.

Richard Hawley, The Cambria Land Trust-who assisted in acquiring existing documentation.

Tom Mastin, California Polytechnic State University-who provided his expertise and technical support for spatial data acquisition, which included aerial imagery cropping and digital elevation modeling.

Stephnie Wald, Central Coast Salmon Enhancement-who provided valuable planning guidance and feedback to develop the Conservation Plan.

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1. EXECUTIVE SUMMARY

The Santa Rosa Creek Watershed, located in northern San Luis Obispo County, California, is a coastal watershed of 30,395 acres and is nestled between the Pacific Ocean and the Santa Lucia Mountains (Fig. 2, pg. 10). Coastal streams within this watershed provide critical habitat for south-central California coast steelhead trout *(Oncorhynchus mykiss irideus)*, a federally threatened species in this region. In recognition of the watershed's importance to the survival of steelhead on the Central Coast, the 2007 funding from the California Coastal Conservancy was allocated to the Land Conservancy of San Luis Obispo County to develop the Santa Rosa Creek Watershed Conservation Plan (Conservation Plan).

Components of the Conservation Plan include:

1. **Compilation of existing data**

   Geography, climate, history, demographic, soil, geology, hydrology, and biology data were gathered to create the direction of the Conservation Plan. Over 230 reports or reference documents, watershed data, websites of interest, and over 30 personal contacts were identified and compiled. In addition, 85 Geographic Information Systems (GIS) data layers were either acquired through San Luis Obispo County and various online databases, or created during the preparation of this plan.

2. **Collection of additional data**

   Data were collected to identify upland erosion sites, predict annual erosion rates, assess land use, and study limiting factors to steelhead in the Santa Rosa Creek Watershed. Upland erosion sites were mapped using 2007 aerial photographs, field reconnaissance, and GIS. Upland erosion appears moderate with only a few large gullies or landslides identified. Smaller gullies associated with drainages were more common and usually present on annual grasslands used for grazing.

   <u>Erosion Rates</u>

   Annual predicted erosion rates were calculated for the upper Santa Rosa Creek Watershed using the United States Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS) RUSLE2 program. The upper watershed drains into Santa Rosa Creek from the Santa Lucia Mountains, downstream to the Main Street and Santa Rosa Creek crossing near Coast Union High School (Fig. 2, pg. 10). The lower watershed could not be assessed using RUSLE2 because the area is highly developed with residential and commercial properties.

   A predicted erosion rate was calculated for each soil map unit according to NRCS Soil Survey data in all drainages within the upper watershed. Land between drainages was studied separately. The upper watershed has a combined probable erosion rate of 56,271 tons of soil per year, with drainages located further upstream having larger total predicted erosion rates. According to Brent Hallock, Earth and Soil Science Department at California Polytechnic State University, annual erosion rates at or exceeding five tons of soil per acre is considered unsustainable. From 1,169 assessed soil map units, 37 units had a predicted soil loss rate of five or more tons of soil per acre, annually. This leads to a combined area of 1,617 acres that exceed sustainable erosion rates. Erosion from gullies, mines, and roads, including ranch roads, are also significant sources of sediment. However, these sources could not be assessed using RUSLE2 within the scope of this project due to limitations on accessing private lands.

Land Use

The land use assessment conducted for the Conservation Plan was completed using parcel data, GIS data, 2007 aerial imagery, and digital topographic quadrangles (Figs. 41-45, pgs. 125-136). The upper and lower watersheds have been summarized separately due to differences in land use. Land use in the lower watershed is primarily residential while land use in the upper watershed is primarily agricultural.

The lower watershed drains from the Main Street and Santa Rosa Creek crossing, downstream to the Pacific Ocean. Land use in the lower watershed is mostly residential with over 80 percent of all property owners in the watershed concentrated here. According to parcel data, 847 acres, or 63 percent of the lower watershed, is residential. Agriculture is the second biggest land use in the lower watershed with two large agricultural properties located on the northern edge of town and totaling 258 acres, or 19 percent of lower watershed area. The business, commercial, and industrial sectors of Cambria are located in the lower watershed. Although they only account for 95 acres, or seven percent of the lower watershed, they are a distinct feature in the town of Cambria.

The upper watershed land uses are noticeably different than the lower watershed land uses. According to parcel data, the primary land use in the upper watershed is agriculture. Using parcel data, aerial imagery, and field reconnaissance, cattle grazing appears to be the most common land use. Other common land uses are dry farming, rural residential, and irrigated crops such as grapes, avocados, and apples. Parcels are generally much larger than lower watershed parcels, there is one high density residential area located along the western boundary of the upper watershed. This area is approximately 67 acres, or less than one percent of the entire upper watershed area, and is a continuation of the lower watershed's residential area that reaches near the confluence of Perry and Santa Rosa Creeks.

The land uses have changed significantly over the last 150 years. Dairies were the first major land use with their accompanying pig farms, orchards, vegetable gardens, and hay fields. When dairies became too costly to maintain they were replaced with grazing practices and dryland farming. Today the land uses are quite varied. Grazing is still a significant land use in the watershed however there is an increasing number of vineyards, avocado and citris orchards, row crops, and hay fields. Although land uses have changes in some cases land ownership has remained fairly constant for many years.

Throughout the watershed's history, family-owned private parcels remain significant with 17 families owning close to 70 percent of the total watershed, or 20,962 acres. These "family" properties often include multiple agricultural parcels that are mostly used for grazing and dry farming. The family parcels are sometimes owned by different members of the same family, and are not located together (Fig. 44, pg. 134).

Limiting Factors to Steelhead Viability in Santa Rosa Creek Watershed

The fisheries assessment of the Santa Rosa Creek Watershed describes factors that limit the long term viability of south-central California coast steelhead (*Oncorhynchus mykiss irideus)*, a federally listed threatened species. Several factors appear to limit the distribution, survival, and growth rate of juvenile steelhead in this watershed. These factors include impediments to passage due to road crossings, shallow riffles due to erosion and sedimentation, poor spawning habitat (proportion of fine sediment), low spring and summer base flows, lack of adequate escape cover (provided by instream wood, undercut banks, un-embedded boulders, water depth itself), high water temperature, and inadequate water depth.

Man-made and natural structures located in the stream impede adult passage upstream. This limits accessible habitat for spawning steelhead. Locations of known and possible fish passage barriers in the Santa Rosa Creek Watershed have been compiled in the California Fish Passage Assessment Database by the California Department of Fish and Game. There are currently seven structures that are “total”, ”partial”, or “temporal” barriers for fish migration in the Santa Rosa Creek Watershed (Fig. 24, pg. 88). There are an additional 14 structures with an “unknown” barrier status, and two structures that are not barriers. Along the mainstem of Santa Rosa Creek there is one total barrier (natural limit to anadromy), two temporal barriers (a road crossing and fish passage facility), one unknown (cascade falls), and one structure that is not a barrier (Highway 1 bridge). The California Department of Fish and Game identified the natural limit to anadromy at a steep elevation change near the headwaters of Santa Rosa Creek.

3. Recommendations

The Conservation Plan’s restoration techniques and conservation strategies are based on the identified limiting factors impacting steelhead in the Santa Rosa Creek Watershed and other goals for improving watershed health and ecosystem function. Criteria were developed to assist with identifying priorities for conservation, placing emphasis on properties that provide habitat for steelhead (especially during dry summer months), and protect or enhance water quality and/or water supply. Management Measures and Practices (also known as techniques and/or Best Management Practices (BMPs)) were developed and identified using Natural Resources Conservation Service technical resources, California Rangelands online resources, and BMP manuals from entities such as Caltrans. These practices were selected for inclusion in the Conservation Plan based on their efficacy to reduce sediment load into streams, protect water resources, and enhance habitat for steelhead and other sensitive species. Practices were organized based on five land uses/project types including general habitat and restoration, ranching and grazing, row crops and orchards, urban, and construction.

Santa Rosa Creek is one of the premier steelhead streams on the central coast of California that supports many sensitive species and habitats. New development and numerous existing land uses have the potential to degrade the watershed as seen in other coastal streams. Conservation and restoration are the primary tools described in this Conservation Plan for improving watershed health and sustaining this relatively pristine watershed.

2. INTRODUCTION

2.1. PURPOSE

Santa Rosa Creek is one of the most viable steelhead fisheries in the south-central California Coast Evolutionary Significant Unit (ESU). Steelhead are currently listed as a threatened species here, however just south of San Luis Obispo County they are listed as endangered (from the Santa Maria River in Santa Barbara County, south to the Mexico border). The proximity of the endangered listing makes preserving the productivity of the Santa Rosa Creek's fishery all the more critical.

In recent years, several fishery studies conducted in the lower reaches of Santa Rosa Creek have concluded that mean pool depths are decreasing, indicating that sedimentation is occurring in the lower watershed. Additionally, riparian buffer zones have diminished where land has been developed tangent to streams. With the loss of vegetation, streambanks are more susceptible to erosion which in turn degrades steelhead habitat. Changes in bank stability, water quality and supply, and fisheries productivity are directly linked to land use. Analysis of land use patterns, combined with predictive erosion modeling, can help define conservation strategies for improving steelhead habitat and overall ecosystem function.

The purpose of the Conservation Plan is to prepare:

- A prioritized list of conservation projects informed by erosion modeling and land use pattern analysis.
- A compilation and summary of land use, water resources, and fisheries information to inform ongoing and future studies.
- Recommended land management practices to improve the viability of the steelhead fishery.

2.2. TECHNICAL ADVISORY COMMITTEE

The role of the Technical Advisory Committee (Table 1) was to inform project planning, assist in avoiding duplication of other conservation efforts, and review this Conservation Plan.

Table 1. Santa Rosa Creek Watershed Conservation Plan Technical Advisory Committee.

Representative	**Agency/Organization**	**Email**
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Michael LeBrun	Land Conservancy of San Luis Obispo County	
Brian Stark	Land Conservancy of San Luis Obispo County	
Kaila Dettman	Land Conservancy of San Luis Obispo County	kailad@lcslo.org

3. BACKGROUND

3.1. GEOGRAPHIC SETTING

Santa Rosa Creek Watershed is located in northern San Luis Obispo County, California, in the southern portion of the Coast Ranges (Fig. 1). The unincorporated community of Cambria is located in the northwestern portion of the watershed while the small community of Harmony is located on the southern edge of the watershed (Fig. 2). Santa Rosa Creek flows east to west, with the headwaters situated in the Santa Lucia Mountains, and the outlet draining into the Pacific Ocean. The upper watershed is characterized by mountain and foothill topography with a maximum elevation of 2,933 feet above mean sea level at Cypress Mountain.

The outlet of Santa Rosa Creek is located in Township 27 South; Range 8 East; Section 22. The western extent of the watershed is located approximately 35°34’19.16”N Latitude, 121°6’46.70”W Longitude, and the eastern extent of the watershed is located approximately 35°32’50.57”N Latitude, 120°54’2.03”W Longitude. The northern extent of the watershed is located approximately 35°36’28.05”N Latitude, 120°59’35.44”W Longitude, and the southern extent of the watershed is located approximately 35°29’59.38”N Latitude, 121°0’4.80”W Longitude.

The Santa Rosa Creek Watershed is composed of two major drainages: the Santa Rosa Creek drainage, and the Perry Creek drainage. The upper Santa Rosa Creek sub-watershed is nearly 16 thousand acres and drains water from the surrounding landscape into the Santa Rosa Creek and numerous unnamed tributaries upstream of the Santa Rosa and Perry Creek confluence. The Perry Creek sub-watershed is nearly 15 thousand acres and is composed of Green Valley and Fiscalini Creeks, as well as numerous unnamed tributaries (Table 2). Green Valley Creek is a tributary to Perry Creek, which is a tributary to Santa Rosa Creek. Although Green Valley Creek is significantly large in this watershed, United States Geological Survey (USGS) nomenclature generally assigns the sub-watershed name to Perry Creek which is the stream of the lowest downstream order and tributary to Santa Rosa Creek.

Santa Rosa Creek Watershed is considered by many to be one of the most pristine watersheds on the Central Coast with much of the watershed undeveloped and mostly vegetated. The headwaters of Santa Rosa and Green Valley Creeks are located in the Santa Lucia Mountains. Creeks in the upper watershed are fed by springs created from the highly fractured bedrock in that area. These spring-fed tributaries drain downstream through rolling foothills and enter wide valleys and fertile floodplains before reaching the Pacific Ocean. The watershed hosts a wide range of vegetative communities with non-native grasslands dominating the lower foothills and floodplains, while scrublands and forests are more prominent in higher elevations. Rare stands of Monterey Pine (*Pinus radiata)* exist throughout the lower watershed and are carefully managed for preservation.

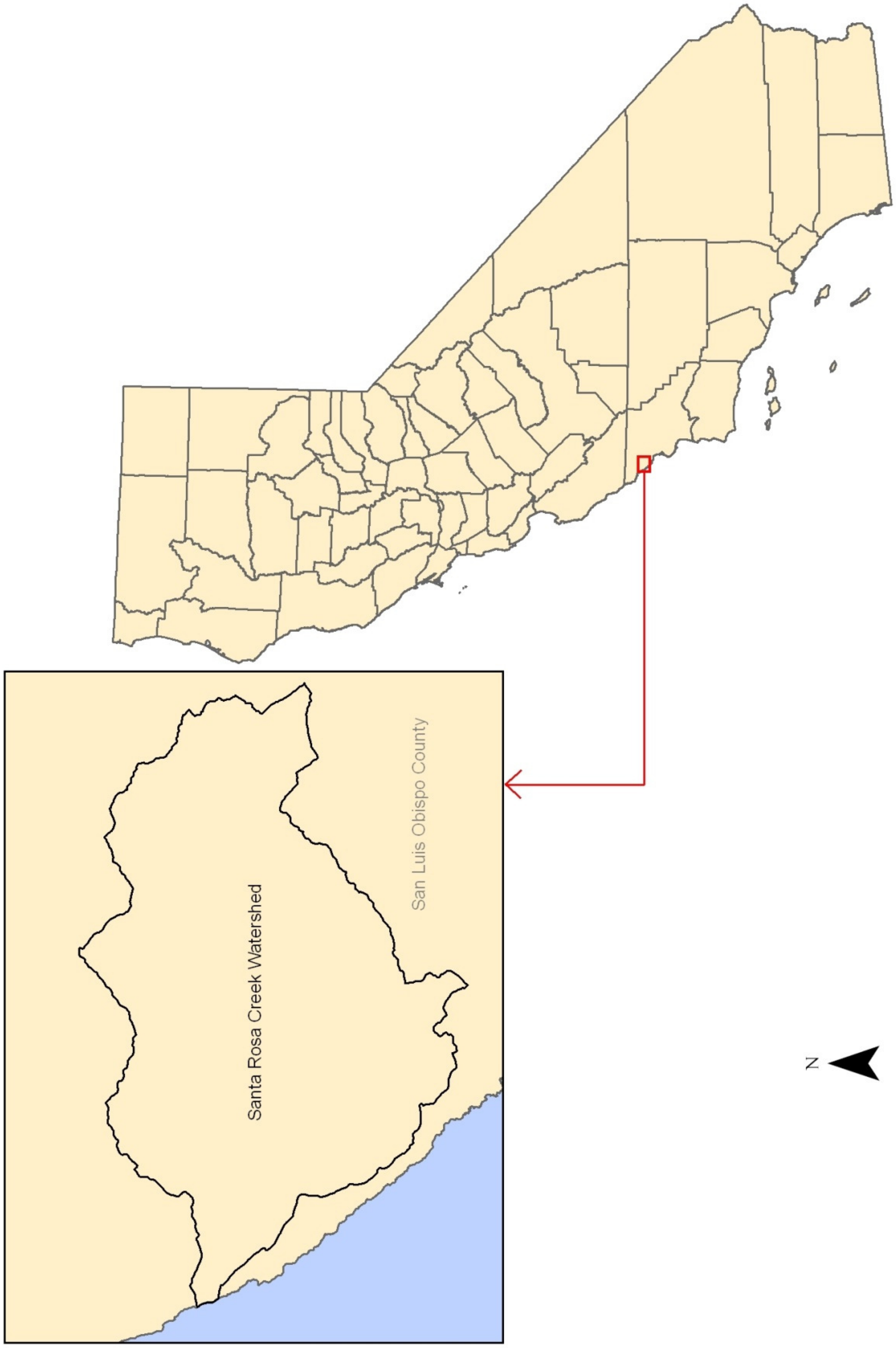
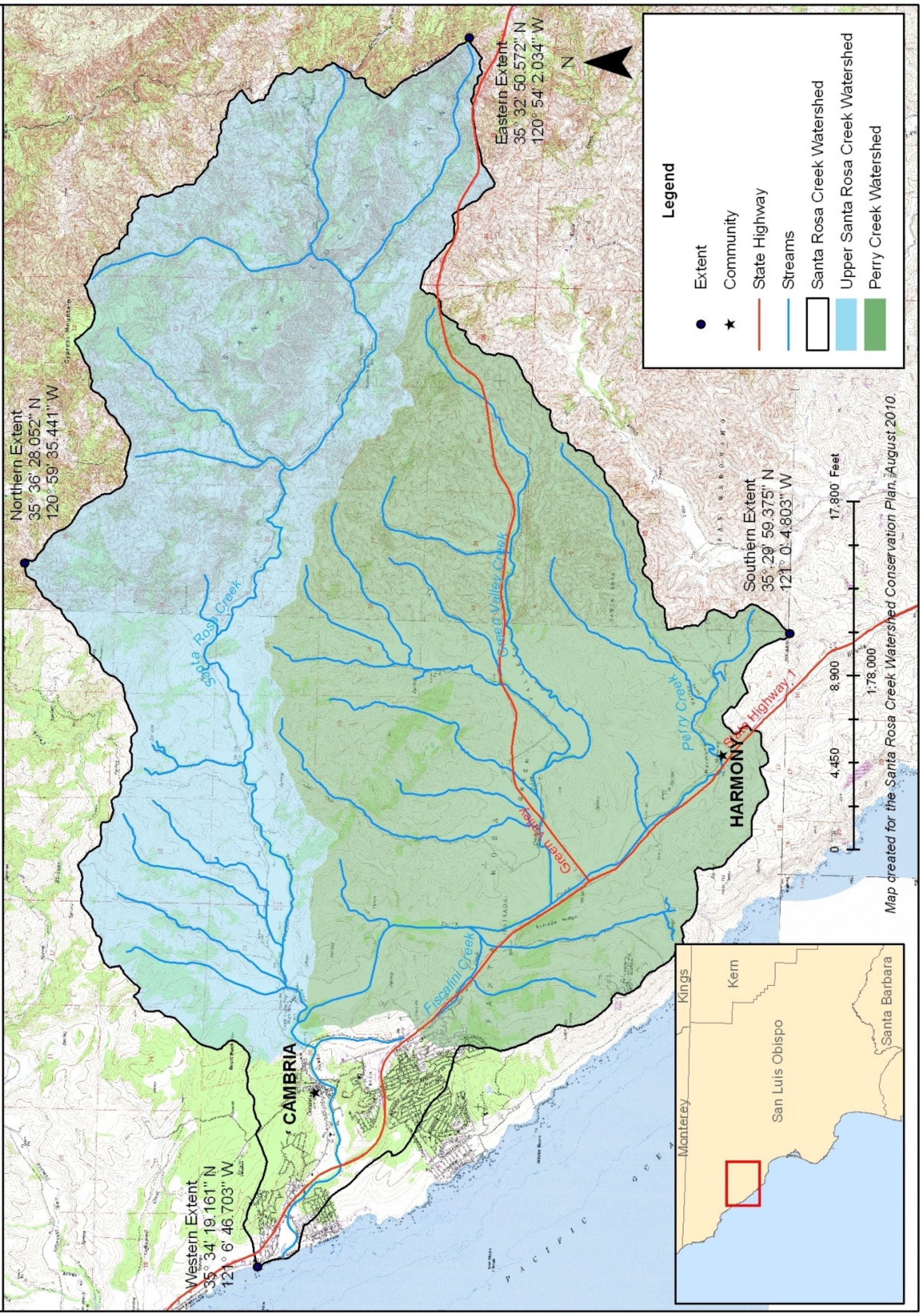


Figure 1
Santa Rosa Creek Watershed Regional Map
Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.

Figure 2. Santa Rosa Creek Watershed and Sub-Watershed Boundaries



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.

Table 2. Total acreage of Santa Rosa Creek Watershed and sub-watersheds.

Boundary	Acres (acres)
Entire Watershed	30,395
Upper Santa Rosa Creek Sub-watershed	15,712
Perry Creek Sub-watershed	14,683

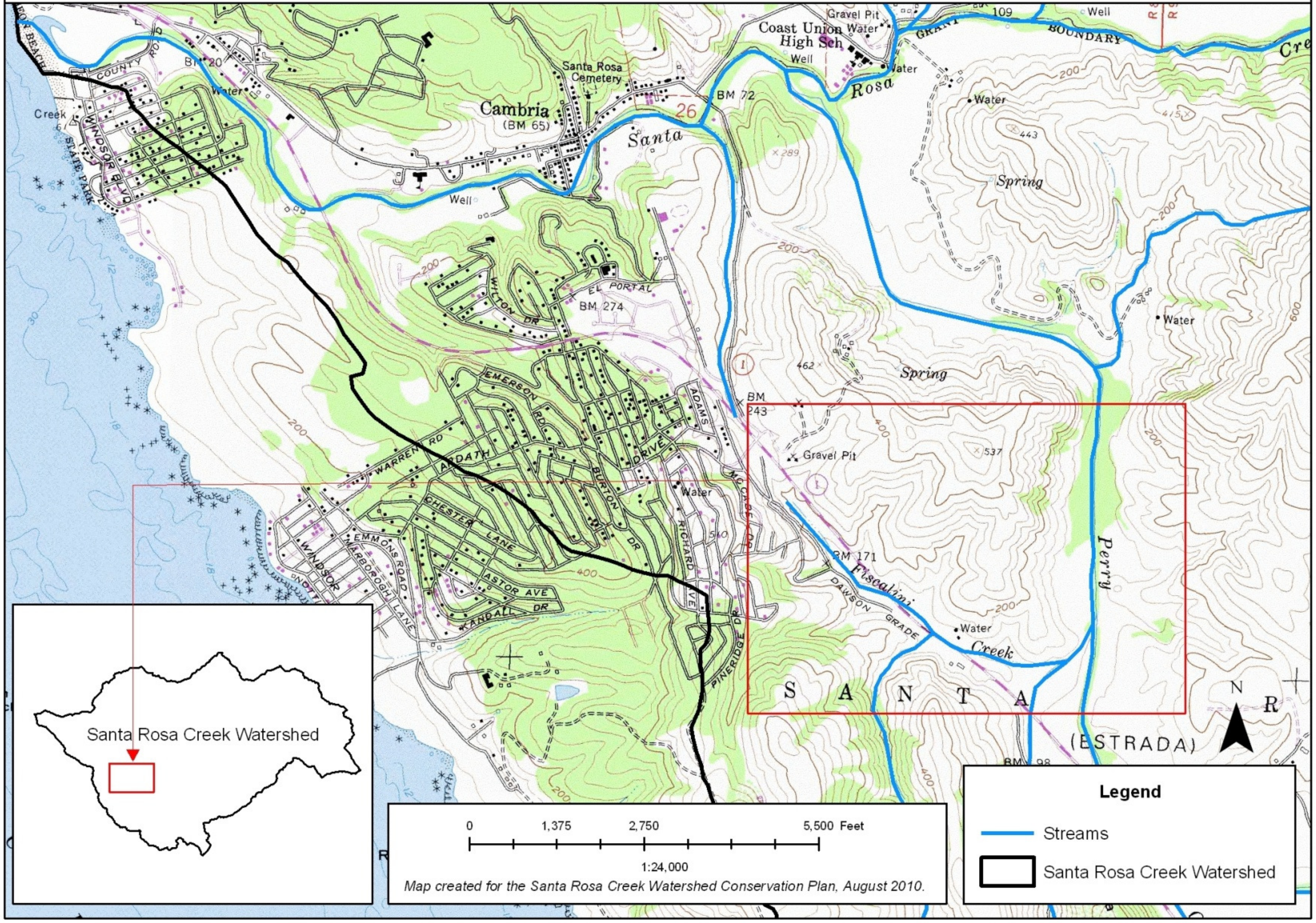
The southern portion of the watershed drains into Perry Creek with low elevation headwaters located in the foothills near Harmony. Perry Creek is 9.3 miles in total length with headwater elevation approximately 820 feet above mean sea level. Fiscalini Creek, a tributary to Perry Creek, is 1.1 miles in length, and collects water from the southwestern portion of the watershed, west of State Highway 1. Fiscalini Creek flows through a residential area on the south-east end of Cambria (Fig. 3).

Green Valley Creek is another tributary to Perry Creek and exists within the Perry Creek sub-watershed. Green Valley Creek is 7.3 miles in length and enters Perry Creek in the lowlands of Green Valley. From the confluence of Perry and Green Valley Creeks, Perry Creek flows downstream for 3.1 miles before it enters Santa Rosa Creek, 0.4 miles upstream of the Main Street-Santa Rosa Creek crossing.

Santa Rosa Creek flows through the commercial and residential districts of Cambria in the lower reaches of the watershed. As it approaches the ocean, the creek passes underneath State Highway 1, 1.25 miles from the coast, and enters San Simeon Beach State Park, which includes Moonstone Beach, before it flows into the Pacific Ocean (Fig. 4).

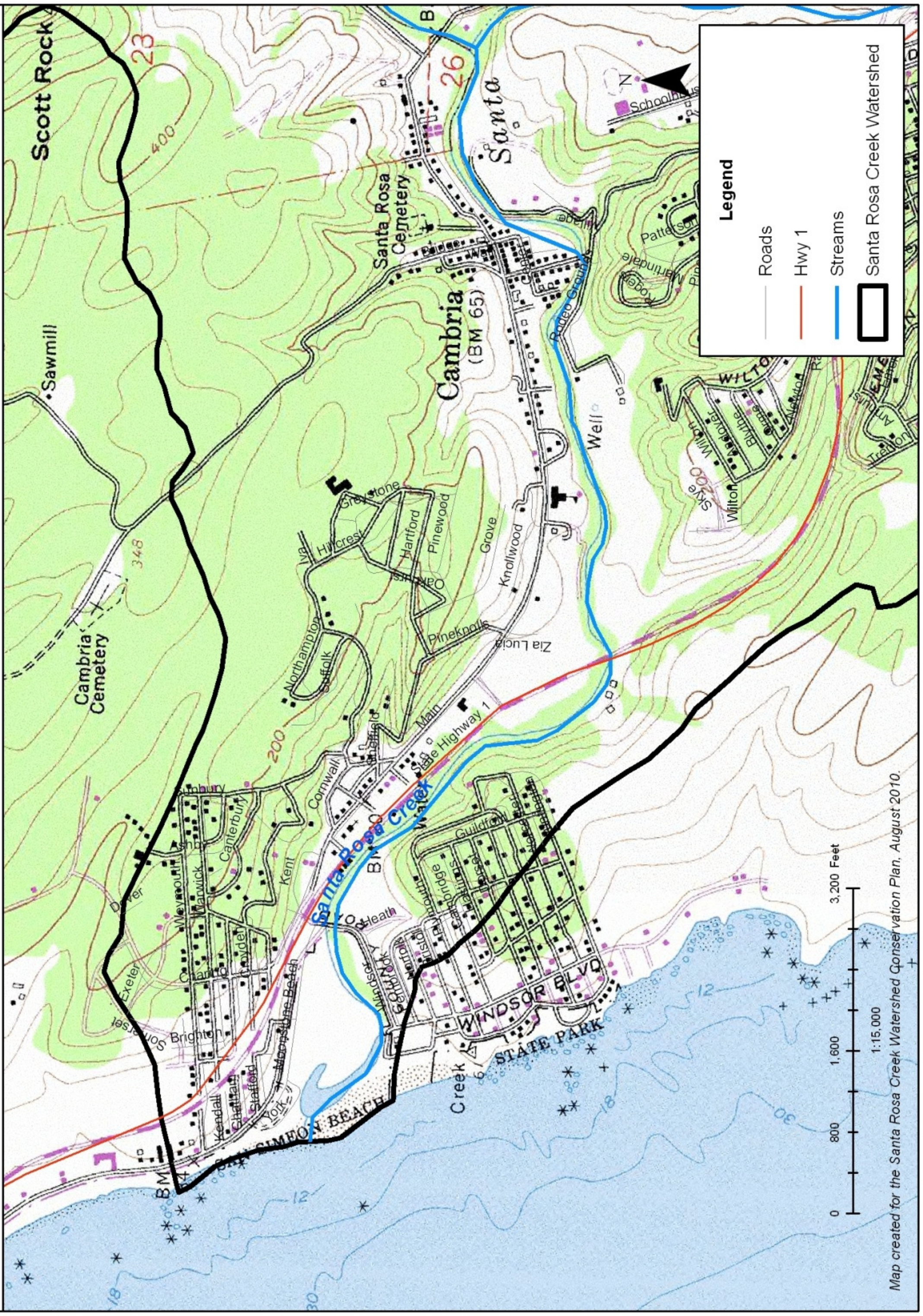
Digital 7.5 minute USGS topographic maps of Cambria and Cypress Mountain were studied using Geographic Information Systems (GIS) to obtain stream order and stream length data. The *California Salmonid Stream Habitat Restoration Manual* (Flosi et al, 1998) used by the California Department of Fish and Game and many watershed planning groups, classifies stream order using the Strahler system. Streams with no tributaries are classified as first-order streams. When two first-order streams meet, they form a second-order stream, and so on. Only where two stream segments of "equal magnitude" join is an increase in order required (Ritter, Kochel & Miller, 2002). Using this system, Santa Rosa Creek is a third-order stream. According to USGS quadrangle data there are 38 miles of blue line streams within the watershed, including Santa Rosa, Perry, Green Valley, Curti, and Fiscalini Creeks, as well as numerous unnamed tributaries (Fig. 5). Although some tributaries are not named on the quadrangles, many of them have been named and are known by those familiar with the watershed. Other named tributaries in the upper watershed include Lehman, Mora, and Trout Creeks (shown in Fig. 25, page 90), as well as Machaci and Soto Creeks.

Figure 3. Perry Creek and Fiscalini Creek Confluence

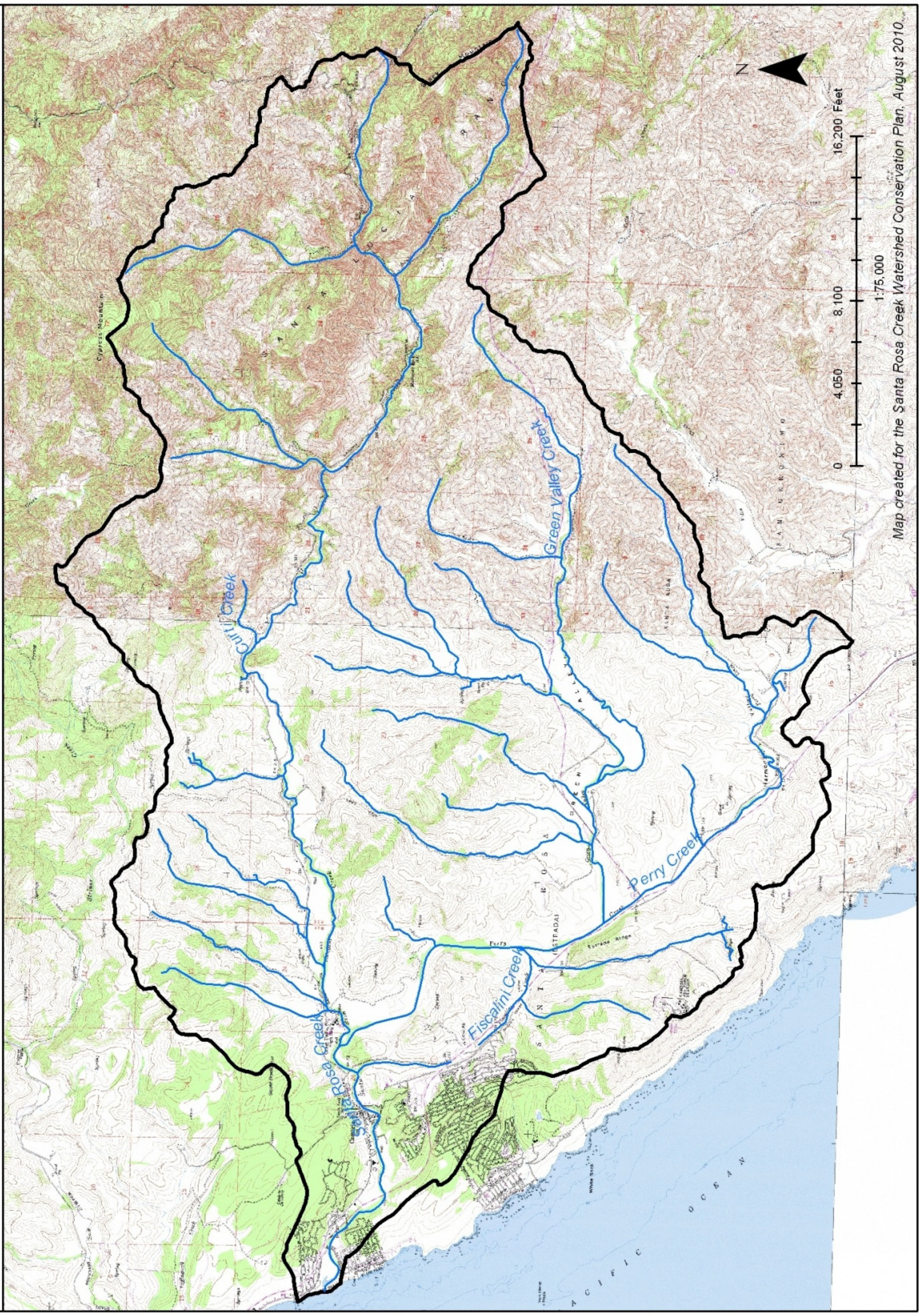


Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.

Figure 4. Santa Rosa Creek Outlet



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.

Figure 5. Santa Rosa Creek Watershed Blue-Line Streams

3.2. CLIMATE

California has one of the most diverse climates of any other state in the nation. Climatic factors include temperature, precipitation, wind, fog, topography and proximity to the ocean. The Santa Rosa Creek Watershed is situated along the Pacific coastline where climate is cool and mild, and little daily or seasonal temperature fluctuations exist. According to the Köppen System of climate classification, the climate of this watershed is characterized as "Mediterranean cool summer with fog, typified by warm, dry summers and mild, moist winters" (Holland and Keil, 1995).

Fog greatly impacts the central coast's climate. It reduces incoming solar radiation which results in cooler temperatures and decreased photosynthesis and transpiration rates. Fog also increases condensation on soil and plant surfaces, which in-turn increases total effective precipitation of an area (Holland and Keil, 1995).

Smaller microclimates are formed within the Mediterranean macroclimate due to slope and aspect. These microclimates occur between north and south-facing slopes of foothills and mountains, and within distinct topographic features such as narrow mountain valleys. Because sun exposure is greater on south-facing slopes, they are hotter and drier than north-facing slopes which are generally cool and moist. Aspect also affects vegetation type and density, for instance trees and shrubs are more common on north-facing slopes where moisture is greater, while chaparral and grasses are more common on drier south-facing slopes. These microclimates are apparent throughout the foothills and upper reaches of the watershed.

Precipitation and temperature data for the watershed were obtained using the Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/), an online database. USDA Service Center Agencies created GIS climate data from information gathered between 1960 and 2001. These data provided the climate information for the Santa Rosa Creek Watershed described below.

Average annual precipitation data from the Geospatial Data Gateway show precipitation ranges from 17 inches at the coast to 23 inches in the Santa Lucia Mountains. Most precipitation occurs between the months of December and March, with January exceeding all months, averaging between 3.75 and 4.75 inches. In contrast, very little precipitation occurs for several months in the summer. Additional resources show precipitation averages below 0.15 inches a month for Cambria from June through September (http://www.weather.com/weather/wxclimatology/monthly/graph/USCA0161?role=). Precipitation data from local farmers show precipitation ranges can be much greater than the average data. In recent years, rainfall amounts have exceeded 40 inches in the headwaters, with some areas in the Santa Lucia Mountains receiving up to 56 inches of rain in a year.

The average annual temperature data from Geospatial Data Gateway show the watershed is a mild 55° F to 59° F. Minimum temperatures range between 33° F and 43° F. The insulating qualities of the Pacific Ocean are evident by the 16° F difference in maximum temperatures between the coast, at 67° F, and the headwaters, at 83° F.

3.3. DEMOGRAPHICS

The United States Census Bureau conducted its latest census in 2000. In the US Department of Commerce's census report published in 2002, census data for Cambria were separated from county-wide data and summarized. Approximately 18 percent of the total watershed area, or 8.57 square miles, was accounted for in the census report. The report results focused on the urbanized core of Cambria, with a density of 727 individuals per square mile.

The Department of Commerce data shows that in 2000, the population of Cambria was 6,232 with a median age of 51 years old. Population under the age of 18 years was 16.4 percent and the population 65 years and older was 26.6 percent. California-born native residents living in Cambria was 56.3 percent. In 1990, the population of Cambria was 5,382 persons with a median age of 45 years old. The population change from 1990 to 2000 indicates an approximate 1.6 percent population growth each year.

The census report also shows that in 2000, over 90 percent of the population was white with Hispanic or Latino individuals accounting for most of the minority population. At that time, there were 3,750 housing units in Cambria, with 13 percent of those units developed between 1995 and 2000. The average household size was 2.21 individuals and median household income was $45,000 per year. In 2000, the majority of housing was owner-occupied at 55 percent with seasonal, recreational, and occasional use accounting for 20 percent of housing.

The Department of Commerce report also shows that in 2000 the population 25 years old, or older, was 4,896, or 79 percent of the total population. Of that population, 91 percent were high school graduates, or higher, and 36 percent of those individuals had a bachelor’s degree, or higher. In 2000, the population within poverty status was determined to be 8.2 percent. About half of the population was involved in the labor force, at 54 percent, with 89 percent of that population driving a car, truck, or van to work, 16 percent carpooling and only 0.8 percent using public transportation.

Additional demographic data were acquired through SLO Datafinder (http://lib.calpoly.edu/collections/gis/slodatafinder/) and included housing and population census data for the year 2000. The census “blocks” or boundaries used to summarize GIS data do not match the watershed boundary exactly. Therefore, GIS data studied for the Santa Rosa Creek Watershed includes area within and tangent to the watershed. Santa Rosa Creek Watershed census “blocks” total 74,703 acres. In 2000, 2,990 dwellings existed and the population within these “blocks” was 5,360, or 0.0717 persons per acre. In the upper watershed (71,821 acres) 494 dwellings existed and the population was 973, or 0.014 persons per acre. In contrast, the remaining population of 4,387 occupied the lower watershed of 2,882 acres. The population density in the lower watershed was 1.52 persons per acre, approximately 113 times greater than population density in the upper watershed. These data show that approximately 82 percent of the population exists within the lower 3.9 percent of the watershed.

3.4. PRE-HISTORY

Radiocarbon dating from archeological sites in San Luis Obispo County provides evidence that Obispeño and Salinan ancestors existed on the Central Coast up to 9,560 years before present (B.P.) In the Cambria area, more than a dozen archeological sites have been discovered, spanning a timeframe of over 8,000 years of occupation (Greenwood in Gibson, 2003). Parker and Associates Archeological Research compiled data describing human occupation on the Central Coast in the past 12,000 years. They published this data in a timeline available on their website (http://www.tcsn.net/sloarcheology). The following description of Cambria pre-history was derived from their data:

> During Paleo-Indian times (12,000 B.P.), Central Coast climate was moist with pine forests, marshes, lakes, and rivers abundant. Small groups of native people existed. They primarily ate large mammals as well as fish and mussels gathered by hand in tidepools. As resources diminished groups of native people moved to different locations. As climate changed to the warmer, drier period of the Lower Archaic (8,500 B.P.), wetlands were replaced with grasslands and chaparral. Small camps of individuals coalesced into larger communities near water resources. Hunting and gathering evolved with the development of tools such as the fish gorge, net weight, milling slab, hand stone, and the spear. By Middle Archaic (5,500 B.P.), diminishing resources necessitated the further development of tools such as the shell hook, dart and atlatl, and bowl and mortar. In this period trade began with inland groups. During the Upper Archaic (2,500 B.P.) siltation from rising ocean levels devastated the fisheries and forced coastal villages to relocate to fringe coastal/inland boundaries. This move increased available food resources. The seagoing plank canoe, or tomol, was developed approximately 2,000 B.P., indicating a greater adaptability to limited resources. At that time, the population grew, a social class developed, and shell-bead currency was introduced. By the Emergent Period (1,000 B.P.) a highly civilized society existed with different classes and political systems in place. The population continued to grow as additional tools were developed, such as the bow and arrow, bone hook, and hopper mortar.

Hamilton (1999) states that diaries written by early Spanish expedition members noted native people existed in the Cambria area by the late 18th century. "These native people had different cultural and dialect traits from the Salinan people located in the Salinas Valley and were therefore labeled Playa Salinans". Chumash believe they also had a presence in the North Coast and may have lived in the Cambria area as well. Contact between the native people and Spaniards was made around 1769, and European diseases were fatal to many natives. Around 1838, additional changes in the lives of the native people occurred when they were integrated into Rancho Santa Rosa, located in the lower Santa Rosa Creek Watershed. They were introduced to domestic plants and animals while forced to labor at the rancho.

3.5. EUROPEAN HISTORY

Settlement and Development

Don Gaspar de Portola, a career-officer in the Army of the King of Spain, was the first to lead a land-expedition into Nueva California in 1769. Portola's objective was to establish outposts in both San Diego harbor and Monterey Bay. At the time, Spain was attempting to protect territories from Holland, England, and Russia. Holland and England were approaching from the Pacific, and Russia was moving southward from Alaska. Friar Juan Crespi traveled with the expedition and recorded Portola's journey in his diary. This diary was later translated by Father Francisco Palóu and published in the book *Captain Portolá in San Luis Obispo County, in 1769*. Portola's route up and down the coast was described in detail by Crespi. On expedition north from San Diego, Portola traveled through Green Valley and arrived at the present-day location of Coast Joint Union High School, on September 10th, 1769. Crespi described the Santa Rosa Creek valley in the following manner:

> From that point (Green Valley) we made out for a mountain range covered with pines, and in a very deep valley filled with a thick growth of willows, cottonwoods, pines, and

> other trees, we came to a large arroyo, which looked to us like a small river. We halted at the head of the valley, and some sixty heathen from a village that they said was not far from the camping place came to visit us. They gave us some baskets of pinole and we returned the gift with beads. They brought a little bear which they have reared and offered it to us, but we did not accept it.

On December 24th, 1769, Portola's expedition returned to the Cambria campsite from the north. They were greeted by over two hundred "heathen of both sexes" who celebrated Christmas with Portola's men. The native people brought them gifts of pinole and fish.

Nearly thirty years later, in 1797, Mission San Miguel was established by the Spanish. It was soon discovered that water resources here were not adequate for extensive agriculture. Other areas were explored to find additional resources. Rancho Santa Rosa, located in the lower Santa Rosa Creek Watershed, provided wood from the watershed's headwaters to Mission San Miguel. Geneva Hamilton describes Rancho Santa Rosa in her book, *Where the Highway Ends* (1999).

> This rancho had an abundance of wild forage for mission stock and numerous springs and streams which flowed throughout the year. In the fertile valleys through which Santa Rosa Creek and its tributaries wandered lived many deer, bear, fox and small animals such as the rabbit, squirrel and marsh rat. Oak, elderberry, sycamore and myrtlewood trees were plentiful in the canyons and along the streams while forage grasses and chaparral covered the drier hill sides and flats. The northern end of the valley through which Perry Creek flows, was quite low and caused the formation of a low, board lake called a laguna by the Spanish. It was fed, not only by Perry Creek flowing from Harmony Valley, but also by the Green Valley stream and several other small streams caused by runoff from the surrounding hills to the west and northwest. During the summer, the lake became a marsh clogged with tules and other water plants and was partially surrounded by willows. The abundance of natural food and water encouraged the establishment of several large Indian camps which were inhabited for many hundreds of years before the first Spaniards arrived.

Rancho Santa Rosa was granted to Don Julian Estrada in 1841 as a result of mission secularization. Estrada spent summers at the property and native people assisted him to raise cattle on the land. By 1849, Estrada moved his family from San Luis Obispo to the Rancho where he had built an adobe home and created gardens, orchards, vineyards, and fields for cultivation. In 1850, California became a state. In order to establish local governments there was heavy taxation on real and personal property (including every chicken, pig, cow, horse, or tree owned). The Rancheros had operated on the barter system for over 50 years and the transition to a cash-based economy was very difficult. Estrada was forced to borrow money from a San Luis Obispo attorney and land speculator, Domingo Pujol, to pay for survey and legal fees incurred to substantiate the boundaries of his Rancho. Estrada eventually transferred 12,000 plus acres of Rancho Santa Rosa in 1864-1865 to Pujol (who was foreclosing on Estrada) and 1,500 acres to George Hearst, retaining 160 acres surrounding his rancho home. Pujol subdivided Rancho Santa Rosa into lots and sold the first lot in September 1866 in what is now modern Cambria (Hamilton, 1999). By 1900, only adobe wall remnants were left of the Estrada home. In 1962, the site was completely covered by the relocation of State Highway 1.

In 1866, the town of Cambria began development and grew rapidly due to the success of offshore whaling, shipping, mercury mining, dairy farming, and sea lettuce cultivation. The

Leffingwell saw mill was established in the late 1850s on the hills north of Santa Rosa Creek. The Pacific Saw Mill, a portable mill, was located south of Santa Rosa Creek in 1866. During the construction of the town, these mills were working at full capacity to fulfill the demand for lumber. The mill quickly cut local trees into wood slabs to be used for the town's development. Often times bark was left on the slabs, which gave the buildings a rough appearance and assigned Cambria the nickname of "Slab Town".

Santa Rosa Creek Trail (now known as Main Street) ran east-west and connected with the Coast Trail (now known as Bridge Street) in town. The Coast Trail was later re-named Bridge Street because many bridges were built to cross the "gulley on the west side of the road" (Adams, 1986). Within town limits, the "gulley" was eventually filled in.

By 1880, Cambria was the second largest community in San Luis Obispo County, with over 2,000 inhabitants in the town of Cambria with many more residents living in surrounding farms and ranches outside town. The community was devastated in 1889, when the "Great Fire" destroyed the central business district and six homes. The community rebounded quickly however, replacing buildings, establishing a town water system, and expanding their fire-fighting capacity. Since then, Cambria has experienced periods of success and decline.

In 1894, the development of the county's railway system caused the coastal shipping industry to drop. Cambria suffered losses and by the early 1900's a boost to the economy was needed. Cambria began to prosper as improvements to roads and the mass production of the automobile made the community more accessible to surrounding cities. The Cambria Development Company purchased the Taylor Ranch in 1927 and built the Cambria Pines Lodge in 1932 to attract buyers who would build seasonal cottages in the resort development. Another tourism boom occurred in 1958 when the William Randolph Hearst "Castle" was built just north of Cambria. The rerouting of State Highway 1 was complete in 1964 and may have impacted tourism slightly; however Cambria is still a popular vacation destination.

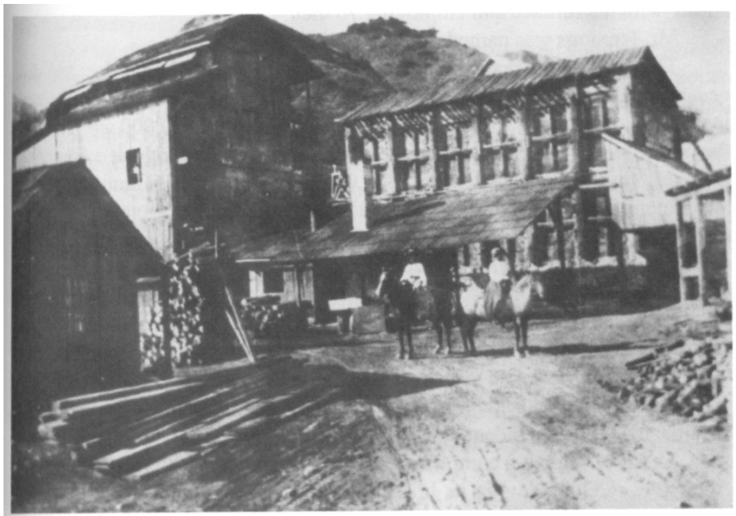
Mining

As early American settlers panned the California countryside looking for gold, a quicksilver boom was about to hit the coast surrounding Cambria. Liquid quicksilver, or mercury, was used during the Gold Rush to isolate flecks of gold. Quicksilver is derived from crushed and heated cinnabar ore. Portolà, in his 1769 expedition, observed local native people who decorated themselves using ground cinnabar to paint their bodies. Sources of cinnabar were kept secret for nearly 100 years, until body painting was relinquished as Native Americans were integrated into Spanish missions. In 1862, Mexican prospectors discovered cinnabar in the Santa Lucia Mountain range east of San Simeon. With the Civil War driving mercury prices high, a "rush of prospecting and claim staking [occurred] on every bit of ground that gave a show of cinnabar" (Hamilton, 1999).

The first cinnabar outcroppings were located in the Santa Rosa Creek headwaters. In January 1864, the Josephine Quicksilver Mining Company was established and successfully shipped $280,000 of quicksilver through the port of San Simeon between 1864 and 1867. Local mining activities expanded and by 1871 a need for a mining district was eminent.

The greatest mineral discovery was found in 1872 by three men riding their horses in the foothills north of town. The men discovered "red streaks" in a rock, later confirmed as mercury. This was a historic find in the watershed as testing samples revealed high mercury content. The three claims resulting from this find were consolidated in 1874 to form the Oceanic Quicksilver Mining Company. The Oceanic Mine was a successful operation, going at "full blast" in September, 1874 (Hamilton, 1999). There were four levels to the mine, 300 feet long at the most, and 900 feet deep. The mine was intermittently active until WWII. The tunnels were filled and covered in the mid-1940s. In the early 1950s, the retort was used to process slag. The yield was of such poor quality it was soon abandoned. In the early 1960s, four small vertical holes approximately 200 feet in depth were drilled. The holes were filled and all mining ceased (personal communication, J. Fitzhugh). Today the Oceanic Mine is closed with conflict surrounding the cleanup of waste produced from the site. High levels of mercury have been detected in the waters of Curti Creek, the stream draining from the Oceanic Mine site. Mercury has also been discovered in crops grown at the organic farm now residing where miners processed the ore (Rigley, Cover Story).

Mining reached its peak in the Santa Rosa Creek Watershed in 1876, hit a near stand-still from 1888 to 1894, and was revitalized and subsided by 1918. At this time, many mines were either abandoned due to poor profits, or depleted of their resources. By 1963 a third wave of mining activity returned to the area as prices for quicksilver reached historic levels. However, activity subsided again within only a few years. Today, there are no active mercury mines in the watershed.



Huge buildings over the shafts of the Oceanic Mine. Taken about 1917. The outbuildings held blacksmithing forges, the office, crushers, etc.

Picture 1. Outbuildings at Oceanic Mine, 1917 (Hamilton, 1999).

Flooding

Cambria has faced several major and minor flooding events, including the 1914, 1956, 1969, and 1995 floods in which the business and residential districts in town were inundated with flood waters. As Santa Rosa Creek flows through the town of Cambria, it becomes confined by structures such as buildings and bridges, in a narrow channel with developed stream terraces. As development along the channel has increased, impacts of flood waters have increased.

In January 1914, after weeks of rain, streams and gullies overflowed leaving the streets of Cambria underwater and cisterns and cesspools full (Hamilton, 1999). Business owners rushed frantically to sandbag doorways in attempt to save their establishments while trying to conduct "business as usual". Homes along the creek were the most impacted. Off the coast, several large waterspouts formed and crashed onto the beach near the outlet of Santa Rosa Creek.

The impacts of the 1956, 1969, and1995 floods were greater than the 1914 flood due to increasing amounts of urban structures, such as culverts and bridges, along the stream. These structures decreased the Santa Rosa Creek water capacity through town, making it easier to flood. Picture 2, below, shows the western portion of Cambria flooded in 1956.

In the 1960's, State Highway 1 was developed and fill was used to elevate the road between the stream and stores in the western portion of Cambria. As a result, mostly minor flooding events have occurred, with two exceptions; the entire West Village was flooded in 1969 and 1995. Businesses were ruined and it took the community several years to recover from each event. In the early 2000s, extensive measures were taken by San Luis Obispo County to address water backflow issues at State Highway 1 culverts.

Heavy rain, an overflowing creek and high tide combined to flood the town of Cambria in 1956. (Courtesy of Ralph Morgan)

Picture 2. The town of Cambria in 1956 after heavy precipitation caused a devastating flood (Hamilton, 1999).

3.6. CULTURAL RESOURCES

Various cultural resources located in the Cambria area are described in Robert Gibson's archeological assessment, conducted for the Santa Rosa Creek Trail Project (2003). Gibson found that at least one dozen cultural sites exist between Lodge Hill and San Simeon Creek. Lodge Hill is located on both sides of State Highway 1, above the East Village and near Cambria Pines Lodge. Lodge Hill is also close to marine terrace and tidepool locations. Gibson noted 11 cultural sites have been found from one-quarter to 1.5 miles upstream of the creek's outlet. Most cultural sites are located on marine and stream terraces in the older sections of town. Gibson also noted that several additional cultural sites are located east of town on flat stream terraces.

There are three historic sites within the watershed boundary (http://lib.calpoly.edu/collections/gis/slodatafinder/). They include the Arthur Beale House (1929), Bianchini House (1889), and the Paul Squibb House (1877). Additionally, the Guthrie House (landmark plaque number N853) and Old Santa Rosa Catholic Church and Cemetery (landmark plaque number N1154) are listed as "National Registers" located in Cambria (http://ohp.parks.ca.gov/listed_resources/). The Office of Historic Preservation defines National Registers as "buildings, structures, objects, sites, and districts of local, state, or national significance in American history, architecture, archeology, engineering, and culture".

3.7. VEGETATION

The geographic classification system used in *The Jepson Manual*: *Higher Plants of California* (1993) divides California into geographic systems, or provinces, according to several landscape features such as natural vegetation types, as well as geologic, topographic, and climatic variations. Using this classification system the Santa Rosa Creek Watershed is located in the Central Coast (CCo) of the Central Western California Floristic Province. The boundaries of CCo extend along the Pacific Ocean, from Point Conception in the south, to Bodega Bay in the north, and by the Great Valley province to the east. The Mediterranean climate of this region allows a wide range of vegetative species to grow here, including rare species.

Monterey Pine (*Pinus radiata*) and Sargent Cypress (*Cupressus sargentii*) are two rare tree species found in the watershed. One of only three naturally occurring stands of Monterey Pine found within California is located in the watershed (Sawyer, Keeler-Wolf, 1995). Additionally, locally rare Sargent Cypress is the name-sake for Cypress Mountain, located on the eastern boundary of the watershed. Sargent Cypress grows at a few sites near Cambria in the Santa Lucia Mountains (Coffman, 1995). In addition to rare species, the watershed is a mosaic of vegetative species which have adapted to the diverse habitats here.

Grasslands, riparian forests, hardwood forests, and an estuary are just a few of the ecosystems found in the Santa Rosa Creek Watershed. Being largely undeveloped, the watershed is full of trees, shrubs, and herbs. In 2009, spatial vegetation data for the watershed was published by the County of San Luis Obispo with Aerial Information Systems, Inc. (AIS). The digital vegetation data were developed using the 2008 National Vegetation Classification System (NVCS) and the *Manual of California Vegetation* (Sawyer and Keeler-Wolf, 1995). The resulting vegetation boundaries within the watershed were mapped (Fig. 6 and 7).

The County/AIS data identified vegetation formation units and oak communities. Formation mapping units describe all vegetative communities within the watershed (Fig. 6). Vegetation formations include: Mesomorphic Tree Vegetation-Forest and Woodlands (Tree), Mesomorphic

Shrub Vegetation (Shrub), Mesomorphic Herbaceous Vegetation (Herbaceous), Temperate Flooded Riparian Vegetation (Wooded Wetland), Temperate Meadow and Freshwater Marsh (Herbaceous Wetland), Lithomorphic or Wetland Associated Naturally Sparse or Unvegetated Areas (Natural Unvegetated), Water, Urban Built Up (Urban), and Agriculture categories. Guidelines used to define vegetation formation and oak communities follow the National Vegetation Classification Hierarchy summarized in the San Luis Obispo County Vegetation Mapping Report, Photo Interpretive and Mapping Guidelines (2009) and are described below.

While the 2009 County vegetation data provide precise locations of general vegetative communities, geographic data produced by the County in 1998 provided detailed data for generalized locations. These data reveal where estuary, riparian scrub, riparian woodland, coastal oak woodland, coast mixed scrub (chaparral and coastal scrub), Monterey Pine, and annual grassland communities exist in the watershed. These data are less accurate than the 2009 vegetation data however they provide reference data for vegetative species found in the watershed. For instance, Monterey Pine species are known to exist in the watershed, however were not mapped in the 2009 vegetation data. It was therefore necessary to reference the 1998 vegetation data to identify the stand locations (Fig. 8). The more precise data (2009) were used to map vegetation in the watershed while the older datasets (1998) were used to explain the data in greater detail.

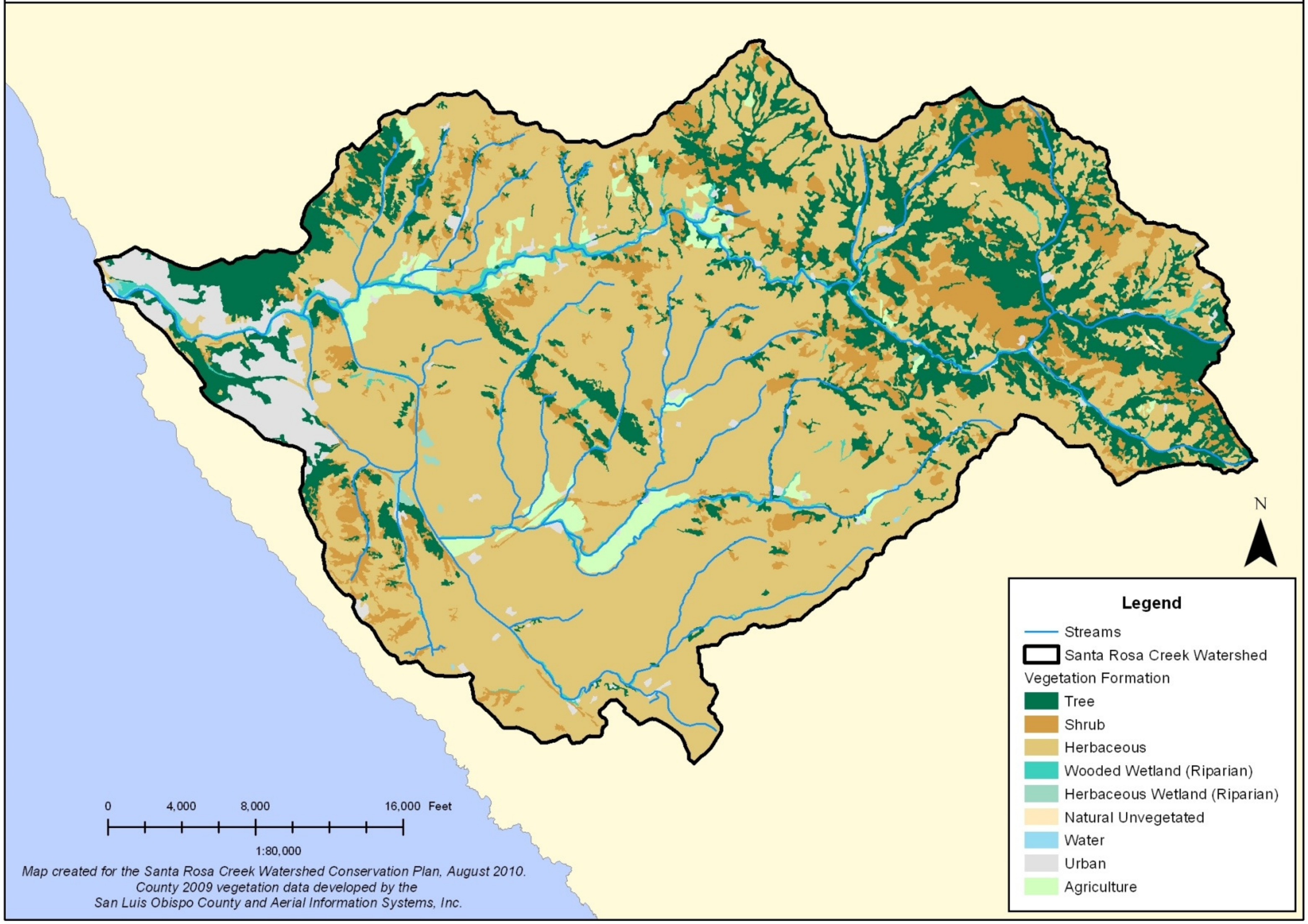
Using the 2009 vegetation data, the total acreage and percent of watershed area was calculated for vegetation formations (Table 3). Mesomorphic Herbaceous Vegetation (Herbaceous) is the most common vegetation type accounting for over 19 thousand acres in the watershed, or 63 percent of the entire watershed area. Mesomorphic Tree Vegetation (Tree) is the second most abundant formation accounting for 5,536 acres, or 18 percent. Mesomorphic Shrub Vegetation (Shrub) is the next abundant with 2,961 acres, or nearly ten percent of the total watershed area.

The watershed's vegetation formations and oak communities are listed and described below using the County's Vegetation Mapping Report (2009). Vegetative communities have been identified for each formation using 1998 County vegetation data. These communities are described in greater detail using information from *California Vegetation* (Holland and Keil, 1995) and the *Manual of California Vegetation* (Sawyer and Keeler-Wolf, 1995).

Mesomorphic Tree Vegetation-Forest and Woodlands

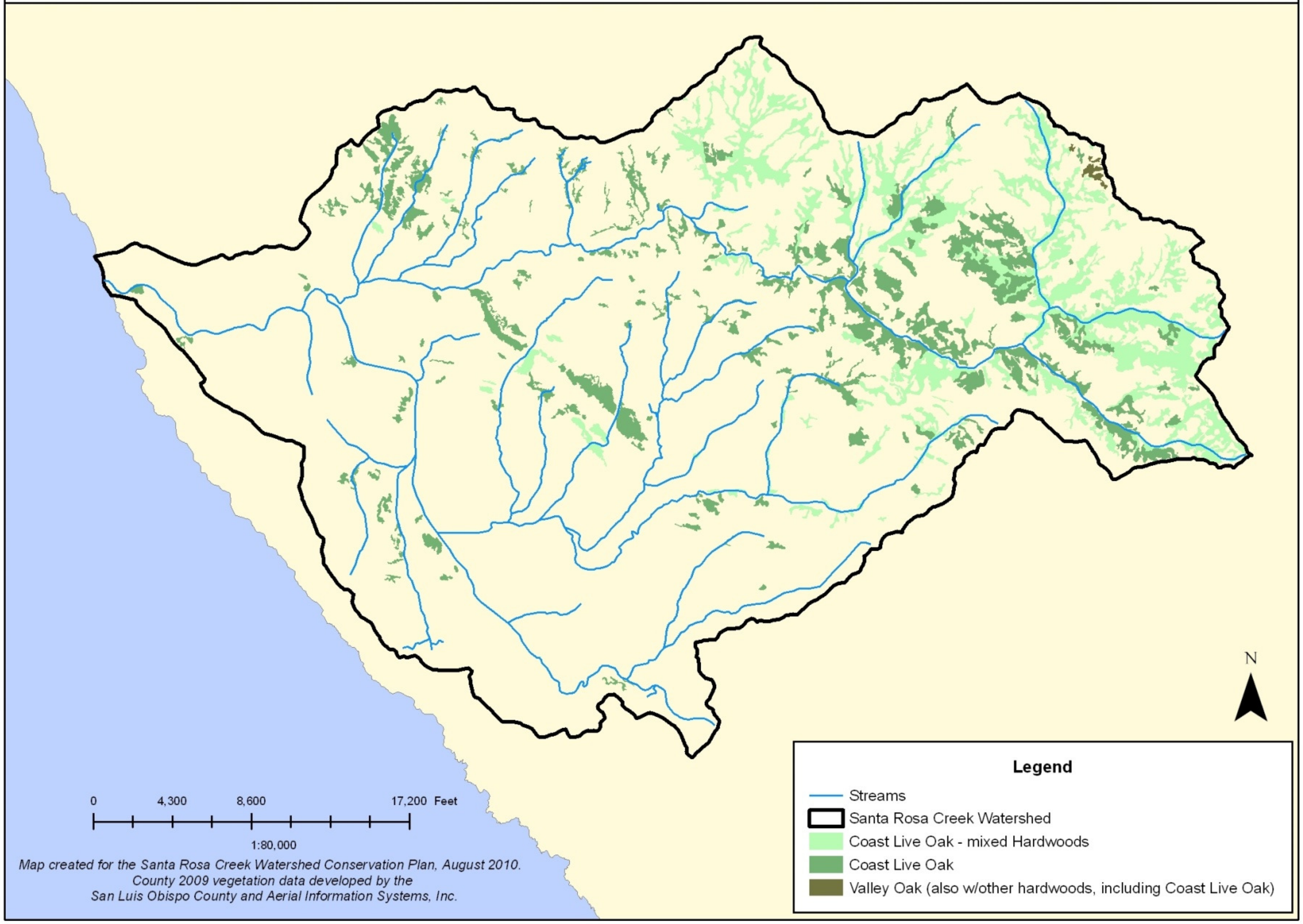
The National Vegetation Classification Hierarchy defines this category as locations where all tree forms dominate the canopy with at least eight to ten percent cover (County of San Luis Obispo, 2009a). There are approximately 5,536 acres of trees in the watershed. They are located throughout the lower watershed, including developed areas, along drainages in the upper foothills, and scattered in the headwaters with shrubs and herbs. Trees in the lower watershed are mostly Monterey Pine, while oak communities are dominant in the foothills and headwaters.

Figure 6. Santa Rosa Creek Watershed Vegetation Formations



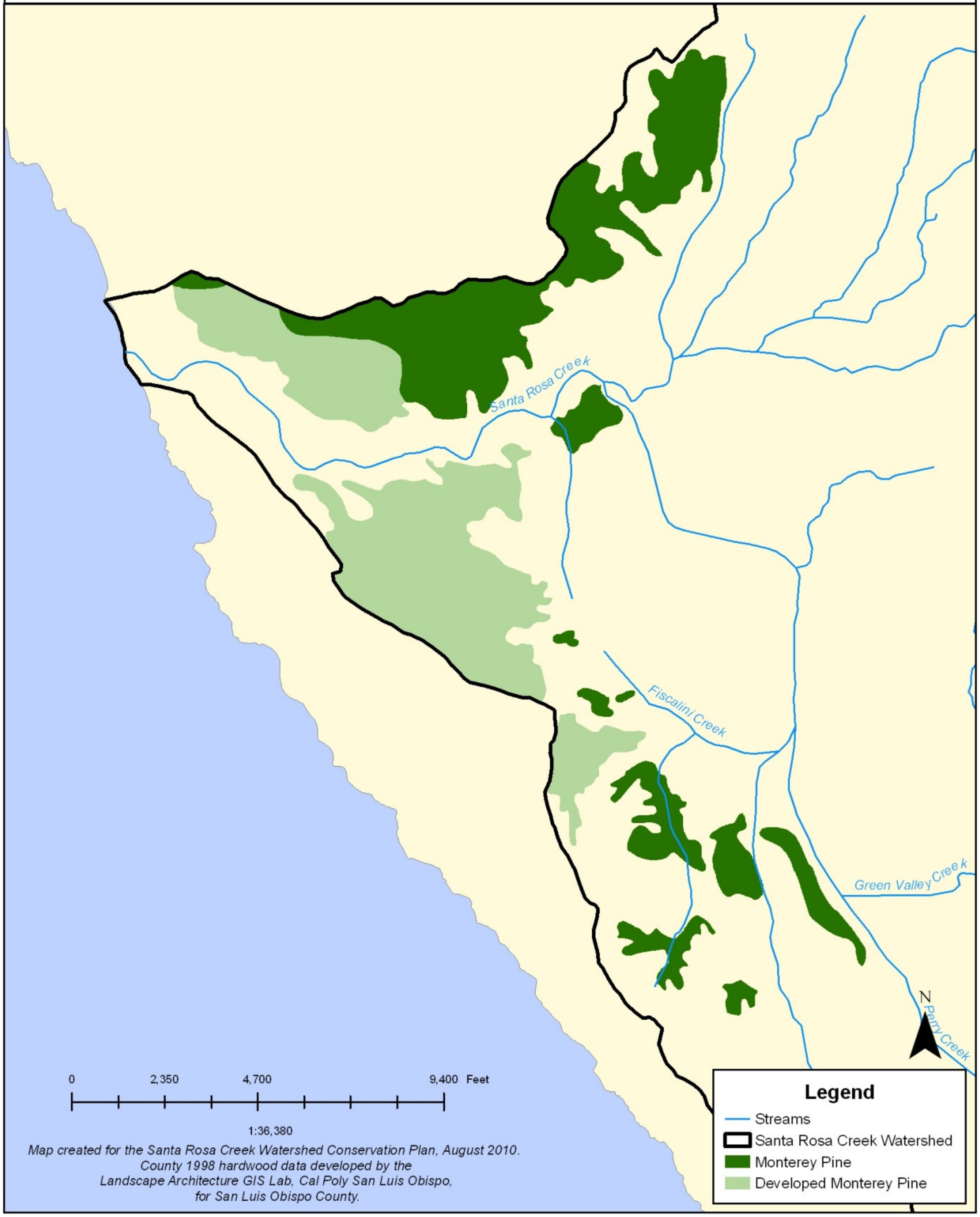
Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010. County 2009 vegetation data developed by the San Luis Obispo County and Aerial Information Systems, Inc.

Figure 7. Santa Rosa Creek Watershed Oak Species



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010. County 2009 vegetation data developed by the San Luis Obispo County and Aerial Information Systems, Inc.

Figure 8. Monterey Pine Forest Stand Locations in the Santa Rosa Creek Watershed



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010. County 1998 hardwood data developed by the Landscape Architecture GIS Lab, Cal Poly San Luis Obispo, for San Luis Obispo County.

The watershed tree formation data were divided in the 2009 County data into three categories of oak communities: Coast Live Oak, Coast Live Oak-mixed Hardwood, and Valley Oak (also with other hardwood including Coast Live Oak) (Fig. 7). There are a total of 4,348 acres of oak communities in the watershed, or about 14 percent of the total watershed area. Coast Live Oak-mixed Hardwood is the most common with 2,346 acres, or approximately eight percent of the total watershed area. Coast Live Oak accounts for 1,979 acres, or nearly seven percent of the total watershed area. Valley Oak with Hardwoods including Coast Live Oak accounts for only 23 acres, or less than one percent of the entire watershed area (Table 4). The Mesomorphic Tree Vegetation-Forest and Woodland mapping unit can be described in greater detail by identifying the forest and woodland communities that exist in the watershed.

Table 3. Santa Rosa Creek Watershed vegetation formation categories, total acres, and percent of watershed area, identified by the County of San Luis Obispo and AIS, 2008.

Vegetation Formation	Acres	Percent Watershed Area
Mesomorphic Tree-Forest and Woodlands	5,536	18
Mesomorphic Shrub	2,962	10
Mesomorphic Herbaceous	19,200	63
Temperate Flooded Riparian	671	2
Temperate Meadow and Freshwater Marsh	50	<1
Lithomorphic or Wetland Associated Naturally Sparse or Unvegetated Areas	17	<1
Water	17	<1
Urban Built Up†	1,141	4
Agriculture	789	3

†Using 2007 aerial imagery of the watershed, it was discovered that Urban Built Up areas correlated with rock outcrops or exposed soil in the upper watershed and that observable mapping errors exist within this formation type in this watershed.

Table 4. Santa Rosa Creek Watershed tree category vegetation identified by the County of San Luis Obispo and AIS, 2008.

Tree Category	Acres	Percent Watershed Area
Coast Live Oak	1,979	7
Coast Live Oak-mixed Hardwood	2,346	8
Valley Oak (with hardwood including Coast Live Oak)	23	<1

Oak Woodland

In the Santa Rosa Creek Watershed, coastal live oak woodlands occur in two conditions. The first is in moist, often north-facing slopes, where coast live oak (*Quercus agrifolia*) form dense communities and intermix with species such as California bay-laurel (*Umbellularia californica*), madrone (*Arbutus menziesii*), and big-leaf maple (*Acer macrophyllum*) with shade-tolerant understory plants. The second condition in which coastal live oak woodlands occur is in drier, more exposed areas where sparsely scattered oaks are associated with shrubby or herbaceous understory plants, or grasslands, in open woodland communities. The most common shrubs associated with open woodlands are Manzanita (*Arctostaphylos spp.*), gooseberries and currants (*Ribes spp.*), lavendar (*Ceanothus spp.*), bush monkeyflower (*Mimulus auranitiacus*), black sage (*Salvia mellifera*), coyote bush (*Baccharis pilularis*), and California sagebrush (*Artemisia californica*) (Holland and Keil, 1995).

Coast live oak communities usually exist on slopes tangent to streams in the Santa Rosa Creek Watershed. As elevation increases oak communities integrate into riparian vegetation and become more complex. In the lower foothills oak communities are classified exclusively coast live oak. In the headwaters, the oak forests intermingle with other hardwood species.

Valley oak (*Quercus lobata*) exists in the watershed as well. A small patch of valley oak is located along the northeastern border, southeast of Cypress Mountain. Valley oak woodlands are found on alluvial terraces and low rolling hills from Lake Shasta to Los Angeles. They are usually found in fertile alluvial valleys where they grade into foothill woodlands (Holland and Keil, 1995). In the Santa Rosa Creek Watershed, the valley oak population is located on a steep hillslope with coast live oak mixed hardwood forests, shrubs, and herbs.

Monterey Pine Forest (Closed Cone Coniferous Forest)

Monterey Pines only grow naturally in three locations in the state, including Cambria. Natural stands of Monterey pine are in danger due to a fatal pine pitch canker disease and urban development. In Cambria, stands of Monterey Pine grow as a closed canopy forest with Coast Live Oak and toyon growing as a short-tree understory (Holland and Keil, 1995). There are approximately 777 acres of undeveloped Monterey Pine forest in the watershed, or three percent of the total watershed area. An additional 772 acres of developed Monterey Pine forest exists in the watershed, and is impacted by residential areas and the community of Cambria. These developed areas account for an additional three percent of the total watershed area. Stands of Monterey Pine are exclusive to the lower watershed.

Sargent Cypress

Although Sargent Cypress is not identified in the County's vegetation data, it is recorded in the upper watershed by Coffman in his book *The Cambria Forest: Reflections of its Native Pines and Eventful Past* (1995). Cypress Mountain, located in the upper Santa Rosa Creek Watershed is named after a stand of Sargent Cypress trees that grow there. The Sargent Cypress series is described by Sawyer and Keeler-Wolf (1995) as typically found in upland slopes and ridges, and in raised stream benches or terraces. These trees grow in sterile soils derived from ultramafic material. Ultramafic rock is an igneous rock formed from magma, and is usually high in magnesium and iron.

Mesomorphic Shrub Vegetation

The National Vegetation Classification Hierarchy defines Mesomorphic Shrub Vegetation when the dominant canopy is shrub forms, covering at least ten percent of a site. Oaks may occur in the stand but are generally not important in the canopy nor are they distributed regularly throughout the unit. Emergent trees may occupy eight to ten percent cover, but are not distributed evenly throughout the site (County of San Luis Obispo, 2009a). There are approximately 2,962 acres of shrubs in the watershed, or roughly ten percent of the total watershed area. The 1998 vegetation data show chaparral and coastal scrub communities exist in the watershed.

Chaparral

In the Coast Range, chaparral communities form on steep, dry slopes and are often closely associated with southern coastal scrub plant communities. Species composition can be highly variable, and depending on dominant species, several different chaparral communities can be found throughout the state. In general, chaparral vegetation grows in dense thickets. Plants form a canopy of needle-leafed or broad-leafed drought-tolerant plants. Chaparral species are characteristically very stiff, woody, and long-lived. Within mature stands, there is often no herbaceous undergrowth present. Chaparral vegetation is diverse with nearly 900 vascular species occurring in these communities; with approximately 240 different woody plants from several different plant families (Holland and Keil, 1995).

Coastal Scrub

Southern coastal scrub communities often form in shallow, nutrient-poor soils with little plant-available water. As a result, vegetation is shallow-rooted and deciduous in the summer when leaves typically drop due to little or no water in the upper soil horizons. In contrast, vegetative growth often occurs in the winter, when moisture is available. Species common in coastal scrub communities include: California sagebrush *(Artemisia californica)*, bush monkey-flower *(Mimulus aurantiacus)*, sages *(Salvia sp.)*, coyote bush *(Baccharis pilularis)*, coffeeberry *(Rhamnus californica)*, and poison-oak *(Toxicodendron diversilobum)* (Holland and Keil, 1995).

Chaparral and coastal scrub communities are mixed throughout the watershed, occurring tangent to one another at some locations. These communities are common throughout foothills near streams on moderate slopes. As elevation and slope steepness increase, chaparral and coastal scrub become more common. In the headwaters these shrub communities are usually associated with tree formations and some herbaceous vegetation. There are fewer shrub communities in the Perry Creek Watershed. Shrubs here are more common on south-facing, moderate slopes and along the southwestern boundary of the watershed near the ocean.

Mesomorphic Herbaceous Vegetation

The National Vegetation Classification Hierarchy defines Mesomorphic Herbaceous Vegetation when all upland herbaceous life forms (forb-like and grassland vegetation) dominate the ground layer with at least ten percent cover. Emergent tree or shrub vegetation, or all woody life forms, can occupy up to ten percent of the site. Herbaceous cover can be present in “fallow” agricultural lands where annual grasses and forbs exist. This can occur as little as one season after harvesting a crop. Some areas classified as herbaceous may contain more than ten percent shrub communities due to the difficulty in distinguishing seral scrub growing in post disturbance situations (County of San Luis Obispo, 2009a). There are approximately 19,200 acres of herbs in the watershed, or roughly 63 percent of the total watershed area. The 1998 vegetation data show grassland communities exist in the watershed.

Grassland

In California, grasslands have been altered more than any other plant community. Experts speculate what unaltered, natural grasslands look like in California, because none exist. Coastal grasslands are often located on marine terraces and grow with coastal scrub, chaparral, and coast live oak woodland communities. Native grasses growing in coastal areas would have been dominated by slender needlegrass *(Nassella lepida)*, large needlegrass *(Achnatherum coronatum)*, purple needlegrass *(Nassella pulchra)*, and nodding needlegrass *(Nassella cernua)*. Junegrass *(Koeleria macrantha)*, melic grass *(Melica imperfect)*, three-awn *(Aristida spp.)*, and deergrass *(Muhlenbergia rigens)* would have also been common (Holland and Keil, 1995).

Today, grassland communities that exist are altered landscapes, largely composed of annual cool-season Mediterranean non-native grasses. These non-native grasses were introduced for livestock grazing during early Spanish colonization. Over time, un-grazed native grasslands were inevitably overtaken by non-native grasses, such as wild oats *(Avena fatua)*. Many non-native grasses out-competed native grasses for water, nutrients, and space. Other common introduced grasses occurring in southern coastal grassland communities are: slender wild oats *(Avena barbata)*, rip-gut brome *(Bromus diandrus)*, soft chess brome *(Bromus hordeaceus)*, and annual ryegrass *(Lolium multiflorum)* to name a few (Holland and Keil, 1995).

Grassland vegetation is the dominant vegetation throughout the watershed’s foothills. They exist on land used for rangeland, grain production, residential, or open space. Grasslands occur sparsely in the lower watershed, where Monterey Pine forests are dominant. Grasslands are also less frequent in the headwaters where they are usually found along steep slopes near streams.

Temperate Flooded Riparian Vegetation

The National Vegetation Classification Hierarchy defines Temperate Flooded Riparian Vegetation as a woodland and shrubby riparian dominated canopy with at least eight to ten percent cover. Either trees or shrubs can dominate or co-dominate the site. Stands are temporarily or seasonally flooded, generally early in the growing season. Valley or coast live oak can be a component to a mixed community of riparian woodland but they do not dominate the canopy (County of San Luis Obispo, 2009a). There are approximately 671 acres of temperate flooded riparian vegetation in the watershed, or roughly two percent of the total watershed area. The 1998 vegetation data show scrub and woodland riparian communities exist in the watershed.

Riparian Communities (Scrub and Woodland)

Riparian communities border streams, lakes and springs and usually consist of deciduous trees and various shrubs and herbs. Riparian vegetation is typically confined to banks and floodplains of waterways. Riparian scrub communities occur on relatively fine-grained sand and gravel bars, close to gravel bars, and along streambanks. Riparian scrub communities consist of various willow species, such as arroyo willow *(Salix lasiolepis)*, that form scrubby streamside thickets. Additional species found in riparian scrub communities include California blackberry *(Rubus ursinus)* and stinging nettle *(Urtica dioica ssp. holosericea)*. Common Central Coast riparian woodland species include: arroyo willow *(Salix lasiolepis)*, red willow *(Salix laevigata)*, sycamore *(Platanus racemosa)*, box elder *(Acer negundo)*, black cottonwood *(Populus balsamifera)*, and coast live oak *(Quercus agrifolia)* (Holland and Keil, 1995).

Scrub and woodland riparian communities are found throughout the watershed tangent to streams. This vegetation forms an almost continuous line from the Santa Rosa Creek outlet at the Pacific Ocean, to the headwaters. Some discontinuity occurs in the foothills where water flow is subterranean. As elevation increases riparian corridors become narrower and coast live oak forests encroach riparian communities. In the Perry Creek sub-watershed riparian vegetation is less apparent. Riparian corridors are not continuous and are extremely narrow here. The dominant land use in this watershed is rangeland with grassland vegetation prevalent.

Temperate Meadow and Freshwater Marsh

The National Vegetation Classification Hierarchy defines Temperate Meadow and Freshwater Marsh Vegetation in meadow settings (temporarily to seasonally flooded environments typically with species from *Carex* or *Juncus* genera) or marsh-like settings (permanently flooded environments) where *Typha sp.* and or *Scirpus sp.* dominate the stand. Stands are usually less than five acres in size (County of San Luis Obispo, 2009a). There are approximately 50 acres of temperate flooded riparian vegetation in the watershed, or roughly less than one percent of the total watershed area. The 1998 vegetation data show marsh and meadow communities exist in the watershed. Only the estuary, located at the confluence of Santa Rosa Creek and the Pacific Ocean, is defined below, however temperate meadow communities associated with seeps and springs likely exist throughout the watershed as well.

Estuary (Coastal Estuarine Community)

Estuaries occur where freshwater and saltwater mix at the confluence of a stream and an ocean. Because estuaries are protected from waves and wind, brackish water and thick layers of sediment can form. Estuarine vegetation is adaptable to extreme variations of salinity levels due to daily tidal fluctuations, along with seasonal fluctuations occurring with increased precipitation in the winter months. Plants occurring in estuaries are often soft-bodied and flexible because they are continuously saturated. Common estuary plants include eel-grass *(Zostera marina)*, ditch-grass *(Ruppia maritime)*, and algae (Holland and Keil, 1995).

The watershed's estuary is located at the confluence of Santa Rosa Creek and the Pacific Ocean. It provides habitat for two federally listed fish species, Tidewater goby (*Eucyclogobius newberryi*) and steelhead (*Oncorhynchus mykiss)*. Tidewater goby spend their entire lives in coastal lagoons/estuaries, spawning when freshwater flows increase during higher creek flows. In contrast, steelhead are an anadromous species that hatch in freshwater, enter the ocean as adults, and return to their natal stream to spawn. Steelhead use the brackish waters in the estuary to acclimate from freshwater to saltwater as smolts. During this stage, fish feed heavily to increase their size. More information about tidewater goby and steelhead is found in Section 4.3 of this report.

Special Status Plant Species

In addition to the diversity of plant communities listed above, there are several "special status" plant species found in the watershed. "Special status" species are considered by Fish and Game to be taxa of the greatest conservation need and fit into one or more of the following categories (State of California The Resources Agency, 2008):

- Officially listed or proposed for listing under the State and/or Federal Endangered Species Acts.
- State or Federal candidate for possible listing.
- Taxa which meet the criteria for listing, even if not currently included on any list, as described in Section 15380 of the California Environmental Quality Act Guidelines.
- Taxa considered by the Department to be a Species of Special Concern (SSC)
- Taxa that are biologically rare, very restricted in distribution, declining throughout their range, or have a critical, vulnerable stage in their life cycle that warrants monitoring.
- Populations in California that may be on the periphery of a taxon's range, but are threatened with extirpation in California.
- Taxa closely associated with a habitat that is declining in California at an alarming rate (e.g., wetlands, riparian, old growth forests, desert aquatic systems, native grasslands, vernal pools, etc.).
- Taxa designated as a special status, sensitive, or declining species by other state or federal agencies, or non-governmental organization (NGO).

"Special status" species were identified using Fish and Game's California Natural Diversity Data Base and the California Native Plant Society's Inventory of Rare and Endangered Plants online database. Each database was queried by location, using Cambria and Cypress Mountain 7.5

minute quadrangles. A list of "special status" species was produced from the results of both database searches and summarized in Appendix A.

Currently, there are 21 "special status" species within the watershed. Most of these species are perennial herbs and shrubs. San Luis Obispo fountain thistle *(Cirsium fontinale* var. *obispoense)* is the only state and federally listed endangered species in the watershed. No other species are listed as either endangered or threatened by the state or federal government.

Non-native Invasive Plant Species

In 2006, the California Invasive Plant Council updated its inventory of state-wide non-native invasive plants that threaten state wildlands. The Invasive Plant Council set the following criteria to define these species: non-native invasive plants are species that 1) are not native to, yet can spread into, wildland ecosystems, and that also 2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes. Non-native invasive plant species are significant in that they change natural communities by altering habitat and impacting food sources for sensitive animal species, such as steelhead.

A list of non-native invasive plant species was produced from the California Invasive Plant Council online database (http://www.cal-ipc.org/ip/inventory/weedlist.php) and is located in Appendix B. A species list was created using the Central Western Floristic Province, the geographic system in which Cambria is part of. Within this province, 202 non-native invasive plant species exist. There are 38 species labeled "Evaluated But Not Listed", meaning there is either insufficient data, or the species does not presently have significant impact. There are 52 species labeled "High" or "Alert", meaning they have high potential to invade new ecosystems. The Central Western Florist Province is large so other data sources were used to edit the list.

In the Cambria Forest Management Plan (2002), developed by the Cambria Forest Committee, invasive species found in the watershed are listed. There are 22 invasive species found in the Cambria Forest and vicinity. Pampas grass *(Cortaderia selloana)*, French broom *(Genista monspessulana)*, Scotch broom *(Cytisus scoparius)*, and Cape ivy or German ivy (*Delairea odorata)* are the most abundant and requiring the most aggressive treatments. Invasive species listed in the Cambria Forest Management Plan are labeled "CFMP" in Appendix B.

3.8. WILDLIFE

Santa Rosa Creek Watershed hosts diverse habitats from the sandy beaches and marshes at the Pacific, to the steep, rocky forests of the headwaters. Within these habitats, a wide array of animal species live, feed, and reproduce, providing this area with a rich assortment of wildlife. Geneva Hamilton, in her book *Where the Highway Ends* (1999), describes the animals found in Rancho Santa Rosa around the early nineteenth century. "In the fertile valleys through which Santa Rosa Creek and its tributaries wandered lived many deer, bear, fox and small animals such as the rabbit, squirrel and marsh rat."

Today, a diverse assortment of animal species still exists within the watershed. A list of animal species found within the Fiscalini Ranch, previously known as East-West Ranch, was composed in the Fiscalini Ranch Preserve Environmental Impact Report (EIR) (County of San Luis Obispo, 2009b). The Fiscalini Ranch Preserve is a coastal property located in the lower watershed and subdivided by State Highway 1 (Appendix C, Fig. C-1). Most habitat types present within the preserve can be found elsewhere in the watershed; therefore wildlife species present on the preserve are likely to be present in similar habitats throughout the watershed. The list of animal species is not a comprehensive account for all wildlife present in the watershed. Additional habitats exist, such as Sargent Cypress forests. Wildlife from these communities could be missing from the list produced from the EIR. Animal species found within the Santa Rosa Creek Watershed as described in the Fiscalini Ranch Preserve EIR are listed (Appendix C).

Special Status Animal Species

Using California Department of Fish and Game's California Natural Diversity Data Base, 10 "special status" animal species were identified in the watershed. Federally endangered species in the watershed include Tidewater goby (*Eucyclogobius newberryi)* and California condor (*Gymnogyps californianus)*. Federally threatened animal species include: bald eagle (*Haliaeetus leucocephalus)*, south-central California coast steelhead (*Oncorhynchus mykiss irideus)*, and California red-legged frog (*Rana aurora draytonii)*. The "special status" species found in the watershed are listed (Appendix D).

Of particular importance to the Conservation Plan is the presence of south-central California coast steelhead *(Oncorhynchus mykiss irideus)* found in local streams. Santa Rosa Creek is considered to be one of the most pristine streams along the Central Coast with one of the best steelhead fisheries in the region. A primary goal of the Conservation Plan is to study the limiting factors to steelhead in the Santa Rosa Creek Watershed, thereby providing the information needed to identify conservation strategies to protect this and other species.

3.9. GEOLOGY

The watershed lies along the south-western edge of the Santa Lucia Range, within the Coast Range Geomorphic Province. To describe the geologic formations within the watershed, printed references were used, geologic GIS data were acquired from SLO Datafinder (http://lib.calpoly.edu/collections/gis/slodatafinder/), and USGS geologic maps were studied. The geologic data from SLO Datafinder were created by SLO County in 2007. Scanned geology maps created by USGS and the California Geologic Survey were digitized to create the GIS data. In addition, two USGS geologic maps were acquired from Cal Poly, San Luis Obispo (Cal Poly) to describe geologic units and verify units with missing data. Cal Poly USGS maps were produced by Clarence Hall, in 1974 and 1979 and are no longer in print. (Geologic terminology is described in Section 9.1 of the Conservation Plan).

There are 37 distinct geologic units in the watershed that are listed in Appendix E. Some geologic unit symbols could not be identified using the resources listed above. The symbols are identified in the table with their map labels in parenthesis. Figure 9 shows the distribution of geologic units throughout the watershed.

Geologic formation of the watershed began on the seafloor of the Pacific Ocean, 180 million years ago (mya). During that time, the coastline was located further east, where the Sierra Nevada foothills now exist, and a marine trench was located where the Coast Ranges now lie. For millions of years the Pacific Plate was pushed eastward under the North American Plate along a subduction zone, or trench. As a result, sediments and debris were mixed and the complex geologic formations of the Central Coast were created (Chipping, 1987).

From the late Cretaceous period (66 mya) through the Eocene period (38 mya) the Franciscan Formation was created. This formation was created from subducted basalts and sediments falling into the subduction zone. In general, the Franciscan Formation is composed of a mixture, or mélange, of igneous and metamorphic rocks, such as greywacke, greenstone, diabase, gabbro, serpentine, chert, shale, tuff, blue schist, and other metamorphic rocks (Yates and Van Konyenbur, 1998). Using GIS, approximately 48 percent of the total watershed area is composed of Franciscan mélange rocks which are common in the upper elevations of the watershed.

Ultramafic outcrops, present in the Franciscan Formation are highly fractured and faulted and contain springs, seeps, and other continuous water sources. In climates where seasonal streams go dry in the summer, ultramafic areas such as serpentines tend to foster year-round water flow. Because these areas are typically barren of vegetation, sheet erosion is common. Other forms of erosion are common on soils derived from serpentine where excavation activities occur, such as road development (Kruckeberg, 1984).

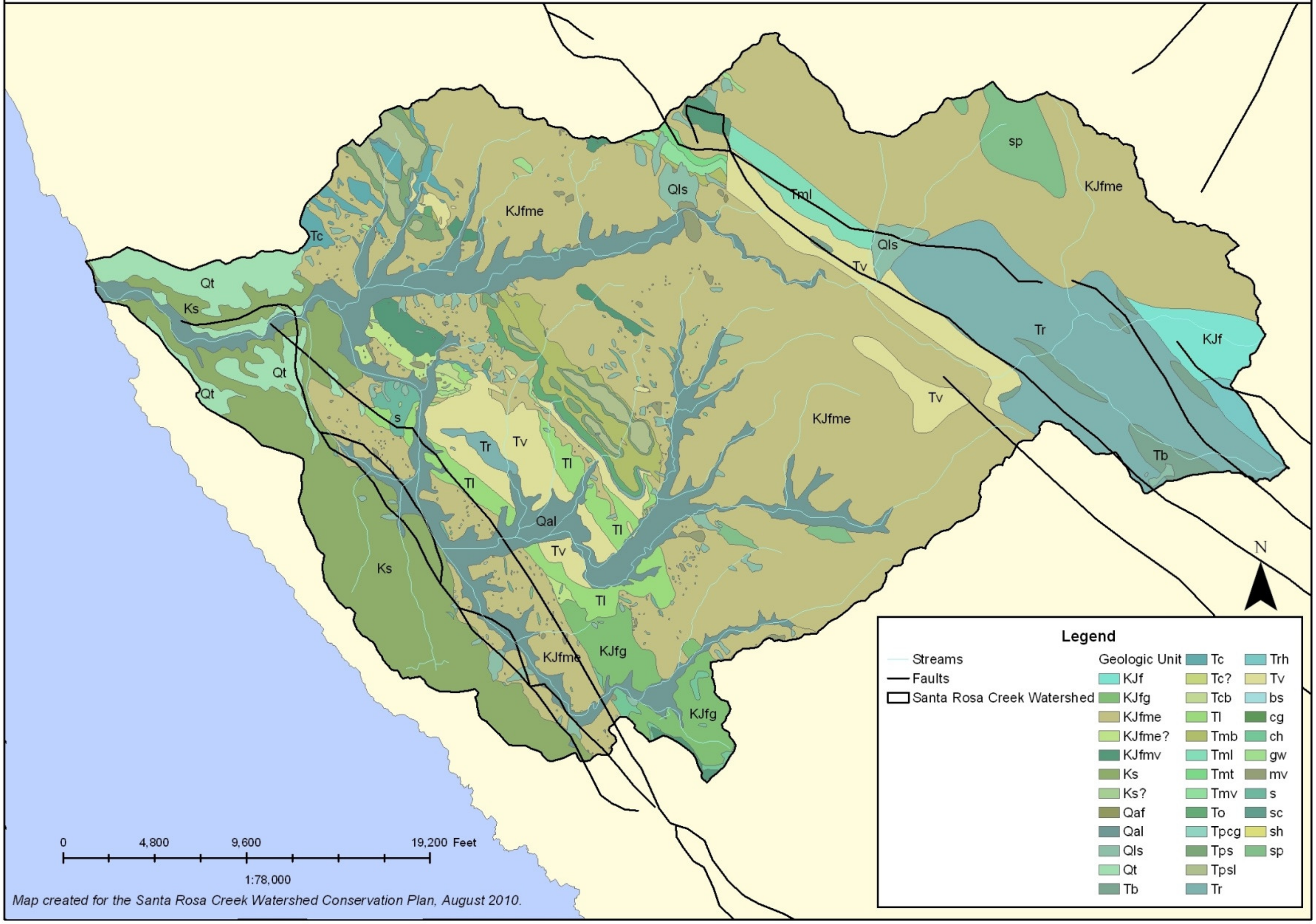
Red chert metavolcanic outcrops of the Franciscan Formation occur in just a few locations along the eastern edge of the Santa Rosa groundwater basin and east of the Santa Rosa Creek and Perry Creek confluence near town. The Franciscan Formation is common throughout the watershed, evident by the numerous springs occurring through the highly brittle and fractured rock. Springs also occur within the interbedded shales of an unnamed Upper Cretaceous (144-66 mya) sandstone, however they are not as common (Yates and Van Konyenbur, 1998).

Between the Cenozoic and uppermost Mesozoic periods (144 mya and younger), marine sedimentary rocks, also known as the Cambria Slab, were thrust over the Mesozoic rocks of the Franciscan Complex. During the late Cretaceous period (66 mya), the Franciscan Complex was fragmented and mixed, creating an aggregation of rocks while the Cambria Slab was moved relatively intact (Chipping, 1987).

Approximately 40 mya, sediments deposited by water, created the Lospe Formation. The Lospe Formation occurs in small areas along north-west trending inactive faults in the western portion of the watershed (Chipping, 1987). Cambria Felsite, an Oligocene (38-24 mya) volcanic complex is located near the center of the town of Cambria, and is contained within the Lospe Formation. The Cambria Felsite is the same age as the Morro Rock-Islay Hill Complex of volcanic rock outcroppings located between Morro Bay and San Luis Obispo (Hall, 2007). Franciscan Formation pebbles are also present within the Lospe Formation, coinciding with continental uplift (Chipping, 1987).

The Monterey Formation was created during the Miocene epoch (24-5 mya) and is dominated by thin bedded, siliceous shales, siltstones, and claystones. At this time, the Coast Ranges were submerged and the coastline was located near where the present-day San Andreas Fault lies (Chipping, 1987). The Monterey Formation exists along the northern watershed boundary and is nearly completely surrounded by the Franciscan Formation.

Figure 9. Geologic Units and Faults in the Santa Rosa Creek Watershed



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.

The Pismo Formation developed between 2-5 mya and is closely associated with the Monterey Formation. It was deposited as the Coast Ranges were created and sea levels dropped (Chipping, 1987). Near the coast, stream terrace deposits overlie sedimentary rocks. These marine deposits formed during a middle-to-late Pleistocene period, approximately 2 mya, in which sea levels were high (Yates and Van Konyenbur, 1998). Cyclical changes in sea level, occurring during the Ice Ages created extensive marine terraces, such as the one located at Moonstone Beach. The more recent stream terraces have developed from alluvium. In the lower watershed, stream bank deposits sit atop relatively impermeable bedrock, forming the Santa Rosa groundwater basin. It is estimated that the alluvium in this basin is approximately 130 feet thick (Chipping, 1987).

Several inactive north-west trending faults lie within the watershed. There are six faults with maximum earthquake magnitudes between 6.25 and 8.25 within 66 miles of the watershed (Cambria, Hosgri, Oceanic, Los Osos, Rinconada, and San Andreas Faults) (County of San Luis Obispo, 2008). On December 22, 2003 a moment magnitude 6.5 earthquake occurred with its epicenter located seven miles northeast of San Simeon, California, north of Cambria. Landslides were observed along State Highway 46 (Green Valley Highway). Due to seismic compression and slope instability, significant road damage occurred along State Highway 46 (EERI, 2004). The estimated recurrence interval with faults located within the watershed is long, the hazards associated with these faults remains low (County of San Luis Obispo, 2008).

Impacts of seismic activity can still be felt as a result of the 2003 San Simeon earthquake. Local ranchers have noticed significant differences in detention pond water levels. Ranchers in the upper portions of the watershed experienced a draining of their detention ponds and overall decrease in their water supply, while ranches located in the lower watershed gained water in areas that were previously dry (personal communication, J. Fitzhugh).

3.10. SOILS

The geologic diversity in the Santa Rosa Creek Watershed is the foundation of the complex soils present in the area. Factors that control soil formation are parent materials, climate, biota, topography, and time. (Soil terminology is described in Section 9.2 of the Conservation Plan). Parent materials are the organic or geologic sources in which soils are formed. They are important because they dictate soil characteristics which determine important watershed functions. For instance, parent material determines soil texture, which in turn controls the rate of water percolation, thereby directing a soil's susceptibility to water erosion. The chemical and mineral components of soils also influence how soils weather and what vegetation can grow. Some soils are highly productive, such as those found in valley floodplains, while other soils are characteristically unproductive (Brady & Weil, 2004). Soils formed from serpentine-rich parent materials are typically unproductive due to their high magnesium content, and are subject to accelerated erosion on steep slopes (Gasser & Dahlgren in Dixon & Schulze, 2002).

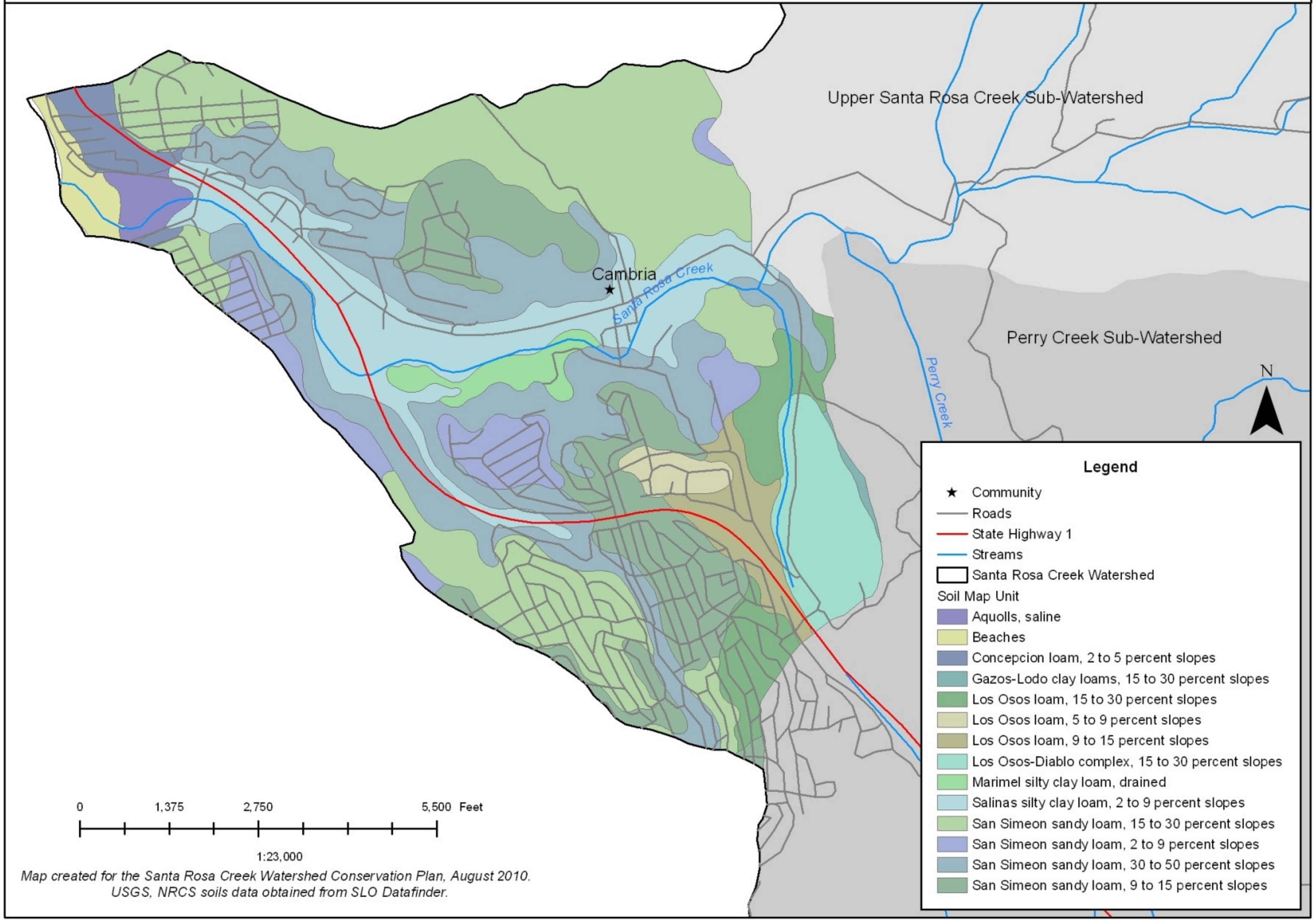
In 2005, the National Cooperative Soil Survey created digital soil surveys from existing maps. Soil Survey geographic data were prepared by USDA, NRCS and downloaded from SLO Datafinder (http://lib.calpoly.edu/collections/gis/slodatafinder/). These data describe the distribution of soil map units in the watershed. Soil map units are areas on the landscape mapped as one or more soil. To study soils located within the Santa Rosa Creek Watershed, digital soil data were extracted using GIS. The *Soil Survey of San Luis Obispo County, California, Coastal Part* (1984) and the *Soil Survey of San Luis Obispo County, California, Paso Robles Area* (1977) (referred to as Soil Surveys) were used as reference documents to describe the soil map units found in the watershed. Figures 10, 11, and 12 show the distribution of soil map units throughout the Santa Rosa Creek Watershed.

There are 64 soil map units within the Santa Rosa Creek Watershed. These soils are listed with the total watershed area and percent of watershed area for each unit in Appendix F. Appendix F also includes descriptions of each soil map unit as discussed in the Soil Surveys, Soil Data Viewer online at Geospatial Data Gateway (http://soildataviewer.nrcs.usda.gov/), and on SLO Datafinder. "No Data" is used to describe soil erodibility of soil map units such as Rock outcrop complexes, Beaches, and Xerorthents. Soil erodibility data are not applicable to these soils.

The most common soil map unit within the watershed is the "Diablo-Lodo complex, 15 to 50 percent slopes". This soil is located on moderately steep to steep terrain and accounts for approximately 13 percent of all soils within the watershed. "Diablo-Lodo complex, 15 to 50 percent slopes" soil is mostly vegetated by grasslands with some woodland habitats located along stream corridors. The component soil within this complex has moderate to high water erosion hazards, rapid surface runoff, low productivity, and is sensitive to overgrazing, leading to excessive sheet erosion.

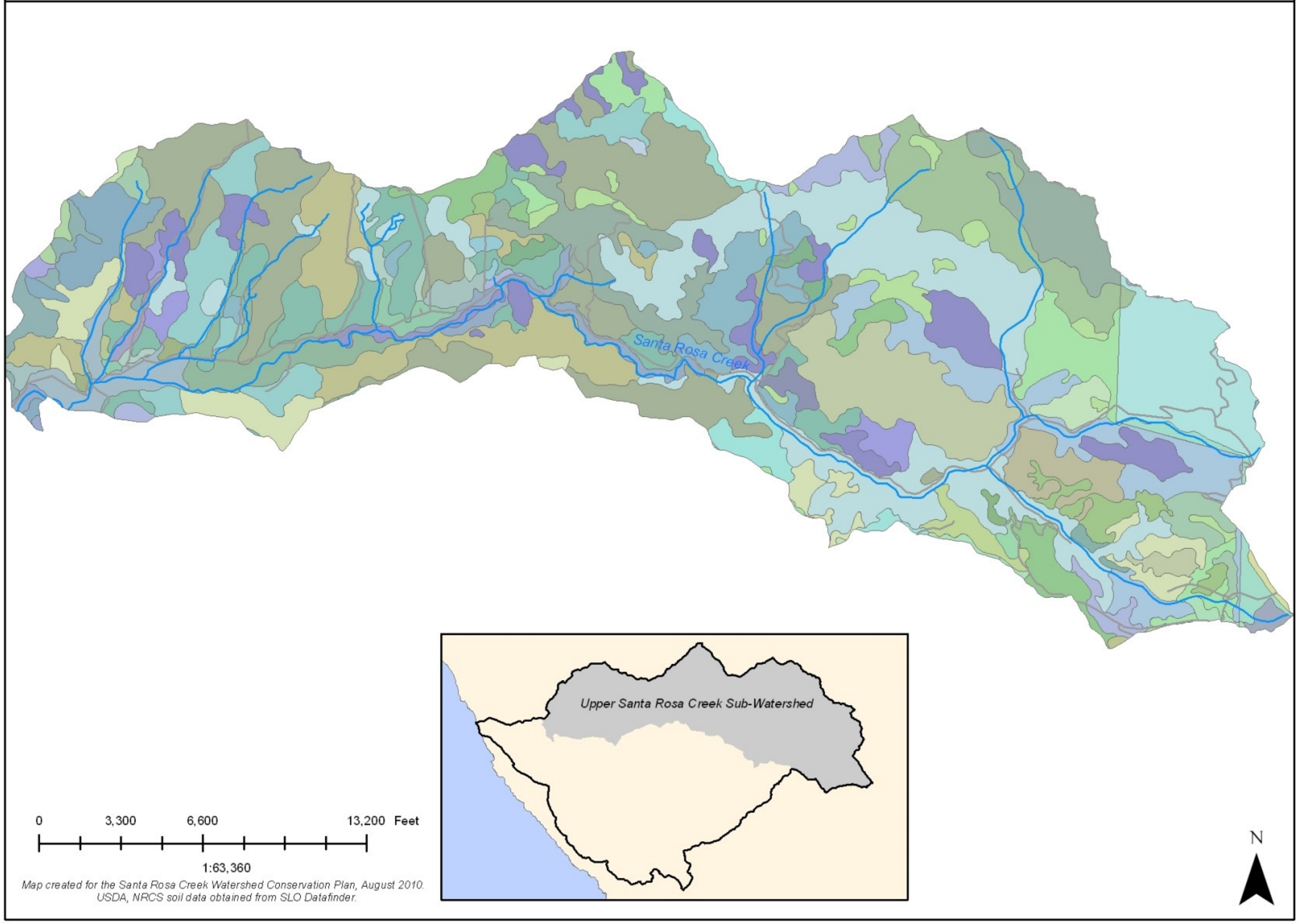
The digital soil data describes soil erodibility using "K Factor" of the whole soil. The "K Factor" is a soil's susceptibility to sheet and rill erosion from water. In general, "K Factor" values range from 0.02 to 0.69 with higher values more susceptible to erosion (USDA, 1984). Soils found in the Santa Rosa Creek Watershed have "K Factor" values ranging from 0.02 to 0.32. These soils are described as "low" to "moderately" erosive in the GIS data. Most of the soils in the upper watershed have low "K Factor" values, while soils in the lower watershed have moderate erosion values and are more susceptible to erosion (Fig. 13). Soils with rock outcrop complexes, mostly located in the upper watershed, have no "K-Factor" values. Additionally, an Aquoll soil, which has an aquatic moisture regime and thick organic-rich topsoil (mollic epipedon), did not have a "K-Factor" value. This soil is located in the lower watershed near the confluence of Santa Rosa Creek and the Pacific Ocean. It is located in a wetland vegetated with wooded wetland species. Further information about soils and soil erosion is described in detail in Section 4 of this report.

Figure 10. Soil Map Units for Lower Santa Rosa Creek Watershed



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.
USGS, NRCS soils data obtained from SLO Datafinder.

Figure 11. Soil Map Units for Upper Santa Rosa Creek Sub-Watershed



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.
USDA, NRCS soil data obtained from SLO Datafinder.

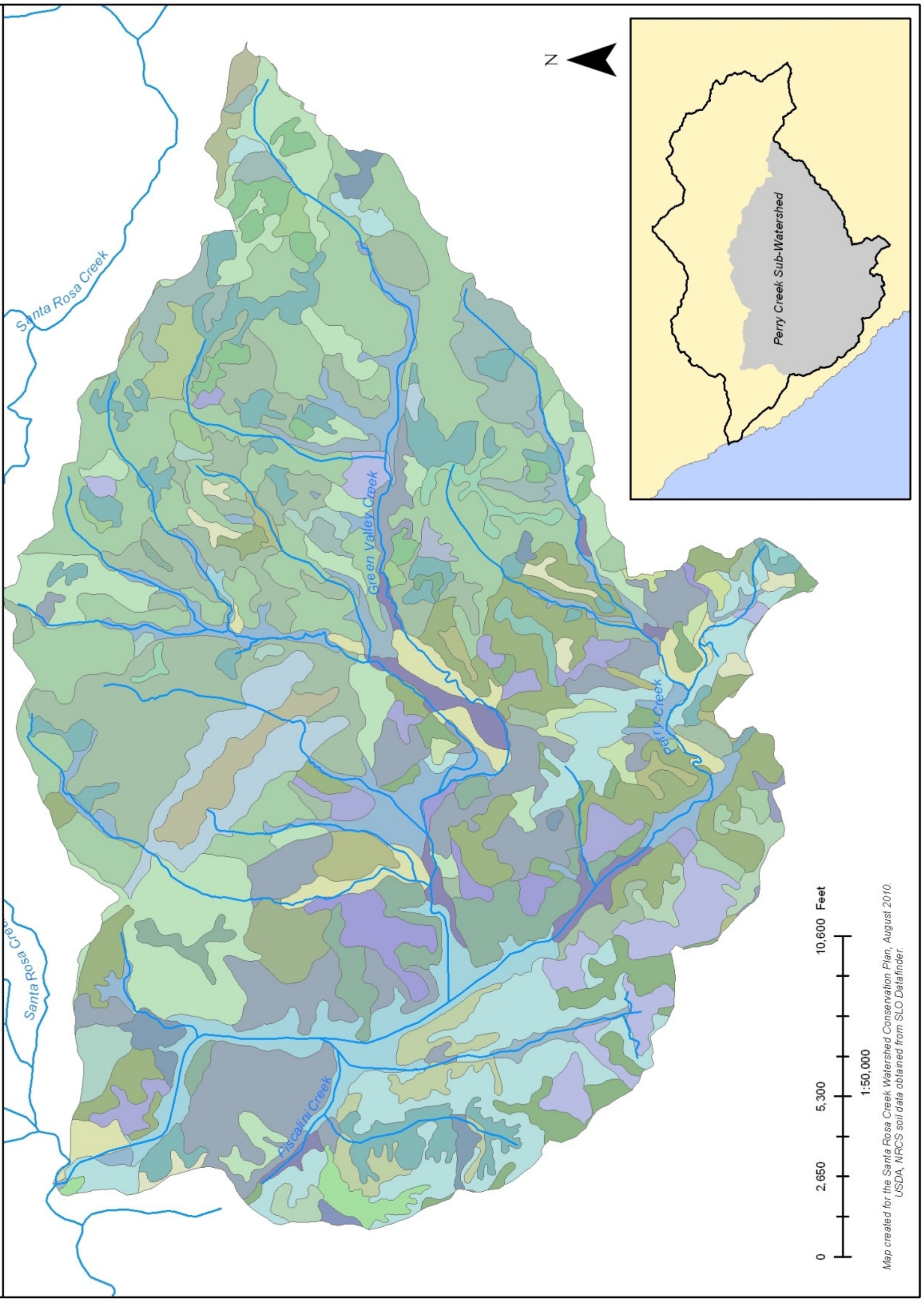
FIGURE 11 LEGEND

- ― Streams
- ― Roads

Soils

- ▨ Balcom-Calleguas complex, 50 to 75 percent slopes
- ▨ Cieneba-Millsap loams, 30 to 75 percent slopes
- ▨ Cropley clay, 0 to 2 percent slopes
- ▨ Cropley clay, 2 to 9 percent slopes
- ▨ Diablo and Cibo clays, 15 to 30 percent slopes
- ▨ Diablo and Cibo clays, 30 to 50 percent slopes
- ▨ Diablo and Cibo clays, 9 to 15 percent slopes
- ▨ Diablo clay, 5 to 9 percent slopes
- ▨ Diablo-Lodo complex, 15 to 50 percent slopes
- ▨ Gaviota fine sandy loam, 15 to 50 percent slopes
- ▨ Gaviota sandy loam, 50 to 75 percent slopes
- ▨ Gaviota-Rock outcrop complex, 30 to 75 percent slopes
- ▨ Gazos-Lodo clay loams, 15 to 30 percent slopes
- ▨ Gazos-Lodo clay loams, 30 to 50 percent slopes
- ▨ Gazos-Lodo clay loams, 50 to 75 percent slopes
- ▨ Henneke-Rock outcrop complex, 15 to 75 percent slopes
- ▨ Lodo clay loam, 15 to 30 percent slopes
- ▨ Lodo clay loam, 30 to 50 percent slopes
- ▨ Lodo clay loam, 50 to 75 percent slopes
- ▨ Lodo-Rock outcrop complex, 30 to 75 percent slopes
- ▨ Lodo-Rock outcrop complex, 9 to 30 percent slopes
- ▨ Lompico-McMullin complex, 50 to 75 percent slopes
- ▨ Lompico-McMullin loams, 30 to 75 percent slopes
- ▨ Lopez very shaly clay loam, 30 to 75 percent slopes
- ▨ Los Osos loam, 15 to 30 percent slopes
- ▨ Los Osos loam, 30 to 50 percent slopes
- ▨ Los Osos loam, 5 to 9 percent slopes
- ▨ Los Osos variant clay loam, 15 to 50 percent slopes
- ▨ Los Osos-Diablo complex, 15 to 30 percent slopes
- ▨ Los Osos-Diablo complex, 30 to 50 percent slopes
- ▨ Los Osos-Diablo complex, 5 to 9 percent slopes
- ▨ Los Osos-Diablo complex, 9 to 15 percent slopes
- ▨ Los Osos-Lodo complex, 30 to 75 percent slopes
- ▨ Los Osos-Lodo complex, 50 to 75 percent slopes
- ▨ Marimel silty clay loam, drained
- ▨ McMullin-Rock outcrop complex, 50 to 75 percent slopes
- ▨ Nacimiento silty clay loam, 30 to 50 percent slopes
- ▨ Nacimiento-Calodo complex, 30 to 50 percent slopes
- ▨ Nacimiento-Calodo complex, 50 to 75 percent slopes
- ▨ Riverwash
- ▨ Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope
- ▨ Salinas silty clay loam, 0 to 2 percent slopes
- ▨ Salinas silty clay loam, 2 to 9 percent slopes
- ▨ San Simeon sandy loam, 15 to 30 percent slopes
- ▨ San Simeon sandy loam, 2 to 9 percent slopes
- ▨ San Simeon sandy loam, 30 to 50 percent slopes
- ▨ San Simeon sandy loam, 9 to 15 percent slopes
- ▨ Santa Lucia shaly clay loam, 30 to 50 percent slopes
- ▨ Santa Lucia shaly clay loam, 50 to 75 percent slopes
- ▨ Santa Lucia very shaly clay loam, 9 to 15 percent slopes
- ▨ Zaca clay, 15 to 30 percent slopes
- ▨ Zaca clay, 30 to 50 percent slopes

Figure 12. Soil Map Units for Perry Creek Sub-Watershed



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010. USDA, NRCS soil data obtained from SLO Datafinder.

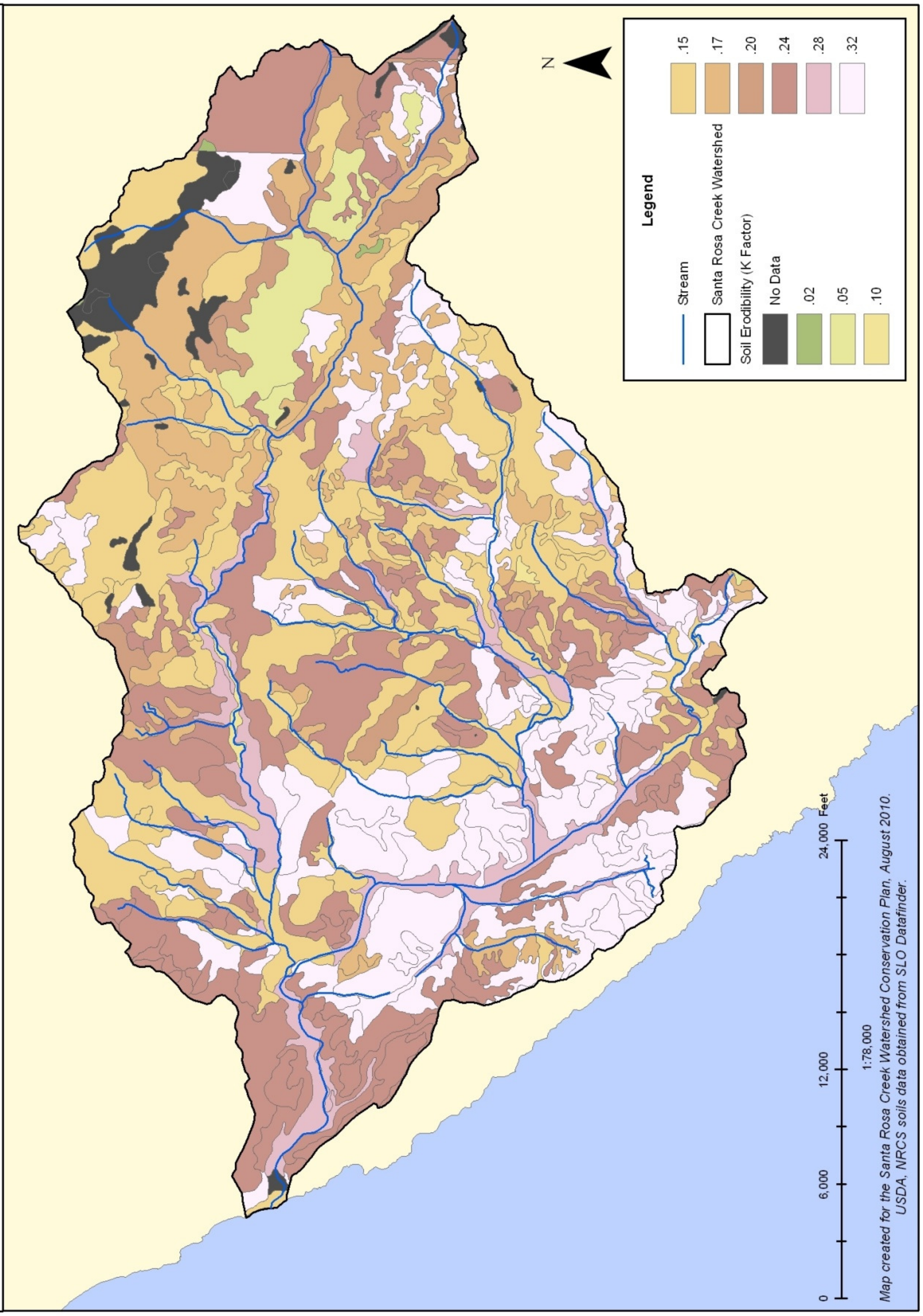
FIGURE 12 LEGEND

- — Streams
- — Roads

Soil Map Unit

- 🟩 BRIONES-TIERRA COMPLEX, 15 TO 50% SLOPES
- 🟩 CIENEBA-MILLSAP LOAMS, 30 TO 75% SLOPES
- 🟩 CROPLEY CLAY, 0 TO 2% SLOPES
- 🟦 CROPLEY CLAY, 2 TO 9% SLOPES
- 🟩 DIABLO AND CIBO CLAYS, 15 TO 30% SLOPES
- 🟩 DIABLO AND CIBO CLAYS, 30 TO 50% SLOPES
- 🟪 DIABLO AND CIBO CLAYS, 9 TO 15% SLOPES
- 🟩 DIABLO CLAY, 5 TO 9% SLOPES
- 🟩 DIABLO-LODO COMPLEX, 15 TO 50% SLOPES
- 🟩 GAVIOTA FINE SANDY LOAM, 15 TO 50% SLOPES
- 🟩 GAZOS-LODO CLAY LOAMS, 15 TO 30% SLOPES
- 🟩 GAZOS-LODO CLAY LOAMS, 30 TO 50% SLOPES
- 🟩 GAZOS-LODO CLAY LOAMS, 50 TO 75% SLOPES
- 🟦 LODO CLAY LOAM, 15 TO 30% SLOPES
- 🟩 LODO CLAY LOAM, 30 TO 50% SLOPES
- 🟩 LODO CLAY LOAM, 5 TO 15% SLOPES
- 🟩 LODO CLAY LOAM, 50 TO 75% SLOPES
- 🟦 LODO-ROCK OUTCROP COMPLEX, 30 TO 75% SLOPES
- 🟦 LOPEZ-ROCK OUTCROP COMPLEX, 75 TO 100% SLOPES
- 🟦 LOS OSOS LOAM, 15 TO 30% SLOPES
- 🟪 LOS OSOS LOAM, 30 TO 50% SLOPES
- 🟩 LOS OSOS LOAM, 5 TO 9% SLOPES
- 🟩 LOS OSOS LOAM, 9 TO 15% SLOPES
- 🟩 LOS OSOS VARIANT CLAY LOAM, 15 TO 50% SLOPES
- 🟦 LOS OSOS-DIABLO COMPLEX, 15 TO 30% SLOPES
- 🟩 LOS OSOS-DIABLO COMPLEX, 30 TO 50% SLOPES
- 🟪 LOS OSOS-DIABLO COMPLEX, 5 TO 9% SLOPES
- 🟩 LOS OSOS-DIABLO COMPLEX, 9 TO 15% SLOPES
- 🟩 LOS OSOS-LODO COMPLEX, 30 TO 75% SLOPES
- 🟦 MARIMEL SILTY CLAY LOAM, DRAINED
- 🟩 MILLSAP LOAM, 15 TO 50% SLOPES
- 🟩 NACIMIENTO-CALODO COMPLEX, 30 TO 50% SLOPES
- 🟦 OBISPO-ROCK OUTCROP COMPLEX, 15 TO 75% SLOPES
- 🟪 SALINAS SILTY CLAY LOAM, 0 TO 2% SLOPES
- 🟦 SALINAS SILTY CLAY LOAM, 2 TO 9% SLOPES
- 🟦 SAN SIMEON SANDY LOAM, 15 TO 30% SLOPES
- 🟦 SAN SIMEON SANDY LOAM, 2 TO 9% SLOPES
- 🟩 SAN SIMEON SANDY LOAM, 30 TO 50% SLOPES
- 🟩 SAN SIMEON SANDY LOAM, 9 TO 15% SLOPES
- 🟦 WATERBODY
- 🟦 XERORTHENTS, ESCARPMENT, 20 TO 50% SLOPES
- 🟩 ZACA CLAY, 15 TO 30% SLOPES
- 🟩 ZACA CLAY, 9 TO 15% SLOPES

Figure 13. Soil Erodibility (K Factor Values) in the Santa Rosa Creek Watershed



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010. USDA, NRCS soils data obtained from SLO Datafinder.

4. ASSESSMENT COMPONENTS

4.1. RUSLE2 PREDICTED SOIL LOSS

Predicted soil loss values for the Upper Santa Rosa Creek Watershed were calculated using GIS and the Revised Universal Soil Loss Equation, Version 2 (RUSLE2) program, developed by the USDA-Agricultural Research Service (ARS) and USDA-Natural Resources Conservation Service (NRCS). RUSLE2 calculates predicted soil loss from rill and interrill erosion using climate, soil, topography, and land use data.

RUSLE2 Background

Long-term annual erosion rates occurring on upland landscapes can be predicted using the RUSLE2 program and supporting data that describe field conditions. The program calculates the estimated amount of sediment produced from upland rill and interrill erosion. RUSLE2 does not account for additional erosion occurring at concentrated flow areas such as ephemeral gullies, classical gullies, stream channels, mass movements, and other major sources of sediment. The output values from RUSLE2 calculations are intended to be used as a guide for conservation planning and are not a precise estimator of soil loss or residue cover (Forester, 2004).

Erosion consists of three processes including detachment, runoff, and deposition. Detachment is the separation of soil particles from the soil surface and occurs through different erosive processes such as runoff, raindrop and waterdrop impact, and overland flow. Runoff on the soil surface produces rill erosion occurring in small channels. Raindrop and vegetative waterdrop impact produces interrill erosion which occurs between rills. Additionally, soil is detached and transported through overland flow, a thin flow of water over the soil surface that moves sediment to rills and concentrated flow areas, or channels (Forester, 2004).

Once soil is detached, deposition can occur within the overland flow path if the surface terrain is not uniform. The total amount of soil deposited is the difference between total detachment (sediment production) and sediment yield. Sediment yield is the total sediment leaving the overland flow path and can be calculated using RUSLE2 (Forester, 2004). Figure 14 shows the relationship between detachment, runoff, and deposition. Local deposition is deposition of sediment close to the location where sediment was detached. Remote deposition is the deposition of sediment far from its point of origin such as deposition in a terrace channel or on the toe of a concave slope (http://www.ars.usda.gov/Research/docs.htm?docid=6016). Remotely deposited sediment can make its way into stream channels and degrade critical habitat for listed species such as steelhead. In addition, sediment deposited in streams can carry harmful pollutants into waterways, degrading water quality, and can increase stream embeddedness, burying potential spawning gravels.

RUSLE2 calculates predicted erosion rates using climate, soil, topography, and land use data collected at an assessment site. These data allow any site to be analyzed where mineral soil is exposed to the impacts of raindrops or waterdrops. Cropland, mined land, disturbed forestland, rangeland, construction sites, landfills, parks, and reclaimed land are examples of sites that can be analyzed using RUSLE2 (Forester, 2004). These sites were not, however, studied individually in the Santa Rosa Creek Watershed Conservation Plan because access to these lands was not acquired and field data could not be collected.

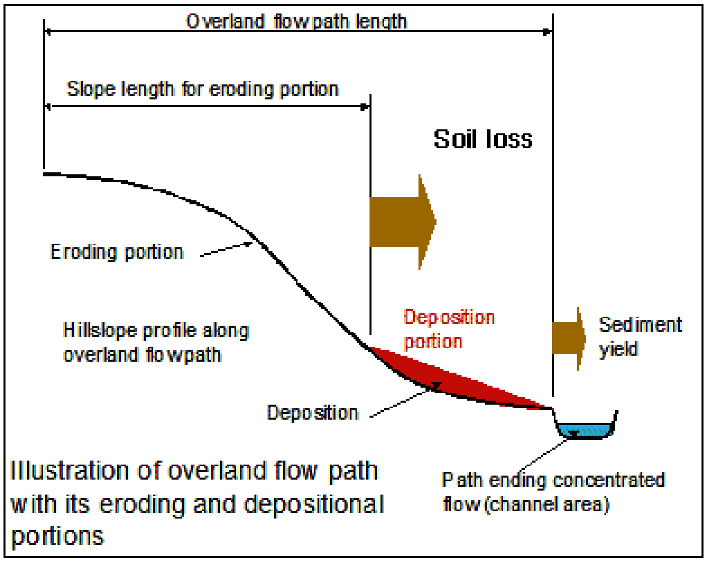


Figure 14. Detachment, runoff, and deposition as described in RUSLE2 calculations (USDA-ARS http://www.ars.usda.gov/Research/docs.htm?docid=6016).

Variables Used in RUSLE2 Calculations

In the erosion study conducted for the Conservation Plan, a uniform slope was used to describe each site. Uniform slopes generalize the overland flow path as a straight line from the top of the site, to the bottom. This creates a condition where detached sediment would not be deposited on site. In this case, sediment production equals sediment yield. Figure 15 shows the relationship between soil loss and sediment yield of a uniform slope, as calculated in RUSLE2.

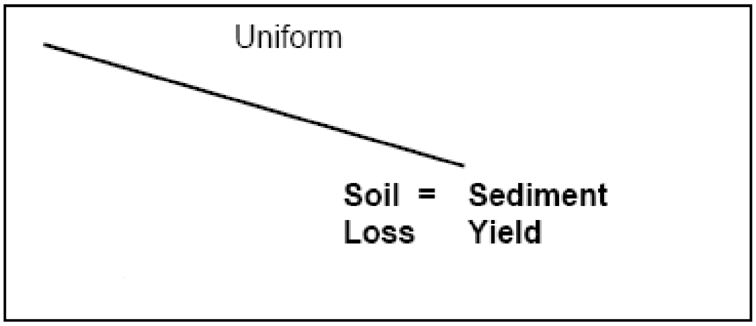


Figure 15. Sediment yield of a uniform slope in RUSLE2 (Forester, 2004).

RUSLE2 uses many different mathematical equations to calculate predicted annual soil loss values. With no deposition occurring in our analysis, the equation that is of greatest significance for the study computes net detachment.

Net detachment for each day is computed using the following variables in Equation 1 (Forester, 2004):

$$\mathbf{a = r\,k\,l\,S\,c\,p} \qquad \textbf{[1]}$$

where:

a = net detachment (mass/unit area)

r = erosivity

k = soil erodibility

l = slope length

S = slope steepness

c = cover management

p = supporting practices

The USDA-NRCS tested various soils for erodibility using “unit plots” of 72.6 feet in length with nine percent slopes. Plots were not vegetated and were maintained in a continuously tilled fallow state using periodic tillage up and down slope creating a “seedbed-like” condition. Daily sediment production of a “unit plot” is a result of erosivity “r” of a location and soil erodibility “k”. Slope length, slope steepness, cover management, and supporting practices data then adjusts the “unit-plot” sediment production value based on site-specific conditions. These factors used in the RUSLE2 calculation help describe the climate, soil, topography, and land use of a site (Forester, 2004).

Climate

Erosivity “r” is the most important climatic variable used by RUSLE2. Erosivity is the relationship between the amount and intensity of rainfall occurring at a location. Annual erosivity values are determined by analyzing historic weather records with erosivity values calculated from the total energy produced during an individual storm’s maximum 30-minute intensity (Forester, 2004). A broad range of erosivity values occur throughout the United States. In the west, erosivity index values as low as eight exist, however in areas like New Orleans, erosivity values range as high as 700 (USDA, May 1, 2008). Erosivity values are listed in the RUSLE2 database by precipitation zones and counties in the western United States.

Soil

Different soils have different degrees of soil erodibility. In Equation 1, the “k” value is the soil erodibility factor on a given day of the year. It is calculated by RUSLE2 as a function of temperature and precipitation. In RUSLE2, base erodibility, or upper-case “K factor”, is used to calculate the daily “k” value. Base soil erodibility is determined using a soil erodibility nomograph developed from the “unit plot” experimentations. Soil properties such as texture, organic matter, structure, and runoff potential due to soil permeability, affect a soil’s “K factor” (Forester, 2004).

Soil properties such as texture give some insight into the soil’s erodibility. For example, high clay soils are generally resistant to detachment and have low “K factors”. Sandy soils usually have high infiltration rates, reduced runoff, and are not easily transported, so they have low "K factors" as well. In contrast, soil particles in silty soils can be detached easily and readily produce high runoff. These soil types usually have high "K factors" (USDA, 1984).

Topography

Topographic features that affect rill and interrill erosion are slope length, steepness, and landscape shape. Slope steepness and overland flow path length are site-specific values used as input fields in RUSLE2. Overland flow path length extends from a point of origin to a concentrated flow area, or channel. Steepness is the percent slope along the overland flow path (Forester, 2004).

The "l" and "S" values used in Equation 1 represent the slope length and steepness. Slope length affects rill erosion rates primarily caused by runoff. As length increases, rill erosion increases. In contrast, interrill erosion rates are not affected by slope length because this type of erosion is caused by raindrop or vegetative waterdrop impact only (Forester, 2004).

In addition, slope steepness and shape can affect the rate of erosion. As slope steepness increases, the rate of erosion increases. Slope shape, or the spatial variation of steepness along a slope, determines if an increase or decrease in the rate of erosion occurs on a landscape. In this study, slope shape was generalized into a uniform slope shape, or straight line.

Land Use

Land use practices are the most important factors affecting rill and interrill erosion because they have the greatest effects on soil erosion and are the most easily changed factors contributing to erosion. Soil loss is controlled by modifying land use with cover-management practices and supporting practices. Cover-management practices include vegetative cover, crop rotations, conservation tillage, and applied mulch. In turn, supporting practices are features that "support" cover- management practices. These include contouring, strip cropping, terracing, and creating drainage basins, and subsurface drainage (Forester, 2004).

Cover-management practices can be defined in RUSLE2 by editing input fields to describe site-specific conditions of vegetative cover. Variables that represent cover-management include percent canopy cover; fall height (from vegetation to soil surface); ground cover provided by live vegetation; plant litter; crop residue; applied materials; surface roughness; soil biomass; degree of soil consolidation; and ridge height (Forester, 2004). RUSLE2 does not model vegetative growth, but uses the vegetation description to make calculations. Vegetation is selected in a drop-down menu in RUSLE2, and production level and yield can be changed to describe site conditions.

Activities occurring on site that reduce erosion rates by causing deposition and decreasing erosivity are described using the supporting practices menu in RUSLE2. On-site features such as ridges (contours), vegetative strips and barriers (buffer strips and fabric fences), runoff interceptors (terraces and diversions), and small impoundments (sediment basins and impoundment terraces) are examples of supporting practices defined in RUSLE2. Supporting practices describe the actual activity occurring at the site.

RUSLE2 Outputs

There are four predicted soil loss values calculated using RUSLE2.

Soil Loss from the Eroding Portion of Slope

This value is the total sediment loss from the eroding overland-flow path. The soil loss value is used to identify cover-management and supporting practices that decrease soil loss to a value less than the soil loss tolerance, or some other conservation planning parameter (http://www.ars.usda.gov/Research/docs.htm?docid=6016).

Detachment for Entire Overland Path

Detachment is the sediment produced over the entire length of the overland flow path.

Conservation Planning Soil Loss

Conservation planning soil loss accounts for some remote deposition of soil along the overland-flow path. It is generally less than the sediment production value, or total detachment, but greater than sediment yield.

Sediment Delivery (Yield)

Sediment delivery is the total sediment leaving the overland flow path.

RUSLE2 Assessment Methods

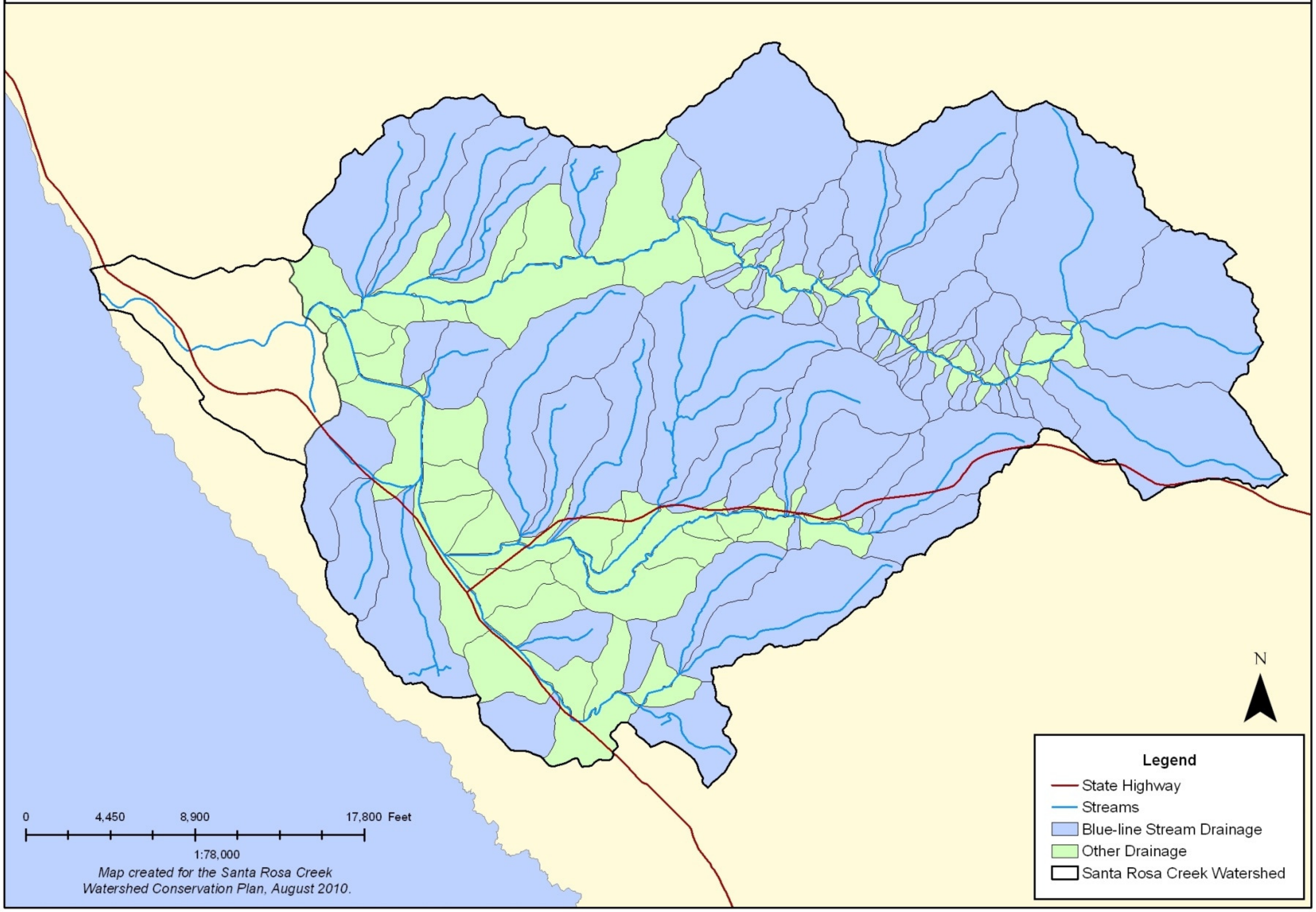
Predicted annual erosion rates were calculated for the upper watershed using ArcView 9.2, RUSLE2, Microsoft Excel, and Soil Surveys. Site visits were conducted to verify general vegetation, land use, and erosion types occurring in the watershed. GIS spatial data were acquired from the County of San Luis Obispo Planning and Building Department, the Geospatial Data Gateway, SLO Datafinder, and the California Spatial Information Library. GIS data used in the Conservation Plan, including the RUSLE2 assessment, are described in Appendix G.

Digital Soil Survey data were used to show the distribution of soil map units throughout the watershed. Published Soil Survey reports were used in conjunction with the GIS data to describe soil properties used in RUSLE2 calculations. To pinpoint locations where predicted soil loss values are high, soils were studied in blue-line stream drainages and areas in between blue-line streams in the upper watershed (Fig. 16). Drainage assessment areas are tributaries to Santa Rosa, Perry, or Green Valley Creeks.

There are 64 different soils found in the Santa Rosa Creek Watershed. Using RUSLE2, a profile was created for each soil occurring in each assessment area. A RUSLE2 profile is the data entry spreadsheet where site conditions can be defined and calculations are run. Once climate, soil type, slope topography, base management, and supporting practices were defined in the profile, the predicted soil loss value was calculated for the soil.

In RUSLE2, a uniform hillslope was used to analyze each soil therefore all four calculated predicted soil loss values were the same. The resulting value is given in tons of soil, per acre, per year. The resulting predicted soil loss value was multiplied by the soil acreage in the assessment area to determine the total predicted soil loss occurring at each soil. The soil loss values were then summarized for each assessment area.

Figure 16. Drainage Boundaries Used for RUSLE2 Analysis



Boundaries of erosion occurring at gravel pits, gullies, and roads were mapped in GIS however RUSLE2 was not used to analyze potential soil loss at these sites. Site visits to these locations are necessary to gather the appropriate data. It was determined that site visits should not be conducted on private property during this assessment to avoid landowner confusion and duplication of efforts with the developing restoration plan conducted by Greenspace. A detailed description of the erosion analysis methodology is included in Appendix H.

RUSLE2 Assessment Results

Land uses and vegetative communities in the lower watershed are highly diverse and are difficult to model, therefore it was determined that RUSLE2 should not be used to assess this area. Impermeable surfaces such as roads, parking lots, and buildings cannot be assessed using the program. In order to use RUSLE2 to predict erosion rates in the lower watershed, it is necessary to identify individual sites of interest and assess them separately with more detailed site information. In contrast, the upper watershed land uses were less variable and largely undeveloped therefore it was easier to assess using RUSLE2.

Using GIS, the upper watershed was subdivided into 74 blue-line stream drainage assessment areas (also referred to as “drainages” in GIS data) with an additional 85 assessment areas (also referred to as “other drainages” in GIS data) identified between drainages. Dividing the upper watershed into assessment areas allowed smaller geographic locations to be identified as potentially contributing higher amounts of soil to the system due to soil erosion. Table 5 shows the acreage and potential soil loss values for the upper watershed, separating values for the Santa Rosa Creek sub-watershed, and Perry Creek sub-watershed (including Green Valley Creek).

Table 5. Acreage and predicted annual soil loss values for the upper Santa Rosa Creek Watershed and sub-watersheds.

Watershed	Acres	Percent Upper Watershed Area	Predicted Soil Loss (tons/year)	Percent of Total Predicted Soil Loss
Upper Santa Rosa Creek	28,624		56,270	
Santa Rosa Creek (sub-watershed)	13,941	49%	32,757	58%
Perry Creek (sub-watershed)	14,683	51%	23,513	42%

RUSLE2 soil erosion prediction assessment results were summarized in a map showing the distribution of soil erosion rates throughout the upper watershed, by drainage (Fig. 17). Potentially 56,270 tons or 1.97 tons/acre of soil is eroded each year in the Upper Santa Rosa Creek Watershed. NRCS considers five tons of soil loss, per acre as the sustainable annual soil loss threshold of deep soils (personal communication, B. Hallock). Soil erosion values greater than five tons/acre/year would be considered non-sustainable. This value decreases for shallow soils to bedrock. The threshold soil loss value was established according to the time it takes for one inch of topsoil to develop, equating 30 years and weighing approximately 150 tons.

The highest potential rates of erosion occur in the headwater reaches of both sub-watersheds and along the western drainage of Perry Creek. Steep north-facing slopes in the upper Santa Rosa Creek sub-watershed have the highest values of potential soil loss. A high frequency of gully erosion was observed using 2007 aerial imagery and observations made during field reconnaissance, confirming these results.

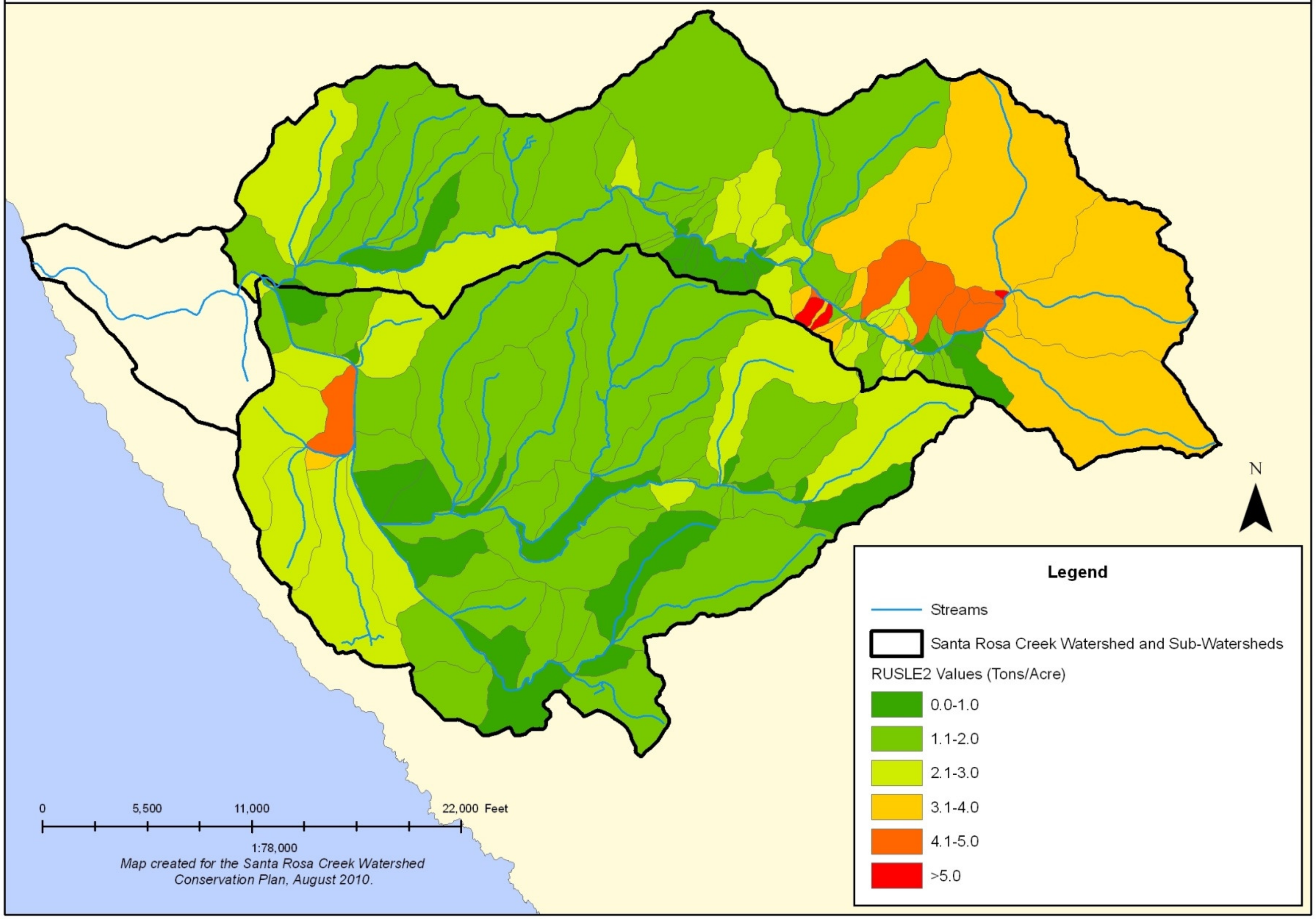
The upper Santa Rosa Creek sub-watershed encompasses 49 percent of the entire upper watershed land area. Within the upper Santa Rosa Creek sub-watershed 32,758 tons of soil can potentially erode each year. This represents 58 percent of the total potential soil loss in the entire upper watershed. The relative frequencies of erosion are shown throughout the upper watershed by soil map units, or soils, defined by the Soil Surveys (Fig. 18). Appendix I lists the total predicted soil loss values for each soil in the upper watershed.

The total predicted erosion values (tons/year) were calculated for each assessment area by adding each soil map unit's predicted erosion value together. Results show that assessment areas between blue-line stream assessment areas are not significant soil contributors due to their small sizes (Fig. 19). There are, however, a few of these sites with the greatest values of soil loss per acre of all areas studied. Slope steepness may be a factor influencing the high potential for soils to erode at these locations. The predicted annual soil loss value for each of the assessment areas are listed in Appendix J.

The RUSLE2 predicted soil loss values show "Gazos-Lodo clay loams, 30 to 50 percent slopes" soil map units are the most abundant soils throughout the blue-line stream assessment areas, accounting for 2,198 acres, or roughly 10 percent of the total area. These soils have the greatest potential to contribute the most soil loss in blue-line stream drainages. Potential soil loss from this soil is 115 tons of soil each year. "Los Osos-Diablo complex, 30 to 50 percent slopes" soils were also significant contributors to soil loss in blue-line stream drainages, potentially contributing approximately 99 tons of soil each year. These soils account for 1,337 acres, or roughly six percent of the blue-line stream drainage assessment area.

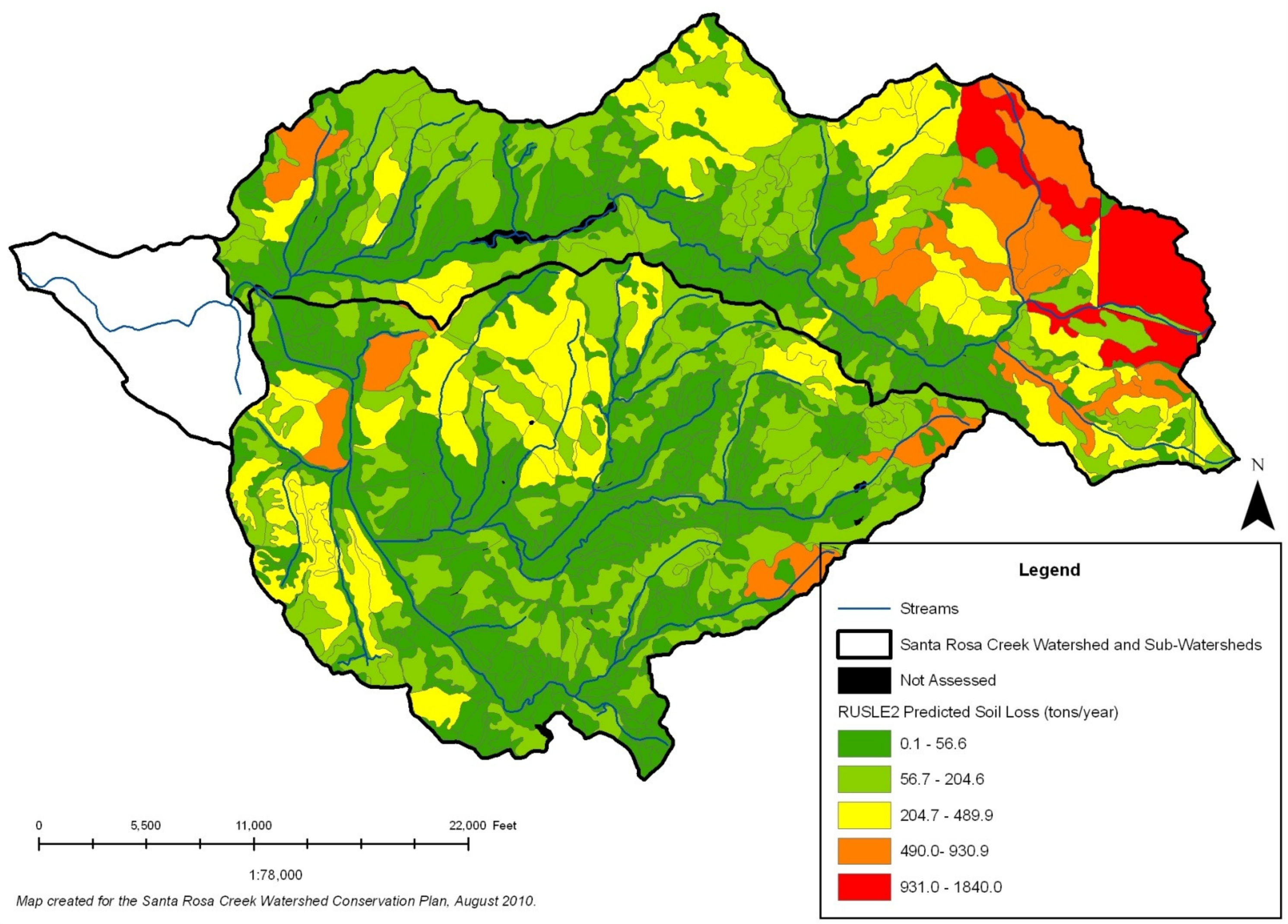
The "Gazos-Lodo clay loam, 30 to 50 percent slopes" soil described above has a high predicted soil loss value in assessment areas between blue-line stream drainages as well. In the upper Santa Rosa Creek sub-watershed, this soil potentially erodes approximately 40 tons of soil each year between blue-line stream drainages. In contrast, the most erosive soil within the Perry Creek sub-watershed is the "Los Osos-Diablo complex, 15 to 30 percent slopes". These soils potentially contribute nearly 47 tons of soil each year in assessment areas between blue-line stream drainages.

Figure 17. Predicted Soil Loss (tons/acre) from Upper Santa Rosa Creek Watershed Using RUSLE2



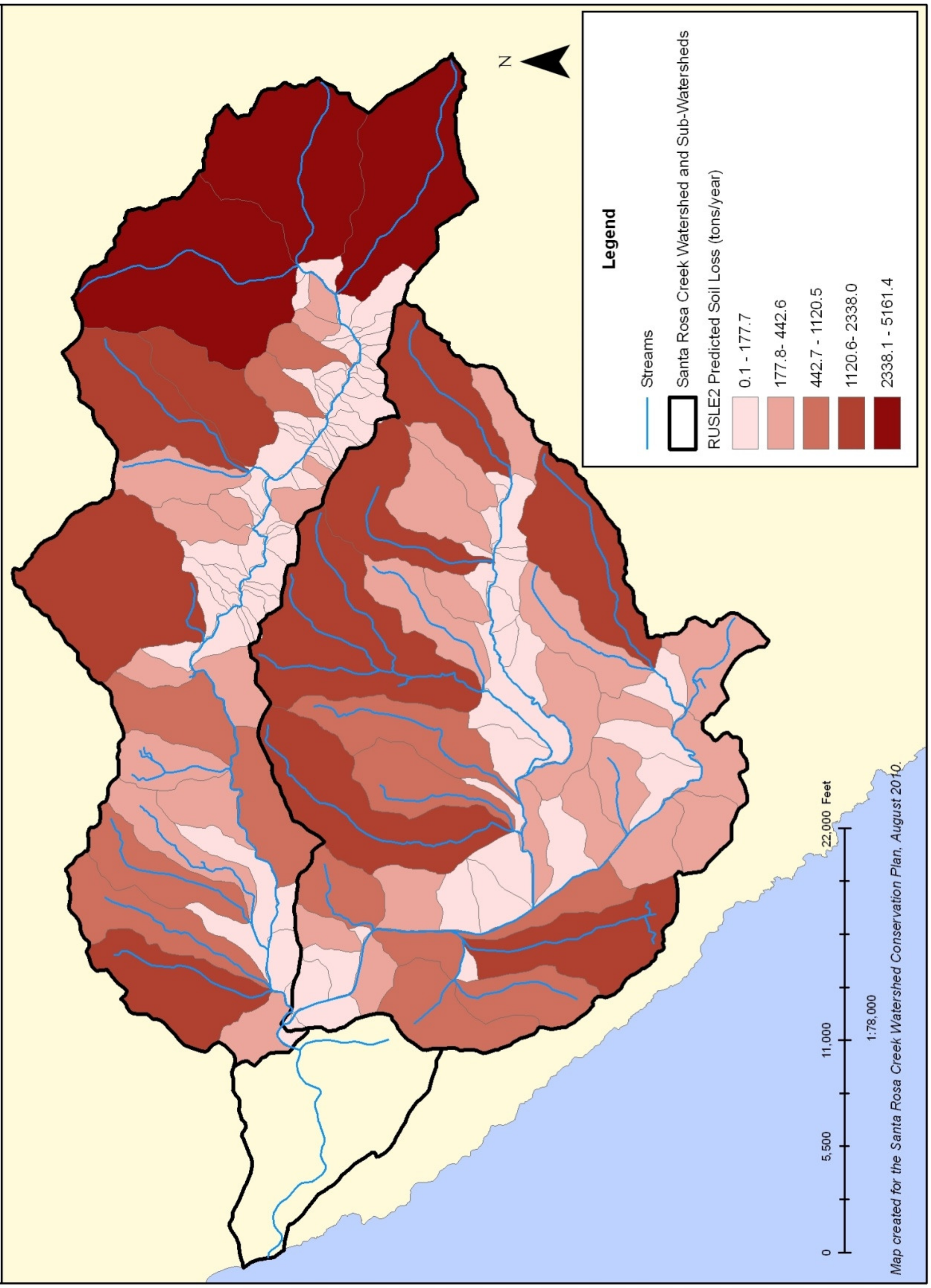
Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.

Figure 18. Predicted Soil Loss (tons/year) from Upper Santa Rosa Creek Watershed by Soil Map Unit Using RUSLE2



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.

Figure 19. Predicted Soil Loss of Upper Santa Rosa Creek Watershed Drainages Using RUSLE2



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.

In describing total predicted erosion values within the upper watershed, it is important to note that some data gaps exist at sites where erosion likely occurs. Approximately 76 acres, or less than one percent of the entire upper watershed area, could not be assessed because "normal rangeland production" values used to describe "base management" in RUSLE2 were not provided in the Soil Survey data. This occurred with soil complexes including rock outcrops and soils that produce very little vegetation, such as soils derived from serpentine rock parent material. In addition, soil map units that were less than 0.065 acres were not assessed because accurate slope length and slope percent could not be captured using the Digital Elevation Model in GIS.

Soil map units without "normal rangeland production" values include "Riverwash", "Xerorthents", and "Water". Approximately 60 acres are "Riverwash" soils, located tangent to streams. These soils are highly susceptible to erosion and should be evaluated using other methods. In addition "Xerorthents, escarpment" soils account for approximately six acres within the upper watershed, and could not be assessed. Soil Surveys describe "Xerorthents, escarpment" soils as highly erosive, having rapid runoff. "Xerorthents, escarpments" are fairly well stabilized, but in bare areas, gullies do exist. These soils occur along State highway 46 on the southern boundary of the Perry Creek sub-watershed. In studying the site using 2007 aerial imagery, no gullies appear to exist within this unit. Finally, there are also approximately seven acres represented in the Soil Survey data, labeled "Water" that were not assessed. These map units are nonsoils and do not apply to the erosion assessment.

4.2. UPLAND EROSION MAPPING

Upland erosion was mapped to identify the location of existing sediment sources and assess the severity and extent of upland erosion throughout the watershed. Upland erosion was mapped using ArcView 9.2, 2007 digital aerial imagery, and field reconnaissance. ArcView 9.2 was used to digitize GIS layers, or on-the-ground features such as a road or a gully, observed using the aerial imagery. (GIS terminology is described in further detail in Section 9.3 of this report.) Digital aerial imagery was flown in the summer of 2007 with a ground resolution of one foot. The high resolution of the aerial allowed the soil surface to be viewed clearly, making identification of erosion features less difficult. Field reconnaissance was conducted to verify mapping results on public lands only. Erosion located on private property could not be checked for accuracy unless it was viewable from public lands or roads.

Several erosion types were identified in the watershed, and include: rill, interrill, ephemeral gully, gully, road, and stream bank erosion. Photographs of erosion occurring in the watershed are included in Appendix K of this report. Although some erosion is typically associated with agricultural land use, such as orchards, vineyards, row crops and tilled fields, they were not mapped as sediment sources in this portion of the Conservation Plan, but are included in the land use assessment as mapped crop boundaries.

Rill and interrill erosion are the two most common erosion features in the watershed. These erosion types occur from soil detachment caused by rainfall and the associated overland water flow during rain events. The overland flow path begins at the top of slope and ends in a concentrated flow channel. RUSLE2 was used to calculate annual predicted soil loss from rill and interrill erosion in the watershed. Results of this assessment are described in Section 4.1 of the Conservation Plan. Rill and interrill erosion were not mapped using GIS because they are difficult features to identify using aerial imagery however gully, ephemeral gully, and road erosion are more distinct features and were digitized for this assessment. Stream bank erosion is an additional source of sediment in the watershed and is briefly discussed by Fisheries Biologist, Don Alley in Appendix L.

Gully erosion is defined by the Soil Science Society of America as "the erosion process whereby water accumulates and often recurs in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, often defined for agricultural land in terms of channels too deep to easily ameliorate with ordinary farm tillage equipment, typically ranging from 0.5 m to as much as 25-30 m". Ephemeral gullies are defined by the Soil Science Society of America as "small channels eroded by concentrated flow that can be easily filled by normal tillage, only to reform again in the same location by additional runoff events" (http://www.soils.org/sssagloss/index.php).

Gully and ephemeral gully erosion are common throughout the watershed, and are typically found in annual grassland drainages and grazed hillsides. The soil erosion occurring at these sites would increase the total predicted annual soil erosion values calculated by RUSLE2 for the erosion assessment described in Section 4.1 of the Conservation Plan. Gullies associated with cattle grazing were mapped separately as "Cattle Trails" or "Cattle Gully" layers depending on the erosion occurring at the site. "Cattle trails" are features where exposed soil has been caused by a high density of cattle trails at a particular location, such as a watering trough, exacerbating the likelihood of erosion at the site during rainfall events. "Cattle Gully" is a gully created in association with cattle grazing land use. It is important to note that the relationship between cattle grazing and soil erosion is not fully understood. Although at some locations soil erosion appears to be caused by a high density of cattle trails (and the associated vegetation loss and soil compaction), some studies show cattle trails that contour hillslopes may actually slow water flow and reduce erosion.

Ephemeral gullies can be difficult to identify using aerial photography because they are smaller, more-subtle features. Ephemeral gullies distinct enough to be viewable using the aerial imagery were mapped. It is likely however; additional ephemeral gullies exist within the watershed and were not identified during this assessment.

Additional gullies were identified in the watershed and were mapped based on landform features such as drainages and stream banks in the "Gully Erosion" layer. Gullies associated with concentrated flow channels that are not blue-line streams were mapped and labeled "gully/drainage". Gullies occurring on banks of blue-line streams or other major drainages were mapped and labeled "gully/bank". Both gully types were identified based on exposed soil surface on the gully floor and headcutting. According to the Soil Science Society of America, headcutting is defined as "small abrupt elevation drops (1-5 cm) on the floor of rills or irrigation furrows that result in accelerated erosion as they undercut the rill floor and migrate upstream" (http://www.soils.org/sssagloss/index.php). Stream bank erosion is common among blue-line streams in the Santa Rosa Creek Watershed. Erosion on stream banks where headcutting appears to be forming a channel migrating upslope of the stream were mapped and labeled "gully/bank".

Some locations in the watershed could not be evaluated for soil erosion due to reflective glare on the aerial imagery. There are six sites located in the upper watershed where erosion appears to be occurring but could not be positively identified. These sites were located in grassland habitats and around rock outcrops. The locations were mapped as points in GIS and labeled "Unknown".

Other upland erosion features were also difficult to identify using the aerial imagery. For instance, road erosion could not be identified where the road is obstructed from view due to vegetative canopy cover or the road bank is difficult to view overhead due to extremely steep slopes. Dense vegetative canopy also obstructs view of the soil surface in coastal scrub and chaparral communities, making it difficult to map upland erosion in these areas as well.

Upland Erosion Mapping Results

To describe sediment transport and local sediment deposition in upland habitats of the Santa Rosa Creek Watershed, nine GIS layers were created. “Cattle gully”, “Cattle trails”, “Gully erosion”, and “Road erosion” layers were created to identify upland erosion sites. Additionally, ranch roads, agricultural roads, and other private roads are known sources of sediment and were mapped as “Other roads”. Excavation and mining sites are other sources of sediment and were mapped as “Mines”. All remaining upland erosion sources were mapped as “Other erosion”. Unconfirmed sites that could not be identified using the aerial but had potential to contribute eroded soil were mapped as “Unknown”. Detention basins or ponds were also mapped to show locations where soil deposition occurs. These sites were located mostly on agricultural properties in the upper watershed and were mapped as “Basins”.

While gullies associated with stream banks were mapped in the “Gully erosion” layer, severe stream bank erosion was identified only while mapping other upland erosion features. Stream bank erosion mapping was not included in the upland erosion assessment because of difficulty in identifying locations under riparian vegetative canopy. Field data collection of these features is required for an accurate assessment of stream bank erosion throughout the watershed. The stream bank erosion layer created for the Conservation Plan is not a complete layer and one should be cautious while using these data.

Figure 20 shows upland erosion locations in the watershed while Table 6 includes erosion statistics for the entire watershed and sub-watersheds. In addition, Table 7 describes unclassified road types within the watershed and sub-watershed. It is important to note the combined road lengths of both sub-watersheds are greater than the watershed total road lengths resulting from the inclusion of road lengths that cross sub-watershed boundaries in both sub-watershed road length statistics.

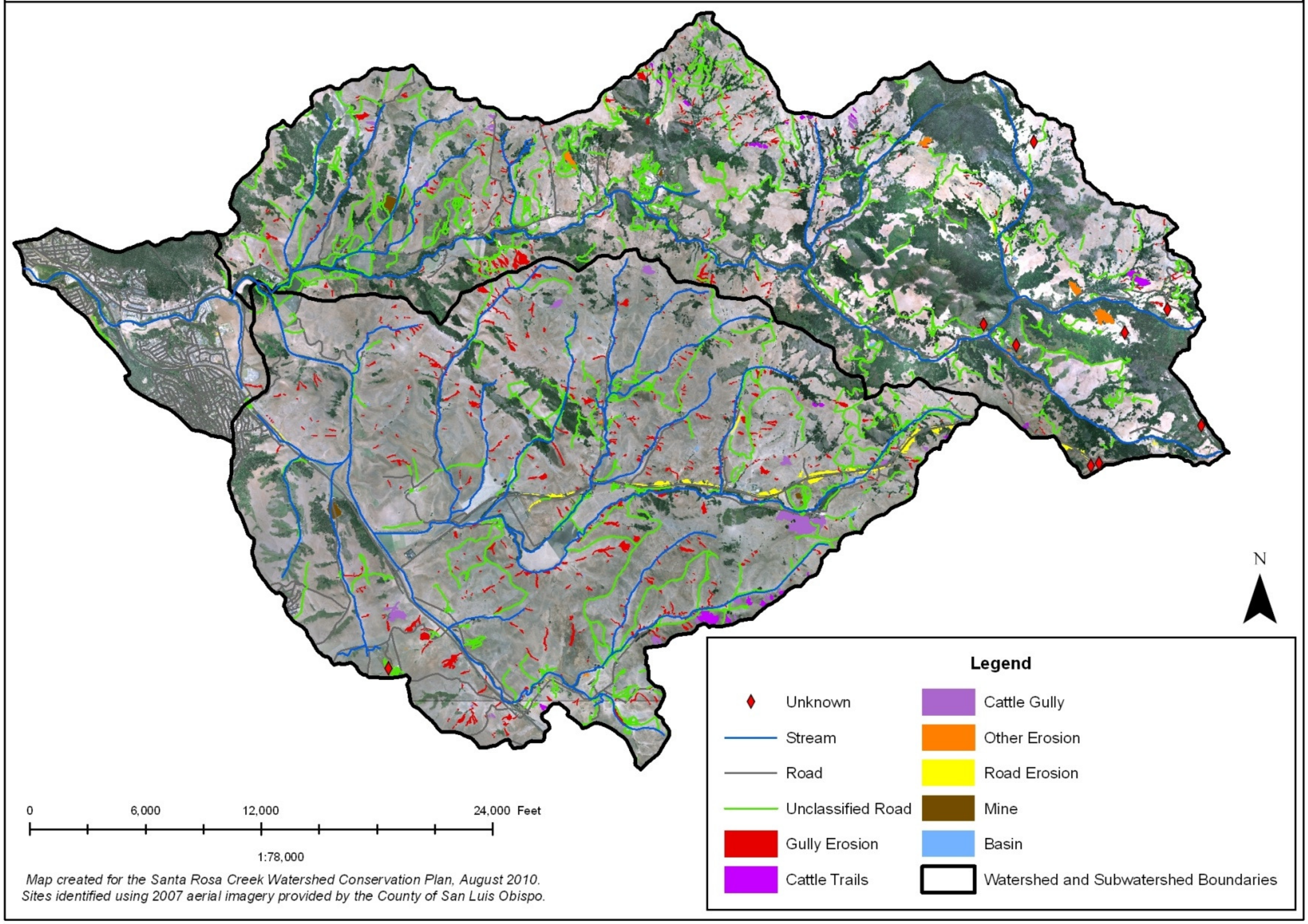
Cattle Trails

Sites where a high frequency of cattle trails have disturbed the soil surface, leaving the ground bare, were mapped in the “Cattle trails” layer. Approximately 1,775 acres in the entire watershed have been mapped as “Cattle trails”. These sites are typically associated with a trough, spring, or stream crossing, and are formed where multiple cattle trails coalesce forming a highly disturbed site. Vegetation at these sites is usually sparse with some annual non-native grasses present. “Cattle trail” sites have the potential to erode during rainfall events due exposed soil surface and likely soil compaction which reduces water infiltration rates and increases runoff. In addition, riparian zones which are instrumental in filtering sediment from runoff entering streams are sometimes reduced at sites where high intensity grazing occurs.

Table 6. Mapped upland erosion site statistics for Santa Rosa Creek Watershed and sub-watersheds.

Feature Type	Santa Rosa Creek Watershed (acres)	Upper Santa Rosa Creek Sub-watershed (acres)	Percent Total Watershed	Perry Creek Sub-watershed (acres)	Percent Total Watershed
Ephemeral gully	781	373	48	407	52
Gully	1523	1172	77	351	23
Gully (severe)	40	40	100	0	0
Gully/bank	916	202	22	714	78
Gully/drainage	6099	874	14	5182	85
Gully/drainage (severe)	182	0	0	182	100
Gully/scrub	16	16	100	0	0
Cattle gully	3202	338	11	2863	89
Cattle trails	1775	953	54	821	46
Other erosion	1287	1225	95	62	5
Road erosion	94	17	18	75	80
Mines	31	19	61	12	39
Basin	14	3	21	11	79
TOTAL	**15961**	**5233**		**10680**	

Figure 20. Upland Erosion Sites Located in the Santa Rosa Creek Watershed



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.
Sites identified using 2007 aerial imagery provided by the County of San Luis Obispo.

Table 7. Mapped unclassified road lengths within Santa Rosa Creek Watershed and sub-watersheds.

Feature Type	Santa Rosa Creek Watershed (miles)	Upper Santa Rosa Creek Sub-watershed (miles)	Percent Total Watershed	Perry Creek Sub-watershed (miles)	Percent Total Watershed
Agricultural road	26	20	78	7	25
Mining road	3	1	56	1	44
Other road	3	1	39	2	70
Ranch road	114	64	57	55	49
Residential road	5	3	64	2	34
TOTAL	**150**	**90**		**67**	

Cattle Gully

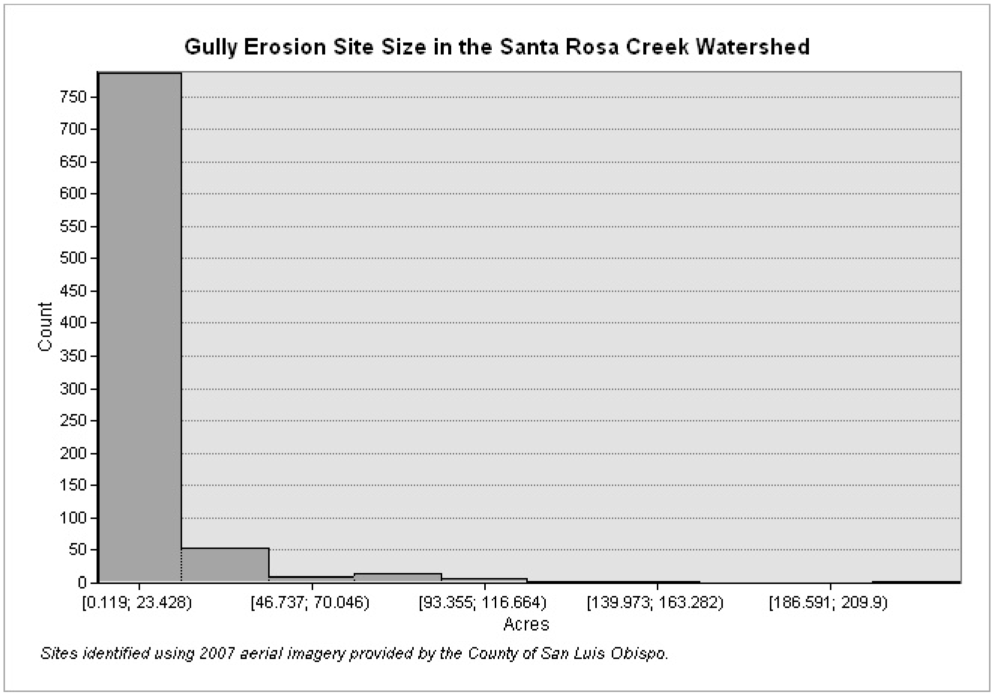
Gully erosion associated with cattle trails were mapped in the "Cattle gully" layer. These sites are often located in the upper reaches of tributaries and unnamed drainages. "Cattle gully" sites are similar to "Cattle trail" sites except that they have a gully within the disturbed area. There are approximately 3,202 acres of land where gullies are associated with observed cattle grazing activities. The smallest site is approximately two acres and the largest site, located on a steep, north-facing slope tangent to a bend in Green Valley Creek, is approximately 1,554 acres. At this site, cattle trails and rill erosion are common throughout the property and few gullies exist.

Gully Erosion

There are 877 "Gully erosion" sites identified in the watershed. Approximately 9,558 acres of land is susceptible to soil loss from gully erosion. Gully site sizes range from 0.1 acre to 233 acres, with a mean gully erosion size of 10.9 acres. The mean gully erosion size is likely skewed due to the presence of a few outlier values, or values that fall far above the normal size of gully erosion occurring within the watershed. Only 35 sites with approximately four percent of the total gully erosion area are over 50 acres in size; of these, two sites are over 200 acres. Large erosion sites are typically observed in sparsely vegetated drainages where the entire drainage appears as one large gully with eroding banks and exposed soil throughout. At these sites the entire area was mapped as "gully/drainage" to represent gully erosion occurring in association with drainages. A histogram of upland gully erosion sizes show most gullies are less than 24 acres in size (Fig. 21). Very few sites are greater than 46 acres.

Areas most impacted by gully erosion were observed to be foothill grassland habitats with steep slopes. Many gully erosion sites are located in association with small, unnamed drainages, as described above. Headcuts are commonly found at the top of unvegetated drainages and tributaries throughout the watershed. These sites typically have more cattle trails than other areas because cattle cannot cross drainages and tributaries in other locations due to steep banks.

Gully erosion appears more evident throughout the Perry Creek sub-watershed with approximately 6,837 acres of gully erosion existing within the Perry Creek sub-watershed, or 72 percent of the total gully erosion occurring within the entire watershed.



Sites identified using 2007 aerial imagery provided by the County of San Luis Obispo.

Figure 21. Histogram of ephemeral gully and gully erosion site size in the Santa Rosa Creek Watershed.

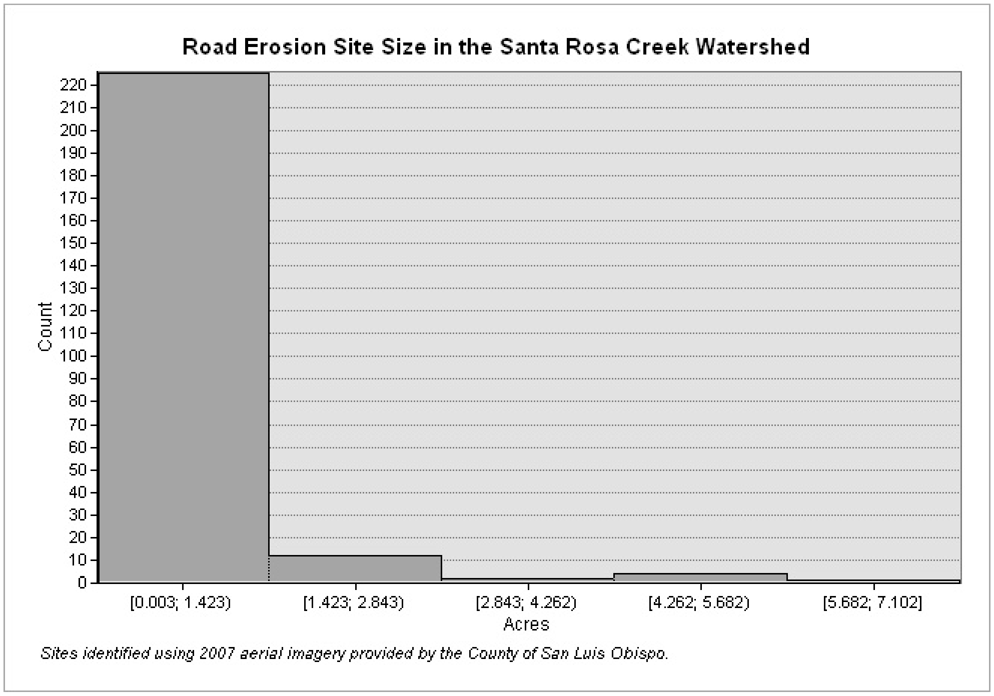
In general, fewer gullies were identified in headwater locations. This could be due to aerial photography viewing restrictions caused by camera glare and vegetation. Less than five percent of the entire watershed area, or less than 1,520 acres, could not be viewed due to reflective glare on the aerial image. At locations where glare is present the ground surface appears almost white and distinct features such as vegetation are muted making mapping erosion features difficult. In addition, grassland communities of the lower foothills are replaced by chaparral, coastal scrub, and forests in upper elevations of the Santa Lucia Mountains. Gullies could exist within densely vegetated areas however the ground surface could not be viewed due to obstructions resulting from vegetation canopy.

Cattle grazing activities are also common in the upper watershed however fewer erosional features exist where vegetation forms dense thickets and steep, rocky hillslopes make navigating the terrain difficult for cattle. Impacts to riparian areas surrounding streams and drainages appear to decrease as well. Although the amount of erosion appears less in the upper watershed, there are issues viewing the aerial imagery at some locations, as discussed above, and erosional features could exist that were not identified.

Road Erosion

Erosion associated with concentrated water flow leaving the surface of a paved or unpaved road were mapped in the "Road erosion" layer. "TIGER" road data acquired from SLO Datafinder (http://lib.calpoly.edu/collections/gis/slodatafinder/) was used to identify road locations. Erosion tangent to these road features were mapped. Road erosion was not studied in the lower residential and business areas of the watershed; however erosion sites were identified along State Highway 1 and Main Street, within the lower watershed.

There are 244 road erosion sites in the Santa Rosa Creek Watershed, totaling 93.5 acres of soil susceptible to erosion due to roads. The minimum road erosion site size is less than 0.1 acre; the maximum site size is 7.1 acres; and the mean road erosion site size is 0.38 acre. Additional road erosion likely exists within the watershed, however could not be identified using the aerial due to vegetation cover or steepness of eroding slope. Road erosion site sizes are displayed on a histogram (Fig. 22). There are 225 sites between 0.003 and 1.423 acres in size, with only 19 additional sites larger than 1.423 acres.



Sites identified using 2007 aerial imagery provided by the County of San Luis Obispo.

Figure 22. Histogram of road erosion site size identified using GIS and 2007 aerial imagery.

Landslides exist along State Highway 46, located in the Perry Creek Watershed. Construction of the highway occurred in the early seventies when preconstruction slope failure was noted and has since been exacerbated. In some locations, the cut slope is impacting personal property and rock armor is transported by slides into Green Valley Creek (Serafini, 2000). After the San Simeon earthquake in 2003, many landslides were noted along State Highway 46 due to liquefaction (EERI, 2004).

Other Roads

Roads not included in the "TIGER" database were mapped in the "Other roads" layer. Roads mapped in this layer include ranch, agricultural and private roads located in the upper watershed mainly. Additional ranch roads were located and mapped in the lower watershed; however roads within the residential and business areas of the community of Cambria were not mapped. Unpaved roads included in this layer have exposed soil surfaces with likely soil compaction making them susceptible to erosion during rainfall events.

Approximately 150 miles of "Other roads" exist in the watershed. There are approximately 26 miles of agricultural roads associated with tilled fields, vineyards, orchards, and row crops. Roads associated with mining operations total 2.5 miles in length. The most common types of unpaved roads in this watershed are ranch roads, with 511 separate ranch road segments totaling 113 miles in length. Ranch roads were identified as unpaved roads located in rangeland. In grazed areas where cattle trails were also observed, ranch roads were identified having two distinct tire tracks, as opposed to one narrow trail. Several ranch roads were identified and mapped, however appear to be abandoned. These roads are faded on the landscape and often-times dissipate in a field, ending at no distinct feature.

Private residential roads such as driveways were also mapped and total 4.7 miles in length. Other private roads that could not be classified in the above categories total 3.3 miles in length and are often associated with large agricultural facilities.

Mines

Using county mines data acquired through SLO Datafinder (http://lib.calpoly.edu/collections/gis/slodatafinder/) and information from aerial imagery and topographic quadrangles, seven mines, gravel pits, and sites where excavation activities exist, were mapped. These sites were mapped in the "Mines" GIS layer and were observed as areas of excavated land and/or exposed rock. Approximately 30.6 acres of land was observed to be excavated in the watershed. The Bianchi Quarry is the largest site at 16.1 acres, with the Cambria Pit being the second largest site at 9.7 acres. Both sites are active rock quarries. The Bianchi Quarry is located in the upper Santa Rosa Creek sub-watershed and the Cambria Pit is located in the Perry Creek sub-watershed, along a tributary to Fiscalini Creek.

Photographs of small excavation activities, the Bianchi Quarry, and other erosion features found within the watershed are included in Appendix K of this report. The gravel pits and mercury mine are located on private property and could not be accessed. Field reconnaissance shows that smaller gravel pits are difficult to identify on the aerial image therefore additional gravel pits may exist.

Historic information of mining activities in the watershed reveals that dozens of mines were created at the height of the mercury mining boom, in the nineteenth century. Many mines were dispersed in the foothills of the Santa Lucia Mountains, as prospectors searched frantically for ruby red cinnabar ore. Rough, hummocky topography located in portions of the headwaters may be remnants of old mining activities. Although vegetation has now covered many of these sites, alterations to the landscape may impact drainage, accelerating erosion in some locations and providing local deposition in others.

Other Erosion

Sites where erosion type could not be confirmed but a feature was distinct enough to indicate possible erosion, were mapped using the "Other erosion" layer. These sites include locations such as rocky hillsides in serpentine areas where erosion appears to be creating ephemeral gullies. Other sites, such as possible excavation sites, were also identified and mapped using this layer. There are 1,287 acres in the watershed mapped as "Other erosion". With permission from private landowners, additional data should be gathered about these sites.

Unknown

Point features were created in the "Unknown" layer to identify locations in which erosion could be occurring but a perimeter could not be mapped using the aerial imagery. There are nine "Unknown" sites mapped in the watershed. These sites differ from "Other erosion" sites in that an area was not mapped around the perimeter of the site because the entire site could not be viewed due to obstructions or reflective glare on the aerial image.

Basins

Basins were mapped to identify locations where detached sediment could be locally deposited during rainfall events. The amount of soil lost to erosion through streams and drainages decreases when eroded soil is collected in features such as basins or ponds. Detention basins and ponds located in the watershed appear to be used in association with ranching activities in the upper watershed. There are 31 basins located within the watershed, of approximately 14.1 acres. The minimum basin size is less than 0.1 acre and the maximum basin size is approximately two acres.

4.3. FISHERIES ASSESSMENT

Fisheries Resources

The following discussion of fisheries resources in the Santa Rosa Creek Watershed is excerpted from a summary report of extensive fisheries surveys conducted by D.W. ALLEY and Associates and supplemental information obtained from the California Department of Fish and Game. Appendix L contains the entirety of the D.W. ALLEY and Associates' report. The information in this discussion is focused on steelhead (*Oncorhynchus mykiss*), a species listed as threatened under the federal Endangered Species Act. Steelhead are considered the primary indicator species of stream health in the watershed. Information is also included describing habitat conditions and limiting factors for the Tidewater goby (*Eucyclogobius newberryi*), listed as an endangered species in the watershed.

Steelhead Ecology

Steelhead are a member of the salmonidae family, or salmonids, which include salmon, trout, chars, freshwater whitefish, and graylings. Steelhead are genetically indistinct from rainbow trout and differ only in their behavior. Steelhead exhibit a life cycle similar to other salmonids in that they are anadromous, meaning they develop into adulthood in the ocean and swim to their natal stream to reproduce. Most adult salmonids migrate to their home stream in January through early May after two years (range of one to three years) of feeding and growth over the continental shelf. However, adult steelhead differ from all other salmonids in that some survive the spawning process to return to the ocean and possibly spawn again the next spawning season. All other adult salmonids spawn only once and die soon after.

Once hatched from their eggs, the young steelhead are referred to as alevins and remain among their spawning gravel, or redd, to feed from their rich yolk sacks. After the yolk is completely absorbed the young fish emerge from the gravel to consume small insects and are then known as fry. These fry spend one to two years as juveniles in their natal, freshwater streams. Steelhead are considered juveniles unless they have entered the ocean. Once large enough to survive ocean conditions, most make their way to the ocean in late winter and spring. At this time the young steelhead undergo physiological and coloration changes, a process known as smolting, which allows them to acclimate to the saline ocean environment, a process known as osmoregulation. The more variable life cycle of steelhead has made them more adaptable to habitat changes and more resilient to natural events that have been exacerbated by human development and water usage, such as floods and droughts, than the simpler life cycle of other salmonids, for instance coho salmon.

Spawning Habitat

Steelhead require spawning sites with gravels from 1/4" to 3 1/2" in diameter, having a minimum of fine material (sand and silt), and with good flows of clean water moving over and through them. Flow of oxygenated water through the redd to the fertilized eggs is restricted by increased fine materials from sedimentation causing the gravels to become cemented with sand and silt. These restrictions reduce hatching success. In many Central Coast streams, steelhead appear to successfully utilize spawning substrates with high percentages of coarse sand, possibly impacting hatching success. In addition, steelhead that spawn earlier in the winter are more likely to have their redds washed out or buried by winter storms. Steelhead spawning success may be limited by scour from winter storms in some streams. Unless hatching success has been severely reduced, survival of eggs and alevins is usually sufficient to saturate the limited available rearing habitat in most reaches of small coastal streams, such as Santa Rosa Creek. The production of young-of-the-year (YOY) fish is related to spawning success, which is a function of several factors including the quality of spawning conditions, the pattern of storm events, and the ease of spawning access to upper reaches of tributaries where spawning conditions are generally better.

Rearing Habitat

Growth of YOY steelhead appears to be regulated by available food and cover resources, as well as water depth. Steelhead YOY diet is mostly composed of insects, however they will also eat smaller fish and crustaceans. Cover habitat, such as undercut banks, large un-embedded rocks, surface turbulence, and so forth, is imperative to their success as well, providing hiding places from predators. Pool, run and riffle depth are also important in regulating juvenile numbers, especially for larger fish. Densities of yearling (second year) and smolt-sized steelhead in small streams, such as Santa Rosa Creek, are usually regulated by water depth and the amount of escape cover during low-flow periods of the year (July-October). In most small coastal streams, availability of this "maintenance habitat" provided by depth and cover appears to determine the number of smolts produced (Alley, 2006a; 2006b). Abundance of food and fast-water feeding positions for capture of drifting insects in "growth habitat" (provided mostly in spring and early summer) determine the size of these smolts. Aquatic insect production is maximized in un-shaded, high gradient riffles dominated by relatively un-embedded substrate larger than about four inches in diameter.

During summer in Santa Rosa Creek, steelhead use pool habitat primarily. Shallower fastwater riffles, runs and step-runs (step-runs present only in the upper canyon) are also used by mostly small YOY and the occasional yearling in deep pockets of step-runs. The shallow (typically 0.2 ft or less average depth and typically 0.4 ft or less maximum depth) fastwater habitat is used almost exclusively by small YOY, although most YOY are in pools. YOY and small yearling steelhead that have moved down into the lower valley from the upper canyon in spring can grow faster, especially if stream flows are high and sustained throughout the summer. Primary feeding habitat is at the heads of pools and in the lower valley where step-runs are absent. The deeper the pools, the more value they have. Higher stream flow enhances food availability, surface turbulence, and habitat depth, which are all factors in increasing steelhead densities and growth rates.

Overwintering Habitat

Deeper pools, undercut banks, side channels, large un-embedded rocks and large wood clusters provide shelter for fish against the high winter flows. In some years, extreme floods may make overwintering habitat the critical factor in steelhead production, especially for smaller steelhead that must over-winter twice before they are ready to migrate to brackish waters to smolt. In years when bankfull or greater storm flows occur, these refuges are critical, and it is unknown how much refuge is actually needed.

Migration

Adult steelhead in small coastal streams tend to migrate upstream from the ocean through an open sandbar after several prolonged storms. The migration seldom begins earlier than December and may extend into May if late spring storms develop. Many of the earliest migrants tend to be smaller than those entering the stream later in the season. Adult fish may be blocked in their upstream migration by barriers such as bedrock falls, wide and shallow riffles and occasionally log-jams. Man-made objects, such as culverts, bridge abutments and dams are often significant barriers. In the Santa Rosa Creek Watershed, the concrete ford at Ferrasci Road between Reaches 0b and 1 has a denil fish ladder through the drainage culvert that may become a passage barrier during storm events. Stream reach boundaries in the Santa Rosa Creek as defined by D.W. ALLEY and Associates are mapped in Figure 23 and described in Table 8, pg. 97.

At times, some barriers may completely block upstream migration, but many barriers in coastal streams are passable at higher stream flows. If the barrier is not absolute, some adult steelhead are usually able to pass in most years, since they can time their upstream movements to match peak flow conditions. In drought years and years when storms are delayed, barriers can seriously impede steelhead spawning migration. Data indicated that in drier years, juvenile steelhead densities tended to increase in the lower valley reaches of Santa Rosa Creek and decrease in the upper canyon (and vice-versa in wetter years), indicating reduced adult passage in drier years.

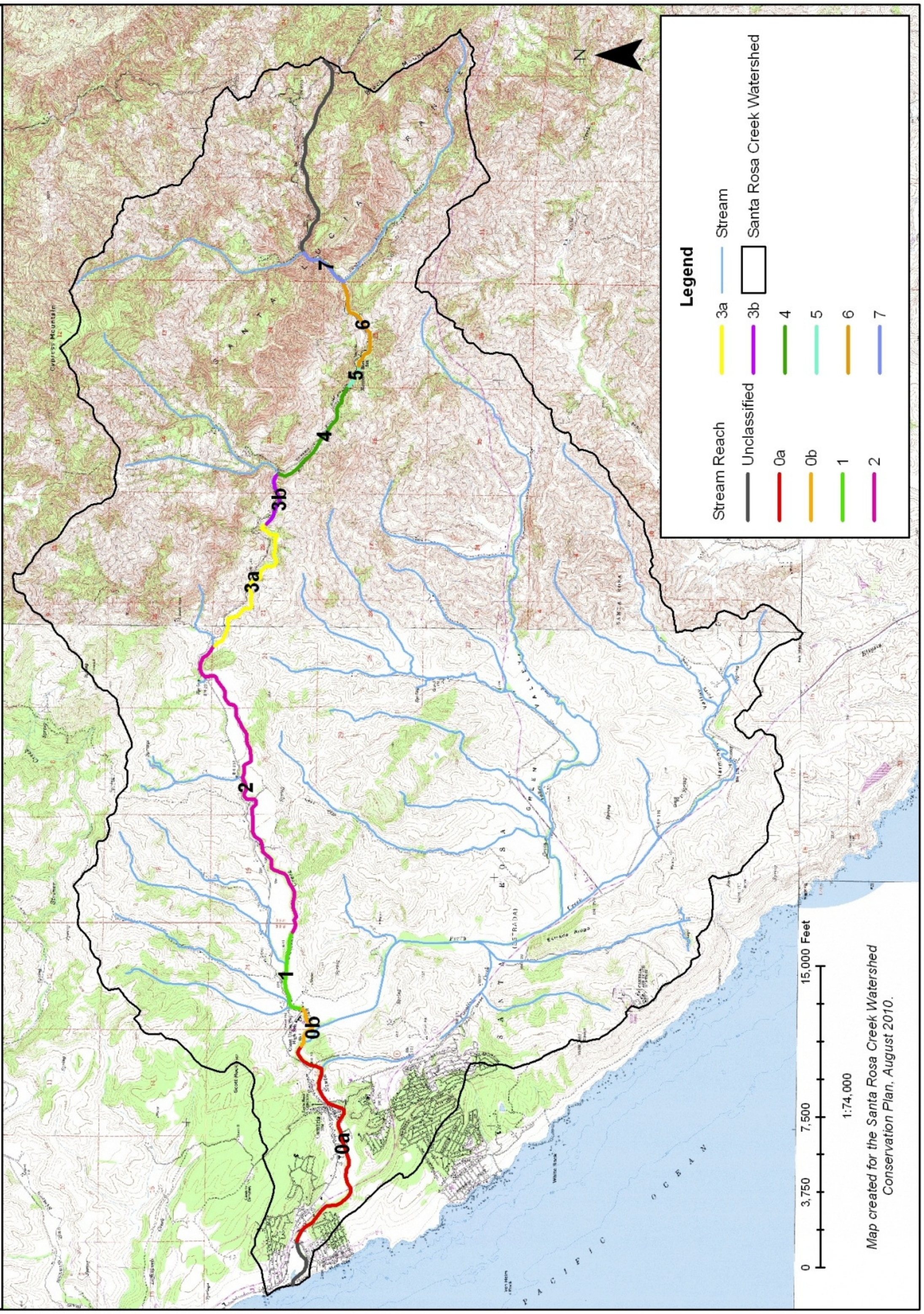
Smolts (young steelhead which have physiologically transformed in preparation for ocean life and initiate their migration to the ocean) in local coastal streams tend to migrate downstream to the lagoon and ocean in March through early June. In streams with lagoons having adequate water quality, YOY and yearling fish may spend several months in this highly productive lagoon habitat and grow rapidly. Santa Rosa Lagoon has provided summer steelhead habitat after wet winters, however it is considerably reduced in size in drier years and/or has lethally high water temperatures due to tidal overwash, providing steelhead habitat only in the upper portion between Windsor Bridge and Shamel Park. In some small coastal streams, downstream migration can occasionally be blocked or restricted by low flows due primarily to heavy streambed percolation or early season stream diversions. Flashboard dams or early closure of the stream mouth or lagoon by sandbars after milder winters are additional factors, which adversely affect downstream migration to the Pacific Ocean. For example, the Santa Rosa Creek sandbar closed for the summer season on 28 March in 1994 after a mild winter, and numerous juvenile smolts that had been trapped in the lagoon after the sandbar closed were observed and some captured

(50+) in early June in the lagoon and immediately upstream. In 2008, with the shortage of March and April storm flows and early sandbar closure, numerous smolts and adult steelhead were trapped in the lagoon behind the closed sandbar in mid-April and were unable to reach the Bay.

During the growing season juvenile steelhead do not move substantially from the location where they are captured and therefore juvenile densities are directly linked to the habitat conditions where they are captured. This deduction is supported by observation of sites in close proximity yet with widely different food availability. The lack of movement between sites is indicated by juveniles that are consistently larger at the mainstem sites where stream flow is greater and there is more food (Don Alley personal observation, e.g. San Lorenzo River and tributaries). Otherwise, juvenile steelhead size would standardize as fish moved between feeding areas. Other studies support this theory as well.

Davis, during an assessment of growth rates in various habitat types, marked juvenile steelhead in June, 1995, in Waddell Creek. In September of the same year, he recaptured the same fish in the same habitats, or immediately adjacent habitats. In addition, Shapovalov and Taft (1954) after nine consecutive years of fish trapping on Waddell Creek detected very limited upstream juvenile steelhead movements, concluding the relatively limited movement was mostly in the winter, perhaps after the lagoon sandbar opened and lagoon habitat was lost. Recent preliminary data from PIT-tag detectors installed by NOAA Fisheries researchers in upper Scott Creek and its tributary, Big Creek (Santa Cruz County) have also indicated little movement of juvenile steelhead during the growing season. PIT-tagging of estuary/lagoon-inhabiting and stream-inhabiting juveniles over a two-year period has shown very little movement of juvenile steelhead during the months of May–November, it being insignificant at the population level (personal communication, S. Hayes). They, however, found that some estuary/lagoon juveniles moved upstream from the lagoon in fall prior to sandbar opening, perhaps due to deteriorating water quality, and after sandbar opening with the loss of lagoon habitat.

Figure 23. Santa Rosa Creek Stream Reaches as Defined by D.W. ALLEY & Associates



Map created for the Santa Rosa Creek Watershed Conservation Plan. August 2010.

Growth Dynamics

"Growth habitat" provided by higher flows in spring and late fall (and in summer of higher baseflow years in lower valley reaches) is very important, since ocean survival to adulthood increases exponentially with smolt size (Shapovalov and Taft, 1954; Bond, 2006). It was determined from scale analysis of captured steelhead that in warm mainstem portions of the San Luis Obispo and Santa Rosa creeks (San Luis Obispo County), YOY steelhead are capable of growing to smolt size their first growing season (Size Class II =>75 mm Standard Length in fall) (Alley, 2008a; 2008b). Except in streams with high summer flow volumes (generally greater than about 0.2 to 0.4 cubic feet per second (cfs) per foot of stream width), steelhead require two summers of residence before reaching smolt size (Smith, 1984). For reaches where yearling steelhead stay a second summer, growth in summer and fall is slightly before leaf drop and fall storms (or even negative in terms of weight) as summer flow reductions eliminate fast-water feeding areas and reduce insect production (Smith, 1982a; Hayes et al., 2008). Data indicated that in Santa Rosa Creek, relatively few YOY reached a size enabling them to smolt the following spring except primarily in lower valley reaches.

The slow growth and often two-year residence time of most Central Coast juvenile steelhead indicate that any year class of steelhead can be adversely affected by low stream flows or other problems during either of the two years of freshwater residence. A small percent of yearlings may stay a third growing season to become 2+ year-olds before smolting if they spend much of their residence time in poor habitat that slows growth (usually in cooler headwater reaches) or if they have the genetically determined behavior to grow especially large before smolting.

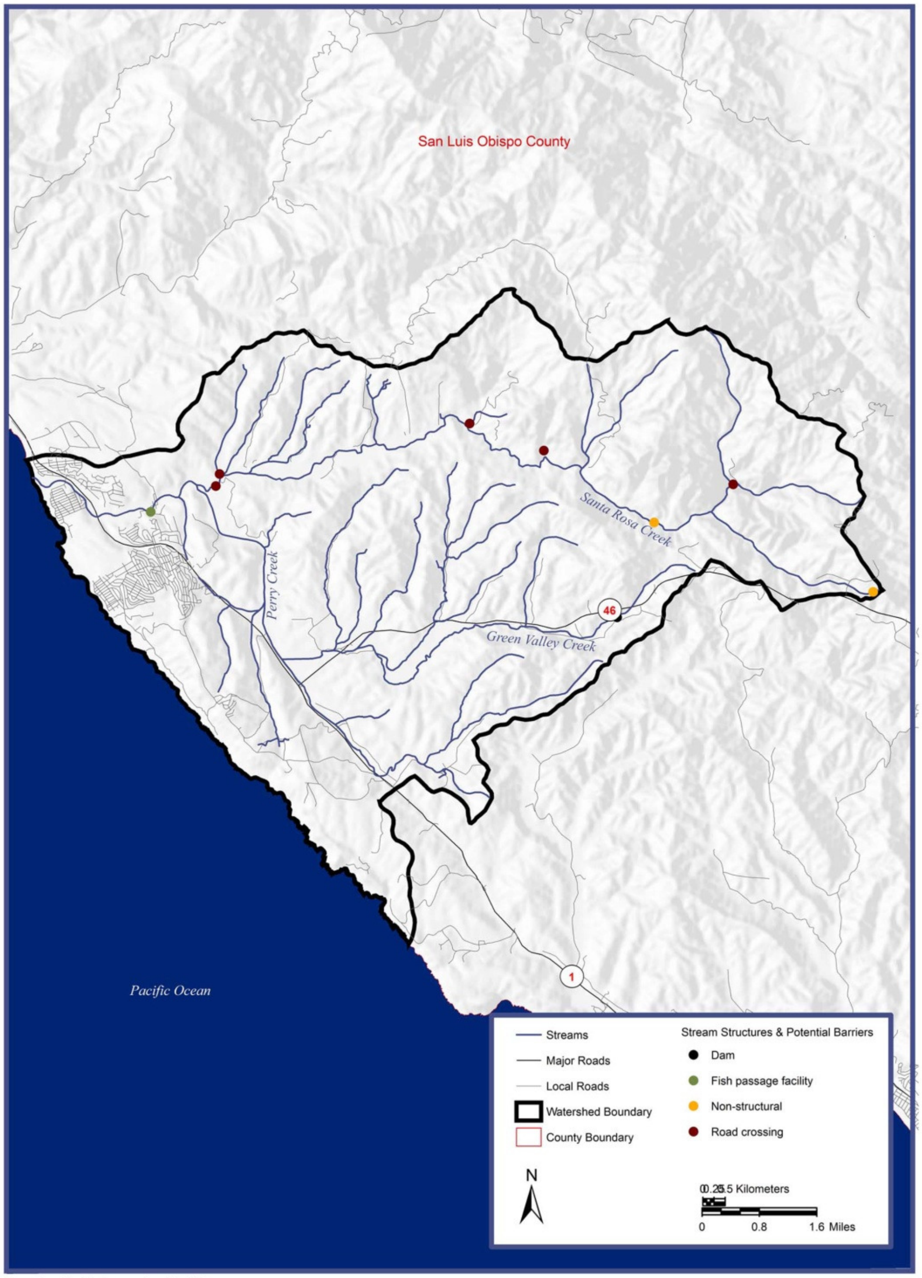
Migration Barriers and Extent of Anadromy

Stream structures and potential barrier data in the Santa Rosa Creek were compiled by the California Department of Fish and Game (CDFG) in the California Fish Passage Assessment Database (ds69), last updated May, 2009. Using BIOS Public Viewer v 4.18 (http://imaps.dfg.ca.gov/viewers/biospublic/app.asp?zoomtobookmark=1562) the fish passage database was queried. Data showed one natural limit to anadromy along Santa Rosa Creek, and six structures listed as “total”, “partial”, or “temporal” barriers for fish migration in the Santa Rosa Creek Watershed. There are an additional 14 structures with a barrier status listed “unknown”, and two structures that are not barriers within the watershed. Along the mainstem of Santa Rosa Creek, there is one “total” barrier (natural limit to anadromy), two “temporal” barriers (a road crossing and fish passage facility), one “unknown” (cascade falls), and one that is “not a barrier” (Highway 1 bridge).

Other barrier data are available for the Santa Rosa Creek Watershed from the Central Coast Watershed Studies Team (http://ccows.csumb.edu/scdp/data.htm) (Fig. 24). These data were published in 2006 by the CDFG for the California Fish Passage Assessment Database Project. The data show there are five road crossings and two non-structural sites that could act as barriers to steelhead migration. The end of anadromy is identified as the eastern-most non-structural site on the map. A dam located in the upper reaches of Perry Creek signifies the uppermost extent of anadromy in that stream. Additional migratory barriers could exist within the watershed, reducing total steelhead habitat.

California Department of Fish and Game
Central Coast Region South District Basin Planning

Santa Rosa Creek Watershed
Stream Structures & Potential Barriers



Map produced by Julie Casagrande and Fred Watson (Central Coast Watershed Studies, Watershed Institute, California State University Monterey Bay) in collaboration with the California Department of Fish and Game. The basemap layer is a shaded relief raster derived from the USGS National Elevation Dataset using TNT Mips software. The stream structures and potential barriers data layer was extracted from the PAD GIS dataset - California Fish Passage Assessment Database Project (January, 2006). The watershed boundaries layer was derived from the California Interagency Watershed Map of 1999 (Calwater 2.2.1, updated May 2004) by merging HSA (Hydrologic Sub-Area) level boundaries.

California Department of Fish and Game
Central Coast Region South District Basin Planning

Figure 24. Map of structures and barriers in the Santa Rosa Creek Watershed, by CDFG.

D.W. ALLEY & Associates state that steelhead anadromy likely extends to the upper reaches of Santa Rosa Creek and upper tributaries, such as Mora, East Fork, and Lehman Creeks. Stream reach and tributary nomenclature along the Santa Rosa Creek were defined by D.W. ALLEY & Associates (Fig. 25). When the mainstem of Santa Rosa Creek was surveyed to the Mora Creek confluence in fall 1994, no passage impediments were observed other than wide transverse riffles in Reach 0a. Although perennial flow exists in Mora Creek, judging from the topography in that area, the gradient rapidly increases and passage impediments likely exist. As a result there may be as much as ¼ -mile of spawning and rearing habitat on lower Mora Creek. Steelhead have been confirmed at other locations in the upper Santa Rosa Creek as well. It is unknown if perennial habitat exists in the East Fork of Santa Rosa Creek, however observations of adults and juveniles have been reported by a local resident. Limitations to migration are probable in this tributary due to gradient and water availability. Just upstream of the confluence with Santa Rosa Creek, the gradient of East Fork sharply increases. In addition, the confluence of East Fork was observed dry during fish sampling activities from 1994-2006. It is estimated that there may be ¼-mile of spawning habitat on the East Fork as well. In addition, Lehman Creek has perennial flow at its mouth and is accessible to adult steelhead, however local topography suggests Lehman Creek may also have ¼-mile of spawning and rearing habitat.

In contrast, Curti Creek and Taylor Creek, both located in lower reaches of the watershed (Fig. 25), are likely inaccessible to adult steelhead throughout the year due to perched culverts. Additional migration barriers include the concrete ford with laddered culvert at Ferracsi Road between Reaches 0b and 1 in the lower valley. This site is a potential steelhead passage impediment if instream wood collects inside or on the upstream entrance to the culvert during stormflows. Sean Grauel, formerly of the Cambria CSD, Don Alley, and Dave Highland of CDFG have cleared wood that has collected at the culvert multiple times throughout the years. Don Alley, however, has no observations of this culvert being completely impassable to steelhead, and sampling data for juvenile densities upstream of the culvert has indicated that the culvert was passable for the entire period of sampling (1993–2006). Based on fish sampling data, the denil ladder through the Ferrasci Road culvert is, however, a passage barrier to sculpins, except in rare instances.

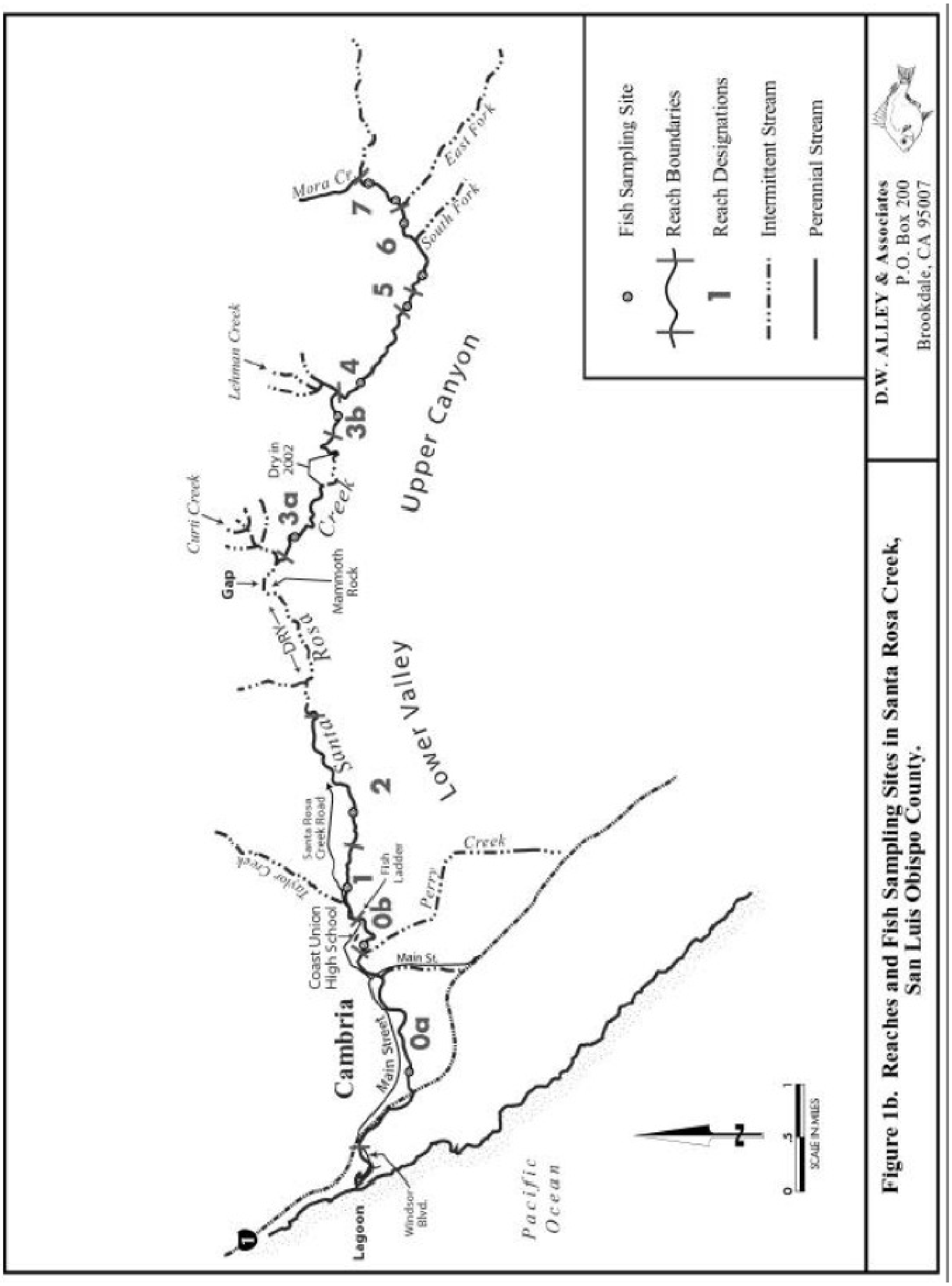
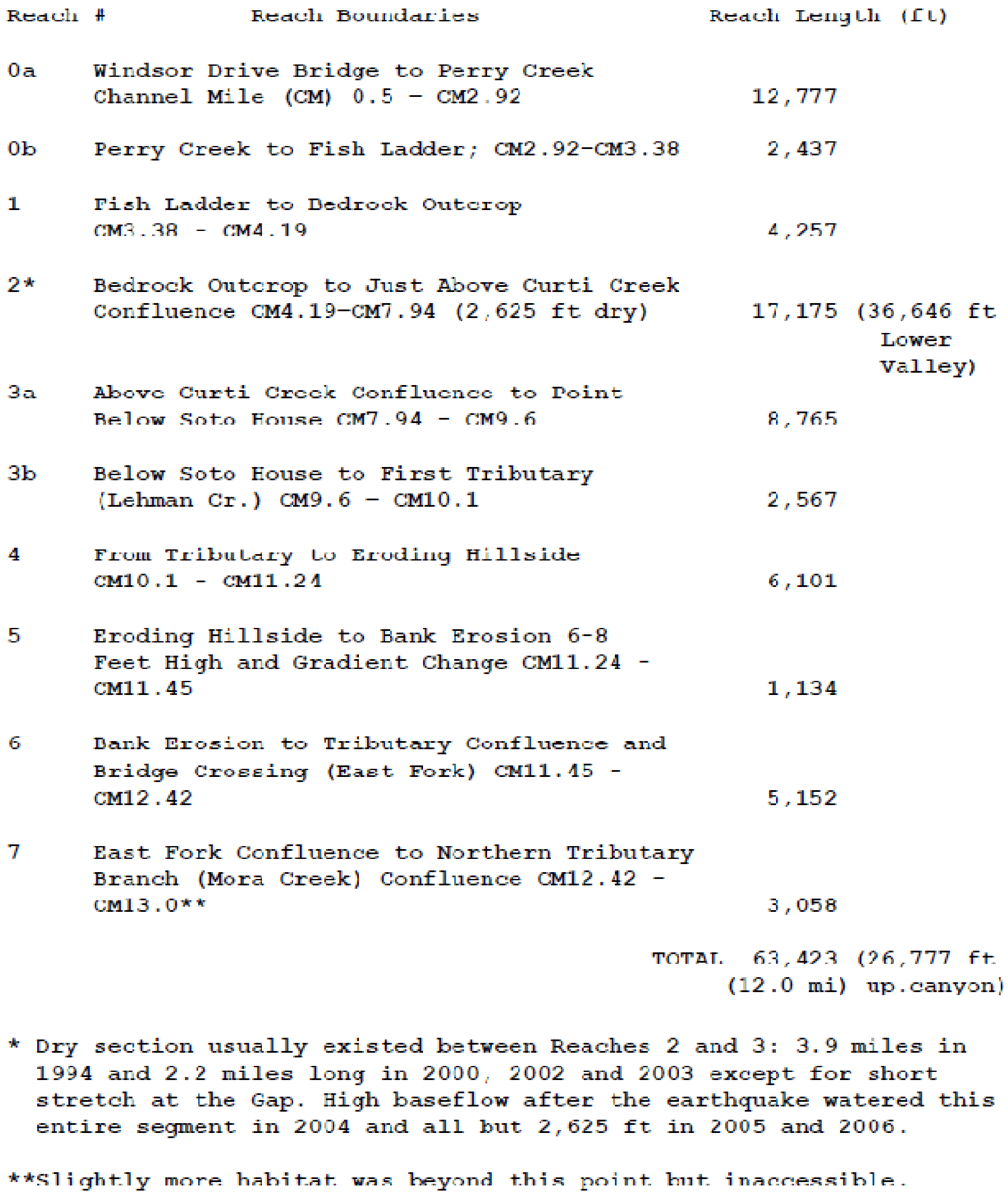


Figure 25. D.W. ALLEY & Associates' map of stream reaches indicating stream nomenclature for tributaries along the Santa Rosa Creek (Appendix L, Fig.1).

Table 8. Santa Rosa Creek mainstem stream reach descriptions and reach lengths, from channel mile 0.5, to Mora Creek, as defined by D.W. Alley & Associates, in Fall 2006 (Appendix L, Table A1).



Reach #	Reach Boundaries	Reach Length (ft)
0a	Windsor Drive Bridge to Perry Creek Channel Mile (CM) 0.5 – CM2.92	12,777
0b	Perry Creek to Fish Ladder; CM2.92-CM3.38	2,437
1	Fish Ladder to Bedrock Outcrop CM3.38 – CM4.19	4,257
2*	Bedrock Outcrop to Just Above Curti Creek Confluence CM4.19-CM7.94 (2,625 ft dry)	17,175 (36,646 ft Lower Valley)
3a	Above Curti Creek Confluence to Point Below Soto House CM7.94 – CM9.6	8,765
3b	Below Soto House to First Tributary (Lehman Cr.) CM9.6 – CM10.1	2,567
4	From Tributary to Eroding Hillside CM10.1 – CM11.24	6,101
5	Eroding Hillside to Bank Erosion 6-8 Feet High and Gradient Change CM11.24 – CM11.45	1,134
6	Bank Erosion to Tributary Confluence and Bridge Crossing (East Fork) CM11.45 – CM12.42	5,152
7	East Fork Confluence to Northern Tributary Branch (Mora Creek) Confluence CM12.42 – CM13.0**	3,058
	TOTAL	63,423 (26,777 ft (12.0 mi) up.canyon)

* Dry section usually existed between Reaches 2 and 3: 3.9 miles in 1994 and 2.2 miles long in 2000, 2002 and 2003 except for short stretch at the Gap. High baseflow after the earthquake watered this entire segment in 2004 and all but 2,625 ft in 2005 and 2006.

**Slightly more habitat was beyond this point but inaccessible.

Benefits of a Properly Functioning Riparian Zone

A properly functioning riparian corridor will reduce limiting factors, such as warm water temperature, excessive stream sedimentation and the shortage of large wood recruitment to the stream channel. There is a growing body of evidence that buffers along streams are necessary to protect aquatic ecosystems from potential disruption and degradation. The purpose of riparian buffer strips is to allow natural interactions between riparian and aquatic systems to be sustained so that appropriate instream ecosystems, sediment regimes and channel forms can be maintained. Reid and Hilton (1998) enumerated specific roles of riparian zones in relation to the instream environment as follows:

- Maintenance of the aquatic food web through provision of leaves, branches and insects.
- Maintenance of appropriate levels of predation and competition through support of appropriate riparian ecosystems.
- Maintenance of water quality through filtering of sediment, chemicals and nutrients from upslope sources.
- Maintenance of an appropriate water temperature regime through provision of shade and regulation of air temperature and humidity.
- Maintenance of bank stability through provision of root cohesion on banks and floodplains.
- Maintenance of channel form and instream habitat through provision of wood and restriction of sediment input.
- Moderation of downstream flood peaks through temporary upstream storage of water.
- Maintenance of downstream channel form and instream habitat through maintenance of an appropriate sediment regime.

According to Reid and Hilton (1998), riparian zones are important to adjacent instream ecosystems because they strongly control the availability of food, distribution of predators, form of channels, and distribution of temperatures (Murphy and Hall, 1981; Naiman and Sedell, 1979; Theurer et al., 1985; Zimmerman et al., 1967). Riparian buffer strips have become a widely accepted way to help protect aquatic ecosystems and water quality from the effects of upslope activities. According to Reid and Hilton (1998), the Forest Ecosystem Management Assessment Team (FEMAT) recommended the establishment of riparian reserves to help sustain the proper functioning of processes that influence habitat, and thus to provide for habitat requirements for coho salmon and aquatic species. Because steelhead habitat requirements are similar to those of coho salmon, riparian reserves would offer them the same protection.

NOAA’s National Marine Fisheries Service (NOAA Fisheries Service) considers riparian habitat to be critical habitat for the federally threatened steelhead. Removal of riparian canopy over a stream is considered an adverse modification and is subject to review by the NOAA Fisheries Service under the Endangered Species Act for projects requiring Army Corps 404 permits for modifications to stream channels. NOAA Fisheries Service typically recommends in short-term Habitat Conservation Plans that an Aquatic Protection Zone (APZ) be established from the outer edge of the bankfull channel, to a distance horizontally equivalent to the potential tree height on Class I and II watercourses in order “to protect the functions and processes of the riparian zone.

Santa Rosa Creek Habitat Characteristics

Classifying Habitat Types and Measuring Habitat Characteristics

In 1994, all watered steelhead habitat in the mainstem of Santa Rosa Creek [upstream of the fish ladder on Santa Rosa Creek at the Ferrasci Road crossing at channel mile (CM) 3.38 was surveyed and habitat typed. In Santa Rosa Creek, the surveyed habitat began at CM3.38 and ended at the Mora Creek confluence at CM13.0. The reach downstream of the fish ladder was not included because much of it was dry. The habitat proportions and stream lengths with surface flow found in 1994 were used in subsequent estimations of juvenile steelhead production through 1997. In 1998, habitat typing was repeated to update habitat conditions and obtain accurate habitat proportions after the two wet winters since 1994. Reaches 0a, 0b and 3a were added in 1998 because these parts of the watershed had newly occurring perennial surface flow due to the higher base flow. Table 8, pg. 90 shows stream reach nomenclature and channel mile markers along Santa Rosa Creek, as used by D.W. ALLEY and Associates during habitat typing.

Habitat parameters were measured at four-year intervals at a reach level beginning in 1994. The proportion of habitat types was determined for each stream reach. Habitat types were classified according to the categories outlined in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al., 1998). Survey sheets provided in the manual were used during stream surveys. In 1994, some habitat characteristics were estimated according to the manual's guidelines, including length, width, mean depth, maximum depth, shelter rating, substrate composition, and tree canopy.

Limiting Factors Affecting the Steelhead Population in Santa Rosa Creek

Several factors appear to limit distribution, survival, and growth rate of juvenile steelhead. These factors include passage impediments such as shallow riffles, spawning habitat quality (proportion of fine sediment), spring and summer base flow, amount of escape cover (provided by instream wood, undercut banks, un-embedded boulders, water depth itself), water temperature and habitat depth. The habitat typing information collected in 2002 and 2006 indicate that each reach of Santa Rosa Creek had an ample diversity of habitat types. Therefore, availability of habitat types necessary for all life stages was not considered a limiting factor for steelhead (Alley, D.W., 2007a). For this assessment the limiting factors have been identified for the Santa Rosa Creek mainstem and lagoon (Table 9).

Table 9. Limiting factors to steelhead in the Santa Rosa Creek mainstem and lagoon (Appendix L, Table 5).

Location	Sediment-Spawning	Sediment-Rearing	Adult Passage Impediments	Spring and Summer Stream flow	Summer Water Temperature	Large Woody Material
Lagoon	**No**	**Yes**	**Yes- Drier Years**	**Yes**	**Yes**	**Yes**
Mainstem-Lower Valley	**Yes**	**Yes**	**Yes- Drier Years**	**Yes**	**Yes**	**Yes**
Mainstem – Upper Canyon	**Yes**	**Yes**	**Yes- Drier Years**	**Yes**	**Yes- Short periods**	**Yes**

Stream Flow for Rearing of Juvenile Steelhead

Stream flow, as a limiting factor, is the primary element that defines total available habitat for salmonids. It is a limiting factor affecting the migratory success of adults reaching spawning habitat and smolts reaching the ocean. Stream flow determines the ability of the stream to move sediment and the force to scour pools and spawning beds, thus affecting habitat quality and microhabitat features. These microhabitat features include habitat width, water depth, water velocity, surface turbulence (affects the amount of cover), rate of insect drift as food for drift-feeding salmonids and, to some degree, water temperature and oxygen concentration. Stream flow plays an important role in the balance between food availability and growth for steelhead. The quantity of stream flow not only dictates the amount of habitat available to fish and aquatic insects (juvenile steelhead's preferred food) but also acts as a "conveyor belt" for delivery of food to feeding steelhead. The more stream flow that is available in spring and summer, the more food that is available to be delivered to the fish. As summer flows recede and less habitat becomes available to fish and aquatic insects, the conveyor belt of food slows down. Water temperatures also rise as flows recede in the summer months, causing higher metabolic rates for fish and increased food requirements.

The result of interactions between stream flow, habitat availability, and the conveyor belt of food is higher growth rates for fish in the spring months and maintenance or reductions in fish size in the summer and fall months. The size of smolts reaching the ocean plays an important role in their survival in the ocean and the probability of them returning as adults. Larger smolts tend to have higher survival rates in the ocean because they are faster and can avoid predators more easily than smaller smolts. Also, mortality rates are reduced for YOY fish that smolt after one growing season, as compared to those fish that over-winter once twice in freshwater.

In addition to requiring adequate food for growth, juvenile steelhead have specific habitats that are essential for their survival including fastwater feeding areas and escape cover locations. Salmonids feed on drifting insects that have either dropped into the water from streamside vegetation or have been produced in riffles and runs as larvae. Generally, the faster the water velocity, the more insect drift along this “conveyor belt” that may be fed upon. Juvenile densities become reduced if fastwater areas become too shallow due to reduced stream flow or sedimentation that has filled in deeper water. Escape cover provides locations for steelhead to hide from predators and find refuge from high winter flows. Escape cover can include deep pools, undercut banks, side channels, large un-embedded cobbles and boulders, rootwads, large wood, and overhanging vegetation. Streams that lack adequate escape cover may have low fish densities, regardless of the amount of food available.

With seasonal rainfall, stream flow is often a scarce resource for human systems where there are water demands for municipal, agricultural, and industrial uses, as well as fire protection and recreation. Human demands for water compete with the need to maintain stream flow for biological systems. Human water demands also peak during summer and early fall when streams are experiencing their lowest flows of the year. Due to the low summer stream flow in most Central Coast streams, stream flow is a limiting factor for steelhead production even when not impacted by human uses. When water extractions are added, stream flow becomes a more severe limiting factor. Seasonal rainfall amounts in Santa Rosa Creek, from 1986-2007 are shown (Fig. 26).

In Santa Rosa Creek, the seasonal water supply and demand have resulted in the need for groundwater pumping. According to Yates and Van Konyenburg (1998), the water supply for the Cambria area is vulnerable to drought because the groundwater basins of San Simeon and Santa Rosa creeks provide the only supply of water during the dry season and because groundwater storage capacity is small relative to the demand for water. The amount of usable groundwater storage capacity above sea level is about 3,800 acre-ft in the Santa Rosa Basin. Total annual pumpage during 1988-89 was about 30 percent of the storage capacity of the basin (Yates and Van Konyenburg, 1998). The average groundwater withdrawals from the Santa Rosa and San Simeon Creek aquifers was an average 729 acre-feet a year from 1988 to 2002. During that time, the Santa Rosa Creek aquifer provided an average 86 acre-feet of groundwater a year (Cambria Community Services District, 2008 and 2010). From 2003-2009, Santa Rosa and San Simeon Creek aquifer groundwater withdrawals increased slightly to an average 744 acre-feet of groundwater a year, with an average 141 acre-feet of groundwater from the Santa Rosa Creek aquifer. From 1988-2009, groundwater withdrawals from the Santa Rosa Creek aquifer have ranged from 254 acre-feet (1988) to zero (2000), with an average of 164 acre-feet in the past four years (Cambria Community Services District, 2010). Water storage in the aquifers at the beginning of the dry season is similar each year, but the length of the dry season varies. If the dry season were exceptionally long and pumping continued undiminished, wells could go dry or subsidence or seawater intrusion could occur before recharge begins the following winter. Land subsidence and ground deformation occurred in Cambria in the summer of 1976 could occur again if the minimum dry-season water level is close to or less than the record low level reached that year (Yates and Van Konyenburg, 1998). Partly for these reasons, there are legal limitations on annual and seasonal quantities of municipal pumping for the basin.

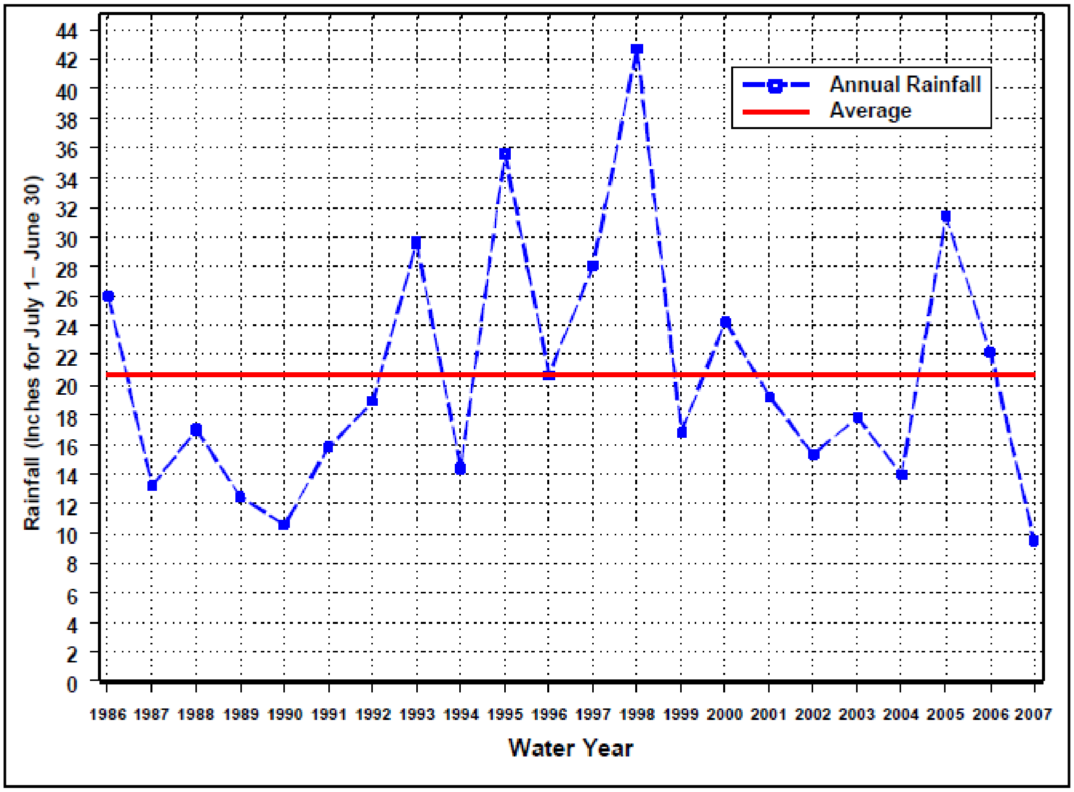


Figure 26. Rainfall amounts in Santa Rosa Creek, from July 1986-June 2007 (Appendix L, Fig. 6).

The impact of water extraction on fish populations depends on timing, magnitude, and location of the surface diversion/well. The timing of water extraction is important in determining which salmonid life stage is impacted. The magnitude is important in terms of amount being extracted and what remains for bypass.

In looking at stream flow measurements down the mainstem through the various reaches in fall of multiple years, the stream flow appears to increase from Reach 6 down to Reach 3b (except in 2004 after the 2003 earthquake) (Fig. 27). The stream loses flow from Reach 3b to 3a (except in 1999 after two storms). Prior to the earthquake, there was an approximate two-mile stretch of dry stream channel in upper Reach 2. In 2004, this normally dry stream segment had flow. In 2005 it had approximately 0.5 miles of dry streambed. In 1998, the stream gained stream flow from Reach 2 to Reach 1. The stream flow increased from Reach 1 to 0a in 1998, 1999, and 2006. There was a decrease in flow from Reach 1 to 0a in 2001–2005. The large decrease in stream flow from Reach 1 to Reach 0a in 2003 and 2004 indicated that groundwater pumping had a significant impact on surface flow. In October 2007 prior to rainfall, stream flow upstream of the Ferrasci Road ford in lower Reach 1 was visually estimated at 0.5 cfs, and stream flow was absent in upper Reach 0a at the Main Street Bridge and downstream.

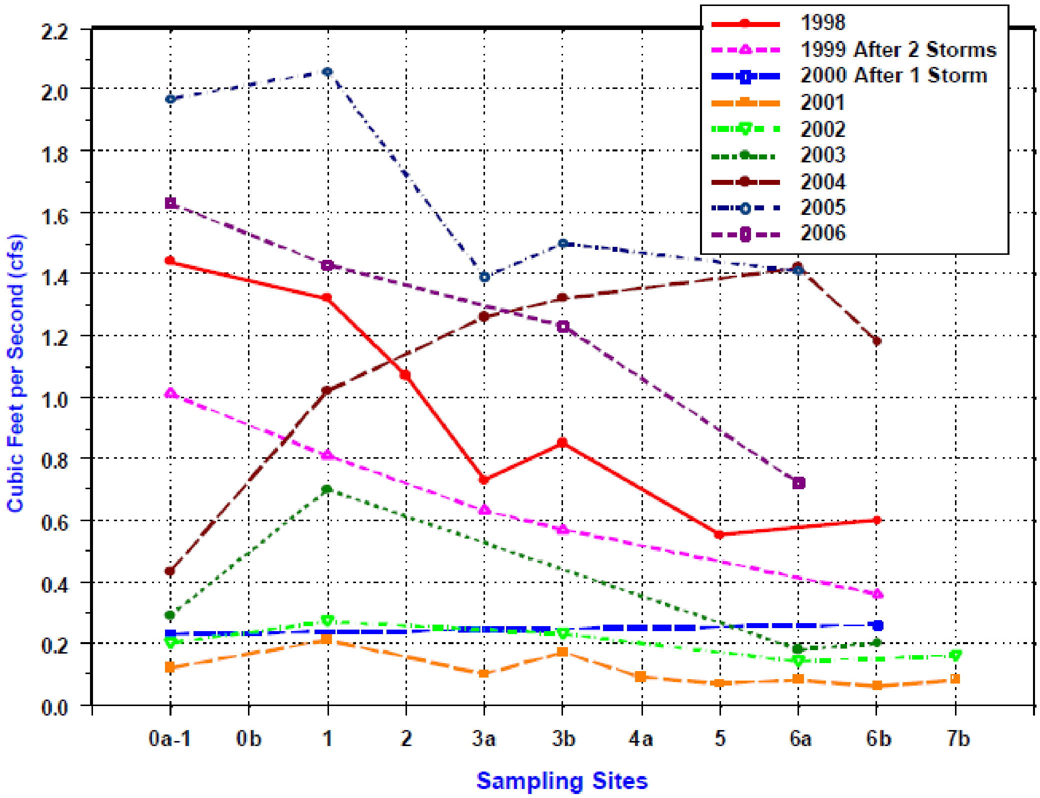


Figure 27. Measured streamflow in fall at sampling sites in Santa Rosa Creek, 1998-2006 (Appendix L, Fig. 17).

Yates and Van Konyenburg (1998) modeled the Santa Rosa Creek groundwater basin for summer 1988 (a drier year), producing a calibration simulation. When agricultural and municipal pumping were included in the model, it was predicted that the stream between the high school (Reach 0b) and the Highway 1 bridge downstream (Reach 0a) was dry from July through mid-December. Without agricultural pumping, but with municipal pumping retained in the model for 1988, the simulation predicted that a trickle of base flow emerged near well 27S/9E-19H2 and flowed continuously in all months except October when a short reach near well 27S/8E-27H1 (near Highway 1) went dry. Between 1998 and 2007, surface flows continued year round through Reaches 0a and 0b, when the stream channel went dry.

Water diversion locations are important in understanding the cumulative effect of multiple diversions on downstream habitat conditions and population numbers. In a very dry year, well pumping may reduce stream flow enough to dry up most of Reach 0a except a few isolated pools, and may reduce the lagoon to small, stagnant, warm pools, eliminating all viable steelhead habitat and nearly all tidewater goby habitat. This dewatering occurred in 2007 and was likely hastened and increased by well pumping. Though stream inflow continued through the dry season, in 2003 and 2004, the lower lagoon went dry at Stations 1 and 2 with only the upper lagoon between Shamel Park and Windsor Bridge providing habitat. The lower lagoon had become more sedimented in 2003, making it more prone to dewatering in both years. The tidewater goby population was very low in fall 2003 and not detected in either the fall or summer of 2004, or the fall of 2005. Tidewater goby were next detected in fall 2006 and early summer 2007. The loss of lagoon habitat in 2003 and 2004 was likely caused by well pumping. The dewatering of the lagoon in 2007, except for two small pools at Stations 1 and 2, was likely hastened by, and was at least partially caused by, well pumping.

Water diversion, particularly in drier springs, may hasten the timing of sandbar closure at the creek mouth. The sandbar at the mouth of Santa Rosa Creek closes each year in the spring to early summer, when stream outflow is insufficient to maintain a channel through the beach. The minimum stream flow to maintain an open channel varies with the year, with records of the sandbar closing at stream flows of between approximately two and 12 cfs. It typically closes at stream flows of less than approximately seven cfs. Steelhead smolts and spawned kelts are out-migrating to the ocean in the spring. If the sandbar closes too early, smolts and kelts are trapped in the lagoon which in most years does not provide adequate habitat for survival until the next rainy season. Years in which many trapped smolts and kelts were observed in the lagoon were 1994, 1997, 2002, 2007 and 2008.

Stream flow for Adult, Kelt and Smolt Passage

As mentioned in the life history description, most adult steelhead migrate up their natal streams from January through early May. Adult salmonids typically migrate as water flow begins to subside from a storm event. Migration occurs primarily at night, though light is required to negotiate obstacles. The likelihood of spawning redds (nests) being scoured or smothered in sediment declines and percent egg survival generally increases in an upstream direction in any watershed. Usually quality of spawning gravel increases upstream, therefore, spawning success is generally highest in the upper reaches of the watershed. A spawning obstacle may be a partial impediment that is passable if the fish reaches it at a time when stream flow is high enough to allow passage but not too high to create a velocity barrier. Fish may congregate below impediments until storm flows are right, increasing their risk to predation and angling and delaying their egg laying. When adult salmonids are impeded or entirely blocked by obstacles to upper stream reaches, the number of YOY fish annually produced may be significantly curtailed. The most successful way to increase the juvenile salmonid population is often by improving passage over obstacles when significant spawning and rearing habitat exists upstream.

Since passage over many riffles in the mainstem is flow dependent, steelhead are more vulnerable to shallow passage conditions in drier years. If winter storms are delayed or drought conditions exist, flows may be inadequate to allow adult steelhead migration over certain critically wide riffles. Judging by the pattern of higher YOY production in the lower valley in drier years and higher YOY production in wetter years (see previous section on juvenile densities), shallow riffles impede adult passage into the upper canyon in some years. The opening and closing of the sandbar at the creek mouth determines the spawning period during the wet season. If storms are delayed, the sandbar remains closed longer. If storms come early and are largely absent in the spring, then the sandbar closes early, thus preventing adults from entering the creek afterwards and stranding kelts trying to return to the ocean after spawning.

Smolt out-migration by steelhead generally occurs from March through May. The primary limiting factor for smolt out-migration from Santa Rosa Creek is the early closure of the sandbar at the mouth before the migration is complete. Early sandbar closure occurs when spring stormflows are limited and low stream flow into the estuary allows closure. If smolts and kelts are stranded in the lagoon due to early sandbar closure (in a dry year), they will most likely not survive the summer because much of the lagoon will either dry up or become hypoxic making survival difficult. Another limiting factor could be the dewatering of the stream channel that creates very shallow riffles or dry sections, which would be physical barriers to migration to the lagoon. In addition, from March through May complete dewatering of the channel could occur under drought conditions with heavy well pumping.

Temperature

In Santa Rosa Creek, as in other Central Coast streams, water temperature impacts food supply. In the lower valley, water temperature is probably not directly lethal except in the lagoon. But higher temperatures increase food demands and restrict steelhead to feed in faster habitats, such as riffles where food production is greater, especially above 21ºC (70ºC) (Smith and Li, 1983). The lethal level for steelhead is believed to be at temperatures above 24–28ºC (75-82ºF) for several hours during the day, depending on their acclimation temperature (Charlon, 1970; Alabaster, 1962; MacAfee, 1966). There are many Central Coast examples of steelhead surviving and growing well at water temperatures above 21ºC. Smith and Li (1983) found juvenile steelhead selecting fastwater habitat at temperatures of 16–21ºC in Uvas Creek, tributary to the Pajaro River. Many examples of steelhead using warm water habitat above 21ºC come from coastal lagoons such as Soquel Lagoon (Alley, 2008c) and Pescadero Lagoon (as high as 26ºC and 24ºC on a regular basis) (Smith, 1990) and lower reaches of less shaded drainages, such as the lower valley of Santa Rosa Creek (Alley, 2007), lower San Luis Obispo Creek (Alley, 2008a), lower Soquel Creek (Alley, 2008b) the lower San Lorenzo River (Alley, 2008c), but only where food is abundant. When food is abundant, growth is actually better at warmer water temperatures because digestive rate is increased, allowing fish to consume and process more food and grow more quickly.

Water temperature is partially controlled by air temperature and stream shading. Stream shading is affected by topography (canyon versus valley), sun angle (daily and seasonal), stream orientation (east-west or north-south), stream flow (less water heats up quicker than more water), tree canopy (over the stream and on surrounding slopes), tree species (deciduous or evergreen, broadleaf or needle leaf) and seasonality of leaf production and leaf-drop by deciduous riparian trees. The volume of stream flow determines the amount of heat from solar radiation and air contact that is required to increase water temperature. The more flow, the slower the increase in daily temperature and the lower the maximum daily temperature for any given amount of sunlight and shading. Creeks will warm up faster in unshaded reaches on a hot summer day during a drought compared to a creek in summer after a wetter winter, given the same amount of shading and air temperature.

Fishes are poikilotherms, meaning their body temperatures conform to the temperature of the water they inhabit. As water temperature increases, fishes' bodies warm up, chemical reactions (metabolism) go faster inside their bodies, their ability for activity increases to a point, they consume more oxygen and they must consume more food to support higher metabolic rates. But the higher water temperatures that occur in the lower valley of Santa Rosa Creek and lagoon speed up primary (plant life) and secondary (aquatic insects) productivity that result in more food available to fish. Juvenile steelhead can digest food faster at warmer temperatures, allowing them to process more food and grow faster to reach smolt size the first year.

Sub-lethal effects of high temperatures on salmonids include increased metabolic rates and decreased scope for activity, decreased food utilization and growth rates, reduced resistance to disease and parasites, increased sensitivity to some toxic materials, interference with migration, reduced ability to compete with more temperature resistant species, and reduced ability to avoid predation.

Sediment

Input of fine sediment to a stream channel degrades salmonid spawning and rearing habitat. Adult steelhead bury their eggs in streambed gravels in nests (redds) in winter and spring. The eggs incubate for weeks before fry emerge as much as two months after the eggs were spawned. Excessive fine sediment in the absence of coarse gravel fills the interstitial spaces and prevents water from moving through the gravel to provide adequate oxygen to the eggs and sac-fry, or alevins. As percent fine material increases, egg survival declines. Also, with spawning areas dominated by fine material, scour of redds by later storms is highly likely. Water depth and hiding places (under wood, boulders, undercut banks) are important for juvenile salmonids to avoid predators. High sediment inputs degrade rearing habitat because it shallows pools and embeds (buries with fine sediment) larger cobbles and boulders, reducing escape cover. Suspended sediment also creates high turbidity that prevents juvenile salmonids from efficiently feeding on drifting insects, thus reducing growth rate.

The Santa Rosa Creek drainage is subject to episodically high inputs of fine sediment during large flood events, such as occurred on March 10, 1995. During this event sediment entered the stream primarily from streambank erosion and landslides. Wide riffles are typically created during large flood events where sedimentation deposits soil into the stream channel. These wide riffles become critically shallow passage areas for migrating adult steelhead. Therefore, sedimentation can decrease water depths, increasing the minimum stream flow required for successful migrational passage of steelhead adults and juvenile smolts. (D.W. ALLEY & Associates performed a steelhead passage study in Reach 0a in lower Santa Rosa Creek in 1993 (Alley, 1993b). Refer to the summary of results in the adult passage section in Appendix L.)

When embededdness of cobbles and boulders in the streambed is greater than 25 percent, it limits the escape cover available under larger substrate. Cobbles greater than 250 mm (10 inches) in diameter that could provide escape cover were only found in the upper canyon reaches of Santa Rosa Creek. Embeddedness in upper canyon step-runs and runs was 35 percent or greater while embeddedness in upper canyon pools was 50 percent or greater in 2006. Therefore, embeddedness is a limiting factor for steelhead in Santa Rosa Creek. Figures 28-31 show percent fines and embeddedness in step-run, run, and pool habitat in Santa Rosa Creek in 2006.

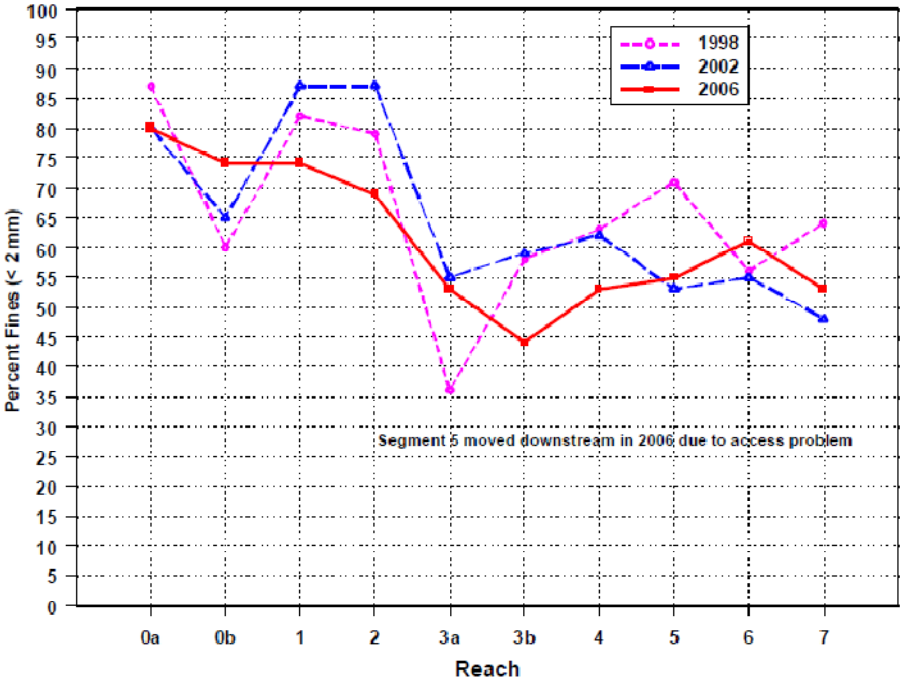


Figure 28. Percent fines in pools in reaches of Santa Rosa Creek at four-year intervals, from 1998-2006 (Appendix L, Fig. 19).

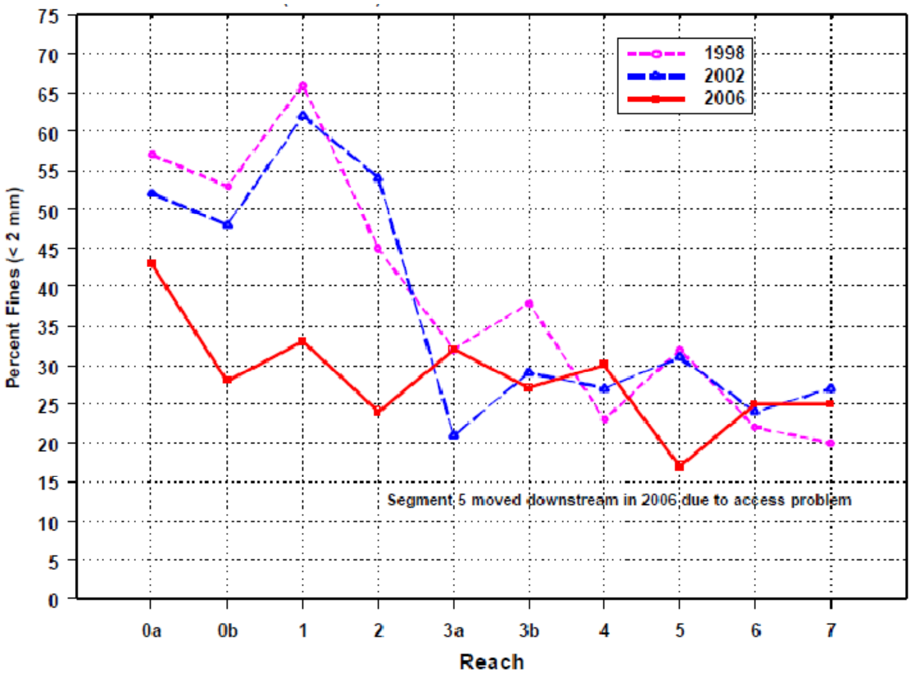


Figure 29. Percent fines in step-runs and runs in reaches of Santa Rosa Creek, at four-year intervals, from 1998-2006 (Appendix L, Fig. 20).

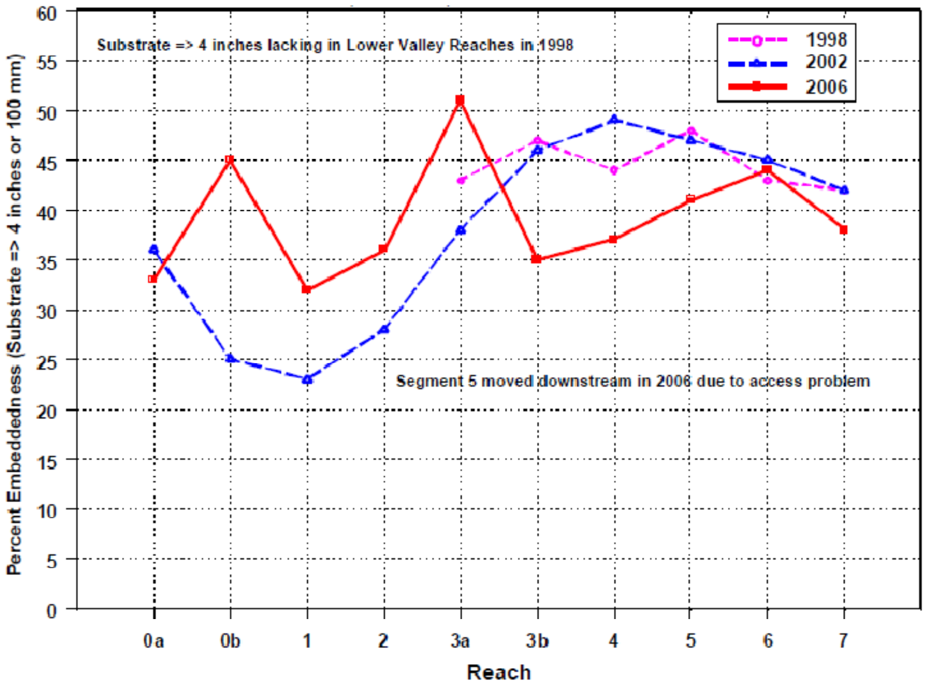


Figure 30. Substrate embeddedness in step-runs and runs in reaches of Santa Rosa Creek, at four-year intervals, from 1998-2006 (Appendix L, Fig. 21).

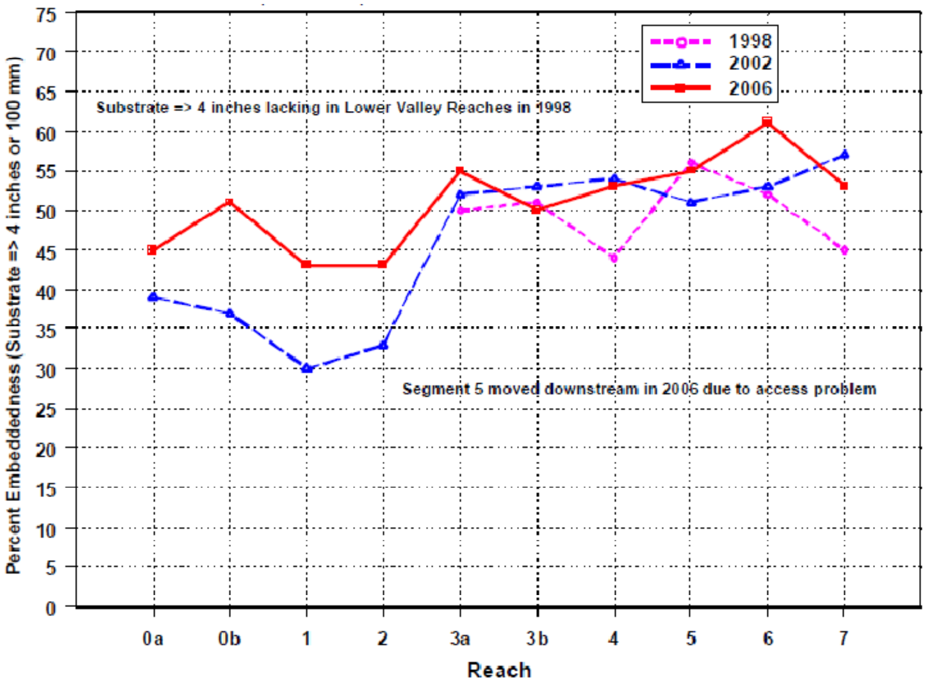


Figure 31. Substrate embeddedness in pools in reaches of Santa Rosa Creek, at four-year intervals, from 1998-2006 (Appendix L, Fig. 22).

Stream sedimentation from erosion has destroyed spawning and rearing habitat in Santa Rosa Creek. Figures 32 and 33 show the relationships between particle size and survival of embryos in the spawning redd and between percent sand in the spawning redd and fry emergence survival. Survival of both life stages is increased with larger particle size and less sand. Sediment also fills pools and buries objects of cover. Juvenile steelhead do best where deep pools exist that possess overhanging tree branches, boulders and large wood for them to hide under.

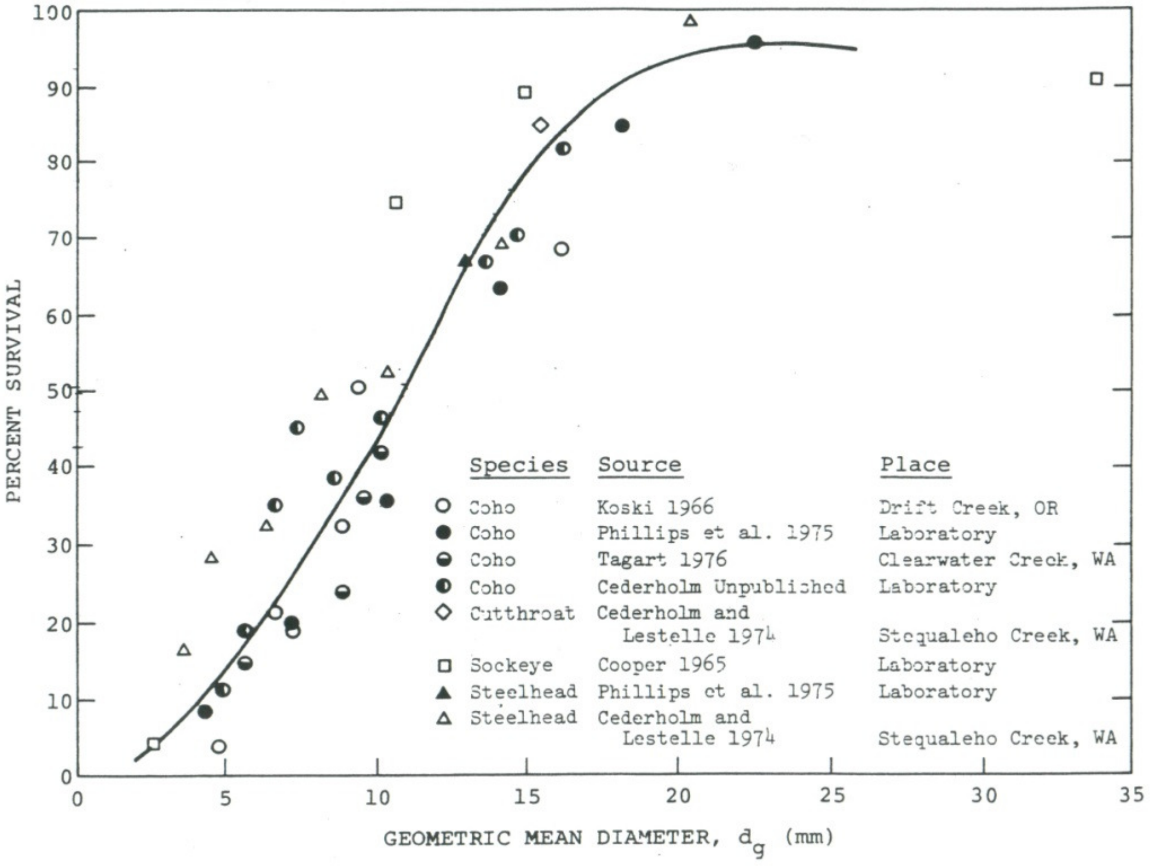


Figure 2. Relationship between percent embryo survival and geometric mean diameter of the spawning substrate (from Shirazi et al. 1981). From Bratovich and Kelley, 1988.

Figure 32. Relationship between percent embryo survival and geometric mean diameter of the spawning substrate (from Shirazi et al. 1981) (Appendix L, Fig. 23).

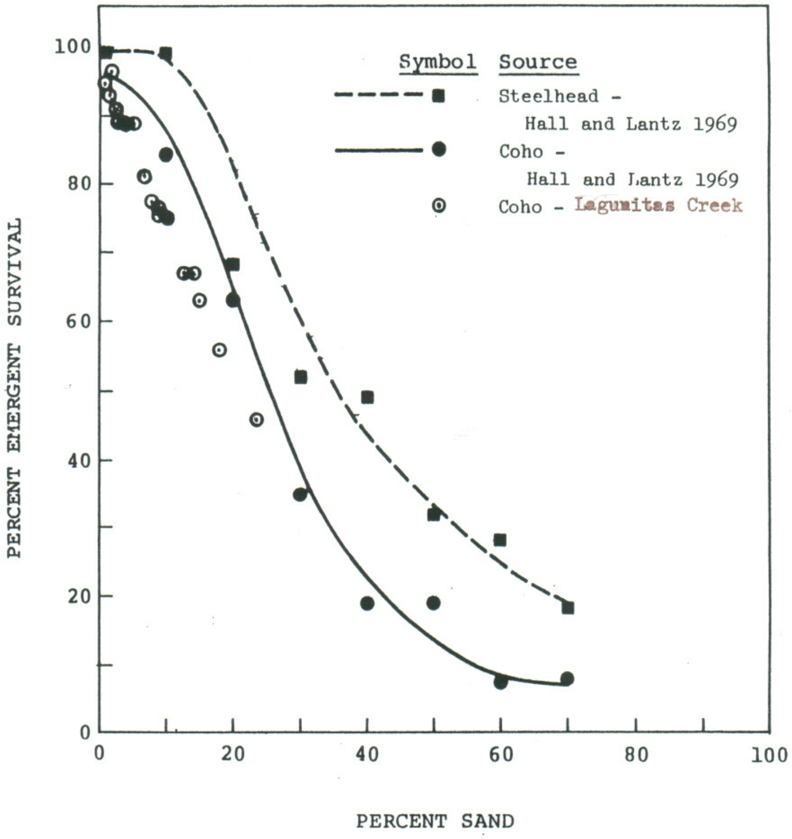


Figure 3. Relationship between average percent fry emergence survival and percentage of 1-3 mm sand (adapted from Hall and Lantz 1969). Values for this study were estimated from the relationship developed by Phillips et al. (1975) and were based upon the percentage of all materials less than 3 mm diameter in the mounds of 17 coho salmon redds in Lagunitas Creek, 1983/84. Presented in Bratovich and Kelley, 1988.

Figure 33. Relationship between average percent fry emergence survival and percentage of 1-3 mm sand (adapted from Hall and Lantz, 1969) (Appendix L, Fig. 24).

Instream Wood

Large instream wood (previously called large woody debris- LWD) in the active channel is important for providing structure necessary for development of pools and backwaters, which are vital summer and overwintering habitat for juvenile steelhead (Smith, 2000). It also serves important habitat functions for other species, such as California red-legged frog. Large wood (1-foot in diameter and 20 feet or more in length) and smaller wood that accumulate in pools are extremely important sources of escape cover for juvenile salmonids. The highest quality large wood includes downed trees or logs with their rootwads attached, whose lengths are about 1.5 times the bankfull width of the channel, or more, and positioned with a sufficient proportion of their lengths on the streambank, or otherwise well-anchored. This positioning of large wood provides stability during high flows as well as scour of the channel bed. The quality of pools formed by large instream wood can vary considerably with the size (length, diameter), type of wood (single or multiple trunks or rootwads) and its position within the channel. Complex pools formed from large logs or rootwads, which extend out into the channel, can provide a variety of water velocities in summer and excellent escape cover. These complex pools are the preferred summer habitat for yearling-sized steelhead. Wood clusters also provide extremely important summer foraging habitat for California red-legged frogs and western pond turtles (*Clemmys marmorata*).

The backwaters and pockets formed by large, current-obstructing wood can also provide refuges during stormflows, and may provide much of the crucial overwintering habitat necessary to prevent heavy loss of juvenile steelhead in wet winters during high storm flows (Smith, 2000). These winter backwater areas may actually be stagnant, shallow or even dry in summer. However, backwater areas may provide important habitat for overwintering fish and recently emerged steelhead fry in spring. They may also provide important reproductive habitat for amphibians, including newts (*Taricha* spp.), Pacific tree frogs (*Hyla regilla*) and California red-legged frogs.

In contrast, wood clusters can produce impediments or complete barriers to fish movement, but the majority of clusters are not significant impediments (Smith, 2000). In weakly entrenched channels, the stream can usually cut around wood clusters. In sandy channels, scour under the cluster usually provides passage. In addition, during high flows a portion of the wood cluster may float. In steeper, entrenched gravel/cobble channels the wood cluster may plug with coarse sediment, producing a pronounced step (grade control) or falls. Even in those cases, removing only a few key pieces may provide passage around the cluster at regular winter flows. In headwater reaches, these grade control clusters may store significant sediment behind, which may prevent sedimentation downstream and outweigh the passage benefit of rearranging or removing the wood cluster. However, if wood clusters are causing lateral (sideways) scour into streambanks with significant bank erosion or landslides, their modification may be necessary. In some cases, protection of the toe of the eroding bank or slide can be accomplished by rearranging the wood, which maintains fish cover. In other cases, more complicated streambed alteration may be necessary.

Steeper, narrow, entrenched channels have high velocities during floods, resulting in poorer wood retention and less complex configurations of the wood that remains (Smith, 2000). In the Santa Rosa Creek Watershed, alder tree species grow along stream banks, in addition to other species such as oak, Monterey pine, California bay, bigleaf maple, cottonwood, willow, and sycamore, to name a few. Alders provide a more continuous supply of in-channel wood, but they are relatively small and have relatively short-term benefits because of their small size and low durability (Smith, 2000). They break up during flood flows and rot quickly. Other broadleaf trees, including bigleaf maple, cottonwood, sycamore, California bay and oak also have small trunk diameters and short longevity in the stream. In Santa Rosa Creek, alders may create much of the pool habitat in wood-scoured pools and much of the wood clusters. Figure 34 shows the escape cover index values for pool habitats throughout the Santa Rosa Creek Watershed. Escape cover includes features such as wood clusters, undercut banks, bubble curtain (water surface disturbance caused by turbulence), and un-embedded rocks.

Santa Rosa Creek has a history of massive influxes of wood during large flood events, such as the March 1995 flood. This is typical of coastal watersheds where recruitment of wood into the channel may be sporadic and occurs mainly during large flood events. At any one time, the majority of the wood within the channel may provide little or transitory habitat benefit, and individual pieces may shift locations, orientation and clustering. However, the total amount of wood available is important in order to maintain the number of beneficial habitat features. The habitat value of new, naturally recruited wood and much of the old wood can be increased by repositioning it in the channel and flood plain. Since much of the cost of habitat improvements is from transporting wood to the site and into the channel, it makes sense to treat episodic flood-year wood as a “windfall” where nature has done most of the work.

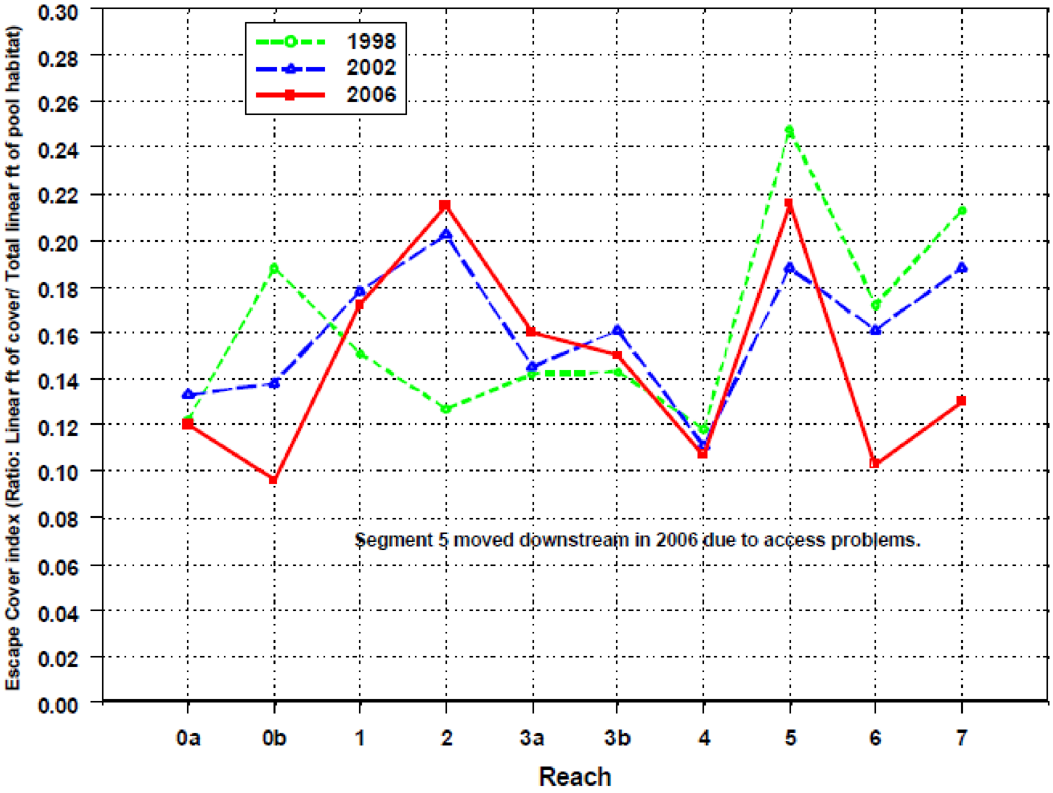


Figure 34. Escape cover index for pool habitat types in habitat typed segments of reaches in Santa Rosa Creek, at four-year intervals, from 1998-2006 (Appendix L, Fig. 18).

Dissolved Oxygen

Oxygen levels are typically lowest at dawn or shortly after, however oxygen levels at these times may be increased if tidal overwash can be minimized or prevented. Water circulation with the air can raise oxygen concentrations and cool water temperature at night. In the lagoon, shading water by maintaining water depth may prevent complete filamentous algae growth throughout the water column. Algal growth prevents water circulation if lagoon inflow is maximized to ideally 0.9 cfs or more. Filamentous algae may be reduced if lagoon shading is increased.

Steelhead Population Assessment

Juvenile steelhead were sampled in the mainstem of the Santa Rosa Creek annually from 1994-2006 by D.W. ALLEY & Associates (with funding from the Cambria Community Services District (CCSD)) using electrofishing techniques. Steelhead habitat was initially evaluated in 1994 (a very low-flow year) in seven reaches (from the fish ladder at the beginning of Reach 1) and in 1998 (a very high-flow year) onward in 10 reaches (from Windsor Boulevard Bridge upstream) (Figures 23 and 25). Electrofishing and habitat data for steelhead were analyzed in annual reports to the CCSD (Alley, 1995a-2007a). Choice of sampling sites was based on their average habitat quality for each reach in terms of the escape cover and water depth in pool habitat. Juvenile steelhead densities from each site were extrapolated to reach densities, with habitat proportioning from habitat-typing during survey work.

Santa Rosa Lagoon was sampled by D.W. ALLEY & Associates in early summer and late fall in 1993–2005, using a fine-meshed beach seine to capture tidewater gobies and occasional steelhead (incidentally). Lagoon monitoring reports were completed every other year for monitored years 1993–2005 (Alley, 1995b–2006b). In most years, one electrofishing site was sampled immediately upstream of the lagoon in early summer at the time of lagoon sampling. Refer to Sub-Appendix A in Appendix L for a more complete description of sampling methods. CCSD staff assisted in lagoon sampling and also collected lagoon water quality and stream inflow data through this period (Sean Grauel). Bailey (1973) and Nelson (1994) previously sampled Santa Rosa Creek. However, their methods and timing of sampling differed significantly from Alley's, so a direct comparison of the data was not possible.

Key Steelhead Density and Population Trends in Santa Rosa Creek

Young of the Year (YOY) densities at sampling sites were generally higher in the upper canyon than the lower valley (individually and on average) except in 2002 (Figs.35, 36, and 37). Two wet years, 1998 and 2005, had the lowest YOY densities in the lower valley. In another wet year, 1995, although YOY densities were not determined, total juvenile densities were low in the lower valley, indicating that YOY densities were also low that year (Fig. 38). In some drier years (1994, 1997 and 2002–2004), YOY densities were relatively higher in the lower valley than other years, and relatively lower in the upper canyon.

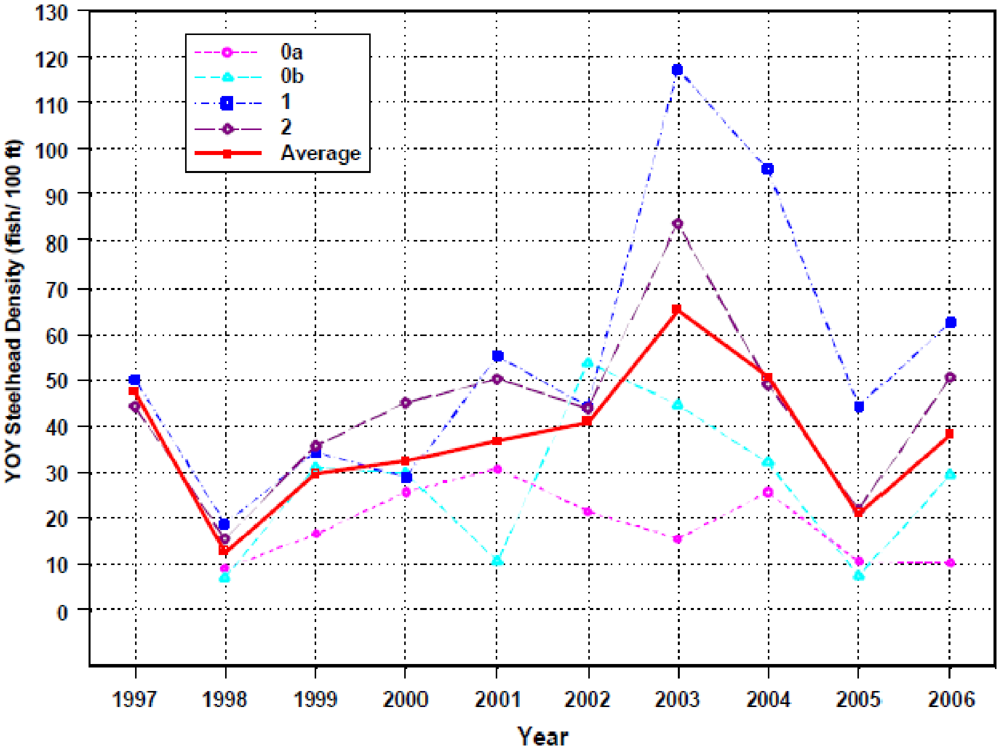


Figure 35. Annual young-of-the-year densities at Lower Valley Santa Rosa Creek sites, from 1997-2006 (Appendix L, Fig. 2).

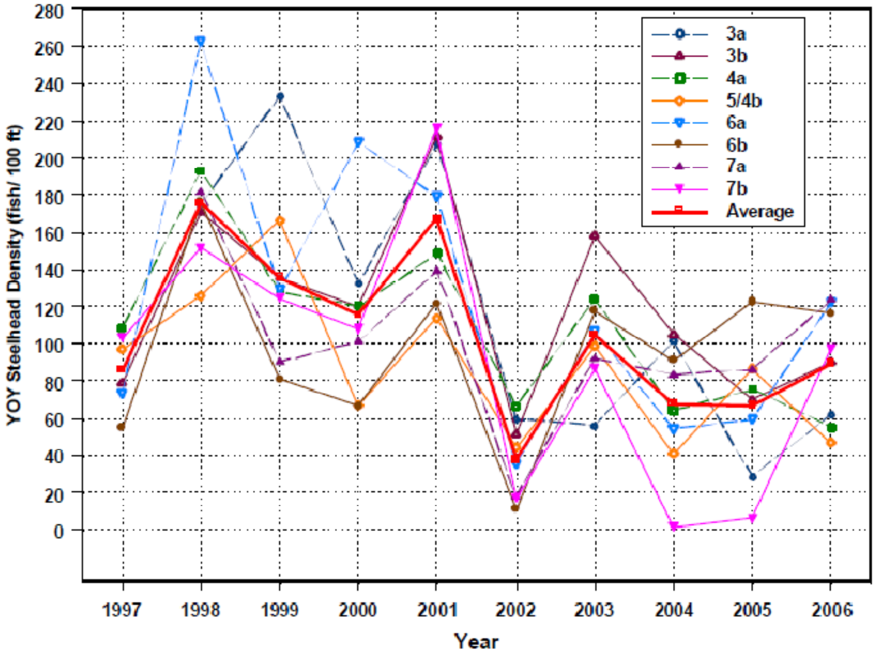


Figure 36. Annual young-of-the-year densities at Upper Canyon Santa Rosa Creek sites, 1997-2006 (Appendix L, Fig. 3).

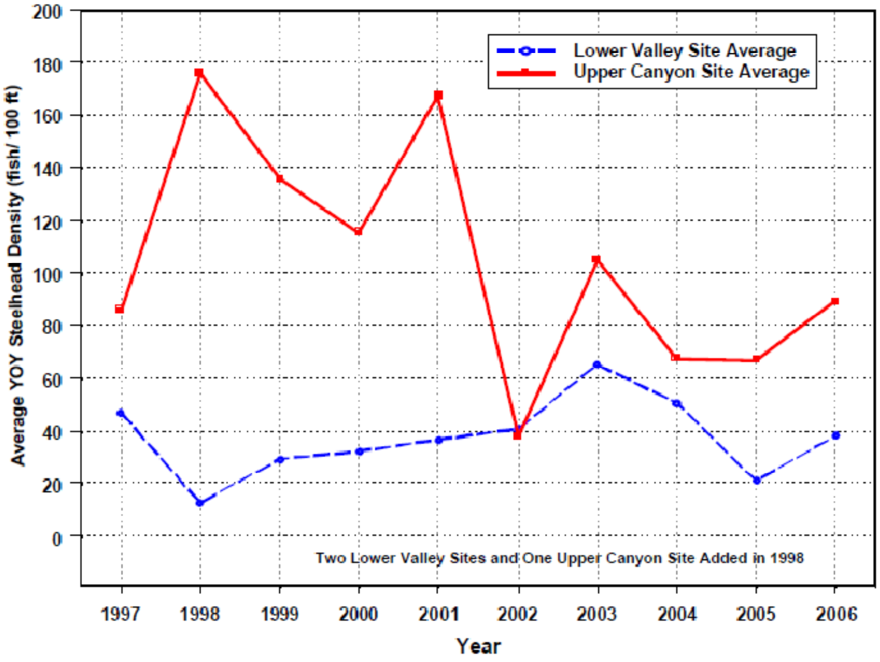


Figure 37. Average site density for young-of-the-year steelhead in the Lower Valley and Upper Canyon of Santa Rosa Creek, 1997-2006 (Appendix L, Fig. 4).

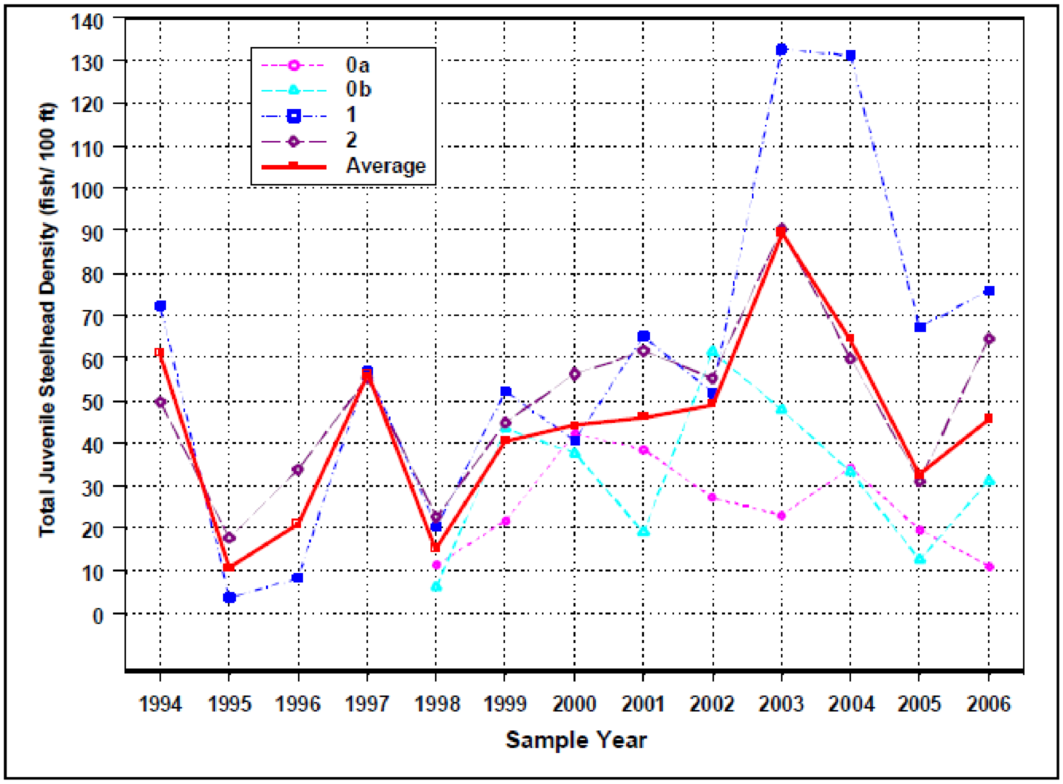


Figure 38. Annual total juvenile densities at Lower Valley Santa Rosa Creek sites, 1994-2006 (Appendix L, Fig. 5).

These patterns indicated that in wetter years, adults had better passage opportunities through the estuary and lower valley to access the upper canyon to spawn more YOY. It also indicated that more habitat was available in the upper canyon in wetter years due to higher stream flow (especially in spring) and presumed greater insect drift and food supply. Whereas in drier years, spawners likely had a narrower window of spawning opportunity due to earlier sandbar closure (Table 10) and shallower passage conditions related to smaller stormflows. This likely caused more spawning effort in the lower valley with less spawning and YOY production in the upper canyon. In drier years, habitat in the upper canyon likely supported fewer fish, with reduced stream flow and reduced insect drift. In 2002, there was very little rain from January-May and the YOY densities in the upper canyon were very low (Fig. 39). That year there was only one storm event in January totaling more than one inch in precipitation. The sandbar closed in mid-April with lagoon inflow likely less than 2.5 cubic feet per second (cfs) most of the time from January until then (Table 10).

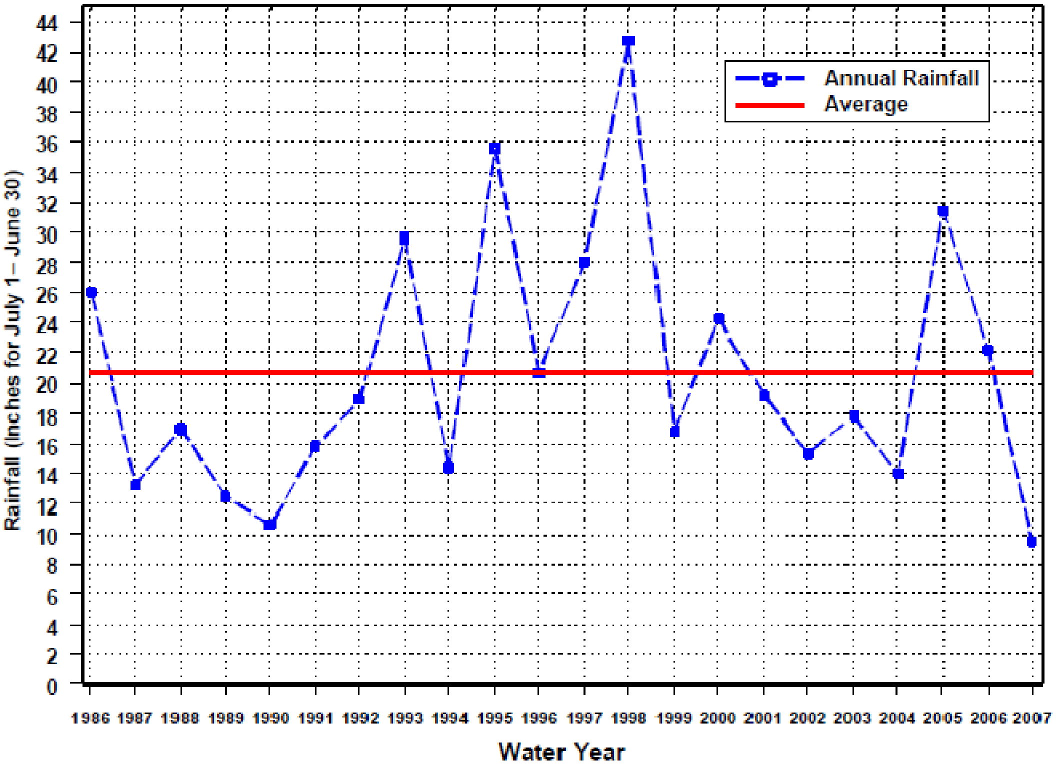
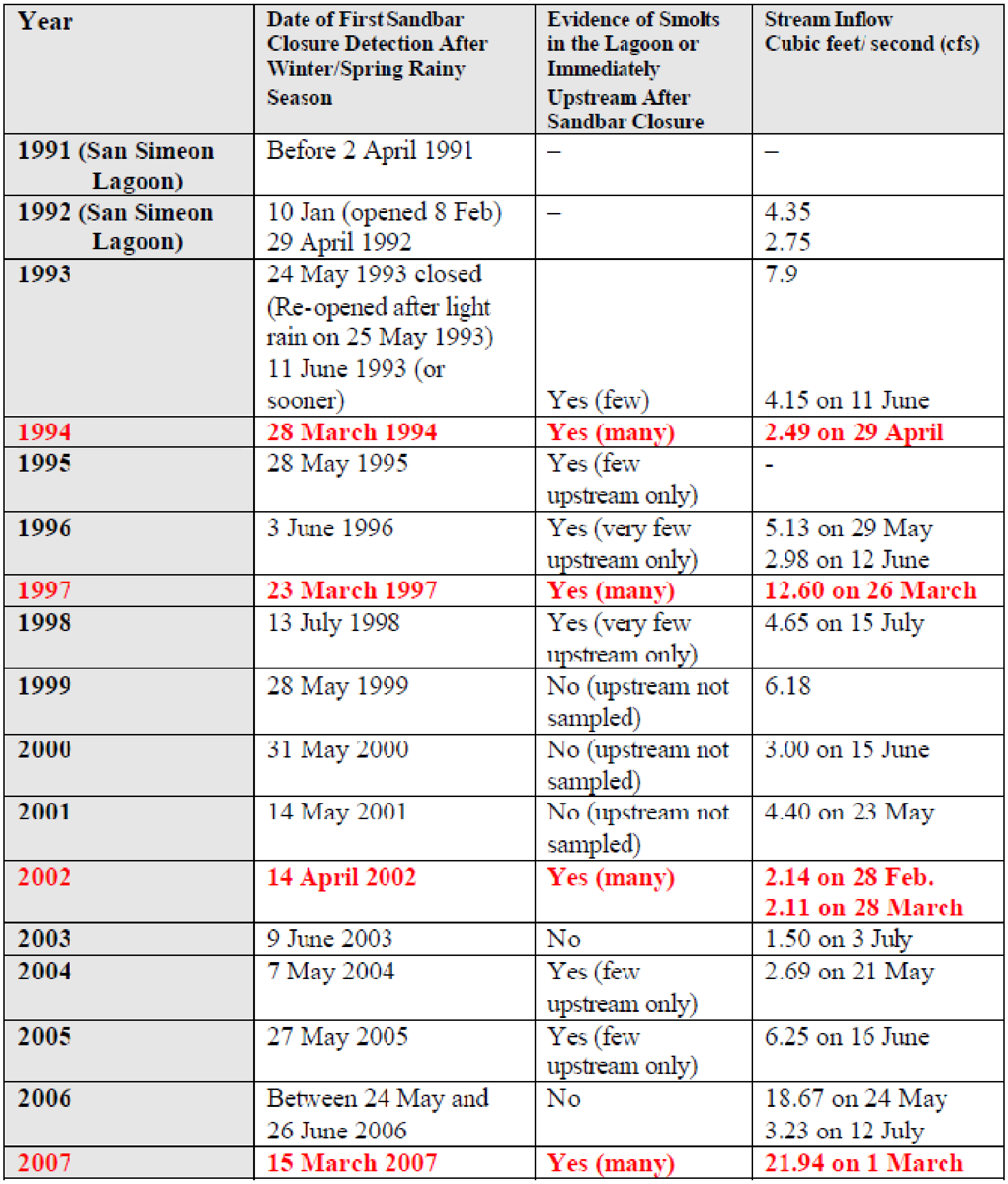


Figure 39. Annual rainfall measured at the Cambria Wastewater Treatment Plant in the Lower Santa Rosa Creek Watershed, 1986-2007 (Appendix L, Fig. 6).

Another significant event which potentially impacted steelhead densities in the Santa Rosa Creek Watershed includes the earthquake of December 2003, with the epicenter located just north near San Simeon, California. This earthquake caused cementing of the streambed and likely poor water quality with heavy seepage of hydrogen sulfide into the stream at Sites 7a and 7b in 2004–2005 (Alley, 2005a; 2006a). This likely contributed to lower YOY and yearling densities than normal there.

Table 10. Historical record of sandbar closure at Santa Rosa Lagoon (1993-2007) and San Simeon Lagoon (1991-92) (Appendix L, Table A13).



Year	Date of First Sandbar Closure Detection After Winter/Spring Rainy Season	Evidence of Smolts in the Lagoon or Immediately Upstream After Sandbar Closure	Stream Inflow Cubic feet/ second (cfs)
1991 (San Simeon Lagoon)	Before 2 April 1991	–	–
1992 (San Simeon Lagoon)	10 Jan (opened 8 Feb) 29 April 1992	–	4.35 2.75
1993	24 May 1993 closed (Re-opened after light rain on 25 May 1993) 11 June 1993 (or sooner)	Yes (few)	7.9 4.15 on 11 June
1994	**28 March 1994**	**Yes (many)**	**2.49 on 29 April**
1995	28 May 1995	Yes (few upstream only)	-
1996	3 June 1996	Yes (very few upstream only)	5.13 on 29 May 2.98 on 12 June
1997	**23 March 1997**	**Yes (many)**	**12.60 on 26 March**
1998	13 July 1998	Yes (very few upstream only)	4.65 on 15 July
1999	28 May 1999	No (upstream not sampled)	6.18
2000	31 May 2000	No (upstream not sampled)	3.00 on 15 June
2001	14 May 2001	No (upstream not sampled)	4.40 on 23 May
2002	**14 April 2002**	**Yes (many)**	**2.14 on 28 Feb.** **2.11 on 28 March**
2003	9 June 2003	No	1.50 on 3 July
2004	7 May 2004	Yes (few upstream only)	2.69 on 21 May
2005	27 May 2005	Yes (few upstream only)	6.25 on 16 June
2006	Between 24 May and 26 June 2006	No	18.67 on 24 May 3.23 on 12 July
2007	**15 March 2007**	**Yes (many)**	**21.94 on 1 March**

Tidewater Goby Ecology

Tidewater goby populations are restricted to coastal, brackish-water habitats in California (Swift et al., 1989). There is no marine phase, although tidewater gobies are periodically flushed out of lagoons during winter stormflows and must find their way back to estuaries. There is evidence that tidewater goby is capable of repopulating adjacent lagoons after being extirpated because they were apparently lost from Santa Rosa Lagoon in 2004 and were again detected in 2006.

Although they tolerate widely varying salinities and oxygen concentration, tidewater goby spawning must occur in freshwater resulting from stream inflow to lagoons, upstream of major tidal fluctuations. Spawning begins mainly in spring (April and May) but continues to a lesser degree into summer and fall. Lagoons should be allowed to seasonally close off from the ocean during the dry season so that tidal fluctuation is absent or minimal. During spawning, males excavate a nest burrow 8–12 inches deep into sandy substrate. Fresh, unconsolidated sand is optimal for burrowing. Females court males and aggressively compete to enter the burrow to mate. Males occupy enlarged areas in the burrow where the eggs hang from the ceiling and walls. Males do not feed during the 9–10 day egg incubation period, and mortality is high for these males after hatching due to starvation, especially with multiple clutches that extend the period with minimal feeding. Older female mortality is high over the winter.

Tidewater gobies are bottom dwelling, and they escape predators by fleeing in long dashes (1–2 m) into deeper water or aquatic vegetation. They are typically abundant in shallow water (<=1 m deep). They feed on bottom invertebrates, such as ostracods, snails, dipteran fly larvae, amphipods and mayfly larvae. When lagoons are especially saline, tidewater gobies are more abundant where stream water enters the lagoon and salinity is reduced. During summer, they avoid areas where algal blooms are thick and hydrogen sulfide builds up in the substrate due to decomposition. Major threats to tidewater goby include 1) groundwater pumping and water diversion that drastically reduce freshwater inflow to lagoons, 2) sandbar breaching in summer after stream flow has declined, 3) dredging to maintain a constant estuary opening, and 4) introduction of non-native predators, such as centrarchids (bass family of fishes), bullfrog, and possibly crayfish.

4.4. LAND USES AND OWNERSHIP PATTERNS

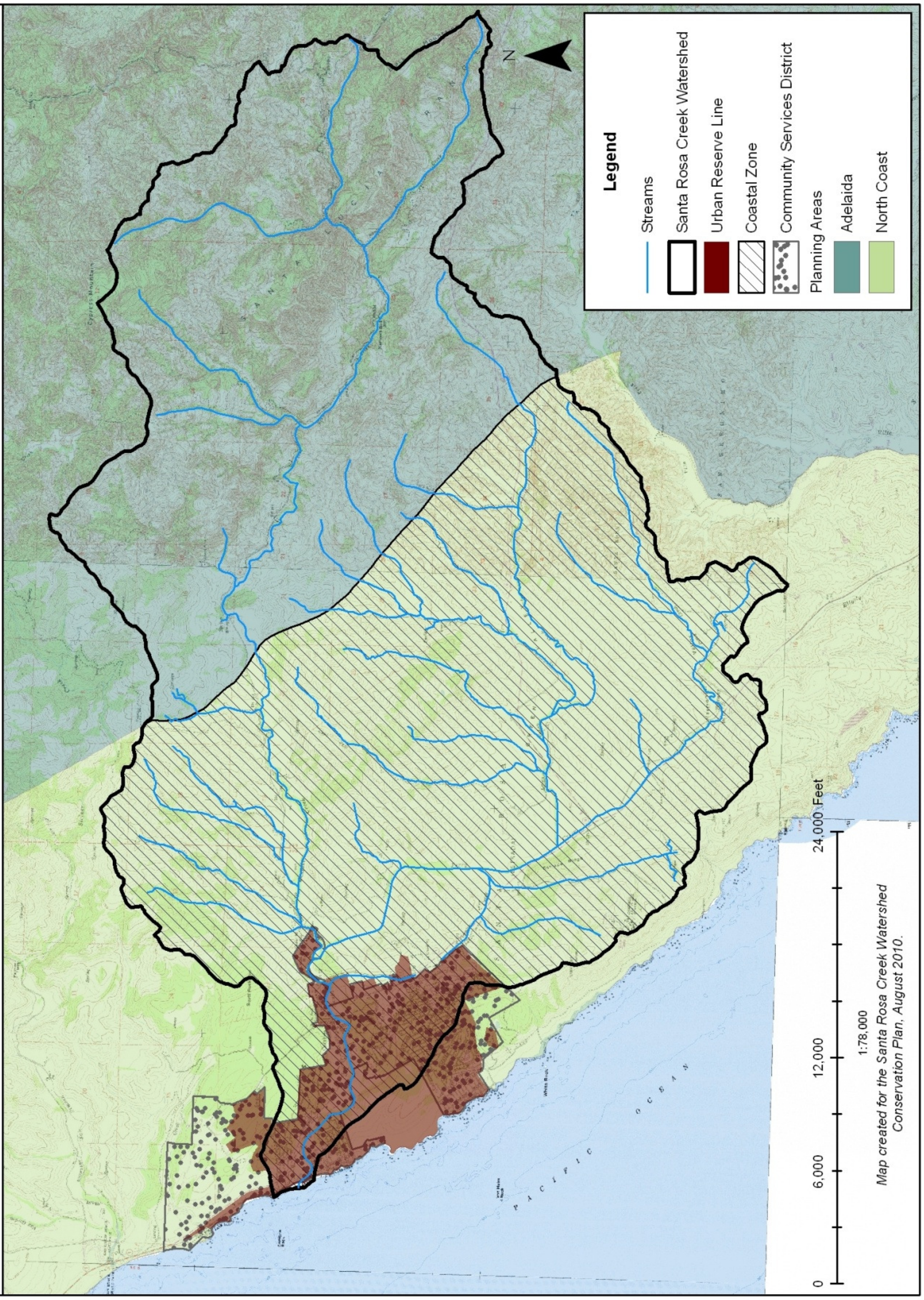
Land Use Assessment Background

From the time Cambria was founded in the late 1860's land use has evolved in response to the community's changing needs. Early Cambria was a town bustling with activities taking advantage of the wealth of natural resources in the area. Teams of horses pulled wagons along dirt roads and winding mountain paths transporting materials to and from mineral mines, dairies, ranches, and lumber mills located throughout the watershed. Cambria was so prosperous that by the late 1870s parcels were subdivided to lots as small as 25 x 50 feet (Hamilton, 1999). Today growth has slowed and most of these historic activities have ceased. Today, Cambria is a peaceful retreat where vacationers from all around the world settle in among the small shops and coastal inns, while old-time farmers continue to work the ground along the streams, coastal foothills, and rustic mountains, ranching, growing crops, and residing.

Existing Plans

Both the County of San Luis Obispo and the Cambria Community Services District (CCSD), include the Santa Rosa Creek Watershed in planning documents. The watershed is included in the San Luis Obispo County General Plan, within the North Coast and Adelaida Inland Planning Areas. In addition, the CCSD provides a variety of services to the urban area of Cambria, including water, fire protection, recreation, garbage pickup, and transportation. Figure 40 shows planning area and jurisdiction boundaries within the watershed.

Figure 40. Santa Rosa Creek Watershed Planning Areas and Jurisdictional Boundaries



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.

San Luis Obispo County General Plan

The San Luis Obispo County General Plan (General Plan) is the framework for future development within the county. The General Plan outlines development goals of local communities and public policy relating to future land uses. The County's Land Use Ordinance (Title 22 of the County Code) and the Coastal Land Use Ordinance (Title 23 of the County Code) contain site development standards for the County. These standards include drainage, grading, erosion, and sedimentation, and can be viewed online at the San Luis Obispo County Planning and Building Department website (http://www.slocounty.ca.gov/planning/General_Plan_Ordinances_and_Elements.htm).

The coastal zone covers roughly half of the Santa Rosa Creek Watershed. The Local Coastal Plan (LCP) is part of the County's General Plan and provides policy direction for land use within the coastal zone. The LCP is organized into four documents, including the Coastal Zone Land Use Ordinance which provides detailed planning guidance. The coastal zone within the Santa Rosa Creek Watershed is part of the North Coast Planning Area. The goals, objectives, policies, programs, and standards for the North Coast Planning Area are outlined by the North Coast Area Plan (Area Plan). The Area Plan was originally approved by the County Board of Supervisors in 1988, updated in 2007, and revised again in 2008. The Urban Reserve Line is the area within the Area Plan that defines urban areas for regional planning. The land area within the Urban Reserve Line in the Santa Rosa Creek Watershed is approximately 2,351 acres, or 7.7 percent of the watershed.

North Coast Area Plan

In the North Coast Area Plan (revised, 2008) agriculture is defined as the primary land use in the rural North Coast Planning Area, outside the urban reserve areas. Rangeland used for cattle grazing accounts for nearly 99 percent of all agricultural land use, with other agricultural activities such as orchards, vineyards, row crops and dry farming covering the remaining one percent. Most crops grown in the area are used as cattle feed. North Coast rangeland is considered some of the best in the county with 10 to 20 acres per animal unit (cow with a calf at her side).

Many of the agricultural properties in the Santa Rosa Creek Watershed hold Agricultural Preserves and Conservation Contracts developed according to the Williamson Act. The Williamson Act restricts land for agricultural uses for 10 years and reduces property tax. Much of the agricultural land outside of the Hearst Ranch in the North Coast Planning Area is contracted under Williamson Act (California Coastal Commission, 1998).

The urban areas of the north coast are mostly single family residences with some commercial uses. Cambria demographics have changed significantly in recent years with larger “family” households replacing smaller “vacation homes” and creating a larger demand on water supplies (California Coastal Commission, 1998).

In 2007, the area within Cambria's urban reserve line was 25 percent “built out” to its capacity. There were 3,408 dwelling units in Cambria with a population of 5,800. Ninety years ago land was parceled into small lots sometimes located on steep terrain unsuitable for development, and, while many of these lots remain today, water service is not available and the lots remain vacant. Projected population growth is estimated to exceed the capacity for providing water services to all parcels. According to Water Wait List information posted by the Cambria Community

Services District website April 2010, (http://www.cambriacsd.org/cm/water_wastewater/water_permits/wait_list.html) a water wait list was created in 1990 for lots planned for development in Cambria. Because of Cambria's limited water supply, in 2000 the County reduced Cambria's growth limit from 2.3 percent to 1 percent annually and placed a hold on all positions on the wait list until viable water resources are implemented. Therefore, no new water hookups for residential or commercial properties are currently being issued. Those properties which received an "Intent to Serve" notice, which allows for a new water hookup, before the current water moratorium can receive water services.

The County North Coast Area Plan evaluates water supply, sewage disposal, schools, roads/circulation, and air quality for the north coast using the Resource Management System (Management System). The Management System annually estimates resource capacities within the planning area and identifies issues that could arise in the future. The County Board of Supervisors reviews these findings which for several years have found that Cambria's water supplies will be inadequate to serve projected future demand.

A list of environmental goals, general goals, and land use standards as defined by the North Coast Area Plan (2008) is included in Appendix M. The goals and criteria included in the appendix deal with key factors discussed in this Plan and provide measures that protect natural resources in this watershed, such as water quality and supply, and fish habitat.

Adelaida Inland Area Plan

The Adelaida Planning Area includes the central northwestern portion of the county. In the Santa Rosa Creek Watershed, the Adelaida Planning Area includes the western slopes of the Santa Lucia Mountains east of the coastal zone. The landscape here is highly scenic, with rural and agricultural areas, extensive farming, range, and watershed lands. Historically, the area was mined extensively, with cinnabar and limestone minerals extracted.

Land in the Adelaida Planning Area is primarily used for agriculture, with steeper and more remote areas providing grazing capabilities and serving as watershed. Agricultural property sizes are generally large, while many smaller properties consolidated to allow for agricultural use as well. Smaller properties are often leased to nearby farmers for agricultural uses. There are two key recommended actions listed in the Adelaida Inland Area Plan that address issues important to the Santa Rosa Creek Conservation Plan. The first is the encouragement of agricultural preserves, and the second is the enlargement of agricultural parcels.

1. Agricultural Preserves – The County should continue to encourage owners of eligible lands to participate in the agricultural preserve program.
2. Agricultural Ownership Enlargement – The County should encourage addition of parcels to existing agricultural ownerships through such means as the Agricultural Preserve program and other appropriate specially-funded programs that may become available.

"Combining Designations" are applied in areas with hazardous conditions or special resources. "Combining Designations" are special overlay categories where a more detailed review of potential projects is necessary in order to avoid negative environmental impacts. Within the Adelaida Inland Area Plan, the Santa Rosa Creek is identified as an area that falls under

"Combining Designation" rules. Because Santa Rosa Creek has potential flood hazards, development within the creek corridor must either be avoided or mitigation measures must be incorporated.

In addition to the above items, combining designations for the Santa Rosa and San Simeon Creek reservoir are described. Studies indicate that surface storage expenses would outweigh storage capacity. Loss of riparian habitat and the creation of another barrier to anadromous fish migration are other concerns associated with development of the facility. In the Adelaida Inland Area Plan it was stated that it is unlikely for this project to move forward.

Cambria Community Services District

Cambria Community Services District: Water Master Plan (Program Environmental Impact Report)

The Cambria Community Services District (CCSD) is the current provider of water services to its customers surrounding Cambria. The CCSD uses wells located along Santa Rosa and San Simeon Creeks to pull water from groundwater aquifers. In the Water Master Plan EIR (2008), it was determined, however, that both basins cannot reliably meet the increasing water demand that currently exists with residential customers, the water waiting list, and grandfathered connections, without an additional source of water recharge.

Currently, the CCSD uses water rights diversion permits issued by the State Water Resources Control Board (SWRCB) to pump 1,118 acre-feet of water during the wet season, and 630 acre-feet during the dry season from the Santa Rosa and San Simeon Basins. In contrast, California Coastal Commission's (CCC) Development Permit only allows the CCSD to pump a maximum of 1,230 acre-feet of water from both basins annually, therefore setting the cap on the maximum groundwater pumpage at 1,230 acre-feet a year. From 1988 to 2002, the average groundwater withdrawal from both basins was 729 acre-feet a year

In recent years existing wells along Santa Rosa Creek have been shut down due to a Methyl Tertiary Butyl Ether (MtBE) plume, necessitating the development of a new well, SR-4, in the area. This well has been used in moderation during the dry season due to possible impacts to listed species. As a result, the reliability of this well, as well as additional wells along Santa Rosa Creek, has been compromised creating the need for a supplemental water source during dry months. To mitigate this issue, the Water Master Plan recommends several actions or tasks.

The "Buildout Reduction Program" (Task 1) in the Water Master Plan seeks to cap the maximum number of potential water service connections to 4,650 within the Services District boundary. In order to do so, potential building sites in Cambria would be retired or merged to match the 864 outstanding residential water connections that the Services District has committed to provide. Most lots would eventually be retired with a deed restriction or conservation easement that the Services District would purchase. Ultimately, if fully implemented this program would effectively control future demands on existing local water supplies.

"Potable Water Distribution" (Task 3) in the Water Master Plan would improve the water distribution system, focusing on advancing fire fighting capabilities. Projects to increase fire water flows and water storage tanks would be completed as recommended by the Cambria Fire Department.

Task 4 of the Water Master Plan outlines strategies the CCSD could pursue to expand its long-term water supply, including seawater desalination, recycled water, and water demand management. Seawater desalination would provide up to 602 acre-feet of water during the dry season using saltwater purified in a desalination plant and distributed. Recycled water would reduce the use of potable water by using recycled water for irrigation throughout Cambria; however, no net change in the volume of water in the aquifer would occur. The Water Demand Management strategy would reduce the use of potable water for landscaping by improving the current conservation program and regulations.

Cambria Community Services District Code

The Cambria Community Services District, California Municipal Code, was published in 2004. Title 4: Water Systems, details water conservation measures implemented by the CCSD to reduce water waste and conserve water during drought years. A summary of elements of interest to the Conservation Plan are included in Appendix N.

GIS Land Use Assessment Methods

Land use for the Santa Rosa Creek Watershed was described using geographic data from SLO Datafinder (http://lib.calpoly.edu/collections/gis/slodatafinder/) and the Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/). Parcel information and aerial imagery were also acquired from the County of San Luis Obispo and used to assess Santa Rosa Creek Watershed land use.

“Rural land use” GIS data were obtained from SLO Datafinder and were created by the County of San Luis Obispo for land use designation. The GIS data were created by digitizing county-wide land use information by township, range and section. The categories are general designations that are not parcel-specific; however they represent a simplified description for land use throughout the watershed (Fig. 41).

National Land Cover Data (Land Cover Data) GIS data were acquired from the Geospatial Data Gateway. The Land Cover Data were created by the USDA, NRCS National Cartography and Geospatial Center from the USGS Land Use Land Cover Data Set at a 30 meter scale, in 1999.

To separate the more densely populated lower watershed from the larger landowners of the upper watershed, a watershed boundary located at the intersection of Santa Rosa Creek and Main Street was developed. This boundary roughly coincides with the eastern edge of the Services District boundary (Fig. 40, pg. 94); however District jurisdiction extends approximately 0.7 miles east; up Santa Rosa Creek Road to include the Coast Union High School parcel. By separating the watershed into upper and lower regions, a more simplified assessment was conducted for the lower watershed using the County of San Luis Obispo Assessor’s Office parcel data. A detailed analysis was conducted for the upper watershed, integrating multiple GIS layers. Each parcel was observed over digital aerial and topographic data to locate any data discrepancies or fill in data gaps.

Land uses in the lower watershed were primarily summarized using parcel Land Use Codes (LUCs) from the County Assessor’s parcel database. For each parcel, up to four codes are included in the database. “PrimLUC” describes the zoned primary land use, while “LUC1”, “LUC2” and “LUC3” are used for subsequent modifications to zoned land uses that occur on the property. The codes were simplified into categories of land use and summarized in Appendix O.

In addition to the parcel data, parks, coastal zone, roads, and category rural land use data layers were used in GIS to help describe land use in the lower watershed.

To assess land uses in the upper watershed, several data layers were overlaid on top of digital aerial photography of the watershed and Digital Raster Graphics (DRG) topographic quadrangles in GIS. The following GIS layers were used to assess land use in the upper watershed: “land use land cover”, “roads”, “category rural land use”, “parks”, “parcels”, “schools”, “mines”, and “crops”. A detailed description of all GIS data used for this project, along with their source information, is included in Appendix G.

Additional data analysis was necessary to assess grazing practices on parcels lacking detailed land use data. If all of the following conditions were met for the parcel in question, then the parcel was determined to be grazed: 1) the parcel was surrounded by other parcels where grazing is said to occur according to the parcel data; 2) grassland vegetation was present on the property (which is more suitable for grazing than other habitats); 3) no fence-lines were observed separating the parcel from other parcels where grazing is occurring; and 4) the parcel land use codes were vague.

In addition, the county crop data is an incomplete dataset including only parcels that have permitted pesticide applications on file with the Agricultural Commissioner’s Office. Crop data were therefore updated based on aerial observations while referencing other county GIS data labeled “agricultural commodities”, “vineyard”, and “graze”. New “crop” locations identified using the aerial imagery were noted in the database as “observed crop location (aerial)”.

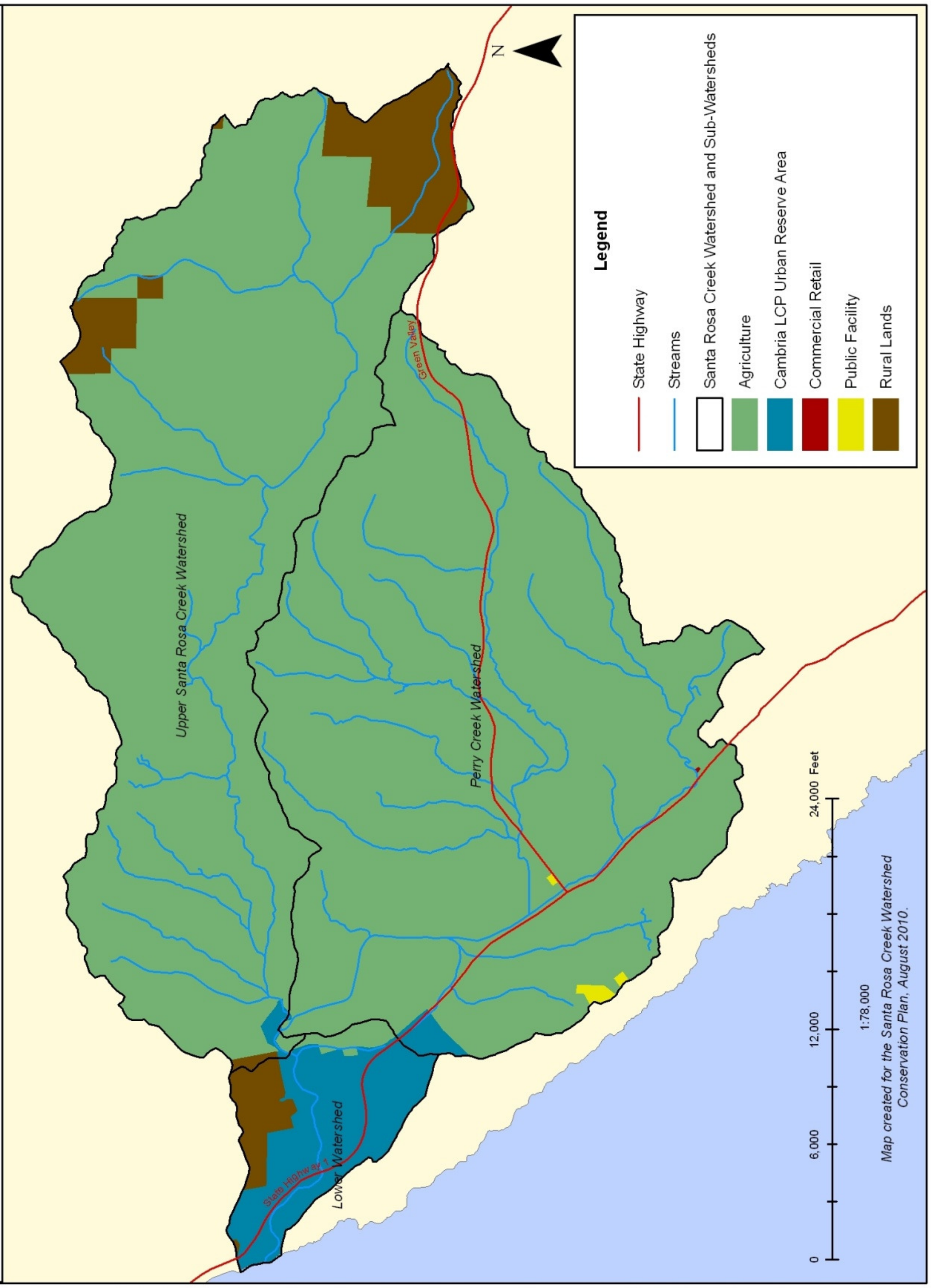
The land use maps created for the land use assessment were verified through field reconnaissance. To confirm general land use in the upper watershed, the San Luis Obispo County Farm Bureau was consulted. The Farm Bureau was able to verify the approximate boundaries between crop and grazing locations. Edits made to the GIS data were described in the GIS metadata.

GIS Land Use Assessment Results

Rural Land Use Classification

Lower watershed land uses are distinctly different than upper watershed land uses. While the lower watershed is predominately designated urban, the upper watershed is almost entirely designated agriculture. A map showing rural land use designations for the entire watershed is included in Figure 41. Table 11 lists each land use category with total acres and percent of total area, for each category in the Santa Rosa Creek Watershed. “Rural Lands” are loosely defined by the County as large parcel low density residential zones, and the “Cambria LCP Urban Reserve Area” is generally comprised of smaller parcel higher density residential zones.

Figure 41. Rural Land Use Classifications for Santa Rosa Creek Watershed



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.

Table 11. Rural land use classification: sum of acres and percent of total watershed area. Statistics calculated from GIS layer in ArcGIS 9.2.

DESCRIPTION	ACRES	PERCENT
Agriculture	27323.7	89.9%
Cambria LCP Urban Reserve Area	1505.8	5.0%
Commercial Retail	1.2	<1%
Public Facility	44.1	<1%
Rural Lands	1518.2	5.0%
TOTAL	**30393.0**	**100%**

National Land Cover Data (Land Cover Data)

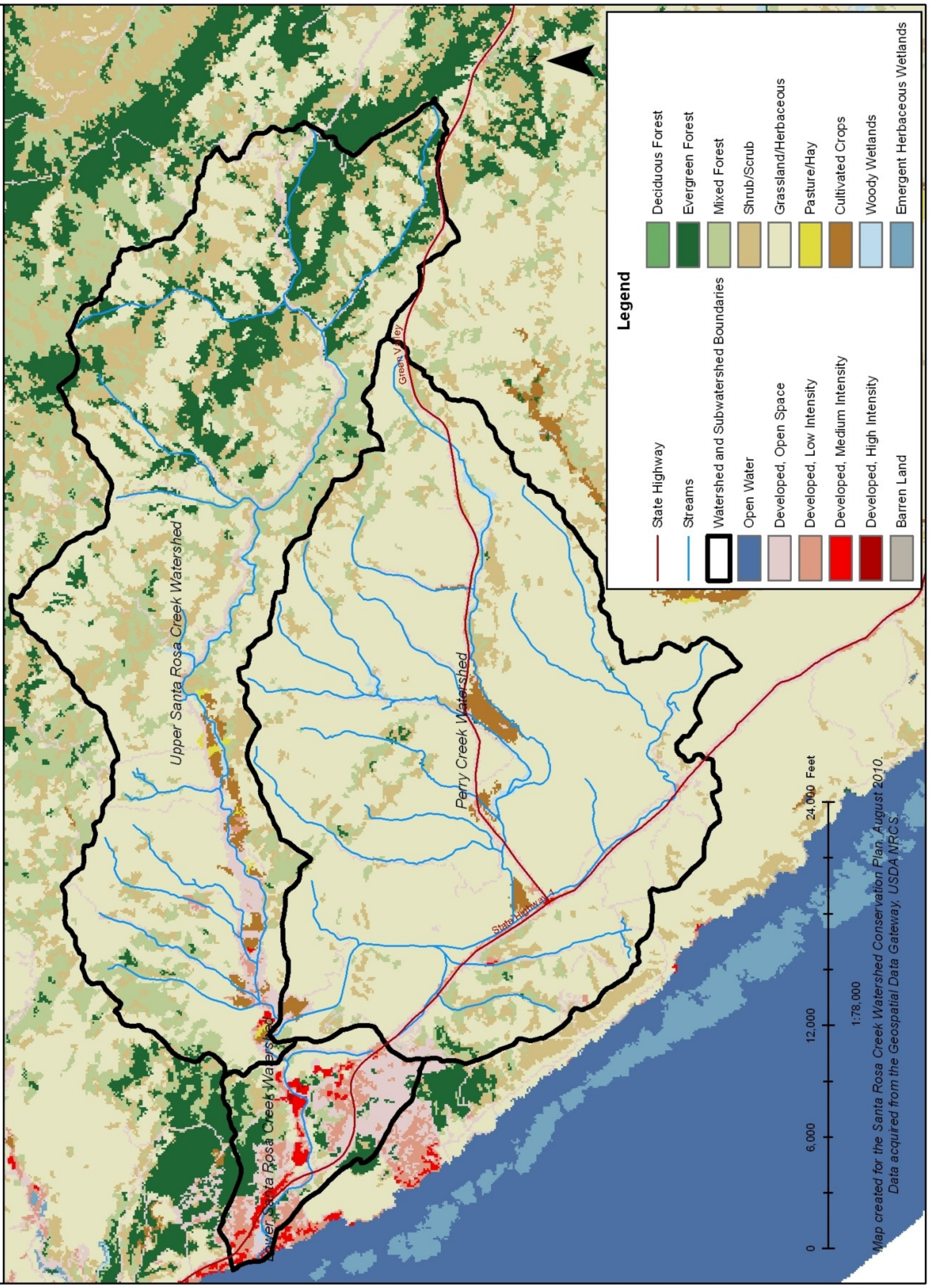
Land use classes and vegetative land cover data from the National Land Cover Data (Land Cover Data) dataset represent the watershed fairly accurately. Figure 42 shows Land Cover Data for the Santa Rosa Creek Watershed and surrounding areas. Interviews with San Luis Obispo County Farm Bureau and field reconnaissance has confirmed that most of the upper watershed is cattle grazed, with crops (vineyards, orchards, avocados, and others) and rural residence land uses common as well. Grazing often occurs in grasslands; however it is not restricted to those areas.

GIS Land Cover Data were checked in the field by conducting site visits and comparing data with field observations. In addition, Land Cover data were also consistent with the results from the parcel land use code assessment from the County Assessor’s Office parcel data.

Lower Watershed Land Use

The lower watershed is 1,349 acres in area and accounts for less than five percent of the entire watershed. This portion of the watershed includes all land draining into the Santa Rosa Creek from the Santa Rosa Creek and Main Street crossing, extending to the ocean. The lower watershed is densely populated with 4,012 parcels, or 83 percent of parcels located in the entire watershed. The primary land use designations for the lower watershed, by land area, used by the County of San Luis Obispo Assessor’s Office are presented in Figure 43. Primary land uses in the lower watershed include school/church, commercial/business, government, recreational, residential, water company, agriculture, vacant, and none. Additional land uses occur in the lower watershed, such as open space, public facilities, and roads, but are not represented within the County’s general land use descriptions. The following summary of land uses is derived from GIS analysis and summation of existing land use documentation from the Cambria Community Services District Water Master Plan (2009).

Figure 42. National Land Cover Data (NLCD) for Santa Rosa Creek Watershed



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010.
Data acquired from the Geospatial Data Gateway, USDA NRCS.

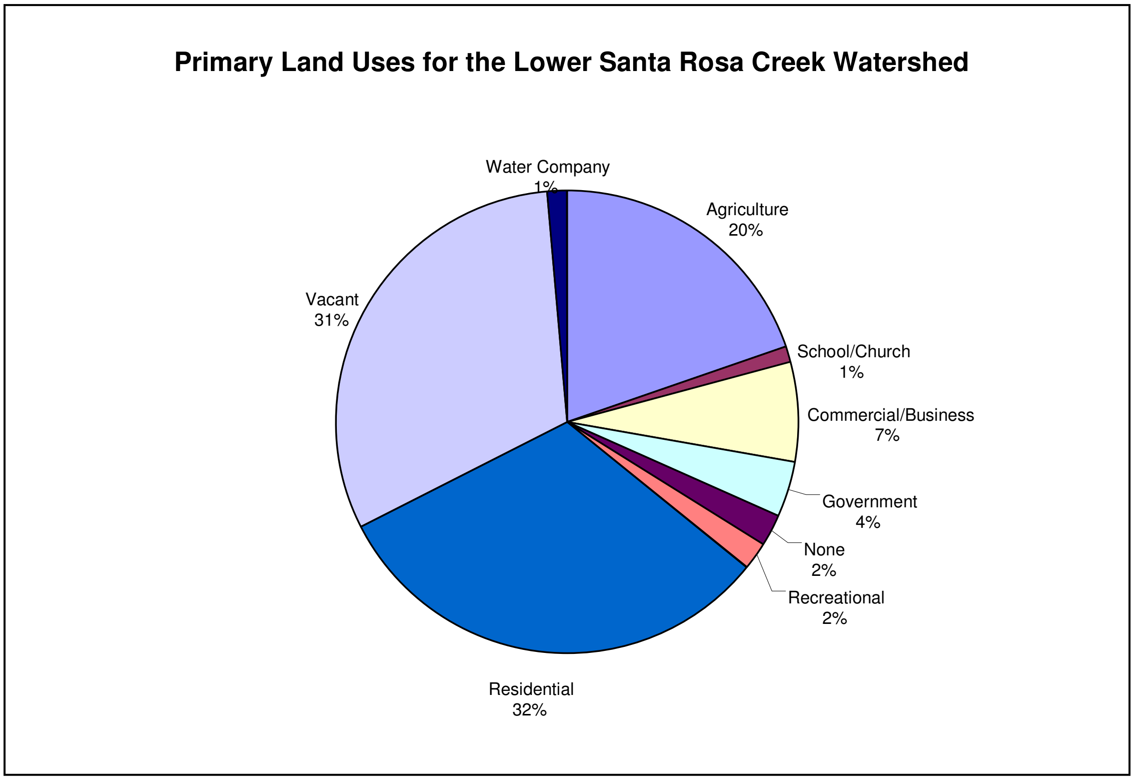


Figure 43. Lower Santa Rosa Creek Watershed land uses based on Primary Land Use Codes (PrimLUC) from the County of San Luis Obispo Assessor's Office parcel data.

Residential

The primary land use in the lower watershed is residential (including vacant lots) totaling 847 acres or 63 percent of the total land in the lower watershed. More restrictive coastal development policies are enforced in the lower watershed because these lands are located within the County's designated Coastal Zone. Because residential lots are typically small in Cambria, averaging 25 feet by 50 feet, over the years landowners have opted to acquire and merge adjacent vacant lots to expand the size of residential property.

Residential multi-family land only occurs in a few areas; however most of this land has been developed with single-family dwellings. Residential multi-family land is considered important for providing affordable housing. Residential single-family units are the dominant feature outside of the East and West Village commercial areas. One residential suburban area exists in the eastern portion of the community, but is presently used for agriculture.

Agriculture

The second largest land use in the lower Santa Rosa Creek Watershed is agriculture which accounts for 264 acres, or approximately 20 percent of the total land use in the lower watershed. There are three agricultural parcels located in the lower watershed exclusively and two additional agricultural parcels in the lower watershed that partially drain into the Perry Creek sub-watershed. Agricultural activities occurring at these parcels include grazing, open space, and orchards.

Commercial, Office and Professional

Business and commercial uses are centrally located east of State Highway 1, along Main Street in the East and West Villages of Cambria. They are connected by the mixed-use area of the Mid-Village. These uses account for only 95 acres, or seven percent of the land in the lower watershed.

Open Space

Open space areas include Fiscalini Ranch, state-owned floodplains located at the mouth of Santa Rosa Creek, flood-prone areas along Santa Rosa Creek, and significant pine stands. In partnership with the Coastal Conservancy and CCSD since 1986, The Land Conservancy has spent over two decades protecting land in the lower Santa Rosa Creek Watershed by acquiring parcels for open space and resource protection though the County's Transferable Development Credit (TDC) Program. As a part of this program, Fern Canyon Reserve near State Highway 1 and Burton Drive was created when the Land Conservancy acquired 260 lots as part of the Monterey Pine Forest Protection Program. The Land Conservancy also purchased 63 lots east of State Highway 1, in Ramsey Canyon, and three lots west of State Highway 1. These were acquired to develop a wildlife corridor around State Highway 1, to Fiscalini Ranch. The Henry Kluck Memorial Trail allows access from Burton Drive to the Fiscalini Ranch. Additionally, the Land Conservancy, the CCSD and the California Conservations Corps (CCC) created a hiking trail on the west side of Santa Rosa Creek at a stream restoration site. The trail is located between Windsor and State Highway 1, and connects to the Fiscalini Ranch. In 2007, the Coastal Conservancy provided additional funding to the Land Conservancy to continue acquiring high priority lots within the boundaries identified in the TDC program.

Recreation

In the addition to the Fiscalini Ranch Preserve and other trails mentioned above, San Simeon Beach State Park is located at the Pacific coastline on the northwestern edge of the watershed. There are approximately 54.7 acres of the park within the watershed boundary. The portion of the park within the Santa Rosa Creek Watershed is the southern extent of the park boundary. The entire park extends north to San Simeon Creek Watershed, and includes hiking trails, preserves, camping and beach access. There is also a community park run by the County of San Luis Obispo, a swimming pool, and a resort within the lower watershed. Ocean shorelines, creek sides, and forests also provide recreation to the public throughout the lower watershed.

Public Facilities

Public facilities include community meeting sites, a fire station, Cambria Community Services District offices, facilities and yards, a library, post office, hospital, and two cemeteries. The former grammar school on Main Street has no current use at this time. The new Cambria Grammar School is located in the upper watershed, on the corner of State Highway 1 and Main Street.

Roads

According to the "TIGER roads" database from SLO Datafinder (http://lib.calpoly.edu/collections/gis/slodatafinder/), there are nearly 40 miles of major and minor roads located within the lower watershed, including 147 separate roads that are each less than one mile in length. State Highway 1 and Main Street are major roads and are each approximately three miles in length. Paved and unpaved roads mapped in the TIGER database are common in the lower watershed.

An erosion study conducted by the USDA, NRCS in 1999 found 46 percent of roads located in the Lodge Hill residential area were unpaved. Lodge Hill is a residential community located south of the village, on the west side of the Main Street and State Highway 1 intersection. The erosion study suggests that due to degeneration from erosion, a typical dirt road should be rebuilt every nine years, while asphalt roads last for approximately 24 years (USDA, 1999).

Upper Watershed Land Uses

The upper Santa Rosa Creek Watershed is composed of both Santa Rosa Creek and Perry Creek sub-watersheds. The upper watershed includes all land draining upstream of the Santa Rosa Creek and Main Street crossing. A residential area located along the western edge of Perry Creek sub-watershed was separated from the rest of the upper watershed for analysis. This area has 436 parcels totaling approximately 67 acres, or less than one percent of the entire upper watershed area. The high-density area was assessed as the lower watershed was, using the County Assessor's Office Primary LUC data, and was found to be nearly completely residential in land use, with one property on the Services District water wait list, and approximately one-half acre without land use data.

The rural area of the upper Santa Rosa Creek Watershed is 28,057 acres with 383 parcels. The upper watershed is owned by far fewer landowners than the rest of the watershed, with 17 families owning 20,962 acres, or 69 percent of the total Santa Rosa Creek watershed area. The average size of the 17 "family" parcels is 1,165 acres, with one family owning 3,100 acres. Some "family" parcels are owned by several different members of the same family. The 17 "families" were selected from the County Assessor's Office parcel data if the combined parcel size in which one family owns, is over 300 acres. Figure 44 shows combined parcels according to the 17 families owning a large portion of the upper watershed. Family names have been withheld for confidentiality. Some families own parcels in more than one area of the watershed, and therefore not all "family" parcels are located together. Approximately 20,954 acres of "family" parcels are agricultural, while the remaining eight acres are designated residential.

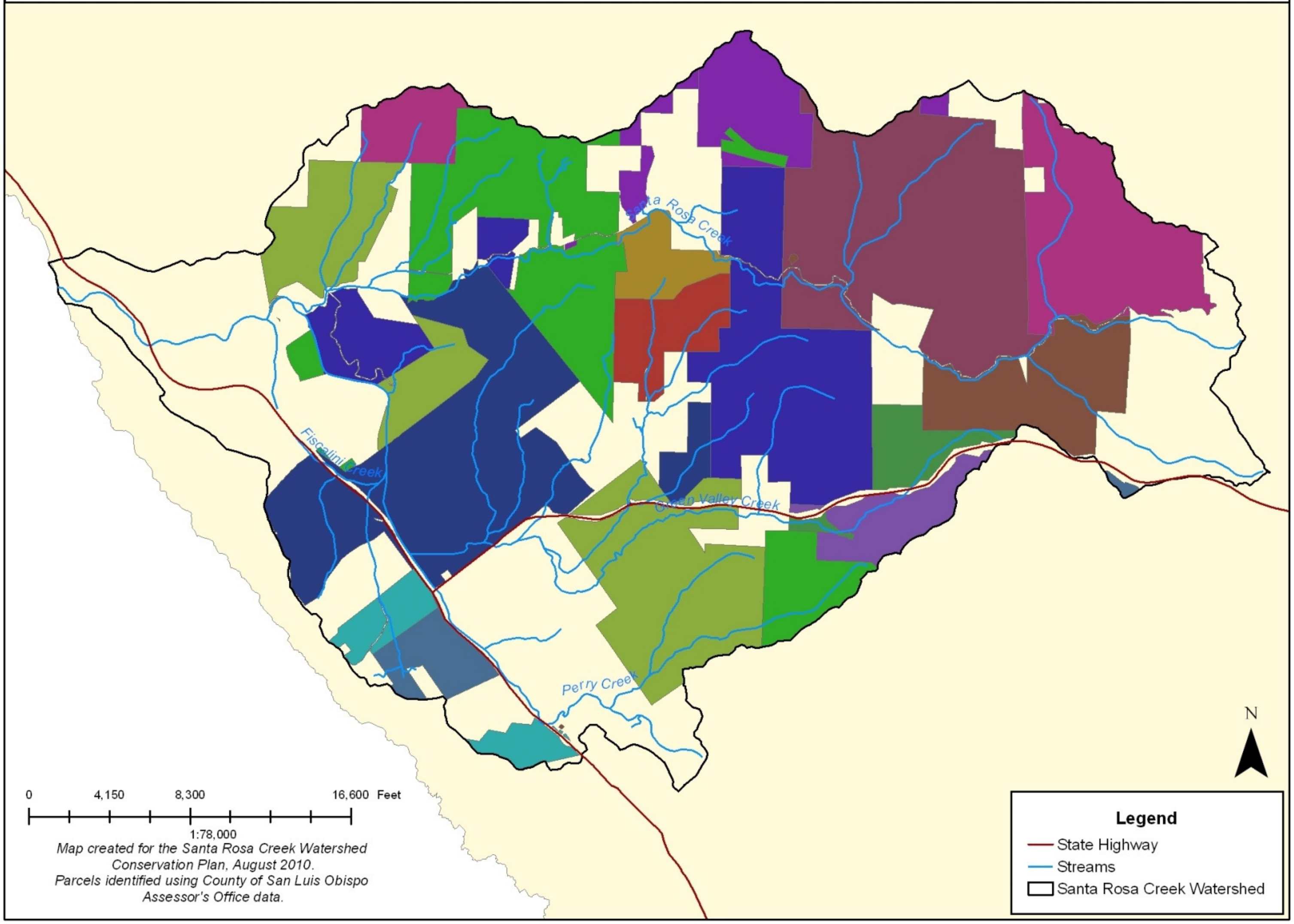
Parks

There are no federal, state, or county parks located in the upper watershed. There are 120 acres owned by the federal government in the Cypress Mountain area of the headwaters that is designated "grazing" in the County's parcel data.

Roads

According to "TIGER roads" data acquired from SLO Datafinder (http://lib.calpoly.edu/collections/gis/slodatafinder/) there are 75 miles of major and minor roads within the upper Santa Rosa Creek Watershed. The longest road in the upper watershed is Santa Rosa Creek Road, which is 11.7 miles in length within the upper watershed boundary. In addition, 9.7 miles of Green Valley Road, also known as State Highway 46, and 4.4 miles of State Highway 1 is within the upper watershed boundary.

Figure 44. "Family" Parcel Blocks in the Upper Santa Rosa Creek Watershed



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010. Parcels identified using County of San Luis Obispo Assessor's Office data.

Mines

There is no current mineral extraction within the upper Santa Rosa Creek Watershed, however rock quarries do exist. The County "mine" data acquired from SLO Datafinder identifies three rock quarries within the upper Santa Rosa Creek Watershed. The Cambria Pit and Bianchi Quarry are both owned by Winsor Construction and the land is leased. The Land Red Rock Pit is owned by Negranti Construction. Excavation appears to be occurring at all three sites. Additional sites were located using information from topographic quadrangles and aerial imagery. The Oceanic Mine is a retired mercury mine located tangent to Curti Creek. The site is unvegetated and excavated soil and rock still exists. Additionally, three gravel pits were located at sites east of Coast Union High School along Santa Rosa Creek Road. A total of 30 acres of gravel pits exist in the upper Santa Rosa Creek Watershed. The retired Oceanic Mine is 1.3 acres in size.

Agriculture

The primary land use in the upper Santa Rosa Creek Watershed is agricultural. Cattle grazing is the most common land use, with irrigated crop, dry farming, and rural residential land uses occurring in the upper watershed as well.

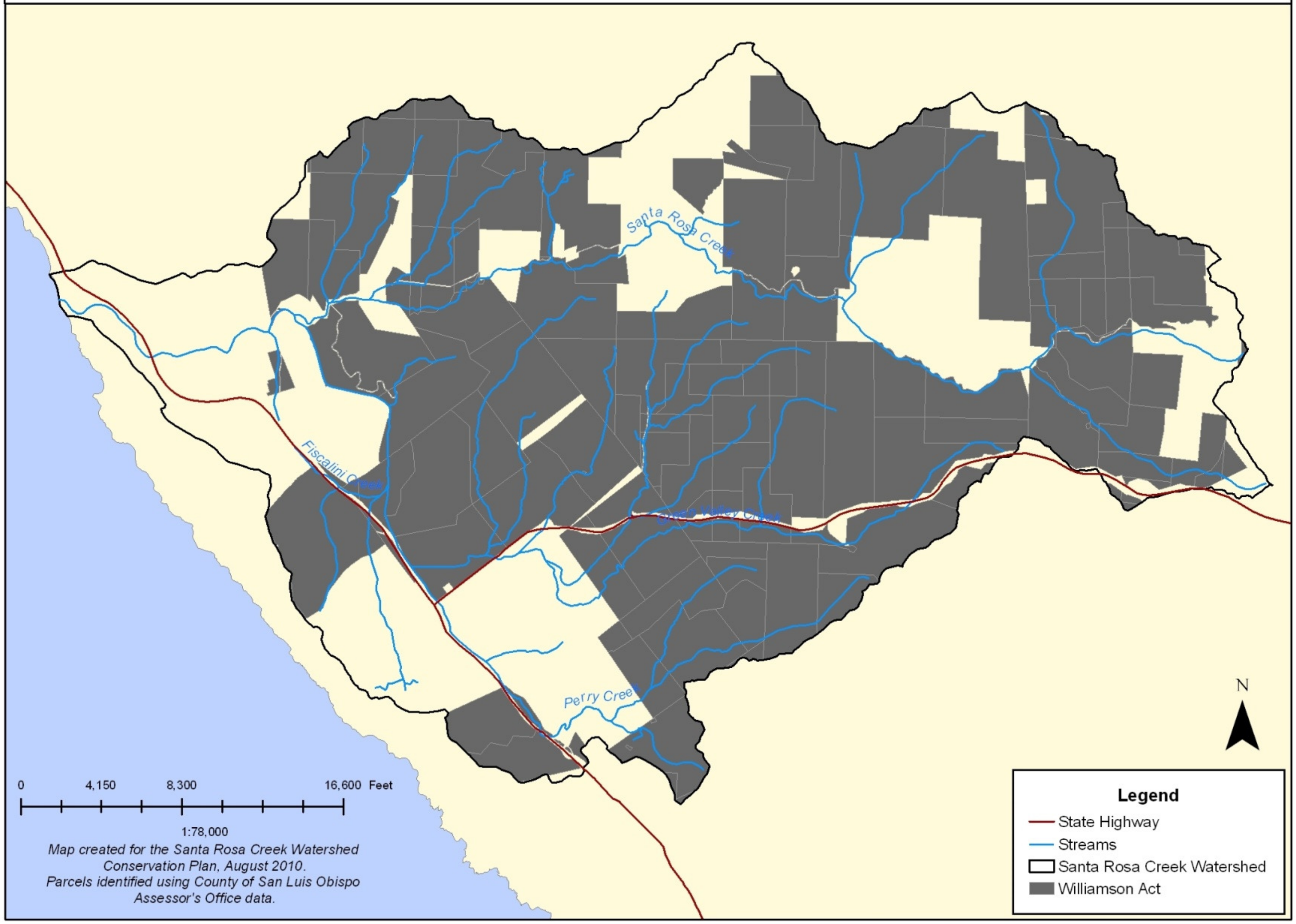
The livestock industry in San Luis Obispo County is large, with over 95,000 heads of cattle produced in the county, bringing nearly $60 million in revenue to the county in 2006 alone (San Luis Obispo County Department of Agriculture, 2006). The upper Santa Rosa Creek Watershed is a large contributor to this industry, with 79 percent, or 22,690 acres of the upper watershed land area designated grazing according to the County's parcel data.

The North Coast Area Plan Update identifies agriculture as the primary land use in the rural North Coast Planning Area. Rangelands account for nearly 99 percent of all land use, with the remaining land used for orchards, vineyards, row crops and dry farming. Most crops grown in the area are used as feed on associated ranges.

Most agricultural properties are under Agricultural Preserves and Conservation Contracts developed according to the Williamson Act. Within the upper watershed, 149 parcels with 20,672 acres of land are contracted under Williamson Act. Williamson Act parcels in the upper watershed account for 72 percent of the entire upper Santa Rosa Creek Watershed land area. Within the lower watershed, two additional parcels totaling 41 acres are also contracted under Williamson Act. Figure 45 shows all parcels in the watershed that are under the Williamson Act.

"Crops" data developed by the County of San Luis Obispo Agricultural Commissioner's Office are used to track parcels with pesticide permits. It is not a comprehensive account of all crop locations within the watershed. Digital aerial photography was used to edit the "crops" data by observing on-the-ground land use activities. From this analysis, there are approximately 988 acres (3.5 percent of upper Santa Rosa Creek Watershed land area) of various crops grown in the upper watershed, including both Santa Rosa Creek and Perry Creek sub-watersheds. Total acres for each crop type recorded by the County's Agricultural Commissioner's Office for pesticide application and edited using 2007 aerial imagery are shown (Table 12).

Figure 45. Williamson Act Parcels in the Upper Santa Rosa Creek Watershed



Map created for the Santa Rosa Creek Watershed Conservation Plan, August 2010. Parcels identified using County of San Luis Obispo Assessor's Office data.

Table 12. County Agricultural Commissioner's Office crop data edited.

CROP TYPE	LOCATIONS	TOTAL ACRES
Aerial-assessment	21	297.1
Berry	1	0.9
Field-rotational	6	199.3
Orchard	28	142.2
Total site	1	22.5
Uncultivated ag	2	8.9
Undeclared	1	1.3
Vegetable-rotational	16	278.3
Vineyard	5	37.7

County of San Luis Obispo Assessor's Office data show the largest land uses in the upper watershed are vacant single family, vacant rural, agricultural property, and grazing (Table 13). The data represent only the primary land use; however three additional land use classifications are recorded in the Assessor's Office parcel data for each parcel of land. Most parcels located in the upper watershed have "agriculture property" and/or "graze" as subsequent land uses if not identified as a primary land use.

Table 13. Primary Land Use Code statistics for Upper Santa Rosa Creek Watershed, excluding the densely populated residential area of Perry Creek Sub-watershed.

PLUC	**Defined**	**Count**	**Min Acres**	**Max Acres**	**Ave Acres**	**Sum Acres**	**Percent of Upper Watershed**
	No Data	21	0.09	637.15	76.73	1611.3	5.7%
100	Vacant Single Family	5	0.01	2856.62	889.77	4448.9	15.9%
106	Vacant Rural	3	9.18	39.92	20.97	62.9	<1%
107	Vacant Rural	7	8.91	45.04	25.88	181.1	<1%
108	Vacant Rural	11	17.53	649.56	102.79	1130.7	4.0%
109	Vacant Rural	17	4.87	779.27	224.90	3823.2	13.6%
110	Single Family	14	0.22	968.93	189.36	2651.0	9.4%
133	Mobile Home	1	19.78	19.78	19.78	19.8	<1%
134	Mobile Home	1	369.38	369.38	369.38	369.4	1.3%
170	Single Family with Secondary Unit	2	2.23	286.93	144.58	289.2	1.0%
171	Single Family with Secondary Unit	1	4.01	4.01	4.01	4.0	<1%
172	Single Family with Secondary Unit	1	488.89	488.89	488.89	488.9	1.7%
173	Single Family with Secondary Unit	5	12.49	780.45	171.48	857.4	3.1%
174	Single Family with Secondary Unit	12	5.40	90.90	31.75	381.0	1.4%
175	Single Family with Secondary Unit	5	15.64	54.76	37.33	186.7	<1%
176	Single Family with Secondary Unit	13	5.54	624.36	185.31	2409.0	8.6%
205	Mixed Living	3	2.84	435.31	156.68	470.0	1.7%
310	Retail Sales	1	1.95	1.95	1.95	1.9	<1%
600	Agricultural Property	5	12.37	2320.77	766.75	3833.7	13.7%
612	Trees/Vines/Lemons	1	87.12	87.12	87.12	87.1	<1%
636	Winery	1	16.20	16.20	16.20	16.2	<1%
650	Graze	21	0.39	660.94	204.21	4288.5	15.3%
660	Specialty	1	217.97	217.97	217.97	218.0	<1%
857	Government	7	3.41	120.25	32.06	224.4	<1%
860	Public Utility	1	2.10	2.10	2.10	2.1	<1%
861	Water Company	1	0.23	0.23	0.23	0.2	<1%
	TOTAL	**161**				**28,056.6**	**100%**

5. RECOMMENDED CONSERVATION STRATEGIES

Santa Rosa Creek Watershed is a healthy and productive ecosystem that supports a robust steelhead population and provides valuable rangeland and farmland for the production of food and fiber. There are common concerns throughout the watershed related to soil health, water supply, degradation of wildlife habitat, and sustainability of ranching and farming operations. Fortunately, there are many tools available to landowners and other stakeholders to help improve land management practices, identify and implement priority conservation activities, and continue the cultural heritage of ranchers and farmers.

To facilitate the compilation of strategies and practices specific to the Santa Rosa Creek Watershed, and to develop specific recommendations, the following objectives (in no particular order) were identified:

- Protect and restore the natural function of streams and associated riparian zones, giving priority to those reaches of Santa Rosa Creek that support steelhead.
- Protect and restore native floral and faunal communities, especially Monterey Pine Forest and Oak Woodland.
- Protect and restore wildlife corridors to maintain connectivity between important habitats.
- Maintain and improve water quality in Santa Rosa Creek and its tributaries at levels sufficient to provide healthy drinking water and support natural resources.
- Provide a sustainable water supply for farms, ranches, wildlife and residents.

Successful conservation to sustain and improve watershed health relies on three primary strategies: land acquisition, restoration, and long term management practices.

5.1. LAND ACQUISITION STRATEGIES

The conservation of the natural resources of the Santa Rosa Creek Watershed relies on continued land protection efforts. Conservation of land is achieved in a variety of ways including traditional land use controls such as zoning requirements, the general plan, and associated local coastal plan, as well as targeted incentive-based programs and agreements such as the Williamson Act, conservation easements, and land purchases for parks, open space and natural resource protection. Future conservation of the watershed's land and water will rely largely on compliance with, and enforcement of, existing land use rules and regulations. However, additional non-regulatory tools and measures are available to ensure conservation of important resources, as described below.

Conservation Easements

A conservation easement is a binding agreement recorded on the deed of the property that protects the targeted resources on all or a portion of the subject property in perpetuity. Each conservation easement is tailored specifically to meet conservation and landowner needs.

Conservation easements are usually held by a non-profit land trust organization or public agency with a conservation purpose, and can be donated or sold by the landowner. Easements can be placed on public land, parks, open space, and on private ranches and farms with willing landowners.

In select instances where important resources or combinations of resources are threatened by land uses that are allowed by right under zoning, general plan, real property law, etc., the use of conservation easements can be a very valuable tool. For example, under San Luis Obispo County's agricultural zoning, a large ranch property comprised of numerous legal parcels located outside the coastal zone in the upper watershed could be eligible for a cluster subdivision with up to a 50 percent density bonus. Such development could lead to erosion and drainage changes due to new roads and correspondent increases in impervious surfaces that can have adverse impacts on aquatic species such as steelhead, fragment wildlife habitat with fencing and human encroachment, and increase demands on use of scarce water supplies for residential and landscaping purposes. On the other hand, selling a conservation easement could provide that same landowner with substantial financial compensation. For many landowners the challenge of keeping a ranch property in the family through the generations can be formidable given that agriculture remains an ever-challenging proposition as increased land values lead to substantial estate tax exposure. A conservation easement, combined with forward-thinking estate planning and business planning, can provide the relief needed for a family to protect their ranch, retain local cultural heritage, and keep the ranch in the family. Conservation easements have become increasingly attractive to private landowners and land and natural resource protection agencies and nonprofit groups alike because they allow a landowner to continue to own and use his or her property with some restrictions to protect targeted natural resources and receive financial compensation for selling such protections.

Land Purchase (Fee Simple)

Land with high priority conservation values can be purchased outright from a willing seller by public agencies, non-profit land trusts, or other organizations to achieve conservation objectives. For example, when very high priority properties are threatened by a sale, the use of a fee simple acquisition may be appropriate. While this classic method of land conservation provides maximum resource protection and land use options, it is typically more expensive compared to easement purchases, especially when land management and stewardship costs are factored in. Another important consideration is the broader impact such a transaction may have on the long term viability of agriculture in the area. For this reason, these types of projects should only be undertaken when a property's agricultural uses are no longer viable or when compatible uses can be achieved. That said, purchasing land when and where appropriate and feasible provides maximum opportunities for public benefit.

5.2. RESTORATION STRATEGIES

Restoration projects, (synonymous with repair, rehabilitation, and enhancement projects) are designed and implemented with the goal of improving the health of ecosystems that have been disturbed and/or damaged by any type of land use. Watershed restoration projects vary from passive native plant installation to engineered fish passage improvement projects. These projects can be implemented on private lands with or without a land acquisition element, depending on the funding source and project goals. Non-profits, State agencies, the Natural Resource

Conservation Service (NRCS) and Resource Conservation Districts (RCDs) can fund and implement restoration activities on private lands. In order to minimize duplication of information specific restoration techniques are included as management practices below in Section 5.3. of this report.

5.3. LONG TERM MANAGEMENT STRATEGIES

Management Measures and Practices (MMPs), also known as Best Management Practices (BMPs), are techniques, treatments, and tools for improving and protecting watershed health and ecological function. All conservation and watershed management plans identify practices that can assist land managers with improving water quality, protecting sensitive species, and restoring habitat. A wealth of information exists related to MMP definitions, descriptions, alternatives, and design specifications.

The Federal Clean Water Act (1977) states that a Best Management Practice is “a practice or combination of practices that is determined by a state to be the most effective means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals”. The terminology “best” is highly debatable so “management measures” and “management practices” have since replaced the “Best Management Practices” term and is thus used throughout this document.

A management measure can be defined as a “goal for management of nonpoint source pollution for a state, basin, watershed or ranch” and describes long-term goals and how they link to beneficial water uses (George & Jolley, 1995). Management practices are either individual applications or they are used in combination to address the management measure goals. Management practices have been developed and defined by regulatory agencies such as State and Regional Water Quality Control Boards and the U.S. Environmental Protection Agency (EPA), restoration organizations, ranchers, professionals, and are described in NRCS Field Office Technical Guides (Technical Guides).

For the Santa Rosa Creek Watershed it is important to select practices appropriate for the resources that have been identified for protection and improvement. Recommendations must also be applicable to current and future land uses in the watershed. Recommended MMPs for the Santa Rosa Creek Watershed are organized by land use, then by MMP type. Each practice is described briefly. Where applicable, each practice includes the corresponding number used by the NRCS in the National Handbook of Conservation Practices for reference. Additional information about NRCS Conservation practices can found at the NRCS website (http://www.nrcs.usda.gov/Technical/efotg/).

5.4. WILDLIFE HABITAT AND RIPARIAN RESTORATION MMPS

Measures and practices that can improve watershed health are not always specific to one land use. The following practices can be implemented across a wide variety of properties, in many different situations, and on most types of projects. Projects can be implemented to directly improve wildlife habitat, maintain or restore migration corridors and critical habitat for sensitive species, and build resiliency of the local ecosystem. The following practices can be implemented on all types of projects or properties. Reference to the NRCS Technical Guides practice number is in parenthesis following practice title. Detailed descriptions and specifications are available through the NRCS, Caltrans, and other groups who have developed MMP/BMP manuals and restoration plans.

Stream Restoration and Streambank Protection (580)

Restore modified or damaged streams using environmentally-sensitive techniques to protect stream banks and infrastructure, reduce or repair erosion, establish riparian vegetation, and improve habitat for sensitive species. The techniques below (Table 14) can be used in combination or independently as warranted. It is strongly encouraged that agencies are consulted prior to any of the following practices being implemented, especially if part of a project that has the potential to negatively impact a stream, river, lake, or wetland. Typical drawings and descriptions for a selection of these techniques are offered in Appendix P.

Table 14. Management measures and practices used to protect stream banks and infrastructure, establish riparian vegetation, and improve habitat for sensitive species.

Biotechnical Engineering	**River Training Structures**
Brush Box	Bendway Weirs
Brushpacking	Cross Vanes
Coconut Fiber (Coir) Roll	Longitudinal Stone Toe Protection
Coconut Fiber (Coir) Mats	Rock Vanes
Compost Berm	Rock Vanes with J-Hooks
Compost Blanket	Spur Dikes
Erosion Control Blankets	Stone Weirs
Geoberm Revetment	**Structural Streambank Stabilization**
Large Woody Debris Structures	Cobble or Gravel Armor
Live Brushlayering	Geocellular Confinement System
Live Brush Mattress	Live Cribwall
Live Fascine	Slope Flattening
Live Gully Fill Repair	Stepped or Terraced Slope
Live Pole Drain	Stream Diversion
Live Siltation	Surface Roughening
Live Staking	Trench Fill Revetment
Straw Anchoring	Vegetated Articulated Concrete Blocks
Straw Rolls/Wattles	Vegetated Gabions
Trench Drain	Vegetated Gabions Mattress
Turf Reinforcement Mats	Vegetated Riprap
Veg. Mech. Stabilized Earth	Stone-Fill trenches
Willow Posts and Poles	
Stream Corridor Habitat Improvement	
Boulder Clusters	
Meander Restoration	
Newbury Rock Riffles	
Rootwad Revetment	
Vegetated Floodways	

A significant amount of information and studies has been published related to how these techniques should be implemented, where the techniques are applicable, and how effective the techniques are under varying conditions. Technique specifications, details, and typical drawings can be obtained from a variety of sources including *Environmentally-Sensitive Streambank Stabilization* (ESenSS, authored by Salix Applied Earthcare), the National Cooperative Highway Research Program, and the California Department of Fish and Game *California Salmonid Stream Habitat Restoration Manual*.

Wetland Creation, Enhancement and Restoration (658, 659, and 657)

Create, enhance, or restore functional wetland habitat by creating hydric soil, introducing or reintroducing conditions where prolonged inundation occurs, planting appropriate native wetland species, and removing invasive weed species.

Wildlife Wetland Habitat Management (644)

Retain, develop, or manage wetland habitat for the benefit of wetland dependent or associated flora and fauna.

Wildlife Upland Habitat Management (645)

Create, maintain, or enhance food supply, cover, and connectivity of habitat for upland wildlife.

Grade Stabilization (410)

Stabilize the grade and control erosion in channels using a structure to prevent the formation and advancement of gullies, enhance environmental quality, and reduce pollution hazards.

Fish Passage (396)

Modify or remove man-made structures that impede migration of steelhead or other aquatic organisms.

Mulching (484)

Apply residual plant material, chipped woody material, or manufactured products to reduce erosion, suppress weeds, provide an ideal seed bed for germination, and to mange soil moisture and temperature for the purposes of supporting the establishment of native, beneficial vegetation.

Tree and Shrub Establishment (612)

Establish native trees and shrubs by planting seeds or woody cuttings to improve wildlife habitat, reduce erosion, improve water quality, and improve biological diversity.

Agricultural MMPs

Most of the Santa Rosa Creek Watershed is composed of large ranches and farming properties. The following practices are organized based on land use.

Ranches and Grazing

Ranching is the primary land use in the upper watershed and Perry Creek Sub-watershed so improvements in cattle grazing practices have a high potential for benefiting rangeland and riparian ecosystems. Exclusion fencing, riparian pastures, and rotational grazing can be implemented to reduce overgrazing impacts to perennial springs and streams in the upper watershed, and to protect highly erodible soils in the Perry Creek Sub-watershed.

Prior to identifying, designing, and implementing MMPs, landowners should develop a Ranch Plan with assistance from local NRCS representatives, Resource Conservation Districts or non-profit organizations with expertise in planning and resource protection. The Ranch Plan can take several formats, such as those presented through NRCS Conservation Planning, UC Cooperative Extension (UCCE) Ranch Planning Short Courses, Holistic Resource Management, or any other organized planning process implemented by the landowner, agency, or private consultant.

The goal of maintaining or improving the quality of water should be included in ranch management plans for livestock operations. Ranch water quality goals need to be linked to water quality problems identified by the Regional Water Quality Control Board for the local basin or sub-basin. A Ranch Plan should contain the follows chapters or components:

1. Describe the environmental setting.
2. Describe livestock and grazing operation.
3. Describe goals of ranch water quality.
4. Describe problems with water quality on the ranch.
5. Describe management measures and practices.
6. Describe techniques for monitoring and evaluation.

California Rangelands Research and Information Center provides a list of management practices for California rangelands. The following practices are listed in the California Rangeland Water Quality Management Plan for California's privately owned rangelands, with reference to the NRCS Technical Guides practice number in parenthesis, and appear to be the most applicable to conditions within the Santa Rosa Creek Watershed. These management practices were derived directly from Fact Sheet No. 9, Rangeland Watershed Program (George & Jolley, 1995) and have been edited to describe only practices that impact rates of erosion, water quality and quantity, and steelhead habitat.

Non-Structural Range Improvements

Prescribed grazing, vegetation management, erosion reduction, and wildlife habitat improvement should be planned, implemented, and maintained to minimize water quality impacts.

Prescribed Grazing (528a)

Prescribed grazing occurs with controlling grazing season, intensity, frequency, and distribution. It is defined as the controlled harvest of vegetation with grazing or browsing animals, managed with the intent to achieve a specified objective, such as:

- Maintain or improve soil condition while improving accelerated soil erosion.

- Maintain or improve water quantity and quality.
- Maintain or improve food and shelter for species of concern.
- Maintain or improve desired plant communities.

Use Exclusion (472)

Exclude people, vehicles, or animals from an area to protect, maintain, or improve the quantity and quality of plant, animal, soil, air, water, and/or aesthetics resources, as well as human health and safety.

Brush Management (314)

Remove or thin undesired species to maintain an ecological balance, improve forage production, provide soil protection, and reduce fire risk.

Prescribed Burning (334)

Use controlled burning in specified areas of the range to promote establishment of perennial native grasses, improve range production, reduce undesirable plant species, control plant disease, and decrease the risk of catastrophic fire.

Firebreak (394)

Reduce the spread of fire or control a prescribed burn using a bare ground or a vegetated strip of land. This practice shall be designed and implemented with erosions and sediment control techniques to minimize impacts to sensitive habitats.

Critical Area Planting (342)

Plant vegetation on highly erodible or critically eroding areas to reduce soil erosion and sediment delivery to surface waters. May temporarily impair surface water quality prior to the establishment of vegetation, such as during grading, seedbed preparation, and mulching activities.

Range Seeding (550)

Seed native grazing land to establish adapted plants. Does not include pasture and hayland planting. May increase erosion and sediment yield during the establishment of plants.

Pasture and Hay Planting (512)

Establish native or introduced vegetation to improve livestock health, improve forage production, reduce erosion, and improve water quality.

Rangeland Mechanical Treatments (548)

Mechanically renovate, contour furrow, pit, or chisel native rangeland to improve plant cover and water quality by aerating the soil, increase available moisture and infiltration, reduce erosion, and protect low lying land or structures from siltation.

Structural Range Improvements

Structural range improvements should be linked in the Ranch Plan to proper grazing use and other ranch water quality goals.

Access Roads (560)

A travel-way constructed to provide a fixed route for vehicular travel for resource activities involving the management of timber, livestock, agriculture, wildlife habitat, and other conservation enterprises while protecting the soil, water, air, fish, wildlife, and other adjacent natural resources.

Fencing (380)

Enclose or divide land with suitable, permanent structure that acts as a barrier to livestock, big game, or people. Fencing may protect riparian areas which act as sediment traps and filters along channels and impoundments.

Pipelines (516)

Convey water for livestock or recreation using installed pipeline. By providing water sources other than lakes or streams, pipelines may decrease sediment, nutrient, organic, and bacteria pollution from livestock.

Ponds (378)

Construct using a dam or embankment or by excavating a dugout or pit. Often used with pipelines, troughs and tanks. Ponds may trap sediment and nutrients and prevent them from entering into the basin. Ponds may also provide alternate water sources away from streams.

Sediment Basins (350)

Construct to collect and store sediment or debris, removing the material from the water being passed downstream. Stockwater ponds often act as sediment basins.

Spring Development (574)

Improve springs and seeps by providing storage facilities and/or excavating, cleaning, or capping. Erosion may occur from disturbed sites immediately after construction, but should be short-lived.

Stock Trails or Walkways (575)

Establish lanes or travel ways that facilitate animal movement, while protecting ecologically sensitive, erosive and/or potentially erosive sites.

Troughs and Tanks (453)

Provide stock water away from streams by installing tanks or troughs to facilitate improved distribution of livestock. This reduces disturbance, compaction, and subsequent erosion in areas close to stream channels.

Landslide Treatments (453)

Treatments used to prevent or stabilize landslides to stop excessive erosion and sedimentation.

Well (642)

Develop new water sources to provide stockwater in stable areas located away from sensitive areas, such as streams. Livestock distribution will improve with new water sources.

Stream Crossing

Fords, culverts, or bridges that provide access across a stream through a stabilized area for livestock watering or farm equipment. This practice reduces erosion, sedimentation and contamination from other pollutants.

Livestock Management Practices

Disease control, feeding, and salting of livestock should be done in a way that protects water quality and sensitive habitat. Livestock tend to congregate at salt blocks and feeding areas so these activities should occur in areas away from streams to reduce impacts. Parasite control and other medications should be administered at the minimum amount needed to be effective. Loading chutes and other corrals where livestock will be concentrated should be located as far from sensitive habitats as possible.

Facility Siting/Design Criteria

Protect water quality by considering site design of facility. Plan the location and/or design of feeding, watering, working, holding, chemical storage, and shipping facilities at the property proximity to water resources.

Irrigated Row Crops and Orchards

A small percentage of land use in the upper watershed of Santa Rosa Creek includes vegetable and fruit production. Details and specifications for conservation practices suitable to row crops, hay fields, and orchards can be found on the NRCS website (http://www.nrcs.usda.gov/Technical/efotg/). Those most suitable for the Santa Rosa Creek Watershed are listed and described below.

Non-Structural Practices

Non-structural practices are those that reduce erosion and sedimentation and improve soil and water quality by implementing techniques in day to day management of farm operations.

Erosion and Sediment Control Plan

Develop plan for the entire farm that seeks to reduce erosion by protecting the soil surface wherever possible, and seeks to reduce sediment transport by retaining flow prior to it leaving the farm and/or flowing into sensitive waterways.

Nutrient Management Plan

Develop plan for the entire farm that seeks to minimize nutrient loads in runoff that could be harmful to sensitive habitats.

Conservation Coverage (327)

Establish permanent vegetation to reduce erosion, improve water quality, provide wildlife habitat, enhance soil quality, and trap pests.

Residue Management (345)

Manage the amount, orientation, and distribution of crop residue on the soil surface while minimizing soil-disturbing activities, for the purpose of reducing soil erosion and wind erosion, improving soil condition, and increasing soil moisture.

Conservation Tillage (329)

Grow crops with the minimum amount of tillage necessary to manage pests and reduce compaction. Reduction of tillage depth and the conservation of plant residue protect the soil surface from erosion; improve soil health, quality, and structure; and increases infiltration.

Nutrient Management (590)

Improve crop production in a manner that protects sensitive waterways, improves soil condition, and properly utilizes manure and organic matter, using the application of soil amendments.

Pesticide Management (595)

Prevent, avoid, monitor and suppress weeds, insects, diseases, animals and other organisms while minimizing negative impacts of pest control on soil, water, air, plant, and animal resources and/or humans.

Riparian Buffer or Filter Strip (391 or 393)

Filter sediment and contaminants from runoff, provide cover for wildlife and beneficial predators, increase shade to reduce surface water temperature, and intercept pesticide drift and airborne particulates by having an area of preserved or restored trees, shrubs, and grasses situated upslope from a waterbody and between the waterbody and actively farmed fields.

Crop Rotation (328)

Reduce soil erosion, maintain or improve organic matter content, stabilize the balance of nutrients in the soil, and control weeds, diseases, and pests by growing a variety of crops on the same field in a recurring sequence as appropriate to achieve management objectives.

Cover Crops (340)

Establish seasonal crops that provide soil protection for the purposes of improving soil quality through nitrogen fixation, redistribution of nutrients, and increased organic matter; reducing erosion and subsequent sediment transport; reducing compaction; suppressing weeds; and managing soil moisture.

Structural Practices

Structural practices for crops include constructing or otherwise implementing projects that reduce pollution into nearby waterways.

Contour Buffer Strips (332)

Establish narrow bands of permanent vegetation on hillslopes that are farmed on the contour, to reduce sheet and rill erosion, reduce sediment and other water-borne contaminants transport, and increase infiltration.

Grassed Waterway (412)

Construct channel with established vegetation suitable for carrying surface water in a non-erosive manner to a stable outlet.

Herbaceous Wind Barriers (603)

Establish vegetation in rows or narrow strips in the field across the prevailing wind direction to reduce wind erosion, protect crops from dust, and to provide food and cover for wildlife.

Mulching (484)

Apply shredded or chipped plant fibers to the soil surface to conserve soil moisture, moderate soil temperature, provide erosion control, suppress weed growth, facilitate the establishment of vegetation, improve soil condition and reduce airborne particulates.

Revetments

Place material on the banks of ditches, channels, and streams to prevent surface erosion and scour. This practice reduces the potential for mast wasting, protects structures, and improves water quality.

Riprap

Construct “blanket” of appropriately-sized rock to protect hillslopes, irrigation ditches, channels, and streambanks from erosion. In sensitive habitats plantings should be integrated into rip rap to mitigate for potentially negative effects on wildlife.

Sediment Basins

Construct basin to intercept runoff with the purpose of capturing sediment, debris and other pollutants originating from farmland, construction sites, or other disturbed sites.

Terraces

Construct benches or berms into a hillside to provide a level or slightly concave surface for supporting plant growth, and intercepting surface runoff. This practice shortens slope length to reduce erosion and provides increased infiltration of irrigation water and rainfall.

Waste Treatment Lagoons

Construct ponds using an embankment or digging a pit with the purpose of intercepting waste discharge/runoff from facilities such as confined animal operations with the intent of biologically treating waste, such as manure and wastewater, thus reducing pollution in sensitive waterways.

Irrigation System

Implement an irrigation system in which all necessary equipment and facilities are installed for efficiently and uniformly applying irrigation to maintain soil moisture at the necessary level to grow crops without causing excessive water loss, erosion, or water quality impairment.

Irrigation Water Conveyance

Design water conveyance structures or systems to prevent waterlogging of soil, maintain water quality, and reduce water loss.

Urban MMPs

Municipalities are typically responsible for managing land such as parks and open space, maintaining urban infrastructure, operating facilities, and overseeing utilities that have the potential to impact sensitive habitats. In the Santa Rosa Creek Watershed the Cambria Community Services District manages or oversees the majority of operations and facilities that a City would. Other agencies also oversee infrastructure such as roads, bridges, and highways, including the County of San Luis Obispo and Caltrans.

The following practices (Table 15) should be considered for implementation in current or future activities to reduce impacts on receiving water bodies. Describing these practices in detail is outside the scope of this plan, but additional information can be found through the California Stormwater Quality Association (CASQA), the Regional Water Quality Control Board, and the San Luis Obispo County Stormwater Quality Management Plan.

Table 15. Management measures and practices used to reduce impacts to water bodies in urban areas. *Source: CASQA Stormwater Best Management Practice (BMP) Handbooks – Municipal Handbook 2004.*

Source Control BMPs	**Source Control BMPs**
SC-10 Non-Stormwater Discharges	SC-43 Parking/Storage Area Maintenance
SC-11 Spill Prevention, Control & Cleanup	SC-50 Over Water Activities
SC-20 Vehicle and Equipment Fueling	SC-60 Housekeeping Practices
SC-21 Vehicle and Equipment Cleaning	SC-61 Safer Alternative Products
SC-22 Vehicle and Equipment Repair	SC-70 Road and Street Maintenance
SC-30 Outdoor Loading/Unloading	SC-71 Plaza and Sidewalk Cleaning
SC-31 Outdoor Container Storage	SC-72 Fountain & Pool Maintenance
SC-32 Outdoor Equipment Maintenance	SC-73 Landscape Maintenance
SC-33 Outdoor Storage of Raw Materials	SC-74 Drainage System Maintenance
SC-34 Waste Handling & Disposal	SC-75 Waste Handling and Disposal
SC-41 Building & Grounds Maintenance	SC-76 Water & Sewer Utility Maint.
Treatment Control BMPs	**Treatment Control BMPs**
TC-10 Infiltration Trench	TC-30 Vegetated Swale
TC-11 Infiltration Basin	TC-31 Vegetated Buffer Strip
TC-12 Retention/Irrigation	TC-32 Bioretention
TC-20 Wet Pond	TC-40 Media Filter
TC-22 Extended Detention Basin	TC-50 Water Quality Inlet

Construction MMPs

Construction MMPs are critical to the protection of Santa Rosa Creek Watershed. Describing these practices in detail is outside the scope of this plan, however a sample of important practices related directly to the protection of Santa Rosa Creek and its tributaries are listed below. The National Pollutant Discharge Elimination System (NPDES) sets requirements for construction projects that include 1 or more acres of soil disturbance that have the potential to generate polluted stormwater. Project sponsors have a legal requirement to protect waters of the State and they must implement appropriate practices, some of which are listed below. Other agencies have jurisdiction over projects that have the potential to impact sensitive resources and are listed in Section 7. The following practices (Table 16) also benefit species of concern by protecting sensitive habitats.

Table 16. Management measures and practices used to protect sensitive habitats during construction projects. *Source: Caltrans Storm Water Quality Handbooks, Construction Site Best Management Practices Manual, March 1, 2003.*

Temporary Soil Stabilization	**Non-Storm Water Management**
SS-1 Scheduling	NS-1 Water Conservation Practices
SS-2 Preservation of Existing Vegetation	NS-2 Dewatering Operations
SS-3 Hydraulic Mulch	NS-3 Paving and Grinding Operations
SS-4 Hydroseeding	NS-4 Temporary Stream Crossing
SS-5 Soil Binders	NS-5 Clear Water Diversion
SS-6 Straw Mulch	NS-6 Illicit Connection/Illegal Discharge
SS-7 Geotextiles, Plastic Covers & Erosion Control Blankets	NS-7 Potable Water/Irrigation
SS-8 Wood Mulching	NS-8 Vehicle and Equipment Cleaning
SS-9 Earth Dikes/Drainage Swales & Lined Ditches	NS-9 Vehicle and Equipment Fueling
SS-10 Outlet Protection/Velocity Dissipation Devices	NS-10 Vehicle and Equipment Maintenance
SS-11 Slope Drains	NS-11 Pile Driving Operations
SS-12 Streambank Stabilization	NS-12 Concrete Curing
Temporary Sediment Control	NS-13 Material and Equipment Use Over Water
SC-1 Silt Fence	NS-14 Concrete Finishing
SC-2 Sediment/Desilting Basin	NS-15 Structure Demolition/Removal Over/Adjacent to Water
SC-3 Sediment Trap	**Waste Management and Materials Pollution Control**
SC-4 Check Dam	WM-1 Material Delivery and Storage
SC-5 Fiber Rolls	WM-2 Material Use
SC-6 Gravel Bag Berm	WM-3 Stockpile Management
SC-7 Street Sweeping and Vacuuming	WM-4 Spill Prevention and Control
SC-8 Sandbag Barrier	WM-5 Solid Waste Management
SC-9 Straw Bale Barrier	WM-6 Hazardous Waste Management
SC-10 Storm Drain Inlet Protection	WM-7 Contaminated Soil Management
Wind Erosion Control	WM-8 Concrete Waste Management
WE-1 Wind Erosion Control	WM-9 Sanitary/Septic Waste Management
Tracking Control	WM-10 Liquid Waste Management
TC-1 Stabilized Construction Entrance/Exit	
TC-2 Stabilized Construction Roadway	
TC-3 Entrance/Outlet Tire Wash	

5.5. RECOMMENDED PRIORITIES AND RANKING SYSTEM

For the purposes of identifying priority properties for acquisition and restoration under this planning document, criteria were identified and a point system was developed. It is suggested the following method be considered when developing future conservation projects in the watershed:

For each of the eight criteria listed below assign a score for the given property. The total points will show how one property compares to another and will also provide a stand-alone ranking according to the criteria. A final tally of 20 points or greater indicates a high priority project area. A total of 15 to 19 points indicates good conservation value and a worthwhile project. A total of 10 to 14 points identifies low priority properties with some important resources. A total of less than 10 points indicates very low priority.

Steelhead Habitat

Properties that contain steelhead spawning and rearing habitat are high priorities for conservation in the Santa Rosa Creek Watershed. Properties that offer summer habitat when most of the tributaries are dry are very important. Properties that offer winter habitat and have the potential to provide habitat if barriers are altered or removed should also be a priority for conservation. Award five (5) points for properties containing summer habitat (when stream flows are lowest); award three (3) points for properties containing winter habitat (when stream flows are highest allowing the greatest potential for migration/passage); and, award one (1) point for properties that could potentially contain steelhead habitat (through removal of migration barriers, or through increased stream flows).

Presence of Listed Threatened or Endangered Species

Properties where threatened or endangered species are known to exist are priorities for conservation. Resources such as the California Natural Diversity Data Base (CNDDB) can be used to determine definitive presence, however, properties should be studied closely (site specific surveys, etc.) during project development to gather more information specific to that property. Award one (1) point per species thought to be present.

Persistent Baseflow

Protecting persistent baseflow in the creek or perennial springs draining to the creek is critical to maintaining summer flow; therefore properties that contain these features are high priorities for conservation. Award five (5) points to properties contributing persistent baseflow.

Stream Corridors

Properties that contain segments of stream corridors are a high priority for conservation as streams and riparian areas offer habitat to sensitive species, provide connectivity between other important habitats, and provide buffers that filter out pollutants such as nutrients and sediment. Properties were ranked based on the presence and number of distinct riparian stream corridors that begin or pass through that property. Award five (5) points to properties containing three or more distinct stream corridors; Award three (3) points for two stream corridors; and, award one (1) for one corridor. Aerial photography, USGS maps (blue line stream designations), and GIS data obtained from the County of San Luis Obispo were are all sources used to identify stream corridors.

Erosion Potential

Properties with high erosion potential can be considered the most fragile and most likely to contribute fine sediment to the system, thus having the highest potential to degrade steelhead habitat; therefore, such properties should be protected, and possibly restored. The RUSLE2 model described in detail in Chapter 4 of this plan should be used to assign points. Award five (5) points to properties where RUSLE2 predicted soil loss is between 4.1 and 5 tons per acre per year; four (4) points for 3.1-4 tons per acre per year; three (3) points for 2.1-3 tons per acre per year; two (2) points for 1.1-2 tons per acre per year; and, one (1) point for 0-1 ton per acre per year.

Monterey Pines

Properties in the lower watershed that support healthy stands of Monterey Pines are a conservation priority and should be awarded five (5) points for presence. Monterey Pine forest can be derived from aerial photography and GIS analysis included in this Conservation Plan.

Development Potential

Properties that are more easily developed based on zoning laws and general plans should be prioritized for the purposes of conservation. Ranches or farms with high priority resource values that contain numerous parcels and/or are not under the protection of the Williamson Act or Coastal Zone restrictions should have the highest priority. This score is based on a combination of several factors that are deemed indicators of development potential. Award three (3) points to properties comprised of 10 or more parcels; two (2) points for 6-9 parcels; one (1) point for 2-5 parcels. Award two (2) points to properties that lie entirely outside of the Coastal Zone, and one (1) point to properties that are partially within and partially outside of the Coastal Zone. Deduct two (2) points from properties that are entirely in the Williamson Act, and deduct one (1) point for those properties that are partially in Williamson Act and partially not. Assessor parcel data, Coastal Zone overlay information, and Williamson Act enrollment information can be obtained from the County of San Luis Obispo.

Connectivity with Existing Public and Private Conservation Land

Properties that contribute to a larger mosaic of public and private conservation lands, including Bureau of Land Management (BLM), US Forest Service, and existing conservation easements are a priority for conservation. Award five (5) points to properties with a connectivity component.

Other Potential Criteria

Other important features that could be considered include oak woodland diversity, scenic viewsheds/corridors, wildlife migration corridors, cultural archaeological features, soils, etc. These were not considered closely in this plan due to the limited availability of data. It is important to note that public agency funders such as the State Coastal Conservancy also consider the availability of public recreational access when evaluating potential acquisition proposals.

5.6. CONCLUSION

Land acquisition, active restoration, and on-the-ground management practices provide key tools necessary to protect the Santa Rosa Creek Watershed. Where willing landowners exist, comprehensive conservation and restoration of land and sensitive areas are a top priority for protecting steelhead, sensitive habitat, soils, perennial base flow, and Monterey pines. It is recommended that the information presented in this Conservation Plan and the associated appendices be utilized to identify priority projects for conservation and restoration. It is also recommended that, where possible, the practices identified above be implemented on lands under conservation protection and on properties where landowners are willing to undertake practices that help reduce soil loss, improve water quality, improve yields and production, and maintain watershed health and function. Projects that include land acquisition/conservation easements, restoration activities, and on-going management practices can be viewed as complete conservation, where protection, repair, and long term stewardship are all combined to provide sustainable conservation of sensitive habitats and important natural resources.

6. EXISTING DATA

Existing informative resources for the Santa Rosa Creek Watershed have been located and summarized into a reference table. Reports, articles, and websites that have information relating to the watershed were included in this table located in Appendix Q. There were 234 existing reports and other informative resources that were located for the Santa Rosa Creek Watershed. Resources are sorted by subject, including: agriculture, assessment, biology, forestry, geology, history, hydrology, land use, plan, regulation, restoration, soils, transportation, water quality, water rights, water treatment, water use, and wetlands.

GIS data including information applicable to Santa Rosa Creek Watershed background, fisheries, soils, erosion, and land use were acquired through different sources. Other GIS data were created by the consultant for this Conservation Plan. Any edits to existing data acquired through other sources were noted in a summary table. There were 85 GIS layers significant to the Santa Rosa Creek Watershed Conservation Plan. The GIS layers content and source information is described in Appendix G of this Conservation Plan.

7. STATUTORY FRAMEWORK

Working at a watershed level requires the collaboration of federal, state, and local agencies. Numerous political agencies and districts operate within the Santa Rosa Creek Watershed boundaries, and are described briefly below.

7.1. POLITICAL DISTRICTS

Congressional District

Congressional District 23

Boundary: Coastal California from the Monterey County line to Oxnard.

Representative: Congresswoman Lois Capps

Committees: Committee on Energy and Commerce, and Natural Resources Committee

Contact information:

<u>Washington, D.C.</u>

1110 Longworth House Office Building

Washington D.C. 20515

Phone: (202) 225-3601

<u>San Luis Obispo</u>

1411 Marsh Street, Suite 205

San Luis Obispo, CA 43401

Phone: (805) 546-8348

State Senate District

Senate District 15

Boundary: Coastal California stretching from Santa Cruz to Santa Maria

Representative: currently vacant

Assembly District

State Assembly District 33

Boundaries: Includes all of San Luis Obispo County and western Santa Barbara County from Santa Maria to Lompoc.

Representative: Assemblyman Sam Blakeslee

Committees: Budget, Rules, and Utilities and Commerce

Contact information:

Capitol Office
State Capitol, Room 4117
Sacramento, CA 95814
Phone: (916) 319-2033

San Luis Obispo District Office
1104 Palm Street
San Luis Obispo, CA 93401
Phone: (805) 549-3400

7.2. FEDERAL REGULATORY AGENCIES

U.S. Army Corps of Engineers (USACE)

The Santa Rosa Creek Watershed is within the South Pacific Division of the Los Angeles District of the US Army Corps of Engineers (USACE). The Army Corps provides engineering services in water resources, environment, infrastructure, homeland security, and warfighting. Through their Civil Works program, they provide flood protection, coastal protection, navigable waters and ports, water supply, as well as recreational opportunities. They are also responsible for programs such as: Ecosystem Restoration, Environmental Stewardship, EPA Superfund, Abandoned Mine Lands, and Regulatory to list a few. USACE regulates discharge of dredge or fill material in coastal and inland waters and wetlands, construction and dredging in navigable waters, and the transport and disposal of dredged materials into ocean waters. USACE wetland-related regulatory mechanisms include:

- Clean Water Act, Section 404 (b)(1) Guideline
- Marine Protection, Research and Sanctuaries Act
- Endangered Species Act
- National Historic Preservation Act
- Coastal Zone Management Act
- National Environmental Policy Act
- Fish and Wildlife Coordination Act

Los Angeles District Regulatory Office: Ventura Field Office
2151 Alessandro Drive, Suite 110
Ventura, CA 93001
Phone: (805) 585-2140

U.S. Fish and Wildlife Service (USFWS)

Santa Rosa Creek Watershed is located in the Pacific Region (Region 1) of the USFWS. The USFWS conserves, protects, and enhances fish, wildlife, plants, and their habitats for the continuing benefit of the public. The USFWS consults with the USACE to assure permitted projects protect fish and wildlife, and assess potential impacts to restrict potentially harmful activities. They are also in charge of enforcing federal laws that protect wildlife, such as the Endangered Species Act.

Local Office: Ventura

Ventura Fish and Wildlife Office

2493 Portola Road, Suite B

Ventura, CA 93003

Phone: (805) 644-1766

National Oceanic and Atmospheric Administration (NOAA) Fisheries Service

Santa Rosa Creek Watershed is located within the Southwest Region of the NOAA Fisheries Service. NOAA Fisheries Service is a division of the Department of Commerce that promotes sustainable fisheries, recovery of protected species, and the health of coastal marine habitats in the United States. NOAA's National Marine Fisheries Service works with communities on fishery management issues and to prevent lost economic potential due to overfishing, declining species and degraded habitats. Like the USFWS, NOAA Fisheries Service also works with other federal agencies to see that projects permitted comply with various federal regulations regarding fisheries and protected species.

Local Office: Long Beach

National Marine Fisheries Service

501 West Ocean Blvd.

Long Beach, CA 90802-4213

Phone: (562) 980-4000

Monterey Bay National Marine Sanctuary (MBNMS)

The MBNMS is a federally protected marine area offshore of central California, stretching from Marin to Cambria. The MBNMS is one of 13 National Marine Sanctuaries and one marine national monument, administered by the National Oceanic and Atmospheric Administration. The MBNMS was created for natural resource protection, education, research, and public use of the sanctuary.

MBNMS San Simeon Office and Coastal Discovery Center:

750 Hearst Castle Road

San Simeon, CA 93452

Phone: (805) 927-2145

U.S. Environmental Protection Agency (USEPA)

Santa Rosa Creek Watershed is located in the Pacific Southwest, Region 9, of the USEPA. EPA is primarily responsible for protecting human health and safeguarding the natural environment in the United States. They regulate environmental hazards, such as air and water pollution, solid waste disposal, radiation and pesticides. The EPA also coordinates and supports research and pollution mitigation activities.

Headquarters Office:

US EPA Region 9

75 Hawthorne Street

San Francisco, CA 94105

Phone: (866) EPA WEST

7.3. STATE REGULATORY AGENCIES

California Department of Fish and Game (CDFG)

The Santa Rosa Creek Watershed lies within the CDFG's Region 4, Central Region, serving Fresno, Kern, Kings, Madera, Mariposa, Merced, Monterey, San Benito, San Luis Obispo, Stanislaus, Tulare and Tuolumne counties. The local regional office is in Yountville, Ca, but local CDFG employees have satellite offices in San Luis Obispo.

The CDFG conserves, protects, and manages the state's fish, wildlife, and native plant resources. Projects that impact a river, stream, or lake must be regulated by CDFG. If the Department determines the project may alter fish and wildlife resources, then a Lake or Streambed Alteration Agreement is required. The principal enforcement mechanism for CDFG is the California Fish and Game Code, Section 1600.

Central Region Headquarters Office:

1234 E. Shaw Avenue

Fresno, CA 93710

Phone: (559) 243-4005 ext. 151

Regional Water Quality Control Board (Regional Boards)

The State Water Resources Control Board has nine Regional Boards designed to develop and enforce water quality objectives. The Santa Rosa Creek Watershed lies within the Central Coast Region (3) of the Regional Board. Regional Board develop "basin plans" for their hydrologic area, monitor water quality, govern requirements, issue waste discharge permits, and identify and take enforcement action against violators.

Their principle regulatory mechanism comes from the federal Clean Water Act (CWA), which is driven in California by the Porter-Cologne Water Quality Control ct of 1970. As part of their responsibilities, the RWQCB maintains the State's 303(d) list of impaired water bodies, which require the Regional Board to prepare studies and remediation plans to bring water bodies water quality to the state's standards. In addition, the RWQCB works with the Army Corps of Engineers to issue compliance documents for Section 401 of the CWA.

Regional Office:

Central Coast Region (3)

895 Aerovista Place, Suite 101

San Luis Obispo, CA 93401

Phone: (805) 549-3147

California Coastal Commission

The Santa Rosa Creek Watershed is within the Central Coast District Office of the California Coastal Commission, which includes Santa Cruz, Monterey, and San Luis Obispo Counties. The Coastal Commission regulates land and water use within the coastal zone. The Coastal Commission also permits activities such as building construction, land divsions, and other acts that change public access or the intensity of land use. The Coastal Commission regulates under the Coastal Act, which includes specific policies that address shoreline public access and recreation, visitor accommodations, protection of terrestrial and marine habitat, visual resources, alteration of landform, agricultural lands, commercial fisheries, industrial uses, water quality, development of offshore oil and gas, transportation, power plants, ports, public works, and development design.

District Office:

725 Front Street, Suite 300

Santa Cruz, CA 9060-4508

Phone: (831) 427-4877

7.4. NON-REGULATORY AGENCIES

Natural Resources Conservation Service (NRCS)

The NRCS assists landowners with conservation planning that benefits soil, water, air, plants, and animals, resulting in healthy ecosystems and productive lands. NRCS works locally, positioned in USDA Service Centers in nearly every county in the nation.

Local Service Center:

Templeton Service Center

65 South Main St., Ste. 106

Templeton, CA 93465-8703

Phone: (805) 434-0396

Resources Conservation District (RCD)

There are several Resource Conservation Districts in California. They are locally governed agencies established under the county's Local Agency Formation Committee (LAFCO). The RCD provides soil and water conservation information and assistance to private landowners, such as farmers and ranchers. They are also a growing component of conservation efforts, participating in watershed outreach and planning organizations, as well as implementing projects on private and public lands.

Upper Salinas-Las Tablas Resources Conservation District

65 South Main St., Ste. 107

Templeton, CA 93465

Phone: (805) 434-0396 ext. 5

San Luis Obispo County Farm Bureau

The San Luis Obispo Farm Bureau preserves farm land and increases agricultural awareness throughout the county. North Coast Farm Center is the district representing Cambria farmers.

651 Tank Farm Road

San Luis Obispo, CA 93401

(805) 543-3654

Land Conservancy of San Luis Obispo County

The Land Conservancy works to permanently protect and enhance lands that have valuable scenic, agricultural, habitat and cultural resources for both people and wildlife. Their goal is to help prevent poorly planned development, protect drinking water sources, restore wildlife habitat, and promote family farmlands and ranches.

Physical Address:

547 Marsh St.

San Luis Obispo, CA 93401

Mailing Address:

P.O. Box 12206

San Luis Obispo, CA 93406

(805) 544-9096

Greenspace The Cambria Land Trust

Greenspace is dedicated to the preservation and enhancement of the North Coast of San Luis Obispo County’s natural environment. Greenspace activities include creating pocket parks, preserving cultural resources, open space protection, managing protected lands, stream restoration, increasing public awareness, and environmental/wildlife advocacy.

Physical Address:

4251 Bridge St., Suite B

Cambria, CA 93428

Mailing Address:

P.O. Box 1505

Cambria, CA 93428

(805) 927-2866

Central Coast Salmon Enhancement (CCSE)

The CCSE is dedicated to the enhancement and restoration of the Central Coast salmon fishery and local creeks. CCSE is also devoted to educating the community on the ecology and economy of these resources.

229 Stanley Ave.

Arroyo Grande, CA 933420

(805) 473-8221

7.5. LOCAL GOVERNMENT

County of San Luis Obispo Planning and Building

The County of San Luis Obispo Planning and Building Department provides public resources for county-wide planning and development. The Planning and Building Department provides land use and development permits, building permits, code enforcement, zoning and maps, long-range community planning and other services.

Office:

Department of Planning and Building

County Government Center

San Luis Obispo, CA 93408

Phone: (805) 781-5600

Cambria Community Services District

The Cambria Community Services District provides water, wastewater, fire protection, trash collection and other services to its customers.

Location:
1316 Tamson Drive
Cambria, CA 93428

Mailing:
P.O. Box 65
Cambria, CA 93428

Phone: 805-927-6223
Fax: 805-927-5584

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9. GLOSSARY

9.1. GEOLOGY TERMINOLOGY[1]

alluvium – general term for clay, silt, sand, gravel, or similar unconsolidated detrital material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semisorted sediment in the bed of the stream or on its flood plain or delta, or as a cone or fan at the base of a mountain slope.

basalt – a general term for dark-colored igneous rocks.

igneous – said of a rock or mineral that solidified from molten or partly molten material.

interbedded – beds lying between or alternating with others of different character.

mélange – a mappable body of rock characterized by the inclusion of fragments and blocks of all sizes embedded in a fragmented and generally sheared matrix of more tractable material.

metamorphic – any rock derived from pre-existing rocks by mineralological, chemical, and/or structural changes, essentially in the solid state.

metavolcanic – volcanic rock that has been metamorphosed.

sediment – solid fragmental material that originates from weathering of rocks and is transported or deposited by air, water, or ice.

sedimentary – a rock resulting from the consolidation of loose sediment that has accumulated in layers.

stream terrace – one of a series of level surfaces in a stream valley, flanking and more or less parallel to the stram channel, originally occurring at or below, but now above, the level of the stream, and representing the dissected remnants of an abandoned flood plain, stream bed, or valley floor produced during a former stage of erosion or deposition.

subduction zone – A long, narrow belt in which subduction takes place (subduction is the process of one lithospheric plate descending beneath another).

ultramafic – igneous rock composed chiefly of mafic minerals (ferromagnesium, dark-colored minerals).

9.2. SOILS TERMINOLOGY[2]

Available water capacity - the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in centimeters of water per centimeter of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water.

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[1] Bates R. & Jackson J. (Ed) (1980). *Glossary of Geology.* Second Edition. Falls Church, Virginia: American Geological Institute.

[2] Soil Data Explorer, Soil Properties and Qualities. Retrieved on May 7, 2008. Web site: http://websoilsurvey.nrcs.usda.gov/app/

The most important properties are the content of organic matter, soil texture, bulk density, and soil structure, with corrections for salinity and rock fragments. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. It is not an estimate of the quantity of water actually available to plants at any given time.
Associations - soils composed of more than one dissimilar soil occurring in a repeated pattern, with the amount of each soil varying from one location to another.

Complexes - soils composed of more than one dissimilar soil occurring in a repeated pattern, with the amount of each soil varying from one location to another.

Consociations - have one soil name and are labeled for their dominant soil type.

Erodibility of total soil (Kw) - erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water. "Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Farmland- identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. It identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the "Federal Register," Vol. 43, No. 21, January 31, 1978.

Irrigated Capability Class - shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations that show suitability and limitations of groups of soils for rangeland, for woodland, and for engineering purposes.

In the capability system, soils are generally grouped at three levels -- capability class, subclass, and unit.

Capability classes, the broadest groups, are designated by the numbers 1 through 8. The numbers indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class 1 soils have few limitations that restrict their use.

Class 2 soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class 3 soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.

Class 4 soils have very severe limitations that reduce the choice of plants or that require very careful management, or both.

Class 5 soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

Class 6 soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

Class 7 soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland, or wildlife habitat.

Class 8 soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or esthetic purposes.

Irrigated Capability Subclass - soil groups within one capability class. They are designated by adding a small letter, "e," "w," "s," or "c," to the class numeral, for example, 2e. The letter "e" shows that the main hazard is the risk of erosion unless close-growing plant cover is maintained; "w" shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); "s" shows that the soil is limited mainly because it is shallow, droughty, or stony; and "c," used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class 1 there are no subclasses because the soils of this class have few limitations. Class 5 contains only the subclasses indicated by "w," "s," or "c" because the soils in class 5 are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, forestland, wildlife habitat, or recreation.

Shrink-swell - the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change. For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Undifferentiated groups - soils that are composed of more than one soil as well however the soils are not consistently associated geographically and may not always occur together in the same location. Soils found within the same “undifferentiated group” are mapped together because they have common features and have similar land uses and land management. These soils are distinguished by the use of the word “and” between the two component soil names in the soil map unit.

9.3. GIS TERMINOLOGY[3]

3D Analyst – an ArcView extension that enables surface modeling.

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[3] GIS Dictionary. Retrieved on May 7, 2008. Web site: http://support.esri.com/index.cfm?fa=knowledgebase.gisDictionary.gateway.

ArcCatalog – ArcGIS application that allows you to view, organize, distribute, manage, and document GIS data.

attribute table - A database or tabular file containing information about a set of geographic features, usually arranged so that each row represents a feature and each column represents one feature attribute. In raster datasets, each row of an attribute table corresponds to a certain zone of cells having the same value. In a GIS, attribute tables are often joined or related to spatial data layers, and the attribute values they contain can be used to find, query, and symbolize features or raster cells.

clip - A command that extracts features from one feature class that reside entirely within a boundary defined by features in another feature class.

feature - A representation of a real-world object on a map.

field - A column in a table that stores the values for a single attribute.

layer - The visual representation of a geographic dataset in any digital map environment. Conceptually, a layer is a slice or stratum of the geographic reality in a particular area, and is more or less equivalent to a legend item on a paper map. On a road map, for example, roads, national parks, political boundaries, and rivers might be considered different layers.

line - On a map, a shape defined by a connected series of unique x,y coordinate pairs. A line may be straight or curved.

point - A geometric element defined by a pair of x,y coordinates.

polygon - On a map, a closed shape defined by a connected sequence of x,y coordinate pairs, where the first and last coordinate pair are the same and all other pairs are unique.

shapefile - A vector data storage format for storing the location, shape, and attributes of geographic features. A shapefile is stored in a set of related files and contains one feature class.

APPENDIX A

SPECIAL STATUS VEGETATIVE SPECIES LOCATED IN THE SANTA ROSA CREEK WATERSHED

List produced from California Department of Fish and Game's
California Natural Diversity Data Base
and California Native Plant Society
Inventory of Rare and Endangered Plants

SPECIAL STATUS VEGETATION SPECIES LOCATED IN THE SANTA ROSA CREEK WATERSHED

SCIENTIFIC NAME	COMMON NAME	FAMILY	LIFE FORM	CNPS LIST	SRANK	GRANK	STATE STAT	FED STAT
Arctostaphylos cruzensis	Arroyo de la Cruz manzanita	Ericaceae	perennial evergreen shrub	List 1B.2	S2.2	G2	None	None
Arctostaphylos luciana	Santa Lucia manzanita	Ericaceae	perennial evergreen shrub	List 1B.2	S2.2	G2	None	None
Arctostaphylos pechoensis	Pecho manzanita	Ericaceae	perennial evergreen shrub	List 1B.2	S2.2	G2	None	None
Arctostaphylos pilosula	Santa Margarita manzanita	Ericaceae	perennial evergreen shrub	List 1B.2	S2.2	G2	None	None
Arctostaphylos wellsii	Wells' manzanita	Ericaceae	perennial evergreen shrub	List 1B.1	S2.1?	G2	None	None
Calystegia subacaulis ssp. *episcopalis*	Cambria morning-glory	Convolvulaceae	perennial rhizomatous herb	List 1B.2	S1.2	G3T1	None	None
Castilleja densiflora ssp. *obispoensis*	San Luis Obispo owl's-clover	Scrophulariaceae	annual herb	List 1B.2	S2.2	G5T2	None	None
Cirsium fontinale var. *obispoense*	San Luis Obispo fountain thistle	Asteraceae	perennial herb	List 1B.2	S1.2	G2T1	Endangered	Endangered
Cirsium occidentale var. *compactum*	compact cobwebby thistle	Asteraceae	perennial herb	List 1B.2	S2.1	G3G4T2	None	None
Delphinium umbraculorum	umbrella larkspur	Ranunculaceae	perennial herb	List 1B.3	S2S3.3	G2G3	None	None
Eryngium aristulatum var. *hooveri*	Hoover's button-celery	Apiaceae	perennial herb	List 1B.1	S2.1	G5T2	None	None
Galium californicum ssp. *luciense*	Cone Peak bedstraw	Rubiaceae	perennial herb	List 1B.3	S2.3	G5T2	None	None
Galium hardhamiae	Hardham's bedstraw	Rubiaceae	perennial herb	List 1B.3	S2.3	G2	None	None
Horkelia cuneata ssp. *sericea*	Kellogg's horkelia	Rosaceae	perennial herb	List 1B.1	S1.1	G4T1	None	None
Malacothamnus palmeri var. *involucratus*	Carmel Valley bush-mallow	Malvaceae	perennial deciduous shrub	List 1B.2	S2.2	G3T2Q	None	None
Malacothamnus palmeri var. *palmeri*	Santa Lucia bush-mallow	Malvaceae	perennial deciduous shrub	List 1B.2	S2.2	G3T2Q	None	None
Microseris paludosa	marsh microseris	Asteraceae	perennial herb	List 1B.2	S2.2	G2	None	None
Pinus radiata	Monterey pine	Pinaceae	perennial evergreen tree	List 1B.1	S1.1	G1	None	None
Streptanthus albidus ssp. *peramoenus*	most beautiful jewel-flower	Brassicaceae	annual to perennial herb	List 1B.2	S2.2	G2T2	None	None
Triteleia ixioides ssp. *cookii*	Cook's triteleia	Liliaceae	perennial bulbiferous herb	List 1B.3	S2.3	G5T2	None	None

Species list created using California Natural Diversity Data Base (CNDDB) (2009) and California Native Plant Society's (CNPS) Inventory of Rare and Endangered Plants online database (2008).

The following plant was listed on CNPS Inventory as uncertain (or uncertain and possibly extirpated).

SCIENTIFIC NAME	COMMON NAME	FAMILY	LIFE FORM	CNPS LIST	SRANK	GRANK	STATE STAT	FED STAT
Grindelia hirsutula var. maritima	San Francisco gumplant	Asteraceae	perennial herb	List 1B.2	S2.1	G5T2	None	None

STATUS DESCRIPTIONS

California Native Plant Society

List 1B- Plants listed rare, threatened, or endangered in California and elsewhere.

New Threat Code Extensions and Meaning

.1 - Seriously endangered in California
.2 - fairly endangered in California
.3 - not very endangered in California

State Rank (SRANK)

The state rank (S-rank) is assigned much the same way as the global rank, except state ranks in California often also contain a threat designation attached to the S-rank.

S1 = Less than 6 EOs OR less than 1,000 individuals OR less than 2,000 acres
S1.1 = very threatened
S1.2 = threatened
S1.3 = no current threats known

S2 = 6-20 EOs OR 1,000-3,000 individuals OR 2,000-10,000 acres
S2.1 = very threatened
S2.2 = threatened
S2.3 = no current threats known
S3 = 21-80 EOs or 3,000-10,000 individuals OR 10,000-50,000 acres
S3.1 = very threatened
S3.2 = threatened
S3.3 = no current threats known

Global Rank (GRANK)

The global rank (G-rank) is a reflection of the overall condition of an element throughout its global range.

Species or Community Level

G1 = Less than 6 viable element occurrences (EOs) OR less than 1,000 individuals OR less than 2,000 acres.
G2 = 6-20 EOs OR 1,000-3,000 individuals OR 2,000-10,000 acres.
G3 = 21-80 EOs OR 3,000-10,000 individuals OR 10,000-50,000 acres.
G4 = Apparently secure; this rank is clearly lower than G3 but factors exist to cause some concern; i.e., there is some threat, or somewhat narrow habitat.
G5 = Population or stand demonstrably secure to ineradicable due to being commonly found in the world.

Subspecies Level

Subspecies receive a T-rank attached to the G-rank. With the subspecies, the G-rank reflects the condition of the entire species, whereas the T-rank reflects the global situation of just the subspecies or variety. For example: *Chorizanthe robusta* var. *hartwegii* . This plant is ranked G2TI. The G-rank refers to the whole species range i.e., *Chorizanthe robusta* . The T-rank refers only to the global condition of var. *hartwegii* .

APPENDIX B

NON-NATIVE INVASIVE PLANT SPECIES LOCATED IN THE CALIFORNIA FLORISTIC PROVINCE, CENTRAL WEST

List produced from California Invasive Plant Council (Cal-IPC)
California Invasive Plant Inventory Database

NON-NATIVE INVASIVE PLANT SPECIES LOCATED IN THE CALIFORNIA FLORISTIC PROVINCE, CENTRAL WEST

SCIENTIFIC NAME	COMMON NAME	RATING	ALERT	HABITATS OF CONCERN AND COMMENTS	CFMP
Acacia dealbata	silver wattle	Moderate	No	Coastal prairie, riparian woodland, riparian forest, North Coast coniferous forest, closed cone coniferous forest.	
Acacia melanoxylon	black acacia, blackwood acacia	Limited	No	Coniferous forest, chaparral, woodland, riparian. Impacts are low in most areas.	Y
Acacia paradoxa	kangaroothorn	Eval No List	No	Does not spread in wildlands.	
Acroptilon repens	Russian knapweed	Moderate	No	Scrub, grasslands, riparian, pinyon-juniper woodland, forest. Severe impacts in other western states. Spreading in many areas of CA.	
Aegilops triuncialis	barb goatgrass	High	No	Grassland, oak woodland; spreading in NW and in Central Valley.	
Ageratina adenophora	croftonweed, eupatorium	Moderate	No	Coastal canyons, scrub, slopes. Very invasive in Australia, limited information and distribution in CA.	
Agrostis avenacea	Pacific bentgrass	Limited	No	Vernal pools, coastal prairie, meadows, grasslands. Impacts are low in most areas.	
Agrostis stolonifera	creeping bentgrass	Limited	No	Wetlands, riparian; grown for domestic forage. Limited distribution and impacts unknown.	
Ailanthus altissima	tree-of-heaven	Moderate	No	Riparian areas, grasslands, oak woodland. Impacts highest in riparian areas.	
Aira caryophyllea	silver hairgrass	Eval No List	No	Widespread in grasslands, but impacts appear negligible.	
Albizia lophantha	plume acacia	Eval No List	No	Present in Golden Gate National Recreation Area. Need more information.	
Allium triquetrum	three-cornered leek	Eval No List	No	Impacts unknown.	
Ammophila arenaria	European beachgrass	High	No	Coastal dunes	
Anthemis cotula	mayweed chamomile, dog fennel	Eval No List	No	Abiotic and wildlife impacts unknown	
Anthoxanthum odoratum	sweet vernalgrass	Moderate	No	Coastal prairie, coniferous forest. Little information available on impacts and limited ecological range.	
Arctotheca calendula (fertile)	fertile capeweed	Moderate	Alert	Coastal prairie; can produce seed. Important agricultural weed in Australia, but limited distribution in CA.	
Arctotheca calendula (sterile)	sterile capeweed	Moderate	No	Coastal prairie; only propagates vegetatively. More competitive than fertile form, but limited distribution.	
Arundo donax	giant reed	High	No	Riparian areas, commercially grown for musical instrument reeds, structural material, etc.	
Asparagus asparagoides	bridal creeper	Moderate	Alert	Riparian woodland	
Atriplex semibaccata	Australian saltbush	Moderate	No	Coastal grasslands, scrub, upper salt marsh. Limited distribution, but can be very invasive regionally.	
Bassia hyssopifolia	fivehook bassia	Limited	No	Alkaline habitats. Weed of agriculture or disturbed sites. Impacts minor in wildlands.	
Bellardia trixago	bellardia	Limited	No	Grasslands, including serpentine. Impacts and invasiveness appear to be minor.	
Bellis perennis	English daisy	Eval No List	No	Present along trails, not known to spread into undisturbed areas	
Berberis darwinii	Darwin barberry	Eval No List	No	Impacts unknown	
Brachypodium distachyon	annual false-brome, false brome, purple false broom, stiff brome	Moderate	No	Valley and foothill grassland, cimontane woodland	

SCIENTIFIC NAME	COMMON NAME	RATING	ALERT	HABITATS OF CONCERN AND COMMENTS	CFMP
Brachypodium sylvaticum	perennial false-brome	Moderate	Alert	Redwoods and mixed evergreen forest in Santa Cruz Mtns. Expanding range rapidly in OR, potentially very invasive.	
Brassica nigra	black mustard	Moderate	No	Widespread. Primarily a weed of disturbed sites, but can be locally a more significant problem in wildlands.	Y
Brassica rapa	birdsrape mustard, field mustard	Limited	No	Coastal scrub, grasslands meadows, riparian. Primarily in disturbed areas, Impacts appear to be minor or unknown in wildlands.	
Briza maxima	big quackingrass, rattlesnakegrass	Limited	No	Grasslands. Widespread in coast range. Impacts generally minor, but locally can be higher.	Y
Bromus diandrus	ripgut brome	Moderate	No	Dunes, scrub, grassland, woodland, forest. Very widespread, but monotypic stands uncommon.	
Bromus hordeaceus	soft brome	Limited	No	Grasslands, sagebrush, serpentine soils, many other habitats. Very widespread, but primarily in converted annual grasslands.	
Bromus japonicus	Japanese brome, Japanese chess	Limited	No	Great Basin grassland, valley and foothill grassland, pinon and juniper woodland, lower montane coniferous forest	
Bromus madritensis ssp. rubens	red brome	High	No	Scrub, grassland, desert washes, woodlands	
Buddleja davidii	butterflybush	Eval No List	No	Not known to be invasive in CA, although it is a problem in Oregon.	
Cakile maritima	European sea-rocket	Limited	No	Coastal dunes. Widespread, but impacts appear to be minor.	
Cardaria chalepensis	lens-podded white-top	Moderate	Alert	Central Valley wetlands. Limited distribution in CA. May not be as invasive as C. draba.	
Cardaria draba	hoary cress	Moderate	No	Riparian areas, marshes of central coast. More severe invasive in northern CA.	
Carduus acanthoides	plumeless thistle	Limited	No	Valley and foothill grasslands. Distribution limited in CA, impacts higher locally.	
Carduus pycnocephalus	Italian thistle	Moderate	No	Forest, scrub, grasslands, woodland. Very widespread. Impacts may be variable regionally.	Y
Carduus tenuiflorus	slenderflower thistle	Limited	No	Valley and foothill grasslands. Limited distribution, Impacts appear to be minor.	
Carpobrotus chilensis	sea-fig, iceplant	Moderate	No	Coastal dunes, scrub, prairie. Little information on species, most inferred from C. edulis.	
Carpobrotus edulis	Hottentot-fig, iceplant	High	No	Coastal habitats, especially dunes	
Carthamus lanatus	woolly distaff thistle	Moderate	Alert	Grasslands. Expanding in coast ranges, may become more severe. Current distribution limited.	Y
Centaurea calcitrapa	purple starthistle	Moderate	No	Grasslands. Impacts regionally variable. Distribution relatively limited.	Y
Centaurea debeauxii	meadow knapweed	Moderate	Alert	Grasslands. Spreading rapidly in NW CA, but distribution limited elsewhere. Little known of impacts.	
Centaurea diffusa	diffuse knapweed	Moderate	No	Severe impacts in other western states. Limited distribution in CA with impacts higher in some locations.	
Centaurea maculosa	spotted knapweed	High	No	Riparian, grasslands, wet meadows, forests. More widely distributed in other western states.	
Centaurea solstitialis	yellow starthistle	High	No	Grasslands, woodlands, occasionally riparian	Y
Cestrum parqui	willow jessamine	Eval No List	No	Impacts unknown	
Chondrilla juncea	rush skeletonweed	Moderate	No	Grasslands. Very invasive in other western states, but currently limited in distribution in CA.	

SCIENTIFIC NAME	COMMON NAME	RATING	ALERT	HABITATS OF CONCERN AND COMMENTS	CFMP
Chrysanthemum coronarium	crown daisy	Moderate	No	Coastal prairie, dunes, and scrub. Impacts generally low to moderate, but can vary regionally.	
Cirsium arvense	Canada thistle	Moderate	No	Grasslands, riparian areas, forests. Severe impacts in other western states. Limited distribution in CA.	
Cirsium vulgare	bull thistle	Moderate	No	Riparian areas, marshes, meadows. Widespread, can be very problematic regionally.	
Cistus ladanifer	gum rockrose	Eval No List	No	Negligible known impacts in wildlands	
Conicosia pugioniformis	narrowleaf iceplant	Limited	No	Coastal dunes, scrub, grassland. Limited distribution. Impacts generally minor but can be higher locally.	
Conium maculatum	poison-hemlock	Moderate	No	Riparian woodland, grassland. Widespread in disturbed areas. Abiotic impacts unknown. Impacts can vary locally.	Y
Convolvulus arvensis	field bindweed	Eval No List	No	Only known as agricultural weed	
Cordyline australis	giant dracaena, New Zealand cabbage tree	Limited	No	Coniferous forest. Two reports of horticultural escape into wildlands. Appears best suited to moist, cool climates.	
Cortaderia jubata	jubatagrass	High	No	Many coastal and interior habitats	
Cortaderia selloana	pampasgrass	High	No	Coastal dunes, coastal scrub, Monterey pine, riparian, grasslands, wetlands, serpentine soils. Still spreading both coastal and inland.	Y
Cotoneaster franchetii	orange cotoneaster	Moderate	No	Coniferous forest. Limited distribution. Abiotic impacts largely unknown.	
Cotoneaster lacteus	Parney's cotoneaster	Moderate	No	Many coastal habitats, mainly a problem from SF Bay Area north along coast but also in San Diego County. Limited distribution. Abiotic impacts largely unknown.	
Cotoneaster pannosus	silverleaf cotoneaster	Moderate	No	Many coastal habitats, mainly a problem from SF Bay Area north along coast. Limited distribution. Abiotic impacts largely unknown.	
Cotula coronopifolia	brassbuttons	Limited	No	Salt and freshwater marshes. Impacts largely unknown, but appear to be minor.	
Crataegus monogyna	hawthorn	Limited	No	Riparian habitats, woodland. Limited distribution. Impacts appear to be minor.	
Crocosmia x crocosmiiflora	montbretia	Limited	No	Coastal scrub and prairie, north coast forests. Abiotic impacts unknown. Higher invasiveness in some areas.	
Cupressus macrocarpa	Monterey cypress	Native	No	Native to Monterey area. Invades coastal prairie, desert scrub, riparian areas.	
Cynara cardunculus	artichoke thistle	Moderate	No	Coastal grasslands. Impacts more severe in southern CA where monotypic stands are more common.	
Cynodon dactylon	bermudagrass	Moderate	No	Riparian scrub in southern CA. Common landscape weed, but can be very invasive in desert washes.	
Cynosurus echinatus	hedgehog dogtailgrass	Moderate	No	Oak woodland, grassland. Widespread, impacts vary regionally, but typically not in monotypic stands.	
Cytisus scoparius	Scotch broom	High	No	Coastal scrub, oak woodland, horticultural varieties may also be invasive.	Y
Cytisus striatus	Portuguese broom	Moderate	No	Coastal scrub, grasslands; often confused with C. scoparius. Limited distribution.	
Dactylis glomerata	orchardgrass	Limited	No	Grasslands, broadleaved forest, woodlands; common forage species. Impacts appear to be minor.	

SCIENTIFIC NAME	COMMON NAME	RATING	ALERT	HABITATS OF CONCERN AND COMMENTS	CFMP
Daucus carota	wild carrot, Queen Anne's lace	Eval No List	No	Very widespread, but primarily in disturbed sites, particularly roadsides	
Delairea odorata	Cape-ivy, German-ivy	High	No	Coastal, occasionally other riparian areas, common discard from gardens.	Y
Descurainia sophia	flixweed, tansy mustard	Limited	No	Scrub, grassland, woodland. Impacts appear to be minor, but locally more invasive in NE CA.	
Digitalis purpurea	foxglove	Limited	No	Forest, woodland. Widely escaped ornamental. Impacts largely unknown but appear to be minor.	
Dimorphotheca sinuata	African daisy	Eval No List	No	Impacts to abiotic processes and plant communities unknown	
Dipsacus fullonum	common teasel	Moderate	No	Grasslands, seep, riparian scrub. Impacts regionally variable, forms dense stands on occasion.	
Dipsacus sativus	fuller's teasel	Moderate	No	Grasslands, seep, bogs. Impacts regionally variable, forms dense stands on occasion.	
Dittrichia graveolens	stinkwort	Moderate	Alert	Grasslands, riparian scrub. Spreading rapidly, impacts may become more important in future.	
Echium candicans	pride-of-Madeira	Limited	No	Little information on impacts.	
Ehrharta calycina	purple veldtgrass	High	No	Sandy soils, especially dunes; rapidly spreading on central coast.	
Ehrharta erecta	erect veldtgrass	Moderate	No	Scrub, grasslands, woodland, forest. Spreading rapidly, impacts may become more important in future.	
Eichhornia crassipes	water hyacinth	High	Alert	Aquatic systems in Sacramento-San Joaquin Delta	
Elaeagnus angustifolia	Russian-olive	Moderate	No	Interior riparian. Impacts more severe in other western states. Current distribution limited in CA.	
Erechtites glomerata, E. minima	Australian fireweed, Australian burnweed	Moderate	No	Coastal woodland, scrub, forests. Widespread on coast, but impacts low overall. May vary locally.	
Erigeron karvinskianus	Mexican daisy	Eval No List	No	Impacts unknown, but appears to be expanding. May become more problematic in future	
Erodium botrys	broadleaf filaree	Eval No List	No	Present in wildlands but known impacts are negligible. Often transient.	
Erodium brachycarpum	short-fruited filaree	Eval No List	No	Present in wildlands but known impacts are negligible.Often transient.	
Erodium cicutarium	redstem filaree	Limited	No	Many habitats. Widespread. Impacts minor in wildlands. High-density populations transient.	
Erodium moschatum	whitestem filaree	Eval No List	No	Primarily an agricultural weed, little impact in wildlands.	
Eucalyptus camaldulensis	red gum	Limited	No	Mainly southern CA urban areas. Impacts, invasiveness and distribution all minor.	Y
Eucalyptus globulus	Tasmanian blue gum	Moderate	No	Riparian areas, coastal grasslands, scrub. Impacts can be much higher in coastal areas.	Y
Euphorbia lathyris	caper spurge	Eval No List	No	Abiotic impacts unknown	
Euphorbia oblongata	oblong spurge	Limited	No	Meadows, woodlands. Limited distribution. Impacts unknown. Locally in dense stands.	
Festuca arundinacea	tall fescue	Moderate	No	Coastal scrub, grasslands; common forage grass. Widespread, abiotic impacts unknown.	
Ficus carica	edible fig	Moderate	No	Riparian woodland. Can spread rapidly. Abiotic impacts unknown. Can be locally very problematic.	
Foeniculum vulgare	fennel	High	No	Grasslands, scrub.	

SCIENTIFIC NAME	COMMON NAME	RATING	ALERT	HABITATS OF CONCERN AND COMMENTS	CFMP
Genista monspessulana	French broom	High	No	Coastal scrub, oak woodland, grasslands. Horticultural selections may also be invasive.	Y
Geranium dissectum	cutleaf geranium	Moderate	No	Numerous habitats but impacts appear minor.	
Geranium molle	dovefoot geranium	Eval No List	No	Present in wildlands, but known impacts are negligible	
Geranium retrorsum	New Zealand geranium	Eval No List	No	Present in wildlands, but known impacts are negligible	
Geranium robertianum	herb-robert, Robert geranium	Eval No List	No	Present in wildlands, but known impacts are negligible	
Hedera helix, H. canariensis	English ivy, Algerian ivy	High	No	Coastal forests, riparian areas. Species combined due to genetics questions.	Y
Helichrysum petiolare	licoriceplant	Limited	No	North coastal scrub. Limited distribution. Impacts unknown, but can form dense stands.	
Hirschfeldia incana	shortpod mustard, summer mustard	Moderate	No	Scrub, grasslands, riparian areas. Impacts not well understood, but appear to be greater in southern CA.	
Holcus lanatus	common velvet grass	Moderate	No	Coastal grasslands, wetlands. Impacts can be more severe locally, especially in wetland areas.	
Hordeum marinum, H. murinum	Mediterranean barley, hare barley, wall barley	Moderate	No	Grasslands; H. marinum invades drier habitats, while H. murinum invades wetlands. Widespread, but generally do not form dominant stands.	
Hypericum perforatum	common St. John's wort, klamathweed	Moderate	No	Many northern CA habitats. Abiotic impacts low. Biological control agents have reduced overall impact.	
Hypochaeris glabra	smooth catsear	Limited	No	Scrub and woodlands. Widespread. Impacts appear to be minor. Some local variability.	
Hypochaeris radicata	rough catsear, hairy dandelion	Moderate	No	Coastal dunes, scrub, and prairie; woodland, forest. Widespread. Impacts unknown or appear to be minor.	
Ilex aquifolium	English holly	Moderate	Alert	North coast forests. Expanding range south from OR.	
Iris pseudacorus	yellowflag iris	Limited	No	Riparian, wetland areas, esp. southern CA. Limited distribution. Abiotic impacts unknown.	
Kochia scoparia	kochia	Moderate	No	Scrub, chaparral, grasslands	
Lactuca serriola	prickly lettuce	Eval No List	No	Primarily an agricultural and roadside weed	
Lepidium latifolium	perennial pepperweed, tall whitetop	High	No	Coastal and inland marshes, riparian areas, wetlands, grasslands; potential to invade montane wetlands.	
Leptospermum laevigatum	Australian tea tree	Eval No List	No	Very limited distribution.	
Leucanthemum vulgare	ox-eye daisy	Moderate	No	Montane meadows, coastal grasslands, coastal scrub. Expanding range, invasiveness varies locally.	
Linaria genistifolia ssp. dalmatica	Dalmation toadflax	Moderate	No	Grasslands, forest clearings. Limited distribution. More severe impacts in other western states.	
Linaria vulgaris	yellow toadflax, butter and eggs	Moderate	No	valley and foothill grassland, Great Basin grassland, riparian woodland, lower montane coniferous forest, upper montane coniferous forest	
Lobularia maritima	sweet alyssum	Limited	No	Coastal dune, coastal scrub, coastal prairie, riparian.	
Lolium multiflorum	Italian ryegrass	Moderate	No	Grasslands, oak woodland, pinyon-juniper woodland; widely used for post-fire erosion control. Widespread. Impacts can vary with region.	Y
Lotus corniculatus	birdsfoot trefoil	Eval No List	No	Primarily a turf or agricultural weed in CA	
Ludwigia hexapetala	Uruguay water-primrose	High	Alert	Freshwater aquatic systems. Clarification needed on taxonomic identification.	
Ludwigia peploides ssp. montevidensis	creeping water-primrose	High	No	Freshwater aquatic systems. Clarification needed on taxonomic identification.	

SCIENTIFIC NAME	COMMON NAME	RATING	ALERT	HABITATS OF CONCERN AND COMMENTS	CFMP
Lupinus arboreus	yellow bush lupine	Native	No	Invasive in NW coastal dunes.	
Lythrum hyssopifolium	hyssop loosestrife	Limited	No	Grasslands, wetlands, vernal pools. Widespread. Impacts unknown, but appear to be minor.	
Malephora crocea	coppery mesembryanthemum	Eval No List	No	A problem on southern CA islands, but statewide impacts are low	
Marrubium vulgare	white horehound	Limited	No	Grasslands scrub, riparian areas. Widespread. Rarely in dense stands. Impacts relatively minor.	
Maytenus boaria	mayten	Eval No List	No	Infestation on Angel Island, San Francisco Bay	
Medicago polymorpha	California burclover	Limited	No	Grasslands. Widespread weed of agriculture and disturbed areas. Impacts in wildlands minor.	
Melilotus officinalis	yellow sweetclover	Eval No List	No	Present in human-disturbed habitats only	
Mentha pulegium	pennyroyal	Moderate	No	Vernal pools, wetlands. Poisonous to livestock. Spreading rapidly. Impacts largely unknown.	
Mesembryanthemum crystallinum	crystalline iceplant	Moderate	Alert	Coastal bluffs, dunes, scrubs, grasslands. Limited distribution. Locally problematic, especially in southern CA.	
Myoporum laetum	myoporum	Moderate	No	Coastal habitats, riparian areas; mostly along the southern coast. Abiotic impacts unknown.	
Myosotis latifolia	common forget-me-not	Limited	No	Coniferous forest, riparian. Little information on impacts.	
Myriophyllum aquaticum	parrotfeather	High	Alert	Freshwater aquatic systems	
Myriophyllum spicatum	Eurasian watermilfoil	High	No	Freshwater aquatic systems	
Nothoscordum gracile	false garlic	Eval No List	No	Mainly an urban garden weed.	
Olea europaea	olive	Limited	No	A problem in Australia. Currently a rare escape in CA but is of concern due to the possibility of spread from planted groves.	
Ononis alopecuroides	foxtail restharrow	Limited	No	Grasslands, oak woodland. Highly invasive. Impacts unknown. Nearly eradicated.	
Onopordum acanthium	Scotch thistle	High	No	Wet meadows, sage brush, riparian areas	
Oxalis corniculata	creeping woodsorrel	Eval No List	No	Primarily a turf weed in CA	
Oxalis pes-caprae	Bermuda buttercup, buttercup oxalis, yellow oxalis	Moderate	No	Coastal dunes, scrub, oak woodland. Impacts in coastal areas may prove more severe in time.	
Parentucellia viscosa	yellow glandweed, sticky parentucellia	Limited	No	Coastal prairie, grassland, and dunes. Impacts unknown, but can be locally significant.	
Pennisetum clandestinum	kikuyugrass	Limited	No	Present at low levels in numerous wildland habitats. Impacts unknown. Common turf weed.	Y
Pennisetum setaceum	crimson fountaingrass	Moderate	No	Coastal dunes and scrub, chaparral, grasslands. Some horticultural cultivars sterile. Very invasive in Hawaii.	
Phalaris aquatica	hardinggrass	Moderate	No	Coastal sites, especially moist soils. Limited distribution. Can be highly invasive locally.	
Phoenix canariensis	Canary Island date palm	Limited	No	Desert washes; agricultural crop plant. Limited distribution in southern CA. Impacts can be higher locally.	
Phragmites australis	common reed	Native	No	Genetic issues make it unclear which strains are native to CA.	
Phytolacca americana	common pokeweed	Limited	No	riparian forest, riparian woodland	
Picris echioides	bristly oxtongue	Limited	No	Coastal prairie, scrub, riparian woodland. Widespread locally. Abiotic impacts unknown.	
Piptatherum miliaceum	smilograss	Limited	No	Coastal dunes, scrub, riparian, grassland. Expanding range. Impacts largely unknown.	
Plantago coronopus	cutleaf plantain	Eval No List	No	Impacts unknown. Common on north coast	

SCIENTIFIC NAME	COMMON NAME	RATING	ALERT	HABITATS OF CONCERN AND COMMENTS	CFMP
Plantago lanceolata	buckhorn plantain, English plantain	Limited	No	Many habitats. Turf weed primarily. Low density and impact in wildlands.	
Poa pratensis	Kentucky bluegrass	Limited	No	Grasslands scrub, riparian areas. Widespread turf plant. Abiotic impacts unknown.	
Polygonum cuspidatum	Japanese knotweed	Moderate	Alert	Riparian areas, wetlands, forest edges. More severe impacts in NW wetlands. Distribution limited in CA.	
Polygonum sachalinense	Sakhalin knotweed	Moderate	Alert	Riparian areas. More severe impacts in NW wetlands. Distribution limited in CA.	
Polypogon monspeliensis and subspp.	rabbitfoot polypogon, annual beardgrass	Limited	No	Margins of ponds and streams, seasonally wet places, edge of coastal dunes. Widespread. Impacts appear to be minor.	
Potamogeton crispus	curlyleaf pondweed	Moderate	No	Freshwater aquatic systems. Can be very invasive locally.	
Prunus cerasifera	cherry plum	Limited	No	Riparian habitats, chaparral, woodland. Limited distribution. Abiotic impacts unknown.	
Pyracantha angustifolia, P. crenulata, P. coccinea	pyracantha, firethorn	Limited	No	Coastal scrub and prairie, riparian areas. Horticultural escape. Impacts unknown or minor.	
Ranunculus repens	creeping buttercup	Limited	No	Riparian areas, coniferous forest. Impacts appear to be minor to negligible in most areas.	
Raphanus sativus	radish	Limited	No	Present at low levels in numerous habitats. Widespread in disturbed sites.	Y
Ricinus communis	castorbean	Limited	No	Coastal scrub and prairie, riparian areas. Widespread in southern CA. Impacts locally variable.	Y
Robinia pseudoacacia	black locust	Limited	No	Riparian areas, canyons. Severe impacts in southern states. Impacts minor in CA.	
Rubus armeniacus	Himalaya blackberry	High	No	Riparian areas, marshes, oak woodlands	
Rumex acetosella	red sorrel, sheep sorrel	Moderate	No	Many habitats, riparian areas, forest, wetlands. Widespread. Abiotic impacts unknown. Impacts can vary locally.	
Rumex crispus	curly dock	Limited	No	Grasslands, vernal pool, meadows, riparian. Widespread. Impacts appear to be minor.	
Salsola soda	oppositeleaf Russian thistle	Moderate	No	marine systems, estuaries, vernal pool, marsh and swamp	
Salsola tragus	Russian-thistle	Limited	No	Desert dunes and scrub, alkali playa. Widespread. Impacts minor in wildlands.	
Salvinia molesta	giant salvinia	High	Alert	Freshwater aquatic systems. Population in San Diego River was eradicated.	
Sapium sebiferum	Chinese tallowtree	Moderate	Alert	Riparian areas. Impacts severe in southeast US. Limited distribution in California, but spreading rapidly regionally.	
Saponaria officinalis	bouncingbet	Limited	No	Riparian scrub and woodland. Impacts unknown or minor, but appear to be locally variable.	
Schinus molle	Peruvian peppertree	Limited	No	Riparian. Limited distribution. Impacts largely unknown in CA.	
Schismus arabicus, Schismus barbatus	mediterraneangrass	Limited	No	Scrub, thorn woodland. Widespread in deserts. Impacts can be more important locally.	
Senecio jacobaea	tansy ragwort	Limited	No	Grasslands, riparian. Impacts generally minor. Can be locally important in NW CA.	
Sesbania punicea	red sesbania, scarlet wisteria	High	Alert	Riparian areas	
Silybum marianum	blessed milkthistle	Limited	No	Grasslands, riparian. Widespread, primarily in disturbed areas Impacts can be higher locally	Y
Sinapis arvensis	wild mustard, charlock	Limited	No	Grasslands. Primarily in disturbed sites. Impacts minor or unknown in wildlands.	

SCIENTIFIC NAME	COMMON NAME	RATING	ALERT	HABITATS OF CONCERN AND COMMENTS	CFMP
Solanum elaeagnifolium	silverleaf nightshade	Eval No List	No	Primarily agricultural weed, but escaping to wildlands in other countries. May prove to be more important in future.	
Sonchus asper	spiny sowthistle	Eval No List	No	Primarily an agricultural weed	Y
Spartina alterniflora (and S. alterniflora x foliosa hybrids)	smooth cordgrass and hybrids, Atlantic cordgrass	High	Alert	San Francisco Bay salt marshes and mudflats. Hybridizes with native S. foliosa.	
Spartina anglica	common cordgrass	Moderate	Alert	San Francisco Bay salt marshes. Very severe impact in other countries. Limited distribution in CA.	
Spartina densiflora	dense-flowered cordgrass	High	Alert	San Francisco and Humboldt Bay salt marshes	
Spartina patens	saltmeadow cord grass	Limited	No	San Francisco Bay salt marshes. Very limited distribution. Impacts currently minor in CA, but high in other countries.	
Spartium junceum	Spanish broom	High	No	Coastal scrub, grasslands, wetlands, oak woodland, forests	
Taeniatherum caput-medusae	medusahead	High	No	Grasslands, scrub, woodland	
Tamarix parviflora	smallflower tamarisk	High	No	Riparian areas, desert washes, coastal scrub	
Tamarix ramosissima	saltcedar, tamarisk	High	No	Desert washes, riparian areas, seeps and springs	
Taraxacum officinale	common dandelion	Eval No List	No	Primarily a turf weed in CA	
Torilis arvensis	hedgeparsley	Moderate	No	Expanding range. Appear to have only moderate ecological impacts.	
Tragopogon dubius	yellow salsify	Eval No List	No	Generally a minor component of disturbed areas.	
Trifolium hirtum	rose clover	Moderate	No	Grasslands, oak woodland. Widely planted in CA. Impacts relatively minor in most areas.	
Ulex europaeus	gorse	High	No	Scrub, woodland, forest, coastal grassland	
Undaria pinnatifida	wakame	Limited	No	Alga of estuaries. First recorded in CA in 2000. Impacts unknown, but do not appear to be significant	
Vicia villosa	hairy vetch	Eval No List	No	Primarily an agricultural weed, Widespread but impacts minor in wildlands.	
Vinca major	big periwinkle	Moderate	No	Riparian, oak woodlands, coastal scrub. Distribution currently limited but spreading in riparian areas. Impacts can be higher locally.	Y
Vulpia bromoides	squirreltail fescue	Eval No List	No	Less common than V. myuros	
Vulpia myuros	rattail fescue	Moderate	No	Coastal sage scrub, chaparral. Widespread. Rarely forms monotypic stands, but locally problematic	
Zantedeschia aethiopica	calla lily	Limited	No	Coastal prairie, wetlands. Impacts high in other countries and local impacts may be high in CA.	
Tropaeolum majus	nasturtium			Steep slopes and recent landslides near developed areas.	Y

RATING DESCRIPTIONS

HIGH - These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.

MODERATE - These species have substantial and apparent—but generally not severe—ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.

LIMITED - These species are invasive but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

EVAL NO LIST - Not sufficient data to give them ranking, or species presently does not have significant impact.

ALERT DESCRIPTION

High potential to invade new ecosystems.

APPENDIX C

ANIMAL SPECIES LOCATED IN LOWER SANTA ROSA CREEK WATERSHED FISCALINI RANCH PRESERVE

List produced from Fiscalini Ranch Preserve Environmental Impact Report
County of San Luis Obispo, 2009

ANIMAL SPECIES FOUND IN THE LOWER SANTA ROSA CREEK WATERSHED

The following is a list of animal species identified at the Fiscalini Ranch Preserve, in the lower watershed. This species list was created by the County of San Luis Obispo, in 2009, in the Fiscalini Ranch Preserve Environmental Impact Report (EIR). Although this is a comprehensive list of animal species found in various habitats throughout the preserve, it is not a complete list of animal species that could be found within the entire watershed. A map showing the location of the Fiscalini Ranch Preserve was created by the County and is located on page C-4 in this Appendix. Animal species are listed below according to habitat.

Annual Grassland Species

- *Microtus* sp. (voles)
- *Peromyscus* spp. (white-footed mice)
- *Peromyscus californicus* (California mouse)
- *Thomomys bottae* (Botta's pocket gopher)
- *Spermophilus beecheyi* (California ground squirrel)
- *Canis latrans* (coyote)
- *Accipiter striatus* (sharp-shinned hawk)
- *Buteo jamaicensis* (red-tailed hawk)
- *Buteo lineatus* (red-shouldered hawk)
- *Elanus leucurus* (white-tailed kite)
- *Falco sparverius* (American kestrel)
- *Bubo virginianus* (great horned owl)

Coastal Scrub Species

- California mouse
- Botta's pocket gopher
- California ground squirrel
- migratory songbirds
- *Sylvilagus bachmanii* (brush rabbit)
- *Procyon lotor* (raccoon)
- *Corvus brachyrhynchos* (American crow)
- *Zenaida macroura* (mourning dove)
- *Toxostoma redivivum* (California thrasher)

- *Aphelocoma coerulescens* (scrub jay)
- *Sceloporus occidentalis* (western fence lizard)
- *Anniella pulchra pulchra** (silvery legless lizard)

Riparian Scrub Species

- western fence lizard
- *Geothlypis trichas* (common yellowthroat)
- *Baeolophus inoratus* (plain titmouse)
- *Melospiza melodia* (song sparrow)
- *Regulus calendula* (ruby-crowned kinglet)
- *Hyla regilla* (Pacific chorus frog)
- *Sceloporus occidentalis* (western fence lizard)

Riparian Forest Species

- migratory birds
- *Rana aurora draytonii** (California red-legged frog)
- *Oncorhynchus mykiss irideus** (south-central California coast steelhead)
- *Eucyclogobius newberryi** (tidewater goby)
- *Clemmys marmorata pallida** (southwestern pond turtle)

Monterey Pine Forest Species

- raccoon
- California mouse
- *Odocoileus hemionus* (black tailed deer)
- *Urocyon cinereoargentus* (gray fox)
- *Puma concolor* (mountain lion)
- *Lynx rufus* (bobcat)
- *Didelphis virginianus* (Virginia opossum)
- *Sciurus griseus* (western gray squirrel)
- *Parus rufescens* (chestnutbacked chickadee)
- *Colaptes auratus* (northern flicker)
- *Picoides nuttallii* (Nuttall’s woodpecker)

- *Cyanocitta stelleri* (steller's jay)
- *Bubo virginianus* (great horned owl)
- *Buteo linatus* (red-shouldered hawk)
- *Danaus plexippus* (Monarch butterfly)

Coast Live Oak Woodland Species

- western gray squirrel
- North American raccoon
- Virginia opossum
- *Callipepla californica* (California quail)
- *Odocoileus hemionus* (mule deer)
- *Odocoileus hemionus* (black-tailed deer)
- *Aneides lugubris* (arboreal salamander)
- *Gerrhonotus multicarinatus* (southern alligator lizard)
- *Lampropeltis getulus* (common king snake)
- *Aphelocoma corulescens* (scrub jay)
- *Parus inornatus* (plain titmouse)
- *Pipilo crissalis* (California towhee)
- *Junco hyemalis* (dark-eyed junco)

**special status animal species*

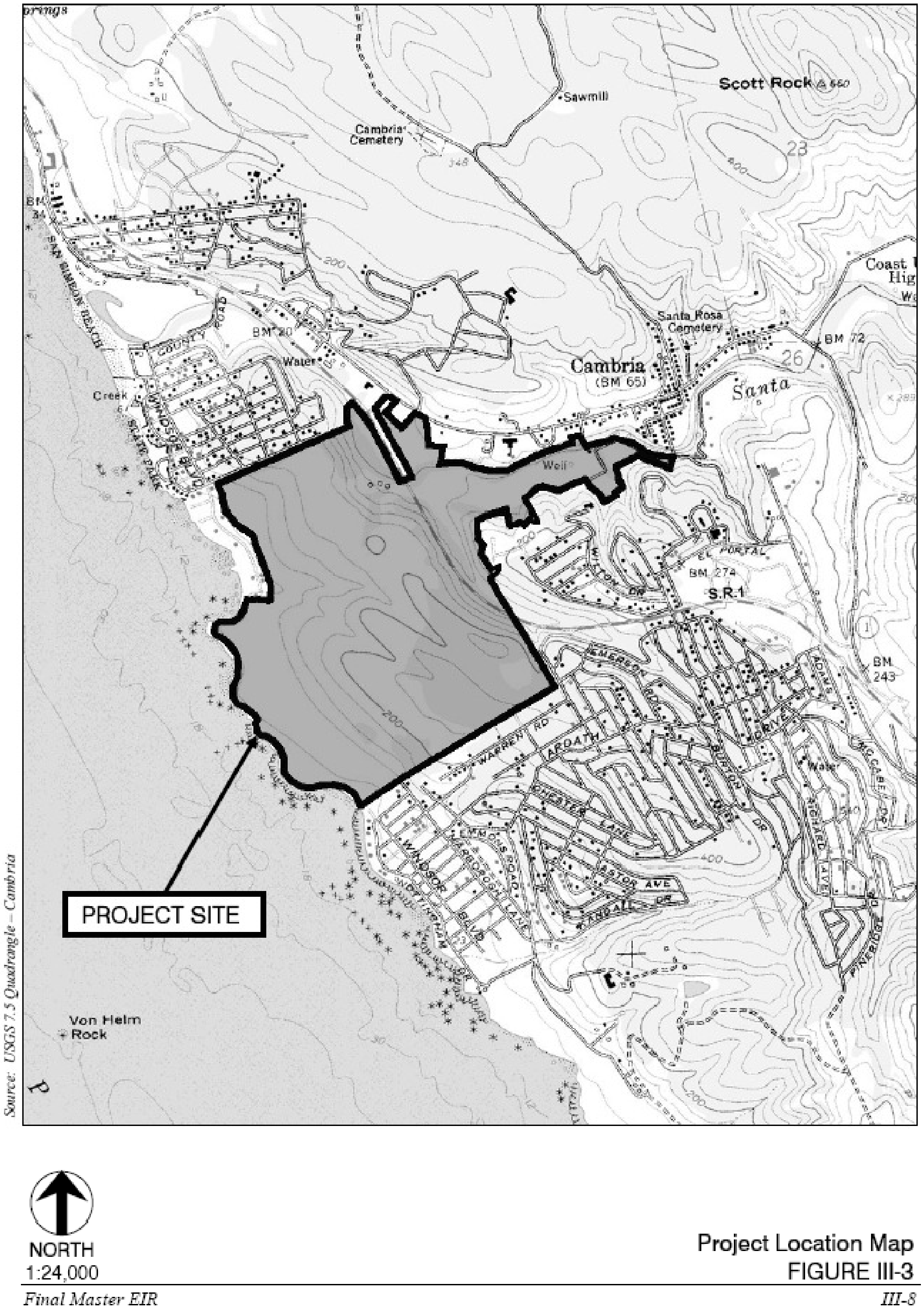

Figure C.1. Location of Fiscalini Ranch Preserve, in the lower Santa Rosa Creek Watershed (County of San Luis Obispo, 2009).

APPENDIX D

SPECIAL STATUS ANIMAL SPECIES
LOCATED IN THE SANTA ROSA CREEK WATERSHED

List produced from California Department of Fish and Game's
California Natural Diversity Data Base

SPECIAL STATUS ANIMAL SPECIES LOCATED IN SANTA ROSA CREEK WATERSHED

SCIENTIFIC NAME	COMMON NAME	FEDERAL STATUS	STATE STATUS	CDFG
Actinemys marmorata pallida	southwestern pond turtle	None	None	SSC
Ammodramus savannarum	grasshopper sparrow	None	None	SSC
Danaus plexippus	monarch butterfly	None	None	SSC
Eucyclogobius newberryi	tidewater goby	Endangered	None	SSC
Myotis thysanodes	fringed myotis	None	None	
Myotis yumanensis	Yuma myotis	None	None	
Oncorhynchus mykiss irideus	steelhead - south/central California coast ESU	Threatened	None	SSC
Rana aurora draytonii	California red-legged frog	Threatened	None	SSC
Taricha torosa torosa	Coast Range newt	None	None	SSC
Thamnophis hammondii	two-striped garter snake	None	None	SSC

Rare species identified using California Natural Diversity Data Base (CNDDB) Cambria and Cypress Mountain 7.5 minute quadrangle search (2009).

CDFG DESCRIPTION

Indicates if the species is a California Department of Fish and Game Species of Special Concern (SSC).

APPENDIX E

GEOLOGIC MAP UNITS
LOCATED IN THE SANTA ROSA CREEK WATERSHED

List produced from County of San Luis Obispo
Geographic Information Systems (GIS) Geology Data
digitized from
USGS and California Geologic Survey Maps

GEOLOGIC UNIT	ACRES	TOTAL %
Franciscan Rocks mélange	14322.90	47.10%
Alluvial Deposits	2871.91	9.45%
Unnamed Sedimentary Rocks	2716.73	8.93%
Rincon Shale	2560.16	8.42%
Vaqueros Sandstone	1659.99	5.46%
Stream Terrace Deposits	807.05	2.65%
Lospe Formation conglomerate, sandstone, claystone	618.66	2.03%
Franciscan Rocks graywacke and micrograywacke	611.76	2.01%
Landslide Deposits	527.15	1.73%
(sp)	432.05	1.42%
Monterey Formation siltstone, claystone/siltstone	430.34	1.42%
Franciscan Rocks	382.23	1.26%
Franciscan Rocks metavolcanic rocks (greenstone)	303.45	1.00%
Pismo Formation claystone and siltstone	289.85	0.95%
(Tml)	273.71	0.90%
(Tb)	262.93	0.86%
Cambria Felsite	220.94	0.73%
Pismo Formation Squire Member	205.26	0.68%
Obispo Formation crystal-bearing vitric tuff	149.63	0.49%
Franciscan Rocks melange?	130.04	0.43%
(Trh)	116.48	0.38%
Franciscan Rocks metavolcanic rocks (greenstone)	115.41	0.38%
Serpentinite	110.96	0.36%
Franciscan Melange chert	105.79	0.35%
Monterey Formation diabase and basaltic rocks	63.24	0.21%
Franciscan Melange greywacke	43.06	0.14%
Monterey Formation hard tuff	40.07	0.13%
Cambria Felsite basalt	18.91	0.06%
Pismo Formation pebble/cobble conglomerate	5.82	0.02%
Franciscan Melange blueschist	3.85	0.01%
Unnamed Sedimentary Rocks?	3.31	0.01%
(Qaf)	1.44	<0.01%
Cambria Felsite?	0.94	<0.01%
Franciscan Melange silica-carbonate rocks	0.14	<0.01%
Fanciscan Melange conglomerate	0.11	<0.01%
Franciscan Melange shale	0.09	<0.01%

APPENDIX F

SOIL MAP UNITS

LOCATED IN THE SANTA ROSA CREEK WATERSHED

List produced from Geospatial Data Gateway
Online USDA Geographic Information Systems (GIS) Soils Data and
USDA, NRCS soils data obtained from SLO Datafinder
Digitized from USDA and NRCS Soil Surveys

SOIL MAP UNITS WITHIN SANTA ROSA CREEK WATERSHED

Map Unit	Watershed Occurances	Total Soil Erodibility (Kw)	Shrink Swell	Farm	Total Acres	Percent Watershed Area
Aquolls, saline	1	No Data	low	Not prime farmland	21.0	0.1%
Balcom-Calleguas complex, 50 to 75 percent slopes	1	No Data	moderate	Not prime farmland	30.1	0.1%
Beaches	1	low	low	Not prime farmland	25.6	0.1%
Briones-Tierra complex, 15 to 50 percent slopes	1	low	low	Not prime farmland	10.1	0.0%
Cieneba-Millsap loams, 30 to 75 percent slopes	3	moderate	low	Not prime farmland	211.0	0.7%
Concepcion loam, 2 to 5 percent slopes	2	moderate	low	Farmland of statewide importance	34.7	0.1%
Cropley clay, 0 to 2 percent slopes	8	low	high	Prime farmland if irrigated	521.7	1.7%

Map Unit	Watershed Occurances	Total Soil Erodibility (Kw)	Shrink Swell	Farm	Total Acres	Percent Watershed Area
Cropley clay, 2 to 9 percent slopes	13	low	high	Prime farmland if irrigated	602.4	2.0%
Diablo and Cibo clays, 15 to 30 percent slopes	28	moderate	high	Not prime farmland	1566.1	5.2%
Diablo and Cibo clays, 30 to 50 percent slopes	29	moderate	high	Not prime farmland	2242.2	7.4%
Diablo and Cibo clays, 9 to 15 percent slopes	14	moderate	high	Farmland of statewide importance	290.1	1.0%
Diablo clay, 5 to 9 percent slopes	10	low	high	Prime farmland if irrigated	173.9	0.6%
Diablo-Lodo complex, 15 to 50 percent slopes	27	low	high	Not prime farmland	4050.5	13.3%
Gaviota fine sandy loam, 15 to 50 percent slopes	6	moderate	low	Not prime farmland	209.9	0.7%

Map Unit	Watershed Occurances	Total Soil Erodibility (Kw)	Shrink Swell	Farm	Total Acres	Percent Watershed Area
Gaviota sandy loam, 50 to 75 percent slopes	3	moderate	low	Not prime farmland	146.7	0.5%
Gaviota-Rock outcrop complex, 30 to 75 percent slopes	1	No Data	low	Not prime farmland	14.0	0.0%
Gazos-Lodo clay loams, 15 to 30 percent slopes	14	low	moderate	Not prime farmland	461.9	1.5%
Gazos-Lodo clay loams, 30 to 50 percent slopes	40	low	moderate	Not prime farmland	2574.9	8.5%
Gazos-Lodo clay loams, 50 to 75 percent slopes	9	low	moderate	Not prime farmland	252.4	0.8%
Henneke-Rock outcrop complex, 15 to 75 percent slopes	3	low	moderate	Not prime farmland	567.5	1.9%
Lodo clay loam, 15 to 30 percent slopes	7	low	moderate	Not prime farmland	199.1	0.7%

Map Unit	Watershed Occurances	Total Soil Erodibility (Kw)	Shrink Swell	Farm	Total Acres	Percent Watershed Area
Lodo clay loam, 30 to 50 percent slopes	8	low	moderate	Not prime farmland	310.2	1.0%
Lodo clay loam, 5 to 15 percent slopes	2	low	moderate	Not prime farmland	67.8	0.2%
Lodo clay loam, 50 to 75 percent slopes	9	low	moderate	Not prime farmland	772.8	2.5%
Lodo-Rock outcrop complex, 30 to 75 percent slopes	18	low	moderate	Not prime farmland	1030.3	3.4%
Lodo-Rock outcrop complex, 9 to 30 percent slopes	3	low	moderate	Not prime farmland	75.1	0.2%
Lompico-McMullin complex, 50 to 75 percent slopes	2	moderate	low	Not prime farmland	99.0	0.3%
Lompico-McMullin loams, 30 to 75 percent slopes	3	low	low	Not prime farmland	615.7	2.0%

Map Unit	Watershed Occurances	Total Soil Erodibility (Kw)	Shrink Swell	Farm	Total Acres	Percent Watershed Area
Lopez very shaly clay loam, 30 to 75 percent slopes	2	low	low	Not prime farmland	638.6	2.1%
Lopez-Rock outcrop complex, 75 to 100 percent slopes	1	low	low	Not prime farmland	6.4	0.0%
Los Osos loam, 15 to 30 percent slopes	14	moderate	moderate	Not prime farmland	1089.4	3.6%
Los Osos loam, 30 to 50 percent slopes	11	moderate	moderate	Not prime farmland	506.8	1.7%
Los Osos loam, 5 to 9 percent slopes	6	moderate	moderate	Farmland of statewide importance	103.3	0.3%
Los Osos loam, 9 to 15 percent slopes	15	moderate	moderate	Not prime farmland	386.7	1.3%
Los Osos variant clay loam, 15 to 50 percent slopes	4	moderate	moderate	Not prime farmland	45.8	0.2%

Map Unit	Watershed Occurances	Total Soil Erodibility (Kw)	Shrink Swell	Farm	Total Acres	Percent Watershed Area
Los Osos-Diablo complex, 15 to 30 percent slopes	22	moderate	moderate	Not prime farmland	1710.2	5.6%
Los Osos-Diablo complex, 30 to 50 percent slopes	25	moderate	moderate	Not prime farmland	1668.0	5.5%
Los Osos-Diablo complex, 5 to 9 percent slopes	6	moderate	moderate	Farmland of statewide importance	199.1	0.7%
Los Osos-Diablo complex, 9 to 15 percent slopes	11	moderate	moderate	Not prime farmland	420.1	1.4%
Los Osos-Lodo complex, 30 to 75 percent slopes	11	moderate	moderate	Not prime farmland	764.0	2.5%

Map Unit	Watershed Occurances	Total Soil Erodibility (Kw)	Shrink Swell	Farm	Total Acres	Percent Watershed Area
Los Osos-Lodo complex, 50 to 75 percent slopes	1	moderate	moderate	Not prime farmland	601.9	2.0%
Marimel silty clay loam, drained	4	moderate	moderate	Prime farmland if irrigated and drained	769.6	2.5%
McMullin-Rock outcrop complex, 50 to 75 percent slopes	3	No Data	low	Not prime farmland	1.2	0.0%
Millsap loam, 15 to 50 percent slopes	1	moderate	low	Not prime farmland	82.0	0.3%
Nacimiento silty clay loam, 30 to 50 percent slopes	3	low	moderate	Not prime farmland	64.8	0.2%
Nacimiento-Calodo complex, 30 to 50 percent slopes	5	low	moderate	Not prime farmland	438.6	1.4%
Nacimiento-Calodo complex, 50 to 75 percent slopes	4	moderate	low	Not prime farmland	160.1	0.5%
Obispo-Rock outcrop complex, 15 to 75 percent slopes	1	low	moderate	Not prime farmland	21.2	0.1%

Map Unit	**Watershed Occurances**	**Total Soil Erodibility (Kw)**	**Shrink Swell**	**Farm**	**Total Acres**	**Percent Watershed Area**
Riverwash	1	low	low	Not prime farmland	60.3	0.2%
Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slop	16	No Data	low	Not prime farmland	225.2	0.7%
Salinas silty clay loam, 0 to 2 percent slopes	9	moderate	moderate	Prime farmland if irrigated	276.5	0.9%
Salinas silty clay loam, 2 to 9 percent slopes	9	moderate	moderate	Prime farmland if irrigated	642.2	2.1%
San Simeon sandy loam, 15 to 30 percent slopes	8	moderate	low	Not prime farmland	619.5	2.0%
San Simeon sandy loam, 2 to 9 percent slopes	8	moderate	low	Not prime farmland	131.2	0.4%
San Simeon sandy loam, 30 to 50 percent slopes	7	moderate	low	Not prime farmland	679.1	2.2%

Map Unit	Watershed Occurances	Total Soil Erodibility (Kw)	Shrink Swell	Farm	Total Acres	Percent Watershed Area
San Simeon sandy loam, 9 to 15 percent slopes	7	moderate	low	Not prime farmland	359.8	1.2%
Santa Lucia shaly clay loam, 30 to 50 percent slopes	1	low	low	Not prime farmland	52.1	0.2%
Santa Lucia shaly clay loam, 50 to 75 percent slopes	2	low	low	Not prime farmland	197.7	0.7%
Santa Lucia very shaly clay loam, 9 to 15 percent slopes	1	low	low	Not prime farmland	13.8	0.0%
Water	4	No Data	low	Not prime farmland	7.6	0.0%
Xerorthents, escarpment	1	No Data	low	Not prime farmland	6.1	0.0%
Zaca clay, 15 to 30 percent slopes	2	low	high	Not prime farmland	146.3	0.5%
Zaca clay, 30 to 50 percent slopes	1	low	high	Not prime farmland	87.8	0.3%
Zaca clay, 9 to 15 percent slopes	1	low	high	Farmland of statewide importance	34.3	0.1%
				Total Acres:	34.3060	

SOIL MAF

Map Unit	Description
Aquolls, saline	Nearly level soils located in tidal marshes. Vegetated by salt-tolerant plants, with some anise, waterhemlock and willows in fringes. Soils are very deep and poorly drained with slow or very slow permeability, slow surface runoff, and water removed through waterways or channels. Water level fluctuates with tides. Recreational land use. Soils valuable for wildlife and aesthetics. Capability subclass VIIIw (14), nonirrigated.
Balcom-Calleguas complex, 50 to 75 percent slopes	Very deep soils located on mountains. 35% Balcom loam; 25% Calleguas shaly loam. Balcom soils are moderately deep, well drained with moderate permeability, low to moderate available water capacity, very rapid surface runoff, and very high erosion hazard. Calleguas soils are shallow, well drained with moderate permeability, very low available water capacity, very rapid surface runoff, and very high erosion hazard. Rangeland land use, however Calleguas soils are poorly suited for it. Capability subclass VIIe (15), nonirrigated.
Beaches	Narrow, sandy beaches along the ocean. Essentially barren, stratified layers of sand or gravel with some cobbles. Dune land and some rock outcrops present. Very rapid permeability, low or very low available water capacity, slow surface runoff, high or very high erosion hazard due to wind and wave action. Land uses include recreation with some farming, rangeland, and urban development. Capability subclass VIIw.
Briones-Tierra complex, 15 to 50 percent slopes	Moderately steep to steep soils located on foothills, mountains, and dissected terraces. Vegetated by annual grasses, forbs, hardwoods, or brush vegetation. 50% Briones soils; 25% Tierra soils. Briones soils are moderately deep and somewhat excessively drained with rapid permeability, very low or low available water capacity, rapid surface runoff, and high water erosion and soil blowing hazards. Tierra soils are very deep and moderately well drained with very slow permeability, low or moderate available water capacity, rapid surface runoff, high water erosion hazard, moderate soil blowig hazard, and high shrink-swell potential in subsoil. Land uses include rangeland, dryfarmed beans, and small grains. Poorly suited for cropland due to high soil blowing and water erosion hazards, and low water holding capacity. Moderately suited for rangelands. Capability subclass VIIe (15), nonirrigated.
Cieneba-Millsap loams, 30 to 75 percent slopes	Steep and very steep soils located on foothills and mountains. Vegetated by annual grasses, forbs, brush, and hardwoods along drainages. 50% Cieneba soils; 30% Millsap soils. Cieneba soils are shallow and somewhat excessively drained with moderately rapid permeability, very low available water capacity, rapid or very rapid surface runoff, and high or very high water erosion hazard. Millsap soils are moderately deep and well drained with very slow permeability, very low or low available water capacity, rapid or very rapid surface runoff, and high or very high water erosion hazard. Moderately to poorly suited for rangelands. Subject to sheet and gully erosion due to soil texture and slope. Capability subclass VIIe (15), nonirrigated.
Concepcion loam, 2 to 5 percent slopes	Gently sloping soils located on marine terraces. Vegetated by annual and perennial grasses, forbs, and some scattered brush. Soils are very deep and moderately well drained with very slow permeability, moderate or high available water capacity, slow surface runoff, slight water erosion hazard, and high shrink-swell potential in subsoil. Land uses include small grains, hay, and rangeland. Well-suited for rangelands. Subject to gully erosion due to dense clay subsoil. Permanent plant cover reduces erosion. Capability units IIIe-3 (14), irrigated and nonirrigated.
Cropley clay, 0 to 2 percent slopes	Nearly level soils located on alluvial fans and plains. Vegetated by annual and perennial grasses. Soils are very deep and moderately well-drained with slow permeability, high available water capacity, slow surface runoff, slight water erosion hazard, and high shrink-swell potential. Land uses include dryland farming, irrigated row crops, pasture, and urban developement. Well-suited for agriculture. Compaction hazard due to clay texture. Capability units IIs-5 (14), irrigated and IIIs-5 (14), nonirrigated.

Map Unit	Description
Cropley clay, 2 to 9 percent slopes	Gently to moderately sloping soils located on alluvial fans and plains. Vegetated by annual and perennial grasses. Soils are very deep and moderately well drained with slow permeability, high available water capacity, slow or medium surface runoff, slight or moderate water erosion hazard, and high shrink-swell potential. Land uses include rangelands, small grains, hay crops, and urban development. Well-suited for rangelands. Capability unit IIe-5 (14), irrigated and IIIe-5 (14), nonirrigated.
Diablo and Cibo clays, 15 to 30 percent slopes	Moderately steep soils located on foothills and mountains. Annual grasses and forbs; hardwoods in swales. Diablo soils are deep and well-drained with slow permeability, moderate to high available water capacity, rapid surface runoff, moderate to high water erosion, high shrink-swell potential, and are subject to slippage when wet. Cibo soils are moderately deep and well-drained with slow permeability, very low to moderate available water capacity, rapid surface runoff, moderate water erosion hazard, high shrink-swell potential, and are subject to slippage when wet. Well-suited for rangelands. Subject to surface compaction due to clay texture. Capability unit IVe-5 (15), nonirrigated.
Diablo and Cibo clays, 30 to 50 percent slopes	Steep soils located on foothills and mountains. Annual grasses and forbs; hardwoods common in swales. Diablo soils are deep and well-drained with slow permeability, moderate to high available water capacity, rapid surface runoff, moderate to high water erosion hazard, high shrink-swell potential, and are subject to slippage when wet. Cibo soils are moderately deep and well-drained with slow permeability, very low to moderate water capacity, rapid surface runoff, high water erosion hazard, high shrink-swell potenital, and are subject to slippage when wet. Well-suited for rangelands. Subject to surface compaction due to clay texture. Capability subclass VIe (15), nonirrigated.
Diablo and Cibo clays, 9 to 15 percent slopes	Strongly sloping soils located on low lying foothills. Vegetated by annual grasses and forbs. Diablo soils are deep and well drained with slow permeability, moderate to very high available water capacity, medium surface runoff, moderate water erosion hazard, high shrink-swell potential, and subject to slippage when wet. Cibo soils are moderately deep and well drained with slow permeability, very low to moderate available water capacity, medium surface runoff, moderate water erosion hazard, high shrink-swell potential, and subject to slippage when wet. Land uses include rangeland and urban development. Well-suited for rangelands. Surface compaction occurs due to clay soil texture. Capability units IIIe-5 (15), irrigated and nonirrigated.
Diablo clay, 5 to 9 percent slopes	Gently rolling soils located on low lying foothills. Vegetated by annual grasses and forbs. Soils are deep and well drained with slow permeability, moderate to very high available water capacity, medium surface runoff, slight or moderate water erosion hazard, and high shrink-swell potential. Land uses include rangeland, hay crops, small grains, and urban development. Well suited for agriculture. Capability units IIe-5 (15), irrigated and IIIe-5 (15), nonirrigated.
Diablo-Lodo complex, 15 to 50 percent slopes	Moderately steep to steep soils located on foothills and mountains. Annual grasses and forbes; some brush and hardwoods along drainages. 45% Diablo soils; 35% Lodo soils. Diablo soils are deep and well-drained with slow permeability, moderate to high available water capacity, rapid surface runoff, moderate to high water erosion hazard, high shrink-swell potential, and are subject to slippage when wet. Lodo soils are very shallow to shallow and somewhat excessively drained with moderate permeability, very low or low available water capacity, rapid surface runoff, and high water erosion hazard. Moderately suited for rangelands. Diablo soils have high surface compaction hazard. Lodo soils have low productivity and are often overgrazed with excessive sheet erosion. Capability subclass VIe (15), nonirrigated.
Gaviota fine sandy loam, 15 to 50 percent slopes	Moderately steep and steep soils located on foothills and mountains. Vegetated by brush, scattered hardwoods, annual grasses and forbs. Soils are shallow and well drained with moderately rapid permeability, very low available water capacity, rapid surface runoff, and high water erosion hazard. Land uses include rangeland and urban development. Poorly suited for rangelands. Subject to sheet and gully erosion due to coarse soil texture, shallow depth, and steep slopes. Capability subclass VIIe (15), nonirrigated.

Map Unit	Description
Gaviota sandy loam, 50 to 75 percent slopes	Very steep soils located on mountains. Vegetated by brush, scattered hardwoods, annual grasses, and forbs. Soils are shallow and well drained with moderately rapid permeability, very low available water capacity, very rapid surface runoff, and very high water erosion hazard. Poorly suited for rangelands. Subject to sheet and gully erosion due to coarse soil texture, shallow depth, and steep slopes. Capability subclass VIIe (15), nonirrigated.
Gaviota-Rock outcrop complex, 30 to 75 percent slopes	Steep to very steep soils located on mountains. 40% Gaviota sandy loam; 25% rock outcrop. Gaviota siols are shallow, well drained with moderately rapid permeability very low available water capacity, very rapid surface runoff, and very high erosion hazard. Rock outcrops are hard sandstone. Watershed, wildlife and asthetic land uses. Soil has very little potential for establishing vegetation suitable for wildlife. Capability subclass VIIIe (15), nonirrigated.
Gazos-Lodo clay loams, 15 to 30 percent slopes	Moderately steep soils located on foothills and mountains. Vegetated by annual grasses, forbs, or brush with scattered hardwoods. 45% Gazos soils; 40% Lodo soils. Gazos soils are moderately deep and well drained with moderately slow permeability, low or moderate available water capacity, rapid surface runoff, and high water erosion hazard. Lodo soils are shallow and somewhat excessively drained with moderate permeability, very low or low available water capacity, rapid surface runoff, and high water erosion hazard. Moderately suited for rangelands. Subject to sheet and gully erosion and compaction due to clay loam surface layer. Capability unit IVe-1 (15), nonirrigated.
Gazos-Lodo clay loams, 30 to 50 percent slopes	Steep soils located on foothills and mountains. Annual grasses and forbs, or brush with scattered hardwoods. 45% Gazos soils; 40% Lodo soils. Gazos soils are moderately deep and well-drained with moderately slow permeability, low or moderate available water capacity, rapid surface runoff, and high water erosion hazard. Lodo soils are shallow and somewhat excessibely drained with moderate permeability, very low or low available water capacity, rapid surface runoff, and high water erosion hazard. Moderately-suited for rangelands. Subject to sheet and gully erosion and soil compaction due to clay loam surface. Capability subclass VIe (15), nonirrigated
Gazos-Lodo clay loams, 50 to 75 percent slopes	Very steep soils located on mountains. Vegetated by annual grasses, forbs, brush, and scattered hardwoods. 45% Gazos soils, 40% Lodo soils. Gazos soils are moderately deep and well drained with moderately slow permeability, low or moderate available water capacity, very rapid surface runoff, and very high water erosion hazard. Lodo soils are shallow and somewhat excessively drained with moderate permeability, very low or low available water capacity, very rapid surface runoff, and very high water erosion hazard. Land uses include rangeland and watershed. Poorly-suited for rangelands. Subject to sheet and gully erosion and soil compaction due to clay loam surface layer and very steep slopes. Capability subclass VIIe (15), nonirrigated.
Henneke-Rock outcrop complex, 15 to 75 percent slopes	Moderately steep to very steep soils located on foothills and mountains. Vegetated by brush, annual and perennial grasses, with few scattered hardwoods or conifers. 45% Henneke soils; 35% rock outcrop. Henneke soils are shallow and somewhat excessively drained, underlain by hard serpentine rock with moderately slow permeability, very low available water capacity, rapid or very rapid surface runoff, and high or very high water erosion hazard. Rock outcrop is hard serpentine exposed or near surface. Land uses include rangelands, watersheds, and wildlife habitat. Poorly suited for rangelands. Subject to sheet erosion due to clay loam surface layer and steep to very steep slopes. Serpentine limits vegetation growth. Capability subclass VIIe (15), nonirrigated.
Lodo clay loam, 15 to 30 percent slopes	Moderately steep soils located on foothills and mountains. Vegetated by brush, annual grasses and forbs. Soils are shallow and somewhat excessively drained with moderate permeability, very low or low available water capacity, rapid surface runoff, and high water erosion hazard. Moderately suited for rangelands. Subject to sheet and gully erosion and soil compaction due to clay loam surface layer. Capability subclass VIe (15), nonirrigated.

Map Unit	Description
Lodo clay loam, 30 to 50 percent slopes	Steep soils located on foothills and mountains. Vegetated by brush, annual grasses and forbs. Soils are shallow and somewhat excessively drained with moderate permeability, very low or low available water capacity, rapid surface runoff, and high water erosion hazard. Moderately suited for rangelands. Subject to sheet and gully erosion due to clay loam surface layer. Capability subclass VIe (15), nonirrigated.
Lodo clay loam, 5 to 15 percent slopes	Moderately and strongly sloping soils located on foothills and mountains. Vegetated by brush, annual grasses, and forbs. Soils are shallow and somewhat excessively drained with moderate permeability, very low or low available water capacity, medium surface runoff, and moderate water erosion hazard. Moderately suited for rangelands. Land uses include rangeland and urban development. Subject to gully erosion and soil compaction due to clay loam surface layer. Capability unit IVe-1 (15), nonirrigated.
Lodo clay loam, 50 to 75 percent slopes	Very steep soils located on foothills and mountains. Vegetated with brush and some grasses and forbs. Soils are shallow and somewhat excessively drained with moderate permeability, very low or low available water capacity, rapid surface runoff, and very high water erosion hazard. Poorly suited for rangelands. Subject to sheet and gully erosion and soil compaction due to clay loam surface layer and steep slopes. Permanent plant cover should be maintained at all times due to high erosion hazard. Capability subclass VIIe (15), nonirrigated.
Lodo-Rock outcrop complex, 30 to 75 percent slopes	Steep and very steep soils located on foothills and mountains. Vegetated with brush and some annual grasses. 55% Lodo soils; 40% rock outcrop. Lodo soils are shallow and somewhat excessively drained with moderate permeability, very low or low available water capacity, rapid or very rapid surface runoff, and high or very high water erosion hazard. Rock outcrop is hard sandstone, red rock, or shale at or near surface. Poorly suited for rangelands. Lodo soils are subject to sheet erosion and soil compaction. Permanent plant cover should be maintained at all times. Capability subclass VIIe (15), nonirrigated.
Lodo-Rock outcrop complex, 9 to 30 percent slopes	Strongly sloping, moderately steep soils located on foothills and mountains. Vegetated by annual grasses and brush. 55% Lodo soils; 40% rock outcrop. Lodo soils are shallow and somewhat excessively drained with moderate permeability, very low or low available water capacity, medium or rapid surface runoff, moderate or high water erosion hazard. Rock outcrop is hard sandstone, red rock, or shale at or near soil surface. Moderately suited for rangelands. Subject to sheet erosion and soil compaction due to clay loam surface layer. Capability subclass VIe (15), nonirrigated.
Lompico-McMullin complex, 50 to 75 percent slopes	Very steep soils located on mountains. Vegetated by coast live oak and California laurel. 40% Lompico loam; 35% McMullin gravelly loam. Lompico soils are moderately deep, well drained with moderate permeability, low to moderate available water capacity, very rapid surface runoff, and very high erosion hazard. McMullin soils are shallow, somewhat excessively drained with moderate permeability, very low to low available water capacity, very rapid surface runoff, and very high erosion hazard. Rangeland land use. Erosion control is essential on these soils. Capability subclass VIIe (15), nonirrigated.
Lompico-McMullin loams, 30 to 75 percent slopes	Steep and very steep soils located on foothills and mountains. Vegetated by hardwoods with some annal grasses or brush. 45% Lompico soils; 20% McMullin soils. Lompico soils are moderately deep and well drained with moderate permeability, low or moderate available water capacity, rapid or very rapid surface runoff, and high or very high water erosion hazard. McMullin soils are shallow and somewhat excessively drained with moderate permeability, very low or low available water capacity, rapid surface runoff, and high water erosion hazard. Watershed and wildlife habitat soils. Poorly suited for rangelands due to compaction, erosion hazard, and woody plant vegetation. Capability subclass VIIe (15), nonirigated.

Map Unit	Description
Lopez very shaly clay loam, 30 to 75 percent slopes	Steep and very steep soils located on mountains. Vegetated by brush, annual grasses, forbs, and scattered hardwoods. Soils are shallow and somewhat excessively drained with moderate permeability, very low available water capacity, rapid or very rapid surface runoff, and high or very high water erosion hazard. Poorly suited for rangelands. Subject to sheet erosion due to very shaly clay loam surface and steep slopes. Capability subclass VIIe (15), nonirrigated.
Lopez-Rock outcrop complex, 75 to 100 percent slopes	Extremely steep soils located on mountains. Vegetated by brush. 60% Lopez soils; 35% rock outcrop. Lopez soils are shallow and somewhat excessively drained with moderate permeability, very low available water capacity, very rapid surface runoff, and very high water erosion hazard. Rock outcrop is exposed, hard, acid shale. Land use is watershed. Poorly suited for rangelands. Subject to sheet erosion due to very shaly clay loam surface texture and extremely steep slopes. Sheet erosion produces shale fragments which hinder vegetation growth. Capability subclass VIIe (15), nonirrigated.
Los Osos loam, 15 to 30 percent slopes	Moderately steep soils located on foothills and mountain ridgetops. Annual grasses and forbs with a few brush areas and hardwoods along drainages. Moderately deep and well drained with slow permeability, low or moderate available water capacity, rapid surface runoff, high water erosion hazard, high shrink-swell potenital in the subsoil, and is subject to slippage when wet. Land uses include rangelands and urban development. Well-suited for rangelands. Subject to gully erosion due to clay subsoil, moderately steep slopes and loam surface layer. Capability unit IVe-1 (15), nonirrigated.
Los Osos loam, 30 to 50 percent slopes	Steep soils located on foothills and mountain ridgetops. Vegetated by annual grasses and forbs, with brush and some hardwoods along drainages. Soils are moderately deep and well drained with slow permeability, low to moderate available water capacity, rapid surface runoff, high water erosion hazard, high shrink-swell potential in subsoil, and subject to slippage when wet. Moderately suited for rangelands. Subject to gully erosion due to clay subsoil, loam surface layer and steep slopes. Capability subclass VIe (15), nonirrigated.
Los Osos loam, 5 to 9 percent slopes	Gently rolling soils located on foothills and mountain ridgetops. Vegetated by annual grasses and forbs. Soils are moderately deep and well drained with slow permeability, low or moderate available water capacity, medium surface runoff, moderate water erosion hazard, and high shrink-swell potential in subsoil. Land uses include rangeland, small grains, hay crops, and urban development. Well-suited for rangelands. Subject to gully erosion due to clay subsoil and loam surface layer. Capability units IIIe-3 (15), irrigated and nonirrigated.
Los Osos loam, 9 to 15 percent slopes	Rolling soils located on foothills and mountain ridgetops. Vegetated by annual grasses and forbs with some hardwoods in drainages. Soils are moderately deep and well drained with slow permeability, low or moderate available water capacity, medium surface runoff, moderate water erosion hazard, high shrink-swell potenital in subsoil, and subject to slippage when saturated. Land uses include rangelands and urban development. Well-suited for rangelands. Capability units IIIe-3 (15), irrigated and nonirrigated.
Los Osos variant clay loam, 15 to 50 percent slopes	Moderately steep and steep soils located on foothills and mountains. Vegetated by annual grasses, forbs, or brush, with hardwoods along drainages. Soils are very deep and well drained with slow permeability, high or very high available water capacity, rapid surface runoff, and moderate or high water erosion hazard. Well suited for rangelands. Compaction hazard due to clay loam surface. Grazing dry soils reduces compaction. Capability subclass VIe (15), nonirrigated.

Map Unit	Description
Los Osos-Diablo complex, 15 to 30 percent slopes	Moderately steep soils located on foothills and mountains. Annual grasses and forbes; some brush and hardwoods along drainages. Grassland soils with coast live oak woodlands. 35% Los Osos soils; 30% Diablo soils. Los Osos soils are moderately deep and well-drained with slow permeability, low or moderate available water capacity, high water erosion hazard, high shrink-swell potential, and are subject to slippage when wet. Diablo soils are deep and well-drained with slow permeability, moderate to high available water capacity, rapid surface runoff, moderate to high water erosion, high shrink-swell potential, and are subject to slippage when wet. Land uses include rangelands and urban development. Well-suited for rangelands. Subject to gully erosion due to loam surface layer and clay subsoil. Capability unit IVe-1 (15), nonirrigated.
Los Osos-Diablo complex, 30 to 50 percent slopes	Steep soils located on foothills and mountains. Annual grasses and forbes; some brush and hardwoods along drainages. Grassland soils with Coast live oak woodlands. 40% Los Osos soils; 35% Diablo soils. Los Osos soils are moderately deep and well-drained with slow permeability, low or moderate available water capacity, high water erosion hazard, high shrink-swell potential, and are subject to slippage when wet. Diablo soils are deep and well-drained with slow permeability, moderate to high available water capacity, rapid surface runoff, moderate to high water erosion, high shrink-swell potential, and are subject to slippage when wet. Moderately-suited for rangelands. Subject to gully erosion due to steep slopes, loam soil surface and clay subsoil. Capability subclass VIe (15), nonirrigated.
Los Osos-Diablo complex, 5 to 9 percent slopes	Gently rolling soils located on foothills and mountain ridgetops. Vegetated by annual grasses and forbs. 35% Los Osos soils; 30% Diablo soils. Los Osos soils are moderately deep and well drained with slow permeability, low or moderate available water capacity, medium surface runoff, moderate water erosion hazard, and high shrink-swell potential in subsoil. Diablo soils are deep and well drained with slow permeability, moderate to very high available water capacity, medium surface runoff, slight water erosion hazard, and high shrink-swell potential. Land uses include hay crops, small grains, rangeland, and urban developement. Well-suited for rangelands. Subject to gully erosion due to clay subsoil and loam surface layer. Capability units IIIe-3 (15), irrigated and nonirrigated.
Los Osos-Diablo complex, 9 to 15 percent slopes	Rolling soils located on foothills and mountain ridgetops. Vegetated by annual grasses and forbs. 35% Los Osos soils and 30% Diablo soils. Los Osos soils are moderately deep and well drained with slow permeability, low or moderate available water capacity, medium surface runoff, moderate water erosion hazard, high shrink-swell potential in subsoil, and subject to slippage when wet. Diablo soils are deep and well-drained with slow permeability, moderate to very high available water capacity, medium surface runoff, moderate water erosion hazard, high shrink-swell potential, and subject to slippage when wet. Land uses include hay crops, small grains, rangeland, and urban development. Well-suited for rangelands. Subject to gully erosion due to clay subsoil and loam surface layer. Capability units IIIe-3 (15), irrigated and nonirrigated.
Los Osos-Lodo complex, 30 to 75 percent slopes	Steep and very steep soils located on foothills and mountains. Vegetated by annual grasses and forbs, with brush and hardwoods along drainageways. 50% Los Osos soils, 30% Lodo soils. Los Osos soils are moderately deep and well drained with slow permeability, low or moderate available water capacity, rapid surface runoff, high or very high water erosion hazard, high shrink-swell potential in subsoil, and are subject to slippage when wet. Lodo soils are shallow and somewhat excessively drained with moderate permeability, very low or low available water capacity, rapid or very rapid surface runoff, and high or very high water erosion hazard. Moderately suited for rangelands. Subject to gully erosion due to clay subsoil, loam surface layer, and very steep slopes. Capability subclass VIIe (15), nonirrigated.

Map Unit	Description
Los Osos-Lodo complex, 50 to 75 percent slopes	Very steep soils located on mountains. 40% Los Osos clay loam; 30% Lodo gravelly clay loam. Los Osos soils are moderately deep, well drained with slow permeability, low to moderate available water capacity, very rapid surface runoff, very high erosion hazard, and high shrink-swell potential. Lodo soils are shallow, somewhat excessively drained with moderate permeability, very low to low available water capacity, very rapid surface runoff, and very high erosion hazard. Rangeland land uses. Capability subclass VIIe (15), nonirrigated.
Marimel silty clay loam, drained	Very deep and well drained soils found on alluvial fans and in narrow valleys. Vegetated with annual grasses and forbs. Presently cultivated. Soils have moderately slow permeability, high or very high available water capacity, slow surface runoff, and slight water erosion hazard. Land uses include crops and orchards. Capability class I (14), irrigated and capability unit IIIc-1 (14), nonirrigated.
McMullin-Rock outcrop complex, 50 to 75 percent slopes	Very steep soils located on mountains. 45% McMullin gravelly loam; 25% rock outcrop. McMullin soils are shallow; somewhat excessively drained with moderate permeability; very low to low available water capacity; very rapid surface runoff; and very erosion hazard. Rock outcrops are areas of hard sandstone and shale. McMullin soils are poorly suited for rangelands. Soil has little potential for vegetation establishment suitable for wildlife. Capability subclass VIIe (15); nonirrigated.
Millsap loam, 15 to 50 percent slopes	Moderately steep and steep soils located on foothills and mountains. Vegetated by annual grasses and forbs, with some hardwoods. Soils are moderately deep and well drained with very slow permeability, very low or low available water capacity, rapid surface runoff, and moderate or high water erosion hazard. Land uses include rangelands and watershed. Moderately suited for rangelands. Subject to gully erosion due to clay subsoil, loam surface layer, and steep slopes. Capability subclass VIe (15), nonirrigated.
Nacimiento silty clay loam, 30 to 50 percent slopes	Steep soils located on hills. Soils are deep, well drained with moderately slow permeability, low to moderate available water capacity, rapid surface runoff, and high erosion hazrd. Cultivated crops and rangeland land uses. Not suited for cultivated crops due to steep slopes and high erosion hazard. Well suited for rangelands. Capability subclass VIe (15), nonirrigated.
Nacimiento-Calodo complex, 30 to 50 percent slopes	Steep soils located on foothills and mountains. Vegetated by annual grasses and forbs, with some brush. 45% Nacimiento soils; 35% Calodo soils. Nacimiento soils are moderately deep and well drained with moderately slow permeability, low or moderate available water capacity, rapid surface runoff, and high water erosion hazard. Calodo soils are shallow and well drained with moderately slow permeability, very low or low available water capacity, rapid surface runoff, and high water erosion hazard. Moderately suited for rangelands. Some rural homesite development also occurs. Subject to sheet erosion due to silty clay loam and loam surface layers. Capabillity subclass VI5 (15), nonirrigated.
Nacimiento-Calodo complex, 50 to 75 percent slopes	Very steep soils located on foothills and mountains. Vegetated by annual grasses and forbs with brush. 45% Nacimiento soils, 25% Calodo soils. Nacimiento soils are moderately deep and well drained with moderately slow permeability, low or moderate available water capacity, very rapid surface runoff, and very high water erosion hazard. Calodo soils are shallow and well drained with moderately slow permeability, very low or low available water capacity, very rapid surface runoff, and very high water erosion hazard. Moderately suited for rangelands. Subject to sheet and gully erosion and soil compaction. Capability suclass VIIe (15), nonirrigated.
Obispo-Rock outcrop complex, 15 to 75 percent slopes	Moderately steep to very steep soils and rock outcrop located on mountain ridges and side slopes. Vegetated by annual and perennial grasses and forbs, with some brush. 50% Obispo soils; 30% rock outcrop. Obispo soils are shallow, well drained, and formed from serpentine. Obispo soils have slow permeability, very low or low available water capacity, rapid or very rapid surface runoff, and high or very high water erosion hazard. Rock outcrop is serpentine at or near soil surface. Land uses include rangelands and watershed. Poorly suited for rangelands. Subject to sheet erosion due to clay surface layer and steep slopes. Capability subclass VIIe (15), nonirrigated.

Map Unit	Description
Riverwash	Active stream and river channels. Excessively drained, water-deposited sand, loamy sand, and sandy loam with various amounts of gravel and cobbles. Highly stratified soils with great variations. Excessively drained, very rapid permeability, very slow surface runoff, and very low available water capacity. Land uses include recreation and wildlife habitat. Capability subclass VIIw (14), nonirrigated.
Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	Steep and very steep complex located on mountains. Sparsely vegetated by annual grasses. 55% rock outcrop; 25% Haploxerolls. Rock outcrop is various types of bedrock. Lithic Haploxerolls are mostly Lodo, Lopez, and Obispo series. Less than 20 inches deep to rock. Poorly suited for most agricultural or urban land uses due to shallow depth to rock, steep slopes, and high percentage of rock. Capability subclass VIIIs (15), nonirrigated.
Salinas silty clay loam, 0 to 2 percent slopes	Nearly level soils located on alluvial fans and plains. Vegetated by annual grasses and forbs, with scattered hardwoods. Soils are very deep and well drained with moderately slow permeability, high or very high available water capacity, slow surface runoff, and slight water erosion hazard. Land uses include vegetable and hay crops, rangeland, and urban development. Well-suited for agriculture. Capability class I (14), irrigated and capability unit IIIc-1 (14), nonirrigated.
Salinas silty clay loam, 2 to 9 percent slopes	Gently to moderately sloping soils located on alluvial fans and plains. Vegetated by annual grasses and forbs with some hardwoods. Soils are very deep and well drained with moderately slow permeability, high or very high available water capacity, slow or medium surface runoff, and slight or moderate water erosion hazard. Land uses include hay crops, small grains, urban development, irrigated pasture, or rangeland. Erosion hazard increases with greater slopes. Capability units IIe-1 (14), irrigated and IIIe-1 (14), nonirrigated.
San Simeon sandy loam, 15 to 30 percent slopes	Moderately steep soils located on foothills. Vegetated by annual and perennial grasses and forbs, with some brush and conifers. Soils are moderately deep and moderately well drained with very slow permeability, very low or low available water capacity, rapid surface runoff, high water erosion hazard, and high shrink-swell potential for subsoil. Poorly suited for rangelands due to clay subsoils restricting plant growth and water movement. Subject to gully erosion due to loamy surface layer and clay subsoil. Capability subclass VIe (15), nonirrigated.
San Simeon sandy loam, 2 to 9 percent slopes	Gently sloping and moderately sloping soils located on foothills and terraces. Vegetated by annual and perennial grasses and forbs, with areas of brush or conifers, such as Monterey pine. Soils are moderately deep and moderately well drained with very slow permeability, very low or low available water capacity, slow or medium surface runoff, slight or moderate water erosion hazard, and high shrink-swell potential of subsoil. Land uses include rangeland and dryland farming. Land uses in Cambria area include urban development and recreation. Poorly-suited for rangelands. Subject to gully erosion due to loamy surface layer and clay subsoil. Capability units IVe-3 (15), irrigated and nonirrigated.
San Simeon sandy loam, 30 to 50 percent slopes	Steep soils located on foothills. Vegetated with annual and perennial grasses and forbs, with areas of brush or confiers. Typically vegetated with Monterey pine and understory shrubs. Soils are moderately deep and moderately well drained with very slow permeability, very low or low available water capacity, rapid surface runoff, high water erosion hazard, and high shrink-swell potential of the subsoil. Poorly suited for rangelands. Subject to gully erosion due to loamy surface layer and clay subsoil. Permanent plant cover should be maintained at all times due to high erosion hazard. Capabilty subclass VIe (15), nonirrigated.

Map Unit	Description
San Simeon sandy loam, 9 to 15 percent slopes	Strongly sloping soils located on foothills and terraces. Vegetated by annual and perennial grasses and forbs, with some brush or conifers. Soils are moderately deep and moderately well drained with very slow permeability, very low or low available water capacity, medium surface runoff, moderate water erosion hazard, and high shrink-swell potenital in subsoil. Land uses In Cambria area include urban development and recreation, with some rangelands. Poorly-suited for rangelands. Subject to gully erosion due to clay subsoil and loamy surface. Typically covered with Monterey pines. Capability units IVe-3 (15), irrigated and nonirrigated.
Santa Lucia shaly clay loam, 30 to 50 percent slopes	Steep soils located on mountains. Vegetated by brush or annual grasses and forbs, with scattered hardwood vegetation. Soils are moderately deep and well drained with moderate permeability, very low or low available water capacity, rapid surface runoff, and moderate or high water erosion hazard. Moderately suited for rangelands. Subject to sheet erosion due to shaly clay loam surface and steep slopes. Sheet erosion produces more shale fragments on soil surface and hinders further vegetative growth. Capability subclass VIe (15), nonirrigated.
Santa Lucia shaly clay loam, 50 to 75 percent slopes	Very steep soils located on mountains. Vegetated by brush, annual grasses, forbs, and areas of hardwood vegetation. Moderately deep and well drained with moderate permeability, very low or low available water capacity, very rapid surface runoff, and high or very high water erosion hazard. Land uses include rangeland and recreation. Poorly suited for rangelands. Subject to sheet erosion due to shaly clay loam surface layer and steep slopes. Capability subclass VIIe (15), nonirrigated.
Santa Lucia very shaly clay loam, 9 to 15 percent slopes	Strongly sloping soils located on foothills and mountains. Vegetated by annual grasses, forbs, or brush, with scattered hardwoods. Soils are moderately deep and well drained with moderate permeability, very low or low available water capacity, medium surface runoff, and slight or moderate water erosion hazard. Land uses include small grains, hay crops, and rangelands. Suited for dryfarming and moderately suited for rangelands. Subject to sheet erosion due to shaly clay loam surface. Capability unit IVe-4 (15), irrigated and nonirrigated.
Water	
Xerorthents, escarpment	Moderately steep and steep, relatively smooth, descending slopes located at the end of terraces. Vegetated by anuual grasses and shrubs. Fairly well stabilized soils. Soil material varies. When surface is bare, runoff is rapid and the water erosion hazard is high. Deep gullies sometimes present. Grazelands. Capability subclass VIIe (15), nonirrigated.
Zaca clay, 15 to 30 percent slopes	Moderately steep soils located on foothills and mountains. Vegetated by annual grasses and forbs with some hardwoods along drainages. Soils are deep and well drained with slow permeability, high available water capacity, rapid surface runoff, moderate water erosion hazard, and subject to slippage when wet. Land uses include rangeland, lemons, avocados, and small grains. Suited for dryland farming on gentle slopes. Well-suited for rangelands. Subject to surface compaction due to clay texture. Capability unit IVe-5 (15), nonirrigated.
Zaca clay, 30 to 50 percent slopes	Steep soils located on foothills and mountains. Vegetated by annual grasses and forbs, with hardwoods along drainages. Soils are deep and well drained with slow permeability, high available water capacity, rapid surface runoff, high water erosion hazard, and subject to slippage when wet. Well-suited for rangelands. Subject to surface compaction due to clay texture. Capability subclass VIe (15), nonirrigated.
Zaca clay, 9 to 15 percent slopes	Strongly sloping or rolling soils located on low lying foothills. Vegetated by annual grasses and forbs, with some hardwoods along drainages. Soils are deep and well drained with slow permeability, high available water capacity, medium surface runoff, and moderate water erosion hazard. Land uses include small grains, hay crops, rangelands, lemons, and avocados. Gentle slopes suited for dry farming. Cover crops needed in orchards to reduce erosion. Well-suited for rangelands. Subject to surface compaction due to clay soil texture. Capability units IIIe-5 (15), irrigated and nonirrigated.

APPENDIX G

GIS DATA DESCRIPTIONS AND SOURCES

FILE NAME	DATA TITLE	DATA FORMAT
Basin	Basin	shapefile
CA_Counties	County Boundaries (1:24000)	shapefile
Cambria_area_housing	Housing Census Data - Cambria	shapefile
Cambria_area_pop	Population Census Data - Cambria	shapefile
canopy2_011007	National Land Cover Database Tree Canopy Layer	remote-sensing image
categ_rural_lu_SRC	Rural land use - Santa Rosa Creek Watershed	shapefile
Cattle gully	Gully Erosion Associated with Cattle Trails	shapefile
Cattle trails	Cattle Trail Erosion	shapefile
climate_precipitation (FOLDER)	103-Year High-Resolution Precipitation Climate Data Set for the Conterminous United States	13 shapefiles within folder
climate_temperature (FOLDER)	Seamless Daily Minimum Temperature for the Conterminous United States; and Seamless Daily Maximum Temperature for the Conterminous United States	3 shapefiles within folder
clu_public_SRC	Common Land Unit - Santa Rosa Creek Watershed	shapefile
Community	Community	shapefile
CommunityAdvisoryCouncils	CAC Boundaries	shapefile
CONUS_wetland_polygons_SRC	WETDBA.CONUS_wet_poly	shapefile
County_Hardwoods	County Hardwoods - Santa Rosa Creek Watershed	shapefile
county_mines	Extracting Activities - Santa Rosa Creek Watershed	shapefile
County_Vegetation	County Vegetation - Santa Rosa Creek Watershed	shapefile
countywide_luc	Land use category - Santa Rosa Creek Watershed	shapefile
csds	csds	shapefile
des-coastal_zone_SRC	Coastal Zone - Santa Rosa Creek Watershed	shapefile

FILE NAME	DESCRIPTION
Basin	Location information of detention basins in the Santa Rosa Creek Watershed, Cambria, California. Basins provide information about sites where local deposition of detached soil may be occurring. Data were acquired for the Santa Rosa Creek Watershed Conservation Plan, 2008.
CA_Counties	California county boundary coverage
Cambria_area_housing	2000 Census Block Data for Housing - Redistricting Census TIGER/Line 2000 Data. This data contains information on: dwelling units, occupancy, vacancy, tenure, and the number of persons in a household.
Cambria_area_pop	2000 Census Blocks for Population Data - Redistricting Census TIGER/Line 2000 Data. This data contains information on total population and ethnicity breakdown.
canopy2_011007	Current, consistent, seamless, and accurate National Land cover Database (NLCD) circa 2001 for the United States at medium spatial resolution.
categ_rural_lu_SRC	Rural Land Use Categories for Santa Rosa Creek Watershed.
Cattle gully	Location information of gully erosion sites occurring in association with cattle trails in the Santa Rosa Creek Watershed, Cambria, California. Sites are often located in the upper reaches of tributaries and unnamed drainages. Data were acquired for the Santa Rosa Creek Watershed Conservation Plan, developed by the Land Conservancy of San Luis Obispo County.
Cattle trails	Location information of erosion sites, excluding gully erosion, occurring in association with a high density of cattle trails resulting in decreased vegetative ground cover in the Santa Rosa Creek Watershed, Cambria, California. Data were acquired for the Santa Rosa Creek Watershed Conservation Plan, 2008.
climate_precipitation (FOLDER)	Spatially distributed daily precipitation for the Conterminous United States (CONUS). Each file represents 1 day for the period 1960-2001 and at the 2.5 min (around 4 km) resolution. The data were obtained via interpolation of daily ratios calculated from ground-based meteorological station records (Eischeid et al. 2000) and combined with the respective fields of monthly topography-enhanced estimates, the PRISM (Parameter-elevation Regressions on Independent Slopes Model) maps (Daly et al. 1994).
climate_temperature (FOLDER)	Spatially distributed daily minimum, maximum, and average temperature for the Conterminous United States (CONUS). Each file represents 1 day for the period 1960-2001 and at the 2.5 min (around 4 km) resolution. The data were obtained via interpolation of daily ratios calculated from ground-based meteorological station records (Eischeid et al. 2000) and combined with the respective fields of monthly topography-enhanced estimates, the PRISM (Parameter-elevation Regressions on Independent Slopes Model) maps (Daly et al. 1994).
clu_public_SRC	digitized farm tract and field boundaries and associated attribute data. The USDA Farm Service Agency (FSA) defines farm fields as agricultural land that is delineated by natural and man-made boundaries such as road ways, tree lines, waterways, fence lines, etc. Field boundaries are visible features that can be identified and delineated on aerial photography and digital imagery. Farm tracts are defined by FSA as sets of contiguous fields under single ownership. Common land units are used to administer USDA farm commodity support and conservation programs in a GIS environment.
Community	Point locations of the communities of Cambria and Harmony using digitized 7.5 minute topography maps, DRGs.
CommunityAdvisoryCouncils	Official Community Area Boundaies for properties in the unincorporated area of San Luis Obispo County. The Coordinates for this dataset are State Plane Coordinate System, Zone 5, NAD 1983 Feet.
CONUS_wetland_polygons_SRC	This data set represents the extent, approximate location and type of wetlands and deepwater habitats in the conterminous United States. These data delineate the areal extent of wetlands and surface waters as defined by Cowardin et al. (1979).
County_Hardwoods	Locations of Hardwoods within Santa Rosa Creek Watershed - Includes species name and their associated density and acreage.
county_mines	Existing and historic mining and extractive activities in the Santa Rosa Creek Watershed.
County_Vegetation	Vegetation Types within the Santa Rosa Creek Watershed for resource management. Also includes species/habitat codes. Mapping was done between 1979 and 1981 by US Forest Service ecologists. The California Dept. of Foresty and Fire Protection created the digital coverage by scanning the source maps.
countywide_luc	Official land use category designations for properties in the unincorporated area of San Luis Obispo County.
csds	Community service district boundaries
des-coastal_zone_SRC	Designated Coastal Zone Area for Santa Rosa Creek Watershed after the passage of the Coastal Act of 1976.

FILE NAME	CREATOR	CONTENT DATE	SCALE
Basin	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	August 2008	≤1:2,000
CA_Counties	California Department of Forestry and Fire Protection (using data from BOR and DOC FMMP)	1997	1:24,000
Cambria_area_housing	San Luis Obispo County - Mapping/Graphics 781-5600	November 2001	Unknown
Cambria_area_pop	San Luis Obispo County - Mapping/Graphics 781-5600	April 2001	Unknown
canopy2_011007	U.S. Geological Survey	2001	Unknown
categ_rural_lu_SRC	San Luis Obispo County - Mapping/Graphics 781-5600	February 2001	Unknown
Cattle gully	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	August 2008	≤1:2,000
Cattle trails	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	August 2008	≤1:2,000
climate_precipitation (FOLDER)	Mauro Di Luzio, Blackland Research Center, Texas Agricultural Experiment Station, Texas A&M University System, Temple, Texas	October 2007	2.5 minute resolution
climate_temperature (FOLDER)	Mauro Di Luzio, Blackland Research Center, Texas Agricultural Experiment Station, Texas A&M University System, Temple, Texas	October 2007	2.5 minute resolution
clu_public_SRC	USDA-FSA Aerial Photography Field Office	October 2007	1:7,920
Community	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	2008	1:24,000
CommunityAdvisoryCouncils	SLO County Planning & Building Geographic Technology & Design	September 2007	Unknown
CONUS_wetland_polygons_SRC	U.S. Fish and Wildlife Service, Division of Habitat and Resouce Conservation	1977 to present	1:24,000 to 1:25,000
County_Hardwoods	California Department of Forestry	December 1998	Unknown
county_mines	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	2008	≤1:2,000
County_Vegetation	California Department of Foresty (CDF)	June 1996	1:250,000
countywide_luc	SLO County Planning & Building Geographic Technology & Design	December 2007	1:24,000
csds	County of San Luis Obispo-Mapping/Graphics	February 2004	Unknown
des-coastal_zone_SRC	San Luis Obispo County - Mapping/Graphics 781-5600	January 2000	1:24,000

FILE NAME	PROJECTED COORDINATE SYSTEM	GEOGRAPHIC COORDINATE SYSTEM (DATUM)	COORDINATE SYSTEM
Basin	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
CA_Counties	NAD_1927_California_Teale_Albers	GCS_North_American_1927	Albers Conical Equal Area
Cambria_area_housing	Custom	GCS_North_American_1983	Lambert Conformal Conic
Cambria_area_pop	Custom	GCS_North_American_1983	Lambert Conformal Conic
canopy2_011007			Albers Conical Equal Area
categ_rural_lu_SRC	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
Cattle gully	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
Cattle trails	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
climate_precipitation (FOLDER)		World Geodetic Spheroid 1972 (WGS72)	
climate_temperature (FOLDER)		World Geodetic Spheroid 1972 (WGS72)	
clu_public_SRC	NAD_1983_UTM_Zone_10N	GCS_North_American_1983	Universal Transverse Mercator
Community	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
CommunityAdvisoryCouncils	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
CONUS_wetland_polygons_SRC			Albers Conical Equal Area
County_Hardwoods	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
county_mines	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
County_Vegetation	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
countywide_luc	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
csds	Custom	GCS_North_American_1983; State Plane, Zone V, Feet	Lambert Conformal Conic
des-coastal_zone_SRC	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic

FILE NAME	HORIZONTAL DATUM	EDITS TO ORIGINAL SHAPEFILE
Basin	North American Datum of 1983	None
CA_Counties	North American Datum of 1927	None
Cambria_area_housing	North American Datum of 1983	Cambria housing census data were extracted by intersecting 2000 census data with the Santa Rosa Creek Watershed boundary.
Cambria_area_pop	North American Datum of 1983	Cambria population census data were extracted by intersecting 2000 census data with the Santa Rosa Creek Watershed boundary.
canopy2_011007	North American Datum of 1983	None
categ_rural_lu_SRC	North American Datum of 1983	Data clipped using the Santa Rosa Creek Watershed boundary.
Cattle gully	North American Datum of 1983	None
Cattle trails	North American Datum of 1983	None
climate_precipitation (FOLDER)		None
climate_temperature (FOLDER)		None
clu_public_SRC	North American Datum of 1983	Data clipped using the Santa Rosa Creek Watershed boundary.
Community	North American Datum of 1983	None
CommunityAdvisoryCouncils	North American Datum of 1983	None
CONUS_wetland_polygons_SRC	North American Datum of 1983	Data clipped using the Santa Rosa Creek Watershed boundary.
County_Hardwoods	North American Datum of 1983	County hardwood dataset downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using shapefile delineating the Santa Rosa Creek Watershed boundary.
county_mines	North American Datum of 1983	County mining data were downloaded from SLO Datafinder at http://lib.calpoly.edu/gis/. Digitized 7.5 minute quadrangle of the central coast and 2007 six inch ground resolution aerial imagery of the watershed were used to compare existing mining activities documented in the county data and locate additional extractive activities.
County_Vegetation	North American Datum of 1983	County vegetation dataset downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using shapefile delineating the Santa Rosa Creek Watershed boundary.
countywide_luc	North American Datum of 1983	Data clipped using the Santa Rosa Creek Watershed boundary.
csds	North American Datum of 1983	None
des-coastal_zone_SRC	North American Datum 1983	Data clipped using Santa Rosa Creek Watershed Boundary

FILE NAME	DATA STORAGE	METADATA STANDARD
Basin	Land Conservancy of San Luis Obispo.	ISO
CA_Counties	SLO Datafinder (http://lib.calpoly.edu/gis/)	FGDC
Cambria_area_housing	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
Cambria_area_pop	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
canopy2_011007	Multi-Resolution Land Characteristics Consortium (http://www.mrlc.gov/)	FGDC
categ_rural_lu_SRC	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
Cattle gully	Land Conservancy of San Luis Obispo.	ISO
Cattle trails	Land Conservancy of San Luis Obispo.	ISO
climate_precipitation (FOLDER)	Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/)	FGDC
climate_temperature (FOLDER)	Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/)	FGDC
clu_public_SRC	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	
Community	Land Conservancy of San Luis Obispo.	ISO
CommunityAdvisoryCouncils	SLO Datafinder (http://lib.calpoly.edu/gis/)	FGDC
CONUS_wetland_polygons_SRC	Original data acquired from National Wetlands Inventory, http://www.fws.gov/wetlands/Data/DataDownload.html. Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
County_Hardwoods	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
county_mines	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	ISO
County_Vegetation	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
countywide_luc	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
csds	SLO Datafinder (http://lib.calpoly.edu/gis/)	FGDC
des-coastal_zone_SRC	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC

FILE NAME	DATA TITLE	DATA FORMAT
des-flood_SRC	Flood Zone - Santa Rosa Creek Watershed	shapefile
des-gsafault	des-gsafault	shapefile
des-gsalandslide_SRC	des-gsalandslide Santa Rosa Creek Watershed	shapefile
des-historical_src	Historical - Santa Rosa Creek Watershed	shapefile
Drainage_2	Blueline Stream Drainage Boundaries - Santa Rosa Creek Watershed	shapefile
Drainage_2_SOILS	Blueline Stream Drainage Soils - Santa Rosa Creek Watershed	shapefile
Drainage_Results	RUSLE2 Results by Drainage - Santa Rosa Creek Watershed	shapefile
Extent	Extent	shapefile
Family_parcels_2	Family Parcels Combined - Santa Rosa Creek Watershed	shapefile
Family_subdivided_2	Family Parcels - Santa Rosa Creek Watershed	shapefile
fault_lines	fault_lines	shapefile
geology_SRC_clip	Digital geologic map database of Santa Rosa Creek Watershed, Cambria, CA	shapefile
Graze_LUC	Grazing Parcels - Santa Rosa Creek Watershed	shapefile
grnd_wtr_basins	grnd_wtr_basins	shapefile
Gully erosion	Gully Erosion	shapefile
GV_roads	Roads - Green Valley Creek Watershed	shapefile
GV_soils_mapunits	Soils - Green Valley Creek Watershed	shapefile
GV_streams	Streams - Green Valley Creek Watershed	shapefile
GVC_watershed	Green Valley Creek Watershed	shapefile
hydrologic_area	hydrologic_area	shapefile
hydrologic_subarea	hydrologic_subarea	shapefile
hydrologic_unit	hydrologic_unit	shapefile
image_03b	image_03b	raster digital data

FILE NAME	DESCRIPTION
des-flood_SRC	Designated Flood Zones (A or B) within Santa Rosa Creek Watershed according to the Federal Emergency Management Agency (FEMA) - http://www.fema.gov.
des-gsafault	Designated Geologic Sensitive Area. Location of major faults by type county wide for safety purposes.
des-gsalandslide_SRC	Designated Geologic Sensitive Area - Landslide Potential within the Santa Rosa Creek Watershed. Polygon locations of areas that have a greater risk for landslide
des-historical_src	Combining Designation - Historic Sites within Santa Rosa Creek Watershed. The Coordinates for this dataset are State Plane Coordinate System, Zone 5, NAD 1983 Feet.
Drainage_2	Drainage boundary of each blueline stream within the Santa Rosa Creek Watershed. Data created to gather information to predict potential erosion rates within Santa Rosa Creek Watershed, using GIS and the RUSLE2 program developed by the United States Department of Agriculture and the Natural Resources Conservation Service (USDA NRCS).
Drainage_2_SOILS	Soil data for blue line stream drainages within the Santa Rosa Creek Watershed. These data were used to evaluate potential soil loss using RUSLE2 and GIS for the Santa Rosa Creek Watershed Conservation Plan, 2008. This data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a lpanimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information.
Drainage_Results	Predicted annual soil erosion rates (tons per year) by drainage, with the Santa Rosa Creek Watershed. Data created to gather information to predict potential erosion rates within Santa Rosa Creek Watershed, using GIS and the RUSLE2 program developed by the United States Department of Agriculture and the Natural Resources Conservation Service (USDA NRCS).
Extent	Point locations of the northern, western, southern, and eastern most extent of the Santa Rosa Creek Watershed boundary using digitized 7.5 minute topography maps, DRGs.
Family_parcels_2	"Family" parcel polygon layer for Santa Rosa Creek Watershed. "Family" parcels are the combined parcel size in which one family owns is over 300 acres. "Family" parcels have the same family last name but may be owned by different members of that family. "Family" parcels with the same last name, adjacent to one another, were combined to show the total family ownership boundary.
Family_subdivided_2	"Family" parcel polygon layer for Santa Rosa Creek Watershed. "Family" parcels are the combined parcel size in which one family owns is over 300 acres. "Family" parcels have the same family last name but may be owned by different members of that family.
fault_lines	County-wide fault lines with fault types.
geology_SRC_clip	Digital compilation of stratigraphic formations using USGS and California Geological Survey maps.
Graze_LUC	Parcel polygon layer with grazing activities for land use, for Santa Rosa Creek Watershed, San Luis Obispo County.
grnd_wtr_basins	County Wide Ground Water Basins database that displays groundwater basins and sub-basins as defined by the California Department of Water Resources. The Coordinates for this dataset are State Plane Coordinate System, Zone 5, NAD 1983 Feet.
Gully erosion	Location information of erosion sites occurring due to gullies, including ephemeral gullies, in the Santa Rosa Creek Watershed, Cambria, California. Data were acquired for the Santa Rosa Creek Watershed Conservation Plan, 2008.
GV_roads	Tiger Line Roads downloaded from the TIGER database - contains names for roads. Roads within the Green Valley Creek Watershed, in Cambria, CA.
GV_soils_mapunits	Soil Classification for Green Valley Creek Watershed.
GV_streams	National Hydrology Dataset (NHD) developed by the USGS mapping out water reaches from lakes, rivers, streams, and other surface water features.
GVC_watershed	Green Valley Creek Watershed boundary, Cambria, California.
hydrologic_area	Division of Region 3 California Central Coast, by hydrologic area.
hydrologic_subarea	Division of Region 3 California Central Coast, by hydrologic subareas.
hydrologic_unit	Division of Region 3 California Central Coast, by hydrologic units.
image_03b	Aerial photograph of Santa Rosa Creek Watershed. Specs to fly were 8,400' above ground level. Ground resolution six inches.

FILE NAME	CREATOR	CONTENT DATE	SCALE
des-flood_SRC	San Luis Obispo County - Mapping/Graphics 781-560	March 2000	1:24,000
des-gsafault	San Luis Obispo County-Mapping/Graphics 781-5600	February 1998	1:24,000
des-gsalandslide_SRC	San Luis Obispo County - Mapping/Graphics 781-5600.	February 2000	1:24,000
des-historical_src	SLO County Planning & Building Geographic Technology & Design	1980	Unknown
Drainage_2	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	May 2008	≤1:2,000
Drainage_2_SOILS	U.S. Department of Agriculture, Natural Resources Conservation Service	October 2005	Unknown
Drainage_Results	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	May 2008	1:24,000
Extent	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	2008	1:24,000
Family_parcels_2	Barclay Maps	March 2005	Unknown
Family_subdivided_2	Barclay Maps	March 2005	Unknown
fault_lines	San Luis Obispo County-Mapping/Graphics for Furgo	July 2000	Unknown
geology_SRC_clip	San Luis Obispo County Planning & Building Department.	2007	1:24,000
Graze_LUC	Barclay Maps	March 2005	Unknown
grnd_wtr_basins	San Luis Obispo County-Mapping/Graphics for State Water Resources Control Board	March 1999	1:250,000
Gully erosion	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	August 2008	≤1:2,000
GV_roads	San Luis Obispo County for the Census Bureau - Mapping/Graphics 781-5600	May 2001	Unknown
GV_soils_mapunits	San Luis Obispo County for the NRCS - Mapping/Graphics 781-5600	July 1999	Unknown
GV_streams	U.S. Geological Survey in cooperation with U.S. Environmental Protection Agency	2003	Unknown
GVC_watershed	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	February 2008	1:24,000
hydrologic_area	Central Coast Regional Water Quality Control Board	May 2003	Unknown
hydrologic_subarea	Central Coast Regional Water Quality Control Board	May 2003	Unknown
hydrologic_unit	Central Coast Regional Water Quality Control Board	May 2003	Unknown
image_03b	County of San Luis Obispo-Mapping/Graphics	June/July 2007	1:1,400

FILE NAME	PROJECTED COORDINATE SYSTEM	GEOGRAPHIC COORDINATE SYSTEM (DATUM)	COORDINATE SYSTEM
des-flood_SRC	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
des-gsafault	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
des-gsalandslide_SRC	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
des-historical_src	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
Drainage_2	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
Drainage_2_SOILS	NAD_1983_StatePlane_California_V_FIPS_0405	GCS_North_American_1983	State Plane Coordinate System
Drainage_Results	NAD_1983_StatePlane_California_V_FIPS_0405	GCS_North_American_1983	Lambert Conformal Conic
Extent	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
Family_parcels_2	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
Family_subdivided_2	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
fault_lines	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
geology_SRC_clip	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
Graze_LUC	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
grnd_wtr_basins	Custom	GCS_North_American_1983	Lambert Conformal Conic
Gully erosion	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
GV_roads	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
GV_soils_mapunits	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
GV_streams	teale_albers	GCS_North_American_1927	Albers Conical Equal Area
GVC_watershed	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
hydrologic_area	teale_albers	GCS_North_American_1927	Albers Conical Equal Area
hydrologic_subarea	teale_albers	GCS_North_American_1927	Albers Conical Equal Area
hydrologic_unit	teale_albers	GCS_North_American_1927	Albers Conical Equal Area
image_03b	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic

FILE NAME	HORIZONTAL DATUM	EDITS TO ORIGINAL SHAPEFILE
des-flood_SRC	North American Datum 1983	Data clipped using Santa Rosa Creek Watershed Boundary
des-gsafault	North American Datum of 1983	None
des-gsalandslide_SRC	North American Datum 1983	Data clipped using Santa Rosa Creek Watershed Boundary
des-historical_src	North American Datum of 1983	Sites selected using Santa Rosa Creek Watershed boundary and exported into new shapefile.
Drainage_2	North American Datum of 1983	None
Drainage_2_SOILS	North American Datum of 1983	Soil dataset downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using shapefile delineating the Santa Rosa Creek Watershed boundary. Clipped soil data were then intersected with blue line stream drainage boundaries
Drainage_Results	North American Datum of 1983	None
Extent	North American Datum of 1983	None
Family_parcels_2	North American Datum of 1983	Parcels selected and clipped using the Santa Rosa Creek Watershed boundary. "Family" parcels were selected if the combined total area of a family exceeded 300 acres. Next, parcels were exported into the "family parcel" layer and lastly, they were dissolved to combine adjacent polygons with the same family last name, showiing the entire area of ownership within one polygon.
Family_subdivided_2	North American Datum of 1983	Data obtained through Barclay Maps and the County of San Luis Obispo. Parcels were selected and clipped using the Santa Rosa Creek Watershed boundary. "Family" parcels were selected if the combined total area of a family exceeded 300 acres. The parcels were then exported into the "family parcel" layer.
fault_lines	North American Datum of 1983	None
geology_SRC_clip	North American Datum of 1983	Data clipped using the Santa Rosa Creek Watershed boundary.
Graze_LUC	North American Datum of 1983	San Luis Obispo County parcels within the Santa Rosa Creek Watershed with grazing LUC descriptors were selected and exported into new shapefile.
grnd_wtr_basins	North American Datum of 1983	None
Gully erosion	North American Datum of 1983	None
GV_roads	North American Datum of 1983	Data clipped using Green Valley Creek Watershed boundary.
GV_soils_mapunits	North American Datum of 1983	Original soils shapefiles merged and then clipped using Green Valley Creek Watershed boundary.
GV_streams	North American Datum of 1927	Data clipped using the Green Valley Creek Watershed boundary.
GVC_watershed	North American Datum of 1983	None
hydrologic_area	North American Datum of 1927	None
hydrologic_subarea	North American Datum of 1927	None
hydrologic_unit	North American Datum of 1927	None
image_03b	North American Datum of 1983	Aerial image clipped using Santa Rosa Creek Watershed Area of Interest (AOI) in ERDAS, a remote sensing editing software, at California Polytechnic State University BioResource Agricultural Engineering laboratory.

FILE NAME	DATA STORAGE	METADATA STANDARD
des-flood_SRC	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
des-gsafault	SLO Datafinder (http://lib.calpoly.edu/gis/)	FGDC
des-gsalandslide_SRC	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
des-historical_src	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
Drainage_2	Land Conservancy of San Luis Obispo.	ISO
Drainage_2_SOILS	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
Drainage_Results	Land Conservancy of San Luis Obispo.	ISO
Extent	Land Conservancy of San Luis Obispo.	ISO
Family_parcels_2	Parcel data purchased from the County Assessor's Office. Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
Family_subdivided_2	Parcel data purchased from the County Assessor's Office. Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
fault_lines	SLO Datafinder (http://lib.calpoly.edu/gis/)	FGDC
geology_SRC_clip	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
Graze_LUC	Parcel data purchased from the County Assessor's Office. Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
grnd_wtr_basins	SLO Datafinder (http://lib.calpoly.edu/gis/)	FGDC
Gully erosion	Land Conservancy of San Luis Obispo.	ISO
GV_roads	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
GV_soils_mapunits	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
GV_streams	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
GVC_watershed	Land Conservancy of San Luis Obispo.	ISO
hydrologic_area	SLO Datafinder (http://lib.calpoly.edu/gis/)	FGDC
hydrologic_subarea	SLO Datafinder (http://lib.calpoly.edu/gis/)	FGDC
hydrologic_unit	SLO Datafinder (http://lib.calpoly.edu/gis/)	FGDC
image_03b	Land Conservancy of San Luis Obispo.	NONE

FILE NAME	DATA TITLE	DATA FORMAT
image_04d	image_04d	raster digital data
impervious2_010407	National Land Cover Database Imperviousness Layer	remote-sensing image
mines	Erosion Associated with Mines	shapefile
nlcd_ca_utm11	nlcd_ca_utm11.tif	raster digital data
North_Coast_Veg	North Coast Vegetation - Santa Rosa Creek Watershed	shapefile
o_sw0204	24K Digital Raster Graphic (DRG) Mosaics	raster digital data
Oak_SRCW	Formation Level Vegetation Mapping Database for San Luis Obispo County, California, 2007	shapefile
Other_drainage	Boundaries of Areas Outside Blueline Stream Drainage Boundaries - Santa Rosa Creek Watershed	shapefile
Other_drainage_SOILS	Soils Outside Blueline Stream Drainages - Santa Rosa Creek Watershed	shapefile
Other_erosion	Other Erosion	shapefile
Other_roads	Unclassified Roads	shapefile
ownership_boundaries	ownership_boundaries	shapefile
park_Clip	Parks - Santa Rosa Creek Watershed	shapefile
planningareas	planningareas	shapefile
Road_erosion	Road Erosion	shapefile
roads	Roads - Santa Rosa Creek Watershed	shapefile
RUSLE2_Bline_Drainages	Predicted Soil Loss for Blueline Stream Drainages within the Santa Rosa Creek Watershed	shapefile
RUSLE2_GV_OD	Predicted Soil Loss for Areas Outside Blueline Stream Drainage Boundaries - Green Valley Creek Subwatershed	shapefile

FILE NAME	DESCRIPTION
image_04d	Aerial photograph of Santa Rosa Creek Watershed. Specs to fly were 8,400' above ground level. Ground resolution six inches.
impervious2_010407	Current, consistent, seamless, and accurate National Land cover Database (NLCD) circa 2001 for the United States at medium spatial resolution.
mines	Location information of erosion sites occurring in association to mining or mineral excavation activities in the Santa Rosa Creek Watershed, Cambria, California. Data were acquired for the Santa Rosa Creek Watershed Conservation Plan, 2008.
nlcd_ca_utm11	The complete, current and consistent public domain information on land use land cover in the United States.
North_Coast_Veg	North Coast Planning Area Vegetation Types within the Santa Rosa Creek Watershed. Vegetation Types cover only coastal zone area of watershed.
o_sw0204	Mosaicked California 7.5 Minute by 7.5 Minute 1:24,000 and 1:25,000 Digital Raster Graphic (DRG) USGS Quad Images.
Oak_SRCW	Boundaries of oak forest communities within the Santa Rosa Creek Watershed.
Other_drainage	Delineated boundaries outside blueline stream drainage boundaries within the Santa Rosa Creek Watershed. Data created to gather information to predict potential erosion rates within Santa Rosa Creek Watershed, using GIS and the RUSLE2 program developed by the United States Department of Agriculture and the Natural Resources Conservation Service (USDA NRCS).
Other_drainage_SOILS	Soil data for areas outside blueline stream boundaries within the Santa Rosa Creek Watershed. These data were used to evaluate potential soil loss using RUSLE2 and GIS for the Santa Rosa Creek Watershed Conservation Plan, 2008. This data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a lpanimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information.
Other_erosion	Location information of erosion sites occurring in the Santa Rosa Creek Watershed, Cambria, California. Erosion sites in these data could not be confirmed, but a feature viewed on the aerial imagery was distinct enough to be mapped. These sites include locations such as rocky hillsides in serpentine areas where erosion appears to be creating ephemeral gullies. Other sites, such as possible excavation sites, were also identified and mapped using this layer. Data were acquired for the Santa Rosa Creek Watershed Conservation Plan, 2008.
Other_roads	Location information of unclassified roads occurring in the Santa Rosa Creek Watershed, Cambria, California. Roads not classified in TIGER road data were digitized using aerial imagery. Road types include ranch, agricultural and private roads mostly located in the upper watershed. Data were acquired for the Santa Rosa Creek Watershed Conservation Plan, 2008.
ownership_boundaries	To determine how well species and plant communities are currently protected, CA-GAP enhanced the 1:100,000 scale land ownership map maintained by the California Teale Data Center by adding boundaries of special managed areas not in the original ownership map, incorporating recent acquisitions, and classifying all lands by management status.
park_Clip	Polyogn locations of parks within the Santa Rosa Creek Watershed.
planningareas	Official Planning Area boundaries of San Luis Obispo County.
Road_erosion	Location information of erosion sites occurring in association with concentrated water flow leaving a road surface during rainfall events in the Santa Rosa Creek Watershed, Cambria, California. Data were acquired for the Santa Rosa Creek Watershed Conservation Plan, 2008.
roads	Tiger Line Roads within the Santa Rosa Creek Watershed, downloaded from the TIGER database - contains names for roads
RUSLE2_Bline_Drainages	Soil data for blue line stream drainages within the Santa Rosa Creek Watershed. These data were used to evaluate potential soil loss using RUSLE2 and GIS for the Santa Rosa Creek Watershed Conservation Plan, 2008. RUSLE2 predicted annual soil loss values included in this dataset. The digital soil survey dataset is generally the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a lpanimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information.
RUSLE2_GV_OD	Soil data for areas outside blueline stream drainages within the Green Valley Creek Subwatershed. These data were used to evaluate potential soil loss using RUSLE2 and GIS for the Santa Rosa Creek Watershed Conservation Plan, 2008. RUSLE2 predicted annual soil loss values included in this dataset. The digital soil survey dataset is generally the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a lpanimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information.

FILE NAME	CREATOR	CONTENT DATE	SCALE
image_04d	County of San Luis Obispo-Mapping/Graphics	June/July 2007	1:1,400
impervious2_010407	U.S. Geological Survey	2001	Unknown
mines	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	May 2008	≤1:2,000
nlcd_ca_utm11	USDA NRCS - National Cartography & Geospatial Center	2001	1:100,000
North_Coast_Veg	San Luis Obispo County-MappingGraphics for Landscape Architecture GIS Lab, California Polytechnic State University	February 1998	Unknown
o_sw0204	U.S. Geological Survey, Teale Data Center GIS Solutions Group, California Department of Transportation, California State Water Resources Control Board, California Department of Fish and Game	re-scans were done between approx 11/1999 and 3/2000	1:24,000 and 1:25,000
Oak_SRCW	County of San Luis Obispo and AIS	unpublished	Variable
Other_drainage	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	May 2008	Unknown
Other_drainage_SOILS	U.S. Department of Agriculture, Natural Resources Conservation Service	October 2005	Unknown
Other_erosion	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	May 2008	≤1:2,000
Other_roads	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	May 2008	≤1:2,000
ownership_boundaries	U.S. Fish and Wildlife Service and researchers at the University of California, Santa Barbara	June 1998	1:100,000
park_Clip	San Luis Obispo County - Mapping/Graphics 781-5600	August 2001	Unknown
planningareas	SLO County Planning & Building Geographic Technology & Design	October 1998	1:24,000
Road_erosion	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	May 2008	≤1:2,000
roads	San Luis Obispo County for the Census Bureau - Mapping/Graphics 781-5600	May 2001	Unknown
RUSLE2_Bline_Drainages	Soils data created by U.S. Department of Agriculture, Natural Resources Conservation Service. RUSLE2 data input into database by Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	October 2005 and May 2008	Unknown
RUSLE2_GV_OD	Soils data created by U.S. Department of Agriculture, Natural Resources Conservation Service. RUSLE2 data input into database by Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	October 2005 and May 2008	Unknown

FILE NAME	PROJECTED COORDINATE SYSTEM	GEOGRAPHIC COORDINATE SYSTEM (DATUM)	COORDINATE SYSTEM
image_04d	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
impervious2_010407			Albers Conical Equal Area
mines	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
nlcd_ca_utm11			NAD_1983_UTM_Zone_11N
North_Coast_Veg	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
o_sw0204	IMAGINE GeoTIFF Support Copyright 1991 - 2001 by ERDAS, Inc. Al	GCS_North_American_1983	Albers Conical Equal Area
Oak_SRCW	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
Other_drainage	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
Other_drainage_SOILS	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	State Plane Coordinate System
Other_erosion	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
Other_roads	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
ownership_boundaries	Custom	GCS_North_American_1983	Lambert Conformal Conic
park_Clip	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
planningareas	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
Road_erosion	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
roads	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
RUSLE2_Bline_Drainages	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	State Plane Coordinate System
RUSLE2_GV_OD	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	State Plane Coordinate System

FILE NAME	HORIZONTAL DATUM	EDITS TO ORIGINAL SHAPEFILE
image_04d	North American Datum of 1983	Aerial image clipped using Santa Rosa Creek Watershed Area of Interest (AOI) in ERDAS, a remote sensing editing software, at California Polytechnic State University BioResource Agricultural Engineering laboratory.
impervious2_010407	North American Datum of 1983	None
mines	North American Datum of 1983	None
nlcd_ca_utm11	North American Datum of 1983	Data clipped using the Santa Rosa Creek Watershed boundary.
North_Coast_Veg	North American Datum of 1983	North Coast Vegetation dataset downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using shapefile delineating the Santa Rosa Creek Watershed boundary.
o_sw0204		None
Oak_SRCW	GCS_North American_1983	Clipped from County layer and calculated areas.
Other_drainage	North American Datum of 1983	None
Other_drainage_SOILS	North American Datum of 1983	Soil dataset downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using shapefile delineating the Santa Rosa Creek Watershed boundary. Clipped soils data intersected with "Other_drainages" shapefile.
Other_erosion	North American Datum of 1983	None
Other_roads	North American Datum of 1983	None
ownership_boundaries	North American Datum of 1983	None
park_Clip	North American Datum of 1983	Parks dataset downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using shapefile delineating the Santa Rosa Creek Watershed boundary.
planningareas	North American Datum of 1983	None
Road_erosion	North American Datum of 1983	None
roads	North American Datum of 1983	Road dataset downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using shapefile delineating the Santa Rosa Creek Watershed boundary.
RUSLE2_Bline_Drainages	North American Datum of 1983	Soil data downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using the Santa Rosa Creek Watershed boundary for the Santa Rosa Creek Watershed Conservation Plan, 2008. The clipped soil data were then intersected with blue line stream drainage boundaries to be able to analyze the soil data for each blue line stream individually. RUSLE2 GIS input values and predicted soil loss value data were added to tabular data.
RUSLE2_GV_OD	North American Datum of 1983	Soil data downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using the Santa Rosa Creek Watershed boundary. The clipped soil data were then intersected with polygon features of areas outside blueline stream drainage boundaries. The edited soil polygons were then clipped using the Green Valley Creek Watershed boundary. RUSLE2 GIS input values and predicted soil loss value data were added to tabular data.

FILE NAME	DATA STORAGE	METADATA STANDARD
image_04d	Land Conservancy of San Luis Obispo.	NONE
impervious2_010407	Multi-Resolution Land Characteristics Consortium (http://www.mrlc.gov/)	FGDC
mines	Land Conservancy of San Luis Obispo.	ISO
nlcd_ca_utm11	Original data located at Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/). Edited data located at Land Conservancy of San Luis Obispo County.	FGDC
North_Coast_Veg	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
o_sw0204	The California Spatial Information Library (CaSIL) at http://casil.ucdavis.edu/casil/imageryBaseMapsLandCover/baseMaps/drg/	FGDC
Oak_SRCW	Vegetation data acquired from the Land Conservancy of San Luis Obispo County through the County of San Luis Obispo.	FGDC
Other_drainage	Land Conservancy of San Luis Obispo.	ISO
Other_drainage_SOILS	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
Other_erosion	Land Conservancy of San Luis Obispo.	ISO
Other_roads	Land Conservancy of San Luis Obispo.	ISO
ownership_boundaries	SLO Datafinder (http://lib.calpoly.edu/gis/)	FGDC
park_Clip	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
planningareas	SLO Datafinder (http://lib.calpoly.edu/gis/)	FGDC
Road_erosion	Land Conservancy of San Luis Obispo.	ISO
roads	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
RUSLE2_Bline_Drainages	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
RUSLE2_GV_OD	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC

FILE NAME	DATA TITLE	DATA FORMAT
RUSLE2_NotAssessed	Soil Map Unit Polygons Not Assessed Using RUSLE2 - Santa Rosa Creek Watershed	shapefile
RUSLE2_USRC_OD	Predicted Soil Loss for Areas Outside Blueline Stream Drainage Boundaries - Upper Santa Rosa Creek Subwatershed	shapefile
soils	Predicted Soil Loss in the Santa Rosa Creek Watershed Using RUSLE2	shapefile
src_dem		raster digital data
src_parcels	Parcels - Santa Rosa Creek Watershed	shapefile
src_stream_reaches	Stream Reaches - Santa Rosa Creek	shapefile
SRCW_crops_edited	Crops - Santa Rosa Creek Watershed	shapefile
SRCW_lowerwatershed_soils	Lower Santa Rosa Creek Watershed Soil Data	shapefile
SRCW_soils_SLODatafinder	Soil Survey Data - Santa Rosa Creek Watershed	shapefile
Stream_bank_erosion	Stream Bank Erosion - Santa Rosa Creek Watershed	shapefile
streams	streams - Santa Rosa Creek Watershed	shapefile
tiger_mjr_roads	tiger_mjr_roads	shapefile
Unknown	Unknown Erosion Status	shapefile
Upper_clip_nonresidential	Rural Parcels - Upper Santa Rosa Creek Watershed	shapefile
upper_src_NRCS_SOILS	NRCS Soil Data - Soil Data Mart - Upper Santa Rosa Creek Subwatershed	shapefile
upper_src_roads	Roads - Upper Santa Rosa Creek Watershed	shapefile
upper_src_soils_mapunits	Soils - Upper Santa Rosa Creek Watershed	shapefile
upper_src_streams	Streams - Upper Santa Rosa Creek Watershed	shapefile

FILE NAME	DESCRIPTION
RUSLE2_NotAssessed	Soil map unit polygons not assessable using RUSLE2 because of size, slope, or soil characteristic constraints. Most polygons of this dataset are located in a stream channel and do not apply to this assessment. These data were used to evaluate potential soil loss using RUSLE2 and GIS for the Santa Rosa Creek Watershed Conservation Plan, 2008. The digital soil survey dataset is generally the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a lpanimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information.
RUSLE2_USRC_OD	Soil data for areas outside blueline stream drainages within the Upper Santa Rosa Creek Subwatershed. These data were used to evaluate potential soil loss using RUSLE2 and GIS for the Santa Rosa Creek Watershed Conservation Plan, 2008. RUSLE2 predicted annual soil loss values included in this dataset. The digital soil survey dataset is generally the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a lpanimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information.
soils	Soil data and RUSLE2 predicted soil loss results for each soil map unit within the Santa Rosa Creek Watershed. Soil map unit polygons were divided using blueline stream drainage polygons and "other" drainages polygons. Data were collected for the Santa Rosa Creek Watershed Conservation Plan, 2008. This data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a lpanimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information.
src_dem	Digital Elevation Model of the Santa Rosa Creek Watershed.
src_parcels	Parcel polygon layer for Santa Rosa Creek Watershed.
src_stream_reaches	Linear delineation of stream reach along Santa Rosa Creek, as defined by Don Alley, Aquatic and Fisheries Biologist, Appendix K, Santa Rosa Creek Watershed Conservation Plan (2008).
SRCW_crops_edited	Crop Layer - Agriculture Commissioner Office and edited by Stacey Smith, Consultant, for the Santa Rosa Creek Watershed Conservation Plan, 2008. Edits were made to remove uncultivated, non-crop, undeclared, and some field rotational data. Additional crop data was added for observed crop land uses using aerial data provided by the County of San Luis Obispo.
SRCW_lowerwatershed_soils	Digital soil data for the lower Santa Rosa Creek Watershed. This data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a lpanimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information.
SRCW_soils_SLODatafinder	Soil Survey data for the Santa Rosa Creek Watershed. This data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a lpanimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information.
Stream_bank_erosion	Location information of stream bank erosion sites occurring in the Santa Rosa Creek Watershed, Cambria, California. Data were acquired for the Santa Rosa Creek Watershed Conservation Plan, developed by the Land Conservancy of San Luis Obispo County. These data are incomplete and additional mapping is necessary.
streams	National Hydrology Dataset (NHD) developed by USGS to map lakes, rivers, stream, and other surface water.
tiger_mjr_roads	Major roads for San Luis Obispo County, downloaded from TIGER database.
Unknown	Location information of potential erosion location occurring in the Santa Rosa Creek Watershed, Cambria, California, however status is unknown due to limitations in viewing aerial imagery. In some instances glare or vegetative cover obstructed view of the soil surface. Data were acquired for the Santa Rosa Creek Watershed Conservation Plan, 2008.
Upper_clip_nonresidential	Parcel polygon layer for the Upper Santa Rosa Creek Watershed, from the Main Street and Santa Rosa Creek crossing, to the headwaters. Parcel data exclude the high density residential area at the western watershed boundary.
upper_src_NRCS_SOILS	This data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a lpanimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information.
upper_src_roads	Tiger Line Roads downloaded from the TIGER database - contains names for roads within the Upper Santa Rosa Creek Watershed.
upper_src_soils_mapunits	Soil Classification for the Upper Santa Rosa Creek Watershed, in Cambria, California. This database contains a detailed listing of the soil's name, unit, drainage, percentage slope, erodibility, shrink swell, septic potential, storie, and irrigation potential. This data can be used in agricultural, land use, water, conservation, and etc. analysis.
upper_src_streams	National Hydrology Dataset (NHD) developed by the USGS mapping out water reaches from lakes, rivers, streams, and other surface water features, within the Upper Santa Rosa Creek Watershed.

FILE NAME	CREATOR	CONTENT DATE	SCALE
RUSLE2_NotAssessed	Soils data created by U.S. Department of Agriculture, Natural Resources Conservation Service. RUSLE2 data input into database by Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	October 2005 and May 2008	Unknown
RUSLE2_USRC_OD	Soils data created by U.S. Department of Agriculture, Natural Resources Conservation Service. RUSLE2 data input into database by Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	October 2005 and May 2008	Unknown
soils	Soils data created by U.S. Department of Agriculture, Natural Resources Conservation Service. RUSLE2 data input into database by Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	October 2005 and May 2008	Unknown
src_dem	Data obtained from the County of San Luis Obispo.	2008	
src_parcels	Barclay Maps	March 2005	Unknown
src_stream_reaches	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	August 2009	1:10,000
SRCW_crops_edited	San Luis Obispo County Agriculture Commissioner_Marlene Bartsch_Chris Morris. Edited by Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	2007 and 2008	Unknown
SRCW_lowerwatershed_soils	U.S. Department of Agriculture, Natural Resources Conservation Service	October 2005	Unknown
SRCW_soils_SLODatafinder	U.S. Department of Agriculture, Natural Resources Conservation Service	October 2005	Unknown
Stream_bank_erosion	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	May 2008	≤1:2,000
streams	U.S. Geological Survey in cooperation with U.S. Environmental Protection Agency	May 2003	Unknown
tiger_mjr_roads	San Luis Obispo County for the Census Bureau - Mapping/Graphics 781-5600	August 2001	Unknown
Unknown	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	May 2008	≤1:2,000
Upper_clip_nonresidential	Barclay Maps	March 2005	Unknown
upper_src_NRCS_SOILS	U.S. Department of Agriculture, Natural Resources Conservation Service	October 2005	1:1,000
upper_src_roads	San Luis Obispo County for the Census Bureau - Mapping/Graphics 781-5600	May 2001	Unknown
upper_src_soils_mapunits	San Luis Obispo County for the NRCS - Mapping/Graphics 781-5600	July 1999	Unknown
upper_src_streams	U.S. Geological Survey in cooperation with U.S. Environmental Protection Agency	May 2003	Unknown

FILE NAME	PROJECTED COORDINATE SYSTEM	GEOGRAPHIC COORDINATE SYSTEM (DATUM)	COORDINATE SYSTEM
RUSLE2_NotAssessed	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	State Plane Coordinate System
RUSLE2_USRC_OD	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	State Plane Coordinate System
soils	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	State Plane Coordinate System
src_dem			
src_parcels	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
src_stream_reaches	teale_albers	GCS_North_American_1927	Albers Conical Equal Area
SRCW_crops_edited	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
SRCW_lowerwatershed_soils	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	State Plane Coordinate System
SRCW_soils_SLODatafinder	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	State Plane Coordinate System
Stream_bank_erosion	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
streams	teale_albers	GCS_North_American_1927	Albers Conical Equal Area
tiger_mjr_roads	Custom	GCS_North_American_1983	Lambert Conformal Conic
Unknown	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
Upper_clip_nonresidential	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
upper_src_NRCS_SOILS	NAD_1983_StatePlane_California_V_FIPS_0405	GCS_North_American_1983	State Plane Coordinate System
upper_src_roads	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
upper_src_soils_mapunits	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
upper_src_streams	teale_albers	GCS_North_American_1927	Albers Conical Equal Area

FILE NAME	HORIZONTAL DATUM	EDITS TO ORIGINAL SHAPEFILE
RUSLE2_NotAssessed	North American Datum of 1983	Soil data downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using the Santa Rosa Creek Watershed boundary for the Santa Rosa Creek Watershed Conservation Plan, 2008. The clipped soil data were then intersected with blueline stream boundaries ("Drainage_2" shapefile) and areas outside blueline stream drainages ("Other_drainage" shapefile). RUSLE2 GIS input values and predicted soil loss value data were added to tabular data. Soil map units with no predicted soil loss values were selected, analyzed, and exported into this file.
RUSLE2_USRC_OD	North American Datum of 1983	Soil data downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using the Santa Rosa Creek Watershed boundary. The clipped soil data were then intersected with polygon features of areas outside blueline stream drainage boundaries. The edited soil polygons were then clipped using the Upper Santa Rosa Creek Watershed boundary. RUSLE2 GIS input values and predicted soil loss value data were added to tabular data.
soils	North American Datum of 1983	Soil dataset downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using shapefile delineating the Santa Rosa Creek Watershed boundary. Dataset was then intersected using "Drainage_2" and "Other_drainage" shapefiles. Fields were added to database and populated with RUSLE2 data.
src_dem		Data clipped using Santa Rosa Creek Watershed boundary.
src_parcels	North American Datum of 1983	Data clipped using Santa Rosa Creek Watershed boundary.
src_stream_reaches	North American Datum of 1927	Stream data downloaded from SLO Datafinder at http://lib.calpoly.edu/gis/ and clipped using Santa Rosa Creek Watershed boundary for the Santa Rosa Creek Watershed Conservation Plan, 2008. Santa Rosa Creek line selected and exported into new shapefile. New creek layer line segments merged into one line and then split according to reach distance along stream in ArcMap.
SRCW_crops_edited	North American Datum of 1983	Dataset edited to remove non-crop polygons and add additional crop polygons based on observed land uses in the watershed from aerial photographs.
SRCW_lowerwatershed_soils	North American Datum of 1983	Soil dataset downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using shapefile delineating the Santa Rosa Creek Watershed boundary. Resulting layer was edited again to erase all soil map unit data within the Upper Santa Rosa Creek Watershed boundary, leaving only soil data for the lower watershed.
SRCW_soils_SLODatafinder	North American Datum of 1983	Soil dataset downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/) and clipped using shapefile delineating the Santa Rosa Creek Watershed boundary.
Stream_bank_erosion	North American Datum of 1983	None
streams	North American Datum of 1927	Data clipped using the Santa Rosa Creek Watershed boundary.
tiger_mjr_roads	North American Datum of 1983	None
Unknown	North American Datum of 1983	None
Upper_clip_nonresidential	North American Datum of 1983	Parcel data clipped using Upper Santa Rosa Creek Watershed boundary. High density residential area at the western edge of watershed boundary selected and deleted from dataset.
upper_src_NRCS_SOILS	North American Datum of 1983	Data clipped using the Upper Santa Rosa Creek Watershed boundary.
upper_src_roads	North American Datum of 1983	Data clipped using the Upper Santa Rosa Creek Watershed boundary.
upper_src_soils_mapunits	North American Datum of 1983	Two soil layers merged to include all data representing the entire watershed. Merged layer was then clipped using the Upper Santa Rosa Creek Watershed boundary.
upper_src_streams	North American Datum of 1927	Stream data were downloaded from SLO Datafinder (http://lib.calpoly.edu/gis/), and clipped using an Upper Santa Rosa Creek Watershed boundary shapefile.

FILE NAME	DATA STORAGE	METADATA STANDARD
RUSLE2_NotAssessed	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
RUSLE2_USRC_OD	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
soils	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	
src_dem	Land Conservancy of San Luis Obispo.	
src_parcels	Parcel data purchased from the County Assessor's Office. Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
src_stream_reaches	Land Conservancy of San Luis Obispo.	FGDC
SRCW_crops_edited	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
SRCW_lowerwatershed_soils	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
SRCW_soils_SLODatafinder	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
Stream_bank_erosion	Land Conservancy of San Luis Obispo.	ISO
streams	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
tiger_mjr_roads	SLO Datafinder (http://lib.calpoly.edu/gis/)	FGDC
Unknown	Land Conservancy of San Luis Obispo.	ISO
Upper_clip_nonresidential	Parcel data purchased from the County Assessor's Office. Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
upper_src_NRCS_SOILS	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
upper_src_roads	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
upper_src_soils_mapunits	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC
upper_src_streams	Original data acquired from SLO Datafinder (http://lib.calpoly.edu/gis/). Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC

FILE NAME	DATA TITLE	DATA FORMAT
upper_watershed	Upper Santa Rosa Creek Watershed	shapefile
url_vrl-poly	url_vrl-poly	shapefile
USRC_watershed	Upper Santa Rosa Creek Subwatershed	shapefile
Veg_Fmtn_SRCW	Formation Level Vegetation Mapping Database for San Luis Obispo County, California, 2007	shapefile
watershed	Santa Rosa Creek Watershed	shapefile
WilliamsonAct_3	Williamson Act Parcels - Santa Rosa Creek Watershed	shapefile

FILE NAME	DESCRIPTION
upper_watershed	Upper Santa Rosa Creek Watershed boundary, located in Cambria, California, San Luis Obispo County. Entire watershed area, including Green Valley Creek Subwatershed, from the Main Street and Santa Rosa Creek crossing, to the headwaters.
url_vrl-poly	Official Urban Reserve and Village Reserve area boundaries of San Luis Obispo County.
USRC_watershed	Upper Santa Rosa Creek Watershed boundary, from Main Street and Santa Rosa Creek crossing to the headwaters, excluding Green Valley Creek Subwatershed.
Veg_Fmtn_SRCW	Boundaries of vegetation formation units within the Santa Rosa Creek Watershed.
watershed	Santa Rosa Creek Watershed boundary, located in Cambria, California, San Luis Obispo County.
WilliamsonAct_3	Parcel polygon layer representing parcels within the Santa Rosa Creek Watershed under the Williamson Act.

FILE NAME	CREATOR	CONTENT DATE	SCALE
upper_watershed	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	2008	1:24,000
url_vrl-poly	SLO County Planning & Building Geographic Technology & Design	October 1998	1:24,000
USRC_watershed	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	February 2008	≤1:2,000
Veg_Fmtn_SRCW	County of San Luis Obispo and AIS	unpublished	Variable
watershed	Stacey Smith, Graduate Student, Soil Science, California Polytechnic State University, for the Santa Rosa Creek Watershed Conservation Plan, 2008.	2008	1:24,000
WilliamsonAct_3	Barclay Maps	March 2005	Unknown

FILE NAME	PROJECTED COORDINATE SYSTEM	GEOGRAPHIC COORDINATE SYSTEM (DATUM)	COORDINATE SYSTEM
upper_watershed	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
url_vrl-poly	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
USRC_watershed	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
Veg_Fmtn_SRCW	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
watershed	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic
WilliamsonAct_3	NAD_1983_StatePlane_California_V_FIPS_0405_Feet	GCS_North_American_1983	Lambert Conformal Conic

FILE NAME	HORIZONTAL DATUM	EDITS TO ORIGINAL SHAPEFILE
upper_watershed	North American Datum of 1983	None
url_vrl-poly	North American Datum of 1983	None
USRC_watershed	North American Datum of 1983	None
Veg_Fmtn_SRCW	GCS_North American_1983	Clipped from County layer and calculated areas.
watershed	North American Datum of 1983	None
WilliamsonAct_3	North American Datum of 1983	Parcels selected using LUC and exported to create new shapefile.

FILE NAME	DATA STORAGE	METADATA STANDARD
upper_watershed	Land Conservancy of San Luis Obispo.	ISO
url_vrl-poly	SLO Datafinder (http://lib.calpoly.edu/gis/)	FGDC
USRC_watershed	Land Conservancy of San Luis Obispo.	ISO
Veg_Fmtn_SRCW	Vegetation data acquired from the Land Conservancy of San Luis Obispo County through the County of San Luis Obispo.	FGDC
watershed	Land Conservancy of San Luis Obispo.	ISO
WilliamsonAct_3	Parcel data purchased from the County Assessor's Office. Edited shapefile retained at the Land Conservancy of San Luis Obispo County.	FGDC

APPENDIX H

METHODS FOR DETERMINING PREDICTED SOIL LOSS USING RUSLE2 AND GIS

METHODS FOR PREDICTING ANNUAL SOIL LOSS RATES USING RUSLE2 AND GIS

Upland erosion rates were calculated for the Santa Rosa Creek Watershed using ArcGIS 9.2, RUSLE2, Microsoft Office Excel 2003, and digital data. Predicted erosion rates were calculated for the upper watershed, including Perry Creek subwatershed and Santa Rosa Creek subwatershed, upstream from Santa Rosa Creek and Main Street road crossing.

GIS data used in RUSLE2 (Table 1, page H-2) were either acquired from various providers or were created by the Environmental Consultant, Stacey Smith, for this project. Data provided by the County of San Luis Obispo Planning and Building Department are labeled “County”. Sources listed as “Consultant” indicate that either existing data were edited or new data were created by the Consultant. SLO Datafinder is an online GIS resource created by Cal Poly State University’s Kennedy Library, the City of San Luis Obispo, and San Luis Obispo County. SLO Datafinder is located online at http://lib.calpoly.edu/gis/browse.jsp. Geospatial Data Gateway is an online GIS resource for natural resources data created by the United States Department of Agriculture. Geospatial Data Gateway is located online at http://datagateway.nrcs.usda.gov/. Digital topographic quadrangle data were retrieved using California Spatial Information Library at http://www.atlas.ca.gov/.

The official RUSLE2 computer program was downloaded from the USDA Agricultural Research Service website (http://www.ars.usda.gov/Research/docs.htm?docid=6038)[4]. The RUSLE2 master database includes regional climate, soils, and management zone input data values used by NRCS field office personnel. This database was downloaded at a USDA RUSLE2 official website (http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm)[5].

STUDY SITE BOUNDARY DELINEATION

The upper Santa Rosa Creek Watershed (“USRC_watershed”) and Perry Creek Watershed (“Perry_watershed”) layers were created using “watershed”, “streams”, and “roads” GIS layers with a digital topographic quadrangle. Smaller drainage boundaries were created in GIS using topographic features from the digital quadrangles to delineate blue-line stream drainages within the upper watershed.

Each of the blue-line stream drainages located off the main-stem of Santa Rosa Creek, north-fork of Santa Rosa Creek, Perry Creek, and Green Valley Creek, were mapped. A separate GIS layer labeled “other drainages” was created to capture the areas where drainage boundaries do not come together, for instance at lower elevations where blue-line streams flow into the main stem of a creek and gaps between drainages exist, or to map drainages that do not appear on a 7.5 minute quadrangle as a blue-line stream. This allowed non-blue-line stream drainages to be assessed separately for the erosion study. The “snapping” function in ArcMap allowed each “drainage” and “other drainage” boundary to be created flush with other drainages surrounding

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[4] USDA, Agricultural Research Service. Retrieved March 1, 2008, website: http://www.ars.usda.gov/Research/docs.htm?docid=6038.

[5] Revised Universal Soil Loss Equation, Version 2 Official NRCS RUSLE2 Program Official NRCS Database. Retrieved March 1, 2008, Website: http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index. htm

it. All drainage boundaries were created at a maximum scale of 1:12,000 at a tolerance of ten pixels to avoid overlaps and data gaps between GIS layers.

Table 1. GIS data used in erosion prediction modeling of the upper Santa Rosa Creek Watershed, using RUSLE2.

Layer Name	Description	Source
Cambria DEM	Interferometric Synthetic Aperature Radar Digital Elevation Model (IFSAR DEM)	County
Cambria_2007_a	2007 Aerial	County
Cambria_2007_b	2007 Aerial	County
watershed	Santa Rosa Creek Watershed boundary	SLO Datafinder
USRC_watershed	Upper Santa Rosa Creek watershed, above Main St.-Santa Rosa Creek crossing	Consultant
Perry_watershed	Perry Creek subwatershed; including Green Valley Creek	Consultant
streams	Streams in watershed	SLO Datafinder
roads	Roads in watershed	SLO Datafinder
soils	Soils in watershed	SLO Datafinder
County Vegetation	Vegetative communities in watershed	SLO Datafinder
precipitation	Average annual precipitation data	Geospatial Data Gateway
o_sw0204	7.5 Minute Series (MrSID) Digital topographic map of Cambria area	California Spatial Information Library

GIS DATA INPUT INTO RUSLE2

Predicting erosion rates using RUSLE2 requires climate, soil type, slope topography, land management, and supporting practices data. In RUSLE2 a profile was created for each soil map unit within the upper watershed to determine the predicted erosion value for each unit. Additionally, boundary layers were created in GIS to separate drainages and areas between drainages that flow directly into Santa Rosa, Perry, or Green Valley Creeks. Areas within blue-line stream drainages were labeled “drainages” and areas outside blue-line stream drainages were labeled “other drainages”.

Climate

Average annual precipitation data for the Santa Rosa Creek Watershed were acquired through the Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/)[6]. The precipitation data were published by the Spatial Climate Analysis Service for the “103 Year High-Resolution Precipitation Climate Data Set for the Conterminous United States”, in 2002.

A column, or “field”, was created in the “soils” GIS layer database, or “attribute table”, to enter precipitation values for each “soil map unit”. Precipitation data is needed to study soil erosion using RUSLE2 therefore it is important to link the soil data to rainfall amounts. The average annual precipitation values were used to select soils in the Santa Rosa Creek Watershed. Soil map units that intersect, or touch, an area with a certain precipitation amount, for instance 17 inches per year, were selected using the “Select by Location” command in ArcMap, an application of ArcGIS. Next, the average annual precipitation values were manually entered for each soil map unit in the “soils” GIS database. The process was repeated for each of the four average annual precipitation values in the watershed.

Most of the watershed has an average annual precipitation of 19 inches per year, therefore soil map units were selected and data were entered for those values first. The process was repeated for the maximum rainfall amount of 23 inches per year; then 17 inches per year; and lastly 21 inches per year. More than one average annual precipitation value can exist within one soil map unit. If, during the process of entering data, precipitation data had already been entered for a map unit, then the first value was left in the table and not replaced by subsequent values.

Soil Type

Digital soil data were created from the National Cooperative Soil Survey in 2005, and prepared by soil scientists and the USDA-NRCS. The soils database was edited by the County to include attribute information from the Soil Data Viewer website (http://soildataviewer.nrcs.usda.gov/)[7]. The “soils” GIS data show the distribution of “soil map units” on the landscape and was used with the *Soil Survey of San Luis Obispo County, California, Coastal Part* (1984)[8] and the *Soil Survey of San Luis Obispo County, California, Paso Robles Area* (1977)[9], or Soil Surveys, to describe soils located in the watershed.

Soils GIS data, created by NRCS and edited by San Luis Obispo County, were “clipped”, or cut out, from the “soils” layer in GIS using the Santa Rosa Creek Watershed boundary. The watershed boundary originated as a “creek watershed” data layer acquired on SLO Datafinder and was edited by the Consultant for greater accuracy using digital 7.5 minute quadrangles.

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[6] Geospatial Data Gateway. Retrieved February 1, 2008, Website: http://datagateway.nrcs.usda.gov/

[7] Soil Data Viewer. Retrieved March 1, 2008, Website: http://soildataviewer.nrcs.usda.gov.

[8] USDA, Soil Conservation Service (1984). Soil Survey of San Luis Obispo County, California Coastal Part.

[9] USDA, Soil Conservation Service (1977). Soil Survey of San Luis Obispo County, California, Paso Robles Area.

The digital soil data were “clipped” again using the “drainage” and “other drainage” boundaries so predicted soil loss values could be determined for each soil within every “drainage” and “other drainage” study site.

Slope Topography

In order to establish slope topography throughout the watershed the Interferometric Synthetic Aperture Radar (IFSAR) Digital Elevation Model (DEM) was used. A DEM is a digital representation of ground surface topography using a grid of regularly spaced elevation data. The IFSAR DEM is a more accurate representation of the ground surface than other DEM data available.

Using the ArcGIS “3D Analyst” extension in ArcMap, slope percent and slope length were calculated. Slope data could not be calculated from the USDA-NRCS “soils” layer alone, so a new GIS shapefile, or layer, was created and labeled “Slope line”. This line feature was created to calculate the slope topography of each soil map unit. Contour lines were created using “3D Analyst”. In consultation with T. Mastin, professor in the Bioresource Agricultural Engineering Department at Cal Poly State University, it was determined that slope lines should be drawn perpendicular to the contour lines from the highest point of elevation, along the longest length of slope represented in each map unit. This would allow for consistency in replicating the method for every “soil map unit” assessed. For uniform slopes, lines were terminated when they reached the edge of the map unit polygon. For map units with a change in slope, lines were terminated where soil deposition would occur, such as a break in slope or in catchment areas such as drainages. Each line was labeled with the same feature identification label (FID) of the GIS “soil map unit” FID in which it represented. This allowed the 3D line length and slope to be related to the “soils” data using GIS.

Using “3D Analyst”, the line was converted from a “2D feature” to a “3D feature” using the DEM data to reference line elevations. New fields were created in the line attribute database for “Length 2D”, “Length 3D”, “Minimum Z value”, “Maximum Z value”, and “Slope”. Elevation data is associated with “Z” data for each point on a DEM; just as “Y” data describes latitude and “X” data describes longitude. Each field was populated with values by right-clicking on the field and choosing the “Field Calculator”. Equation routines were downloaded online (http://www.ian-ko.com/), and loaded into the “Field Calculator” to be used to calculate values for the new fields. “Minimum Z value” and “Maximum Z value” calculations captured the change in elevation occurring along the length of the line, and allowed for an easy average slope calculation ((Max Z – Min Z)/ Length 2D)), which was manually entered into the “Field Calculator” to determine slope for each line. The attribute data for the slope line was then joined to the “soils” attribute data to bring together all the data needed to input fields in RUSLE2.

Land Management

Rangeland production was entered into the soils “attribute table”, or spreadsheet. “Normal rangeland production” values are described in Soil Surveys and they describe the amount of vegetative production that occurs on a “soil map unit” in a normal growing year. These values are provided in Soil Surveys and were used in the erosion study to describe “Base Management” in a RUSLE2 profile. “Soil complexes” and “associations” are composed of more than one soil so “normal rangeland production” value for the dominant component soil was used for the RUSLE2 analysis. The “normal rangeland production” value for the component soil with the greater “K-factor”, or soil erodibility, was used for soils of “undifferentiated groups”.

One soil of an “undifferentiated group” had to be considered differently, however. Generally, only a small amount of vegetation grows on “rock outcrops” soils and “normal rangeland production” values do not exist in the Soil Surveys. Therefore, special considerations must be made in describing “Base Management” for soils containing “rock outcrops”. “195, Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slopes” is a soil found in the watershed with “rock outcrop” the dominant component soil. In consultation with B. Hallock, Earth and Soil Science Department at Cal Poly State University, it was determined to use the “Lodo” soil series “normal rangeland production” value to represent the soil listed above. The resulting predicted soil loss value determined by the RUSLE2 calculation was multiplied by the percent rock outcrop within the soil complex area. This value was subtracted from the predicted soil loss value of the total area of “195, Rock outcrop-Lithic Haploxerolls complex, 30-75 percent slopes”, preventing the percent area of “rock outcrop” from being added to the total predicted soil loss value calculated for the entire soil.

Supporting Practices

Supporting practices input were left at the default value in the drop-down menu in the RUSLE2 profile. Conservation practices were not identified in the watershed because landowner outreach would need to be conducted to gather land management activity information.

RUNNING RUSLE2 CALCULATIONS

In RUSLE2, there are five steps to complete in order to run a basic calculation for predicting soil erosion rates.

STEP 1: Choose location to set climate

A San Luis Obispo County “R value” based on rainfall was selected in a drop-down menu. Average annual precipitation amounts are distinctly different from the lower to upper watershed boundaries, averaging 17” a year at the coast and 23” a year at the headwaters.

Depending on the location of the soil being analyzed, one of the following values were selected from a drop-down list: “CA_San Luis Obispo County_R 16-18”, “CA_San Luis Obispo County_R 18-20”, “CA_San Luis Obispo County_R 20-22”, and “CA_San Luis Obispo County_R 22-24”.

STEP 2: Choose soil type

The “soils” layer was “clipped” using “drainage” and “other drainage” boundaries to assess target areas. Each “soil map unit” within the “soils” layer was analyzed separately using a RUSLE2 profile. The “soil map unit” name was selected in the drop-down menu on the profile screen. For soil “complexes” and “associations”, the most prominent soil type in the map unit was selected. For “undifferentiated group” soils, the soil with the highest soil erodibility was selected to conservatively represent erosion potential of that group. And for the “soil map unit” with “rock outcrop” as the dominant component soil, the “Lodo” soil series was selected.

STEP 3: Set slope topography

Slope length and percent were manually entered according to calculated values produced for each line drawn in every “soil map unit” using GIS. A slope length of 1000 feet was not exceeded because it decreases the accuracy of the calculated value produced in RUSLE 2. In general, the greater the slope length, the less accurate the predicted soil loss value is as stated by USDA-NRCS. Where slope length values exceeded the recommended maximum value, 1000 feet was used instead. This normally occurred in large "soil map units" with a low, uniform slope that extended for a great distance, usually in the low-lying areas of floodplains and terraces. In these circumstances, potential soil loss due to erosion was usually very low.

STEP 4: Describe management

Land use analysis using parcel data and digital agricultural data acquired on SLO Datafinder (http://lib.calpoly.edu/gis/browse.jsp) shows the upper watershed consists of two primary land uses: cattle grazing and crops. The GIS data acquired from the County Assessor's Office and the Agricultural Commissioner's Office was edited using information acquired from 2007 digital aerial photography. Crop locations that are retired were deleted from the layer and additional crop locations were mapped in GIS using 2007 aerial imagery. The result showed that approximately 988 acres, or three percent, of the land use in the upper watershed is used for crops, with an average crop size of 12 acres. The remaining area in the upper watershed is either grazed, rural residential, or "watershed" as described by the Soil Surveys. In reviewing parcel data and aerial photographs in GIS and by conducting site surveys and consulting with San Luis Obispo County Farm Bureau, it was determined that land use in the upper watershed is mostly grazed.

Due to time-limitations, generalizations for land management had to be made. With nearly 600 "soil map units" analyzed separately, it was not possible to describe specific management practices for each unit. In the "Base Management" drop-down menu, the "Strip/barrier management" file was chosen, and "Cool season grass; not harvested" was selected. After the Base Management is selected in the drop-down menu, the chosen field is displayed in the Base Management window on the profile screen. Edits can be made to describe site conditions by clicking on the yellow folder next to the selected Base Management. The Operations and Information tabs are displayed in a new window. In the "Vegetation" field of the Operations tab, the "Permanent cover not harvested" folder was selected and "Brome, California, established cover" was chosen. After the selection was made, it is displayed in a drop-down window beneath the "Vegetation" field. For each soil map unit, the vegetation "Yield (# of harvestable units)" was edited to represent the "normal rangeland production" value for each "soil map unit" according to Table 5 in the Soil Surveys. All other fields were left unchanged in order to preserve the integrity of the management data developed by the Agricultural Resources Service. This selection was made after consulting B. Hallock of Cal Poly and choosing a vegetation type that best represents the growth characteristics of vegetation present in this watershed.

STEP 5: Set supporting practices

Practices such as contouring, strip systems, terrace/diversion, impoundments, and tile drainages, can be defined in this step. Supporting practices in the Santa Rosa Creek Watershed were unknown during this assessment. In Step 5 of the RUSLE2 analysis, "default" supporting practice was selected for "Contouring". Input fields for "strips/barriers", "diversion/terrace" and "sediment basin" were left at "none".

PREDICTED SOIL LOSS VALUE

After the above five steps were completed for a soil map unit, the "Soil loss for cons. plan" value under the "Soil Loss Values" tab located at the bottom of the profile page, was documented in the soils GIS layer database. The predicted values are given in tons of soil for each acre, annually. Acreage of the soil map unit was calculated in GIS and an additional field was added in the spreadsheet where the RUSLE2 predicted erosion rate and the soil map unit acreage were multiplied to calculate the predicted tons of sediment from each soil map unit in one year. Features such as exposed gravel pits, large gullies, and roads were not analyzed for predicted soil loss using RUSLE2. Site visits to these locations are necessary in order to gather the appropriate data to run the model.

APPENDIX I

RUSLE2 RESULTS FOR SOIL MAP UNITS
IN THE UPPER SANTA ROSA CREEK WATERSHED

Data produced from “soils” GIS layer

RUSLE2 RESULTS FOR SOIL MAP UNITS IN THE UPPER SANTA ROSA CREEK WATERSHED

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Santa Rosa Creek	0	4	163	Los Osos-Lodo complex, 50 to 75 percent slopes	593.5	3.1	1839.9	North Fork Santa Rosa
Santa Rosa Creek	1	3	154	Lompico-McMullin loams, 30 to 75 percent slopes	250.6	5.6	1403.3	North Fork Santa Rosa
Santa Rosa Creek	2	2	146	Henneke-Rock outcrop complex, 15 to 75 percent slopes	379.7	2.9	1101.3	North Fork Santa Rosa Creek
Santa Rosa Creek	3	1	150	Lodo clay loam, 50 to 75 percent slopes	321.0	2.9	930.9	North Fork Santa Rosa Creek
Santa Rosa Creek	4	7	167	Los Osos-Lodo complex, 30 to 75 percent slopes	179.0	5.1	912.8	North Fork Santa Rosa Creek
Santa Rosa Creek	5	7	202	San Simeon sandy loam, 30 to 50 percent slopes	197.8	4.2	830.7	
Santa Rosa Creek	6	7	141	Gaviota sandy loam, 50 to 75 percent slopes	82.7	9.8	810.0	Headwater
Santa Rosa Creek	7	7	156	Lopez very shaly clay loam, 30 to 75 percent slopes	145.1	5.2	754.3	
Santa Rosa Creek	8	28	154	Lompico-McMullin loams, 30 to 75 percent slopes	188.9	3.8	718.0	North Fork Santa Rosa Creek
Santa Rosa Creek	9	27	164	Los Osos-Diablo complex, 15 to 30 percent slopes	122.0	5.7	695.3	
Santa Rosa Creek	10	16	156	Lopez very shaly clay loam, 30 to 75 percent slopes	125.2	5.4	676.2	
Santa Rosa Creek	11	15	167	Los Osos-Lodo complex, 30 to 75 percent slopes	180.1	3.5	630.4	Perry Creek Headwaters
Santa Rosa Creek	12	14	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	287.0	2.0	574.0	North Fork Santa Rosa Creek
Santa Rosa Creek	13	7	165	Los Osos-Diablo complex, 30 to 50 percent slopes	147.9	3.6	532.4	Perry Creek
Santa Rosa Creek	14	1	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	208.4	2.5	520.9	Headwater
Santa Rosa Creek	15	7	165	Los Osos-Diablo complex, 30 to 50 percent slopes	154.8	3.3	511.0	Headwaters
Santa Rosa Creek	16	7	156	Lopez very shaly clay loam, 30 to 75 percent slopes	92.4	5.3	489.9	
Santa Rosa Creek	17	14	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	136.5	3.5	477.8	
Santa Rosa Creek	18	7	150	Lodo clay loam, 50 to 75 percent slopes	210.2	2.2	462.5	Curti Creek Watershed
Santa Rosa Creek	19	7	146	Henneke-Rock outcrop complex, 15 to 75 percent slopes	166.0	2.7	448.1	
Santa Rosa Creek	20	15	164	Los Osos-Diablo complex, 15 to 30 percent slopes	142.9	3.1	442.9	Fiscalini Creek
Santa Rosa Creek	21	14	165	Los Osos-Diablo complex, 30 to 50 percent slopes	215.2	2.0	430.4	
Santa Rosa Creek	22	27	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	137.8	3.1	427.0	North Fork Santa Rosa Creek
Santa Rosa Creek	23	5	165	Los Osos-Diablo complex, 30 to 50 percent slopes	102.7	4.1	421.2	
Santa Rosa Creek	24	4	154	Lompico-McMullin loams, 30 to 75 percent slopes	85.4	4.9	418.6	Headwater
Santa Rosa Creek	25	3	160	Los Osos loam, 15 to 30 percent slopes	173.3	2.4	415.8	Fiscalini Creek
Santa Rosa Creek	26	15	132	Diablo and Cibo clays, 30 to 50 percent slopes	287.5	1.4	402.6	
Santa Rosa Creek	27	7	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	283.3	1.4	396.7	
Santa Rosa Creek	28	7	142	Gaviota fine sandy loam, 15 to 50 percent slopes	50.9	7.2	366.5	Fiscalini Creek
Santa Rosa Creek	29	3	149	Lodo clay loam, 30 to 50 percent slopes	98.3	3.7	363.5	
Santa Rosa Creek	30	3	132	Diablo and Cibo clays, 30 to 50 percent slopes	229.2	1.5	343.9	
Santa Rosa Creek	31	2	162	Lompico-McMullin complex, 50 to 75 percent slopes	58.1	5.9	342.9	Headwater
Santa Rosa Creek	32	3	167	Los Osos-Lodo complex, 30 to 75 percent slopes	93.8	3.5	328.2	
Santa Rosa Creek	33	5	133	Diablo-Lodo complex, 15 to 50 percent slopes	491.4	0.7	324.3	Curti Creek Watershed
Santa Rosa Creek	34	4	165	Los Osos-Diablo complex, 30 to 50 percent slopes	137.9	2.3	317.1	
Santa Rosa Creek	35	7	164	Los Osos-Diablo complex, 15 to 30 percent slopes	97.1	3.1	301.1	
Santa Rosa Creek	36	6	160	Los Osos loam, 15 to 30 percent slopes	105.5	2.8	295.5	Fiscalini Creek
Santa Rosa Creek	37	5	142	Gaviota fine sandy loam, 15 to 50 percent slopes	35.9	8.2	294.4	
Santa Rosa Creek	38	27	164	Los Osos-Diablo complex, 15 to 30 percent slopes	78.6	3.7	290.9	
Santa Rosa Creek	39	16	161	Los Osos loam, 30 to 50 percent slopes	90.9	3.2	290.9	Perry Creek
Santa Rosa Creek	40	15	156	Lopez very shaly clay loam, 30 to 75 percent slopes	85.1	3.4	289.4	North Fork Santa Rosa Creek
Santa Rosa Creek	41	14	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	133.2	2.1	279.7	Headwater
Santa Rosa Creek	42	7	204	Santa Lucia shaly clay loam, 50 to 75 percent slopes	115.0	2.4	276.1	North Fork Santa Rosa
Santa Rosa Creek	43	11	167	Los Osos-Lodo complex, 30 to 75 percent slopes	76.9	3.5	269.1	Curti Creek Watershed
Santa Rosa Creek	44	10	165	Los Osos-Diablo complex, 30 to 50 percent slopes	98.6	2.7	266.1	
Santa Rosa Creek	45	9	167	Los Osos-Lodo complex, 30 to 75 percent slopes	46.4	5.7	264.4	North Fork Santa Rosa
Santa Rosa Creek	46	8	160	Los Osos loam, 15 to 30 percent slopes	108.1	2.4	259.6	Fiscalini Creek
Santa Rosa Creek	47	7	164	Los Osos-Diablo complex, 15 to 30 percent slopes	71.9	3.6	259.0	
Santa Rosa Creek	48	6	164	Los Osos-Diablo complex, 15 to 30 percent slopes	83.0	3.1	257.2	
Santa Rosa Creek	49	7	156	Lopez very shaly clay loam, 30 to 75 percent slopes	42.9	5.8	248.9	
Santa Rosa Creek	50	7	171	Millsap loam, 15 to 50 percent slopes	82.0	3.0	245.9	
Santa Rosa Creek	51	1	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	105.7	2.3	243.0	
Santa Rosa Creek	52	7	132	Diablo and Cibo clays, 30 to 50 percent slopes	146.2	1.6	233.9	
Santa Rosa Creek	53	6	160	Los Osos loam, 15 to 30 percent slopes	68.7	3.4	233.6	
Santa Rosa Creek	54	13	154	Lompico-McMullin loams, 30 to 75 percent slopes	51.2	4.5	230.3	
Santa Rosa Creek	55	12	202	San Simeon sandy loam, 30 to 50 percent slopes	68.6	3.3	226.3	Fiscalini Creek
Santa Rosa Creek	56	11	156	Lopez very shaly clay loam, 30 to 75 percent slopes	39.7	5.7	226.1	
Santa Rosa Creek	57	10	167	Los Osos-Lodo complex, 30 to 75 percent slopes	55.1	4.0	220.5	Headwater

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Santa Rosa Creek	58	9	182	Nacimiento-Calodo complex, 50 to 75 percent slopes	83.4	2.6	216.8	Headwater
Santa Rosa Creek	59	8	165	Los Osos-Diablo complex, 30 to 50 percent slopes	45.0	4.8	216.2	Headwater
Santa Rosa Creek	60	5	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	112.7	1.9	214.0	Fiscalini Creek
Santa Rosa Creek	61	15	164	Los Osos-Diablo complex, 15 to 30 percent slopes	76.1	2.8	213.1	
Santa Rosa Creek	62	7	119	Cieneba-Millsap loams, 30 to 75 percent slopes	23.9	8.9	212.9	
Santa Rosa Creek	63	6	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	51.8	4.0	207.2	Curti Creek Watershed
Santa Rosa Creek	64	7	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	66.0	3.1	204.6	
Santa Rosa Creek	65	5	165	Los Osos-Diablo complex, 30 to 50 percent slopes	54.8	3.6	197.3	Perry Creek Headwaters
Santa Rosa Creek	66	4	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	54.9	3.5	192.2	
Santa Rosa Creek	67	6	149	Lodo clay loam, 30 to 50 percent slopes	59.5	3.2	190.4	Headwater
Santa Rosa Creek	68	1	119	Cieneba-Millsap loams, 30 to 75 percent slopes	41.2	4.6	189.4	Curti Creek Watershed
Santa Rosa Creek	69	7	160	Los Osos loam, 15 to 30 percent slopes	68.6	2.7	185.2	Perry Creek
Santa Rosa Creek	70	6	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	91.7	2.0	183.4	Curti Creek Watershed
Santa Rosa Creek	71	7	165	Los Osos-Diablo complex, 30 to 50 percent slopes	48.7	3.7	180.3	Headwater
Santa Rosa Creek	72	6	132	Diablo and Cibo clays, 30 to 50 percent slopes	105.8	1.7	179.9	
Santa Rosa Creek	73	3	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	112.0	1.6	179.2	
Santa Rosa Creek	74	2	133	Diablo-Lodo complex, 15 to 50 percent slopes	290.2	0.6	177.0	
Santa Rosa Creek	75	15	150	Lodo clay loam, 50 to 75 percent slopes	59.5	2.9	172.6	
Santa Rosa Creek	76	14	132	Diablo and Cibo clays, 30 to 50 percent slopes	100.5	1.7	170.8	
Santa Rosa Creek	77	13	142	Gaviota fine sandy loam, 15 to 50 percent slopes	32.9	5.1	167.6	Fiscalini Creek
Santa Rosa Creek	78	12	133	Diablo-Lodo complex, 15 to 50 percent slopes	151.2	1.1	166.3	
Santa Rosa Creek	79	11	164	Los Osos-Diablo complex, 15 to 30 percent slopes	92.3	1.8	166.2	Curti Creek Watershed
Santa Rosa Creek	80	1	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	78.1	2.1	164.1	
Santa Rosa Creek	81	15	119	Cieneba-Millsap loams, 30 to 75 percent slopes	26.0	6.3	163.5	
Santa Rosa Creek	82	27	164	Los Osos-Diablo complex, 15 to 30 percent slopes	74.2	2.2	163.2	
Santa Rosa Creek	83	1	161	Los Osos loam, 30 to 50 percent slopes	31.3	5.2	162.7	
Santa Rosa Creek	84	7	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	49.2	3.3	162.3	
Santa Rosa Creek	85	6	133	Diablo-Lodo complex, 15 to 50 percent slopes	252.2	0.6	158.9	
Santa Rosa Creek	86	5	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	101.2	1.5	151.8	North Fork Santa Rosa
Santa Rosa Creek	87	2	165	Los Osos-Diablo complex, 30 to 50 percent slopes	61.2	2.4	146.9	
Santa Rosa Creek	88	4	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	51.6	2.8	144.4	
Santa Rosa Creek	89	14	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	51.1	2.8	143.1	
Santa Rosa Creek	90	7	162	Lompico-McMullin complex, 50 to 75 percent slopes	40.6	3.5	142.2	North Fork Santa Rosa
Santa Rosa Creek	91	11	131	Diablo and Cibo clays, 15 to 30 percent slopes	106.7	1.3	138.8	
Santa Rosa Creek	92	15	113	Balcom-Calleguas complex, 50 to 75 percent slopes	30.1	4.6	138.2	Headwater
Santa Rosa Creek	93	3	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	44.5	3.1	138.0	
Santa Rosa Creek	94	2	133	Diablo-Lodo complex, 15 to 50 percent slopes	191.2	0.7	137.7	
Santa Rosa Creek	95	15	156	Lopez very shaly clay loam, 30 to 75 percent slopes	45.8	3.0	137.5	Headwater
Santa Rosa Creek	96	14	132	Diablo and Cibo clays, 30 to 50 percent slopes	83.9	1.6	134.2	
Santa Rosa Creek	97	7	161	Los Osos loam, 30 to 50 percent slopes	49.0	2.7	132.3	Fiscalini Creek
Santa Rosa Creek	98	10	119	Cieneba-Millsap loams, 30 to 75 percent slopes	31.7	4.1	130.1	Headwaters
Santa Rosa Creek	99	8	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	92.2	1.4	129.1	
Santa Rosa Creek	100	7	164	Los Osos-Diablo complex, 15 to 30 percent slopes	58.4	2.2	128.5	
Santa Rosa Creek	101	6	141	Gaviota sandy loam, 50 to 75 percent slopes	35.0	3.6	126.1	
Santa Rosa Creek	102	6	164	Los Osos-Diablo complex, 15 to 30 percent slopes	59.8	2.1	125.5	
Santa Rosa Creek	103	7	132	Diablo and Cibo clays, 30 to 50 percent slopes	113.7	1.1	125.0	
Santa Rosa Creek	104	7	165	Los Osos-Diablo complex, 30 to 50 percent slopes	39.0	3.2	124.6	
Santa Rosa Creek	105	6	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	125.9	1.0	122.1	
Santa Rosa Creek	106	2	165	Los Osos-Diablo complex, 30 to 50 percent slopes	50.3	2.4	120.8	Perry Creek Headwaters
Santa Rosa Creek	107	7	159	Los Osos loam, 9 to 15 percent slopes	84.1	1.4	117.8	Fiscalini Creek
Santa Rosa Creek	108	6	161	Los Osos loam, 30 to 50 percent slopes	46.9	2.5	117.2	Fiscalini Creek
Santa Rosa Creek	109	13	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	58.2	2.0	116.5	
Santa Rosa Creek	110	12	156	Lopez very shaly clay loam, 30 to 75 percent slopes	25.3	4.6	116.4	North Fork Santa Rosa Creek
Santa Rosa Creek	111	11	160	Los Osos loam, 15 to 30 percent slopes	54.9	2.1	115.2	Fiscalini Creek
Santa Rosa Creek	112	10	161	Los Osos loam, 30 to 50 percent slopes	47.7	2.4	114.5	
Santa Rosa Creek	113	9	164	Los Osos-Diablo complex, 15 to 30 percent slopes	36.7	3.1	113.8	
Santa Rosa Creek	114	8	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	50.4	5.0	113.5	
Santa Rosa Creek	115	46	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	56.6	2.0	113.1	Headwaters
Santa Rosa Creek	117	47	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	70.2	1.6	112.3	North Fork Santa Rosa

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Santa Rosa Creek	118	45	150	Lodo clay loam, 50 to 75 percent slopes	23.0	4.8	110.3	
Santa Rosa Creek	119	5	160	Los Osos loam, 15 to 30 percent slopes	41.8	2.6	108.6	
Santa Rosa Creek	120	27	160	Los Osos loam, 15 to 30 percent slopes	48.9	2.2	107.7	
Santa Rosa Creek	121	16	167	Los Osos-Lodo complex, 30 to 75 percent slopes	26.6	4.0	106.2	Perry Creek Headwaters
Santa Rosa Creek	122	4	131	Diablo and Cibo clays, 15 to 30 percent slopes	81.2	1.3	105.6	
Santa Rosa Creek	123	3	133	Diablo-Lodo complex, 15 to 50 percent slopes	155.5	0.7	104.2	Perry Creek
Santa Rosa Creek	124	5	161	Los Osos loam, 30 to 50 percent slopes	33.6	3.1	104.1	
Santa Rosa Creek	125	1	132	Diablo and Cibo clays, 30 to 50 percent slopes	94.7	1.1	104.1	
Santa Rosa Creek	126	4	167	Los Osos-Lodo complex, 30 to 75 percent slopes	23.0	4.5	103.6	Curti Creek Watershed
Santa Rosa Creek	127	3	165	Los Osos-Diablo complex, 30 to 50 percent slopes	25.9	4.0	103.4	
Santa Rosa Creek	128	5	133	Diablo-Lodo complex, 15 to 50 percent slopes	145.3	0.7	103.2	
Santa Rosa Creek	129	1	165	Los Osos-Diablo complex, 30 to 50 percent slopes	31.0	3.3	102.2	Headwaters
Santa Rosa Creek	130	2	132	Diablo and Cibo clays, 30 to 50 percent slopes	71.7	1.4	100.3	
Santa Rosa Creek	131	1	150	Lodo clay loam, 50 to 75 percent slopes	25.7	3.9	100.3	
Santa Rosa Creek	132	15	149	Lodo clay loam, 30 to 50 percent slopes	45.4	2.2	99.9	Perry Creek
Santa Rosa Creek	133	14	167	Los Osos-Lodo complex, 30 to 75 percent slopes	31.7	3.1	98.1	Headwaters
Santa Rosa Creek	134	16	133	Diablo-Lodo complex, 15 to 50 percent slopes	154.5	0.6	97.3	Perry Creek Headwaters
Santa Rosa Creek	135	15	150	Lodo clay loam, 50 to 75 percent slopes	26.1	3.7	96.5	
Santa Rosa Creek	136	14	141	Gaviota sandy loam, 50 to 75 percent slopes	20.9	4.6	96.1	Headwater
Santa Rosa Creek	137	27	131	Diablo and Cibo clays, 15 to 30 percent slopes	96.0	1.0	96.0	Perry Creek
Santa Rosa Creek	138	16	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	45.2	2.1	95.0	
Santa Rosa Creek	139	6	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	31.4	3.0	94.3	
Santa Rosa Creek	140	15	142	Gaviota fine sandy loam, 15 to 50 percent slopes	31.1	3.0	93.2	Fiscalini Creek
Santa Rosa Creek	141	1	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	48.7	1.9	92.5	
Santa Rosa Creek	142	5	201	San Simeon sandy loam, 15 to 30 percent slopes	34.1	2.7	92.0	
Santa Rosa Creek	143	16	132	Diablo and Cibo clays, 30 to 50 percent slopes	76.4	1.2	91.6	
Santa Rosa Creek	144	15	164	Los Osos-Diablo complex, 15 to 30 percent slopes	37.8	2.4	90.7	Perry Creek
Santa Rosa Creek	145	14	164	Los Osos-Diablo complex, 15 to 30 percent slopes	49.7	1.8	89.5	
Santa Rosa Creek	146	13	150	Lodo clay loam, 50 to 75 percent slopes	24.1	3.7	89.1	
Santa Rosa Creek	148	7	160	Los Osos loam, 15 to 30 percent slopes	33.0	2.7	89.0	Perry Creek
Santa Rosa Creek	149	10	119	Cieneba-Millsap loams, 30 to 75 percent slopes	13.3	6.6	88.1	
Santa Rosa Creek	150	9	156	Lopez very shaly clay loam, 30 to 75 percent slopes	17.6	5.0	87.9	
Santa Rosa Creek	151	8	164	Los Osos-Diablo complex, 15 to 30 percent slopes	33.6	2.6	87.4	
Santa Rosa Creek	152	6	163	Los Osos-Diablo complex, 9 to 15 percent slopes	89.6	1.0	86.9	
Santa Rosa Creek	153	1	154	Lompico-McMullin loams, 30 to 75 percent slopes	15.8	5.5	86.9	Headwater
Santa Rosa Creek	154	16	164	Los Osos-Diablo complex, 15 to 30 percent slopes	27.9	3.1	86.5	
Santa Rosa Creek	155	2	160	Los Osos loam, 15 to 30 percent slopes	53.2	1.6	85.0	Fiscalini Creek
Santa Rosa Creek	156	28	133	Diablo-Lodo complex, 15 to 50 percent slopes	157.0	0.5	84.8	
Santa Rosa Creek	157	27	133	Diablo-Lodo complex, 15 to 50 percent slopes	119.4	0.7	84.8	
Santa Rosa Creek	158	27	133	Diablo-Lodo complex, 15 to 50 percent slopes	95.1	0.9	83.7	
Santa Rosa Creek	159	1	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	15.5	5.3	82.3	North Fork Santa Rosa Creek
Santa Rosa Creek	160	5	150	Lodo clay loam, 50 to 75 percent slopes	27.4	3.0	82.2	Headwaters
Santa Rosa Creek	161	2	165	Los Osos-Diablo complex, 30 to 50 percent slopes	26.2	3.1	81.3	
Santa Rosa Creek	162	27	201	San Simeon sandy loam, 15 to 30 percent slopes	38.5	2.1	81.0	
Santa Rosa Creek	163	16	164	Los Osos-Diablo complex, 15 to 30 percent slopes	25.2	3.2	80.7	
Santa Rosa Creek	164	26	119	Cieneba-Millsap loams, 30 to 75 percent slopes	11.3	7.1	79.9	
Santa Rosa Creek	165	28	165	Los Osos-Diablo complex, 30 to 50 percent slopes	44.3	1.8	79.7	Fiscalini Creek
Santa Rosa Creek	166	29	131	Diablo and Cibo clays, 15 to 30 percent slopes	65.9	1.2	79.1	Perry Creek
Santa Rosa Creek	167	27	204	Santa Lucia shaly clay loam, 50 to 75 percent slopes	30.3	2.6	78.8	
Santa Rosa Creek	168	16	165	Los Osos-Diablo complex, 30 to 50 percent slopes	24.4	3.2	78.2	
Santa Rosa Creek	169	19	131	Diablo and Cibo clays, 15 to 30 percent slopes	71.0	1.1	78.0	
Santa Rosa Creek	170	3	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	15.4	5.0	77.1	
Santa Rosa Creek	172	1	165	Los Osos-Diablo complex, 30 to 50 percent slopes	14.5	5.3	77.0	Headwater
Santa Rosa Creek	173	4	164	Los Osos-Diablo complex, 15 to 30 percent slopes	28.4	2.7	76.6	Perry Creek
Santa Rosa Creek	174	3	163	Los Osos-Diablo complex, 9 to 15 percent slopes	16.3	4.7	76.6	
Santa Rosa Creek	175	2	160	Los Osos loam, 15 to 30 percent slopes	50.6	1.5	75.9	Perry Creek
Santa Rosa Creek	176	1	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	54.2	1.4	75.9	
Santa Rosa Creek	177	1	133	Diablo-Lodo complex, 15 to 50 percent slopes	134.8	0.6	75.5	Headwaters
Green Valley Creek	178	59	164	Los Osos-Diablo complex, 15 to 30 percent slopes	29.9	2.5	74.8	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Santa Rosa Creek	179	49	201	San Simeon sandy loam, 15 to 30 percent slopes	41.5	1.8	74.6	
Santa Rosa Creek	180	50	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	30.8	2.4	73.9	
Santa Rosa Creek	181	48	159	Los Osos loam, 9 to 15 percent slopes	60.8	1.2	72.9	Fiscalini Creek
Santa Rosa Creek	182	47	164	Los Osos-Diablo complex, 15 to 30 percent slopes	45.5	1.6	72.8	
Santa Rosa Creek	183	2	133	Diablo-Lodo complex, 15 to 50 percent slopes	78.8	0.9	72.5	
Santa Rosa Creek	184	1	165	Los Osos-Diablo complex, 30 to 50 percent slopes	34.1	2.1	71.5	
Santa Rosa Creek	185	2	131	Diablo and Cibo clays, 15 to 30 percent slopes	58.3	1.2	70.0	
Santa Rosa Creek	187	27	141	Gaviota-Rock outcrop complex, 30 to 75 percent slopes	14.0	5.0	69.9	Headwater
Santa Rosa Creek	188	26	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	20.5	3.4	69.7	
Santa Rosa Creek	189	27	203	Santa Lucia shaly clay loam, 30 to 50 percent slopes	32.9	2.1	69.1	
Santa Rosa Creek	190	16	164	Los Osos-Diablo complex, 15 to 30 percent slopes	29.8	2.3	68.6	
Santa Rosa Creek	191	25	154	Lompico-McMullin loams, 30 to 75 percent slopes	11.0	6.2	68.3	
Santa Rosa Creek	192	23	163	Los Osos-Diablo complex, 9 to 15 percent slopes	24.9	2.7	67.2	Perry Creek
Santa Rosa Creek	193	20	147	Lodo clay loam, 5 to 15 percent slopes	30.2	2.2	66.3	Perry Creek
Santa Rosa Creek	194	19	156	Lopez very shaly clay loam, 30 to 75 percent slopes	13.4	4.9	65.6	
Santa Rosa Creek	195	18	142	Gaviota fine sandy loam, 15 to 50 percent slopes	9.0	7.3	65.5	
Santa Rosa Creek	196	17	133	Diablo-Lodo complex, 15 to 50 percent slopes	68.1	1.0	65.4	
Santa Rosa Creek	197	4	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	16.3	4.0	65.1	
Santa Rosa Creek	198	3	132	Diablo and Cibo clays, 30 to 50 percent slopes	46.3	1.4	64.8	
Santa Rosa Creek	199	2	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	38.0	1.7	64.6	
Santa Rosa Creek	200	11	161	Los Osos loam, 30 to 50 percent slopes	30.7	2.1	64.5	
Santa Rosa Creek	201	10	165	Los Osos-Diablo complex, 30 to 50 percent slopes	27.9	2.3	64.3	
Santa Rosa Creek	202	4	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	37.7	1.7	64.1	
Santa Rosa Creek	203	3	160	Los Osos loam, 15 to 30 percent slopes	21.3	3.0	63.8	Fiscalini Creek
Santa Rosa Creek	204	2	161	Los Osos loam, 30 to 50 percent slopes	29.0	2.2	63.8	Fiscalini Creek
Santa Rosa Creek	205	1	133	Diablo-Lodo complex, 15 to 50 percent slopes	99.6	0.6	63.8	
Santa Rosa Creek	206	16	160	Los Osos loam, 15 to 30 percent slopes	23.6	2.7	63.7	Headwaters
Santa Rosa Creek	207	2	167	Los Osos-Lodo complex, 30 to 75 percent slopes	12.9	4.9	63.4	Headwater
Green Valley Creek	208	59	202	San Simeon sandy loam, 30 to 50 percent slopes	15.4	4.1	63.3	
Green Valley Creek	209	58	161	Los Osos loam, 30 to 50 percent slopes	17.9	3.5	62.6	
Green Valley Creek	210	56	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	16.4	3.8	62.3	
Santa Rosa Creek	211	3	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	44.3	1.4	62.0	
Santa Rosa Creek	212	1	149	Lodo clay loam, 30 to 50 percent slopes	20.6	3.0	61.7	
Santa Rosa Creek	213	2	151	Lodo-Rock outcrop complex, 9 to 30 percent slopes	17.4	3.5	60.8	
Santa Rosa Creek	214	1	132	Diablo and Cibo clays, 30 to 50 percent slopes	68.7	0.9	60.5	
Santa Rosa Creek	215	16	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	24.2	2.5	60.4	
Santa Rosa Creek	216	18	161	Los Osos loam, 30 to 50 percent slopes	28.6	2.1	60.0	
Santa Rosa Creek	217	17	204	Santa Lucia shaly clay loam, 50 to 75 percent slopes	46.1	1.3	59.9	Headwater
Green Valley Creek	218	59	133	Diablo-Lodo complex, 15 to 50 percent slopes	61.0	1.0	59.7	
Santa Rosa Creek	219	49	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	20.9	2.8	58.6	
Santa Rosa Creek	220	50	178	Nacimiento silty clay loam, 30 to 50 percent slopes	27.7	2.1	58.1	Headwaters
Santa Rosa Creek	221	1	164	Los Osos-Diablo complex, 15 to 30 percent slopes	20.0	2.9	57.9	
Santa Rosa Creek	222	2	132	Diablo and Cibo clays, 30 to 50 percent slopes	36.1	1.6	57.7	
Santa Rosa Creek	223	28	165	Los Osos-Diablo complex, 30 to 50 percent slopes	15.2	3.8	57.7	
Santa Rosa Creek	224	27	131	Diablo and Cibo clays, 15 to 30 percent slopes	47.2	1.2	56.6	
Green Valley Creek	225	62	131	Diablo and Cibo clays, 15 to 30 percent slopes	42.7	1.3	55.5	
Green Valley Creek	226	59	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	30.8	1.8	55.5	Perry Creek Headwaters
Green Valley Creek	227	60	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	14.2	3.9	55.3	
Green Valley Creek	228	61	165	Los Osos-Diablo complex, 30 to 50 percent slopes	19.0	2.9	55.1	
Santa Rosa Creek	230	46	165	Los Osos-Diablo complex, 30 to 50 percent slopes	15.6	3.5	54.8	
Santa Rosa Creek	231	44	148	Lodo clay loam, 15 to 30 percent slopes	49.4	1.1	54.3	
Santa Rosa Creek	232	48	133	Diablo-Lodo complex, 15 to 50 percent slopes	67.9	0.8	54.3	Perry Creek Headwaters
Santa Rosa Creek	233	47	161	Los Osos loam, 30 to 50 percent slopes	13.5	4.0	54.0	
Santa Rosa Creek	234	45	132	Diablo and Cibo clays, 30 to 50 percent slopes	48.8	1.1	53.7	
Santa Rosa Creek	235	43	148	Lodo clay loam, 15 to 30 percent slopes	33.2	1.6	53.1	Perry Creek
Santa Rosa Creek	236	42	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	25.2	2.1	52.9	
Santa Rosa Creek	237	29	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	30.8	1.7	52.3	
Green Valley Creek	238	62	161	Los Osos loam, 30 to 50 percent slopes	13.0	4.0	51.8	
Santa Rosa Creek	239	25	133	Diablo-Lodo complex, 15 to 50 percent slopes	89.1	0.6	51.7	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Santa Rosa Creek	240	24	131	Diablo and Cibo clays, 15 to 30 percent slopes	42.6	1.2	51.1	Perry Creek
Santa Rosa Creek	241	23	164	Los Osos-Diablo complex, 15 to 30 percent slopes	18.9	2.7	51.0	Perry Creek
Santa Rosa Creek	242	22	132	Diablo and Cibo clays, 30 to 50 percent slopes	36.1	1.4	50.5	
Santa Rosa Creek	243	21	119	Cieneba-Millsap loams, 30 to 75 percent slopes	9.6	5.2	49.8	
Santa Rosa Creek	244	20	132	Diablo and Cibo clays, 30 to 50 percent slopes	35.5	1.4	49.6	
Santa Rosa Creek	245	19	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	11.2	4.4	49.5	
Santa Rosa Creek	246	18	131	Diablo and Cibo clays, 15 to 30 percent slopes	38.0	1.3	49.4	
Santa Rosa Creek	247	17	133	Diablo-Lodo complex, 15 to 50 percent slopes	66.5	0.7	49.2	
Santa Rosa Creek	248	44	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	25.6	1.9	48.7	
Santa Rosa Creek	249	43	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	14.3	3.4	48.5	Curti Creek Watershed
Santa Rosa Creek	250	42	160	Los Osos loam, 15 to 30 percent slopes	30.3	1.6	48.5	Fiscalini Creek
Santa Rosa Creek	251	41	131	Diablo and Cibo clays, 15 to 30 percent slopes	28.4	1.7	48.2	
Santa Rosa Creek	252	40	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	21.9	2.2	48.1	
Santa Rosa Creek	253	39	170	Marimel silty clay loam, drained	77.0	0.6	47.8	
Santa Rosa Creek	254	38	165	Los Osos-Diablo complex, 30 to 50 percent slopes	18.3	2.6	47.7	
Santa Rosa Creek	255	37	199	San Simeon sandy loam, 2 to 9 percent slopes	22.7	2.1	47.7	
Santa Rosa Creek	256	36	119	Cieneba-Millsap loams, 30 to 75 percent slopes	10.6	4.5	47.6	
Santa Rosa Creek	257	35	131	Diablo and Cibo clays, 15 to 30 percent slopes	47.5	1.0	47.5	Perry Creek Headwaters
Santa Rosa Creek	258	34	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	26.2	1.8	47.2	
Santa Rosa Creek	259	33	167	Los Osos-Lodo complex, 30 to 75 percent slopes	11.5	4.1	47.1	Headwaters
Santa Rosa Creek	260	32	165	Los Osos-Diablo complex, 30 to 50 percent slopes	13.7	3.4	46.5	
Santa Rosa Creek	261	31	131	Diablo and Cibo clays, 15 to 30 percent slopes	63.8	0.7	46.0	
Santa Rosa Creek	262	30	133	Diablo-Lodo complex, 15 to 50 percent slopes	70.4	0.7	45.8	
Santa Rosa Creek	263	4	149	Lodo clay loam, 30 to 50 percent slopes	19.0	2.4	45.5	
Santa Rosa Creek	264	46	163	Los Osos-Diablo complex, 9 to 15 percent slopes	20.7	2.2	45.5	
Santa Rosa Creek	265	45	131	Diablo and Cibo clays, 15 to 30 percent slopes	34.8	1.3	45.2	
Santa Rosa Creek	266	2	160	Los Osos loam, 15 to 30 percent slopes	28.2	1.6	45.1	Perry Creek
Santa Rosa Creek	267	1	202	San Simeon sandy loam, 30 to 50 percent slopes	19.6	2.3	45.0	
Green Valley Creek	268	59	131	Diablo and Cibo clays, 15 to 30 percent slopes	37.2	1.2	44.6	
Green Valley Creek	269	58	142	Gaviota fine sandy loam, 15 to 50 percent slopes	12.7	3.5	44.6	Fiscalini Creek
Green Valley Creek	270	57	133	Diablo-Lodo complex, 15 to 50 percent slopes	46.7	1.0	44.4	
Green Valley Creek	271	56	200	San Simeon sandy loam, 9 to 15 percent slopes	29.2	1.5	43.7	Perry Creek
Santa Rosa Creek	272	28	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	16.6	2.6	43.1	Curti Creek Watershed
Green Valley Creek	273	56	133	Diablo-Lodo complex, 15 to 50 percent slopes	59.6	0.7	42.9	
Green Valley Creek	274	59	182	Nacimiento-Calodo complex, 50 to 75 percent slopes	20.3	2.1	42.6	Headwater
Santa Rosa Creek	275	1	128	Cropley clay, 2 to 9 percent slopes	96.3	0.4	42.4	
Green Valley Creek	276	56	167	Los Osos-Lodo complex, 30 to 75 percent slopes	14.6	2.9	42.3	
Green Valley Creek	277	59	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	23.4	1.8	42.2	
Green Valley Creek	278	52	131	Diablo and Cibo clays, 15 to 30 percent slopes	21.0	2.0	42.0	
Green Valley Creek	279	51	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	15.0	2.8	41.9	
Santa Rosa Creek	280	20	141	Gaviota sandy loam, 50 to 75 percent slopes	8.0	5.2	41.5	North Fork Santa Rosa
Santa Rosa Creek	281	19	131	Diablo and Cibo clays, 15 to 30 percent slopes	29.6	1.4	41.4	
Santa Rosa Creek	282	18	132	Diablo and Cibo clays, 30 to 50 percent slopes	27.3	1.5	40.9	Headwaters
Santa Rosa Creek	283	17	131	Diablo and Cibo clays, 15 to 30 percent slopes	27.2	1.5	40.7	
Green Valley Creek	284	56	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	25.3	1.6	40.5	
Green Valley Creek	285	52	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	21.2	1.9	40.4	Curti Creek Watershed
Green Valley Creek	286	51	226	Zaca clay, 30 to 50 percent slopes	55.4	0.7	39.9	
Green Valley Creek	287	62	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	36.1	1.1	39.8	Fiscalini Creek
Green Valley Creek	288	59	132	Diablo and Cibo clays, 30 to 50 percent slopes	24.7	1.6	39.5	
Santa Rosa Creek	289	44	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	23.2	1.7	39.5	
Santa Rosa Creek	290	43	142	Gaviota fine sandy loam, 15 to 50 percent slopes	19.7	2.0	39.3	Fiscalini Creek
Santa Rosa Creek	291	42	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	24.4	1.6	39.1	
Santa Rosa Creek	292	41	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	22.8	1.7	38.8	Headwaters
Santa Rosa Creek	293	40	168	Los Osos variant clay loam, 15 to 50 percent slopes	15.4	2.5	38.4	Headwater
Santa Rosa Creek	294	39	182	Nacimiento-Calodo complex, 50 to 75 percent slopes	22.5	1.7	38.3	Headwater
Santa Rosa Creek	295	23	165	Los Osos-Diablo complex, 30 to 50 percent slopes	11.2	3.4	38.1	
Santa Rosa Creek	296	22	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	25.4	1.5	38.1	
Santa Rosa Creek	297	21	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	18.1	2.1	38.0	
Santa Rosa Creek	298	20	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	17.3	2.2	38.0	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Santa Rosa Creek	299	19	200	San Simeon sandy loam, 9 to 15 percent slopes	33.9	1.1	37.3	Fiscalini Creek
Green Valley Creek	300	51	133	Diablo-Lodo complex, 15 to 50 percent slopes	44.6	0.8	37.0	
Green Valley Creek	301	56	151	Lodo-Rock outcrop complex, 9 to 30 percent slopes	11.9	3.1	36.9	Curti Creek Watershed
Green Valley Creek	302	56	182	Nacimiento-Calodo complex, 50 to 75 percent slopes	13.6	2.7	36.8	
Santa Rosa Creek	303	28	133	Diablo-Lodo complex, 15 to 50 percent slopes	63.3	0.6	36.7	
Santa Rosa Creek	304	28	148	Lodo clay loam, 15 to 30 percent slopes	20.4	1.8	36.7	
Santa Rosa Creek	305	29	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	22.9	1.6	36.6	
Green Valley Creek	306	59	164	Los Osos-Diablo complex, 15 to 30 percent slopes	15.2	2.4	36.4	
Green Valley Creek	307	51	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	20.2	4.0	36.3	North Fork Santa Rosa Creek
Green Valley Creek	308	59	148	Lodo clay loam, 15 to 30 percent slopes	20.1	1.8	36.2	
Green Valley Creek	309	59	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	20.1	1.8	36.1	
Green Valley Creek	310	56	131	Diablo and Cibo clays, 15 to 30 percent slopes	25.8	1.4	36.1	Curti Creek Watershed
Green Valley Creek	311	59	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	19.0	1.9	36.0	
Santa Rosa Creek	313	22	165	Los Osos-Diablo complex, 30 to 50 percent slopes	11.2	3.2	35.9	
Santa Rosa Creek	314	21	164	Los Osos-Diablo complex, 15 to 30 percent slopes	18.9	1.9	35.9	
Santa Rosa Creek	315	20	163	Los Osos-Diablo complex, 9 to 15 percent slopes	35.7	1.0	35.7	
Santa Rosa Creek	316	19	163	Los Osos-Diablo complex, 9 to 15 percent slopes	57.1	0.6	35.4	
Santa Rosa Creek	317	18	150	Lodo clay loam, 50 to 75 percent slopes	9.8	3.6	35.2	
Green Valley Creek	318	59	197	Salinas silty clay loam, 0 to 2 percent slopes	44.0	0.8	35.2	
Santa Rosa Creek	319	44	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	22.0	1.6	35.1	Perry Creek Headwaters
Green Valley Creek	320	56	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	17.5	2.0	34.9	
Green Valley Creek	321	52	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	18.3	1.9	34.8	
Green Valley Creek	322	51	164	Los Osos-Diablo complex, 15 to 30 percent slopes	14.3	2.4	34.3	
Green Valley Creek	323	59	119	Cieneba-Millsap loams, 30 to 75 percent slopes	5.8	5.9	34.0	
Green Valley Creek	324	59	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	17.0	2.0	33.9	Curti Creek Watershed
Green Valley Creek	325	52	164	Los Osos-Diablo complex, 15 to 30 percent slopes	22.5	1.5	33.8	
Santa Rosa Creek	326	28	163	Los Osos-Diablo complex, 9 to 15 percent slopes	35.1	1.0	33.7	
Santa Rosa Creek	327	29	170	Marimel silty clay loam, drained	36.6	0.9	33.7	Fiscalini Creek
Green Valley Creek	328	62	198	Salinas silty clay loam, 2 to 9 percent slopes	37.0	0.9	33.3	Fiscalini Creek
Green Valley Creek	329	62	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	15.1	2.2	33.2	
Santa Rosa Creek	330	39	110	Briones-Tierra complex, 15 to 50 percent slopes	7.1	4.7	33.2	
Santa Rosa Creek	331	38	131	Diablo and Cibo clays, 15 to 30 percent slopes	48.1	0.7	33.2	
Santa Rosa Creek	332	37	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	27.5	1.2	33.0	
Santa Rosa Creek	333	36	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	15.6	2.1	32.7	
Green Valley Creek	334	62	164	Los Osos-Diablo complex, 15 to 30 percent slopes	13.0	2.5	32.6	
Santa Rosa Creek	335	41	161	Los Osos loam, 30 to 50 percent slopes	11.2	2.9	32.5	
Santa Rosa Creek	336	40	154	Lompico-McMullin loams, 30 to 75 percent slopes	6.2	5.2	32.4	
Santa Rosa Creek	337	39	131	Diablo and Cibo clays, 15 to 30 percent slopes	20.2	1.6	32.4	
Santa Rosa Creek	338	38	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	36.1	0.9	32.1	
Santa Rosa Creek	339	37	165	Los Osos-Diablo complex, 30 to 50 percent slopes	20.0	1.6	32.0	
Santa Rosa Creek	341	24	133	Diablo-Lodo complex, 15 to 50 percent slopes	65.2	0.5	32.0	
Green Valley Creek	342	52	131	Diablo and Cibo clays, 15 to 30 percent slopes	21.2	1.5	31.8	
Green Valley Creek	343	51	165	Los Osos-Diablo complex, 30 to 50 percent slopes	10.9	2.9	31.7	
Santa Rosa Creek	344	37	164	Los Osos-Diablo complex, 15 to 30 percent slopes	10.2	3.1	31.7	
Santa Rosa Creek	345	36	133	Diablo-Lodo complex, 15 to 50 percent slopes	48.4	0.7	31.5	
Green Valley Creek	346	59	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	31.5	1.0	31.5	
Green Valley Creek	347	58	165	Los Osos-Diablo complex, 30 to 50 percent slopes	11.5	2.7	31.1	
Green Valley Creek	348	57	131	Diablo and Cibo clays, 15 to 30 percent slopes	14.1	2.2	31.0	
Green Valley Creek	349	56	160	Los Osos loam, 15 to 30 percent slopes	14.6	2.1	30.7	Headwaters
Green Valley Creek	350	59	132	Diablo and Cibo clays, 30 to 50 percent slopes	30.6	1.0	30.6	
Green Valley Creek	351	58	165	Los Osos-Diablo complex, 30 to 50 percent slopes	20.4	1.5	30.6	
Green Valley Creek	352	59	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	25.5	1.2	30.5	
Green Valley Creek	353	59	165	Los Osos-Diablo complex, 30 to 50 percent slopes	15.3	2.0	30.5	
Green Valley Creek	354	62	164	Los Osos-Diablo complex, 15 to 30 percent slopes	13.8	2.2	30.4	
Green Valley Creek	355	59	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	9.2	3.3	30.4	
Green Valley Creek	356	52	225	Zaca clay, 15 to 30 percent slopes	73.0	0.4	29.9	
Green Valley Creek	357	55	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	22.9	1.3	29.8	
Green Valley Creek	358	54	164	Los Osos-Diablo complex, 15 to 30 percent slopes	24.8	1.2	29.7	Perry Creek
Green Valley Creek	359	53	132	Diablo and Cibo clays, 30 to 50 percent slopes	18.5	1.6	29.6	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Green Valley Creek	360	51	133	Diablo-Lodo complex, 15 to 50 percent slopes	30.7	1.0	29.5	
Green Valley Creek	361	56	127	Cropley clay, 0 to 2 percent slopes	51.4	0.6	29.3	
Green Valley Creek	362	52	148	Lodo clay loam, 15 to 30 percent slopes	10.9	2.7	29.3	Headwaters
Santa Rosa Creek	363	29	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	22.5	1.3	29.3	
Santa Rosa Creek	364	33	163	Los Osos-Diablo complex, 9 to 15 percent slopes	19.4	1.5	29.2	
Santa Rosa Creek	365	32	133	Diablo-Lodo complex, 15 to 50 percent slopes	45.4	0.6	29.1	
Santa Rosa Creek	366	31	165	Los Osos-Diablo complex, 30 to 50 percent slopes	9.6	3.0	28.9	
Santa Rosa Creek	367	30	133	Diablo-Lodo complex, 15 to 50 percent slopes	31.0	0.9	28.9	Perry Creek Headwaters
Santa Rosa Creek	368	28	150	Lodo clay loam, 50 to 75 percent slopes	6.5	4.4	28.7	
Santa Rosa Creek	369	29	178	Nacimiento silty clay loam, 30 to 50 percent slopes	20.2	1.4	28.3	Headwater
Santa Rosa Creek	370	28	132	Diablo and Cibo clays, 30 to 50 percent slopes	18.8	1.5	28.1	
Santa Rosa Creek	371	29	162	Los Osos-Diablo complex, 5 to 9 percent slopes	62.1	0.5	27.9	
Green Valley Creek	372	59	164	Los Osos-Diablo complex, 15 to 30 percent slopes	10.3	2.7	27.9	Fiscalini Creek
Green Valley Creek	373	55	164	Los Osos-Diablo complex, 15 to 30 percent slopes	21.4	1.3	27.9	Perry Creek
Santa Rosa Creek	374	29	132	Diablo and Cibo clays, 30 to 50 percent slopes	18.5	1.5	27.7	
Santa Rosa Creek	375	30	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	29.3	2.1	27.6	Curti Creek Watershed
Green Valley Creek	376	55	148	Lodo clay loam, 15 to 30 percent slopes	25.0	1.1	27.5	Fiscalini Creek
Santa Rosa Creek	378	29	133	Diablo-Lodo complex, 15 to 50 percent slopes	33.9	0.8	27.5	
Green Valley Creek	379	55	131	Diablo and Cibo clays, 15 to 30 percent slopes	18.3	1.5	27.5	Curti Creek Watershed
Green Valley Creek	380	59	159	Los Osos loam, 9 to 15 percent slopes	16.1	1.7	27.4	
Green Valley Creek	381	58	161	Los Osos loam, 30 to 50 percent slopes	11.4	2.4	27.3	
Green Valley Creek	382	57	149	Lodo clay loam, 30 to 50 percent slopes	15.0	1.8	27.0	
Green Valley Creek	383	56	160	Los Osos loam, 15 to 30 percent slopes	14.2	1.9	27.0	
Green Valley Creek	384	59	131	Diablo and Cibo clays, 15 to 30 percent slopes	16.7	1.6	26.8	
Green Valley Creek	385	60	165	Los Osos-Diablo complex, 30 to 50 percent slopes	11.1	2.4	26.5	
Green Valley Creek	386	62	131	Diablo and Cibo clays, 15 to 30 percent slopes	18.8	1.4	26.4	
Green Valley Creek	388	62	200	San Simeon sandy loam, 9 to 15 percent slopes	20.2	1.3	26.3	
Green Valley Creek	389	59	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	12.9	2.0	25.8	
Green Valley Creek	390	60	131	Diablo and Cibo clays, 15 to 30 percent slopes	19.8	1.3	25.8	
Santa Rosa Creek	391	29	170	Marimel silty clay loam, drained	30.0	0.9	25.8	
Santa Rosa Creek	392	30	150	Lodo clay loam, 50 to 75 percent slopes	8.3	3.1	25.7	
Green Valley Creek	393	59	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	12.6	2.0	25.2	
Santa Rosa Creek	394	29	161	Los Osos loam, 30 to 50 percent slopes	8.6	2.9	25.0	
Santa Rosa Creek	395	29	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	12.6	4.4	25.0	Curti Creek Watershed
Green Valley Creek	396	59	163	Los Osos-Lodo complex, 50 to 75 percent slopes	8.3	3.0	24.9	North Fork Santa Rosa Creek
Green Valley Creek	397	60	132	Diablo and Cibo clays, 30 to 50 percent slopes	20.7	1.2	24.9	
Green Valley Creek	398	62	132	Diablo and Cibo clays, 30 to 50 percent slopes	20.5	1.2	24.6	
Green Valley Creek	399	66	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	13.3	4.1	24.5	Headwater
Santa Rosa Creek	400	35	198	Salinas silty clay loam, 2 to 9 percent slopes	26.0	0.9	24.4	
Santa Rosa Creek	401	34	132	Diablo and Cibo clays, 30 to 50 percent slopes	24.2	1.0	24.2	
Santa Rosa Creek	402	33	156	Lopez very shaly clay loam, 30 to 75 percent slopes	4.2	5.7	24.1	
Santa Rosa Creek	403	32	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	9.6	2.5	24.1	
Green Valley Creek	404	59	119	Cieneba-Millsap loams, 30 to 75 percent slopes	6.7	3.6	24.1	
Green Valley Creek	405	64	198	Salinas silty clay loam, 2 to 9 percent slopes	14.1	1.7	24.0	
Green Valley Creek	406	66	161	Los Osos loam, 30 to 50 percent slopes	8.0	3.0	23.9	
Green Valley Creek	407	62	164	Los Osos-Diablo complex, 15 to 30 percent slopes	11.4	2.1	23.9	
Santa Rosa Creek	408	36	132	Diablo and Cibo clays, 30 to 50 percent slopes	19.7	1.2	23.7	Curti Creek Watershed
Santa Rosa Creek	409	35	132	Diablo and Cibo clays, 30 to 50 percent slopes	15.8	1.5	23.6	
Green Valley Creek	410	63	133	Diablo-Lodo complex, 15 to 50 percent slopes	35.0	0.7	23.4	
Green Valley Creek	411	64	131	Diablo and Cibo clays, 15 to 30 percent slopes	23.9	1.0	23.2	
Green Valley Creek	412	66	147	Lodo clay loam, 5 to 15 percent slopes	21.1	1.1	23.2	Perry Creek Headwaters
Green Valley Creek	413	62	150	Lodo clay loam, 50 to 75 percent slopes	5.6	4.1	23.2	
Green Valley Creek	414	59	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	17.8	1.3	23.1	
Green Valley Creek	415	60	183	Obispo-Rock outcrop complex, 15 to 75 percent slopes	12.1	1.9	23.0	Perry Creek
Green Valley Creek	416	63	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	6.8	3.4	23.0	
Green Valley Creek	417	62	132	Diablo and Cibo clays, 30 to 50 percent slopes	17.7	1.3	23.0	
Santa Rosa Creek	418	29	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	12.7	1.8	22.9	
Santa Rosa Creek	419	30	132	Diablo and Cibo clays, 30 to 50 percent slopes	13.4	1.7	22.8	
Green Valley Creek	420	62	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	12.0	1.9	22.8	Headwaters

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Santa Rosa Creek	421	29	131	Diablo and Cibo clays, 15 to 30 percent slopes	15.1	1.5	22.7	Perry Creek
Green Valley Creek	422	62	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	14.2	1.6	22.7	
Green Valley Creek	423	60	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	14.1	1.6	22.6	
Green Valley Creek	424	60	150	Lodo clay loam, 50 to 75 percent slopes	5.0	4.5	22.6	
Santa Rosa Creek	425	29	151	Lodo-Rock outcrop complex, 9 to 30 percent slopes	17.3	1.3	22.5	
Santa Rosa Creek	426	29	161	Los Osos loam, 30 to 50 percent slopes	10.2	2.2	22.5	Perry Creek
Green Valley Creek	427	60	197	Salinas silty clay loam, 0 to 2 percent slopes	18.7	1.2	22.5	Fiscalini Creek
Santa Rosa Creek	428	29	131	Diablo and Cibo clays, 15 to 30 percent slopes	24.1	0.9	22.5	Perry Creek
Green Valley Creek	429	66	165	Los Osos-Diablo complex, 30 to 50 percent slopes	10.2	2.2	22.4	
Santa Rosa Creek	430	32	159	Los Osos loam, 9 to 15 percent slopes	10.6	2.1	22.3	
Santa Rosa Creek	431	31	132	Diablo and Cibo clays, 30 to 50 percent slopes	22.2	1.0	22.2	
Santa Rosa Creek	432	30	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	15.8	1.4	22.1	
Green Valley Creek	433	59	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	14.7	1.5	22.0	
Green Valley Creek	434	55	163	Los Osos-Diablo complex, 9 to 15 percent slopes	3.8	5.7	21.9	
Green Valley Creek	435	66	148	Lodo clay loam, 15 to 30 percent slopes	14.6	1.5	21.8	Perry Creek
Green Valley Creek	437	63	132	Diablo and Cibo clays, 30 to 50 percent slopes	18.2	1.2	21.8	
Green Valley Creek	438	62	131	Diablo and Cibo clays, 15 to 30 percent slopes	22.4	1.0	21.7	
Green Valley Creek	439	58	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	16.6	2.9	21.6	
Green Valley Creek	440	57	119	Cieneba-Millsap loams, 30 to 75 percent slopes	3.5	6.2	21.6	
Green Valley Creek	441	56	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	16.6	1.3	21.6	
Green Valley Creek	442	66	150	Lodo clay loam, 50 to 75 percent slopes	7.7	2.8	21.5	
Green Valley Creek	443	66	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	17.9	1.2	21.5	
Green Valley Creek	444	62	160	Los Osos loam, 15 to 30 percent slopes	11.3	1.9	21.5	
Santa Rosa Creek	445	36	164	Los Osos-Diablo complex, 15 to 30 percent slopes	8.1	2.6	21.0	
Santa Rosa Creek	446	29	201	San Simeon sandy loam, 15 to 30 percent slopes	13.1	1.6	21.0	Fiscalini Creek
Green Valley Creek	447	66	198	Salinas silty clay loam, 2 to 9 percent slopes	24.9	0.8	21.0	Curti Creek Watershed
Green Valley Creek	448	59	132	Diablo and Cibo clays, 30 to 50 percent slopes	15.0	1.4	20.9	
Green Valley Creek	449	60	127	Cropley clay, 0 to 2 percent slopes	46.2	0.5	20.8	
Santa Rosa Creek	450	29	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	32.4	0.6	20.7	
Green Valley Creek	451	59	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	15.9	1.3	20.7	
Green Valley Creek	452	58	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	8.3	2.5	20.7	
Green Valley Creek	453	66	133	Diablo-Lodo complex, 15 to 50 percent slopes	32.8	0.6	20.7	
Green Valley Creek	454	60	201	San Simeon sandy loam, 15 to 30 percent slopes	10.9	1.9	20.6	
Green Valley Creek	455	59	170	Marimel silty clay loam, drained	23.5	0.9	20.4	
Green Valley Creek	456	60	203	Santa Lucia shaly clay loam, 30 to 50 percent slopes	15.7	1.3	20.4	
Santa Rosa Creek	457	29	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	12.7	1.6	20.4	
Santa Rosa Creek	458	29	162	Los Osos-Diablo complex, 5 to 9 percent slopes	28.6	0.7	20.3	
Santa Rosa Creek	459	29	182	Nacimiento-Calodo complex, 50 to 75 percent slopes	8.8	2.3	20.3	North Fork Santa Rosa
Green Valley Creek	460	63	119	Cieneba-Millsap loams, 30 to 75 percent slopes	4.3	4.7	20.0	
Green Valley Creek	461	64	159	Los Osos loam, 9 to 15 percent slopes	12.5	1.6	20.0	
Green Valley Creek	462	66	142	Gaviota fine sandy loam, 15 to 50 percent slopes	16.6	1.2	20.0	
Green Valley Creek	463	62	131	Diablo and Cibo clays, 15 to 30 percent slopes	23.4	0.9	19.9	Perry Creek
Green Valley Creek	464	63	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	15.2	1.3	19.8	
Green Valley Creek	465	62	131	Diablo and Cibo clays, 15 to 30 percent slopes	16.4	1.2	19.7	
Green Valley Creek	466	59	226	Zaca clay, 30 to 50 percent slopes	16.4	1.2	19.6	
Santa Rosa Creek	467	29	130	Diablo and Cibo clays, 9 to 15 percent slopes	25.3	0.8	19.5	
Green Valley Creek	468	55	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	10.7	1.8	19.3	Perry Creek Headwaters
Green Valley Creek	469	55	132	Diablo and Cibo clays, 30 to 50 percent slopes	19.6	1.0	19.2	
Green Valley Creek	470	63	164	Los Osos-Diablo complex, 15 to 30 percent slopes	9.1	2.1	19.1	Fiscalini Creek
Santa Rosa Creek	471	29	164	Los Osos-Diablo complex, 15 to 30 percent slopes	10.0	1.9	19.0	Perry Creek
Green Valley Creek	472	60	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	12.6	1.5	18.9	Perry Creek Headwaters
Green Valley Creek	473	62	146	Henneke-Rock outcrop complex, 15 to 75 percent slopes	9.0	2.1	18.9	
Green Valley Creek	474	62	168	Los Osos variant clay loam, 15 to 50 percent slopes	15.7	1.2	18.9	Perry Creek
Green Valley Creek	475	60	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	8.9	2.1	18.7	North Fork Santa Rosa Creek
Green Valley Creek	476	61	133	Diablo-Lodo complex, 15 to 50 percent slopes	28.3	0.7	18.7	
Green Valley Creek	477	63	204	Santa Lucia shaly clay loam, 50 to 75 percent slopes	6.2	3.0	18.7	Headwater
Green Valley Creek	478	62	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	12.4	1.5	18.6	
Green Valley Creek	479	66	132	Diablo and Cibo clays, 30 to 50 percent slopes	15.5	1.2	18.6	
Green Valley Creek	480	56	160	Los Osos loam, 15 to 30 percent slopes	6.4	2.9	18.6	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Green Valley Creek	481	59	133	Diablo-Lodo complex, 15 to 50 percent slopes	25.4	0.7	18.5	Curti Creek Watershed
Green Valley Creek	482	57	160	Los Osos loam, 15 to 30 percent slopes	10.3	1.8	18.5	
Green Valley Creek	483	56	131	Diablo and Cibo clays, 15 to 30 percent slopes	15.4	1.2	18.5	
Green Valley Creek	484	66	130	Diablo and Cibo clays, 9 to 15 percent slopes	19.4	1.0	18.4	
Green Valley Creek	485	62	132	Diablo and Cibo clays, 30 to 50 percent slopes	26.9	0.7	18.3	
Green Valley Creek	486	60	161	Los Osos loam, 30 to 50 percent slopes	12.1	1.5	18.2	
Green Valley Creek	487	61	225	Zaca clay, 15 to 30 percent slopes	42.1	0.4	18.1	
Green Valley Creek	488	59	200	San Simeon sandy loam, 9 to 15 percent slopes	15.0	1.2	18.0	
Green Valley Creek	489	60	163	Los Osos-Diablo complex, 9 to 15 percent slopes	15.0	1.2	18.0	
Green Valley Creek	490	66	198	Salinas silty clay loam, 2 to 9 percent slopes	7.8	2.3	17.9	
Green Valley Creek	493	58	163	Los Osos-Diablo complex, 9 to 15 percent slopes	25.7	0.7	17.7	
Green Valley Creek	494	57	165	Los Osos-Diablo complex, 30 to 50 percent slopes	7.4	2.4	17.7	
Santa Rosa Creek	495	29	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	23.6	0.8	17.7	
Green Valley Creek	496	57	131	Diablo and Cibo clays, 15 to 30 percent slopes	17.6	1.0	17.6	
Green Valley Creek	497	55	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	11.7	1.5	17.5	
Green Valley Creek	498	64	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	17.5	1.0	17.5	Perry Creek
Green Valley Creek	499	66	132	Diablo and Cibo clays, 30 to 50 percent slopes	18.2	1.0	17.5	Perry Creek
Green Valley Creek	500	60	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	18.0	1.0	17.5	
Green Valley Creek	501	61	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	11.6	1.5	17.5	
Green Valley Creek	502	63	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	9.7	1.8	17.5	
Green Valley Creek	503	62	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	11.6	1.5	17.4	
Green Valley Creek	504	66	160	Los Osos loam, 15 to 30 percent slopes	9.5	1.8	17.1	Perry Creek
Green Valley Creek	505	63	149	Lodo clay loam, 30 to 50 percent slopes	8.5	2.0	17.1	
Green Valley Creek	506	62	119	Cieneba-Millsap loams, 30 to 75 percent slopes	10.7	1.6	17.1	
Green Valley Creek	507	55	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	14.2	1.2	17.0	
Green Valley Creek	508	57	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	14.2	1.2	17.0	
Green Valley Creek	509	56	128	Cropley clay, 2 to 9 percent slopes	21.0	0.8	16.8	
Green Valley Creek	510	63	131	Diablo and Cibo clays, 15 to 30 percent slopes	16.5	1.0	16.5	
Green Valley Creek	511	64	119	Cieneba-Millsap loams, 30 to 75 percent slopes	5.3	3.1	16.5	
Green Valley Creek	512	57	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	15.0	1.1	16.5	
Santa Rosa Creek	513	29	131	Diablo and Cibo clays, 15 to 30 percent slopes	24.1	0.7	16.4	
Green Valley Creek	514	58	151	Henneke-Rock outcrop complex, 15 to 75 percent slopes	8.2	2.0	16.4	North Fork Santa Rosa Creek
Green Valley Creek	515	57	160	Los Osos loam, 15 to 30 percent slopes	7.4	2.2	16.3	
Green Valley Creek	516	60	151	Lodo-Rock outcrop complex, 9 to 30 percent slopes	17.3	0.9	16.2	
Green Valley Creek	517	63	149	Lodo clay loam, 30 to 50 percent slopes	9.6	1.7	16.2	
Green Valley Creek	518	64	200	San Simeon sandy loam, 9 to 15 percent slopes	21.9	0.7	16.2	
Green Valley Creek	519	65	198	Salinas silty clay loam, 2 to 9 percent slopes	23.5	0.7	16.2	
Green Valley Creek	520	67	133	Diablo-Lodo complex, 15 to 50 percent slopes	31.9	0.5	16.0	
Green Valley Creek	521	66	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	10.5	1.5	15.7	
Green Valley Creek	522	68	131	Diablo and Cibo clays, 15 to 30 percent slopes	14.2	1.1	15.6	
Green Valley Creek	523	63	163	Los Osos-Diablo complex, 9 to 15 percent slopes	11.0	1.4	15.3	
Green Valley Creek	524	62	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	9.0	1.7	15.3	
Green Valley Creek	525	58	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	11.7	1.3	15.3	
Green Valley Creek	526	60	165	Los Osos-Diablo complex, 30 to 50 percent slopes	5.9	2.6	15.2	
Green Valley Creek	527	63	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	6.9	2.2	15.2	
Green Valley Creek	528	64	127	Cropley clay, 0 to 2 percent slopes	49.1	0.3	15.2	
Green Valley Creek	529	65	133	Diablo-Lodo complex, 15 to 50 percent slopes	18.3	0.8	15.2	Perry Creek Headwaters
Green Valley Creek	530	67	201	San Simeon sandy loam, 15 to 30 percent slopes	5.2	2.9	15.1	
Green Valley Creek	531	66	132	Diablo and Cibo clays, 30 to 50 percent slopes	15.1	1.0	15.1	
Green Valley Creek	532	60	132	Diablo and Cibo clays, 30 to 50 percent slopes	21.0	0.7	14.9	
Green Valley Creek	533	61	165	Los Osos-Diablo complex, 30 to 50 percent slopes	6.2	2.4	14.9	
Santa Rosa Creek	534	29	132	Diablo and Cibo clays, 30 to 50 percent slopes	15.2	1.0	14.9	
Green Valley Creek	535	56	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	8.7	1.7	14.8	
Green Valley Creek	536	63	128	Cropley clay, 2 to 9 percent slopes	33.7	0.4	14.8	
Green Valley Creek	538	67	133	Diablo-Lodo complex, 15 to 50 percent slopes	16.7	0.9	14.7	
Green Valley Creek	539	66	198	Salinas silty clay loam, 2 to 9 percent slopes	19.2	0.8	14.6	
Green Valley Creek	540	61	133	Diablo-Lodo complex, 15 to 50 percent slopes	22.5	0.6	14.4	
Green Valley Creek	541	57	132	Diablo and Cibo clays, 30 to 50 percent slopes	13.0	1.1	14.4	
Green Valley Creek	542	56	198	Salinas silty clay loam, 2 to 9 percent slopes	11.9	1.2	14.3	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Green Valley Creek	543	67	163	Los Osos-Diablo complex, 9 to 15 percent slopes	8.4	1.7	14.2	
Green Valley Creek	544	66	132	Diablo and Cibo clays, 30 to 50 percent slopes	17.5	0.8	14.2	Perry Creek
Green Valley Creek	545	60	198	Salinas silty clay loam, 2 to 9 percent slopes	42.7	0.3	14.1	Perry Creek Headwaters
Santa Rosa Creek	546	29	198	Salinas silty clay loam, 2 to 9 percent slopes	9.4	1.5	14.0	
Green Valley Creek	547	59	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	10.8	1.3	14.0	
Green Valley Creek	548	60	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	15.6	2.0	14.0	North Fork Santa Rosa Creek
Green Valley Creek	549	56	133	Diablo-Lodo complex, 15 to 50 percent slopes	24.9	0.6	13.9	Perry Creek
Green Valley Creek	550	55	165	Los Osos-Diablo complex, 30 to 50 percent slopes	7.3	1.9	13.8	
Green Valley Creek	551	54	133	Diablo-Lodo complex, 15 to 50 percent slopes	17.2	0.8	13.6	
Green Valley Creek	552	55	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	10.4	1.3	13.6	Perry Creek
Green Valley Creek	554	67	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	11.2	1.2	13.4	Perry Creek Headwaters
Green Valley Creek	555	66	164	Los Osos-Diablo complex, 15 to 30 percent slopes	13.3	1.0	13.3	
Green Valley Creek	557	72	160	Los Osos loam, 15 to 30 percent slopes	3.7	3.6	13.3	
Green Valley Creek	558	61	162	Los Osos-Diablo complex, 5 to 9 percent slopes	32.3	0.4	13.3	
Green Valley Creek	559	62	182	Nacimiento-Calodo complex, 50 to 75 percent slopes	8.3	1.6	13.2	North Fork Santa Rosa
Green Valley Creek	560	61	165	Los Osos-Diablo complex, 30 to 50 percent slopes	6.9	1.9	13.2	
Green Valley Creek	561	60	131	Diablo and Cibo clays, 15 to 30 percent slopes	7.3	1.8	13.2	
Green Valley Creek	562	61	132	Diablo and Cibo clays, 30 to 50 percent slopes	10.1	1.3	13.1	
Green Valley Creek	564	60	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	17.3	0.8	13.1	
Green Valley Creek	566	63	132	Diablo and Cibo clays, 30 to 50 percent slopes	11.9	1.1	13.1	
Green Valley Creek	567	64	159	Los Osos loam, 9 to 15 percent slopes	13.4	1.0	13.1	Perry Creek
Green Valley Creek	568	55	131	Diablo and Cibo clays, 15 to 30 percent slopes	20.2	0.6	13.0	Perry Creek
Green Valley Creek	569	54	130	Diablo and Cibo clays, 9 to 15 percent slopes	16.8	0.8	12.9	
Green Valley Creek	570	59	133	Diablo-Lodo complex, 15 to 50 percent slopes	23.9	0.5	12.9	
Green Valley Creek	571	58	147	Lodo clay loam, 5 to 15 percent slopes	5.4	2.4	12.8	
Green Valley Creek	572	54	129	Diablo clay, 5 to 9 percent slopes	53.3	0.2	12.8	
Green Valley Creek	573	53	170	Marimel silty clay loam, drained	15.5	0.8	12.7	
Green Valley Creek	574	55	131	Diablo and Cibo clays, 15 to 30 percent slopes	10.6	1.2	12.7	
Green Valley Creek	575	54	131	Diablo and Cibo clays, 15 to 30 percent slopes	6.0	2.1	12.7	
Green Valley Creek	576	67	131	Diablo and Cibo clays, 15 to 30 percent slopes	13.0	1.0	12.6	
Green Valley Creek	577	66	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	6.3	2.0	12.6	
Green Valley Creek	578	54	132	Diablo and Cibo clays, 30 to 50 percent slopes	11.4	1.1	12.5	
Green Valley Creek	579	53	132	Diablo and Cibo clays, 30 to 50 percent slopes	10.4	1.2	12.4	
Green Valley Creek	580	59	168	Los Osos variant clay loam, 15 to 50 percent slopes	6.5	1.9	12.4	Headwater
Green Valley Creek	581	60	170	Marimel silty clay loam, drained	82.2	0.2	12.3	
Green Valley Creek	582	61	133	Diablo-Lodo complex, 15 to 50 percent slopes	16.7	0.7	12.3	
Green Valley Creek	583	68	149	Lodo clay loam, 30 to 50 percent slopes	7.2	1.7	12.2	
Green Valley Creek	584	58	133	Diablo-Lodo complex, 15 to 50 percent slopes	23.1	0.5	12.2	
Green Valley Creek	585	56	133	Diablo-Lodo complex, 15 to 50 percent slopes	19.1	0.6	12.2	
Green Valley Creek	586	55	160	Los Osos loam, 15 to 30 percent slopes	8.7	1.4	12.1	
Green Valley Creek	587	54	130	Diablo and Cibo clays, 9 to 15 percent slopes	18.4	0.7	12.1	
Green Valley Creek	588	71	132	Diablo and Cibo clays, 30 to 50 percent slopes	5.8	2.1	12.1	Headwater
Green Valley Creek	589	72	130	Diablo and Cibo clays, 9 to 15 percent slopes	41.5	0.3	12.0	Perry Creek
Green Valley Creek	590	58	160	Los Osos loam, 15 to 30 percent slopes	9.3	1.3	12.0	
Green Valley Creek	592	71	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	5.4	2.2	12.0	
Green Valley Creek	593	72	131	Diablo and Cibo clays, 15 to 30 percent slopes	10.8	1.1	11.9	
Green Valley Creek	594	68	158	Los Osos loam, 5 to 9 percent slopes	10.8	1.1	11.9	
Green Valley Creek	595	53	158	Los Osos loam, 5 to 9 percent slopes	15.0	0.8	11.8	
Green Valley Creek	596	71	132	Diablo and Cibo clays, 30 to 50 percent slopes	12.0	1.0	11.8	
Green Valley Creek	597	53	119	Cieneba-Millsap loams, 30 to 75 percent slopes	2.9	4.0	11.8	
Green Valley Creek	598	71	165	Los Osos-Diablo complex, 30 to 50 percent slopes	4.5	2.6	11.6	
Green Valley Creek	599	71	130	Diablo and Cibo clays, 9 to 15 percent slopes	8.9	1.3	11.5	
Green Valley Creek	600	72	131	Diablo and Cibo clays, 15 to 30 percent slopes	12.0	1.0	11.5	
Green Valley Creek	601	58	162	Los Osos-Diablo complex, 5 to 9 percent slopes	11.5	1.0	11.5	
Green Valley Creek	602	58	110	Briones-Tierra complex, 15 to 50 percent slopes	3.0	3.8	11.5	
Green Valley Creek	603	58	130	Diablo and Cibo clays, 9 to 15 percent slopes	13.8	0.8	11.5	
Green Valley Creek	604	69	198	Salinas silty clay loam, 2 to 9 percent slopes	20.8	0.6	11.5	Perry Creek Headwaters
Green Valley Creek	605	53	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	9.5	1.2	11.4	
Green Valley Creek	606	71	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	4.0	2.8	11.3	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Green Valley Creek	607	55	132	Diablo and Cibo clays, 30 to 50 percent slopes	8.7	1.3	11.3	
Green Valley Creek	608	54	132	Diablo and Cibo clays, 30 to 50 percent slopes	4.2	2.7	11.3	
Green Valley Creek	609	53	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	9.4	1.2	11.2	
Green Valley Creek	610	67	133	Diablo-Lodo complex, 15 to 50 percent slopes	18.7	0.6	11.2	
Green Valley Creek	611	72	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	7.4	1.5	11.2	
Green Valley Creek	612	55	154	Lompico-McMullin loams, 30 to 75 percent slopes	3.2	3.5	11.1	
Green Valley Creek	613	54	198	Salinas silty clay loam, 2 to 9 percent slopes	10.0	1.1	11.1	
Green Valley Creek	614	72	200	San Simeon sandy loam, 9 to 15 percent slopes	12.3	0.9	11.0	Perry Creek
Green Valley Creek	615	72	170	Marimel silty clay loam, drained	32.4	0.3	11.0	
Green Valley Creek	616	72	133	Diablo-Lodo complex, 15 to 50 percent slopes	10.0	1.1	11.0	
Green Valley Creek	617	72	131	Diablo and Cibo clays, 15 to 30 percent slopes	6.1	1.8	11.0	
Green Valley Creek	618	54	167	Los Osos-Lodo complex, 30 to 75 percent slopes	6.8	1.6	10.9	
Green Valley Creek	619	54	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	10.9	1.0	10.9	Perry Creek
Green Valley Creek	620	71	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	12.4	0.9	10.9	Perry Creek
Green Valley Creek	621	72	164	Los Osos-Diablo complex, 15 to 30 percent slopes	4.7	2.3	10.8	
Green Valley Creek	622	70	132	Diablo and Cibo clays, 30 to 50 percent slopes	9.8	1.1	10.8	
Green Valley Creek	623	69	149	Lodo clay loam, 30 to 50 percent slopes	3.5	3.1	10.8	
Green Valley Creek	624	71	160	Los Osos loam, 15 to 30 percent slopes	5.1	2.1	10.7	
Green Valley Creek	625	70	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	8.9	1.2	10.7	
Green Valley Creek	626	71	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	7.6	1.4	10.7	
Green Valley Creek	627	53	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	11.2	1.0	10.6	Perry Creek Headwaters
Green Valley Creek	628	72	130	Diablo and Cibo clays, 9 to 15 percent slopes	17.4	0.6	10.6	
Green Valley Creek	629	54	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	8.1	1.3	10.5	Perry Creek Headwaters
Green Valley Creek	630	53	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	6.6	3.5	10.4	Curti Creek Watershed
Green Valley Creek	631	71	131	Diablo and Cibo clays, 15 to 30 percent slopes	6.1	1.7	10.4	
Green Valley Creek	632	72	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	6.3	3.6	10.2	
Green Valley Creek	633	72	197	Salinas silty clay loam, 0 to 2 percent slopes	21.9	0.5	10.1	
Green Valley Creek	634	72	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	9.1	1.1	10.1	
Green Valley Creek	635	71	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	7.7	1.3	10.1	
Green Valley Creek	636	72	132	Diablo and Cibo clays, 30 to 50 percent slopes	11.6	0.9	10.0	
Green Valley Creek	637	72	164	Los Osos-Diablo complex, 15 to 30 percent slopes	7.7	1.3	10.0	
Green Valley Creek	638	71	162	Los Osos-Diablo complex, 5 to 9 percent slopes	5.2	1.9	9.9	
Green Valley Creek	639	72	133	Diablo-Lodo complex, 15 to 50 percent slopes	11.2	0.9	9.9	
Green Valley Creek	640	69	170	Marimel silty clay loam, drained	105.7	0.1	9.8	
Green Valley Creek	641	70	159	Los Osos loam, 9 to 15 percent slopes	13.0	0.8	9.8	
Green Valley Creek	642	72	159	Los Osos loam, 9 to 15 percent slopes	6.5	1.5	9.7	Fiscalini Creek
Green Valley Creek	643	69	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	6.1	1.6	9.7	
Green Valley Creek	644	70	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	8.0	2.7	9.7	North Fork Santa Rosa Creek
Green Valley Creek	645	69	162	Los Osos-Diablo complex, 5 to 9 percent slopes	6.0	1.6	9.7	
Green Valley Creek	646	69	130	Diablo and Cibo clays, 9 to 15 percent slopes	7.4	1.3	9.6	
Green Valley Creek	647	53	162	Los Osos-Diablo complex, 5 to 9 percent slopes	10.1	1.0	9.6	
Green Valley Creek	648	71	163	Los Osos-Diablo complex, 9 to 15 percent slopes	7.9	1.2	9.4	
Green Valley Creek	649	70	132	Diablo and Cibo clays, 30 to 50 percent slopes	11.6	0.8	9.4	
Green Valley Creek	650	71	164	Los Osos-Diablo complex, 15 to 30 percent slopes	7.2	1.3	9.4	
Green Valley Creek	651	70	128	Cropley clay, 2 to 9 percent slopes	37.2	0.3	9.3	
Green Valley Creek	652	69	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	5.8	1.6	9.3	
Green Valley Creek	653	71	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	4.2	2.1	9.3	
Green Valley Creek	655	70	154	Lompico-McMullin loams, 30 to 75 percent slopes	1.7	5.3	9.2	North Fork Santa Rosa Creek
Green Valley Creek	656	53	133	Diablo-Lodo complex, 15 to 50 percent slopes	12.6	0.7	9.2	
Green Valley Creek	657	74	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	4.0	2.3	9.2	
Green Valley Creek	658	72	147	Lodo clay loam, 5 to 15 percent slopes	7.6	1.2	9.2	
Green Valley Creek	659	72	133	Diablo-Lodo complex, 15 to 50 percent slopes	16.0	0.6	9.1	
Green Valley Creek	660	69	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	4.0	2.3	9.1	
Green Valley Creek	661	69	164	Los Osos-Diablo complex, 15 to 30 percent slopes	4.8	1.9	9.1	Perry Creek Headwaters
Green Valley Creek	662	72	159	Los Osos loam, 9 to 15 percent slopes	11.2	0.8	9.1	
Green Valley Creek	663	69	129	Diablo clay, 5 to 9 percent slopes	19.7	0.5	9.1	
Green Valley Creek	664	69	130	Diablo and Cibo clays, 9 to 15 percent slopes	16.0	0.6	9.0	Perry Creek
Green Valley Creek	665	53	161	Los Osos loam, 30 to 50 percent slopes	3.3	2.7	8.9	
Green Valley Creek	666	72	163	Los Osos-Diablo complex, 9 to 15 percent slopes	8.9	1.0	8.9	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Green Valley Creek	668	69	161	Los Osos loam, 30 to 50 percent slopes	2.8	3.2	8.9	
Green Valley Creek	669	71	132	Diablo and Cibo clays, 30 to 50 percent slopes	13.0	0.7	8.8	
Green Valley Creek	670	72	159	Los Osos loam, 9 to 15 percent slopes	11.3	0.8	8.7	
Green Valley Creek	671	71	128	Cropley clay, 2 to 9 percent slopes	4.5	1.9	8.6	
Green Valley Creek	672	72	159	Los Osos loam, 9 to 15 percent slopes	4.5	1.9	8.5	Fiscalini Creek
Green Valley Creek	673	69	159	Los Osos loam, 9 to 15 percent slopes	13.6	0.6	8.5	
Green Valley Creek	674	70	167	Los Osos-Lodo complex, 30 to 75 percent slopes	2.2	3.8	8.4	
Green Valley Creek	675	53	165	Los Osos-Diablo complex, 30 to 50 percent slopes	5.6	1.5	8.3	
Green Valley Creek	676	69	128	Cropley clay, 2 to 9 percent slopes	36.2	0.2	8.3	
Green Valley Creek	677	74	162	Los Osos-Diablo complex, 5 to 9 percent slopes	6.9	1.2	8.3	Perry Creek
Green Valley Creek	678	72	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	6.6	2.8	8.3	
Green Valley Creek	679	73	148	Lodo clay loam, 15 to 30 percent slopes	5.9	1.4	8.3	Perry Creek Headwaters
Green Valley Creek	680	53	128	Cropley clay, 2 to 9 percent slopes	25.8	0.3	8.2	
Green Valley Creek	681	74	133	Diablo-Lodo complex, 15 to 50 percent slopes	24.2	0.3	8.2	
Green Valley Creek	682	72	131	Diablo and Cibo clays, 15 to 30 percent slopes	11.3	0.7	8.2	
Green Valley Creek	683	73	161	Los Osos loam, 30 to 50 percent slopes	3.4	2.4	8.2	
Green Valley Creek	684	70	151	Lodo-Rock outcrop complex, 9 to 30 percent slopes	8.3	1.0	8.2	
Green Valley Creek	685	70	159	Los Osos loam, 9 to 15 percent slopes	7.4	1.1	8.2	Fiscalini Creek
Green Valley Creek	686	53	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	12.2	0.7	8.2	
Green Valley Creek	687	74	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	8.6	0.9	8.1	
Green Valley Creek	688	74	197	Salinas silty clay loam, 0 to 2 percent slopes	11.6	0.7	8.1	
Green Valley Creek	689	73	182	Nacimiento-Calodo complex, 50 to 75 percent slopes	2.5	3.2	8.1	
Green Valley Creek	690	73	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	5.7	1.4	8.0	
Green Valley Creek	691	73	133	Diablo-Lodo complex, 15 to 50 percent slopes	13.7	0.6	7.9	
Green Valley Creek	692	73	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	8.8	0.9	7.9	Curti Creek Watershed
Green Valley Creek	693	74	150	Lodo clay loam, 50 to 75 percent slopes	2.8	2.8	7.9	
Green Valley Creek	694	73	198	Salinas silty clay loam, 2 to 9 percent slopes	16.8	0.5	7.9	Perry Creek
Green Valley Creek	695	73	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	6.2	2.8	7.9	North Fork Santa Rosa
Green Valley Creek	696	73	154	Lompico-McMullin loams, 30 to 75 percent slopes	1.5	5.4	7.8	
Green Valley Creek	697	73	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	3.3	2.4	7.8	
Green Valley Creek	698	73	162	Los Osos-Diablo complex, 5 to 9 percent slopes	7.8	1.0	7.8	
Green Valley Creek	699	74	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	7.1	1.1	7.8	
Green Valley Creek	700	73	133	Diablo-Lodo complex, 15 to 50 percent slopes	11.6	0.7	7.8	
Green Valley Creek	701	73	130	Diablo and Cibo clays, 9 to 15 percent slopes	8.0	1.0	7.8	
Green Valley Creek	702	74	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	6.6	2.6	7.7	Curti Creek Watershed
Green Valley Creek	703	73	163	Los Osos-Diablo complex, 9 to 15 percent slopes	4.5	1.7	7.7	
Green Valley Creek	704	73	225	Zaca clay, 15 to 30 percent slopes	15.7	0.5	7.7	
Green Valley Creek	705	73	148	Lodo clay loam, 15 to 30 percent slopes	4.0	1.9	7.7	Perry Creek
Green Valley Creek	706	74	165	Los Osos-Diablo complex, 30 to 50 percent slopes	4.5	1.7	7.6	
Green Valley Creek	707	74	150	Lodo clay loam, 50 to 75 percent slopes	3.2	2.4	7.6	
Green Valley Creek	708	74	131	Diablo and Cibo clays, 15 to 30 percent slopes	10.9	0.7	7.6	Perry Creek
Green Valley Creek	709	73	183	Obispo-Rock outcrop complex, 15 to 75 percent slopes	5.1	1.5	7.6	
Green Valley Creek	710	74	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	3.6	2.1	7.5	
Green Valley Creek	711	73	178	Nacimiento silty clay loam, 30 to 50 percent slopes	6.8	1.1	7.5	
Green Valley Creek	712	73	132	Diablo and Cibo clays, 30 to 50 percent slopes	7.7	1.0	7.4	
Green Valley Creek	713	73	131	Diablo and Cibo clays, 15 to 30 percent slopes	18.0	0.4	7.4	
Green Valley Creek	714	73	159	Los Osos loam, 9 to 15 percent slopes	6.7	1.1	7.4	Perry Creek
Green Valley Creek	715	73	158	Los Osos loam, 5 to 9 percent slopes	12.2	0.6	7.3	
Green Valley Creek	716	73	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	4.6	1.6	7.3	
Santa Rosa Creek	717	27	130	Diablo and Cibo clays, 9 to 15 percent slopes	7.5	1.0	7.2	Perry Creek
Santa Rosa Creek	718	27	131	Diablo and Cibo clays, 15 to 30 percent slopes	6.5	1.1	7.2	
Santa Rosa Creek	719	15	133	Diablo-Lodo complex, 15 to 50 percent slopes	20.0	0.4	7.2	
Santa Rosa Creek	720	28	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	9.2	0.8	7.1	
Santa Rosa Creek	721	27	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	7.1	1.0	7.1	Perry Creek
Santa Rosa Creek	722	27	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	13.9	0.5	7.1	Perry Creek
Santa Rosa Creek	723	28	157	Lopez-Rock outcrop complex, 75 to 100 percent slopes	6.4	1.1	7.0	Perry Creek
Santa Rosa Creek	724	28	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	5.9	1.2	7.0	
Santa Rosa Creek	725	27	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	5.8	1.2	7.0	
Santa Rosa Creek	726	28	130	Diablo and Cibo clays, 9 to 15 percent slopes	8.8	0.8	6.9	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Santa Rosa Creek	727	28	198	Salinas silty clay loam, 2 to 9 percent slopes	5.7	1.2	6.9	
Santa Rosa Creek	728	29	130	Diablo and Cibo clays, 9 to 15 percent slopes	9.9	0.7	6.8	
Santa Rosa Creek	729	29	159	Los Osos loam, 9 to 15 percent slopes	11.3	0.6	6.8	Perry Creek
Santa Rosa Creek	730	29	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	3.8	1.8	6.8	
Santa Rosa Creek	731	29	128	Cropley clay, 2 to 9 percent slopes	32.1	0.2	6.7	
Santa Rosa Creek	768	28	149	Lodo clay loam, 30 to 50 percent slopes	3.1	2.2	6.7	
Santa Rosa Creek	771	29	119	Cieneba-Millsap loams, 30 to 75 percent slopes	2.5	2.7	6.7	
Green Valley Creek	0	124	148	Lodo clay loam, 15 to 30 percent slopes	5.2	1.3	6.7	
Green Valley Creek	1	125	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	5.2	1.3	6.7	
Green Valley Creek	2	158	159	Los Osos loam, 9 to 15 percent slopes	8.4	0.8	6.7	
Green Valley Creek	3	135	131	Diablo and Cibo clays, 15 to 30 percent slopes	7.0	1.0	6.7	
Green Valley Creek	4	132	165	Los Osos-Diablo complex, 30 to 50 percent slopes	3.7	1.8	6.7	
Green Valley Creek	5	133	197	Salinas silty clay loam, 0 to 2 percent slopes	17.1	0.4	6.7	
Green Valley Creek	6	124	133	Diablo-Lodo complex, 15 to 50 percent slopes	12.7	0.5	6.6	
Green Valley Creek	7	127	164	Los Osos-Diablo complex, 15 to 30 percent slopes	4.7	1.4	6.6	Fiscalini Creek
Green Valley Creek	8	124	159	Los Osos loam, 9 to 15 percent slopes	8.5	0.8	6.5	
Green Valley Creek	9	125	133	Diablo-Lodo complex, 15 to 50 percent slopes	9.9	0.7	6.5	
Green Valley Creek	10	158	149	Lodo clay loam, 30 to 50 percent slopes	3.8	1.7	6.4	
Green Valley Creek	11	124	197	Salinas silty clay loam, 0 to 2 percent slopes	28.9	0.2	6.4	
Green Valley Creek	12	125	198	Salinas silty clay loam, 2 to 9 percent slopes	15.1	0.4	6.4	Perry Creek
Green Valley Creek	13	124	133	Diablo-Lodo complex, 15 to 50 percent slopes	13.5	0.5	6.3	
Green Valley Creek	14	158	226	Zaca clay, 30 to 50 percent slopes	7.3	0.9	6.3	
Green Valley Creek	15	124	132	Diablo and Cibo clays, 30 to 50 percent slopes	5.7	1.1	6.2	
Green Valley Creek	16	125	165	Los Osos-Diablo complex, 30 to 50 percent slopes	2.4	2.6	6.2	
Green Valley Creek	17	158	164	Los Osos-Diablo complex, 15 to 30 percent slopes	3.6	1.7	6.2	
Green Valley Creek	18	125	158	Los Osos loam, 5 to 9 percent slopes	13.3	0.5	6.1	Perry Creek
Green Valley Creek	19	126	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	4.7	1.3	6.1	
Green Valley Creek	20	133	206	Santa Lucia very shaly clay loam, 9 to 15 percent slopes	10.7	0.6	6.0	Headwater
Green Valley Creek	21	124	168	Los Osos variant clay loam, 15 to 50 percent slopes	4.6	1.3	6.0	Perry Creek
Green Valley Creek	22	125	178	Nacimiento silty clay loam, 30 to 50 percent slopes	4.3	1.4	6.0	
Green Valley Creek	23	126	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	7.4	0.8	5.9	
Green Valley Creek	24	127	199	San Simeon sandy loam, 2 to 9 percent slopes	13.1	0.5	5.9	
Green Valley Creek	25	128	167	Los Osos-Lodo complex, 30 to 75 percent slopes	1.7	3.5	5.9	
Green Valley Creek	26	129	158	Los Osos loam, 5 to 9 percent slopes	5.3	1.1	5.8	Perry Creek
Green Valley Creek	27	130	133	Diablo-Lodo complex, 15 to 50 percent slopes	7.9	0.7	5.8	
Green Valley Creek	28	145	131	Diablo and Cibo clays, 15 to 30 percent slopes	5.3	1.1	5.8	
Green Valley Creek	29	146	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	3.6	1.6	5.8	
Green Valley Creek	30	147	162	Los Osos-Diablo complex, 5 to 9 percent slopes	9.5	0.6	5.8	
Green Valley Creek	31	154	131	Diablo and Cibo clays, 15 to 30 percent slopes	5.7	1.0	5.7	
Green Valley Creek	32	155	128	Cropley clay, 2 to 9 percent slopes	18.3	0.3	5.7	
Green Valley Creek	33	156	149	Lodo clay loam, 30 to 50 percent slopes	4.4	1.3	5.7	
Green Valley Creek	34	157	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	3.8	1.5	5.7	North Fork Santa Rosa Creek
Green Valley Creek	35	158	130	Diablo and Cibo clays, 9 to 15 percent slopes	6.7	0.8	5.7	
Green Valley Creek	36	127	197	Salinas silty clay loam, 0 to 2 percent slopes	4.0	1.4	5.6	
Green Valley Creek	37	125	163	Los Osos-Diablo complex, 9 to 15 percent slopes	5.1	1.1	5.6	Perry Creek
Green Valley Creek	38	155	133	Diablo-Lodo complex, 15 to 50 percent slopes	7.6	0.7	5.5	
Green Valley Creek	39	157	198	Salinas silty clay loam, 2 to 9 percent slopes	29.2	0.2	5.5	
Green Valley Creek	40	157	133	Diablo-Lodo complex, 15 to 50 percent slopes	8.0	0.7	5.5	
Green Valley Creek	41	158	130	Diablo and Cibo clays, 9 to 15 percent slopes	10.5	0.5	5.5	
Green Valley Creek	42	157	132	Diablo and Cibo clays, 30 to 50 percent slopes	2.3	2.4	5.5	Curti Creek Watershed
Green Valley Creek	43	158	164	Los Osos-Diablo complex, 15 to 30 percent slopes	5.8	0.9	5.5	
Green Valley Creek	44	155	133	Diablo-Lodo complex, 15 to 50 percent slopes	5.8	0.9	5.4	
Green Valley Creek	45	157	130	Diablo and Cibo clays, 9 to 15 percent slopes	8.1	0.7	5.4	
Green Valley Creek	46	127	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	5.4	1.0	5.4	
Green Valley Creek	47	128	163	Los Osos-Diablo complex, 9 to 15 percent slopes	10.3	0.5	5.4	
Green Valley Creek	48	136	158	Los Osos loam, 5 to 9 percent slopes	10.1	0.5	5.4	Curti Creek Watershed
Green Valley Creek	49	127	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	4.1	1.3	5.3	Headwaters
Green Valley Creek	50	128	127	Cropley clay, 0 to 2 percent slopes	18.3	0.3	5.3	Perry Creek
Green Valley Creek	51	131	130	Diablo and Cibo clays, 9 to 15 percent slopes	8.4	0.6	5.3	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Green Valley Creek	52	132	163	Los Osos-Diablo complex, 9 to 15 percent slopes	4.8	1.1	5.3	
Green Valley Creek	54	134	183	Obispo-Rock outcrop complex, 15 to 75 percent slopes	2.4	2.2	5.3	
Green Valley Creek	55	144	133	Diablo-Lodo complex, 15 to 50 percent slopes	12.8	0.4	5.2	
Green Valley Creek	56	145	165	Los Osos-Diablo complex, 30 to 50 percent slopes	2.4	2.2	5.2	
Green Valley Creek	57	130	127	Cropley clay, 0 to 2 percent slopes	28.6	0.2	5.1	
Green Valley Creek	58	131	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	3.2	1.6	5.1	Perry Creek Headwaters
Green Valley Creek	59	145	159	Los Osos loam, 9 to 15 percent slopes	5.4	1.0	5.1	Perry Creek
Green Valley Creek	60	137	130	Diablo and Cibo clays, 9 to 15 percent slopes	9.5	0.5	5.0	
Green Valley Creek	61	131	131	Diablo and Cibo clays, 15 to 30 percent slopes	7.4	0.7	5.0	
Green Valley Creek	62	136	150	Lodo clay loam, 50 to 75 percent slopes	1.9	2.6	5.0	
Green Valley Creek	63	137	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	4.5	1.1	4.9	
Green Valley Creek	64	138	168	Los Osos variant clay loam, 15 to 50 percent slopes	3.5	1.4	4.9	Perry Creek Headwaters
Green Valley Creek	65	139	165	Los Osos-Diablo complex, 30 to 50 percent slopes	5.2	0.9	4.9	
Green Valley Creek	66	140	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	8.2	0.6	4.9	
Green Valley Creek	67	136	164	Los Osos-Diablo complex, 15 to 30 percent slopes	2.1	2.3	4.9	
Green Valley Creek	68	138	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	4.0	1.2	4.8	
Green Valley Creek	69	128	130	Diablo and Cibo clays, 9 to 15 percent slopes	5.4	0.9	4.8	
Green Valley Creek	70	129	149	Lodo clay loam, 30 to 50 percent slopes	5.6	0.9	4.8	
Green Valley Creek	71	130	128	Cropley clay, 2 to 9 percent slopes	19.0	0.3	4.7	Headwaters
Green Valley Creek	72	137	165	Los Osos-Diablo complex, 30 to 50 percent slopes	2.0	2.3	4.7	
Green Valley Creek	73	135	150	Lodo clay loam, 50 to 75 percent slopes	1.7	2.8	4.6	
Green Valley Creek	74	128	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	4.7	1.0	4.6	
Green Valley Creek	75	129	158	Los Osos loam, 5 to 9 percent slopes	5.7	0.8	4.6	
Green Valley Creek	76	130	131	Diablo and Cibo clays, 15 to 30 percent slopes	2.2	2.1	4.6	
Green Valley Creek	77	139	148	Lodo clay loam, 15 to 30 percent slopes	3.5	1.3	4.6	
Green Valley Creek	78	135	142	Gaviota fine sandy loam, 15 to 50 percent slopes	1.0	4.8	4.6	Fiscalini Creek
Green Valley Creek	79	135	198	Salinas silty clay loam, 2 to 9 percent slopes	4.8	0.9	4.6	
Green Valley Creek	80	136	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	1.6	2.8	4.6	
Green Valley Creek	81	140	198	Salinas silty clay loam, 2 to 9 percent slopes	5.1	0.9	4.5	
Green Valley Creek	82	134	150	Lodo clay loam, 50 to 75 percent slopes	2.0	2.3	4.5	Curti Creek Watershed
Green Valley Creek	83	134	197	Salinas silty clay loam, 0 to 2 percent slopes	4.7	1.0	4.4	
Green Valley Creek	84	137	131	Diablo and Cibo clays, 15 to 30 percent slopes	4.0	1.1	4.4	
Green Valley Creek	85	132	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	3.6	2.7	4.3	
Green Valley Creek	86	133	133	Diablo-Lodo complex, 15 to 50 percent slopes	6.1	0.7	4.3	
Green Valley Creek	87	134	162	Los Osos-Diablo complex, 5 to 9 percent slopes	15.4	0.3	4.3	
Green Valley Creek	88	156	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.9	2.2	4.3	
Green Valley Creek	89	156	133	Diablo-Lodo complex, 15 to 50 percent slopes	8.8	0.5	4.2	
Green Valley Creek	91	156	131	Diablo and Cibo clays, 15 to 30 percent slopes	12.5	0.3	4.2	
Green Valley Creek	92	133	149	Lodo clay loam, 30 to 50 percent slopes	2.8	1.5	4.2	
Green Valley Creek	93	134	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	4.3	1.0	4.2	Perry Creek
Green Valley Creek	94	144	163	Los Osos-Diablo complex, 9 to 15 percent slopes	2.0	2.0	4.1	
Green Valley Creek	95	134	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	2.5	1.6	4.1	
Green Valley Creek	96	135	119	Cieneba-Millsap loams, 30 to 75 percent slopes	1.3	3.1	4.0	
Green Valley Creek	97	139	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	4.3	0.9	4.0	
Green Valley Creek	98	140	133	Diablo-Lodo complex, 15 to 50 percent slopes	6.0	0.7	4.0	
Green Valley Creek	99	141	170	Marimel silty clay loam, drained	12.3	0.3	3.9	Perry Creek
Green Valley Creek	100	142	164	Los Osos-Diablo complex, 15 to 30 percent slopes	4.7	0.8	3.9	
Green Valley Creek	101	129	149	Lodo clay loam, 30 to 50 percent slopes	2.6	1.5	3.9	
Green Valley Creek	102	130	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	5.9	0.7	3.9	
Green Valley Creek	103	134	151	Lodo-Rock outcrop complex, 9 to 30 percent slopes	3.0	1.3	3.9	
Green Valley Creek	104	142	178	Nacimiento silty clay loam, 30 to 50 percent slopes	2.6	1.5	3.9	Headwater
Green Valley Creek	105	143	159	Los Osos loam, 9 to 15 percent slopes	4.2	0.9	3.9	Fiscalini Creek
Green Valley Creek	106	132	225	Zaca clay, 15 to 30 percent slopes	11.3	0.3	3.8	
Green Valley Creek	107	130	170	Marimel silty clay loam, drained	10.0	0.4	3.8	
Green Valley Creek	108	141	132	Diablo and Cibo clays, 30 to 50 percent slopes	5.9	0.6	3.8	
Green Valley Creek	109	142	132	Diablo and Cibo clays, 30 to 50 percent slopes	6.6	0.6	3.8	
Green Valley Creek	110	140	128	Cropley clay, 2 to 9 percent slopes	41.3	0.1	3.8	
Green Valley Creek	111	141	203	Santa Lucia shaly clay loam, 30 to 50 percent slopes	3.1	1.2	3.7	
Green Valley Creek	112	143	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	4.0	0.9	3.7	Perry Creek

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Green Valley Creek	113	144	165	McMullin-Rock outcrop complex, 50 to 75 percent slopes	1.0	3.6	3.6	North Fork Santa Rosa
Green Valley Creek	114	132	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	4.7	0.8	3.6	
Green Valley Creek	115	141	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	2.4	1.5	3.6	Curti Creek Watershed
Green Valley Creek	116	142	170	Marimel silty clay loam, drained	27.2	0.1	3.5	
Green Valley Creek	117	133	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	3.5	1.0	3.5	Perry Creek Headwaters
Green Valley Creek	118	134	165	Los Osos-Diablo complex, 30 to 50 percent slopes	1.1	3.2	3.5	
Green Valley Creek	119	141	170	Marimel silty clay loam, drained	34.6	0.1	3.5	
Green Valley Creek	120	142	133	Diablo-Lodo complex, 15 to 50 percent slopes	5.3	0.7	3.5	Curti Creek Watershed
Green Valley Creek	121	143	197	Salinas silty clay loam, 0 to 2 percent slopes	9.3	0.4	3.5	
Green Valley Creek	122	132	132	Diablo and Cibo clays, 30 to 50 percent slopes	2.9	1.2	3.4	
Green Valley Creek	123	133	146	Henneke-Rock outcrop complex, 15 to 75 percent slopes	2.1	1.6	3.4	North Fork Santa Rosa
Green Valley Creek	124	134	128	Cropley clay, 2 to 9 percent slopes	6.5	0.5	3.4	
Green Valley Creek	125	143	198	Salinas silty clay loam, 2 to 9 percent slopes	5.5	0.6	3.4	
Green Valley Creek	126	144	224	Zaca clay, 9 to 15 percent slopes	12.6	0.3	3.3	Perry Creek
Green Valley Creek	127	140	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.7	1.9	3.2	
Green Valley Creek	128	139	132	Diablo and Cibo clays, 30 to 50 percent slopes	4.5	0.7	3.2	Perry Creek
Green Valley Creek	129	140	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	1.6	2.0	3.1	
Green Valley Creek	130	139	159	Los Osos loam, 9 to 15 percent slopes	4.8	0.7	3.1	Perry Creek
Green Valley Creek	131	142	164	Los Osos-Diablo complex, 15 to 30 percent slopes	2.8	1.1	3.1	
Green Valley Creek	132	143	131	Diablo and Cibo clays, 15 to 30 percent slopes	3.7	0.8	3.0	
Green Valley Creek	133	139	128	Cropley clay, 2 to 9 percent slopes	7.1	0.4	3.0	
Green Valley Creek	134	142	131	Diablo and Cibo clays, 15 to 30 percent slopes	3.9	0.8	2.9	
Green Valley Creek	135	143	133	Diablo-Lodo complex, 15 to 50 percent slopes	6.8	0.4	2.9	
Green Valley Creek	136	154	149	Lodo clay loam, 30 to 50 percent slopes	1.4	2.0	2.9	
Green Valley Creek	137	142	148	Lodo clay loam, 15 to 30 percent slopes	4.2	0.7	2.9	Perry Creek
Green Valley Creek	138	143	133	Diablo-Lodo complex, 15 to 50 percent slopes	6.3	0.5	2.8	
Green Valley Creek	139	140	226	Zaca clay, 30 to 50 percent slopes	4.7	0.6	2.8	Headwater
Green Valley Creek	140	141	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.7	1.7	2.8	
Green Valley Creek	141	142	128	Cropley clay, 2 to 9 percent slopes	6.7	0.4	2.8	
Green Valley Creek	142	143	129	Diablo clay, 5 to 9 percent slopes	10.3	0.3	2.8	
Green Valley Creek	143	140	130	Diablo and Cibo clays, 9 to 15 percent slopes	8.9	0.3	2.8	
Green Valley Creek	144	143	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.9	1.4	2.7	Perry Creek
Green Valley Creek	145	144	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	3.0	0.9	2.7	
Green Valley Creek	146	132	130	Diablo and Cibo clays, 9 to 15 percent slopes	9.0	0.3	2.7	Perry Creek
Green Valley Creek	147	133	197	Salinas silty clay loam, 0 to 2 percent slopes	4.0	0.7	2.6	
Green Valley Creek	148	132	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	2.6	1.0	2.6	
Green Valley Creek	149	130	158	Los Osos loam, 5 to 9 percent slopes	3.3	0.8	2.6	
Green Valley Creek	150	131	170	Marimel silty clay loam, drained	40.0	0.1	2.6	
Green Valley Creek	151	145	198	Salinas silty clay loam, 2 to 9 percent slopes	12.1	0.2	2.6	
Green Valley Creek	153	144	128	Cropley clay, 2 to 9 percent slopes	21.2	0.1	2.5	Perry Creek
Green Valley Creek	154	145	164	Los Osos-Diablo complex, 15 to 30 percent slopes	1.5	1.7	2.5	
Green Valley Creek	155	132	197	Salinas silty clay loam, 0 to 2 percent slopes	60.1	0.0	2.5	
Green Valley Creek	156	133	163	Los Osos-Diablo complex, 9 to 15 percent slopes	3.9	0.7	2.5	
Green Valley Creek	157	133	198	Salinas silty clay loam, 2 to 9 percent slopes	2.7	0.9	2.5	
Green Valley Creek	158	134	130	Diablo and Cibo clays, 9 to 15 percent slopes	4.4	0.6	2.5	
Green Valley Creek	159	144	129	Diablo clay, 5 to 9 percent slopes	9.5	0.3	2.5	
Green Valley Creek	160	131	159	Los Osos loam, 9 to 15 percent slopes	3.1	0.8	2.4	
Green Valley Creek	161	144	133	Diablo-Lodo complex, 15 to 50 percent slopes	4.9	0.5	2.4	
Green Valley Creek	162	145	225	Zaca clay, 15 to 30 percent slopes	4.2	0.6	2.3	Headwater
Green Valley Creek	163	146	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.9	1.2	2.3	
Green Valley Creek	164	147	131	Diablo and Cibo clays, 15 to 30 percent slopes	3.9	0.6	2.3	
Green Valley Creek	165	131	199	San Simeon sandy loam, 2 to 9 percent slopes	2.4	1.0	2.3	
Green Valley Creek	166	145	127	Cropley clay, 0 to 2 percent slopes	30.6	0.1	2.3	
Green Valley Creek	167	143	132	Diablo and Cibo clays, 30 to 50 percent slopes	4.1	0.6	2.2	
Green Valley Creek	168	144	133	Diablo-Lodo complex, 15 to 50 percent slopes	4.1	0.6	2.2	
Green Valley Creek	169	143	165	Los Osos-Diablo complex, 30 to 50 percent slopes	1.2	1.8	2.2	
Green Valley Creek	170	144	226	Zaca clay, 30 to 50 percent slopes	3.5	0.6	2.2	
Green Valley Creek	171	154	198	Salinas silty clay loam, 2 to 9 percent slopes	6.2	0.4	2.2	
Green Valley Creek	172	139	133	Diablo-Lodo complex, 15 to 50 percent slopes	4.2	0.5	2.2	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Green Valley Creek	173	132	156	Lopez very shaly clay loam, 30 to 75 percent slopes	1.8	1.2	2.2	
Green Valley Creek	174	133	198	Salinas silty clay loam, 2 to 9 percent slopes	12.8	0.2	2.2	
Green Valley Creek	175	134	224	Zaca clay, 9 to 15 percent slopes	19.8	0.1	2.2	
Green Valley Creek	176	145	170	Marimel silty clay loam, drained	34.0	0.1	2.2	
Green Valley Creek	177	144	132	Diablo and Cibo clays, 30 to 50 percent slopes	3.2	0.7	2.2	
Green Valley Creek	178	145	170	Marimel silty clay loam, drained	6.9	0.3	2.2	Fiscalini Creek
Green Valley Creek	179	146	127	Cropley clay, 0 to 2 percent slopes	43.7	0.0	2.1	
Green Valley Creek	180	147	127	Cropley clay, 0 to 2 percent slopes	42.3	0.0	2.1	
Green Valley Creek	181	145	132	Diablo and Cibo clays, 30 to 50 percent slopes	2.7	0.7	2.0	
Green Valley Creek	182	146	129	Diablo clay, 5 to 9 percent slopes	6.1	0.3	2.0	
Green Valley Creek	183	144	170	Marimel silty clay loam, drained	3.0	0.7	2.0	
Green Valley Creek	184	145	133	Diablo-Lodo complex, 15 to 50 percent slopes	3.3	0.6	2.0	
Green Valley Creek	185	146	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	1.4	1.4	2.0	
Green Valley Creek	186	147	128	Cropley clay, 2 to 9 percent slopes	11.4	0.2	1.9	
Green Valley Creek	187	144	128	Cropley clay, 2 to 9 percent slopes	38.4	0.1	1.9	
Green Valley Creek	188	144	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	1.5	2.8	1.9	
Green Valley Creek	189	149	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.7	1.1	1.9	Perry Creek
Green Valley Creek	190	146	127	Cropley clay, 0 to 2 percent slopes	17.1	0.1	1.9	
Green Valley Creek	191	147	127	Cropley clay, 0 to 2 percent slopes	56.9	0.0	1.9	
Green Valley Creek	192	144	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	1.4	1.3	1.9	
Green Valley Creek	193	144	133	Diablo-Lodo complex, 15 to 50 percent slopes	4.8	0.4	1.9	
Green Valley Creek	194	144	128	Cropley clay, 2 to 9 percent slopes	8.9	0.2	1.9	Perry Creek
Green Valley Creek	195	144	129	Diablo clay, 5 to 9 percent slopes	16.9	0.1	1.9	
Green Valley Creek	196	147	131	Diablo and Cibo clays, 15 to 30 percent slopes	1.4	1.3	1.8	
Green Valley Creek	197	146	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.1	1.6	1.8	
Green Valley Creek	198	147	198	Salinas silty clay loam, 2 to 9 percent slopes	2.1	0.9	1.8	
Green Valley Creek	199	151	199	San Simeon sandy loam, 2 to 9 percent slopes	2.3	0.8	1.8	Perry Creek
Green Valley Creek	200	147	176	Nacimiento silty clay loam, 30 to 50 percent slopes	1.0	1.8	1.8	Headwater
Green Valley Creek	201	149	127	Cropley clay, 0 to 2 percent slopes	14.9	0.1	1.8	
Green Valley Creek	202	150	133	Diablo-Lodo complex, 15 to 50 percent slopes	4.5	0.4	1.8	
Green Valley Creek	203	147	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	3.9	0.5	1.8	
Green Valley Creek	204	144	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	1.0	1.8	1.8	Curti Creek Watershed
Green Valley Creek	205	149	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	2.0	0.9	1.8	
Green Valley Creek	206	144	159	Los Osos loam, 9 to 15 percent slopes	2.8	0.6	1.8	Perry Creek
Green Valley Creek	207	147	133	Diablo-Lodo complex, 15 to 50 percent slopes	4.4	0.4	1.8	
Green Valley Creek	208	153	147	Lodo clay loam, 5 to 15 percent slopes	3.6	0.5	1.7	
Green Valley Creek	209	154	202	San Simeon sandy loam, 30 to 50 percent slopes	0.6	2.7	1.7	
Green Valley Creek	210	147	163	Los Osos-Diablo complex, 9 to 15 percent slopes	2.0	0.8	1.7	
Green Valley Creek	211	150	128	Cropley clay, 2 to 9 percent slopes	3.6	0.5	1.7	
Green Valley Creek	212	147	198	Salinas silty clay loam, 2 to 9 percent slopes	8.7	0.2	1.6	
Green Valley Creek	213	148	183	Obispo-Rock outcrop complex, 15 to 75 percent slopes	1.1	1.5	1.6	
Green Valley Creek	214	153	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.3	1.3	1.6	
Green Valley Creek	215	154	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	0.9	1.9	1.6	
Green Valley Creek	216	153	131	Diablo and Cibo clays, 15 to 30 percent slopes	1.5	1.1	1.6	
Green Valley Creek	217	154	198	Salinas silty clay loam, 2 to 9 percent slopes	1.6	1.0	1.6	
Green Valley Creek	218	153	162	Los Osos-Diablo complex, 5 to 9 percent slopes	1.1	1.4	1.6	
Green Valley Creek	219	154	133	Diablo-Lodo complex, 15 to 50 percent slopes	2.6	0.6	1.6	
Green Valley Creek	220	151	128	Cropley clay, 2 to 9 percent slopes	12.2	0.1	1.6	
Green Valley Creek	221	147	170	Marimel silty clay loam, drained	46.4	0.0	1.6	
Green Valley Creek	222	148	129	Diablo clay, 5 to 9 percent slopes	3.6	0.4	1.5	Perry Creek
Green Valley Creek	223	149	170	Marimel silty clay loam, drained	2.7	0.6	1.5	Perry Creek
Green Valley Creek	224	152	178	Nacimiento silty clay loam, 30 to 50 percent slopes	2.3	0.7	1.5	
Green Valley Creek	225	148	128	Cropley clay, 2 to 9 percent slopes	5.4	0.3	1.5	
Green Valley Creek	226	153	133	Diablo-Lodo complex, 15 to 50 percent slopes	3.1	0.5	1.5	Headwaters
Green Valley Creek	227	154	131	Diablo and Cibo clays, 15 to 30 percent slopes	1.9	0.7	1.4	
Green Valley Creek	229	148	197	Salinas silty clay loam, 0 to 2 percent slopes	9.4	0.2	1.4	Perry Creek Headwaters
Green Valley Creek	230	150	170	Marimel silty clay loam, drained	0.8	1.7	1.4	Fiscalini Creek
Green Valley Creek	231	151	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.0	1.4	1.4	
Green Valley Creek	232	148	128	Cropley clay, 2 to 9 percent slopes	10.0	0.1	1.4	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Green Valley Creek	233	149	159	Los Osos loam, 9 to 15 percent slopes	1.3	1.1	1.4	
Green Valley Creek	234	150	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	0.9	1.6	1.4	
Green Valley Creek	235	151	131	Diablo and Cibo clays, 15 to 30 percent slopes	2.6	0.5	1.4	
Green Valley Creek	236	150	170	Marimel silty clay loam, drained	38.8	0.0	1.4	
Green Valley Creek	237	148	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.6	0.9	1.3	
Green Valley Creek	238	153	182	Nacimiento-Calodo complex, 50 to 75 percent slopes	0.6	2.2	1.3	
Green Valley Creek	239	153	127	Cropley clay, 0 to 2 percent slopes	3.0	0.5	1.3	
Green Valley Creek	240	148	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.2	1.1	1.3	
Green Valley Creek	241	151	158	Los Osos loam, 5 to 9 percent slopes	3.4	0.4	1.3	Perry Creek
Green Valley Creek	242	149	160	Los Osos loam, 15 to 30 percent slopes	2.3	0.6	1.3	
Green Valley Creek	243	150	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.6	0.8	1.3	Perry Creek
Green Valley Creek	244	151	128	Cropley clay, 2 to 9 percent slopes	5.3	0.2	1.3	
Green Valley Creek	245	152	159	Los Osos loam, 9 to 15 percent slopes	4.0	0.3	1.3	
Green Valley Creek	246	148	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.8	0.7	1.3	
Green Valley Creek	247	149	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	1.6	1.7	1.2	Headwater
Green Valley Creek	248	149	198	Salinas silty clay loam, 2 to 9 percent slopes	0.7	1.7	1.2	
Green Valley Creek	249	148	170	Marimel silty clay loam, drained	20.4	0.1	1.2	
Green Valley Creek	250	149	133	Diablo-Lodo complex, 15 to 50 percent slopes	2.5	0.5	1.2	
Green Valley Creek	251	153	197	Salinas silty clay loam, 0 to 2 percent slopes	6.2	0.2	1.2	
Green Valley Creek	253	151	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.4	0.8	1.2	
Green Valley Creek	254	148	165	Los Osos-Diablo complex, 30 to 50 percent slopes	1.3	0.9	1.1	
Green Valley Creek	255	149	159	Los Osos loam, 9 to 15 percent slopes	6.6	0.2	1.1	Perry Creek
Green Valley Creek	256	152	165	Los Osos-Diablo complex, 30 to 50 percent slopes	0.6	2.0	1.1	
Green Valley Creek	257	153	127	Cropley clay, 0 to 2 percent slopes	2.8	0.4	1.1	
Green Valley Creek	258	150	131	Diablo and Cibo clays, 15 to 30 percent slopes	1.0	1.1	1.1	
Green Valley Creek	259	151	164	Los Osos-Diablo complex, 15 to 30 percent slopes	3.8	0.3	1.0	
Green Valley Creek	260	152	163	Los Osos-Diablo complex, 9 to 15 percent slopes	7.8	0.1	1.0	Perry Creek
Green Valley Creek	261	149	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.2	0.8	1.0	
Green Valley Creek	262	152	131	Diablo and Cibo clays, 15 to 30 percent slopes	0.8	1.3	1.0	
Green Valley Creek	263	151	133	Diablo-Lodo complex, 15 to 50 percent slopes	2.4	0.4	1.0	Perry Creek
Green Valley Creek	264	153	127	Cropley clay, 0 to 2 percent slopes	2.7	0.4	1.0	
Green Valley Creek	265	152	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	0.7	1.5	1.0	
Green Valley Creek	266	149	132	Diablo and Cibo clays, 30 to 50 percent slopes	0.7	1.3	1.0	
Green Valley Creek	267	152	167	Los Osos-Lodo complex, 30 to 75 percent slopes	0.3	2.8	1.0	
Green Valley Creek	268	151	127	Cropley clay, 0 to 2 percent slopes	28.8	0.0	0.9	
Green Valley Creek	269	152	162	Los Osos-Diablo complex, 5 to 9 percent slopes	2.4	0.4	0.9	
Green Valley Creek	270	152	158	Los Osos loam, 5 to 9 percent slopes	2.9	0.3	0.9	Perry Creek
Green Valley Creek	271	152	198	Salinas silty clay loam, 2 to 9 percent slopes	1.8	0.5	0.9	
Green Valley Creek	272	152	170	Marimel silty clay loam, drained	10.2	0.1	0.9	
Green Valley Creek	273	152	127	Cropley clay, 0 to 2 percent slopes	11.7	0.1	0.9	
Green Valley Creek	275	152	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.4	0.7	0.9	
Green Valley Creek	276	152	128	Cropley clay, 2 to 9 percent slopes	3.9	0.2	0.9	
Santa Rosa Creek	0	77	128	Cropley clay, 2 to 9 percent slopes	18.1	0.0	0.9	
Santa Rosa Creek	1	77	132	Diablo and Cibo clays, 30 to 50 percent slopes	1.2	0.7	0.9	
Santa Rosa Creek	2	78	129	Diablo clay, 5 to 9 percent slopes	4.8	0.2	0.9	
Santa Rosa Creek	3	79	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	0.9	1.0	0.8	
Santa Rosa Creek	4	79	133	Diablo-Lodo complex, 15 to 50 percent slopes	1.1	0.8	0.8	
Santa Rosa Creek	5	81	128	Cropley clay, 2 to 9 percent slopes	1.9	0.4	0.8	
Santa Rosa Creek	6	83	170	Marimel silty clay loam, drained	24.1	0.0	0.8	
Santa Rosa Creek	7	79	128	Cropley clay, 2 to 9 percent slopes	23.9	0.0	0.8	
Santa Rosa Creek	8	80	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	1.0	0.8	0.8	
Santa Rosa Creek	9	81	128	Cropley clay, 2 to 9 percent slopes	11.2	0.1	0.8	
Santa Rosa Creek	10	83	133	Diablo-Lodo complex, 15 to 50 percent slopes	1.7	0.5	0.8	
Santa Rosa Creek	11	84	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	0.4	2.1	0.8	
Santa Rosa Creek	12	79	127	Cropley clay, 0 to 2 percent slopes	20.0	0.0	0.8	
Santa Rosa Creek	13	80	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.3	0.6	0.8	
Santa Rosa Creek	14	79	206	Santa Lucia very shaly clay loam, 9 to 15 percent slopes	2.9	0.3	0.8	
Santa Rosa Creek	15	80	129	Diablo clay, 5 to 9 percent slopes	6.4	0.1	0.8	
Santa Rosa Creek	17	85	167	Los Osos-Lodo complex, 30 to 75 percent slopes	0.4	1.9	0.8	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Santa Rosa Creek	18	86	129	Diablo clay, 5 to 9 percent slopes	5.1	0.2	0.8	
Santa Rosa Creek	19	87	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.0	0.8	0.8	Fiscalini Creek
Santa Rosa Creek	20	79	129	Diablo clay, 5 to 9 percent slopes	7.9	0.1	0.7	
Santa Rosa Creek	21	80	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	0.6	1.2	0.7	
Santa Rosa Creek	22	76	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	0.9	0.8	0.7	
Santa Rosa Creek	23	80	128	Cropley clay, 2 to 9 percent slopes	8.2	0.1	0.7	
Santa Rosa Creek	24	79	119	Cieneba-Millsap loams, 30 to 75 percent slopes	0.3	2.7	0.7	
Santa Rosa Creek	25	79	132	Diablo and Cibo clays, 30 to 50 percent slopes	0.8	1.0	0.7	
Santa Rosa Creek	26	79	183	Obispo-Rock outcrop complex, 15 to 75 percent slopes	0.5	1.3	0.7	
Santa Rosa Creek	27	80	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	0.8	0.9	0.7	
Santa Rosa Creek	28	79	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	1.3	0.5	0.7	Perry Creek
Santa Rosa Creek	29	80	131	Diablo and Cibo clays, 15 to 30 percent slopes	0.6	1.2	0.7	
Santa Rosa Creek	30	81	198	Salinas silty clay loam, 2 to 9 percent slopes	16.4	0.0	0.7	
Santa Rosa Creek	31	82	131	Diablo and Cibo clays, 15 to 30 percent slopes	1.6	0.4	0.7	Perry Creek
Santa Rosa Creek	32	83	129	Diablo clay, 5 to 9 percent slopes	4.7	0.1	0.7	Perry Creek
Santa Rosa Creek	33	84	170	Marimel silty clay loam, drained	1.3	0.5	0.7	
Santa Rosa Creek	34	85	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	1.0	0.7	0.7	
Santa Rosa Creek	35	86	142	Gaviota fine sandy loam, 15 to 50 percent slopes	0.2	3.0	0.6	Fiscalini Creek
Santa Rosa Creek	36	87	198	Salinas silty clay loam, 2 to 9 percent slopes	1.1	0.6	0.6	
Santa Rosa Creek	37	114	148	Lodo clay loam, 15 to 30 percent slopes	1.1	0.6	0.6	Fiscalini Creek
Santa Rosa Creek	38	115	127	Cropley clay, 0 to 2 percent slopes	1.9	0.3	0.6	
Santa Rosa Creek	39	116	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	0.6	1.1	0.6	
Santa Rosa Creek	40	117	161	Los Osos loam, 30 to 50 percent slopes	0.8	0.7	0.6	Fiscalini Creek
Santa Rosa Creek	41	118	148	Lodo clay loam, 15 to 30 percent slopes	1.8	0.3	0.6	
Santa Rosa Creek	42	119	128	Cropley clay, 2 to 9 percent slopes	8.3	0.1	0.6	
Santa Rosa Creek	43	120	198	Salinas silty clay loam, 2 to 9 percent slopes	2.3	0.3	0.6	
Santa Rosa Creek	44	77	127	Cropley clay, 0 to 2 percent slopes	2.4	0.2	0.6	
Santa Rosa Creek	45	78	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	1.0	0.6	0.6	
Santa Rosa Creek	46	121	170	Marimel silty clay loam, drained	16.5	0.0	0.6	
Santa Rosa Creek	47	122	133	Diablo-Lodo complex, 15 to 50 percent slopes	0.8	0.7	0.6	Headwaters
Santa Rosa Creek	49	88	133	Diablo-Lodo complex, 15 to 50 percent slopes	1.7	0.3	0.5	
Santa Rosa Creek	50	79	133	Diablo-Lodo complex, 15 to 50 percent slopes	1.7	0.3	0.5	
Santa Rosa Creek	51	79	197	Salinas silty clay loam, 0 to 2 percent slopes	4.1	0.1	0.5	
Santa Rosa Creek	52	75	151	Henneke-Rock outcrop complex, 15 to 75 percent slopes	0.5	1.1	0.5	North Fork Santa Rosa
Santa Rosa Creek	53	78	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	0.6	0.8	0.5	
Santa Rosa Creek	54	87	119	Cieneba-Millsap loams, 30 to 75 percent slopes	0.2	3.0	0.5	
Santa Rosa Creek	55	88	164	Los Osos-Diablo complex, 15 to 30 percent slopes	3.4	0.2	0.5	
Santa Rosa Creek	56	89	127	Cropley clay, 0 to 2 percent slopes	14.6	0.0	0.5	
Santa Rosa Creek	57	81	129	Diablo clay, 5 to 9 percent slopes	17.1	0.0	0.5	
Santa Rosa Creek	58	82	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	0.4	1.3	0.5	
Santa Rosa Creek	59	83	164	Los Osos-Diablo complex, 15 to 30 percent slopes	2.2	0.2	0.5	
Santa Rosa Creek	60	79	132	Diablo and Cibo clays, 30 to 50 percent slopes	0.8	0.6	0.5	
Santa Rosa Creek	61	80	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	0.2	2.1	0.5	
Santa Rosa Creek	62	79	150	Lodo clay loam, 50 to 75 percent slopes	0.9	0.5	0.5	Headwaters
Santa Rosa Creek	64	79	197	Salinas silty clay loam, 0 to 2 percent slopes	12.8	0.0	0.4	
Santa Rosa Creek	65	119	128	Cropley clay, 2 to 9 percent slopes	5.2	0.1	0.4	
Santa Rosa Creek	66	120	165	Los Osos-Diablo complex, 30 to 50 percent slopes	0.4	1.1	0.4	Perry Creek
Santa Rosa Creek	67	79	132	Diablo and Cibo clays, 30 to 50 percent slopes	0.9	0.5	0.4	
Santa Rosa Creek	68	77	133	Diablo-Lodo complex, 15 to 50 percent slopes	0.6	0.7	0.4	
Santa Rosa Creek	69	78	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	0.1	3.3	0.4	
Santa Rosa Creek	70	98	129	Diablo clay, 5 to 9 percent slopes	0.8	0.5	0.4	
Santa Rosa Creek	71	99	167	Los Osos-Lodo complex, 30 to 75 percent slopes	0.2	1.6	0.4	
Santa Rosa Creek	72	100	167	Los Osos-Lodo complex, 30 to 75 percent slopes	0.3	1.3	0.4	
Santa Rosa Creek	77	75	198	Salinas silty clay loam, 2 to 9 percent slopes	0.9	0.4	0.4	
Santa Rosa Creek	78	76	128	Cropley clay, 2 to 9 percent slopes	2.9	0.1	0.4	
Santa Rosa Creek	79	77	161	Los Osos loam, 30 to 50 percent slopes	2.1	0.2	0.4	
Santa Rosa Creek	80	122	128	Cropley clay, 2 to 9 percent slopes	9.3	0.0	0.4	Perry Creek
Santa Rosa Creek	81	123	165	Los Osos-Diablo complex, 30 to 50 percent slopes	0.6	0.6	0.3	Perry Creek
Santa Rosa Creek	82	81	224	Zaca clay, 9 to 15 percent slopes	1.9	0.2	0.3	Perry Creek

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Santa Rosa Creek	83	82	132	Diablo and Cibo clays, 30 to 50 percent slopes	0.8	0.4	0.3	
Santa Rosa Creek	85	116	133	Diablo-Lodo complex, 15 to 50 percent slopes	1.0	0.3	0.3	
Santa Rosa Creek	86	117	170	Marimel silty clay loam, drained	5.8	0.1	0.3	
Santa Rosa Creek	87	118	127	Cropley clay, 0 to 2 percent slopes	9.9	0.0	0.3	
Santa Rosa Creek	88	119	164	Los Osos-Diablo complex, 15 to 30 percent slopes	1.7	0.2	0.3	
Santa Rosa Creek	89	120	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	0.7	0.5	0.3	
Santa Rosa Creek	90	121	198	Salinas silty clay loam, 2 to 9 percent slopes	1.2	0.3	0.3	
Santa Rosa Creek	91	76	167	Los Osos-Lodo complex, 30 to 75 percent slopes	0.3	1.1	0.3	
Santa Rosa Creek	93	98	197	Salinas silty clay loam, 0 to 2 percent slopes	0.3	1.0	0.3	
Santa Rosa Creek	94	99	128	Cropley clay, 2 to 9 percent slopes	5.0	0.1	0.3	
Santa Rosa Creek	95	120	165	Los Osos-Diablo complex, 30 to 50 percent slopes	0.3	0.9	0.3	
Santa Rosa Creek	96	83	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	0.3	0.9	0.3	
Santa Rosa Creek	97	84	131	Diablo and Cibo clays, 15 to 30 percent slopes	0.8	0.4	0.3	
Santa Rosa Creek	98	120	198	Salinas silty clay loam, 2 to 9 percent slopes	0.5	0.5	0.3	
Santa Rosa Creek	99	89	127	Cropley clay, 0 to 2 percent slopes	4.8	0.1	0.3	
Santa Rosa Creek	100	76	127	Cropley clay, 0 to 2 percent slopes	5.7	0.0	0.3	
Santa Rosa Creek	101	120	197	Salinas silty clay loam, 0 to 2 percent slopes	6.5	0.0	0.3	
Santa Rosa Creek	102	121	203	Santa Lucia shaly clay loam, 30 to 50 percent slopes	0.2	1.2	0.3	
Santa Rosa Creek	103	76	226	Zaca clay, 30 to 50 percent slopes	0.3	0.8	0.3	
Santa Rosa Creek	104	75	198	Salinas silty clay loam, 2 to 9 percent slopes	1.0	0.3	0.2	
Santa Rosa Creek	105	89	129	Diablo clay, 5 to 9 percent slopes	5.9	0.0	0.2	
Santa Rosa Creek	106	90	151	Henneke-Rock outcrop complex, 15 to 75 percent slopes	1.9	0.1	0.2	
Santa Rosa Creek	107	118	197	Salinas silty clay loam, 0 to 2 percent slopes	6.8	0.0	0.2	
Santa Rosa Creek	109	120	164	Los Osos-Diablo complex, 15 to 30 percent slopes	0.7	0.3	0.2	
Santa Rosa Creek	110	75	141	Gaviota sandy loam, 50 to 75 percent slopes	0.1	2.0	0.2	Headwater
Santa Rosa Creek	111	76	133	Diablo-Lodo complex, 15 to 50 percent slopes	0.5	0.4	0.2	
Santa Rosa Creek	112	87	198	Salinas silty clay loam, 2 to 9 percent slopes	1.7	0.1	0.2	
Santa Rosa Creek	113	112	165	Los Osos-Diablo complex, 30 to 50 percent slopes	0.1	1.6	0.2	
Santa Rosa Creek	114	113	131	Diablo and Cibo clays, 15 to 30 percent slopes	1.4	0.1	0.2	
Santa Rosa Creek	115	114	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	0.3	0.7	0.2	
Santa Rosa Creek	116	115	198	Salinas silty clay loam, 2 to 9 percent slopes	0.2	0.8	0.2	
Santa Rosa Creek	117	116	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	0.4	0.9	0.2	
Santa Rosa Creek	118	118	197	Salinas silty clay loam, 0 to 2 percent slopes	0.4	0.4	0.2	
Santa Rosa Creek	119	87	127	Cropley clay, 0 to 2 percent slopes	3.2	0.1	0.2	
Santa Rosa Creek	120	89	132	Diablo and Cibo clays, 30 to 50 percent slopes	1.1	0.1	0.2	
Santa Rosa Creek	121	90	131	Diablo and Cibo clays, 15 to 30 percent slopes	0.1	1.3	0.2	
Santa Rosa Creek	122	91	161	Los Osos loam, 30 to 50 percent slopes	0.6	0.3	0.1	
Santa Rosa Creek	123	92	152	Lodo-Rock outcrop complex, 30 to 75 percent slopes	0.1	1.1	0.1	
Santa Rosa Creek	124	93	150	Lodo clay loam, 50 to 75 percent slopes	0.4	0.3	0.1	Headwaters
Santa Rosa Creek	125	94	133	Diablo-Lodo complex, 15 to 50 percent slopes	0.2	0.7	0.1	
Santa Rosa Creek	126	95	198	Salinas silty clay loam, 2 to 9 percent slopes	0.3	0.5	0.1	
Santa Rosa Creek	127	96	197	Salinas silty clay loam, 0 to 2 percent slopes	4.0	0.0	0.1	Perry Creek
Santa Rosa Creek	128	97	163	Los Osos-Diablo complex, 9 to 15 percent slopes	0.2	0.7	0.1	
Santa Rosa Creek	129	98	131	Diablo and Cibo clays, 15 to 30 percent slopes	2.1	0.1	0.1	
Santa Rosa Creek	130	100	197	Salinas silty clay loam, 0 to 2 percent slopes	0.4	0.3	0.1	
Santa Rosa Creek	131	101	203	Santa Lucia shaly clay loam, 30 to 50 percent slopes	0.1	1.0	0.1	
Santa Rosa Creek	132	102	165	Los Osos-Diablo complex, 30 to 50 percent slopes	0.4	0.3	0.1	
Santa Rosa Creek	133	103	131	Diablo and Cibo clays, 15 to 30 percent slopes	0.4	0.3	0.1	Perry Creek
Santa Rosa Creek	134	104	198	Salinas silty clay loam, 2 to 9 percent slopes	0.3	0.4	0.1	
Santa Rosa Creek	135	105	132	Diablo and Cibo clays, 30 to 50 percent slopes	0.8	0.1	0.1	
Santa Rosa Creek	136	106	127	Cropley clay, 0 to 2 percent slopes	5.3	0.0	0.1	
Santa Rosa Creek	137	107	145	Gazos-Lodo clay loams, 50 to 75 percent slopes	0.1	0.9	0.1	
Santa Rosa Creek	138	108	167	Los Osos-Lodo complex, 30 to 75 percent slopes	0.1	1.1	0.1	
Santa Rosa Creek	139	109	128	Cropley clay, 2 to 9 percent slopes	0.6	0.2	0.1	
Santa Rosa Creek	140	110	164	Los Osos-Diablo complex, 15 to 30 percent slopes	0.1	0.6	0.1	
Santa Rosa Creek	141	111	128	Cropley clay, 2 to 9 percent slopes	1.6	0.1	0.1	
Santa Rosa Creek	142	112	164	Los Osos-Diablo complex, 15 to 30 percent slopes	0.2	0.6	0.1	
Santa Rosa Creek	143	113	127	Cropley clay, 0 to 2 percent slopes	2.6	0.0	0.1	
Santa Rosa Creek	145	77	197	Salinas silty clay loam, 0 to 2 percent slopes	0.3	0.3	0.1	

Watershed	Soil Map Unit ID	Drainage ID	Soil Map Unit Symbol	Soil Name	Acres	RUSLE2 Predicted Annual Soil Loss (tons/acre/year)	Total Predicted Annual Soil Loss (tons)	Comment
Santa Rosa Creek	146	121	181	Nacimiento-Calodo complex, 30 to 50 percent slopes	0.1	0.8	0.1	
Santa Rosa Creek	147	84	127	Cropley clay, 0 to 2 percent slopes	0.5	0.2	0.1	
Santa Rosa Creek	148	114	182	Nacimiento-Calodo complex, 50 to 75 percent slopes	0.1	1.2	0.1	North Fork Santa Rosa
Santa Rosa Creek	149	115	198	Salinas silty clay loam, 2 to 9 percent slopes	0.3	0.3	0.1	
Santa Rosa Creek	150	116	165	Los Osos-Diablo complex, 30 to 50 percent slopes	0.1	1.1	0.1	
Santa Rosa Creek	151	75	206	Santa Lucia very shaly clay loam, 9 to 15 percent slopes	0.2	0.4	0.1	
Santa Rosa Creek	152	76	129	Diablo clay, 5 to 9 percent slopes	0.9	0.1	0.1	Perry Creek
Santa Rosa Creek	153	75	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	0.4	0.2	0.1	
Santa Rosa Creek	154	89	133	Diablo-Lodo complex, 15 to 50 percent slopes	0.2	0.3	0.1	
Santa Rosa Creek	155	89	195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slope	0.2	0.7	0.1	
Santa Rosa Creek	156	75	119	Cieneba-Millsap loams, 30 to 75 percent slopes	0.1	0.9	0.1	
Santa Rosa Creek	157	123	131	Diablo and Cibo clays, 15 to 30 percent slopes	0.2	0.4	0.1	
Santa Rosa Creek	158	121	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	0.1	0.8	0.1	
Santa Rosa Creek	159	75	151	Henneke-Rock outcrop complex, 15 to 75 percent slopes	0.1	0.5	0.1	North Fork Santa Rosa Creek
Green Valley Creek	160	159	129	Diablo clay, 5 to 9 percent slopes	0.8	0.1	0.1	
Santa Rosa Creek	161	122	165	McMullin-Rock outcrop complex, 50 to 75 percent slopes	0.1	0.8	0.1	North Fork Santa Rosa Creek
Santa Rosa Creek	162	123	154	Lompico-McMullin loams, 30 to 75 percent slopes	0.1	0.8	0.1	
Santa Rosa Creek	163	89	133	Diablo-Lodo complex, 15 to 50 percent slopes	0.2	0.3	0.0	
Santa Rosa Creek	164	90	197	Salinas silty clay loam, 0 to 2 percent slopes	0.2	0.2	0.0	
Santa Rosa Creek	165	91	165	Los Osos-Diablo complex, 30 to 50 percent slopes	0.3	0.2	0.0	
Santa Rosa Creek	166	93	161	Los Osos loam, 30 to 50 percent slopes	0.2	0.2	0.0	
Santa Rosa Creek	167	121	163	Los Osos-Diablo complex, 9 to 15 percent slopes	0.1	0.5	0.0	
Santa Rosa Creek	168	122	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	0.3	0.1	0.0	
Santa Rosa Creek	169	110	133	Diablo-Lodo complex, 15 to 50 percent slopes	0.3	0.1	0.0	
Santa Rosa Creek	170	111	143	Gazos-Lodo clay loams, 15 to 30 percent slopes	0.1	0.3	0.0	Fiscalini Creek
Santa Rosa Creek	171	112	165	McMullin-Rock outcrop complex, 50 to 75 percent slopes	0.1	0.4	0.0	North Fork Santa Rosa Creek
Santa Rosa Creek	172	113	132	Diablo and Cibo clays, 30 to 50 percent slopes	0.3	0.1	0.0	
Santa Rosa Creek	173	93	198	Salinas silty clay loam, 2 to 9 percent slopes	0.3	0.1	0.0	
Santa Rosa Creek	174	94	162	Lompico-McMullin complex, 50 to 75 percent slopes	0.2	0.2	0.0	North Fork Santa Rosa
Santa Rosa Creek	175	123	133	Diablo-Lodo complex, 15 to 50 percent slopes	0.1	0.2	0.0	
Santa Rosa Creek	176	121	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	0.1	0.2	0.0	
Santa Rosa Creek	177	100	197	Salinas silty clay loam, 0 to 2 percent slopes	0.7	0.0	0.0	
Green Valley Creek	178	159	132	Diablo and Cibo clays, 30 to 50 percent slopes	0.2	0.2	0.0	Perry Creek Headwaters
Santa Rosa Creek	180	123	158	Los Osos loam, 5 to 9 percent slopes	0.1	0.2	0.0	
Green Valley Creek	181	159	127	Cropley clay, 0 to 2 percent slopes	1.2	0.0	0.0	
Santa Rosa Creek	182	91	198	Salinas silty clay loam, 2 to 9 percent slopes	0.6	0.0	0.0	
Santa Rosa Creek	183	93	127	Cropley clay, 0 to 2 percent slopes	0.1	0.2	0.0	
Santa Rosa Creek	184	94	128	Cropley clay, 2 to 9 percent slopes	0.1	0.2	0.0	
Santa Rosa Creek	185	121	159	Los Osos loam, 9 to 15 percent slopes	0.2	0.1	0.0	
Santa Rosa Creek	186	100	127	Cropley clay, 0 to 2 percent slopes	0.6	0.0	0.0	
Santa Rosa Creek	187	109	127	Cropley clay, 0 to 2 percent slopes	0.3	0.1	0.0	
Santa Rosa Creek	188	96	158	Los Osos loam, 5 to 9 percent slopes	0.1	0.2	0.0	
Santa Rosa Creek	189	97	127	Cropley clay, 0 to 2 percent slopes	0.2	0.1	0.0	
Santa Rosa Creek	190	107	128	Cropley clay, 2 to 9 percent slopes	0.1	0.1	0.0	
Santa Rosa Creek	191	108	164	Los Osos-Diablo complex, 15 to 30 percent slopes	0.1	0.2	0.0	
Santa Rosa Creek	194	102	170	Marimel silty clay loam, drained	0.2	0.1	0.0	
Santa Rosa Creek	195	101	144	Gazos-Lodo clay loams, 30 to 50 percent slopes	0.2	0.0	0.0	
Santa Rosa Creek	196	105	197	Salinas silty clay loam, 0 to 2 percent slopes	0.1	0.0	0.0	
Santa Rosa Creek	197	107	162	Los Osos-Diablo complex, 5 to 9 percent slopes	0.1	0.1	0.0	

APPENDIX J

PREDICTED SOIL LOSS BY BLUE-LINE STREAM DRAINAGES AND OTHER DRAINAGES WITHIN THE UPPER SANTA ROSA CREEK WATERSHED

Results from RUSLE2 analysis

PREDICTED SOIL LOSS BY BLUE-LINE STREAM DRAINAGES AND OTHER DRAINAGES WITHIN THE UPPER SANTA ROSA CREEK WATERSHED

Drainage ID	Watershed	Comment	Drainage Acres	Predicted Soil Loss (T/Ac/Yr)
1	Santa Rosa Creek		679.40	1728.13
2	Santa Rosa Creek		530.35	699.47
3	Santa Rosa Creek		453.31	837.36
4	Santa Rosa Creek		325.10	363.17
5	Santa Rosa Creek		271.91	343.13
6	Santa Rosa Creek		102.08	195.99
7	Santa Rosa Creek	Curti Creek	1360.53	2338.04
8	Santa Rosa Creek		39.96	67.96
9	Santa Rosa Creek		26.11	43.76
10	Santa Rosa Creek		81.45	174.85
11	Santa Rosa Creek		164.26	412.38
12	Santa Rosa Creek		68.82	205.64
13	Santa Rosa Creek		17.61	28.55
14	Santa Rosa Creek		313.91	368.20
15	Santa Rosa Creek		766.66	1465.36
16	Santa Rosa Creek		494.10	1523.58
17	Santa Rosa Creek		12.42	17.79
18	Santa Rosa Creek		33.43	120.37
19	Santa Rosa Creek		164.90	760.35
20	Santa Rosa Creek		35.33	97.24
21	Santa Rosa Creek		7.90	18.80
22	Santa Rosa Creek		17.32	44.05
23	Santa Rosa Creek		143.80	688.74
24	Santa Rosa Creek		14.96	19.53
25	Santa Rosa Creek		53.82	243.05
26	Santa Rosa Creek	North Fork Santa Rosa Creek	27.05	125.65
27	Santa Rosa Creek	North Fork Santa Rosa Creek	1667.17	5161.38
28	Santa Rosa Creek	North Fork Santa Rosa Creek	1252.86	4280.50
29	Santa Rosa Creek	Headwater	1194.95	4358.87
30	Santa Rosa Creek		113.23	76.63
31	Santa Rosa Creek		29.25	33.71
32	Santa Rosa Creek		23.80	37.67
33	Santa Rosa Creek		21.16	41.83
34	Santa Rosa Creek		22.31	62.85
35	Santa Rosa Creek		23.45	51.36
36	Santa Rosa Creek		65.30	99.65
37	Santa Rosa Creek		48.12	120.95
38	Santa Rosa Creek		17.68	53.03
39	Santa Rosa Creek		26.89	95.26
40	Santa Rosa Creek		13.30	46.93
41	Santa Rosa Creek		16.99	86.26
42	Santa Rosa Creek		30.13	217.23
43	Santa Rosa Creek		26.19	97.46
44	Santa Rosa Creek		90.86	213.20
45	Santa Rosa Creek		9.20	7.08
46	Santa Rosa Creek		49.90	41.28
47	Santa Rosa Creek		18.13	11.20
48	Santa Rosa Creek		25.08	16.32
49	Santa Rosa Creek		17.44	34.88
50	Santa Rosa Creek		13.71	17.68
51	Perry Creek		122.08	207.33
52	Perry Creek		296.78	726.07

Drainage ID	Watershed	Comment	Drainage Acres	Predicted Soil Loss (T/Ac/Yr)
53	Perry Creek	Fiscalini Creek	747.65	1894.01
54	Perry Creek	Fiscalini Creek	371.93	785.50
55	Perry Creek	Fiscalini Creek	471.60	1091.72
56	Perry Creek		1082.23	1588.46
57	Perry Creek		421.34	615.71
58	Perry Creek		576.42	1120.53
59	Perry Creek		1443.32	1680.86
60	Perry Creek		387.02	388.00
61	Perry Creek		127.29	210.39
62	Perry Creek		647.73	1346.72
63	Perry Creek		370.45	436.29
64	Perry Creek		166.52	197.87
65	Perry Creek		16.34	8.28
66	Perry Creek		651.24	1456.43
67	Perry Creek		217.60	210.46
68	Perry Creek		22.73	44.42
69	Perry Creek		224.69	327.69
70	Perry Creek		107.18	194.89
71	Perry Creek		404.11	379.69
72	Perry Creek		852.72	1542.29
73	Perry Creek		346.76	410.14
74	Perry Creek		230.77	420.53
75	Santa Rosa Creek		183.20	255.30
76	Santa Rosa Creek		110.83	177.73
77	Santa Rosa Creek		199.65	93.20
78	Santa Rosa Creek		230.62	250.34
79	Santa Rosa Creek		429.27	556.78
80	Santa Rosa Creek		56.43	152.78
81	Santa Rosa Creek		50.28	75.09
82	Santa Rosa Creek		12.80	10.04
83	Santa Rosa Creek		19.35	21.38
84	Santa Rosa Creek		45.01	63.38
85	Santa Rosa Creek		1.27	0.78
86	Santa Rosa Creek		4.66	4.26
87	Santa Rosa Creek		43.53	103.30
88	Santa Rosa Creek		1.48	1.79
89	Santa Rosa Creek		91.99	164.44
90	Santa Rosa Creek		7.78	11.82
91	Santa Rosa Creek		12.76	14.27
92	Santa Rosa Creek		0.34	0.30
93	Santa Rosa Creek		13.68	36.85
94	Santa Rosa Creek		25.60	79.74
95	Santa Rosa Creek		1.20	1.32
96	Santa Rosa Creek		17.76	13.33
97	Santa Rosa Creek		13.22	17.54
98	Santa Rosa Creek		64.74	314.00
99	Santa Rosa Creek		5.68	31.92
100	Santa Rosa Creek		49.36	154.36
101	Santa Rosa Creek		31.73	31.54
102	Santa Rosa Creek		3.76	2.23
103	Santa Rosa Creek		1.03	0.58
104	Santa Rosa Creek		1.69	3.22
105	Santa Rosa Creek		12.56	35.82
106	Santa Rosa Creek		4.68	4.64

Drainage ID	Watershed	Comment	Drainage Acres	Predicted Soil Loss (T/Ac/Yr)
107	Santa Rosa Creek		23.17	50.40
108	Santa Rosa Creek		18.60	35.62
109	Santa Rosa Creek		4.30	8.49
110	Santa Rosa Creek		9.71	11.95
111	Santa Rosa Creek		7.95	25.69
112	Santa Rosa Creek		4.91	22.66
113	Santa Rosa Creek		29.55	40.57
114	Santa Rosa Creek		24.85	15.55
115	Santa Rosa Creek		12.47	8.75
116	Santa Rosa Creek		60.67	42.55
117	Santa Rosa Creek		1.99	1.04
118	Santa Rosa Creek		33.19	24.64
119	Santa Rosa Creek		95.07	136.64
120	Santa Rosa Creek		218.68	303.22
121	Santa Rosa Creek		438.47	848.23
122	Santa Rosa Creek		58.65	158.15
123	Santa Rosa Creek		106.92	144.99
124	Perry Creek		109.15	70.28
125	Perry Creek		101.52	104.13
126	Perry Creek		10.98	7.05
127	Perry Creek		226.57	442.62
128	Perry Creek		136.32	169.47
129	Perry Creek		142.32	105.15
130	Perry Creek		148.32	74.77
131	Perry Creek		45.67	7.64
132	Perry Creek		142.96	167.13
133	Perry Creek		99.95	132.78
134	Perry Creek		202.00	33.12
135	Perry Creek		41.93	78.35
136	Perry Creek		15.37	10.23
137	Perry Creek		29.12	9.25
138	Perry Creek		10.52	12.62
139	Perry Creek		104.70	162.02
140	Perry Creek		68.84	131.49
141	Perry Creek		59.55	133.89
142	Perry Creek		48.97	85.60
143	Perry Creek		118.61	146.79
144	Perry Creek		361.06	436.63
145	Perry Creek		146.90	206.87
146	Perry Creek		192.89	160.25
147	Perry Creek		184.44	233.89
148	Perry Creek		143.92	80.08
149	Perry Creek		147.37	168.56
150	Perry Creek		71.98	103.51
151	Perry Creek		66.65	52.68
152	Perry Creek		242.09	186.55
153	Perry Creek		252.79	347.86
154	Perry Creek		244.86	722.92
155	Perry Creek		172.25	718.84
156	Perry Creek		29.35	93.35
157	Perry Creek		143.06	392.24
158	Perry Creek		98.22	161.67
159	Perry Creek		36.25	77.98

APPENDIX K

PICTURES OF EROSION EXAMPLES OCCURRING THROUGHOUT THE SANTA ROSA CREEK WATERSHED

Pictures of erosion occurring in the Green Valley Creek sub-watershed
were taken from State Highway 46;
Upper Santa Rosa Creek subwatershed erosion pictures taken from Santa Rosa Creek Road.

Road erosion along State Highway 46 in Perry Creek Watershed.

Road erosion along State Highway 46 in Perry Creek Watershed.

Road erosion along State Highway 46 in Perry Creek Watershed.

Rill and sheet erosion occurring in Perry Creek Watershed.

Rill, sheet, and ephemeral gully erosion occurring in Perry Creek Watershed.

Headcutting in upper portions of Green Valley Creek along State Highway 46.

Ephemeral gullies highly impacted with cattle grazing trails in lower Perry Creek Watershed.

Gullies located near Coast Union High School in Upper Santa Rosa Creek sub-watershed.

Excavated site located in foothills of Upper Santa Rosa Creek sub-watershed.

Bianchi Quarry, located in foothills of Upper Santa Rosa Creek sub-watershed,

along Santa Rosa Creek Road.

Stream bank erosion in oxbow area of Santa Rosa Creek in the upper watershed.

Gullies forming on stream bank of Santa Rosa Creek in the upper watershed.

Ephemeral gullies on grazed site in Upper Santa Rosa Creek sub-watershed.

Stream bank erosion on Santa Rosa Creek in upper watershed.

Upslope road erosion in upper watershed along Santa Rosa Creek Road.

Upslope road erosion in upper watershed along Santa Rosa Creek Road. Site underneath tree canopy and would not have been mapped using GIS and aerial imagery.

Landslide or excavated site in headwaters of Upper Santa Rosa Creek sub-watershed.

Sheet erosion and hummocky topography typical of landslides in headwaters of

Upper Santa Rosa Creek sub-watershed.

APPENDIX L

SANTA ROSA CREEK WATERSHED FISHERIES AND HYDROLOGIC ASSESSMENT

Written by Don Alley, Fisheries Biologist

D.W. ALLEY & Associates aquatic biology

SANTA ROSA CREEK FISHERY SUMMARY, HABITAT CONDITIONS, WATERSHED MANAGEMENT GUIDELINES AND ENHANCEMENT GOALS, 2008

Upper Canyon Sampling Site in October 2006

Prepared For the

Land Conservancy of San Luis Obispo County
743 Pacific Street, San Luis Obispo, CA 93401

Prepared by

D.W. ALLEY & Associates, aquatic biology
P.O. Box 200, Brookdale, CA 95007-0200

July 2008 **Project Number 211-01**

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RECOMMENDATIONS AND ENHANCEMENT GOALS TO PROTECT AND IMPROVE HABITAT FOR STEELHEAD AND TIDEWATER GOBY

The following enhancement goals are based on experienced gained from our sampling Santa Rosa Creek and for juvenile steelhead (*Oncorhynchus mykiss*) (until fall 2006) and its lagoon for primarily tidewater goby (*Eucyclogobius newberryi*) (until June 2007) for 15 consecutive years and the sampling of three other central coast watersheds for a similar period. Habitat conditions were also monitored annually to help understand the trends in population size. We also conducted a steelhead passage study on lower Santa Rosa Creek in 1993, using the Instream Flow Incremental Methodology (IFIM) (**Alley 1993**). The degree of success for meeting enhancement goals for temperature, streamflow and oxygen are provided in Appendix A. Explanations for the enhancement goals are provided in Appendices A and B. The trend in the juvenile steelhead population is provided in Appendix A and summarized in the Current Research section of the main body of the report.

Water Temperature Enhancement Goals

1. The recommended water temperature enhancement goal during the important growth period of April and May for steelhead in stream of Santa Rosa Creek, upstream of the lagoon, is to maintain stream temperature below 20ºC (68ºF).

2. The recommended water temperature enhancement goal for lower valley reaches of Santa Rosa Creek to protect steelhead habitat should be to maintain the average daily temperature at 20ºC (68ºF) or less, with a 23ºC (73.4ºF) daily maximum from June 1 to October 15.

3. The recommended water temperature enhancement goal for lower valley reaches of Santa Rosa Creek to protect steelhead habitat should be to maintain the average daily temperature at 20ºC (68ºF) or less, with a 22ºC (71.6ºF) maximum daily temperature from June 1 to October 15.

4. Regarding Santa Rosa Lagoon for the period of sandbar closure, the water temperature enhancement goals to provide steelhead habitat are as follows:

- The 7-day rolling average water temperature within 0.25 m of the bottom should be 19°C or less.
- Maintain the daily maximum water temperature below 25ºC (77°F).
- If the maximum daily water temperature should reach 26.5ºC (79.5ºF), it may be lethal and should be considered the lethal limit.
- Water temperature at dawn near the bottom for at least one of the two monitoring stations (adjacent Moonstone parking lot or Shamel Park) should be 16.5°C (61.7°F) or less on sunny days without morning fog or overcast and 18.5°C (65.3°F) or less on days with morning fog or overcast.

5. Maintain a freshwater lagoon of maximum depth during the dry months of summer and fall.

6. Protect and enhance the health and extent of existing trees bordering the lagoon that provide shade.

7. After sandbar closure, increase the height of the berm sufficiently high to prevent tidal overwash of salt water during the summer and fall lagoon season.

8. Maximize summer baseflow through proper watershed management. Important considerations include maximization of water percolation to supply underground aquifers by minimizing impermeable surfaces. Where new housing developments occur, construct water catchment basins to encourage percolation and slow the runoff into the creek. Minimize surface water diversions and groundwater pumping when it draws from the creek underflow.

9. Increase native tree densities and stature on the south side of the riparian corridor by planting where they may offer increased stream shading. The most important areas are 1) Reach 0a along vertically eroded bank adjacent to the East-West Ranch property (now owned by the CCSD), 2) Reach 0b along vertically eroded bank across from the high school, 3) upper Reach 1 along vertically eroded bank, 4) middle Reach 2 along vertically eroded bank adjacent to agricultural field and 5) upper Reach 2 where previous instream project occurred, downstream of the Gap. Streambank stabilization work must occur in combination with tree planting. Vertical banks will likely need to be re-configured from their present state prior to tree planting. Trees must be planted in areas that are not likely to be subject to erosive flood flows that would soon wash them away. If trees must be planted a distance from the low flow channel, then they will need to reach heights that will ultimately provide shade. Sycamores offer shading benefits due to their tall stature, wide branching and overhanging qualities. Cottonwoods also offer tall stature. Cattle exclusion fencing may be necessary to allow riparian restoration.

10. In order to allow the riparian corridor to recover, construct cattle exclusion fencing and alternative watering troughs in lower valley reaches where cattle now have access to the stream channel. Reaches 1 and 2 are key areas where riparian recovery has been difficult in the past. Provide incentives to landowners to install livestock exclusion fencing along the perimeters of riparian corridors to preserve riparian vegetation and prevent livestock wastes, sediment and other pollutants from entering the stream. In the upper canyon, cattle grazing at heretofore levels of observed intensity appeared to be compatible with the steelhead fishery.

11. Through education, residents should be discouraged from cutting riparian trees.

12. Through education, residents should be discouraged from cutting downed wood in and adjacent to the stream channel. Inform them of sources of expert consultation to contact when loss of property is a concern.

13. The public agency responsible for flood control should be discouraged from cutting seedlings on gravel bars adjacent to the creek and cutting up large wood that serves to trap sediment, scour pools, provide overwintering fish shelter, provide juvenile escape cover and hastens recovery of riparian vegetation. After large floods, tree seedlings must be allowed to regenerate on exposed bars.

14. Encourage the California Department of Fish and Game to continue to protect riparian vegetation and tree canopy, to reduce stream and lagoon sedimentation and turbidities, to prevent removal of large trees within the riparian and stream protection zones that provide tree canopy and a source of large wood for the stream channel.

15. Continue to monitor water temperature on an annual basis at historical stations used our previous monitoring program in the lagoon and mainstem Santa Rosa Creek.

Sediment Recommendations and Enhancement Goals

1. Reduce embeddedness (the amount that larger particles are buried in fine sediment) of cobbles and boulders greater than 250 mm diameter in the streambed to 25% or less. This would allow for hiding places for more juvenile fish under larger rocks and would provide interstitial cracks and crevices for increased aquatic insect production.

2. Land use and road construction should be carried out with extreme caution in landslide-prone areas of the watershed, using best management practices to prevent re-activation of old slides and initiation of new ones.

3. Follow the erosion-related recommendations in the water conservation chapter regarding water conservation and Protective Water Quality Recommendations for Range and Agricultural Land Uses

4. Identify and repair manageable bank failures or landslide toes that are significant sources of chronic fine sediment loads to the Mainstem and tributaries. Repairs should be completed using bioengineering techniques and material, where appropriate. Changes in water flow patterns should be made if existing flow patterns exacerbate slope failures. Habitat enhancement should be incorporated into the engineering design, where feasible. When using riprap, rocks placed at the toe of the bank should be large enough (at least 2.5 feet diameter) to provide escape cover and scour objects. Significant locations of streambank erosion that have been identified for revegetation are 1) Reach 0a along vertically eroded bank adjacent to the East-West Ranch property (now owned by the CCSD), 2) Reach 0b along vertically eroded bank across from the high school, 3) upper Reach 1 along vertically eroded bank, 4) middle Reach 2 along vertically eroded bank adjacent to agricultural field and 5) upper Reach 2 where previous instream project occurred, downstream of the Gap.

5. Locations for sediment catchment basins should be identified and developed, where appropriate. Though a limited number of areas may be suitable for sediment catchment basins, they should be used to retain and remove chronic fine sediment loads, where feasible. To make sediment catchment basins successful, each site must have a maintenance plan along with a reliable source of funding to periodically remove the retained sediment. A likely candidate for basins is in middle Reach 2 across a pasture, south of the stream channel.

6. Retain wood clusters throughout the watershed to increase channel complexity (pool formation and increased fish cover) and create more steep, constricting riffles adjacent to the wood clusters that have caused bar formation. This will increase spawning habitat in this sediment-laden watershed.

7. Take measures to minimize the flashiness of storm runoff, which increases peak flows and encourages streambank erosion. With new developments, include open space with water catchment basins to pond runoff and increase percolation.

8. Implement a sediment reduction program for private roads.

9. Reduce erosion from unpaved rural roads.

10. Promote educational efforts regarding the watershed benefits of properly functioning riparian buffers along watercourses to control erosion and stream sedimentation, in maintaining cool water temperatures and in providing critical fish habitat through recruitment of durable, coniferous, large wood.

11. Include urban runoff infiltration basins in all new housing and other developments approved by the County.

Instream Wood Recommendations and Enhancement Goals

1. Promote education of property owners to avoid removing streamside trees, which help to stabilize banks during high flows, sieve out smaller wood further upstream than otherwise, provide shade to maintain cooler water temperatures in summer and are a source of large wood. Focus on areas where the riparian corridor fails to provide adequate stream shading.

2. Allow wood to remain in the channel after flood events when major amounts of large wood are recruited. Judiciously modify wood clusters when they pose a threat to property, leaving as much in place as possible without cutting it into shorter pieces. It is crucial that crews working with in-channel wood deposits be supervised by personnel knowledgeable in the fishery benefits and risks of large, in-channel wood.

3. Have a fishery biologist survey the mainstem of Santa Rosa Creek each spring to map locations of wood clusters that have formed in the channel over the winter.

Contact adjacent landowners, assess the erosion potential of the wood clusters and inform landowners on the value of leaving uncut, large wood in the channel.

4. Replace culverts with free-span bridges on tributaries and on the mainstem at Ferrasci Road to allow the free passage of large wood into the mainstem from tributaries during flood events and downstream toward the lagoon.

5. Until existing culverts can be replaced, when crews clear jams on the upstream sides, have them move wood through the culverts into the larger downstream channel.

Streamflow Recommendations and Enhancement Goals

1. Continue to monitor the juvenile steelhead population to better understand how the juvenile population size is influenced by winter stormflow patterns, baseflow (spring through fall), and rearing habitat quality (water temperature, habitat depth and escape cover from overhanging vegetation, instream wood and unembedded boulders). Population trends should be followed during drought and afterwards. The previous 15 years of monitoring did not include a drought period because it was discontinued before the dry years of 2007 and 2008.

2. Re-establish the streamflow gages above the Main Street Bridge and below the Highway 1 Bridge.

3. Until the 1993 steelhead passage study is updated, in order to promote upstream adult steelhead spawning migration during the primary spawning season of January 1 – April 15, any water diversion or well extraction capable of reducing surface flow should be interrupted during stormflow episodes when streamflow between Perry Creek and Main Street Bridge is less than 60 cfs and streamflow between Main Street Bridge and the bay is less than 35 cfs.

4. In dry fall/ winters in which no storms have occurred by January 1, any water diversion or well extraction capable of reducing surface flow should be interrupted from January 1 until the first stormflow. After that, follow the guideline listed above.

5. Until the 1993 steelhead passage study is updated, in order to promote out-migration of post-spawning steelhead kelts, water diversion or well extraction capable of reducing surface flow should not resume after a stormflow until the baseflow between storm events is shown to be greater than 15 cfs at the Highway 1 Bridge until May 1, and water extraction should be discontinued if streamflow declines below 15 cfs between the first storm event and May 1.

6. Critical instream flow requirements for steelhead passage should be re-calibrated every few years because of the dynamic nature of streambed morphology, particularly in the lower valley. These flow requirements may vary before and

after large flood flows that widen the channel and flatten its cross-sectional profile with sediment, necessitating periodic re-evaluation of fishery needs.

7. In order to insure adequate steelhead smolt passage to the Monterey Bay, reduce well pumping along Santa Rosa Creek in order to maximize inflow to the Santa Rosa Creek estuary up to at least 7 cfs with an open sandbar in spring until at least 15 May.

8. Maintain stream inflow to Santa Rosa Lagoon at 0.9 cfs or greater through the period of sandbar closure in summer and fall in order to provide tidewater goby habitat in the lower lagoon, to protect the tidewater goby population from extirpation and to maintain steelhead habitat between Shamel Park and Windsor Bridge. Reduce well pumping along Santa Rosa Creek to maximize lagoon inflow up to at least 0.9 cfs during the period of sandbar closure.

9. Protect hydraulic continuity (continuous surface flow) throughout the watershed. Prevent the loss of hydraulic continuity in Reaches 0a and 0b through Cambria by reducing groundwater pumping, if necessary.

10. Protect and enhance streamflow in spring. The purpose of this recommendation is to encourage water conservation and alternatives to well pumping during salmonid out-migration and during the critical juvenile spring growth period.

11. Maximize summer baseflow through water conservation on agricultural and non-agricultural lands. Maximize streamflow into the summer lagoon. Important considerations include maximization of water percolation to supply underground aquifers by minimizing impermeable surfaces. Where new housing and commercial developments are planned, construct water catchment basins to encourage percolation and to slow runoff into the creek. Minimize surface water diversions and groundwater pumping when it draws from the creek underflow. Use drip irrigation when possible. Protect ground cover on grazing lands to slow winter runoff. Install grade controls and sediment catchment basins to stop gullying on agricultural lands. This will slow runoff and maximize percolation into the aquifer.

12. Follow the water conservation recommendations in the water conservation chapter regarding water conservation and protective water quality guidelines for range and agricultural land uses.

13. Follow the water conservation recommendations in the water conservation chapter regarding water conservation for non-agricultural land uses

14. Perennial flow should be maintained down through Reaches 0a and 0b to the lagoon.

15. For instream flow concerns with salmonid rearing, install continuous streamflow monitoring stations for the months of May through October to better understand

the gaining and losing of streamflow. These low-flow gages will be less expensive than a year round continuous stream gage. Specific locations may be worked out during the implementation phase.

16. In order to maximize the instream flow benefits to fish, water extraction from the stream channel or its underflow for domestic and commercial uses should occur as low in the watershed as possible, where this action is feasible. Water diversions and well pumping should be consolidated where feasible. By removing the water at the lowest point in the system, the maximum length of stream has the maximum streamflow becomes available to aquatic resources for important rearing and growth. The Cambria CSD should be encouraged to assess their operations and to develop a means of municipal water supply that sustains the aquatic and riparian ecosystem within the influence of their wells and preserves perennial streamflow to the lagoon, even during drought.

17. Conduct water supply pumping overnight. Streamflow is often the highest during the nighttime hours as evaporation and vegetative transpiration are reduced. This is also the period when fish are relatively inactive and not feeding. During the low-flow summer months, water that is being stored off-channel for use during peak demand periods should be diverted during the hours of 9 p.m. and 5 a.m. The Cambria CSD should assess their operations during low-flow summer months based on this recommendation.

18. A streamflow monitoring system should be established with real-time streamflow measurements available at the Cambria CSD website to inform water diverters and the community when water conservation is of greatest importance. Critical seasonal flow values necessary for steelhead migration and rearing habitat should be included with the real-time measurement to inform people when streamflow is inadequate.

19. For educational purposes, perform an instream flow analysis on the mainstem of Santa Rosa Creek. The instream flow incremental methodology (IFIM) is used to model fish habitat as a function of streamflow. As a context for this modeling, install 3 continuous streamflow gages in the vicinity of IFIM transects for at least the months of April through October.

20. Protect existing and potential refugia in Reaches 1, 2 and 3b–7 from catastrophic events. Purchase fee titles or conservation easements in these reaches to protect instream flow and the riparian corridor.

21. Use appropriate methods, such as the development of exceedence probability curves or a rainfall-runoff curve, to predict late summer flow conditions based on winter and spring rainfall amounts and flow conditions. Exceedence probability curves would be based on historic flow data for wet, average, dry, and drought conditions. This information, specifically the data developed for the former County gages at Main Street and Highway 1, can be used to determine the range of flows that could be expected in the low-flow summer and fall months. If

predicted flows are below the critical level to maintain viable rearing habitat for salmonids, measures to reduce water consumption can be initiated by the Cambria CSD and other primary diverters through conservation programs.

Dissolved Oxygen Recommendations and Enhancement Goals for Steelhead in the Stream and Lagoon

1. Maintain the daily dissolved oxygen concentration near the bottom at 5 milligrams/liter or greater, though it does not become critically low and potentially lethal until it is less than 2 mg/l, with the daily minimum occurring near dawn or soon after.

STEELHEAD ECOLOGY

General Life History

In order to understand the factors that limit steelhead salmon, the life history requirements of the species must be described. Steelhead (*Oncorhynchus mykiss*) are genetically indistinct from rainbow trout and differ only in their behavior. Steelhead exhibit a life cycle similar to other members of the salmon family known as anadromy, in which they develop into adulthood in the ocean and swim to their natal stream to reproduce. Most adults migrate to their home stream in January through early May after 2 years (range of 1-3 years) of feeding and growth over the continental shelf. However, adult steelhead differ from all other salmon species in that some survive the spawning process, return to the ocean and may spawn again the next spawning season. Adult salmon of other species die after they spawn. The hatched young that emerge from the spawning gravel are known as fry and spend 1-2 years as juveniles in their natal, freshwater streams. Once large enough to survive ocean conditions, most make their way to the ocean in late winter and spring, undergoing physiological and coloration changes, a process known as smolting, which allows them to osmoregulate in the saline ocean environment. The more variable life cycle of steelhead has made them more adaptable to habitat changes and more resilient to increased acuteness of natural events (flood and drought) caused by human development and water usage than the simpler life cycle of coho salmon. In addition, steelhead are the only salmon species that can survive their first spawning to spawn in later years.

Migration

Adult steelhead in small coastal streams tend to migrate upstream from the ocean through an open sandbar after several prolonged storms; the migration seldom begins earlier than December and may extend into May if late spring storms develop. Many of the earliest migrants tend to be smaller than those entering the stream later in the season. Adult fish may be blocked in their upstream migration by barriers such as bedrock falls, wide and shallow riffles and occasionally log-jams. Man-made objects, such as culverts, bridge abutments and dams are often significant barriers. The concrete ford at Ferrasci Road between Reaches 0b and 1 had a denil fish ladder through the drainage culvert but may become a passage barrier when logs jam at the upstream entrance to this drainage culvert. Some barriers may completely block upstream migration, but many barriers in coastal streams are passable at higher streamflows. If the barrier is not absolute, some adult steelhead are usually able to pass in most years, since they can time their upstream movements to match peak flow conditions. However, in drought years and years when storms are delayed, natural and man-made barriers can be serious barriers to steelhead spawning migration. Data indicated that in drier years, juvenile steelhead densities tended to increase in the lower valley reaches of Santa Rosa Creek and decrease in the upper canyon (and vice-versa in wetter years), indicating impeded adult passage through shallow riffles in drier years.

Smolts (young steelhead which have physiologically transformed in preparation for ocean life and initiate their migration to the ocean) in local coastal streams tend to migrate downstream to the lagoon and ocean in March through early June. In streams with lagoons having adequate water quality, young-of-the-year (first year) and yearling (second year) fish may spend several months in this highly productive lagoon habitat and grow rapidly. Santa Rosa Lagoon provided summer steelhead habitat after the wettest winters but was considerably reduced in size in drier years and/or experienced lethally high water temperatures due to tidal overwash, providing steelhead habitat only in the upper portion between Windsor Bridge and Shamel Park. In some small coastal streams, downstream migration can occasionally be blocked or restricted by low flows due primarily to heavy streambed percolation or early season stream diversions. Flashboard dams or early closure of the stream mouth or lagoon by sandbars after milder winters are additional factors, which adversely affect downstream migration to the Monterey Bay. For example, the Santa Rosa Creek sandbar closed for the summer season on 28 March in 1994 after a mild winter, and numerous juvenile smolts that had been trapped in the lagoon after the sandbar closed were observed and some captured (50+) in early June in the lagoon and immediately upstream. In 2008 with the shortage of March and April stormflows and early sandbar closure, numerous smolts and adult steelhead were trapped in the lagoon behind the closed sandbar in mid-April, unable to reach the Bay.

Spawning

Steelhead require spawning sites with gravels (from 1/4" to 3 1/2" diameter) having a minimum of fine material (sand and silt) and with good flows of clean water moving over and through them. Flow of oxygenated water through the redd (nest) to the fertilized eggs is restricted by increased fine materials from sedimentation and cementing of the gravels with fine materials. These restrictions reduce hatching success. In many Central Coast streams, steelhead appear to successfully utilize spawning substrates with high percentages of coarse sand, which probably reduces hatching success. Steelhead that spawn earlier in the winter are more likely to have their redds washed out or buried by winter storms. Steelhead spawning success may be limited by scour from winter storms in some streams. Unless hatching success has been severely reduced, however, survival of eggs and alevins is usually sufficient to saturate the limited available rearing habitat in most reaches of small coastal streams, such as Santa Rosa Creek. The production of young-of-the-year (YOY) fish is related to spawning success, which is a function of the quality of spawning conditions, the pattern of storm events and ease of spawning access to upper reaches of tributaries, where spawning conditions are generally better.

Rearing Habitat

In the lower valley reaches of lower Santa Rosa Creek, downstream of the Gap, and in the sunny portion of lower Reach 3a (**Figure 1b** below), many steelhead require only one summer of residence before reaching smolt size. Except in streams with high summer flow volumes (generally greater than about 0.2 to 0.4 cubic feet per second (cfs) per foot of stream width), steelhead require two summers of residence before reaching smolt size (**Smith 1984**). Our data indicated that this was likely the case for most juveniles inhabiting the upper canyon of Santa Rosa Creek except in years with high spring flows, such as 1998. Smith (**1982a**) found that juvenile steelhead in small central coast tributaries required 2 years to reach smolt size except in flow augmented streams below reservoirs (Uvas, Llagas and Pacheco creeks in the Pajaro River system). Juvenile steelhead are generally identified as YOY and yearlings. The slow growth and often two-year residence time of most Central

Coast juvenile steelhead indicate that any year class of steelhead can be adversely affected by low streamflows or other problems during either of the two years of freshwater residence. A small percent of yearlings may stay a third growing season to become 2+ year-olds before smolting if they spend much of their residence time in poor habitat that slows growth (usually in cooler headwater reaches) or if they have the genetically determined behavior to grow especially large before smolting. Steelhead are considered juveniles unless they have entered the ocean.

Growth of YOY steelhead appears to be regulated by available insect food, although cover (hiding areas, provided by undercut banks, large rocks which are not buried or "embedded" in finer substrate, surface turbulence, etc.) and pool, run and riffle depth are also important in regulating juvenile numbers, especially for larger fish. Densities of yearling and smolt-sized steelhead in small streams, such as Santa Rosa Creek, are usually regulated by water depth and the amount of escape cover during low-flow periods of the year (July-October). In most small coastal streams, availability of this "maintenance habitat" provided by depth and cover appears to determine the number of smolts produced (**Alley 2006a; 2006b**). Abundance of food (aquatic insects and terrestrial insects that fall into the stream) and fast-water feeding positions for capture of drifting insects in "growth habitat" (provided mostly in spring and early summer) determine the size of these smolts. Aquatic insect production is maximized in unshaded, high gradient riffles dominated by relatively unembedded substrate larger than about 4 inches in diameter.

It was determined from scale analysis of captured steelhead that in warm mainstem portions of the San Luis Obispo and Santa Rosa creeks) (San Luis Obispo County), San Lorenzo River and Soquel Creek watersheds (Santa Cruz County), YOY juvenile steelhead are capable of growing to smolt size their first growing season (Size Class II =>75 mm Standard Length in fall) (**Alley 2008a; 2008b**). In the San Lorenzo River mainstem, the density of YOY that obtain this size was positively correlated with the mean monthly streamflow for May–September (**Alley et al. 2004**). Furthermore, it has been shown that the density of slower growing YOY in tributaries of the San Lorenzo River watershed was positively correlated with the minimum annual streamflow (**Alley et al. 2004**). In Santa Rosa Creek, as in other central Coast streams, water temperature is primarily a food issue. In the lower valley, water temperature is probably not directly lethal except in the lagoon. But higher temperatures increase food demands and restrict steelhead to faster habitats for feeding, especially above 21ºC (70ºC) (**Smith and Li 1983**). The lethal level for steelhead would probably be at temperatures above 24–28ºC (75-82ºF) for several hours during the day, depending on their acclimation temperature (**Charlon** (**1970**); **Alabaster** (**1962**); **MacAfee** (**1966**)).

Kubicek and Price (**1976**) concluded that although temperatures less than 26.5ºC (79.7ºF) were not assumed to directly cause steelhead mortality in the Big Sulphur Creek drainage (tributary to the Russian River, Mendocino County), temperatures consistently above 20ºC (68ºF) were assumed to cause sub-lethal stress that could result in decreased fish production and indirect mortality. They noted that juvenile steelhead disappeared from a section of Big Sulphur Creek when hot springs caused summer temperatures to rise above 26ºC. *They assumed their monitoring that stations that had temperatures greater than 20ºC (68ºF) for less than 50% of the time in any one month were not expected to cause* *significant sub-lethal effects in that month, unless that station reached a marginal or lethal maximum temperature.*

Charlon (**1970**) found that steelhead acclimated at 24ºC (75.2ºF) experienced a lethal temperature of 26.35ºC (79.4ºF). Alabaster (**1962**) found steelhead acclimated to 20ºC (68ºF) to experience a lethal temperature of 26.6ºC (79.9°F). McAfee (**1966**) found steelhead lethal temperatures in the range of 24-29ºC (75.2º- 84.2ºF) with unspecified acclimation temperatures.

There are many central coast examples of steelhead surviving and growing well at water temperatures above 21ºC. Smith and Li (**1983**) found juvenile steelhead selecting fastwater habitat at temperatures of 16–21ºC in Uvas Creek, tributary to the Pajaro River. Many examples of steelhead using warm water habitat above 21ºC come from coastal lagoons such as Soquel Lagoon (**Alley 2008c**) and Pescadero Lagoon (as high as 26ºC and 24ºC on a regular basis) (**Smith 1990**) and lower reaches of less shaded drainages, such as the lower valley of Santa Rosa Creek (**Alley 2007**), lower San Luis Obispo Creek (**Alley 2008a**), lower Soquel Creek (**Alley 2008b**) the lower San Lorenzo River (**Alley 2008c**), but only where food is abundant. When food is abundant, growth is actually better at warmer water temperatures because digestive rate is increased, allowing fish to consume and process more food and grow more quickly.

It has been reported that rainbow trout (same species as steelhead but with a freshwater life history pattern) survive temperatures from 0 to 28ºC, provided that they are gradually acclimated to higher temperatures and that saturated oxygen conditions exist (**Moyle 1976**). Rainbow trout in Big Sulphur Creek, tributary to the Russian River, are often exposed to stream temperatures in excess of 20ºC (**Price et al. 1978**). This is particularly the case in Big Sulphur Creek below Little Geysers Creek where daily minimum temperatures sometimes exceed 20ºC. Daily stream temperatures fluctuate up to, and perhaps greater than 28ºC in Big Sulphur Creek in summer rainbow trout habitat (**Price et al. 1978**). Steelhead inhabited the Creek, downstream of where these data were collected. More than 100 rainbow trout/ steelhead were observed during snorkeling in pools, runs and riffles on 24 July 1976 in Deer Creek, Tehama County, where water temperature fluctuated daily between 19 and 24º C (**Alley 1977**).

Yearling steelhead usually show a large growth increment in spring with little growth in late summer (**Smith 1982a; Smith 1993, AFS presentation**). Larger steelhead then may smolt as young yearlings in spring after only one previous summer in freshwater. For reaches where yearling steelhead stay a second summer, growth in summer and fall is slight before leaf drop and fall storms (or even negative in terms of weight) as summer flow reductions eliminate fast-water feeding areas and reduce insect production (**Smith 1982a; Hayes et al. 2008**). Our data indicated that in Santa Rosa Creek, relatively few YOY reached a size enabling them to smolt the following spring except primarily in lower valley reaches. A short growth period may occur in late fall and early winter after leaf-drop from riparian trees, after increased streamflow from early storms, and before water temperatures decline below about 48ºF or water clarity becomes too turbid for feeding. This growth spurt occurs after typical late summer and early fall sampling of fish, which is intended to occur before fall stormflows. "Growth habitat" provided by higher flows in spring and late fall (and in summer of higher baseflow years in lower valley reaches) is very important, since ocean survival to adulthood increases exponentially with smolt size (**Shapovalov and Taft 1954; Bond 2006**).

During summer in Santa Rosa Creek, steelhead use primarily pool habitat. Shallower fastwater riffles, runs and step-runs (step-runs present only in the upper canyon) are also used by mostly small YOY and the occasional yearling in deep pockets of step-runs. The shallow (typically 0.2 ft or less average depth and typically 0.4 ft or less maximum depth) fastwater habitat is used almost exclusively by small YOY, although most YOY are in pools. YOY and small yearling steelhead that have moved down into the lower valley from the upper canyon in spring can grow faster, especially if streamflows are high and sustained throughout the summer. Primary feeding habitat is at the heads of pools and in the lower valley where step-runs are absent. The deeper the pools, the more value they have. Higher streamflow enhances food availability, surface turbulence and habitat depth, all factors in increasing steelhead densities and growth rates.

Juvenile steelhead captured during fall sampling were divided into two size classes. The smaller one was Size Class I of juveniles less than (<) 75 mm (3 inches) Standard Length (SL); these fish would almost always require another growing season before smolting. The larger Size Class II included juveniles 75 mm SL or greater (=>) and constituted fish that are called "smolt size" because a majority will likely out-migrate the following spring. Smolt size was based on scale analysis of out-migrant smolts captured in 1987-89 in the lower San Lorenzo River (**Smith 1993** (AFS presentation). The smolt size class may include fast growing YOY steelhead inhabiting primarily the lower valley reaches of Santa Rosa Creek and slower growing yearlings and older fish from the entire mainstem.

A basic assumption in relating juvenile densities to habitat conditions where they are captured is that juveniles do not move substantially from the vicinity where they are captured during the growing season. This assumption is supported by observation of sites in close proximity yet with widely different food availability (**Don Alley personal observation**) (e.g. larger mainstem San Lorenzo River sites with nearby smaller tributary sites), where juveniles are consistently larger at the mainstem sites where streamflow is greater and there is more food. This indicates a lack of movement between sites. Otherwise, juvenile steelhead size would standardize as fish moved between feeding areas. In addition, Davis (**1995**) marked juvenile steelhead in June in Waddell Creek and recaptured the same fish in September in the same (or immediately adjacent) habitats where they were marked during a study of growth rates in various habitat types. Shapovalov and Taft (**1954**) after 9 consecutive years of fish trapping on Waddell Creek detected very limited upstream juvenile steelhead movements; the relatively limited movement was mostly in the winter, perhaps after the lagoon sandbar opened and lagoon habitat was lost. Recent preliminary data from PIT-tag detectors installed by NOAA Fisheries researchers in upper Scott Creek and its tributary, Big Creek (Santa Cruz County) after PIT-tagging of estuary/lagoon-inhabiting and stream-inhabiting juveniles over a two-year period indicated very little movement of juvenile steelhead during the months of May–November, it being insignificant at the population level (**Sean Hayes 2008, personal communication**). They found that some estuary/lagoon juveniles moved upstream from the lagoon in fall prior to sandbar opening, perhaps due to deteriorating water quality, and after sandbar opening with the loss of lagoon habitat.

Overwintering Habitat

Deeper pools, undercut banks, side channels, large unembedded rocks and large wood clusters provide shelter for fish against the high winter flows. In some years, extreme floods may make overwintering habitat the critical factor in steelhead production, especially for Size Class I YOY that must over-winter twice. In years when bankfull or greater stormflows occur, these refuges are critical, and it is unknown how much refuge is actually needed. Cutting of instream wood should be discouraged.

TIDEWATER GOBY ECOLOGY

Tidewater goby populations are restricted to coastal, brackish-water habitats in California (**Swift et. al 1989**). There is no marine phase, although tidewater gobies are periodically flushed out of lagoons during winter stormflows and must find their way back to estuaries. There is evidence that tidewater goby is capable of repopulating adjacent lagoons after being extirpated because they were apparently lost from Santa Rosa Lagoon in 2004 and were again detected in 2006. Although they tolerate widely varying salinities and oxygen concentration, tidewater goby spawning must occur in freshwater resulting from stream inflow to lagoons, upstream of major tidal fluctuations. Spawning begins mainly in spring (April and May) but continues to a lesser degree into summer and fall. Lagoons should be allowed to seasonally close off from the ocean during the dry season so that tidal fluctuation is absent or minimal. Males excavate a nest burrow 8–12 inches deep into sandy substrate. Fresh, unconsolidated sand is optimal for burrowing. Females court males and aggressively compete to enter the burrow to mate. Males occupy enlarged areas in the burrow where the eggs hang from the ceiling and walls. Males do not feed during the 9–10 day egg incubation period, and mortality is high for these males after hatching due to starvation, especially with multiple clutches that extend the period with minimal feeding. Older female mortality is high over the winter. Tidewater gobies are bottom dwelling, and they escape predators by fleeing in long dashes (1–2 m) into deeper water or aquatic vegetation. They are typically abundant in shallow water (<=1 m deep). They feed commonly on bottom invertebrates, such as ostracods, snails, dipteran fly larvae, amphipods and mayfly larvae. When lagoons are especially saline, tidewater gobies are more abundant at the upper ends where salinity is reduced. During summer, they avoid areas where algal blooms are thick and hydrogen sulfide builds up in the substrate due to decomposition. Major threats to tidewater goby include 1) groundwater pumping and water diversion that drastically reduce freshwater inflow to lagoons, 2) sandbar breaching in summer after streamflow has declined, 3) dredging to maintain a constant estuary opening, and 4) introduction of non-native predators, such as centrarchids (bass family of fishes), bullfrog and possibly crayfish.

CURRENT RESEARCH ON SALMONID HABITAT AND TRENDS IN JUVENILE POPULATION SIZE

Data Collection Program

Juvenile steelhead were sampled annually by D.W. ALLEY & Associates (with funding from the Cambria Community Services District (CCSD)) using electrofishing throughout the mainstem Santa Rosa Creek by electrofishing in 1994–2006, and steelhead habitat was evaluated initially in 1994 (a very low-flow year) in 7 reaches (from the fish ladder at the beginning of Reach 1) and in 1998 (a very high-flow year) onward in 10 reaches (from Windsor Boulevard Bridge upstream) (**Figure 1**). Electrofishing and habitat data for steelhead were analyzed in annual reports to the Cambria Community Services District (CCSD) (**Alley 1995a-2007a**). Choice of sampling sites was based on their average habitat quality for each reach in terms of the escape cover and water depth in pool habitat. Juvenile steelhead densities from each site were extrapolated to reach densities, with habitat proportioning from habitat-typing during survey work. Santa Rosa Lagoon was sampled by D.W. ALLEY & Associates in early summer and late fall in 1993–2005, using a fine-meshed beach seine to capture tidewater gobies and occasional steelhead (incidentally). Lagoon monitoring reports were completed every other year for monitored years 1993–2005 (**Alley 1995b–2006b**). In most years, one electrofishing site was sampled immediately upstream of the lagoon in early summer at the time of lagoon sampling. Refer to **Appendix A** for a more complete description of sampling methods. CCSD staff assisted in lagoon sampling and also collected lagoon water quality and stream inflow data through this period (Sean Grauel). They also collected data in 2006, but it was not reported on. Bailey (**1973**) and Nelson (**1994**) previously sampled Santa Rosa Creek. However, their methods and timing of sampling differed significantly from ours, making their data unusable for trend analysis on a size class, age class or reach basis. Refer to the Literature Review section for a summary of their findings.

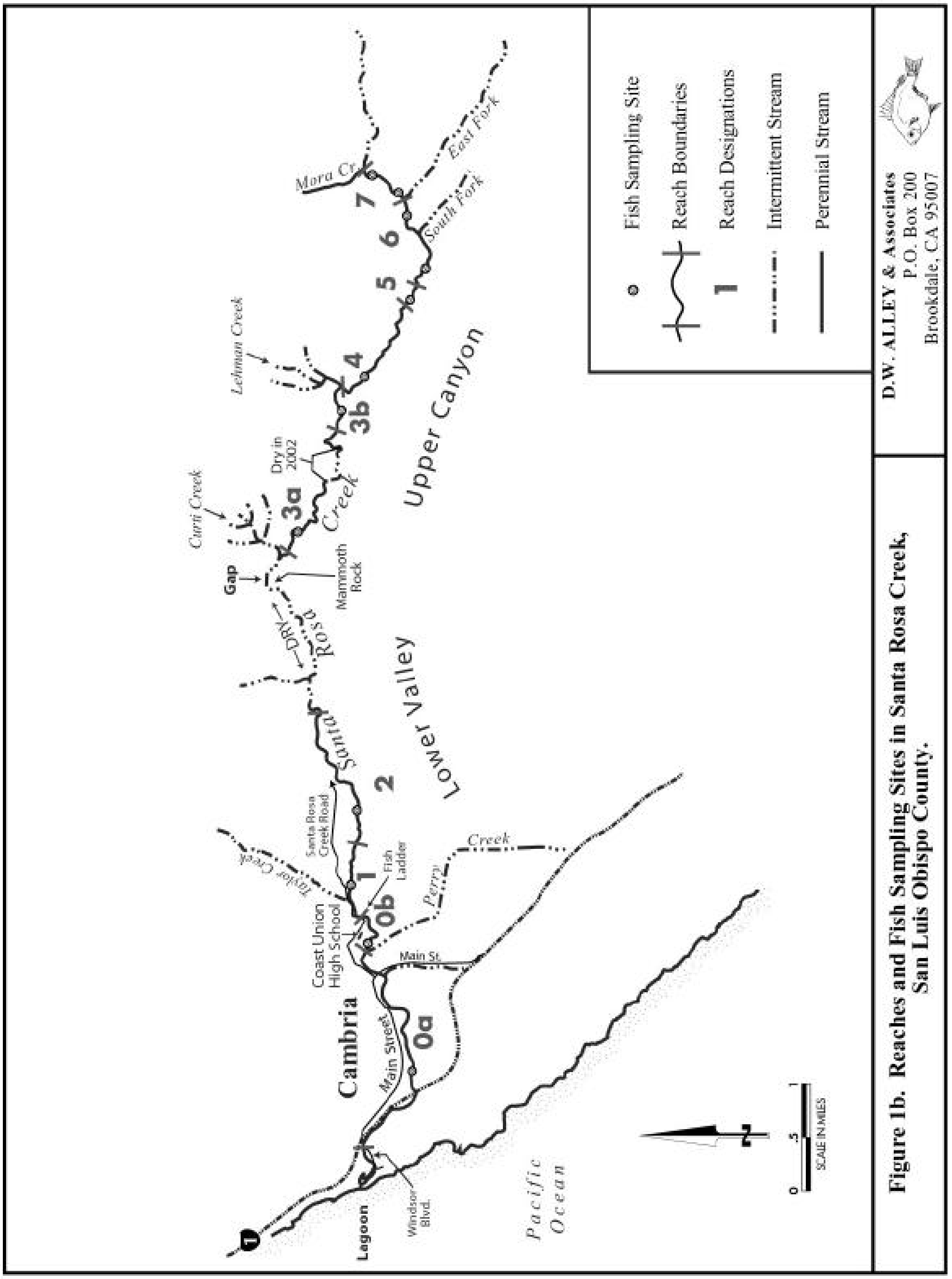


Figure 1. Reaches and Sampling Sites in Santa Rosa Creek.

Key Steelhead Density and Population Trends in Santa Rosa Creek

YOY densities at sampling sites were generally higher in the upper canyon than the lower valley (individually and on average) except in 2002 (**Figures 2, 3 and 4**). Two wet years, 1998 and 2005, had the lowest YOY densities in the lower valley. In another wet year, 1995, although YOY densities were not determined, total juvenile densities were low in the lower valley, indicating that YOY densities were also low that year (**Figure 5**). In some drier years (1994, 1997 and 2002–2004), YOY densities were relatively higher in the lower valley than other years, and relatively lower in the upper canyon. These patterns indicated that in wetter years, adults had better passage opportunities through the estuary and lower valley to access the upper canyon to spawn more YOY. It also indicated that more habitat was available in the upper canyon in wetter years due to higher streamflow (especially in spring) and presumed greater insect drift and food supply. Whereas in drier years, spawners likely had a narrower window of spawning opportunity due to earlier sandbar closure (**Table A13**) and shallower passage conditions related to smaller stormflows. This likely caused more spawning effort in the lower valley with less spawning and YOY production in the upper canyon. In drier years, habitat in the upper canyon likely supported fewer fish, with reduced streamflow and reduced insect drift. In 2002, when YOY densities in the upper canyon were very low, it rained very little in January–May the previous winter/spring in a very mild winter (**Figure 6**), with only one storm event in January totaling more than one inch in precipitation. The sandbar closed in mid-April with lagoon inflow likely less than 2.5 cubic feet per second (cfs) most of the time from January until then (**Table A13**).

The earthquake of December 2003 brought cementing of the streambed and likely poor water quality with heavy seepage of hydrogen sulfide into the stream at Sites 7a and 7b in 2004–2005 (**Alley 2005a; 2006a**). This likely contributed to lower YOY and yearling densities than normal there.

Figure 2. Annual Young-of-the-Year Steelhead Densities at Lower Valley Santa Rosa Creek Sites, 1997-2006.

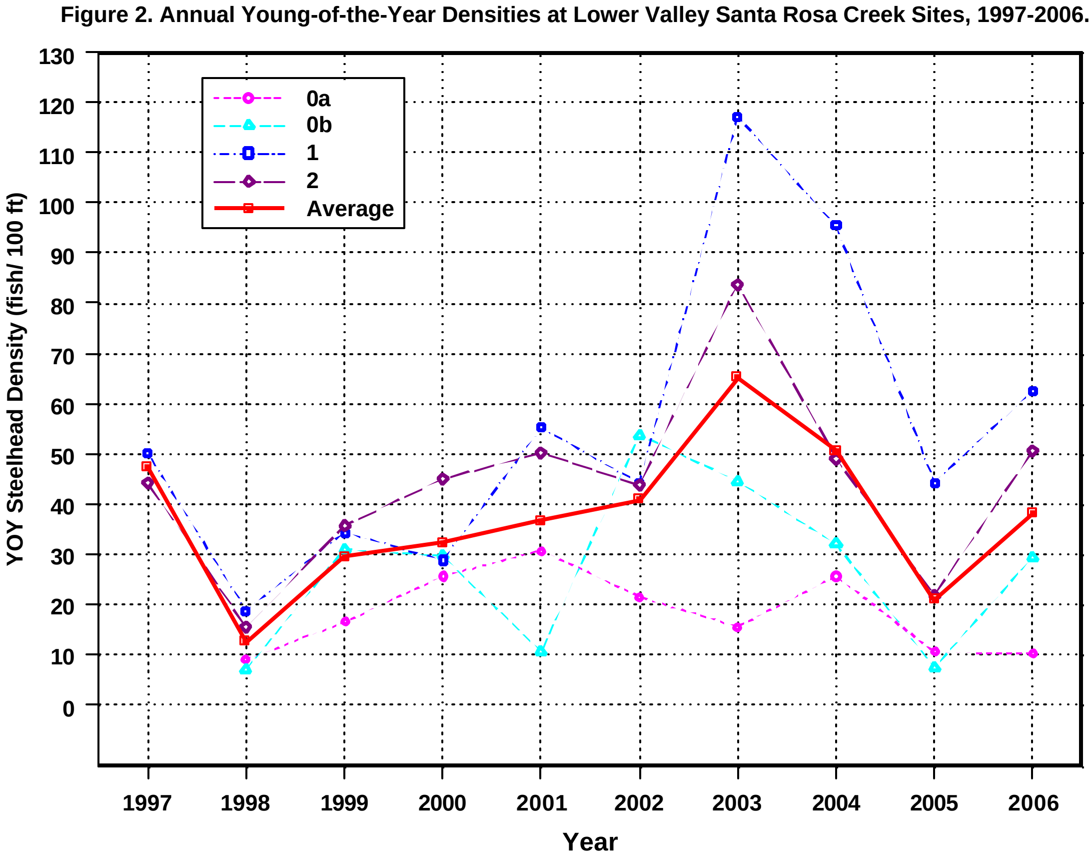


Figure 3. Annual Young-of-the-Year Steelhead Densities at Upper Canyon Santa Rosa Creek Sites, 1997-2006.

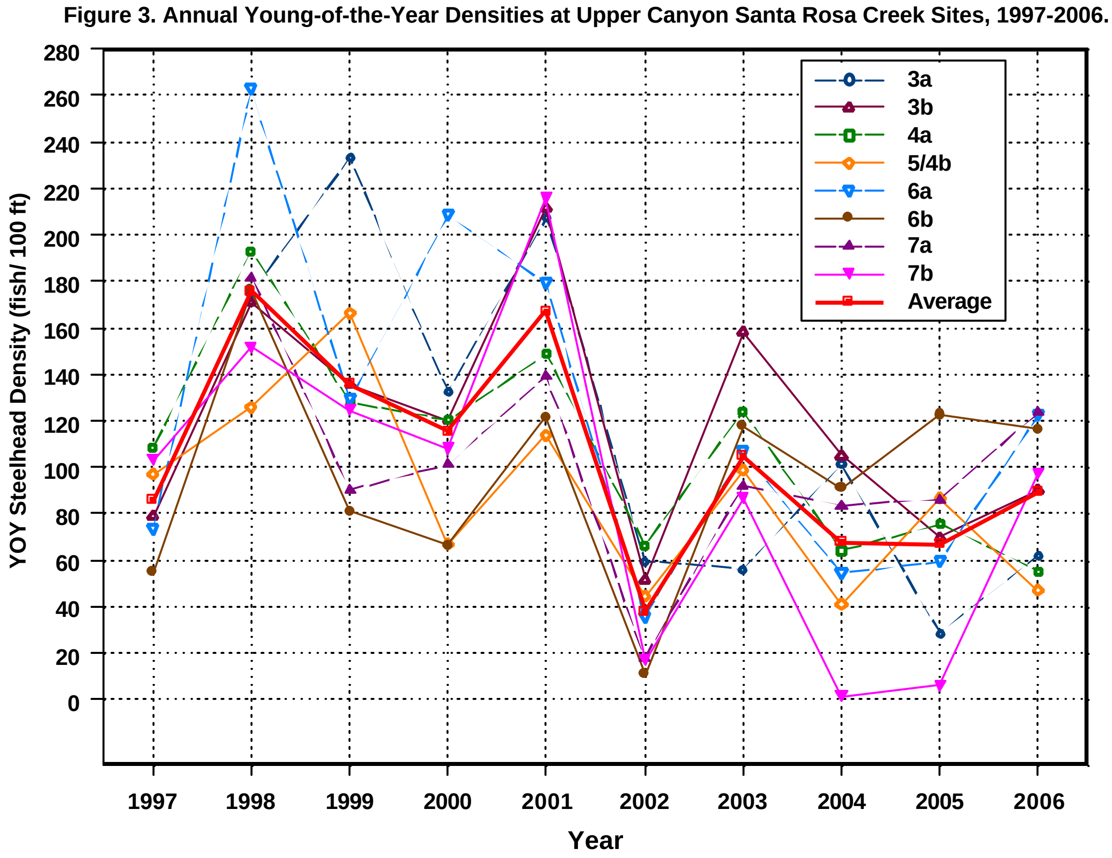


Figure 4. Average Site Density of Young-of-the-Year Steelhead in the Lower Valley and Upper Canyon of Santa Rosa Creek, 1997-2006.

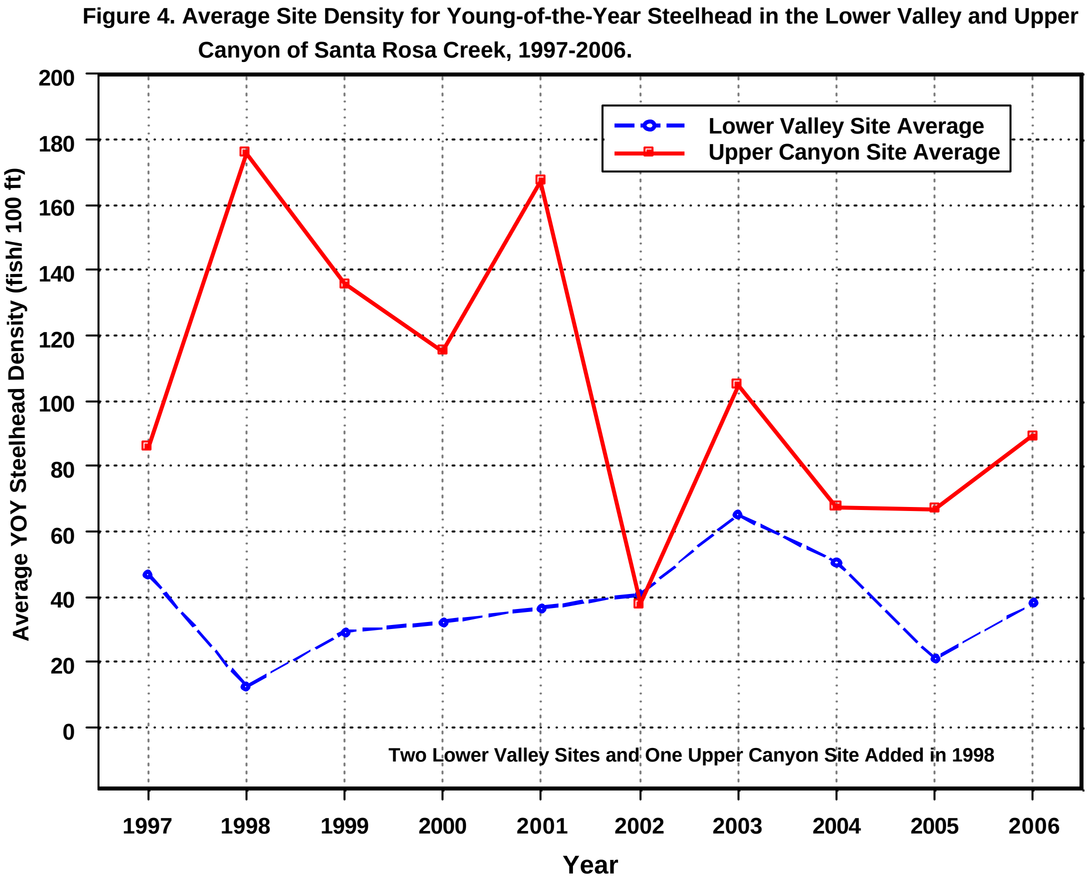


Figure 5. Annual Total Juvenile Steelhead Densities at Lower Valley Santa Rosa Creek Sites, 1994-2006.

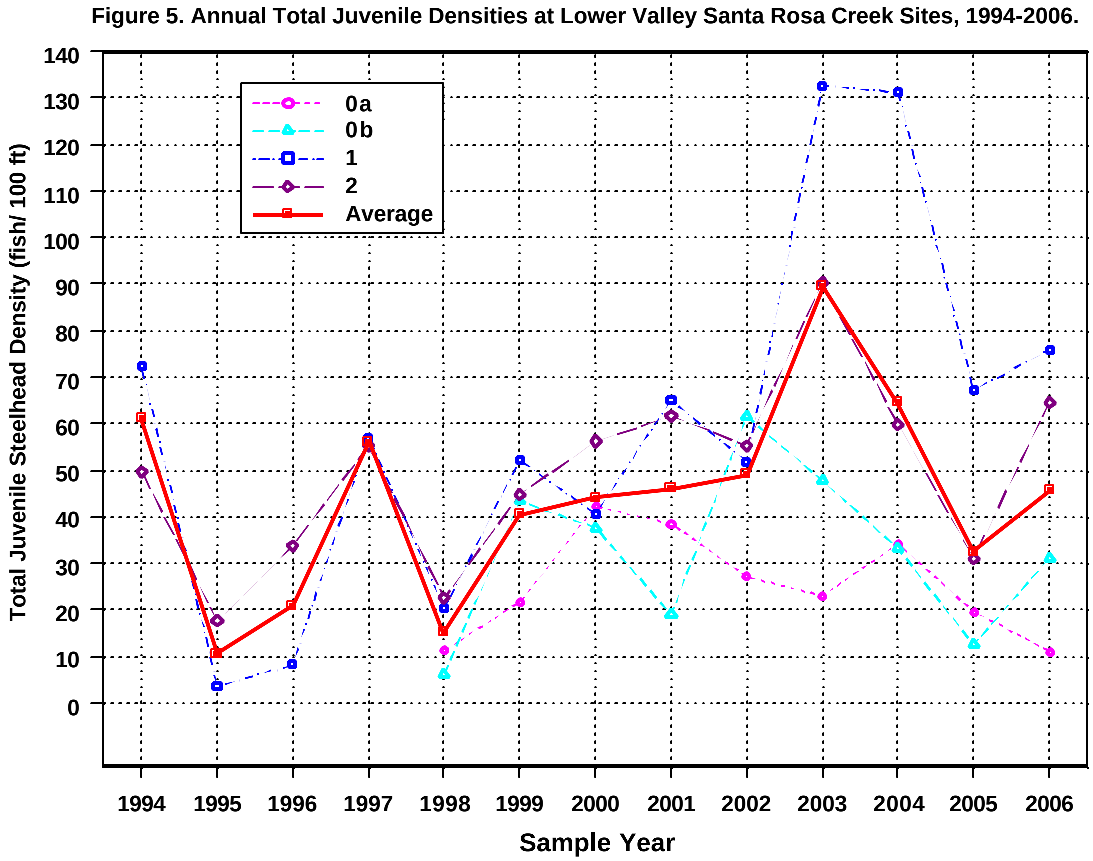
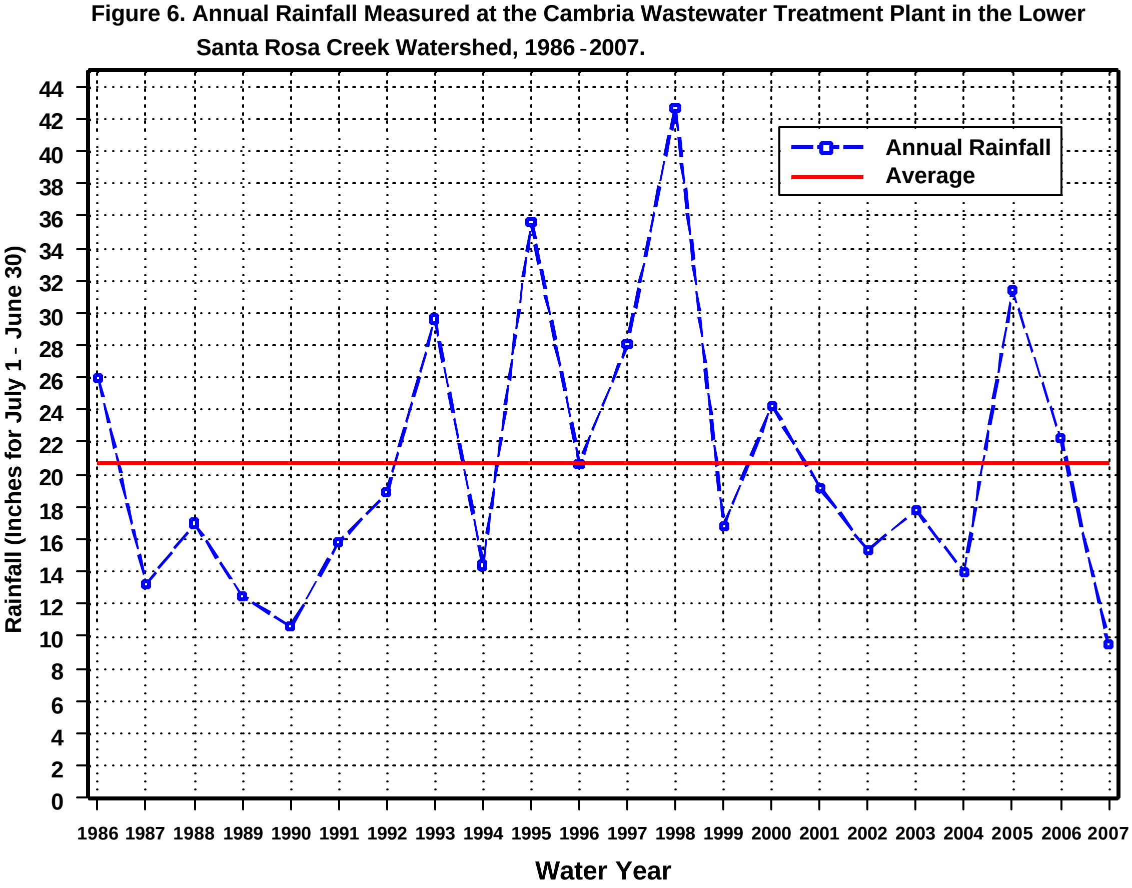


Figure 6. Annual Rainfall Measured in the Lower Santa Rosa Creek Watershed.



Site densities of Size Class II and III (smolt size) juveniles were higher in the lower valley than the upper canyon or similar in many years (**Figures 7, 8 and 9**). In some wet years with large storm events (1995 and 1998) densities of these larger fish were relatively low in the lower valley, likely due to the reduced YOY densities and reduced yearling survival over the winter (**Figure 6**). However, in other above-average rainfall years (1997, 2000 and 2005), Size Class II and III steelhead densities were relatively high in the lower valley, likely because of higher proportions of YOY reaching smolt size their first growing season with the higher spring/ early summer flows when growth is fastest. Then in drier years (or years when few storms came late in the spawning season and the sandbar closed early, like 1997), when more spawning effort likely occurred in the lower valley, densities of these larger fish (with large YOY) were also relatively high (1997, 2000, 2003 and 2004). As a general trend, Size Class II and III densities in the lower valley fluctuated up and down annually in 1994–2002 but increased in 2003 and remained relatively high in 2003–2006.

In the upper canyon, Size Class II and III densities generally increased in 1994–1998 but decreased steadily to lows in 2003 and 2004, with a large increase in 2005 after a wet winter (except at Site 7b with earthquake-related poor water quality). Then they declined in the close to normal rainfall year of 2006 **(Figure 6)**.

Figure 7. Annual Size Class II/ III Steelhead Densities at Lower Valley Santa Rosa Creek Sites, 1994-2006.

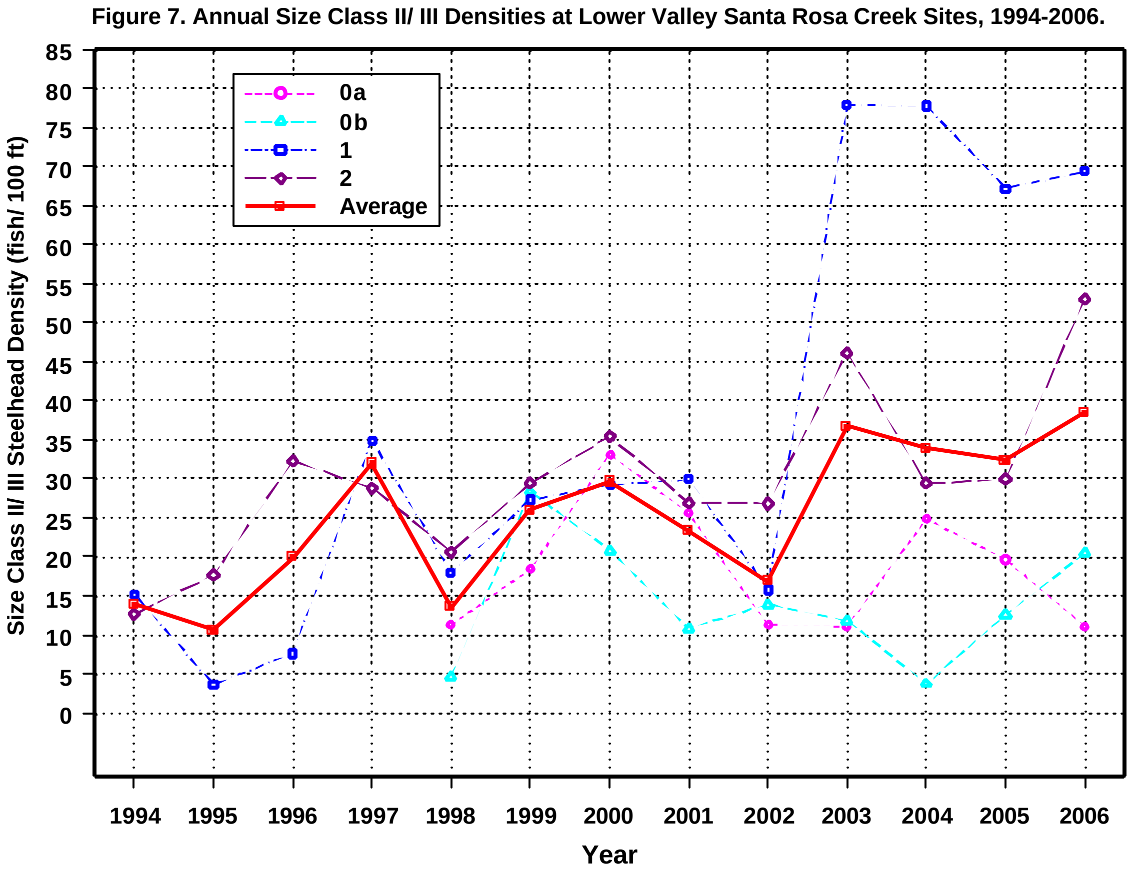


Figure 8. Annual Size Class II/ III Steelhead Densities at Upper Canyon Santa Rosa Creek Sites, 1994-2006.

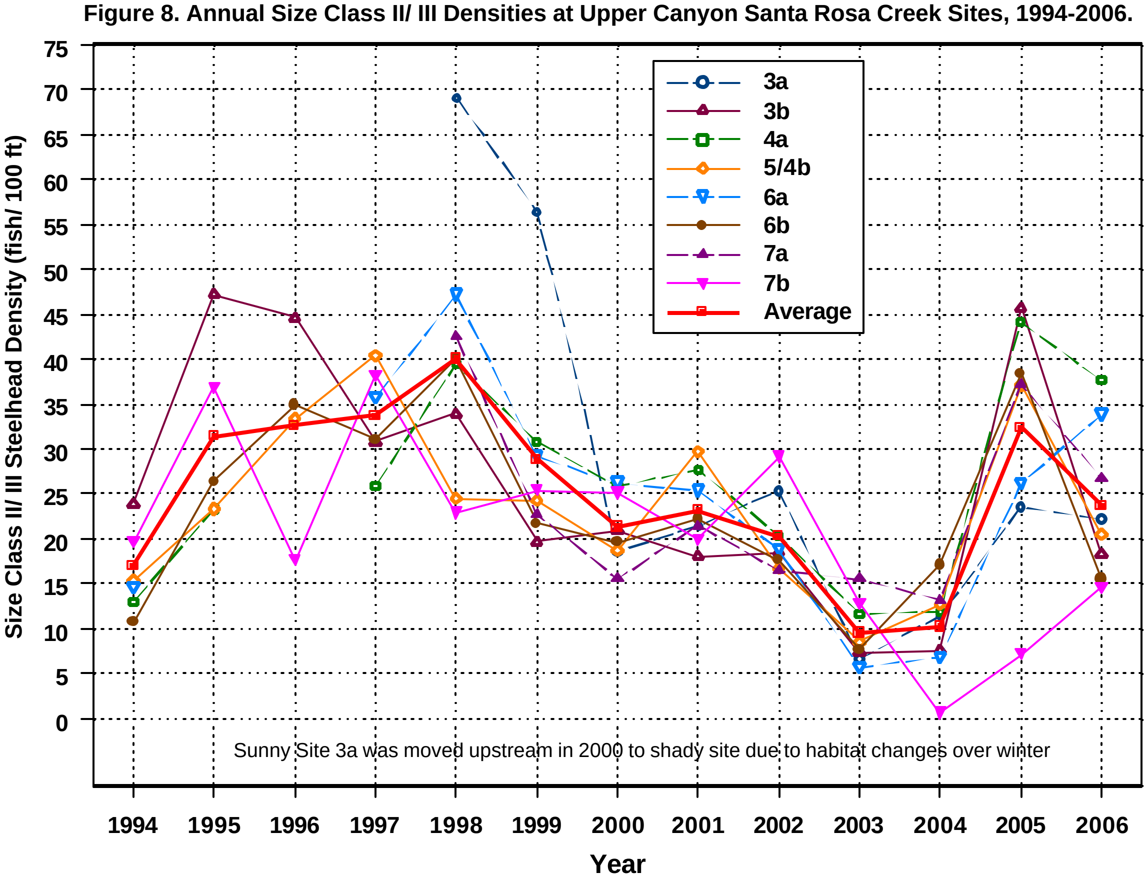
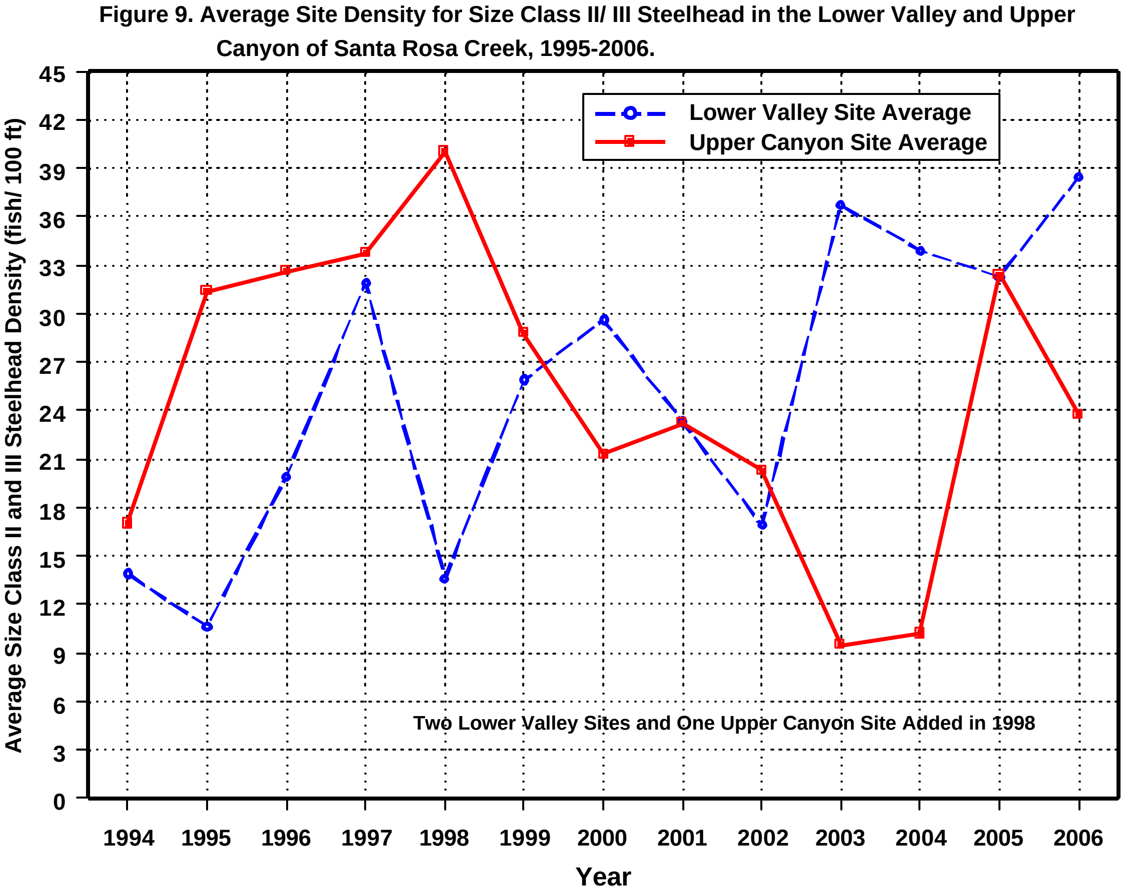


Figure 9. Average Site Density for Size Class II/ III Steelhead in the Lower Valley and Upper Canyon of Santa Rosa Creek, 1995-2006.



Santa Rosa Creek juvenile densities in 2006 (a year with moderate total, YOY and Size Class II densities and after a near-average rainfall year in Santa Rosa Creek (**Figures 1–11**) were compared to those in other watersheds along the Central California Coast (**Table 1 from Alley 2007a**). Santa Rosa Creek had the highest average site densities in most age and size classes and for total juveniles.

Table 1. Average Juvenile Steelhead Densities in Multiple Watersheds Along the Central California Coast in 2006.

Watershed (Listed from South to North)**	Number of Sites	Avg. YOY Density*	Avg. Yearling Density*	Avg. Size Class II and III Density*	Avg. Total Density*
Santa Rosa	14	67	10	26	77
San Simeon	3	57	6	16	63
Corralitos	7	44	17	18	61
Aptos	4	26	6	11	32
Soquel	6	17	1	5	18
San Lorenzo	16	26	2	11	28
Scott	10	48	7	–	55
Waddell	9	20	2	–	22
Gazos	8	19	5	–	24

* Density measured in fish/ 100 ft.

**From Alley 2004a.

Figure 10. Annual Total Juvenile Steelhead Densities at Upper Canyon Santa Rosa Creek Sites, 1994-2006.

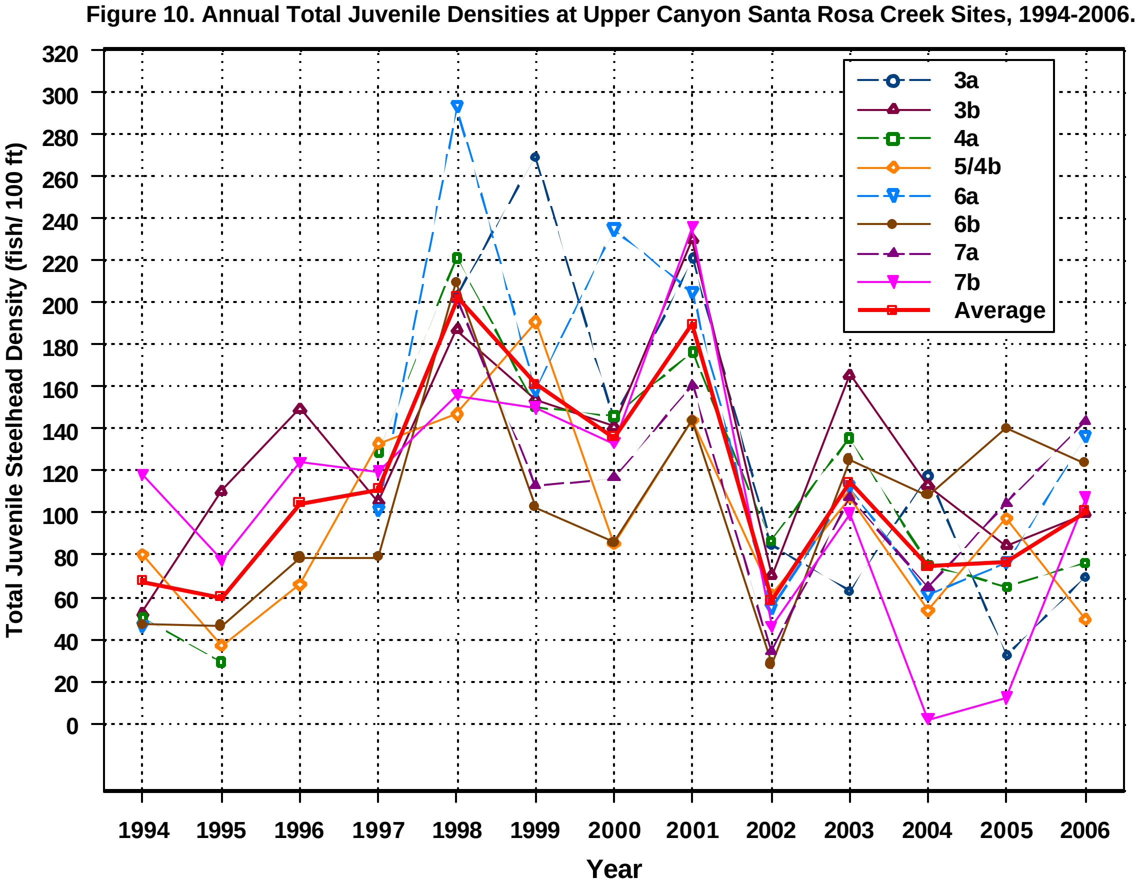
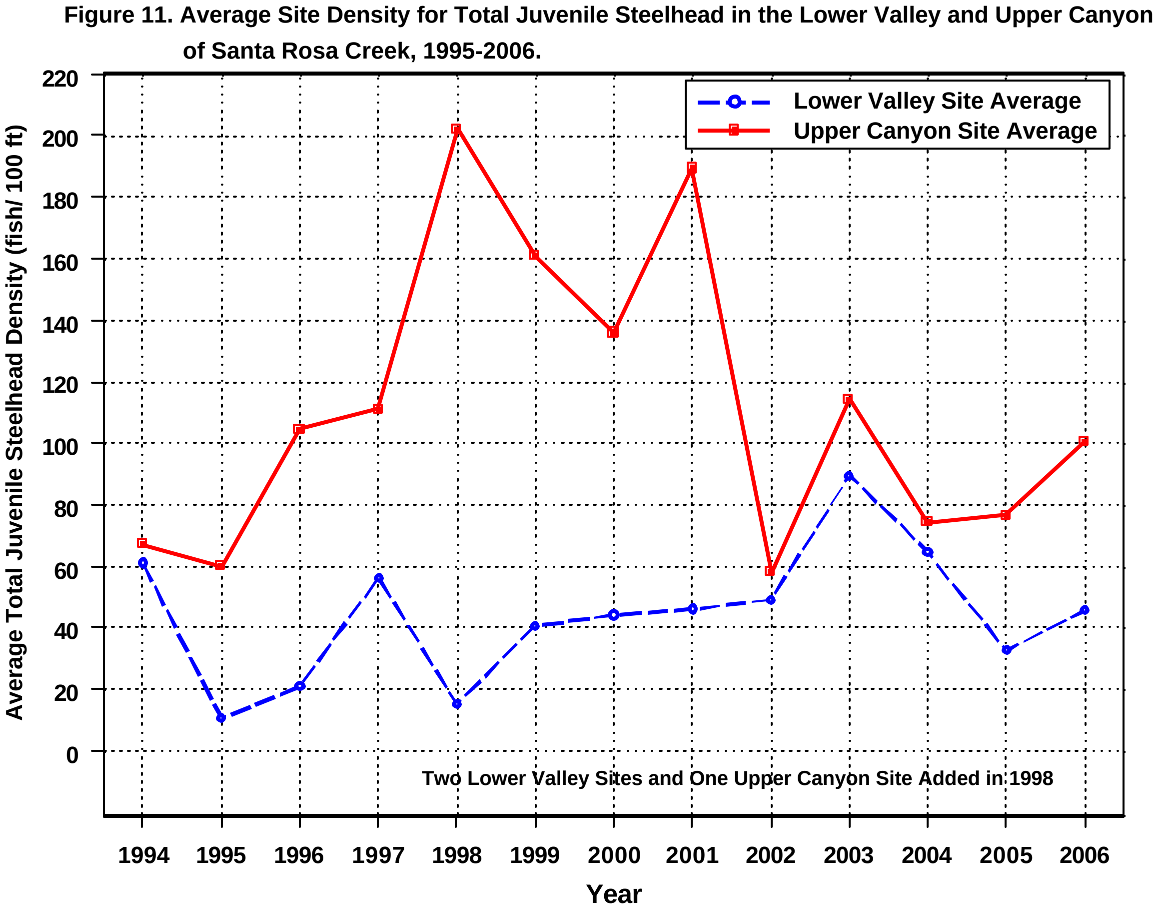


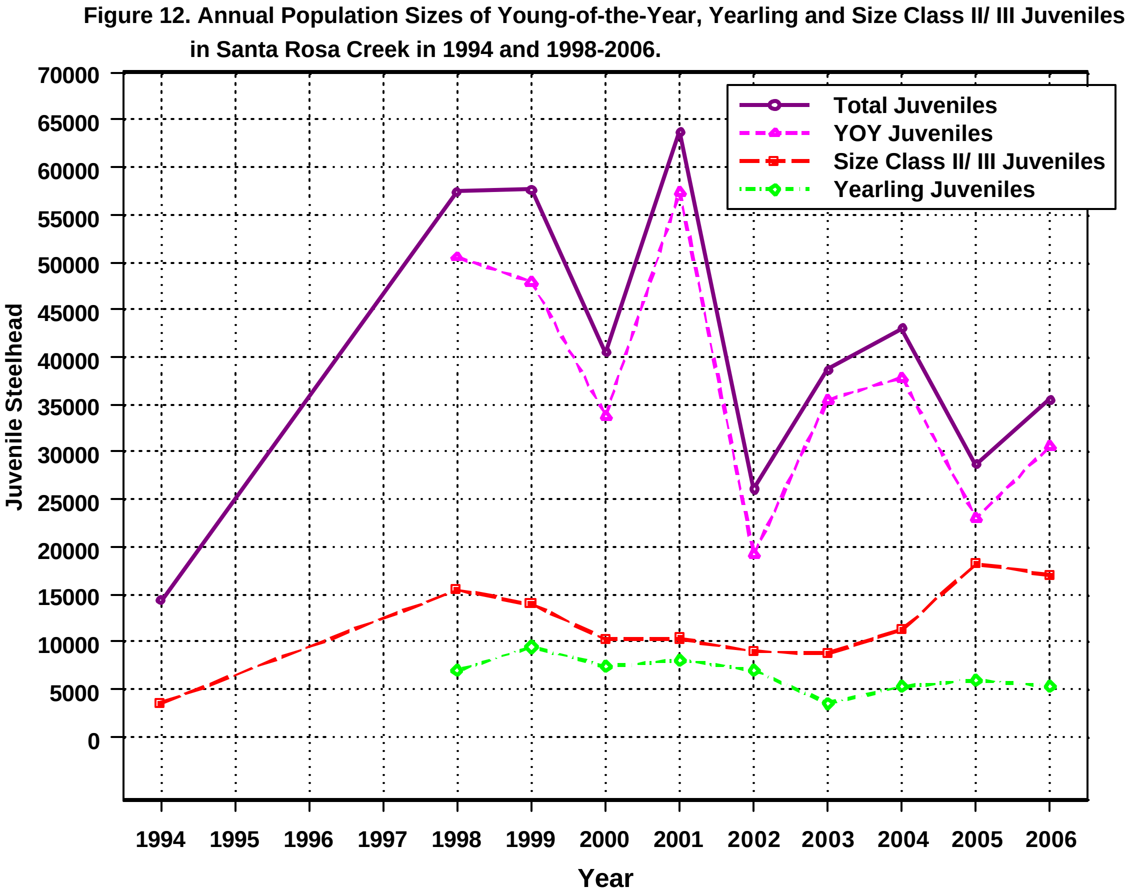
Figure 11. Average Site Density for Total Juvenile Steelhead in the Lower Valley and Upper Canyon of Santa Rosa Creek, 1995-2006.



Trends in annual population size for age classes, size classes and total juveniles indicated that 1994 represented a low point in the 13-year monitoring period (**Tables 2 and 3; Figure 12**). In 1994, Reaches 0a and 3a were dry and Reach 0b was partially dry with very few juvenile steelhead after an especially mild winter that had caused early sandbar closure (**Table 4**) (**Alley 1995a**). The steelhead population had expanded by 1998 and 1999, with relatively large YOY and Size Class II and III populations (**Figure 12**). In 2000, the population dropped due largely to the smaller YOY population. Habitat conditions were poorer in 2000 compared to 1999 with regard to less escape cover and lower baseflow, which also likely resulted in the smaller yearling population (**Alley 2001a**). This 2000 decline in population size corresponded with declines in other monitored central coast watersheds in Santa Cruz and San Mateo Counties (Soquel, San Lorenzo and Gazos). Reduced YOY populations in 2000 may have partially been caused by poor spawning success and/or fewer spawners resulting from events associated with the El Nino period beginning in 1998.

The juvenile population bounced back in 2001, only to plummet in 2002, after a winter that offered few storms with likely poor passage through the sandbar and early final sandbar closure (**Table 4**). This resulted in poor adult passage into the upper watershed, where YOY are usually most abundant. In the continued drier years of 2003 and 2004, the population size was intermediate, relying more heavily on YOY production in the lower valley. The total juvenile population in 2005 was smaller than the 2 previous years, and it was below average. This probably resulted from a smaller adult population spawning the previous winter. Seven of the 8 monitored watersheds along the Central California Coast experienced YOY and total population reductions in 2005.

Figure 12. Annual Steelhead Population Sizes of Young-of-the-Year, Yearling and Size Class II/ III Juveniles in Santa Rosa Creek in 1994 and 1998-2006.



Beneficially, YOY growth rate in 2005 was relatively high with the higher spring flows, and the Size Class II and III population increased substantially from 2004 to 2005 (**Figure 12**). In 2005, an estimated 55% of YOY (12,500) reached Size Class II compared to 16% (6,100) in 2004. This same trend was detected in the San Lorenzo River and Soquel Creek (**Alley 2006c; 2006d**).

Table 2. Summary Table of Steelhead Size Class Site Densities, Reach Densities, Juvenile Production and Adult Indices in Mainstem Santa Rosa Creek, 1994–2006.

Year	Size Class 1 (<75 mm SL) Avg Site Density / 100 ft	Size Class 1 Avg. Reach Density / 100 ft	Size Classes 2 & 3 (=>75 mm SL) Avg. Site Density / 100 ft	All Sizes Avg. Site Density / 100 ft	Size Classes 2 & 3 Avg. Reach Density / 100 ft	Size Classes 2& 3 Creek-Wide Density / 100 ft	Size Classes 2& 3 Upper Canyon-Wide Density / 100 ft	All Sizes Avg. Reach Density / 100 ft	All Sizes Creek-Wide Density / 100 ft	Size Class 1 Production	Size Class 2 & 3 Production	Total Juvenile Production	Adult Index
1994	51.3		***15.8***	67.1					47.3	10,800	***3,500***	***14,300***	***203***
1995	***28.7****		26.5	45.9					30.8	4,400 partial***	4,900 partial	9,300 partial	253 partial
1996	48.2		28.4	76.6					52.3	9,800 partial	6,000 partial	15,800 partial	317 partial
1997	64.1	51.0	33.2	97.3	23.1	25.8		74.1	76.0	15,800 partial	7,800 partial	23,600 partial	409 partial
1998	111.7	100.6	32.0	***143.6***	30.1	***28.6***	***47.6***	***130.7***	106.1	42,000	15,400	57,400	836
1999	92.9	102.9	27.8	120.7	26.4	25.8	35.8	129.7	106.4	43,700	14,000	57,600	775
2000	81.3	62.2	24.1	105.3	19.1	18.9	19.8	81.0	74.8	30,300	10,300	40,500	566
2001	***118.4*****	***111.0***	23.3	141.6	19.1	19.0	21.9	130.1	***117.6***	***53,400***	10,300	***63,700***	658
2002	35.9	35.3	19.2	***55.1***	18.4	17.6	21.3	55.9	51.0	17,100	9,000	26,100	462
2003	73.9	72.2	18.6	100.8	15.9	***17.1***	***9.2***	88.2	71.9	29,900	8,800	38,700	498
2004	53.1	54.3	18.1	71.1	***14.8***	***17.1***	11.3	69.1	65.1	31,700	11,300	43,000	615
2005	29.4	***27.1***	***32.4***	61.9	***31.5***	***28.6***	33.1	***58.6***	***45.1***	***10,400***	***18,200***	28,700	***886***
2006	49.6	41.3	27.5	77.1	25.5	26.8	22.9	66.8	55.9	18,500	17,000	35,500	832
Avg.	64.5	65.8	25.2	89.6	22.7	22.6	24.8	88.4	69.3	24,400	10,500	34,900	562

* Lowest Density/ Population Estimate in 1994-2006.

** Highest Density/ Population Estimate in 1994-2006.

***Reaches in 1995–1997 conformed to wetted reaches in 1994. However, in 1995–1997, downstream reaches (0a and 0b) also had perennial flow to varying degrees but were not entirely wetted throughout the dry season and not sampled until 1998 and afterwards.

Table 3. Summary Table of Average Steelhead Age Class Site Densities, Reach Densities and Juvenile Production in Santa Rosa Creek, 1997–2006.

Year	YOY Avg Site Density ----------- (fish/100 ft)	YOY Avg. Reach Density ----------- (fish/100 ft)	YOY Avg. Reach Density- Upper Canyon ---------- (fish/100 ft)	YOY Creek-Wide Density ---------- (fish/100 ft)	Yearling Avg. Site Density ----------- (fish/ 100 ft)	Yearling Avg. Reach Density ---------- (fish/100 ft)	Yearling Creek-Wide Density ---------- (fish/100 ft)	YOY Pro-duction	Percent YOY's Reaching Smolt-Size In First Year	Yearling Pro-duction	Total Juvenile Pro-duction
1997	76.1				***20.8***	12.7		19,500 partial***	19	3,800 partial	23,300 partial
1998	***123.9****	115.6	168.2	93.1	15.8	14.8	12.7	50,400	17	6,900	57,300
1999	100.4	108.4	151.3	88.5	21.2	***20.8***	***17.5***	48,000	9	***9,500***	57,500
2000	87.7	67.2	98.0	62.4	18.5	14.0	13.6	33,800	10	7,400	41,200
2001	123.6	***116.8***	***178.2***	***105.9***	18.0	14.5	14.8	***57,400***	***7***	8,000	***65,400***
2002	***38.8*****	***40.3***	***43.8***	37.4	16.9	15.3	13.7	***19,200***	12	7,000	***26,200***
2003	91.7	87.1	102.4	69.3	***8.9***	***7.7***	***6.9***	35,500	16	***3,500***	39,000
2004	62.7	59.9	77.3	57.3	10.5	9.3	8.0	37,800	16	5,300	43,100
2005	51.5	48.1	68.9	***36.2***	11.7	10.3	9.3	23,000	55	5,900	28,900
2006	67.2	56.1	74.4	48.3	10.1	8.6	8.3	30,600	***69***	5,300	35,900
Avg	82.3	72.5	106.9	66.4	15.2	12.8	11.7	35,500	23	6,300	41,800

* Highest Density/ Population Estimate in 1994-2006.

** Lowest Density/ Population Estimate in 1994-2006.

***Reaches in 1995–1997 conformed to wetted reaches in 1994. However, in 1995–1997, downstream reaches (0a and 0b) also had perennial flow to varying degrees but were not entirely wetted throughout the dry season and not sampled until 1998 and afterwards.

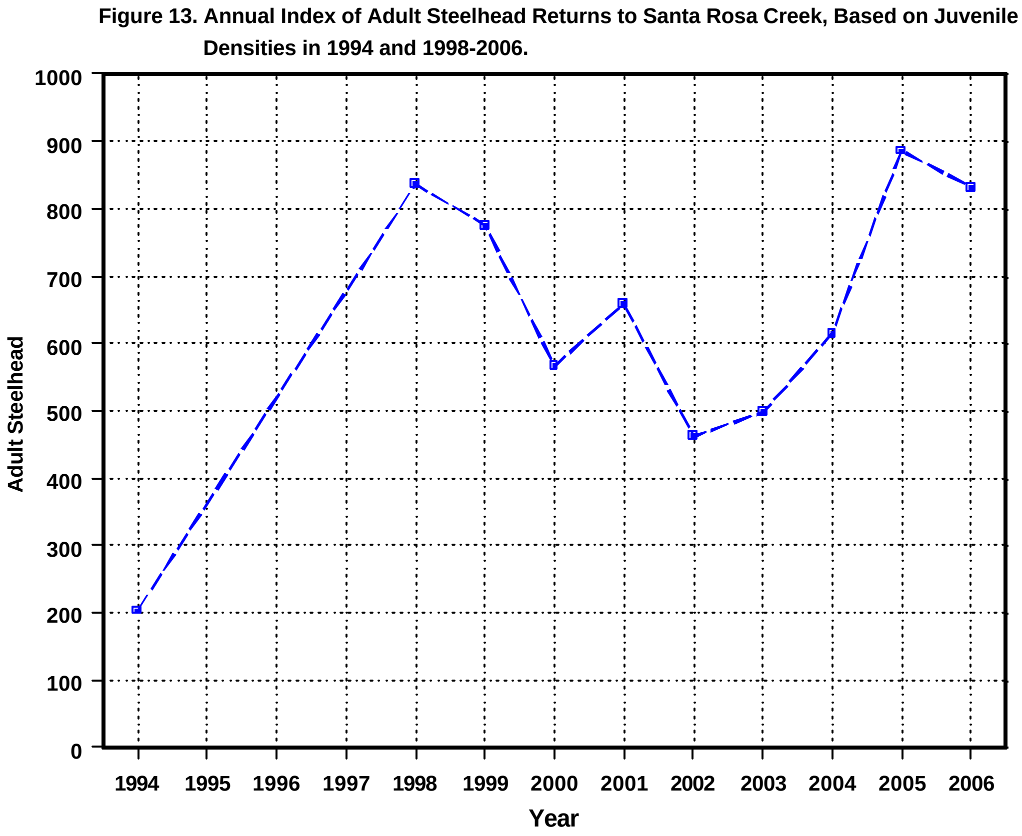
Table 4. Historical Record of Sandbar Closure at Santa Rosa Lagoon (1993–2007) and San Simeon Lagoon (1991–1992).

Year	**Date of First Sandbar Closure Detection After Winter/Spring Rainy Season**	**Evidence of Smolts in the Lagoon or Immediately Upstream After Sandbar Closure**	**Stream Inflow Cubic feet/ second (cfs)**
1991 (San Simeon Lagoon)	Before 2 April 1991	–	–
1992 (San Simeon Lagoon)	10 Jan (opened 8 Feb) 29 April 1992	–	4.35 2.75
1993	24 May 1993 closed (Re-opened after light rain on 25 May 1993) 11 June 1993 (or sooner)	Yes (few)	7.9 4.15 on 11 June
1994	**28 March 1994**	**Yes (many)**	**2.49 on 29 April**
1995	28 May 1995	Yes (few upstream only)	-
1996	3 June 1996	Yes (very few upstream only)	5.13 on 29 May 2.98 on 12 June
1997	**23 March 1997**	**Yes (many)**	**12.60 on 26 March**
1998	13 July 1998	Yes (very few upstream only)	4.65 on 15 July
1999	28 May 1999	No (upstream not sampled)	6.18
2000	31 May 2000	No (upstream not sampled)	3.00 on 15 June
2001	14 May 2001	No (upstream not sampled)	4.40 on 23 May
2002	**14 April 2002**	**Yes (many)**	**2.14 on 28 Feb.** **2.11 on 28 March** **1.13 on 29 April**
2003	9 June 2003	No	1.50 on 3 July
2004	7 May 2004	Yes (few upstream only)	2.69 on 21 May
2005	27 May 2005	Yes (few upstream only)	6.25 on 16 June
2006	Between 24 May and 26 June 2006	No	18.67 on 24 May 3.23 on 12 July
2007	**15 March 2007**	**Yes (many)**	**21.94 on 1 March**

In 2006, the juvenile population increased modestly in Santa Rosa Creek after a near-average rainfall winter (**Figure 12**). However, the YOY and yearling population estimates were below average, consistent with other watersheds (San Simeon, San Lorenzo, Soquel) and low YOY densities in Scott, Waddell and Gazos creeks (**Alley 2007a**). This may have been the second year in a row with relatively below average adult returns and the third in the 5-year period of 2002–2006.

The trend in the annual adult steelhead index that was generated from juvenile population sizes. Adult indices were calculated to estimate trends in adult returns and not to estimate actual adult returns. A conservative juvenile-to-adult survival rate in the ocean was estimated from adult return data on a Santa Cruz County stream (Waddell Creek) in the early 1990's and remained constant in calculation of adult indices. See **Appendix A** for detailed methods regarding the adult index. However, El Niño events likely change survival rate in the ocean. The adult index was most influenced by the Size Class II and III juvenile population. It could increase from one year to the next even if the total juvenile population decreased, if the Size Class II/ III population had increased, as occurred from 2004 to 2005. The Size Class II and III population is more important than the total juvenile population, making it very important to measure steelhead densities by size class. The adult index increased by four times from 1994 to 1998 (**Figure 13**). Then it declined in 1999 and 2000, coincident with smaller Size Class II/ III populations when lower spring flows reduced the growth rate of YOY compared to 1998 (**Figure 12**). The adult index increased in 2001 due to a greatly increased YOY population and despite a no larger Size Class II/ III population during a drier year that did not promote very rapid YOY growth in the lower valley.

Figure 13. Annual Index of Adult Steelhead Returns to Santa Rosa Creek, Based on Juvenile Densities in 1994 and 1998-2006.



In 2002 the adult index was the lowest in the 9-year period, 1998–2006, with relatively small YOY and Size Class II/III populations after a mild late winter/ spring that offered poor adult access, low streamflow and poor juvenile growing conditions (**Figure 13**). The next 2 years, 2003 and 2004, afforded limited spawning and growth opportunities, but YOY populations increased over 2002 levels (**Figure 12**). The Size Class II/III population decreased in 2003 and then increased modestly in 2004. Accordingly, the adult index increased in 2003 and 2004.

The juvenile population was relatively small in 2005 (**Figure 12**), but habitat conditions were good and spring flows were likely relatively high after a wet winter. As a result, YOY growth rate was high in the lower valley and resulted in a substantial increase in the Size Class II/ III population, an increase in the yearling population in the upper canyon and the highest adult index during the monitoring period 1994–2006 (**Figure 13**).

In 2006, the YOY population increased during a near-average rainfall year, with adequate growth of YOY in the lower valley to maintain a relatively high Size Class II/ III population and a high adult index, despite the relatively low total juvenile population size (**Figures 12 and 13**).

Key Results of Habitat Analysis in Santa Rosa Creek, with Recommended Management Guidelines

Comparisons of tree canopy closure in fall at four-year intervals was not clear-cut because data in1994 and 2002 were collected approximately a month earlier than in 1998 and 2006. Data in 1994 and 2002 were collected after below average rainfall winters (perhaps hastening earlier leaf drop), and data in 1998 and 2006 were collected after above average rainfall winters (perhaps delaying leaf drop). Despite these ambiguities, tree canopy closure in lower valley reaches and the 2 lower reaches of the upper canyon (Reaches 3a and 3b) was trending in a negative direction since the 1995 flood (**Figure 14**). The upper 4 reaches of the upper canyon had somewhat more tree canopy than prior to the 1995 flood. In 2006, the lower valley and Reach 3a in the upper canyon had relatively lower tree canopy closure (25–45%), while the remainder of the upper canyon had relatively higher closure (55–70%).

Habitat typing was performed in reach segments at four-year intervals in 1994–2006. For a more detailed description of findings, refer to **Appendix A**. Between 1994 and 1998, an extremely large flood event occurred in March 1995 that resulted in massive streambank erosion and loss of riparian forest in the lower valley (**Don Alley personal observation**). A conservative estimate of streamflow on 10 March was 16,000 cfs. Since the gage was installed in 1976, it was more than double the previously highest flow of 7,900 cfs recorded in 1986. After a very wet winter, habitat conditions improved in 1998 compared to 1994 with regard to generally deeper pools in the lower valley and upper canyon and increased perennial surface flow in Reaches 0a, 0b and 3a (**Figures 15 and 16**). However, tree canopy closure in 1998 was reduced in the lower valley and the lower two of six reaches of the upper canyon compared to 1994, presumably due to loss of riparian forest during the 1995 flood (**Figure 14**).

In 2002, fall baseflow was much less than in 1998, leading to overall reduced habitat quality in Santa Rosa Creek in 2002 (**Figure 17**). However, in 2002 the beyond-streamflow related habitat quality generally improved in the lower valley because of more pool escape cover and continued recovery of riparian vegetation with increased tree canopy (**Figure 18**). On the negative side, pool sedimentation was observed with greatly reduced maximum pool depth in all but Reach 2 (**Figure 16**). In 2002, beyond-streamflow related habitat quality in the upper canyon generally declined due to reduced maximum pool depth (except Reach 6) and generally reduced escape cover. These habitat depth changes were beyond what would be expected from differences in baseflow.

Figure 14. Tree Canopy Closure in Fall in Wetted Reaches of Santa Rosa Creek in Habitat Typed Segments at Four-Year Intervals (1994-2006).

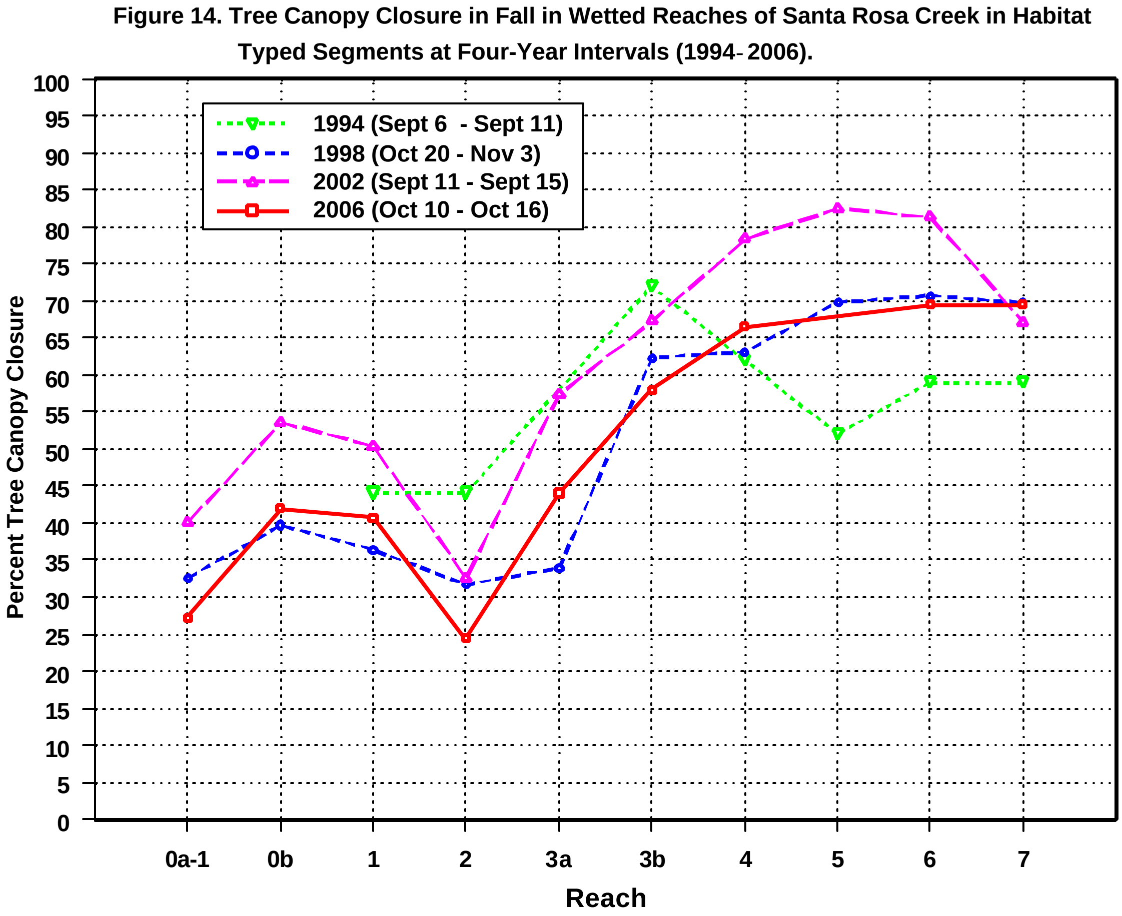


Figure 15. Average Mean Pool Depth in Habitat Typed Segments of Reaches in Santa Rosa Creek at Four-Year Intervals, 1994-2006.

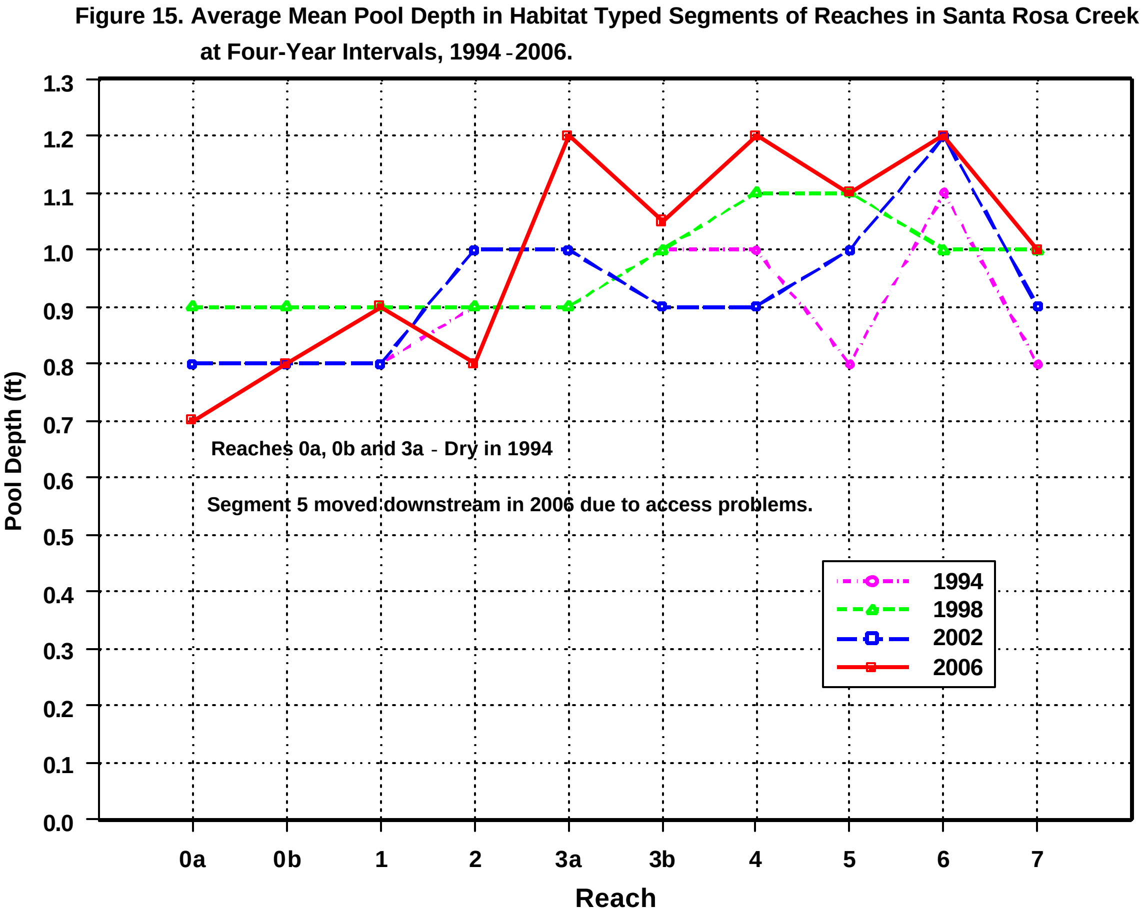


Figure 16. Average Maximum Pool Depth in Habitat Typed Segments of Reaches in Santa Rosa Creek at Four-Year Intervals, 1994-2006.

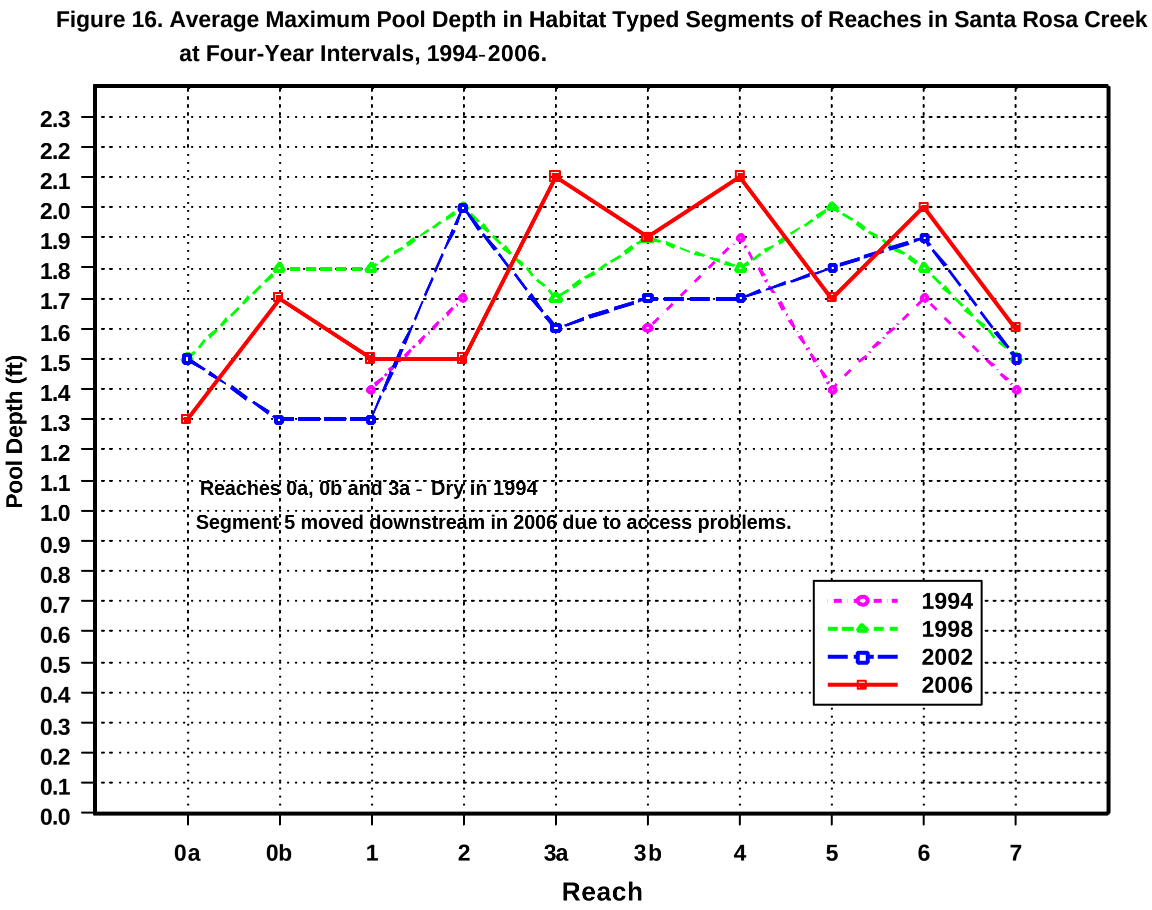


Figure 17. Measured Streamflow in Fall at Sampling Sites in Santa Rosa Creek, 1998-2006.

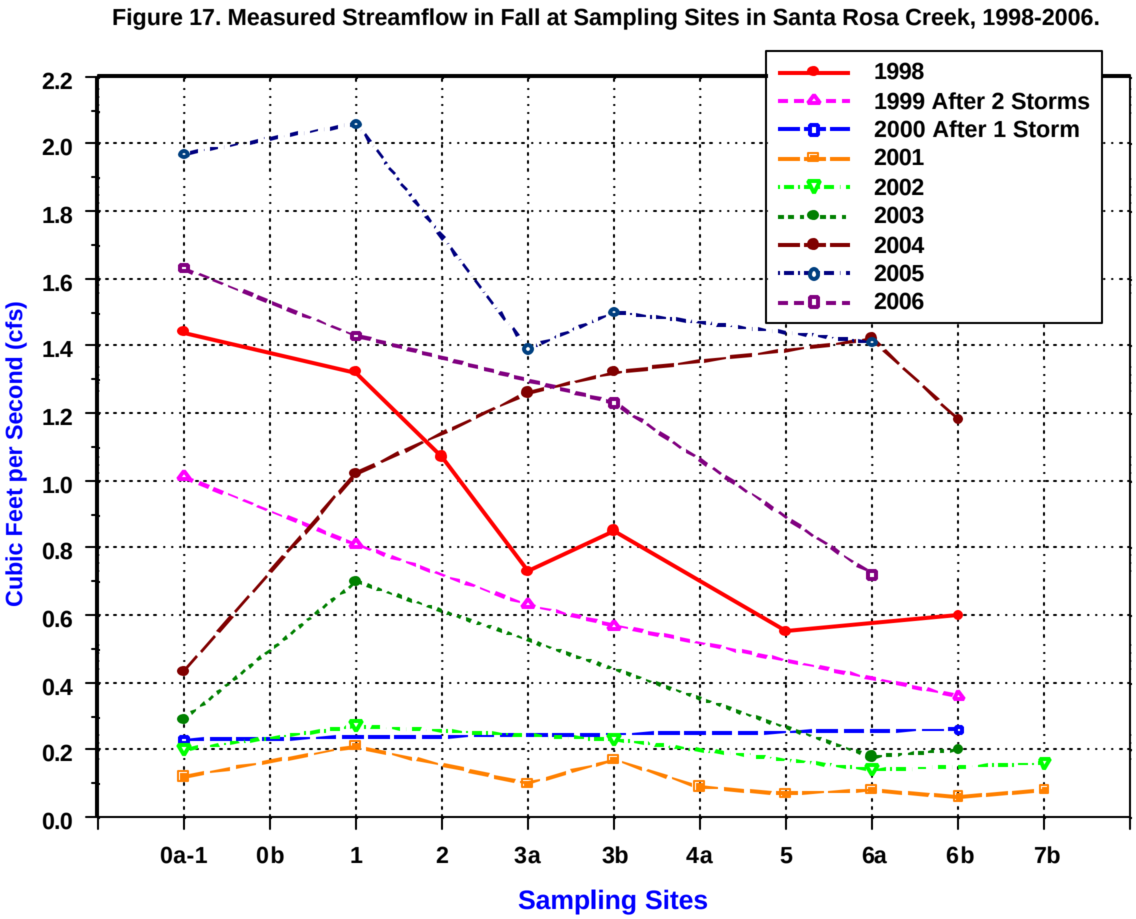
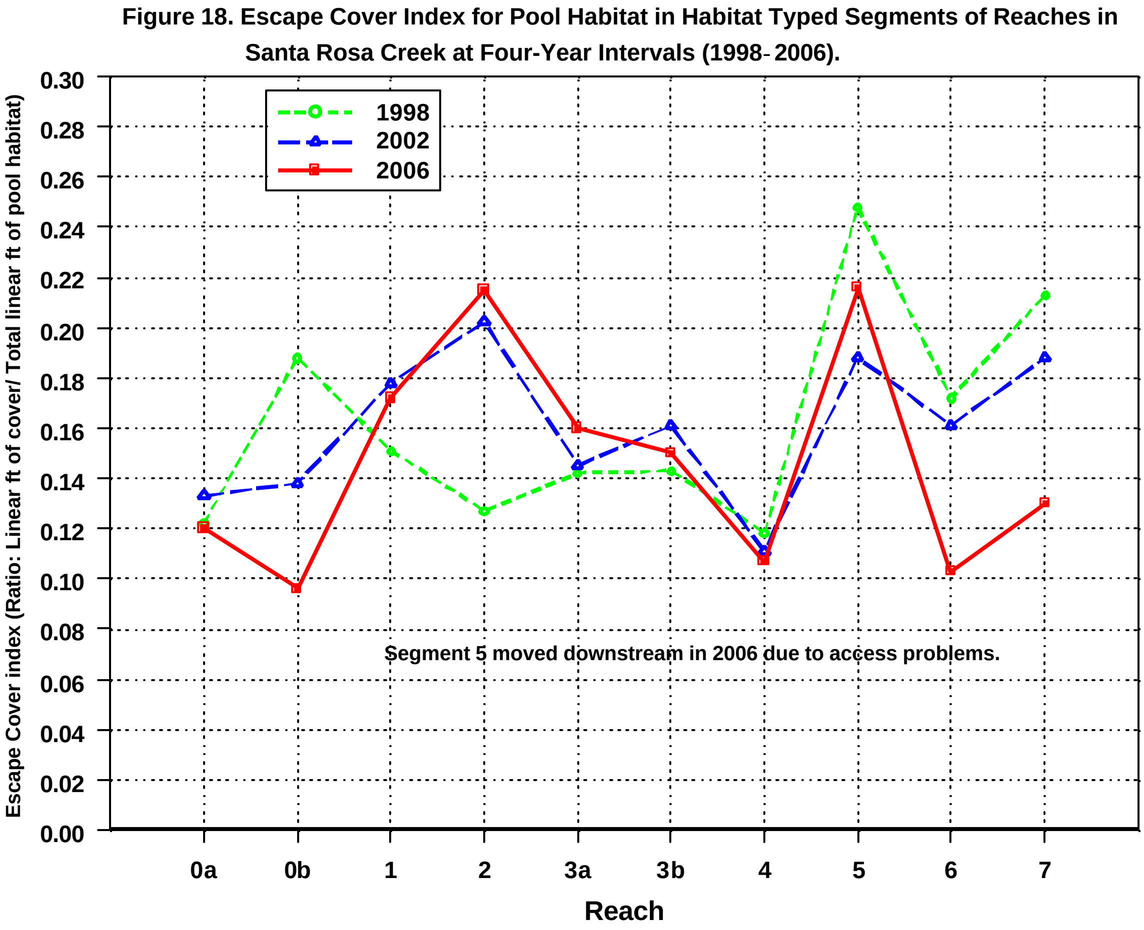


Figure 18. Escape Cover Index for Pool Habitat in Habitat Typed Segments of Reaches in Santa Rosa Creek at Four-Year Intervals, 1998-2006.



In 2006, baseflow was much more than in 2002, primarily due to earthquake-caused enhancement. Increased baseflow created overall habitat improvement in 2006. Regarding beyond-streamflow related habitat conditions, they declined overall in the lower valley in 2006 due to sedimentation that reduced average and maximum pool depth in Reaches 0a and 2 (**Figure 16**), with reduced tree canopy and no improvement in escape cover compared to 2002 conditions (**Figures 14 and 18**). However, pools deepened in the middle Reaches 0b and 1 of the lower valley, and percent fines were reduced in pools of Reaches 1 and 2 and in runs throughout the lower valley (**Figures 15, 16, 19 and 20**). In 2006, beyond-streamflow related habitat conditions generally improved in the lower portion of the upper canyon (Reaches 3a-5) due to scouring that increased average and maximum pool depth, reduced embeddedness in step-runs/ runs (**Figure 21**) and reduced percent fines in pools (**Figure 19**). Beyond-streamflow related habitat conditions in 2006 were similar to 2002 conditions in the upper portion of the upper canyon (Reaches 6 and 7) with regard to average pool depth, embeddedness in step-runs, pool embeddedness (**Figure 22**) and percent fines in pools and step-runs. Maximum pool depth increased slightly, but escape cover declined by a third to make overall habitat quality less in 2006 for non-streamflow related conditions.

Figure 19. Percent Fines in Pools in Reaches of Santa Rosa Creek at Four-Year Intervals, 1998-2006.

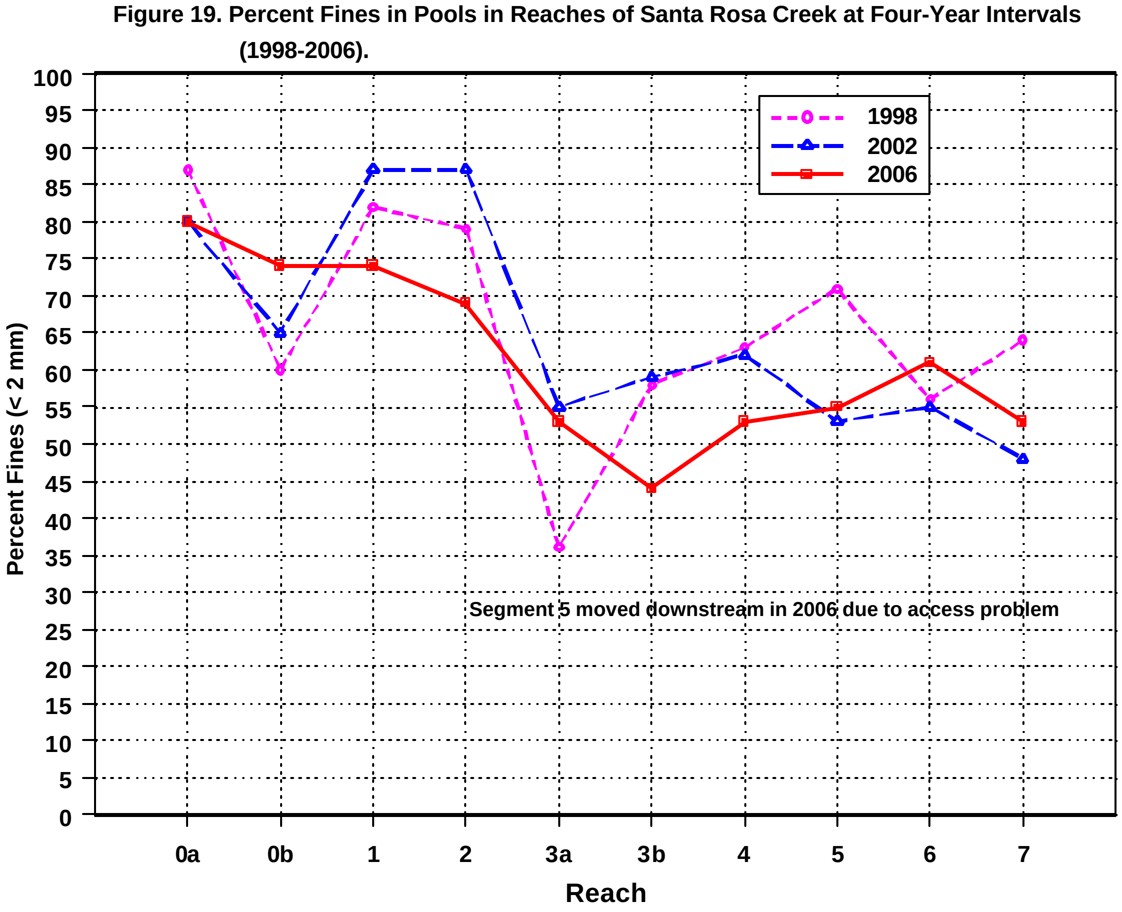


Figure 20. Percent Fines in Step-Runs and Runs in Reaches of Santa Rosa Creek at Four-Year Intervals, 1998-2006.

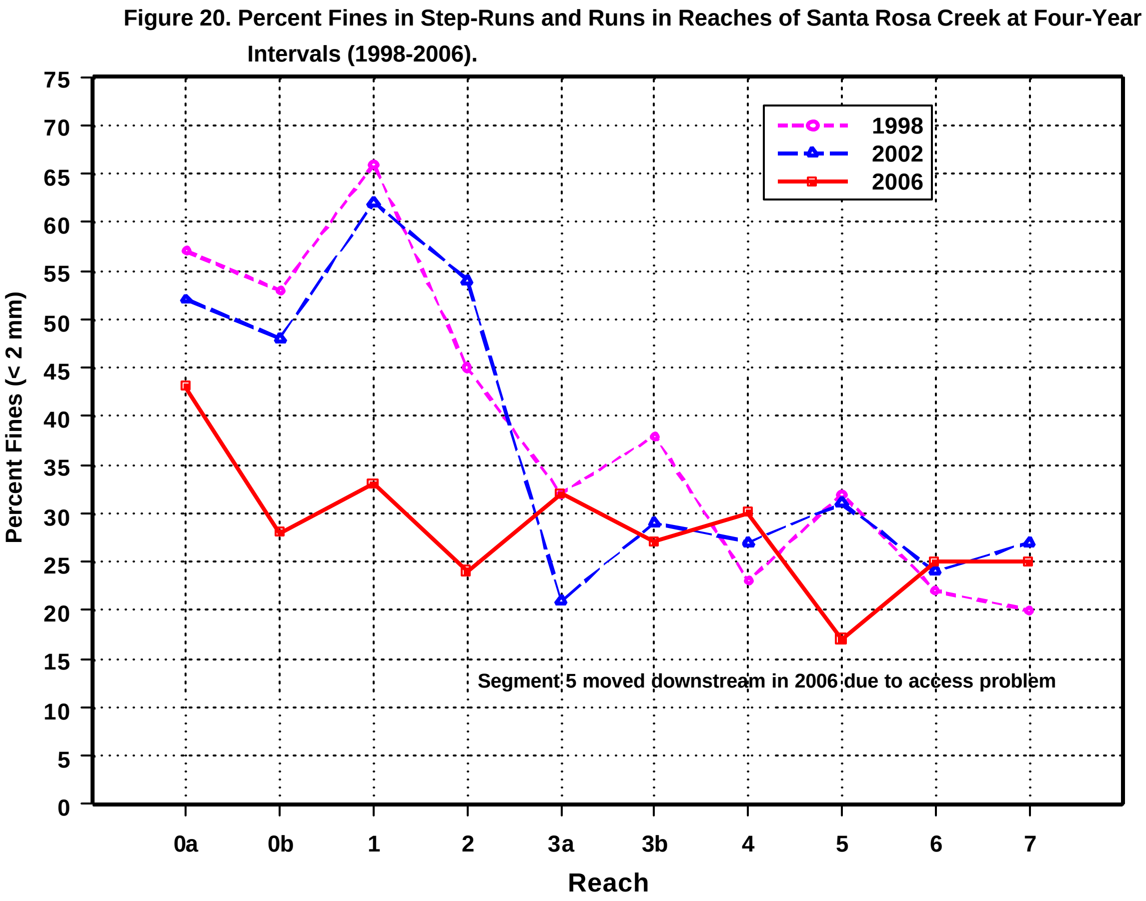


Figure 21. Substrate Embeddedness in Step-Runs and Runs in Reaches of Santa Rosa Creek at Four-Year Intervals, 1998-2006.

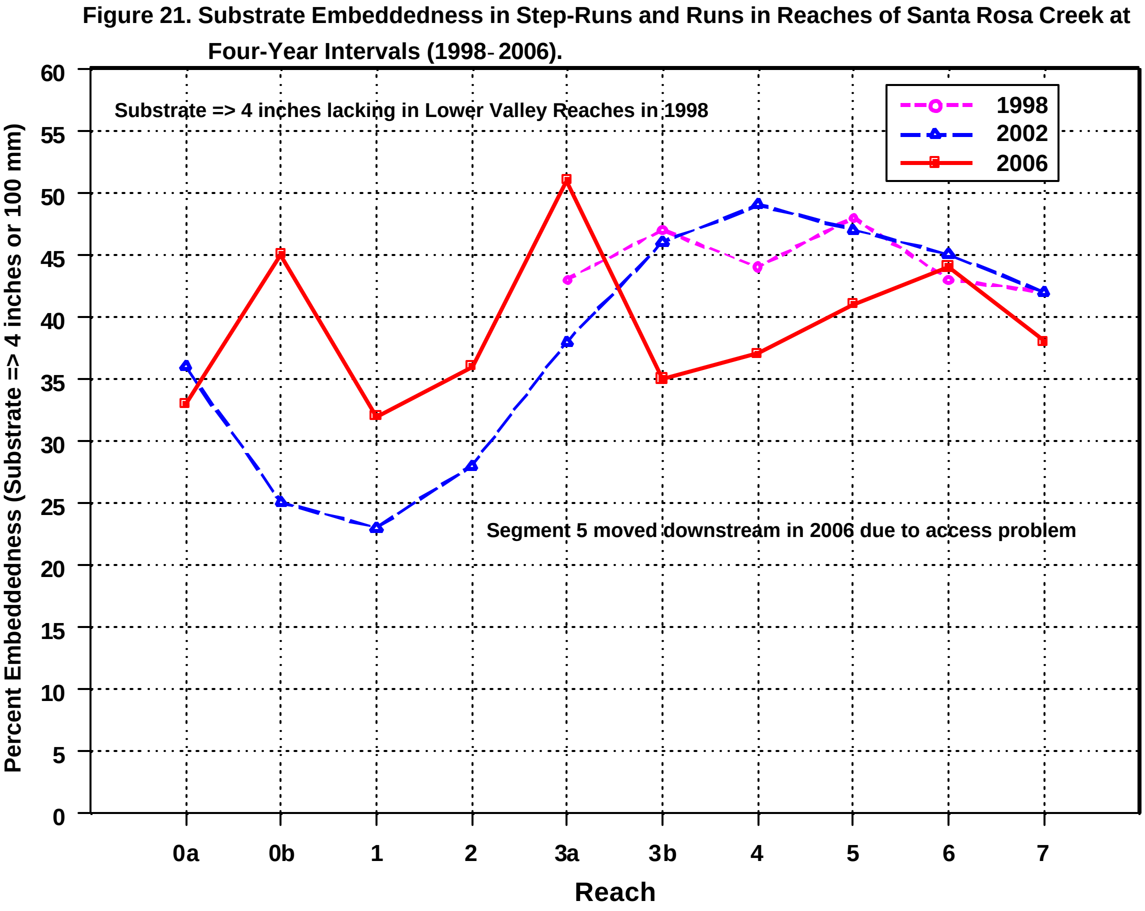
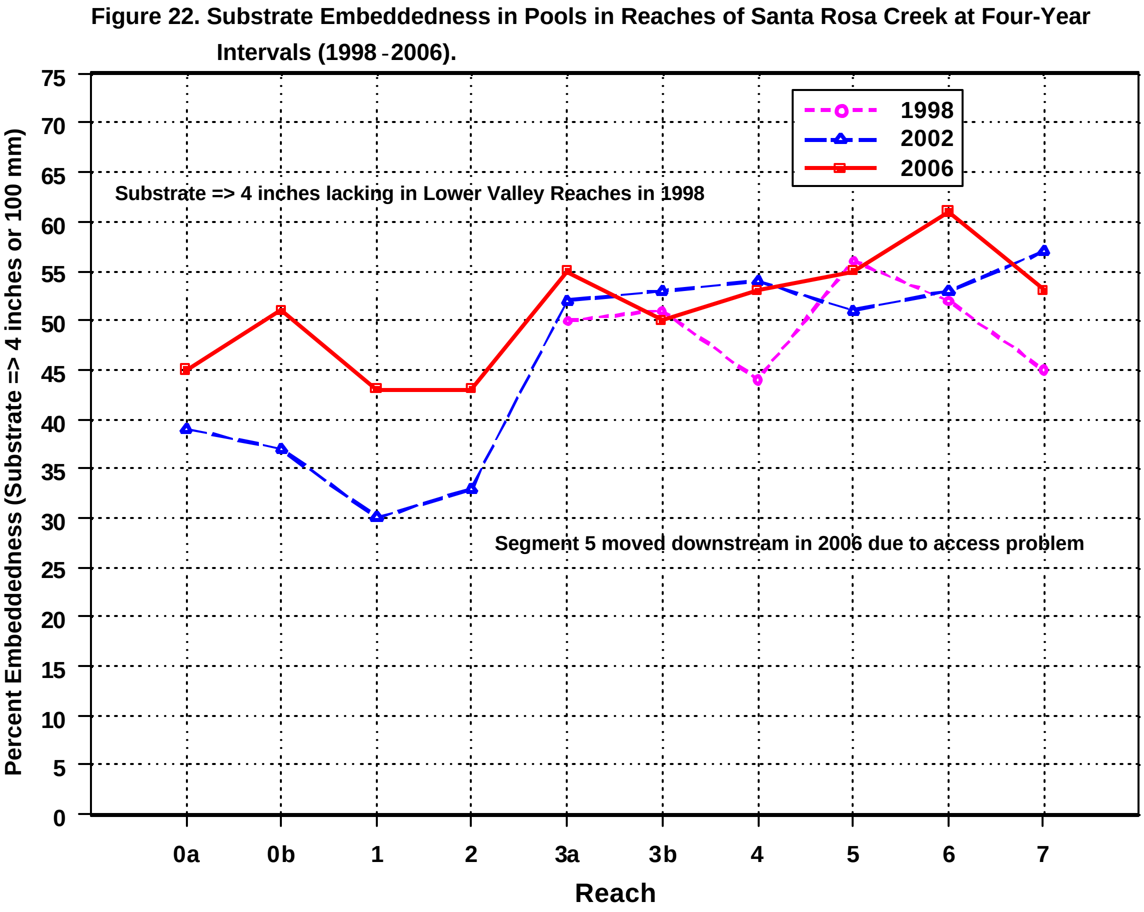


Figure 22. Substrate Embeddedness in Pools in Reaches of Santa Rosa Creek at Four-Year Intervals, 1998-2006.



In comparing habitat conditions in 2006 to those in 1994 in the lower valley, Reach 1 had similar conditions with slightly deeper pools (mean and maximum) in 2006 (**Figures 15 and 16**), which may have been partially due to higher baseflow in 2006 (**Figure 17**), and similar tree canopy closure (**Figure 14**). Reach 2 conditions had worsened by 2006, with shallower pools (mean and maximum) in 2006 despite higher baseflow. Tree canopy closure in Reach 2 was the lowest in the 13-year period and had not recovered to 1994 levels after the 1995 flood. In comparing 2006 to 1994 in the upper canyon, habitat conditions had improved in 2006 with deeper pools (mean and maximum depth) in all reaches (3b, 4, 5, 6 and 7). Tree canopy was very similar in 1994 and 2006 in the upper canyon. Escape cover could not be compared due to the change to better methods in 1998 that were used thereafter.

Mapped results of CDFG habitat evaluation from a stream survey of mainstem Santa Rosa Creek conducted in 2005 (according to the accompanying report, although the map descriptions say summer 1996) are available at the link,
http://ccows.csumb.edu/scdp/data.htm
The level of detail on these maps was low, thus limiting their value in describing habitat conditions in Santa Rosa Creek. The plotted statistics had no connection to the specific habitat conditions of our defined reaches. Reach boundaries were unclear, indicating that many plotted statistics may have been stream-wide values in cases where the entire mainstem was given the same rating. When the stream is not divided into reaches based on distinct changes in stream characteristics (gradient, geomorphology, relative proportion of habitat types, streamflow due to tributary confluences, or tree canopy), trends in habitat quality and their connection to fish densities are very difficult to detect. Mapping of habitat types lacked clear definition on the maps. In some segments, it appeared that long stretches were either run or step-run, which is inaccurate based on our experience. There was no mapping of escape cover, although it is of great importance in assessing habitat quality and determining Size Class II juvenile steelhead density. Apparent stream-wide ratings of tree canopy on the CDFG maps did not detect the increased tree canopy in the upper canyon that our monitoring indicated. The maps of streambank erosion do not indicate whether the mapped sites are actively eroding or not. Much of the streambank erosion occurred during the March 1995 flood, and some sites are no longer active. In our judgment, future streambank stabilization work should focus on active sites in the lower valley, especially in Reach 2. Some of the maps from this CDFG Basin Planning and Habitat Mapping Project have been included in **Appendix C**. However, the magnification must be increased to read them, using the zoom function on the tool bar in Microsoft Word. No actual habitat data were forthcoming from CDFG at the time of this writing.

Recommended Water Temperature Enhancement Goals and Previous Success in Meeting These Goals

The recommended water temperature guidelines to protect steelhead habitat in the lower valley reaches of Santa Rosa Creek should be upper limits of 20ºC (68ºF) average daily temperature with a 23ºC (73.4ºF) daily maximum.

In 2004–2006, our recommended temperature guidelines regarding average daily water temperature were likely met at lower valley sites regarding average daily temperature except for a 10-day period in July 2006, based on the 7-day rolling average. The 7-day rolling average was less than 20°C in all three years. In 2004, the temperature guidelines regarding daily maximum temperature were met at Site 0a except for a small number of days but less so at Site 1. In 2005, the guidelines were approached less at Site 0a for maximum daily temperature than at Site 1, with exceedence about a third of the days at each site. In 2006, the maximum daily temperature guideline was not met much of July and half of August at Site 0a and for a warm 10-day period in July at Site 1. The increased baseflow effects from the December 2003 earthquake may have promoted cooler water temperatures in the lower valley than under pre-earthquake baseflow conditions. Refer to **Appendix A** for more detailed information on water temperature.

To protect steelhead habitat in the upper canyon, the average daily water temperature should have upper limits of 20ºC (68ºF) and the maximum daily temperature should not rise above 22ºC (71.6ºF).

In the upper canyon, where baseflow was less than in the lower valley except in 2003 and 2004 (**Figure 17)**, more restrictive guidelines than in the lower valley should be followed. Since the December 2003 earthquake that increased summer baseflow, our recommended temperature guidelines were met at upper canyon temperature monitoring sites in 2004–2006 except for short periods. Once summer baseflows return to pre-earthquake levels, more water temperature monitoring will indicate if the guidelines are still being met. More detailed discussion of water temperature data and the basis for management guidelines is contained in **Appendix A**.

Prior to the baseflow-augmenting effects of the December 2003 earthquake, Santa Rosa Creek water temperature was monitored at stream sites for only the latter part of the summer/fall in 2003. However, for the month of September in 2003 vs. 2004, daily maximum water temperatures were very similar at lower valley Sites 0a and 1 and within 1°F at the upper Site 6a (slightly cooler in 2004), despite the increased baseflow in 2004 resulting from the 2003 earthquake (**Alley 2004a and 2005a**). Monitoring of water temperature in 2003 and the post-December 2003 earthquake era (2004–2006) at stream sites indicated that the upper canyon was cooler than in the lower valley (about 5 °F cooler in 2006 for the maximum daily water temperature). However, the maximum 7-day rolling average at Site 6a in 2006 was equal to that at Site 0a (20.4 °C (68.8 °F); 19 July to 28 July) between 1 July and 10 September. In all years, the daily water temperature varied more between days in the upper canyon but the diurnal (daily) variation in water temperature was greatest in the lower valley. It is significant to note that although the baseflow in 2004 was much less at Site 0a than in 2005 and 2006 (**Figure 17**), water temperature was cooler there in 2004 than in the two succeeding years. Therefore, the degree of persistence of fog and overcast nearer the coast during the summer (and their effect on air temperature) may be more important in maintaining cooler water temperature than higher streamflow (within the ranges of streamflow in 2004–2006).

Regarding Santa Rosa Lagoon for the period of sandbar closure, the water temperature guidelines to provide steelhead habitat include maintenance of the 7-day rolling average water temperature within 0.25 m of the bottom at 19°C or less. Maintain the daily maximum water temperature below 25ºC (77°F).

If the maximum daily water temperature should reach 26.5ºC (79.5ºF), it may be lethal and should be considered the lethal limit. Water temperature at dawn near the bottom for at least one of three monitoring stations (1) adjacent Moonstone parking lot or 2) adjacent Shamel Park or 3) between Shamel Park and Windsor Bridge) should be 16.5°C (61.7°F) or less on sunny mornings without fog or overcast and 18.5°C (65.3°F) or less on days with morning fog or overcast. Refer to **Appendices A and B** for the explanation for these temperature goals.

In the four years when continuous water temperature data were available (2001, 2002, 2005 and 2006) Santa Rosa Lagoon did not meet temperature guidelines regarding maximum daily temperature (25°C) at either Station 1 (adjacent the Moonstone Drive parking lot) or Station 2 (adjacent Shamel Park) in any year for the annual period of monitoring. Water temperature probes malfunctioned in 2003, and Stations 1 and 2 went dry in 2004 (there was a small, stagnant pool remaining near Shamel Park at Site 2, with the probe not remaining submerged). The lethal limit (26.5°C) was reached at Station 1 in every year and at Station 2 in 2006. With the 7-day rolling average calculated in 2005 and 2006, the temperature guideline for 7-day rolling average (19°C) was exceeded in both years at both sites.

In 2005, a year with the maximum stream inflow to the lagoon in the nine-year period 1998–2006, as indicated by streamflow measured near the Highway 1 bridge, none of the lagoon temperature guidelines were met for the entire period of sandbar closure. The lethal limit (26.5°C) was reached on 5 days at Site 1. The 7-day rolling average guideline (19°C) was exceeded at Site 1 until approximately 26 September 2005 (95% of the days between 23 June and 1 October), after which it was met. At Site 2 the guideline for the 7-day rolling average (19°C) was not met until approximately 1 September 2005 (70% of the days between 23 June and - October) (after which it was met). Daily maxima at Station 2 exceeded the guideline for daily maxima (25ºC) on 4 days (4%) and exceeded 24ºC) on 12 days (12%). Water temperatures at Stations 1 and 2 likely caused sub-lethal stress, reduced scope for activity leading to indirect mortality from higher vulnerability to predation and higher susceptibility to disease for Central Coast steelhead during the periods in which the 7-day rolling average was 20°C or greater (75% of days at Station 1 and 25% of days at Station 2 between 23 June and 1 October). Thus, the 2005 lagoon was a difficult location for steelhead to survive the period of sandbar closure. No juvenile steelhead were observed or captured in the fall of 2005 in the lagoon, after a wet winter when spawning near the lagoon was unlikely.

The lagoon was even warmer in 2006 than 2005. None of the lagoon temperature guidelines were met for the entire period of sandbar closure. The lethal limit of 26.5°C was reached near the bottom on 7 days at Station 1 and 9 days at Station 2, resulting from tidal overwash on most days. The daily maximum temperature guideline (25°C) was exceeded on 20 days at Station 1 and 30 days at Station 2. The 7-day rolling average guideline (19°C) was exceeded at Site 1 until approximately 23 September 2006 (91% of the days between 29 June and 1 October), after which it was met. The 7-day rolling average guideline (19°C) was exceeded at Site 2 until approximately 27 August 2006 (64% of the days between 29 June and 1 October), after which it was met. The water temperatures at Stations 1 and 2 likely caused sub-lethal stress, leading to indirect mortality from higher vulnerability to predation and higher susceptibility to disease for Central Coast steelhead during the periods in which the 7-day rolling average was 20°C or greater (66% of days at Station 1 and 46% of days at Station 2 between 29 June and 1 October). Thus, the 2006 lagoon was a difficult, if not impossible location for steelhead to survive the period of sandbar closure. Even so, 3 juvenile steelhead were captured and approximately 20 more were observed (all likely large YOY) in the upper lagoon between Shamel Park and the Windsor Bridge.

In the years 1993–2004 when water temperature was monitored at dawn at stations at two-week intervals during sandbar closure, the sunny morning temperature guideline was not met between 1 and 10 monitorings per year at one of the stations. The foggy or overcast morning temperature guideline was met in 6 of the 13 years at one of the stations. Stations 1 and 2 went dry (the lower lagoon) in 2000, 2003, 2004 and 2007, with Station 3 used in 2004 after Station 2 went dry. Refer to **Appendix A** for details.

Recommended Oxygen Concentration Enhancement Goals in the Lagoon and Previous Success in Meeting These Goals

The recommended lagoon guideline for oxygen concentration within 0.25 m of the lagoon bottom and in stream habitat is to maintain dissolved oxygen concentration at 5 mg/l or higher at one of the monitoring stations. Dissolved oxygen levels less than 2 mg/l should be considered critically low, it being close to the lethal limit and prevented if possible.

Refer to **Appendix B** for the explanation for these guidelines. Oxygen levels were not monitored in stream habitat because they are typically close to full saturation for any given temperature and seldom go below 5 mg/l, based on our experience.

Oxygen levels are typically at their lowest at dawn or shortly after. Oxygen levels at dawn may be increased if tidal overwash can be minimized or prevented. Water circulation with the air can raise oxygen concentrations and cool water temperature at night. Lagoon depth may be maintained to prevent complete filamentous algae growth throughout the water column that prevents water circulation if lagoon inflow is maximized to ideally 0.9 cfs or more. Filamentous algae may be reduced if lagoon shading is increased.

For the monitoring years 1992–2005, the 5mg/l oxygen guideline was met at one of the monitoring stations for the entire lagoon season in 3 of 14 years (1995, 1996 and 2001). The near lethal limit of 2 mg/l oxygen was avoided at one station for the entire lagoon season in 8 of 14 years. Although oxygen levels frequently failed to meet guidelines and were likely restrictive on scope of activity, they were likely less limiting than temperature to steelhead survival in the lagoon.

The recommended lagoon guideline for salinity within 0.25 m of the bottom is to avoid sudden increases in salinity to 10-12 parts per thousand associated with tidal overwash. These increased salinities should be considered stressful to non-smolting, freshwater-acclimated steelhead and should be prevented if possible. Refer to **Appendix A** for the explanation for these guidelines.

During the 4 years of continuous water temperature monitoring in the lagoon (2001, 2002, 2005 and 2006), there was evidence of 2 tidal washes in 2001, 3 tidal overwashes in 2002, 4 tidal overwashes in 2005 and 3 tidal overwashes in 2006. These tidal overwashes may cause osmoregulatory stress to steelhead, as well as raise water temperature near the bottom, forcing juveniles higher in the water column to seek cooler water and making them more vulnerable to predation. Tidal overwashes were responsible for water temperature exceeding the lethal limit near on many occasions. If the saltwater lens remains on the bottom for days, it becomes a solar collector that warms the entire lagoon. Unless the incidence of tidal overwash can be prevented, particularly after milder winters and later in the dry season when stream inflow is reduced, there will be at least short periods when lagoon water temperature guidelines for daily maximum and lethal limit will not be met, even at times other than when tidal overwash occurs. In addition, if steelhead must move out of deep areas to avoid warm saltwater lenses, they are more vulnerable to bird predation. At Soquel Lagoon in Santa Cruz County, the sandbar is artificially raised around the lagoon to help prevent tidal overwash. Usually, the sandbar is lowest where the stream exited prior to sandbar closure.

Steelhead surface hits were observed between Shamel Park and Windsor Bridge in Santa Rosa Lagoon throughout the summer of 2004, and juveniles were captured there in the fall by seining. This was the only viable steelhead habitat in the 2004 lagoon. Tidewater gobies were detected only in very low numbers in the lagoon in fall 2003 after the lower lagoon dried up, and they appeared absent in 2004 and 2005 during both the early summer and late fall sampling and in early summer 2006. (They were detected in fall 2006 and June 2007 before the lagoon mostly dried up again by October 2007.) Thus, dewatering of the lower lagoon below Shamel Park had a very negative impact on the tidewater goby population, although steelhead habitat was available upstream of Shamel Park. Based on monitoring of streamflows as the lower portions of Santa Rosa Lagoon dried up in 2003 and 2004, the recommended streamflow guideline is to maintain stream inflow to Santa Rosa Lagoon at 0.9 cfs or more through the period of sandbar closure in order to provide tidewater goby habitat in the lower lagoon, protect the tidewater goby population from extirpation and maintain steelhead habitat between Shamel Park and Windsor Bridge. **Table A7** provides information on minimum stream inflow in fall to Santa Rosa Lagoon in 1993–2007. This inflow guideline has been satisfied in only 4 years of that 15-year period. Therefore, it unlikely to be met unless a new source of water is provided to the summer/ fall lagoon from treated effluent and/or less water is pumped from wells that reduce stream inflow to the lagoon.

Recommended Streamflow to Insure Upstream Adult Steelhead Passage and Downstream Kelt Passage to the Estuary

Since passage over many riffles in the mainstem is flow dependent, steelhead are more vulnerable to shallow passage conditions in drier years. If winter storms are delayed or drought conditions exist, flows may be inadequate to allow adult steelhead migration over certain critically wide riffles. Judging by the pattern of higher YOY production in the lower valley in drier years and higher YOY production in wetter years (see pervious section on juvenile densities), shallow riffles impede adult passage into the upper canyon in some years. The opening and closing of the sandbar at the creek mouth determines the spawning period during the wet season. If storms are delayed, the sandbar remains closed longer. If storms come early and are largely absent in the spring, then the sandbar closes early, thus preventing adults from entering the creek afterwards and stranding kelts trying to return to the ocean after spawning.

Regarding minimum bypass flows downstream of the Perry Creek confluence and until 1993 IFIM data are updated, the following management guidelines are recommended:

- *In order to promote upstream adult steelhead spawning migration during the primary spawning season of January 1 – April 15, any water diversion or well extraction capable of reducing surface flow should be interrupted during stormflow episodes when streamflow between Perry Creek confluence and Main Street Bridge is less than 60 cfs and streamflow between Main Street Bridge and the bay is less than 35 cfs.*

- *In dry fall/ winters in which no storms have occurred by January 1, any water diversion or well extraction capable of reducing surface flow should be interrupted from January 1 until the first stormflow. After that, follow the guideline listed above.*

- *In order to promote out-migration of post-spawning steelhead kelts, water diversion or well extraction capable of reducing surface flow should not resume after a stormflow until the baseflow between storm events is shown to be greater than 15 cfs at the Highway 1 Bridge until May 1, and water extraction should be discontinued until May 1 if streamflow declines below 15 cfs between the first storm event and May 1.*

D.W. ALLEY & Associates performed a steelhead passage study in Reach 0a in lower Santa Rosa Creek in 1993 (**Alley 1993b**). With limited data at that time, it was estimated that a minimum bypass flow of 7 cfs would be necessary at the Windsor Bridge to prevent sandbar closure and to insure sandbar passage for kelts and smolts to the ocean. Later data on lagoon closure times and streamflow confirmed this initial estimate to be correct. Regarding upstream spawning migration, it was determined that a minimum bypass of 60 cfs was required at the critical riffle # 1upstream of Main Street (channel mile 2.80) and 35 cfs downstream through Cambria to negotiate the critical riffle # 2 at the concrete apron under the Burton Street Bridge (channel mile 2.16) (now removed), critical riffle # 3 a short distance downstream of Highway 1 (channel mile 1.19) and critical riffle # 4 just downstream of the CCSD lift station (channel mile 1.0). The Thompson rule was used, requiring 25% of the top (surface) width of the stream channel or 10% of continuous (contiguous and unbroken) top stream width be at least 0.6 feet deep. An additional condition placed on the passage criteria was that a minimum of 5 continuous feet of channel width most be at least 0.6 feet deep if the channel width was narrowed to less than 50 feet. It was determined that 25 cfs was required to maintain a minimum depth of 0.4 feet over a width of 4 feet for kelt (post-spawner) downstream passage at critical riffle # 1 and 13-15 cfs for critical riffles downstream. It was determined that 17 cfs was required to maintain a minimum depth of 0.3 feet over a width of at least 5 feet for downstream passage of juvenile smolts over critical riffle # 1 and 5.8 to 8 cfs for critical riffles downstream. However, probably a more realistic minimum of 6 cfs was required to maintain a minimum depth of 0.2 feet over a width of at least 5 feet at critical riffle # 1 and 0.2-0.3 feet depth over the other critical riffles for downstream passage of juvenile smolts, yearlings and YOY.

Recommended Streamflow Guideline to Insure Steelhead Smolt Passage to the Monterey Bay

Based on data regarding streamflow at the time of sandbar closure and data of stranded smolts after sandbar closure, the recommended guideline for insuring sufficient steelhead smolt passage to the Monterey Bay is to maintain stream inflow to the estuary at 7 cfs or greater until at least 15 May. Refer to data contained in **Table A13 in Appendix A,** which led to this recommendation.

Smolt out-migration by steelhead occurs primarily from March through May. The primary limiting factor for smolt out-migration from Santa Rosa Creek to the Monterey Bay is the early closure of the sandbar at the mouth before the migration is complete. Early sandbar closure occurs when spring stormflows are limited and low streamflow into the estuary allows closure. If smolts and kelts (adults trying to return to the Bay after spawning) are stranded in the lagoon due to early sandbar closure (in a dry year), they will most likely not survive the summer because much of the lagoon will either dry up or become too inhospitable for survival. Another limiting factor could be the dewatering of the stream channel that creates very shallow riffles or dry sections, which would be physical barriers to migration to the lagoon. From March through May, complete dewatering of the channel could occur under drought conditions with heavy well pumping.

Recommended Streamflow Guidelines to Maintain Steelhead and Tidewater Goby Habitat Through the Dry Season of Sandbar Closure and the Influence of Cambria CSD Well Pumping Upon Lagoon Inflow

Based on monitoring of streamflows as the lower portions of Santa Rosa Lagoon dried up in 2003 and 2004, the recommended streamflow guideline is to maintain stream inflow to Santa Rosa Lagoon at 0.9 cfs or greater through the period of sandbar closure in order *to provide tidewater goby habitat in the lower lagoon, protect the tidewater goby population from extirpation and maintain steelhead habitat between Shamel Park and Windsor Bridge.*

This inflow guideline was satisfied in only 4 of 15 years, 1993–2007. Therefore, the likelihood of this guideline being met in the future is unlikely unless additional water supplies are developed, such as seawater desalination and recycled water as described in the Draft Program-Level Environmental Impact Report for the CCSD Water Master Plan (**Robert Bein, William Frost & Associates 2008**), that would reduce the demand for Santa Rosa Creek well water from wells that reduce inflow to the lagoon. According the draft EIR, under one build-out scenario, approximately 602 acre-feet of supplemental water will be needed above current usage for 4,650 residences with a 50% quality of life increase over existing water consumption.

Yates and Van Konyenburg (**1998**) modeled groundwater in the drought years of 1988-89. At that time, two CCSD wells existed along Santa Rosa Creek- 27S/8E-2C5 and 26D1). They were up and downstream of the Burton Street Bridge. The San Simeon Creek wells generally were used in preference to the Santa Rosa wells due to their higher water quality, so pumpage from the Santa Rosa wells typically varied depending on streamflow patterns and groundwater levels in the San Simeon Basin. Unfortunately, the Yates model did not relate groundwater pumpage to the presence/ absence of surface flow in Santa Rosa Creek. He considered no-flow in the creek to be flows less than 0.5 cfs. Although the previous wells were replaced by one well adjacent the high school, due to petro-chemical contamination, the results of the 1988-89 model regarding groundwater drawdown and surface flow reductions may generally hold true in 2008.

Our fall streamflow measurements taken prior to any fall storms indicated that surface flow lost approximately 0.4 cfs in 2003 and 0.6 cfs in 2004 between the bridge crossing in Reach 1 and a point downstream in Reach 0a near the Highway 1 Bridge (**Figure 17**). This losing stream may have been caused by well pumping at the new CCSD P3 well adjacent to the high school after it came on line to replace the downstream wells that had been taken off line due to petro-chemical contamination. The winters of 2002-2003 and 2003-2004 had below average rainfall, although baseflow was augmented in the upper watershed in 2004 due to the December 2003 earthquake (**Figure 6**). In 2005 and 2006, when rainfall was above average, the stream was slightly losing in 2005 and gaining in 2006.

Agricultural pumpage caused as much as 25 ft of dry-season water-level decline downstream of the high school even though there was little agricultural pumpage in that area, according to the model simulation for 1988-89 (**Yates and Van Konyenburg 1998**). This drawdown resulted because agricultural pumpage in the upstream areas intercepted groundwater that would have flowed down-valley. Most of this down-valley flow would have occurred as streamflow. Municipal pumpage had no effect on water levels upstream of well 27S/8E-24L1, but contributed a maximum of about 33 ft of dry-season water-level decline near well 27S/8E-26D1 for the 1988-89 simulation.

Yates and Van Konyenburg (**1998**) stated that if streamflow is insufficient during winter, groundwater recharge will be incomplete and water levels will not return to the levels of the preceding winter. Recharge of the groundwater basin will be incomplete if stream discharge during winter is less than the cumulative storage deficit of the preceding dry season. Even if total stream discharge exceeded the deficit, recharge could be incomplete if the daily distribution of streamflow were such that some of it flowed out to the ocean. They noted that dry season storage deficits have been increasing in recent years because of increases in dry season pumpage. For example, the deficit from April 1 through December 20, 1988 was 660 acre-ft. The deficit equaled the minimum quantity of stream discharge needed for complete basin recharge and is the threshold at which detrimental effects of drought conditions will begin to appear.

According to Yates and Van Konyenburg (**1998**), a year with less than the minimum amount of stream discharge necessary to completely recharge the groundwater basin is likely to occur once every 18 years in the Santa Rosa Creek basin. The recurrence interval for a year with zero discharge is 32 years for Santa Rosa Creek. They added that, given that the consequences of even a single winter with incomplete recharge can be fairly severe, the consequences of two successive winters with incomplete recharge could be devastating. The likelihood of this occurrence would be an important factor in motivating the Cambria CSD to develop new water supplies, efficiently use recycled water and reduce municipal water demand.

In 2003, the lower lagoon in the vicinity of Station 1 went dry by 24 July with a stream inflow of 0.83 cfs, and the portion of the lagoon as far upstream as Shamel Park was dry by 18 September with a stream inflow of 0.3 cfs. There had been considerable sedimentation over the winter of 2002/2003, with the lagoon bed aggrading 2.4 feet at Station 1 and likely as much at Station 2. In 2004, lower portions of the lagoon began to dry up when stream inflow declined to about 0.8 cfs, with the lagoon bed at Station 1, 1.2 feet lower than 2003 conditions. The water surface elevation of the lagoon between Shamel Park and the Windsor Bridge started to decline when streamflow declined below 0.9 cfs in 2004. By 9 August 2004, when the stream inflow had declined to 0.64 cfs, Station 1 adjacent the Moonstone parking lot had completely dried up. As the lagoon shrank, tidewater goby and steelhead habitat were lost. Steelhead surface hits were observed between Shamel Park and Windsor Bridge throughout the summer of 2004, and juveniles were captured there in the fall by seining. This was the only viable steelhead habitat in the 2004 lagoon.

Tidewater gobies were detected only in very low numbers in the lagoon in fall 2003 after the lower lagoon dried up, and they appeared absent in 2004 and 2005 during both the early summer and late fall sampling and in early 2006. (They were detected in fall 2006 and June 2007 before the lagoon mostly dried up again by October 2007.) Thus, dewatering of the lower lagoon below Shamel Park had a very negative impact on the tidewater goby population, although steelhead habitat was available upstream of Shamel Park. **Table A11** provides information on minimum stream inflow to Santa Rosa Lagoon in 1993–2007.

Extent of Anadromy

Updated survey work for barriers to steelhead anadromy was beyond the scope of this report. Road crossings and potential steelhead barriers were mapped by CDFG in 2005 (refer to **Appendix C;** http://ccows.csumb.edu/scdp/data.htm). When the mainstem Santa Rosa Creek was surveyed to the Mora Creek confluence in fall 1994, no passage impediments were observed other than wide transverse riffles in Reach 0a. However, sometime after the 1995 flood, a potential passage impediment was observed in upper Reach 2. This was a stretch where an instream project had been completed, and the streambed had been graded into a wide, flat configuration between vertical, unvegetated streambanks. The stream thalweg had been destroyed, causing a critically shallow cross section during winter stormflows until a thalweg was re-established. This location was not re-visited, and the thalweg likely reformed during the wet winter of 1998. The concrete ford with laddered culvert at Ferracsi Road between Reaches 0b and 1 in the lower valley is a potential steelhead passage impediment if instream wood collects on the upstream entrance to the culvert and inside during stormflows. Sean Grauel, formerly of the Cambria CSD, Don Alley and Dave Highland of CDFG have cleared wood multiple times that has collected at the culvert through the years. However, Don Alley has no observations of this culvert being completely impassable to steelhead, and sampling data for juvenile densities upstream of the culvert has indicated that the culvert was passable for the entire period of sampling (1993–2006). However, the denil ladder through the Ferrasci Road culvert was impassable to sculpins except in rare instances, based on fish sampling through the years.

Although perennial flow exists in Mora Creek (**Figure 1**), judging from the topography, the gradient rapidly increases and passage impediments likely exist. There may be as much as ¼ -mile of spawning and rearing habitat on lower Mora Creek. A resident on the East Fork (**Figure 1**) reported observations of adults and juveniles in that tributary at times. However, this tributary was dry at its mainstem confluence in every year of fish sampling 1994–2006 and the gradient steepens quickly not far from the confluence. There may be ¼-mile of spawning habitat on the East Fork. It is unknown if perennial habitat exists in the East Fork. Lehman Creek has perennial flow at its mouth and is accessible to adult steelhead (**Figure 1**). Judging by the topography, Lehman Creek may have ¼-mile of spawning and rearing habitat. Curti Creek (**Figure 1**) likely is inaccessible to adult steelhead due to a perched culvert at its mouth under Santa Rosa Creek Road. It has been ephemeral at its mouth during past sampling and likely has no rearing habitat. Taylor Creek in the lower valley (**Figure 1**) is likely inaccessible to adult steelhead due to a perched culvert.

LIMITING FACTORS ASSESSMENT

Introduction

Several factors appear to limit distribution, survival and growth rate of juvenile steelhead (both small young-of-the-year fish and larger yearlings/ smolt sized YOY). These factors include passage impediments as shallow riffles, spawning habitat quality (proportion of fine sediment), spring and summer baseflow, amount of escape cover (provided by instream wood, undercut banks, unembedded boulders, water depth itself), water temperature and habitat depth. In this assessment the limiting factors have been identified for the Santa Rosa Creek mainstem and lagoon (**Table 5**).

Two wet years, 1998 and 2005, had the lowest YOY densities in the lower valley. In another wet year, 1995, although YOY densities were not determined, total juvenile densities were low in the lower valley, indicating that YOY densities were also low that year (**Figure 5**). In some drier years (1994, 1997 and 2002–2004), YOY densities were relatively higher in the lower valley than other years, and relatively lower in the upper canyon. These patterns indicated that in wetter years, adults had better passage opportunities through the estuary and lower valley to access the upper canyon to spawn more YOY. It also indicated that more habitat was available in the upper canyon in wetter years due to higher streamflow (especially in spring) and presumed greater insect drift and food supply. Whereas in drier years, spawners likely had a narrower window of spawning opportunity due to earlier sandbar closure (**Table 4**) and shallower passage conditions related to smaller stormflows.

The proportion of young-of-the-year (YOY) fish reaching smolt size in one growing season has been shown to increase with higher baseflow through regression analysis in the middle mainstem of the San Lorenzo River (**Alley et al. 2004**). Though no formal analysis has been done for Santa Rosa Creek, the same relationship between fish growth and streamflow exists in Santa Rosa Creek, especially in the lower valley.

Scale analysis of juvenile steelhead captured in fall 2006 in the lower valley verified that YOY commonly grew into Size Class II there (**Smith 2008; Appendix D**). All but one of the 15 scale samples of juveniles with standard lengths of 108 to 152 mm SL from Sites 0a-1 and 0a-2 in the lower valley were YOY. Scales from the 175 mm SL fish indicated that it was a yearling. In 2006, all except one of 49 steelhead captured up to 156 mm SL at Sites 0a-1 and 0a-2 were larger than 75 mm SL, indicating that nearly all YOY (98%) likely reached Size Class II at these sites in 2006.

For Sites 1 and 2 in the lower valley, all but 1 of 15 scale samples from steelhead between 108 and 131 mm SL long indicated they were YOY. All 10 scale samples of fish with lengths 132–156 mm SL were yearlings. The 175 mm SL fish from Site 2 was probably a yearling, also, but may have been a 2-year old with negligible growth in 2006. A 267 mm SL fish from Site 1 was at least 3 years old (all scales were regenerated to some degree). It may have been a resident (male) fish. Only 57 of the 314 captured juveniles (18%) up to 129 mm SL in length (all likely YOY) were less than 75 mm SL

(Size Class I). Likely more than 80% of the YOY reached Size Class II at these sites in 2006.

In 1995, 1996, 1998 and 2005–2006, most YOY fish at the lower 4 sites (lower valley) grew into the larger Size Class 2 by fall, thus leading to the small Size Class 1 number in those years. However, in the years with less baseflow, 1994, 1997, 1999 and 2000–2004, fewer did (**Alley 2006a**). For example, in 2005 in lower valley Reaches 0a through 2, approximately 99% of YOY's reached Size Class 2 compared to 44% in 2004 and 47% in 2003. In 2005 in upper canyon Reaches 3a through 7, approximately 38% of the YOY's grew into Size Class 2 compared 1% in 2004 and none in 2003. For the entire mainstem, an estimated 55% of YOY (12,500) reached Size Class II compared to 16% (6,100) in 2004. This same trend was detected in the San Lorenzo River and Soquel Creek (**Alley 2006c; 2006d**). In the upper canyon of Santa Rosa Creek, the growth rate of YOY's was less than that in the lower valley in all years, even in particularly high-baseflow years like earthquake-influenced 2004 and 2005. This underscored the importance of higher spring flows in wetter years that influenced growth much more than higher baseflows through the summer and fall.

Table 5. Assessment of Limiting Factors for Steelhead Salmon in Mainstem Santa Rosa Creek.

Location	Sediment-Spawning	Sediment-Rearing	Adult Passage Impediments	Spring and Summer Streamflow	Summer Water Temperature	Large Woody Material
Lagoon	No	Yes	Yes- Drier Years	Yes	Yes	Yes
Mainstem-Lower Valley	Yes	Yes	Yes- Drier Years	Yes	Yes	Yes
Mainstem – Upper Canyon	Yes	Yes	Yes- Drier Years	Yes	Yes- Short periods	Yes

Water Temperature as a Limiting Factor to Juvenile Rearing

Brett (**1956**) defined lethal temperature theoretically as that temperature at which 50% of a fish population could withstand for an infinite time. At the lethal temperature and beyond, the is a period of tolerance before death known as the resistance time (**Fry 1947**) Because of the resistance time, fish are able to tolerate diurnal fluctuations exceeding lethal temperatures (**Fry et al. 1946**). Between the upper and lower lethal temperatures is found the preferred temperature for each species. Fry (**1947**) defined the preferred temperature as the temperature range in which a given fish population will congregate when given the choice of an infinite range of temperatures. Optimal temperature is considered that which is most beneficial to the species. Tolerable temperature is that which the species can survive at.

Lethal temperature limits and the preferred temperature of a species can be altered through acclimation to changing environmental temperatures. As the acclimation temperature increases, the lethal and preferred temperatures progressively increase (**Brett 1956**). If a fish is allowed to acclimate (adjust) to a warmer temperature, it can survive at higher temperatures. This process allows a species to survive over an extended temperature range. However, the fish's food requirements increase with temperature because its metabolic rate increases. A review of the literature concerning the effects of high temperature on steelhead-rainbow trout shows considerable variation in results between different researchers. This was partially due to differences in laboratory conditions under which the studies were conducted. Uncontrolled variables such as water chemistry, season, day length, acclimation level, physiological condition, size, age, sex, reproductive condition, nutritional state and genetic history of tested fish may influence their response to water temperature levels.

Sub-lethal effects of high temperatures on salmonids include increased metabolic rates and decreased scope for activity, decreased food utilization and growth rates, reduced resistance to disease and parasites, increased sensitivity to some toxic materials, interference with migration, reduced ability to compete with more temperature resistant species and reduced ability to avoid predation.

In Santa Rosa Creek, as in other central Coast streams, water temperature is primarily a food issue. In the lower valley, water temperature is probably not directly lethal. But higher temperatures increase food demands and restrict steelhead to faster habitats for feeding, especially above 21ºC (70ºC) (**Smith and Li 1983**). The lethal level for steelhead would probably be above 26-28ºC (79-82ºF) for several hours during the day. But this is rarely, if ever reached. Even so, warmer temperatures could result in slow growth or starvation in steelhead if food supply becomes very limited. Summer water temperatures were measured in the lagoon in 1993–2005 (**Alley 1995b-2006b**) and further upstream in 2003–2006 (**Alley 2004a-2007a**). Daily maximum water temperature often rose above 21ºC (70ºF) in the lagoon and upstream. Daily temperature maxima commonly rose into the 23-24ºC (73-75ºF) range in the lower valley. These lower mainstem reaches often provide habitat for large yearling steelhead and fast-growing YOY. The high growth rate in the lower valley mainstem leads to relatively high densities of smolt-sized juveniles in some years and a substantial proportion of the smolt-sized (=>75 mm SL) steelhead in the watershed.

Water temperature is partially controlled by air temperature and stream shading. Stream shading is affected by topography (canyon versus valley), sun angle (daily and seasonal), stream orientation (east-west or north-south), streamflow (less water heats up quicker than more water), tree canopy (over the stream and on surrounding slopes), tree species (deciduous or evergreen, broadleaf or needle leaf) and seasonality of leaf production and leaf-drop by deciduous riparian trees. The volume of streamflow determines the amount of heat from solar radiation and air contact that is required to increase water temperature. The more flow, the slower the increase in daily temperature and the lower the maximum daily temperature for any given amount of sunlight and shading. The creek will warm up faster in unshaded reaches on a hot summer day during a drought compared to the creek in summer after a wetter winter, given the same amount of shading and air temperature.

Fishes are poikilotherms, meaning their body temperatures conform to the temperature of the water they inhabit. As water temperature increases, fishes' bodies warm up, chemical reactions (metabolism) go faster inside their bodies, their ability for activity increases to a point, they consume more oxygen and they must consume more food to support higher metabolic rates. But higher water temperatures that occur in the lower valley of Santa Rosa Creek and lagoon speed up primary (plant life) and secondary (aquatic insects) productivity that result in more food available to fish. Juvenile steelhead can digest food faster at warmer temperatures, allowing them to process more food and grow faster to reach smolt size the first year, so long as they can find enough food.

Sediment as a Limiting Factor

Input of fine sediment to the stream channel degrades salmonid spawning and rearing habitat. Adult steelhead salmon bury their eggs in the streambed gravels in nests (redds) in winter and spring, where they incubate for weeks before fry emerge as much as 2 months after the eggs were spawned. Excessive fine sediment in the absence of coarse gravel fills the interstitial spaces and prevents water from move through the gravel to provide adequate oxygen to the eggs and sac-fry. As percent fine material increases, egg survival declines. Also, with spawning areas dominated by fine material, scour of redds by later storms is highly likely. Water depth and hiding places (under wood, boulders, undercut banks) are important for juvenile salmonids to avoid predators. High sediment inputs degrade rearing habitat because it shallows pools and embeds larger cobbles and boulders to reduce escape cover. Suspended sediment also creates high turbidity that prevents juvenile salmonids from efficiently feeding on drifting insects, thus reducing growth rate.

The Santa Rosa Creek drainage is subject to episodically high inputs of fine sediment during large flood events, such as occurred on 10 March 1995. Sediment enters the stream primarily from streambank erosion and landslides.

Sedimentation during large floods tends to create wide riffles that become critically shallow passage areas for migrating adult steelhead. Therefore, sedimentation can increase the minimum streamflow required for successful migrational passage of steelhead adults and juvenile smolts. D.W. ALLEY & Associates performed a steelhead passage study in Reach 0a in lower Santa Rosa Creek in 1993 (**Alley 1993b**). Refer to the summary of results in the adult passage section below.

When embededdness (the amount that larger particles are buried in fine sediment) of cobbles and boulders in the streambed to greater than 25%, it limits the escape cover available under larger substrate. The upper canyon reaches were the only ones that contained cobbles greater than 250 mm (10 inches) in diameter that could provide escape cover. Embeddedness in upper canyon step-runs and runs was 35% or greater (**Figure 21**). Embeddedness in upper canyon pools was 50% or greater in 2006 (**Figure 22**). Therefore, embeddedness was limiting.

Stream sedimentation from erosion destroys spawning and rearing habitat. **Figures 23 and 24** show the relationships between particle size and survival of embryos in the spawning redd and between percent sand in the spawning redd and fry emergence survival. Survival of both life stages is increased with larger particle size and less sand. Sediment also fills pools and buries objects of cover. Juvenile steelhead do best where deep pools exist that possess overhanging tree branches, boulders and large wood for them to hide under.

Figure 23. Relationship between percent embryo survival and geometric mean diameter of the spawning substrate.

(from Shirazi et al. 1981).

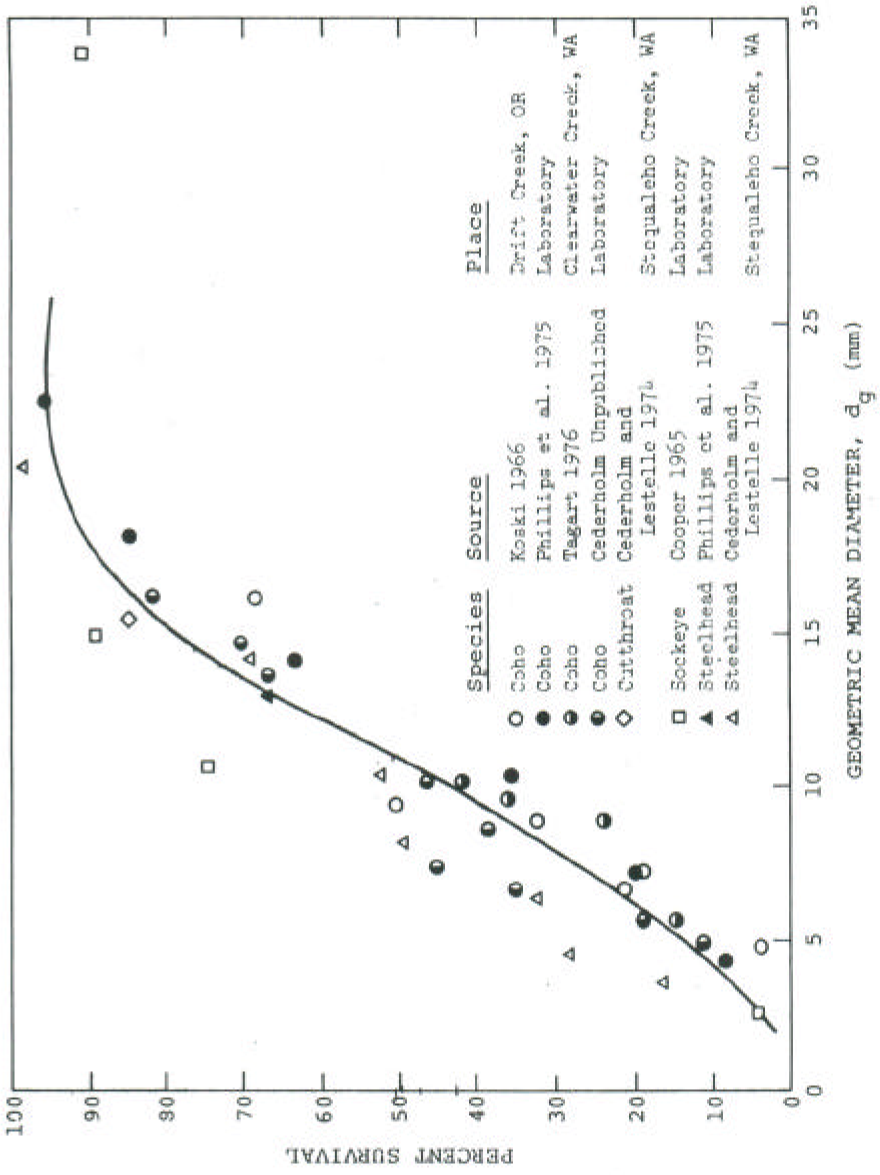


Figure 2. Relationship between percent embryo survival and geometric mean diameter of the spawning substrate (from Shirazi et al. 1981). From Bratovich and Kelley, 1988.

Figure 24. Relationship between average percent fry emergence survival and percentage of 1-3 mm sand.

(adapted from Hall and Lantz 1969)

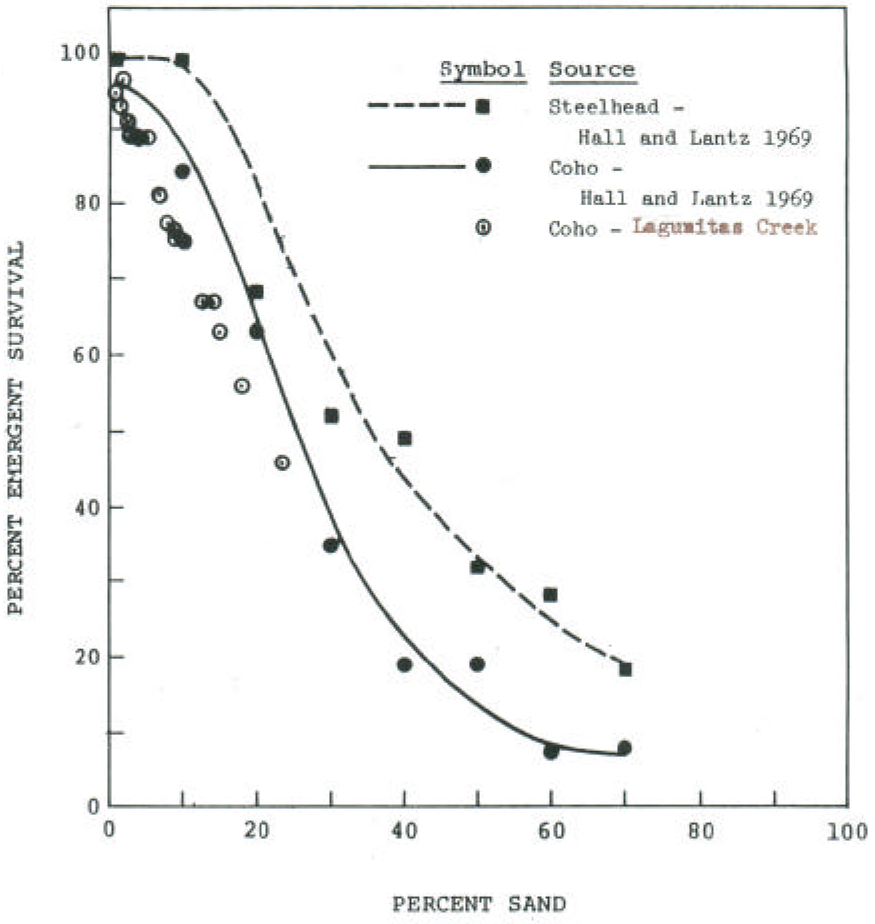


Figure 3. Relationship between average percent fry emergence survival and percentage of 1-3 mm sand (adapted from Hall and Lantz 1969). Values for this study were estimated from the relationship developed by Phillips et al. (1975) and were based upon the percentage of all materials less than 3 mm diameter in the mounds of 17 coho salmon redds in Lagunitas Creek, 1983/84. Presented in Bratovich and Kelley, 1988.

Instream Wood as a Limiting Factor

Large instream wood (previously called large woody debris- LWD) in the active channel is important for providing structure necessary for development of pools and backwaters, which are vital summer and overwintering habitat for juvenile steelhead (*Oncorhynchus mykiss*) (**Smith 2000**). It serves important habitat functions for other species, such as California red-legged frog (*Rana aurora draytonii*). Large wood (1-foot in diameter and 20 feet or more in length) and smaller wood that accumulate in pools are extremely important sources of escape cover for juvenile salmonids. The highest quality large wood includes downed trees or logs with their rootwads attached, whose lengths are about 1.5 times the bankfull width of the channel or more and positioned with a sufficient proportion of their lengths on the streambank, or otherwise well-anchored, so as to provide stability during high flows as well as scour of the channel bed. The quality of pools formed by large instream wood can vary considerably with the size (length, diameter), type of wood (single or multiple trunks or rootwads) and its position within the channel. Complex pools formed from large logs or rootwads, which extend out into the channel, can provide a variety of water velocities in summer and excellent escape cover. These complex pools are the preferred summer habitat for yearling-sized steelhead. Wood clusters also provide extremely important summer foraging habitat for California red-legged frogs and western pond turtles (*Clemmys marmorata*).

The backwaters and pockets formed by large, current-obstructing wood can also provide refuges during stormflows, and may provide much of the crucial overwintering habitat necessary to prevent heavy loss of juvenile steelhead in wet winters during high stormflows (**Smith 2000**). These winter backwater areas may actually be stagnant, shallow or even dry in summer. However, they may provide important habitat for overwintering fish and recently emerged steelhead fry in spring. They may also provide important reproductive habitat for amphibians, including newts (*Taricha* spp.), Pacific tree frogs (*Hyla regilla*) and California red-legged frogs.

Wood clusters can produce impediments or complete barriers to fish movement, but the majority of clusters are not significant impediments (**Smith 2000**). In weakly entrenched channels, the stream can usually cut around wood clusters. In sandy channels, scour under the cluster usually provides passage. In addition, during high flows a portion of the wood cluster may float. In steeper, entrenched gravel/cobble channels the wood cluster may plug with coarse sediment, producing a pronounced step (grade control) or falls. Even in those cases, removing only a few key pieces may provide passage around the cluster at regular winter flows. In headwater reaches, these grade control clusters may store significant sediment behind, which may prevent sedimentation downstream and outweigh the passage benefit of rearranging or removing the wood cluster. However, if wood clusters are causing lateral (sideways) scour into streambanks with significant bank erosion or landsliding, their modification may be warranted, particularly if the toe of the eroding bank or slide can be protected with rearrangement of the wood and fish cover can be maintained.

Steeper, narrow, entrenched channels have high velocities during floods, resulting in poorer wood retention and less complex configurations of the wood that remains (**Smith 2000**).

Alders provide a more continuous supply of in-channel wood, but they are relatively small and have relatively short-term benefits because of their small size and low durability (**Smith 2000**). They break up during flood flows and rot quickly. Other broadleaf trees, including bigleaf maple, cottonwood, sycamore, California bay and oak also have small trunk diameters and short longevity in the stream. Alders may create much of the pool habitat in wood-scoured pools and much of the wood clusters.

Santa Rosa Creek has a history of massive influxes of wood during large flood events, such as the March 1995 flood. This is typical of coastal watersheds, where recruitment of wood into the channel may be sporadic and occurs mainly during large flood events. At any one time, the majority of the wood within the channel may provide little or transitory habitat benefit, and individual pieces may shift locations, orientation and clustering. However, the total amount of wood available is important in order to maintain the number of beneficial habitat features. The habitat value of new, naturally recruited wood and much of the old wood can be increased relatively cheaply by repositioning it in the channel and flood plain. Since much of the cost of habitat improvements is from transporting wood to the site and into the channel, it makes sense to treat episodic flood-year wood as a "windfall" where nature has done most of the work.

Streamflow as a Limiting Factor for Rearing of Juvenile Steelhead

Streamflow as a limiting factor is the primary element that defines total available habitat for salmonids. It is a limiting factor affecting the migratory success of adults reaching spawning habitat and smolts reaching the Monterey Bay. Streamflow determines the ability of the stream to move sediment and the force to scour pools and spawning beds, thus affecting habitat quality and microhabitat features. These microhabitat features include habitat width, water depth, water velocity, surface turbulence (affects the amount of cover), rate of insect drift as food for drift-feeding salmonids and, to some degree, water temperature and oxygen concentration.

Streamflow plays an important role in the balance between food availability and growth for steelhead. The quantity of streamflow not only dictates the amount of habitat available to fish and aquatic insects (juvenile steelhead's preferred food) but also acts as a "conveyor belt" for delivery of food to feeding steelhead. The more streamflow that is available in spring and summer, the more food that is available to be delivered to the fish. As summer flows recede and less habitat becomes available to fish and aquatic insects, the conveyor belt of food slows down. Water temperatures also rise as flows recede in the summer months, causing higher metabolic rates for fish and increased food requirements.

The result of interactions between streamflow, habitat availability, and the conveyor belt of food is higher growth rates for fish in the spring months and maintenance or reductions in fish size in the summer and fall months. The size of smolts reaching the ocean plays an important role in ocean survival and probability of them returning as adults. Larger smolts tend to have higher survival rates in the ocean because they can swim faster and avoid predators more easily than smaller ones. Also, YOY fish that can smolt after one growing season need only to over-winter once instead of twice in freshwater, greatly reducing their mortality rate prior to smolting. Therefore, growth rate is very important.

In addition to requiring adequate food for growth, juvenile steelhead have specific habitat requirements, essential for survival. These include fastwater feeding areas to take advantage of food moving along the "conveyor belt" and locations to hide from predators (referred to as escape cover) and find refuge from high winter flows. Salmonids feed on drifting insects that have either dropped into the stream as adults from streamside vegetation or have been produced in riffles and runs as larvae. Generally, the faster the water velocity, the more insect drift that may be fed upon. Juvenile densities become reduced if fastwater areas become too shallow due to reduced streamflow or sedimentation that has filled in deeper pocket water. Escape cover can include deep pools, undercut banks, side channels, large unembedded cobbles and boulders, rootwads, large wood, and overhanging vegetation. Streams that lack adequate escape cover may have low fish densities, regardless of the amount of food available.

Many other factors besides streamflow affect microhabitat quality. Streamflow in combination with the stream's geomorphic features affect spawning habitat and rearing habitat in different ways. Scour objects (wood, large boulders, bedrock outcrops) affect pool depth and escape cover. Other geomorphic features that influence microhabitat include steepness of the streambank, degree of channel entrenchment, undercut streambanks, amount of fine sediment deposition, substrate size composition, substrate embeddedness, stream gradient, frequency and length of shallow fastwater habitat versus slower deepwater habitat and the hydraulic features of transitional breaks between habitat types. Still other factors are riparian tree composition (species and size), proximity of riparian trees to the streambank (affecting frequency of undercut streambanks) and tree canopy (affecting visual clarity for feeding, food productivity and water temperature). These microhabitat features impact each phase of fish life history.

With seasonal rainfall, streamflow is often a scarce resource for human systems where there are water demands for municipal, agricultural, and industrial uses, as well as fire protection and recreation. Human demands for water compete with the need to maintain streamflow for biological systems. Human water demand also peaks during summer and early fall when streams are experiencing their lowest flows of the year. Due to the low summer streamflow in most streams, streamflow is a limiting factor for steelhead production even in the absence of human use of this valuable resource. When water extractions are added, streamflow becomes a more severe limiting factor.

In Santa Rosa Creek, the seasonal water supply and demand have resulted in the need for groundwater pumping. According to Yates and Van Konyenburg (**1998**), the water supply for the Cambria area is vulnerable to drought because the groundwater basins of San Simeon and Santa Rosa creeks provide the only supply of water during the dry season and because groundwater storage capacity is small relative to the demand for water. The amount of usable ground-water storage capacity above sea level is about

3,800 acre-ft in the Santa Rosa Basin. Total annual pumpage during 1988-89 was about 30 percent of the storage capacity of the basin (**Yates and Van Konyenburg 1998)**. Water storage in the aquifer at the beginning of the dry season is similar each year, but the length of the dry season varies. If the dry season were exceptionally long and pumping continued undiminished, wells could go dry or subsidence or seawater intrusion could occur before recharge begins the following winter. Land subsidence and ground deformation occurred in Cambria in the summer of 1976 and could occur again if the minimum dry-season water level is close to or less than the record low level reached that year (**Yates and Van Konyenburg 1998)**. Partly for these reasons, there are legal limitations on annual and seasonal quantities of municipal pumpage for the basin.

The impact of water extraction on fish populations depends on timing, magnitude, and location of the surface diversion/ well. The timing of water extraction is important in determining which salmonid life stage is impacted. The magnitude is important in terms of amount being extracted and what remains for bypass.

In looking at streamflow measurements down the mainstem through the various reaches in fall of multiple years, the stream appears to gain streamflow from Reach 6 down to Reach 3b (except in 2004 after the 2003 earthquake) (**Figures 1 and 17**). The stream loses streamflow from Reach 3b to 3a (except in 1999 after 2 storms). Prior to the earthquake, there was an approximate 2-mile stretch of dry stream channel in upper Reach 2. In 2004, this normally dry stretch had streamflow. In 2005 and 2005, it had approximately 0.5 miles of dry streambed. In 1998, the stream gained streamflow from Reach 2 to Reach 1. The stream gained streamflow from Reach 1 to 0a in 1998, 1999 (after 2 storms) and 2006. It lost streamflow from Reach 1 to 0a in 2001–2005. The large decrease in streamflow from Reach 1 to Reach 0a in 2003 and 2004 indicated that groundwater pumping had a significant impact on surface flow. In October 2007 prior to rainfall, streamflow upstream of the Ferrasci Road ford in lower Reach 1 was visually estimated at 0.5 cfs, and streamflow was absent in upper Reach 0a at the Main Street Bridge and downstream.

Yates and Van Konyenburg (**1998**) modeled the Santa Rosa Creek groundwater basin for summer 1988 (a drier year), producing a calibration simulation that predicted that the stream between the high school (Reach 0b) and the Highway 1 Bridge downstream (Reach 0a) was dry from July through mid-December when agricultural and municipal pumping were included in the model. Without agricultural pumpage, but with municipal pumpage retained in the model for 1988, the simulation predicted that a trickle of baseflow emerged near well 27S/9E-19H2 and flowed continuously in all months except October when a short reach near well 27S/8E-27H1 (near Highway 1) went dry. Since 1998, surface flows continued year round through Reaches 0a and 0b until fall 2007, when the stream channel went dry.

The location is important in understanding the cumulative effect of multiple diversions on downstream habitat conditions and population numbers. In a very dry year, well pumping may reduce streamflow enough to dry up most of Reach 0a except a few isolated pools and may reduce the lagoon to small, stagnant, warm pools, eliminating all steelhead habitat and nearly all tidewater goby habitat. This dewatering occurred in 2007 and was likely hastened and increased by well pumping. Though stream inflow continued through the dry season, in 2003 and 2004, the lower lagoon went dry at Stations 1 and 2, with only the upper lagoon between Shamel Park and Windsor Bridge providing habitat. The lower lagoon had become more sedimented in 2003, making it more prone to dewatering in both years. The tidewater goby population was very low in fall 2003 and not detected in fall 2004 or summer and fall 2005. It was next detected in fall 2006 and early summer 2007. The loss of lagoon habitat in 2003 and 2004 and was likely caused by well pumping. The dewatering of the lagoon in 2007, except for 2 small pools at Stations 1 and 2, was likely hastened and was at least partially caused by well pumping.

Water diversion, particularly in drier springs, may hasten the timing of sandbar closure at the creek mouth. The sandbar at the mouth of Santa Rosa Creek closes each year in the spring/ early summer when stream outflow is insufficient to maintain a channel through the beach. The minimum streamflow to maintain an open channel varies with the year, with records of the sandbar closing at streamflows between approximately 2 and 12 cfs. It typically closes at streamflows less than approximately 7 cfs. Steelhead smolts and spawned kelts are out-migrating to the Monterey Bay in the spring. If the sandbar closes too early, smolts and kelts are trapped in the lagoon, which in most years does not provide adequate habitat for survival until the next rainy season. Years in which many trapped smolts and kelts have been observed in the lagoon were 1994, 1997, 2002, 2007 and 2008.

Streamflow as a Limiting Factor in Adult, Kelt and Smolt Passage

As mentioned in the life history description, most adult steelhead migrate up their natal streams from January through early May. Adult salmonids typically migrate as stormflow begins to subside from any storm event. Migration occurs primarily at night, though light is required to negotiate obstacles. The likelihood of spawning redds (nests) being scoured or smothered in sediment declines and percent egg survival generally increases in an upstream direction in any watershed. Usually quality of spawning gravel increases upstream. Therefore, spawning success is generally highest in the upper reaches of the watershed. A spawning obstacle may be a partial impediment that is passable if the fish reaches it at a time when streamflow is high enough to allow passage but not too high to create a velocity barrier. Fish may congregate below impediments until stormflows are right, increasing their risk to predation and angling and delaying their egg laying. When adult salmonids are impeded or entirely blocked by obstacles to upper stream reaches, the number of young-of-the-year fish annually produced may be significantly curtailed. The cheapest way to increase the juvenile salmonid population is often by improving passage over obstacles when significant spawning and rearing habitat exists upstream.

Benefits of a Properly Functioning Riparian Zone

A properly functioning riparian corridor will reduce limiting factors, such as warm water temperature, excessive stream sedimentation and the shortage of large wood recruitment to the stream channel.

There is a growing body of evidence that buffers along streams are necessary to protect aquatic ecosystems from potential disruption and degradation. The purpose of riparian buffer strips is to allow natural interactions between riparian and aquatic systems to be sustained so that appropriate instream ecosystems, sediment regimes and channel forms can be maintained. Reid and Hilton (**1998**) enumerated specific roles of riparian zones in relation to the instream environment as follows:

- Maintenance of the aquatic food web through provision of leaves, branches and insects
- Maintenance of appropriate levels of predation and competition through support of appropriate riparian ecosystems
- Maintenance of water quality through filtering of sediment, chemicals and nutrients from upslope sources
- Maintenance of an appropriate water temperature regime through provision of shade and regulation of air temperature and humidity
- Maintenance of bank stability through provision of root cohesion on banks and floodplains
- Maintenance of channel form and instream habitat through provision of wood and restriction of sediment input
- Moderation of downstream flood peaks through temporary upstream storage of water
- Maintenance of downstream channel form and instream habitat through maintenance of an appropriate sediment regime

According to Reid and Hilton (**1998**), riparian zones are important to adjacent instream ecosystems because the strongly control the availability of food, distribution of predators, form of channels and distribution of temperatures (**Murphy and Hall 1981, Naiman and Sedell 1979, Theurer and others 1985, Zimmerman and others 1967**).

Riparian buffer strips in timber harvest zones have been recommended in the past because they have been demonstrated to protect instream habitat (**Erman and others 1977, Murphy and others 1986, USDA 1994**). Riparian buffer strips have become a widely accepted way to help protect aquatic ecosystems and water quality from the effects of upslope activities. According to Reid and Hilton (**1998**), the Forest Ecosystem Management Assessment Team (FEMAT) recommended the establishment of riparian reserves to help sustain the proper functioning of processes that influence habitat, and thus to provide for habitat requirements for coho salmon and aquatic species. Because steelhead habitat requirements are similar to those of coho salmon, riparian reserves would offer them the same protection. Such buffer zones were recommended for Federal lands in the Pacific Northwest (**Femat 1993**). The National Marine Fisheries Service (**Spence and others 1996; in the ManTech report**) made similar recommendations for the design of Habitat Conservation Plans on non-federal lands in the same region. Under the Northwest Forest Plan, prescribed buffer widths for fish-bearing streams are a minimum of two tree heights' width, and the ManTech report concluded that buffers equal to or greater than one tree height's width were necessary, depending on which riparian functions were to be maintained. The Nevada Ecosystem Project recommended a minimum of a one-tree-height buffer (**Kondolf and others 1996**). According to Reid and Hilton (**1998**), all of these recommendations specify that management activities be avoided within riparian zones unless they are compatible with the restoration and preservation of appropriate riparian and aquatic function.

The National Marine Fisheries Service considered riparian habitat to be critical habitat for the federally Threatened steelhead. Removal of riparian canopy over a stream is considered an adverse modification and is subject to review by the National Marine Fisheries Service (NMFS) under the Endangered Species Act for projects requiring Army Corps 404 permits for modifications to stream channels. The National Marine Fisheries Service typically recommends in short-term Habitat Conservation Plans that an Aquatic Protection Zone (APZ) be established from the outer edge of the bankfull channel a distance horizontally equivalent to the site potential tree height on Class I and II watercourses in order "to protect the functions and processes of the riparian zone." Within this APZ the National Marine Fisheries Service typically recommends that, other than road related activities, no management operations be allowed within the APZ or adjacent bankfull channel. For Class III watercourses, the National Marine Fisheries Service typically recommends 50-foot Aquatic Management Zones (AMZ) for slopes <30% and a 100-foot AMZ for slopes >30% where conifer tree size distributions will be left representative of the pre-management stand, with no management operations within 30 feet of the outer edge of the AMZ or adjacent bankfull channel.

Brown (**1991**) stated that the mass soil movement in forest watersheds is often triggered by road construction. He stated that one landslide or slump can place several times more sediment into a stream than is normally carried during a year. Roads made by cut and fill operations on slopes create roadbeds of potentially unstable fill material. These roads may change drainage patterns and sometimes focus runoff onto unstable slopes below, especially if the roads are not out-sloped.

Erosion, sedimentation and habitat degradation may be expected to increase in association with increased road building in suburban areas, with increased impermeable surfaces that lead to higher stormflow from increased runoff and less percolation, with continued land-use management without adequate protection of the riparian corridor and lack of maintenance of erosion control measures, with increased clearing of forested areas for human development and increased use of unpaved road surfaces, with continued clearing of streamside vegetation by streamside residents and with continued removal or cutting of instream large woody material.

GROUNDWATER HYDROLOGY

The Santa Rosa Valley Groundwater Basin lies under the Santa Rosa Valley. Its surface area is 4,480 acres (7.0 square miles). The groundwater storage capacity of the basin was estimated at 24,700 acre-feet by the California Department of Water Resources (**1975**). The groundwater basin is bounded on all sides by impermeable rocks of the Jurassic to Cretaceous age Franciscan Group except for the Pacific Ocean to the west. The valley is drained primarily by Santa Rosa Creek, with Green Valley and Perry creeks to the south. The groundwater contains concentrations of dissolved solids, chloride, iron and manganese in some locations that exceed drinking water standards (**Yates and Van Konyenburg 1998**). Annual rainfall averages from approximately 20 inches near the coast to approximately 26 inches at the eastern end of the valley floor to more than 40 inches at the headwaters (**Yates and Van Konyenburg 1998**). Groundwater exists in alluvial deposits with an average specific yield of 17% (**California Department of Water Resources 1975**). It is confined and generally flows westward to the ocean. The alluvial deposits are about 100 feet thick under the center of the valley and more than 120 feet thick at the coast (**Yates and Van Konyenburg 1998**). These deposits are made up of gravel, unconsolidated sand, silt and clay. Basin recharge is primarily by percolation of streamflow with some infiltration of rainfall and excess irrigation flow (**California Department of Water Resources 1958**).

There is likely seasonal fluctuation in groundwater level, as indicated in 1988 when it declined 1 to 7 feet/ month from February through August and slowed or even reversed the decline at most wells during November and early December (**Yates and Van Konyenburg 1998**).

Yates and Konyenburg (**1998**) simulated a groundwater budget from their model for April 1988 through March 1989 during a dry period. They estimated 140 acre-feet/year recharge from rainfall, 470 acre-feet/year from creek flow, 370 acre-feet/year from subsurface inflow, with 60 acre-feet/year subsurface outflow to the ocean. Agricultural pumpage was estimated at 890 acre-feet/year, with recharge to the basin of 330 acre-feet/year from irrigation-return flow. Municipal and rural pumpage at the time was estimated to be 260 acre-feet/year, while phreatophyte (vegetation) transpiration (evaporation through the leaves) was estimated at 160 acre-feet. Some cropland has been converted to drip irrigation, and new orchards and vineyards have appeared since 1988 (**Alley personal observation**).

In summer, Santa Rosa Creek acts locally as a drain for groundwater. Yates and Konyenburg (**1998**) were able to follow subsurface flow by noting changes in groundwater level in their study with numerous test wells during a drought. They noted that because of subsurface flow obstructions, the water table intersected the streambed near a certain well (27S/9E-19H2) and emerged as streamflow in the creek. During the summer of 1988, this flow was several cubic feet per second and continued downstream as far as another well (27S/8E-24N2). During the summer of 1989, flow eventually receded to the vicinity of another well 27S/8E-24J4.

It seems likely to conclude that well pumping was influencing groundwater level and surface flow during their work. The first reach of the creek to dry up during streamflow recession is important from a fisheries management perspective. After each of two streamflow peaks in December 1988 (presumably resulting from storm events), one of the first reaches of Santa Rosa Creek to go dry was the reach adjacent to well 27S/8E-27H1 (**Yates and Van Konyenburg 1998**).

Agricultural pumpage caused as much as 25 ft of dry-season water-level decline downstream of the high school even though there was little agricultural pumpage in that area, according to the model simulation for 1988-89 (**Yates and Van Konyenburg 1998**). This drawdown resulted because agricultural pumpage in the upstream areas intercepted groundwater that would have flowed down-valley. Most of this down-valley flow would have occurred as streamflow. Municipal pumpage had no effect on water levels upstream of well 27S/8E-24L1, but contributed a maximum of about 33 ft of dry-season water-level decline near well 27S/8E-26D1 for the 1988-89 simulation.

Yates and Konyenburg (**1998**) noted that the water supply for the Cambria area is vulnerable to drought because the groundwater basins provide the only supply of water during the dry season and because groundwater storage capacity is small relative to the demand for water. They stated that the amount of usable groundwater storage capacity above sea level is about 3,800 acre-ft in the Santa Rosa Basin. According to them, there had been a fourfold increase in municipal pumpage between 1960 and 1988 due to the rapid growth in population in Cambria. Total annual pumpage (agricultural and municipal) during 1988-89 was about 30 percent of the storage capacity of the basin.

Yates and Van Konyenburg (**1998**) stated that if streamflow is insufficient during winter, groundwater recharge will be incomplete, and water levels will not return to those of the preceding winter. Recharge of the groundwater basin will be incomplete if stream discharge during winter is less than the cumulative storage deficit of the preceding dry season. Even if total stream discharge exceeded the deficit, recharge could be incomplete if the daily distribution of streamflow were such that some of it flowed out to the ocean. They noted that dry season storage deficits have been increasing in recent years because of increases in dry season pumpage. For example, the deficit from April 1 through December 20, 1988 was 660 acre-feet. This deficit equaled the minimum quantity of stream discharge needed for complete basin recharge and is the threshold at which detrimental effects of drought conditions will begin to appear.

Yates and Van Konyenburg (**1998**) stated that land subsidence and ground deformation occurred in Cambria in the summer of 1976 during drought and could occur again if the minimum dry-season water level is close to or less than the record low level reached that year. Ground fractures developed on the north side of Santa Rosa Creek in the commercial district near Burton Avenue. The building formerly used by the Cambria CSD on the north side of Santa Rosa Creek had to be abandoned due to foundation instability (**Alley personal observation**). Cleveland (**1980**) attributed the subsidence to a trend of increasing water use and below-average recharge in the early 1970's, combined with the short-term effects of the drought of 1975-76. An additional factor was that in late 1972, individual septic systems in Cambria were replaced with a central sewer system, which decreased the quantity of local groundwater recharge. By decreasing the quantity of local recharge, sewering caused water levels to decrease faster in response to pumping than they would have otherwise.

According to Yates and Van Konyenburg (**1998**), a year with less than the minimum amount of stream discharge necessary to completely recharge the groundwater basin is likely to occur once every 18 years in the Santa Rosa Creek basin. The recurrence interval for a year with zero discharge is 32 years for Santa Rosa Creek. They added that, given that the consequences of even a single winter with incomplete recharge can be fairly severe, the consequences of two successive winters with incomplete recharge could be devastating. The likelihood of this occurrence would be an important factor in motivating the Cambria CSD to develop new water supplies, efficiently use recycled water and reduce municipal water demand.

Yates and Van Konyenburg (**1998**) noted that streamflow in Santa Rosa Creek at the Windsor Boulevard Bridge (just above the lagoon) was greater than the flow at the upstream Highway 1 Bridge, on several occasions during low-flow conditions. This gain was less than 1 cfs, but could make a significant difference to inflow to the lagoon and the viability of habitat there. They surmised that this gain in flow was probably caused by groundwater that was forced to the surface by a bedrock constriction in the aquifer.

WATER CONSERVATION RECOMMENDATIONS FOR NON-AGRICULTURAL LAND USES

The following list of water conservation recommendations is based on information provided at Internet links (listed below) of the Cambria Community Services District, California American Water Company (Monterey County) and the Soquel Creek Water District (Santa Cruz County). More detailed information and links are provided in the sections following the list.

1. Provides a free water-wise house call to customers. The water district representative should survey the customer's existing water use equipment and suggest improvements to decrease water usage.

2. Install low-flush toilets (1.5 gallon-per-minute or less).

3. Install self–regenerating water softeners.

4. Install hot water recirculating systems.

5. Install pressure regulators on the incoming water supply (set at a maximum of 50 pounds per square inch gage and locate close to water meter).

6. Install 70-gallon maximum capacity bathtubs, Jacuzzi and Whirlpool spas for units designed to be drained after use

7. Install showerheads with maximum flow of 2 gallons-per-minute at 50 pounds of pressure, equipped with shut-off valve near showerhead.

8. Install kitchen faucets with aerator that allows a maximum flow of 2 gallons-per-minute at 50 pounds of pressure.

9. Install lavatory faucets that allow 0.5 gallons-per-minute at 50 pounds of pressure.

10. Limit showers to 5 minutes. Turn off shower while lathering up. Take quick showers instead of baths.

11. Do not leave water running while shaving or brushing your teeth.

12. Run dishwashers and clothes washers only when full. Use water saver cycles when possible.

13. Substitute alternatives to turf lawns, such as drought-tolerant trees, shrubs, boulders, mulched areas, pathways and other materials.

14. If possible, choose native plants that thrive without irrigation, or plants with needs that match the climate and soil conditions. Natives are easy to grow and have adapted to the local climate and pests.

15. Install drip irrigation systems for shrubs and trees and always locate turf (preferably minimal or non-existent) on a separate valve.

16. Add organic matter to the soil before you plant to increase water retention and penetration.

17. Plant in the fall or winter, or early in spring after the last frost. Dig the hole large enough for the plant's roots. Prepare the soil by loosening and adding compost and mulch to keep roots moist.

18. Water drought-tolerant plants for their first two or three seasons. Drip irrigation and water soaker hoses are preferable to sprinklers.

19. Spread two to three inches of mulch around trees and shrubs to keep soil cool, enhance water retention and retard weed growth. Mulch can include rocks, wood chips, bark, or shredded wood.

20. Group plants according to their water and sun needs so that each area receives the proper amount.

21. Set your irrigation system to match the permeability of the soil. If soils are clay, reduce irrigation amounts and intervals to prevent standing water and runoff. Keep watering intervals on slopes short to prevent water waste from runoff.

22. Make seasonal irrigation adjustments and efficiency checks to save water. As air temperatures and day length change, so do irrigation requirements.

23. Do not allow water to run off onto other properties or the street.

24. Do not leave watering/irrigation of landscaping unattended.

25. Do not irrigate landscape between 10:00 a.m. and 6:00 p.m. Water landscaping during the coolest part of the day to reduce evaporation.

26. Irrigate the minimal amount to maintain landscaping.

27. Do not wash down sidewalks, driveways, parking lots, etc. Use a broom.

28. Repair leaks in plumbing or your water distribution system within 8 hours of discovery.

29. Wash cars with a bucket and only rinse with a hose that has a shutoff nozzle.

30. Restaurants should not serve water to customers unless requested.

31. Provide to businesses restroom mirror decals that ask guests to contact the management if they notice water leaking and remind them to use water wisely.

32. Provide to restaurants table tents and menu decals that explain to guests the businesses' interests in conserving water. The materials ask customers to choose for themselves as to whether they would like water or not.

33. Provide to hotels/ motels linen choice cards that go on the vanity and bedside tables that let the guest choose to use the towels and linens again on multiple day visits.

34. Make available water-wise garden mini-grants to non-profit organizations and schools to help fund innovative projects designed to encourage public participation in water conservation.

35. Do not use potable water for dust control or construction activities.

NON-AGRICULTURAL WATER CONSERVATION PROGRAMS AND RECOMMENDATIONS

Information and Incentives Provided by the Cambria Community Services

Source Cambria Community Services District Internet link
http://www.cambriacsd.org/Library/Publications/PDF/CCSD_Nov02_FINAL.pdf.

As of 2002, the District continued to offer $150 rebates on installation of Energy Star washing machines and 1.0 gallon-per-flush toilets. A $100 rebate was offered on 1.5 gallon-per-flush toilets.

The following are key guidelines governing the retrofit rebate program in Cambria:

- Only one rebate per service address per type of fixture will be allowed in any five-year period.
- Washing machine locations will be tracked if applicants move from one address to another within the Cambria Community Services District.
- Only new fixtures purchased after 1/24/02 are eligible for rebate.
- Original purchase receipts must be provided to CCSD for copying.
- Toilet retrofits must be pre-inspected to verify size and number of toilets to be replaced, and final-inspected after installation.
- Toilets for retrofit due to home resale do not qualify for rebates.
- Applicant is responsible for timely disposal of removed fixtures

Install the following water-saving fixtures (optional for existing structures and mandatory for new structures):

1. Low-flush toilet (1.5 gallon-per-minute)

2. Self–regenerating water softener

3. Hot water recirculating system

4. Pressure regulator on incoming water supply (set at a maximum of 50 pounds per square inch gage and locate close to water meter)

5. 70-gallon maximum capacity bathtubs, Jacuzzi and Whirlpool spas for units designed to be drained after use.

6. Showerheads with maximum flow of 2 gallons-per-minute at 50 pounds of pressure, equipped with shut-off valve near showerhead

7. Kitchen faucets with aerator that allows a maximum flow of 2 gallons-per-minute at 50 pounds of pressure.

8. Lavatory faucets that allow 0.5 gallons-per-minute at 50 pounds of pressure.

The Cambria Community Services District also recommends use of native vegetation and provides guidelines on water-conserving landscaping. They recommend the planting drought-tolerant plants, minimizing or avoiding turf, and landscaping with rocks, bricks, gravel, wood and other materials that do not require water.

The Cambria Community Services District provided design basics for landscaping:

1. Planning and design. Taking the time to plan your garden for water efficiency and aesthetics is important. Using the services of a professional often saves time and money in the long run.

2. Turf. Turf is the thirstiest of all landscape components. Alternatives include drought-tolerant trees, shrubs, boulders, mulched areas, pathways and other materials.

3. Efficient irrigation. Many recent innovations in irrigation technology enable slow and selected water application. In selecting an irrigation system, look for words like “low gallonage” or “low application rate.” Consider drip systems for shrubs and trees and always locate turf (preferably minimal or non-existent) on a separate valve.

4. Soil analysis. The addition of organic matter to the soil before you plant increases water retention and penetration.

5. Mulching. Two to three inches of mulch will keep soil cool, enhance water retention and retard weed growth. Mulch can include rocks, wood chips, bark, or shredded wood.

6. Drought tolerant plants. There are numerous native and Mediterranean-climate plants that thrive in the Cambria area. Replace high-water, high-maintenance plant/lawn areas with drought-resistant shrubs and groundcovers. Group plants according to their water and sun needs.

7. Ongoing Maintenance. Seasonal irrigation adjustments and efficiency checks are practices that save water. Organic fertilizers and composting will improve texture and maintain vigorous growth.

Water conservation rules are included in Cambria and water saving tips at another Internet link www.cambriacsd.org/cm/Services/Water/water%20conservation.html

RULES-
Do not allow water to run off onto other properties or the street.
Unattended watering/irrigation of landscaping is prohibited.

- Do not irrigate landscape between 10:00 a.m. and 6:00 p.m.
- Irrigation should only provide sufficient water to maintain minimal landscaping needs.
- Do not wash down sidewalks, driveways, parking lots, etc. Use a broom.
- Repair leaks in plumbing or your water distribution system within 8 hours of discovery.
- Wash cars with a bucket and only rinse with a hose that has a shutoff nozzle.
- Restaurants may not serve water to customers unless requested.
- Do not use potable water for dust control or construction activities.

WATER SAVING TIPS-
Limit showers to 5 minutes and install a 2.0 gallon-per-minute showerhead.
Install water efficient fixtures, i.e. replace 3.5 or 5-gallon toilets with 1.6 gallon-per-flush toilets.
Run only full loads in your washing machine and dishwasher.
Don't leave water running while shaving or brushing your teeth.
Use drought-tolerant plants.
Adjust watering schedule seasonally and with changes in weather.
Use Drip (micro) irrigation systems.
Periodically check your sprinkler system to ensure it is operating properly. (Frequent power outages in Cambria can wreak havoc with timers).
Replace lawns with ground cover requiring minimal water.

Information and Incentives Provided by the California American Water Company

Water conservation tips provided by the California American Water Company Internet link www.montereywaterfacts.com/ include recommendations on water conservation in Monterey:

- Consider purchasing an ultra low-flush toilet (can save 60% with each flush) and a high-efficiency clothes washer (uses 40% less water than standard top-loading machines).

- Install a low-flow showerhead and reduce water use by an average of 8 gallons-per-shower. Showers account for approximately 20% of indoor water use.
- Run dishwashers and clothes washers only when full. Use water saver cycles when possible.
- Take quick showers instead of baths.
- Regularly check your faucets, pipes and toilet for leaks. Fix leaks as soon as possible.
- Water you lawn during the coolest part of the day to reduce evaporation.
- Use a broom instead of a hose to clean sidewalks, driveways and other paved areas.
- Check your sprinkler settings and adjust for wetter weather or seasonal changes.
- Use a low-flow hose nozzle to water your lawn or car. Using a standard watering hose to wash your car can waste as much as 300 gallons of water.

The California-American Water Company also instructs on how to create a water-wise garden. Important aspects include:

PLAN AND DESIGN. Assess site conditions for light, soil, drainage and moisture to determine what plants will thrive. Plan to put higher water-use plants near the house and/or where natural water drainage flows while planting a wildlife garden in a less-traveled area.

PREPARE THE SITE. Add the right amount of organic matter and other amendments to the soil prior to planting. Create raised beds (if desired), remove weeds and add rock or water features (if desired).

PICK THE RIGHT PLANTS. If possible, choose native plants that thrive without irrigation, or plants with needs that match the climate and soil conditions. Natives are easy to grow and have adapted to the local climate and pests.

PLANT PROPERLY. Plant in the fall or winter, or early in spring after the last frost. Dig the hole large enough for the plant's roots. Prepare the soil by loosening and adding compost and mulch to keep roots moist.

BE WATER SMART. Water drought-tolerant plants for their first two or three seasons. Group plants by water needs so that each area receives the proper amount. Drip irrigation and water soaker hoses are preferable to sprinklers.

PREVENT WATER WASTE. Set your irrigation system to match the permeability of the soil. If soils are clay, reduce irrigation amounts and intervals to prevent standing water and runoff. Keep watering intervals on slopes short to prevent water waste from runoff.

MAINTAIN THE MOMENTUM. Regularly check the effectiveness of irrigation systems. Adjust them seasonally and as plants become established. Install a weather-based timer that adjusts to changes in climate and provides the right amount of watering.

Prune, weed and annually add mulch to control weeds, save water and enhance the beauty of your landscape.

Information and Incentives Provided by the Soquel Creek Water District

The Soquel Creek Water District in Santa Cruz County provides water conservation guidelines, information and incentives that include free surveys, free devices and recommendations at the Internet link www.soquelcreekwater.com/Cons_Main.htm

The Soquel Creek Water District provides a free water-wise house call. A water district representative will survey the customer's existing water use equipment and suggest improvements to decrease water usage. During the survey, the District representative will

- Measure showerhead flow rates and install free showerheads, if requested.
- Measure faucet flow rates and provide faucet aerators for kitchens and bathrooms.
- Check toilets for leaks and install tank displacement devices, if needed.
- Evaluate the efficiency of the irrigation system.
- Provide a personalized irrigation schedule, if appropriate.
- Identify irrigation leaks, broken or mismatched sprinkler heads, high pressure and other common problems.
- Provide water conservation materials and water-wise landscaping tips.
- See if the customer qualifies for a free toilet or a synthetic turf rebate through the Water Demand Offset Program.

Toilet water can be cut by 10-15% with a toilet tank fill cycle diverter and displacement bag. Faucet water use can be cut by up to 50% with a low-flow faucet aerator. Shower water use can be cut by up to 50% with a low-flow showerhead.

The Soquel Creek Water District provides free water saving devices to their customers that include:

- Low-flow showerheads
- Low-flow faucet aerators
- Automatic shutoff hose nozzles
- Leak detection tablets
- Toilet displacement bags
- Five-minute shower timers
- Toilet tank fill diverters
- Toilet flappers
- Water conserving brochures
- Free toilet program

The Soquel Creek Water District provides the steps for obtaining a free low-flow toilet (1.28 gallons per flush or less), including free installation, with faucet aerators installed free of charge. There is cost to the customer only if special design specifications require toilet and installation fees exceeding $660 for residents and $1,000 for businesses. However, a waiting list exists. If the toilet is needed more quickly, a $250 rebate is available instead if the resident makes the purchase. A list of local retailers is provided that sell these toilets, with brands, addresses and telephone numbers provided.

The Soquel Creek Water District provides a list of water-wise turf substitutes. Each alternative grass is described according its characteristics (appearance, color and height), water requirements, appropriate geographic locations and application conditions (degree of maintenance required and compatibility with animal use). Common names for these substitute grasses are blue grama, dune sedge, tufted hairgrass, California fescue, Idaho fescue, red fescue, junegrass, California oniongrass and pine bluegrass. A list of local nurseries that sell water-wise grasses and plants is provided with addresses and phone numbers.

The Soquel Creek Water District has developed a water-wise business program. Under this program, free water awareness materials are provided to businesses to conserve water. They include:

- Restroom mirror decals that ask guests to contact the management if they notice water leaking and remind them to use water wisely.

- Table tents and menu decals that explain to guests the businesses' interests in conserving water. The materials ask customers to choose for themselves as to whether they would like water.

- Linen choice cards that go on the vanity and bedside table of hotels/ motels that let the guest choose to use the towels and linens again on multiple day visits.

The Soquel Creek Water District also provides educational material related to water-wise landscaping, similar to those recommended by the Cambria CSD and Cal-Am Water Company in Monterey. A super efficient sprinkler is recommended that puts out a multi-stream spray that has high uniformity with low precipitation rates to allow the water to more effectively enter the soil.

The Soquel Creek Water District makes available water-wise garden mini-grants to non-profit organizations and schools to help fund innovative projects designed to encourage public participation in water conservation.

WATER CONSERVATION AND PROTECTIVE WATER QUALITY RECOMMENDATIONS FOR AGRICULTURAL LAND USES

The following list of water conservation recommendations is based on information and publications provided at Internet links by the University of California Cooperative Extension, the USDA Natural Resources Conservation Service (NRCS), CalMAX (California Materials Exchange) and the Avocado Grower's Handbook. More detailed information and links are provided in the sections following the list.

1. Each landowner who grazes livestock should develop a ranch plan with the goal of maintaining or improving water quality and retention of runoff through management of livestock operations. The plan should describe the environmental setting, livestock and grazing operation, water quality goals, water quality problems (including erosion problems), management measures and practices, and monitoring and evaluation methods (Fact Sheet #9 from U.C. Cooperative Extension and the USDA Natural Resources Conservation Service (NRCS)).

2. Develop grazing practices that control the season, intensity, frequency and distribution of grazing. The objective should be to improve or maintain the health and vigor of selected plants and to maintain stability of desired plant communities. The goal is to improve or maintain animal health and productivity while maintaining or improving water quality and quantity. Soil erosion must be reduced and soil condition must be maintained or improved (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

3. Periodically exclude animals, people or vehicles from areas to protect, maintain or improve quantity and quality of plant, animal, soil, air, water and aesthetic resources, as well as human health and safety (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

4. Facilitate grazing practices by constructing structural improvements, including access roads, permanent fencing to protect riparian areas, grade structures to control erosion in natural or artificial channels to prevent gully formation and gully deepening, pipelines to convey water to livestock as water sources other than streams and lakes, and ponds to provide alternate water sources away from streams in conjunction with construction of pipelines, troughs and tanks (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

5. Construct sediment basins to collect and store sediment and debris (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

6. Develop springs excavating, cleaning, capping or providing collection and storage facilities (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

7. Construct stock trails to improve grazing distribution and access to forage and water so as to reduce livestock concentrations (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

8. Protect and stabilize streambanks of streams, lakes or excavated channels against scour and erosion by using vegetation and/or structures. Vegetation and/or structures may also be used to prevent or stabilize landslides (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

9. Construct or improve wells to provide stock-water away from streams. As a new water source, it will improve livestock distribution (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

10. Stream crossings by livestock and farm machinery and water access points should be restricted to stabilized areas (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

11. Manage brush to increase ground cover, reduce fire hazard, improve water quality (long-term), improve forage production and quality, and increase groundwater recharge (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

12. Plant vegetation such as trees, shrubs, vines, grasses or legumes on highly erodible or critically eroding areas. The range may be seeded to establish adaptive plants.

13. Periodically renovate grazing land with contour furrowing, pitting or chiseling to improve plant cover and water quality by aerating the soil, increasing water infiltration and available moisture, reducing erosion and protecting low lying land and streams from siltation (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

14. Restore the damaged stream corridor with bioengineering to protect stream banks and to re-establish riparian vegetation. Exclusionary fencing may be necessary to allow recovery of riparian vegetation (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

15. Institute livestock management practices that include methods of disease control. Minimize livestock concentration near streams and facilitate more uniform livestock distribution. Arrange feeding and salting locations away from streams to protect water quality by reducing internal parasites and pathogens that may be excreted in manure or urine that may enter surface streams (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

16. Facilities designed for feeding, watering, working, holding, chemical storage and shipping should be placed in proper proximity to water bodies (far enough away) to protect water quality (Fact Sheet #9 from U.C. Cooperative Extension and the NRCS).

17. Establish and maintain riparian buffer adjacent to and up gradient from streams or other water bodies to 1) create shade to lower or maintain water temperatures to improve habitat for aquatic organisms, 2) provide a source of detritus and large instream wood to improve aquatic habitat, 3) reduce excess amounts of sediment, organic material, nutrients and pesticides in surface runoff and in shallow groundwater flow, 4) reduce pesticide drift entering the stream or other water bodies and 5) increase carbon storage in plant biomass and soils (from NRCS, January 2006).

18. Livestock should be controlled or excluded as necessary to establish and maintain the riparian buffer. Harmful plant and animal pests present on the site must be controlled or eliminated as necessary (from NRCS, January 2006).

19. Manage grape vineyards organically and sustainably without the use of chemicals (CalMAX 2005).

20. Use dry farming in vineyards where possible and drip irrigation elsewhere (CalMAX 2005).

21. Carefully monitor plants in the vineyard so that diseases or pests can be treated early on (CalMAX 2005).

22. Promote biodiversity by having other plants besides just grapevines in the vineyards. Biodiversity insures habitat available for beneficial insects and birds that inhibit the spread of pests and disease (CalMAX 2005).

23. On sloped vineyards, use cover cropping because it protects soil against erosion and retains moisture. Thus, less watering is necessary. It improves soil structure, adds organic matter, increases microorganism diversity, creates habitat for beneficial insects and adds fertility. The cover crop may be tilled in if the soil needs more organic material or is weak in nitrogen. Legumes are good cover crops because they fix nitrogen (CalMAX 2005).

24. Vary irrigation rate of the vineyard according to the soil type, the climate and the health and age of the vines. Excess water can lead to rot and mildew (CalMAX 2005).

25. Use overhead sprinklers sparingly for frost protection in vineyards and during occasional hot spells in summer to cool the grapes and prevent sunburn (CalMAX 2005).

26. In grape wineries, put meters on every well and in every building to track where the water is going and to detect any spikes in use in order to detect water leaks (CalMAX 2005).

27. In grape wineries, put nozzles on all water hoses for easy shut off when they were set down (CalMAX 2005).

28. For barrel washing in grape wineries, install water line heads with intensive jet sprays to put the water under greater pressure so that a minimum of less water is used (CalMAX 2005).

29. In the grape winery, use ozone to treat the barrels, as well as sulfur sticks, to kill mold and bacteria rather than soap and water (CalMAX 2005).

30. In the grape winery, minimize the sterilization time of the bottle filler bowls during the wine bottling process. The flushing time may be reduced to 25 minutes with a constant flush of clean, 190° F water (CalMAX 2005).

31. In the grape winery, use ultraviolet light rather than toxic chlorine to treat the well water supplying the winery so that the water does not get contaminated with anything (CalMAX 2005).

32. Construct a wastewater treatment plant at the grape winery, which includes a reed bed to filter the water (CalMAX 2005).

33. To conserve well water, recycle the treated wastewater from the winery by using it on the vineyard before fruit appears on the vine. When the grapes have set, use the treated wastewater for landscaping or watering the hillsides (CalMAX 2005).

34. Discharge no treated wastewater from wineries into waterways (CalMAX 2005).

35. Use drip irrigation to water orchards (avocado, citrus, etc.) and other crops because it is the best method to conserve groundwater, avoid runoff and maximize stream baseflow. According to the Avocado Grower's Handbook, drip irrigating of young trees may save 75% on water compared to sprinkler irrigation, while drip irrigating of older trees will save perhaps 25% compared to sprinkler irrigation (Avocado Grower's Handbook 1983).

36. If sprinkler irrigation is used to water orchards and other crops, ideally, water from sprinklers should infiltrate the soil where it lands in order to minimize runoff and maintain uniform irrigation (University of California Extension Publication 8216).

37. On orchard floors or other cropland with low intake rates (more clayey and less sandy), growers should irrigate more frequently with shorter set times to minimize water runoff (University of California Extension Publication 8216).

38. Avoid soil compaction in orchards and other croplands because when soils become compacted, they have reduced uptake rate. Soil compaction may result from machinery traffic, especially when the soil is wet, or even from water droplets (University of California Extension Publication 8216).

39. To significantly increase the water intake rate, periodically work the soils. However, this effect may not remain after one or two irrigations (University of California Extension Publication 8216).

40. Plant a cover crop in orchards to increase water intake rate to the soil by protecting the soil from compaction due to water droplets and by keeping the soil permeable. The cover crop slows water runoff from a sloped orchard, giving more time for water infiltration. However, a cover crop may increase water use up to 30% in some situations (University of California Extension Publication 8216).

41. If furrow irrigation or border irrigation is used in orchards or other croplands, prevent runoff from the orchard property by using early shut off before the water reaches the lower end of the orchard or by blocking the end and sides of the orchard with a berm, having an associated tailwater return system installed to collect tailwater in a storage pond for reuse on another orchard section or other irrigated land (University of California Extension Publication 8214).

42. Excavate stormwater catchment basins on orchard lands or other croplands to retain stormwater and prevent high runoff when rainfall rates overwhelm soil intake rates during the rainy season (University of California Extension Publication 8214).

43. Determine the proper irrigation amount to prevent runoff from an orchard by estimating the amount of water the trees used since the last irrigation, which is known as the evapotranspiration (ET) through their leaves (University of California Extension Publication 8212).

Background Information for Water Conservation and Water Quality Measures on Grazing Land

Loss of ground cover and soil erosion leading to gullying and rapid water runoff, reduce water quality and water recharge and ultimately reduce stream baseflows. Therefore, best management practices that maintain or promote improved water quality by reducing erosion will also promote water conservation in the watershed.

Fact Sheet #9 provided by the U.C. Cooperative Extension and the USDA Natural Resources Conservation Service (NRCS) describes a Rangeland Watershed Program. This fact sheet may be found at the Internet link www.danr.ucop.edu/uccelr/htoc.htm

Water quality and water conservation will be better achieved in Santa Rosa Creek if ranchers develop ranch plans. The rancher may seek assistance from the UC Cooperative Extension, NRCS, Resource Conservation District (RCD) or other agencies to help identify water quality problems, develop management measures and choose appropriate management practices for his/her land.

A ranch plan may be developed with the goal of maintaining or improving water quality and retention of runoff through management of livestock operations. The plan should describe the environmental setting, livestock and grazing operation, water quality goals, water quality problems (including erosion problems), management measures and practices, and monitoring and evaluation methods.

Grazing practices include prescribed grazing that controls the season, intensity, frequency and distribution of grazing. The objective should be to improve or maintain the health and vigor of selected plants and to maintain stability of desired plant communities. The goal is to improve or maintain animal health and productivity while maintaining or improving water quality and quantity. Soil erosion must be reduced and soil condition must be maintained or improved. Periodic exclusion of animals, people or vehicles from areas will be necessary to protect, maintain or improve quantity and quality of plant, animal, soil, air, water and aesthetic resources, as well as human health and safety.

Proper grazing practices may be facilitated with structural improvements. These include access roads, permanent fencing to protect riparian areas, grade structures to control erosion in natural or artificial channels to prevent gully formation and gully deepening, pipelines to convey water to livestock as water sources other than streams and lakes, and ponds to provide alternate water sources away from streams in conjunction with construction of pipelines, troughs and tanks. Sediment basins may be constructed to collect and store sediment and debris. Springs may be developed and improved by excavating, cleaning, capping or providing collection and storage facilities. Construction of stock trails can improve grazing distribution and access to forage and water so as to reduce livestock concentrations. Streambanks of streams, lakes or excavated channels should be protected and stabilized against scour and erosion by using vegetation and/or structures. Vegetation and/or structures may be used to prevent or stabilize landslides. A well may be constructed or improved to provide stock-water away from streams. As a new water source, it will improve livestock distribution. Stream crossings by livestock and farm machinery and water access points should be restricted to stabilized areas.

Several land treatments may be used to improve ground cover and reduce erosion. Practices include brush management to increase ground cover, reduce fire hazard, improve water quality (long-term), improve forage production and quality, and increase groundwater recharge. Vegetation such as trees, shrubs, vines, grasses or legumes may be planted on highly erodible or critically eroding areas. The range may be seeded to establish adaptive plants. The grazing land may be renovated with contour furrowing, pitting or chiseling to improve plant cover and water quality by aerating the soil, increasing water infiltration and available moisture, reducing erosion and protecting low lying land and streams from siltation. The damaged stream corridor may be restored to a more natural, stable state with bioengineering to protect stream banks and to re-establish riparian vegetation. Exclusionary fencing may be necessary to allow recovery of riparian vegetation. Finally, livestock management practices, such as methods of disease control, feeding and salting may be instituted to protect water quality by reducing internal parasites and pathogens that may be excreted in manure or urine that enter surface streams and by minimizing livestock concentration near streams and facilitating more uniform livestock distribution. Facilities designed for feeding, watering, working, holding, chemical storage and shipping should be placed in proper proximity to water bodies (far enough away) to protect water quality.

The NRCS provided information in January 2006 to create or improve riparian habitat in the riparian forest buffer at the Internet link www.efotg.nrcs.usda.gov/references/public/MN/391mn.pdf

The beneficial purposes of creating and protecting the riparian buffer adjacent to and up gradient from streams or other water bodies are to:

- Create shade to lower or maintain water temperatures to improve habitat for aquatic organisms.
- Provide a source of detritus and large instream wood to improve aquatic habitat.
- Reduce excess amounts of sediment, organic material, nutrients and pesticides in surface runoff and in shallow groundwater flow.
- Reduce pesticide drift entering the stream or other water bodies.
- Increase carbon storage in plant biomass and soils.

According to the NRCS, establishment or maintenance of a riparian buffer is insufficient, however, to stabilize streambanks that are already failing.

In order to create or improve riparian habitat, planting should be done at a time and manner to insure survival and growth of riparian species. Livestock should be controlled or excluded as necessary to achieve the intended purpose. Harmful plant and animal pests present on the site must be controlled or eliminated as necessary.

According to the NRCS, the minimum width of the riparian buffer should be at least 35 feet measured horizontally on a line perpendicular to the water body beginning at the normal water line, bank-full elevation, or the top of the bank as determined locally. The width should be extended in areas of high nutrient, sediment and animal waste application where the area is inadequately treated or where an additional level of protection is needed. Existing underground drains through the riparian area should be plugged, removed or replaced with perforated pipe/end plugs to allow drain water to pass and filter through the riparian forest root zone before entering the stream. This will allow filtration of pollutants instead of direct outlet into streams.

Background Information for Water Conservation Measures for Vineyard Lands

Grape vineyards exist in the lower valley and upper canyon of Santa Rosa Creek. A winery, with expanded vineyard, is in under environmental review for the lower valley. A CalMAX (California Materials Exchange) feature article in 2005 on the Fetzer Vineyards located in the Russian River watershed provided valuable information on growing grapes organically and sustainably, while minimizing water use in growing the grapes and making wine. CalMAX is connected to the California Waste Management Board. The Fetzer article may be found at the Internet link www.ciwmb.ca.gov/**Calmax**/Inserts/2005/Summer/**Fetzer**.htm

According to Ann Thrupp in the article, "Fetzer annually produces about 9.25 million gallons of wine (44.4 million bottles). Of this, about 11 percent is produced from the organically grown grapes on their 1,600 acres. They buy the rest of the grapes from about 150 California growers, whose grapes are produced on a total of 12,850 acres." Thrupp is the manager of organic development for the Fetzer vineyards, with the job of providing information about organic practices and encouraging the conversion to organic production when it is possible. Thrupp is also the managing director of the California Sustainable Winegrowing Alliance (Internet link www.sustainablewinegrowing.org). To promote sustainable winegrowing practices among California's wineries and vineyards, the Alliance provides a self-assessment workbook. It helps wineries look at their current level of sustainability and suggests ways they can improve it.

According to the Fetzer environmental manager, Patrick Healy, there must be a systematic approach to sustainability in which relationships between soil, insects and plants are understood. It does not rely on the use of chemicals. Soil building is the goal, with careful monitoring of plants so that diseases or pests can be treated early on, and through promoting biodiversity by having other plants besides just grapevines in the vineyards. Biodiversity insures habitat available for beneficial insects and birds that inhibit the spread of pests and disease. Chickens and sheep are allowed among the vines in some circumstances and at certain times in Fetzer vineyards. Some other vineyards grow vegetables between the vines. Cows are grazed among vines in one vineyard.

At Fetzer vineyards, they use cover cropping because it protects soil against erosion and retains moisture. Thus, less watering is necessary. It improves soil structure, adds organic matter, increases microorganism diversity, creates habitat for beneficial insects and adds fertility. The cover crop may be tilled in if the soil needs more organic material or is weak in nitrogen. Legumes are good cover crops because they fix nitrogen.

Water use in Fetzer vineyards is varied according to the soil type, the climate and the health and age of the vines. Excess water can lead to rot and mildew. They dry farm with no irrigation in some vineyards, but may use up to 80 gallons per vine per year in others. Water from overhead sprinklers must also be used occasionally for frost protection in all vineyards. The overhead sprinklers are also used during occasional hot spells in summer to cool the grapes and prevent sunburn. Along the Russian River, they use an estimated average of 72,000 gallons per acre or about 0.22 acre-feet per acre. This is relatively low. According to the Irrigation Training and Research Center at Cal Poly State University, "premium wine grapes in California require 0–1.5 acre-feet of irrigation water depending on management, location and precipitation."

The Fetzer Winery has significantly reduced water usage in the processing of grapes to make wine. In 1999, they were using 24 million gallons from onsite wells for the winemaking process. By implementing water conservation measures, they have reduced water usage to the 2005 level of 18 million gallons per year. This translates to 2.1 gallons of water used for every gallon of wine. According to the article, the industry standard is 6–8 gallons of water per gallon of wine.

The Fetzer Winery put meters on every well in every building to track where the water was going and to detect any spikes in use. They initially found big water leaks that, when repaired, resulted in huge water savings. They put nozzles on all of their water hoses for easy shut off when they were set down. For barrel washing, they installed new heads with more intensive jet sprays to put the water under greater pressure so that less water would be used. They used ozone to treat the barrels, as well as sulfur sticks, to kill mold and bacteria rather than soap and water. They saved about 1.5 million gallons of water per year and used significantly less natural gas by reducing the sterilization time of the bottle filler bowls during the wine bottling process. They have reduced the flushing time from 45 minutes to 25 minutes with a constant flush of clean, 190° F water. They use ultraviolet light rather than toxic chlorine to treat the well water supplying the winery so that the water does not get contaminated with anything.

Very importantly, Fetzer Winery has its own wastewater treatment plant, which includes a reed bed to filter the water. To conserve well water by recycling wastewater, the treated wastewater is used on the vineyard before fruit appears on the vine. When the grapes have set, they use the treated wastewater for landscaping or watering the hillsides. None of this treated wastewater is discharged into the Russian River.

Contact information for the Fetzer Vineyard:

Patrick Healy- (707) 744-7469, Patrick_healy@b-f.com (underscore between Patrick and healy)

Ann Thrupp- (707) 744-7558, Ann_thrupp@b-f.com (underscore between Ann and thrupp)

Fetzer Vineyards, 13601 East Side Road, Hopland, CA 95449 (1-800-846-8637)

Background Information for Water Conservation Measures in Orchards and Other Croplands

The Avocado Grower's Handbook was consulted for information regarding water conservation in avocado orchards. This handbook is available from the Internet link www.**avocados**ource.com/books/Koch_1983/Koch_TOC.htm

The handbook stated that water waste by runoff from a sprinkler system could be sizeable. This reality, combined with ever-increasing water costs, lead to the recommendation that irrigation planning should be directed toward the most efficient and beneficial use of water. In comparing drip irrigation to sprinkler irrigation, it was pointed out that drip irrigation used less water. Therefore, drip irrigation is the best method to conserve groundwater and maximize stream baseflow. According to the handbook, drip irrigating of young trees may save 75% on water compared to sprinkler irrigation, while drip irrigating of older trees will save perhaps 25% compared to sprinkler irrigation. Other advantages over sprinkler irrigation include dry barriers between trees with drip irrigation that will slow root rot fungus movement if this problem develops. With drip irrigation it is possible to irrigate more acres at one time with the available water pressure and volume compared to sprinkler irrigation. Drip irrigation systems are also cheaper to install with savings in pipe size and wall thickness. A fertilizer injector is required with drip irrigation that saves labor and material because there is little waste of either. With drip irrigation, the tree root zone goes deeper in the soil to better protect the tree from wind throw. This is compared to the increased danger of wind throw resulting from shallow root systems that are encouraged by sprinkler irrigation. Routine maintenance of drip irrigation systems is less, also. There is less moisture for weed competition in areas surrounding the tree, requiring less weed control with drip irrigation. However, there are some disadvantages to drip irrigation.

Disadvantages of drip irrigation include no chance to fight fire or cold and higher frequency of irrigating (every other day during the irrigation season as opposed to once a week with sprinklers). With drip irrigation, water must be well filtered (expensive filtration equipment) to prevent high labor costs in checking emitter operations, and animals chew on soft plastic parts and hoses to cause leaks.

One may assume that drip irrigation systems are more beneficial than sprinkler irrigation systems in conserving water for citrus orchards, as well as avocado orchards.

Additional information related to water conservation in orchards was obtained from the University of California Extension Publication 8216 under the heading, Reducing Runoff from Irrigated Lands, entitled- "Soil Intake Rates and Application Rates in Sprinkler-Irrigated Orchards." It is provided by the University of California Division of Agriculture and Natural Resources at the Internet link
http://cesonoma.ucdavis.edu/**Water**shed_Management923/**Water**_Use_&_**Conservation**.htm

Publication 8216 states that California State Water Code requires that anyone who discharges waste that could affect waters of the state must obtain a permit or coverage under a waiver. Furthermore, agricultural runoff from either irrigation or rainfall that leaves a property has been determined to likely contain waste (sediment, nutrients, chemicals, etc.).

Ideally, water from sprinklers should infiltrate the soil where it lands in order to minimize runoff and maintain uniform irrigation. This allows efficient irrigation and adequate irrigation to the entire crop. If the sprinkler application rate exceeds the soil infiltration rate, water will pond on the soil surface and eventually runoff. Generally speaking, soil intake rate of water is higher for lighter-textured soil (sandy) than for heavier textured soil (clay). Intake rate varies with time. It is greatest initially and decreases with time during the irrigation episode. Runoff is prevented when the sprinkler application rate matches the final, or basic, intake rate. On soils with low intake rates, growers must often irrigate more frequently with shorter set times to minimize water runoff.

Orchard floor management affects the soil's water uptake rate. Soils that become compacted have reduced uptake rate. Soil compaction may result from machinery traffic, especially when the soil is wet, or even from water droplets. To significantly increase the water intake rate, soils may be worked. However, this effect may not remain after one or two irrigations. A cover crop in the orchard may also increase water intake rate by protecting the soil from compaction due to water droplets and keeping the soil permeable. The cover crop slows water runoff from the field, giving more time for water infiltration. However, a cover crop may increase water use up to 30% more than without it.

The University of California Extension Publication 8214, entitled-"Causes and Management of Runoff from Surface-Irrigated Orchards" (same link as above), provides additional information in preventing surface runoff as part of the discussion of reducing runoff from surface-irrigated lands. It states that many orchards in California are irrigated with the use of furrow irrigation or border irrigation (also called flood irrigation). In both methods, water is introduced at the top of the orchard. It is applied in excess of infiltration rate so that excess water flows across the orchard floor. When the water reaches the lowest part of the orchard, tailwater runoff occurs unless the water is shut off or the end of the orchard is blocked with berms. In order to prevent runoff in border irrigation, the water should be shut off before it reaches the end of the orchard. This early shut off is not as commonly used in furrow irrigation as it is in flood irrigation, with good distribution of infiltrated water in furrows typically associated with a 10-15% loss of water as runoff. The difficulty with using early shut off is that water will not advance far after the furrow irrigation system is shut off, causing trees at the end of the row to be under-irrigated.

Runoff may be kept on the orchard by blocking the end and sides of the orchard with a berm. The blocked water may either be ponded in the furrows or borders being irrigated or be diverted into adjacent dry furrows or borders. Still, the lower end of the orchard tends to be over-irrigated, reducing irrigation efficiency and possibly leading to root disease. Tailwater return systems may be installed to collect tailwater in a storage pond for reuse on another orchard section or other irrigated land. Reusing the collected water maintains high irrigation efficiency, conserves water and makes room in the pond for additional runoff.

Retaining all stormwater on an orchard is difficult because the soil intake rate may be easily overwhelmed by high rainfall rates, resulting in high runoff amounts unless stormwater catchment basins are present to retain the overland flow.

The University of California Extension Publication 8212 entitled- "Understanding Your Orchard's Water Requirements" (same link as above) stated that a potential cause of irrigation water runoff from an orchard is over-irrigation or irrigation in excess of that required to refill the trees' root zone. The way to determine the proper irrigation amount and prevent runoff is to estimate the amount of water the trees used since the last irrigation, which is known as the evapotranspiration (ET) through their leaves. There are tables available that provide historical average evapotranspiration estimates for selected California locations during approximate 2-week periods for various crops. A sum of the daily crop evapotranspiration since the last irrigation is calculated from these tables or can be estimated from specific equipment stationed at the orchard. This is the amount of soil water that must be replaced by irrigation. Additional water must also be applied to offset irrigation inefficiencies.

APPENDIX A. MEASURMENT AND TRENDS IN HABIAT CONDITIONS AND JUVENILE STEELHEAD DENSITIES, WITH RECOMMENDATIONS

METHODS

Determining Reach Boundaries in Santa Rosa Creek

Dividing a watershed into reaches is critical to analysis of watershed characteristics and directing enhancement. Santa Rosa Creek was originally divided into 7 reaches, based on a stream survey and habitat typing in fall, 1994. A short portion of Reach 4 was dry in 1994. With more surface flow in 1998, reaches and sampling sites were added. Three new reaches were added (0a, 0b and 3a), with a sampling site established in each (**Table A1; Figure A13**). An additional site was added to Reach 7 at Site 7a. Therefore, 10 reaches were identified. In 2006, an additional habitat typing segment and sampling site were added upstream of Burton Street Bridge in Reach 0a. In 1998–2003 and 2005–2006, a 2.2-mile dry section existed in upper Reach 2. In 2004, the first summer after the December 2003 earthquake, this normally dry stretch remained perennial. In 2002 and 2003 there was a dry section in upper Reach 3a. In 2005, upper Reach 2 had a dry section that was 2,625 feet long (pre-earthquake it was 2.2 miles long) while Reach 3a was perennial. In 2006, the same dry section in Reach 2 was assumed to exist, while Reach 3a was perennial.

Reaches were primarily demarcated by 1) changes in stream gradient that created differences in the proportion of habitat types, 2) differences in streamflow caused by tributary confluences or locations of stretches prone to going dry, 3) differences in shading and 4) the potential passage impediment at Ferrasci Road ford. The denil ladder through the Ferrasci Road culvert was impassable to sculpins except in rare instances, based on fish sampling.

Table A1. Defined Reaches on Santa Rosa Creek from Channel Mile 0.5 (Windsor Boulevard) to Channel Mile 13 (Mora Creek Confluence) That Provided Surface Flow in Fall, 2006.

Reach #	Reach Boundaries	Reach Length (ft)
0a	Windsor Drive Bridge to Perry Creek Channel Mile (CM) 0.5 – CM2.92	12,777
0b	Perry Creek to Fish Ladder; CM2.92–CM3.38	2,437
1	Fish Ladder to Bedrock Outcrop CM3.38 - CM4.19	4,257
2*	Bedrock Outcrop to Just Above Curti Creek Confluence CM4.19–CM7.94 (2,625 ft dry)	17,175 (36,646 ft Lower Valley)
3a	Above Curti Creek Confluence to Point Below Soto House CM7.94 - CM9.6	8,765
3b	Below Soto House to First Tributary (Lehman Cr.) CM9.6 – CM10.1	2,567
4	From Tributary to Eroding Hillside CM10.1 - CM11.24	6,101
5	Eroding Hillside to Bank Erosion 6-8 Feet High and Gradient Change CM11.24 - CM11.45	1,134
6	Bank Erosion to Tributary Confluence and Bridge Crossing (East Fork) CM11.45 - CM12.42	5,152
7	East Fork Confluence to Northern Tributary Branch (Mora Creek) Confluence CM12.42 - CM13.0**	3,058
	TOTAL	63,423 (26,777 ft (12.0 mi) up.canyon)

* Dry section usually existed between Reaches 2 and 3: 3.9 miles in 1994 and 2.2 miles long in 2000, 2002 and 2003 except for short stretch at the Gap. High baseflow after the earthquake watered this entire segment in 2004 and all but 2,625 ft in 2005 and 2006.

**Slightly more habitat was beyond this point but inaccessible.

Classifying Habitat Types and Measuring Habitat Characteristics

In 1994, all watered steelhead habitat in the mainstem of Santa Rosa Creek [upstream of the fish ladder on Santa Rosa Creek at the Ferrasci Road ford at channel mile (CM) 3.38] was surveyed and habitat typed. In Santa Rosa Creek, the surveyed habitat began at CM3.38 and ended at the Mora Creek confluence at CM13.0. The reach downstream of the fish ladder was not included because much of it was dry. The proportion of habitat types was determined for each stream reach. Habitat types were classified according to the categories outlined in the *California Salmonid Stream Habitat Restoration Manual* (**Flosi et al. 1998**). Survey sheets provided in the manual were used during stream surveys. In 1994, some habitat characteristics were estimated according to the manual's guidelines, including length, width, mean depth, maximum depth, shelter rating, substrate composition, and tree canopy. The habitat proportions and stream lengths with surface flow found in 1994 were used in subsequent estimations of juvenile steelhead production through 1997.

In 1998, habitat typing was repeated with the same methods as those used in 1994 and by the same biologist, Don Alley, except for shelter rating. In 1998, shelter rating that was visually estimated in 1994 was actually measured as linear distance of escape cover in habitats in order to better quantify this important habitat parameter, and an escape cover index was calculated. This prevented comparison of escape cover in 1994 with later results. In 1998, habitat typing was repeated to update habitat conditions and obtain accurate habitat proportions after the two wet winters since 1994. However, Reaches 0a, 0b and 3a were added in 1998 because these parts of the watershed had newly occurring perennial surface flow due to the higher baseflow in 1998. In 1998, approximately 0.5-mile segments of each reach that encompassed former sampling sites were habitat typed. In 2002, approximately the same 0.5-mile segments were habitat typed by Don Alley. In 2003, nearly all of Reach 2 and all of Reach 6 were habitat typed before Alley chose random habitats to sample, in addition to regular, average habitat quality sites. In 2006, approximately the same 0.5-mile segments were habitat typed by Don Alley as in 2002. In 2006, an additional 0.5-mile segment was added to upper Reach 0a between the Burton Street and Main Street bridges. Habitat typing for Reach 5 had to be moved downstream into upper Reach 4 due to access problems, where 1,114 feet were habitat typed.

Measuring Habitat Parameters

Habitat parameters were measured at four-year intervals at a reach level beginning in 1994 and annually at each fish-sampling site through 2006. In 1994, substrate composition regarding percentage fines and embeddedness were visually estimated in each habitat type in some reaches. Embeddedness was estimated as the percentage that cobbles and boulders larger than 100 mm (4 inches) in diameter were buried in finer substrate in some reaches. Percent fines and embeddedness estimates were made at the reach level from 1998 onward. Data collection was not biased by a review of previous years' data before the latest data collection. Cobbles and boulders larger than approximately 150 mm in diameter provide good, heterogeneous habitat for aquatic insects in riffles and runs if embedded less than 25%. Cobbles and boulders larger than 225 mm provide potential fish cover if embedded less than 25%.

Quantitative estimates of tree canopy closure were made using a densiometer. Included in this measurement were trees growing on slopes a considerable distance from the stream when streamside vegetation was limited. In the upper reaches of the watershed, where the canopy was more immediately close to the stream, the riparian corridor provided most of the shading. In addition, the tree canopy estimates were based on the shade provided by the trees on the day of the measurements, which was probably between 5 and 10% lower than summer conditions because leaf-drop had begun by the time of fall sampling and during habitat typing in 1998 and 2006. Riparian tree canopy reduces water temperature and protects steelhead habitat in coastal streams. Elevated water temperature greatly increases food requirements and reduces steelhead swimming ability. However, heavy shading reduces food abundance and hinders visual feeding for salmonids. When less tree canopy closure stimulates food production due to greater light penetration, fish growth rate can be faster despite increased water temperature, such as in the lower valley of Santa Rosa Creek.

Escape cover is important because the more that is present in a habitat, the higher the production of steelhead there, particularly for the important Size Class II and II steelhead (=>75 mm SL). Water depth is excellent escape cover when it is 3 feet (1 meter) or deeper and of some benefit when 2 feet or deeper. Objects of cover included unembedded boulders, submerged woody debris, undercut banks, soft, submerged tree roots extending out from the streambank and overhanging tree branches and vines. Unnatural objects provided cover, as well. Man-made litter objects should not be removed if large enough to provide cover, except during high flow conditions in the winter. Removing them otherwise will destroy valuable rearing habitat.

In 1994, escape cover was visually estimated as the percent of area of the habitat that contained escape cover. However, this method was insufficiently quantitative to detect annual trends. Therefore, from 1998 onward, an escape cover index was quantified for each habitat type on the reach level and at sampling sites. The index was measured as the ratio of the linear distance under submerged objects within the habitat type under which fish of at least 75 mm (3 inches) SL could hide, divided by the length of the habitat type at the sampling site or for the reach segment being habitat typed. The cover index was calculated for individual habitats and for combined habitats of the same habitat type in a sampling site or reach. The total escape cover of each habitat type was divided by the total length of that habitat type at the sampling site. All pools in a sampling site were combined, for example, to obtain a cover index for the pool habitat type at the site. All pools in a reach segment were combined to obtain a reach cover index.

Water depth was important to measure because deeper habitat is used more by steelhead. Mean depth and maximum depth were determined with a dip net handle graduated in half-foot increments for the first foot and foot increments for the remainder of the handle. Soundings throughout the habitat type were made to estimate minimum, maximum and mean depth. Minimum depth was determined approximately 1 foot from the stream margin. Stream length was measured with a hip chain. Stream width was measured with the graduated dip net. Deeper pools had scour objects that often provided substantial escape cover.

Streamflow has usually been measured immediately after fish sampling in the fall. However, in 1999–2001, rainfall occurred during sampling and prevented the measurement of summer baseflow. Consequently, in 2000–2004 Sean Grauel of the Cambria CSD measured streamflow earlier in the fall to obtain baseflow measurements prior to any storm events. Don Alley measured streamflow prior to fall storms in 2005 and 2006. A Marsh–McBirney Model 2000 electronic flowmeter was used since 1998 to measure the mean column velocity at 0.6 the column depth from the surface along points (verticals) on a transect across the stream. The streambed was modified where necessary to obtain more uniform depth and to minimize turbulence across transects used for streamflow measurement.

In 1994–1997, Don Alley visually estimated the streamflow by measuring the stream cross-sectional area in portions of uniform velocity and estimating the channel velocity for the uniform portions of the cross-sections. The channel velocity was estimated at several locations across the stream channel by measuring the speed of floating objects and multiplying that quantity by 0.6. The flow volumes of all of the portions of the cross-section were then added to obtain a streamflow estimate. Estimates were likely within +/- 10–20% of actual streamflow, based on experience.

The fourth year of dry-season water temperature monitoring occurred in 2006. HOBO water temperature probes were launched at 2 lower valley fish sampling sites (0a and 1) and 1 upper canyon site (6a) in late June. They were retrieved in late October. Temperature was recorded in Farenheit and Celsius at 30-minute intervals.

Fish Sampling in Lagoon Habitat

Multiple beach seine hauls were used to sample fish at different locations throughout the lagoons. A 30-foot long by 4-foot high by 1/8-inch meshed seine was used because it was suitable for smaller fish such as tidewater gobies. The purpose of lagoon sampling was to monitor the tidewater goby population. The sampling method was inadequate to effectively capture juvenile steelhead, and they were captured only incidentally. The deepest part of the lagoon at Station 1 was too deep to seine, though juvenile steelhead commonly inhabited this location. Visual observations of juvenile steelhead were recorded to confirm their presence. The lagoon was sampled in early summer only in 1993–1996 and 2007. In 1997–2006, it was sampled in both the early summer and in fall. A total count of each species caught was taken for each seine haul and then these totals were combined for a total at each lagoon. Size ranges were determined for tidewater goby and steelhead. A population index was determined for tidewater goby from each sampling, with approximately equal effort expended each time in the fall (8–10 seine hauls) through the years 1997–2006. Prior to 1996, tidewater goby sampling was less with 6 seine hauls in 1993 and 3 seine hauls in 1995 in the early summer only. In 1994, this species had become listed and our permit had not been secured. The reach adjacent to Shamel Park was stream-like in early June 1994 and was electrofished with the expectation that no tidewater goby would be present. However, tidewater goby were detected there and sampling was discontinued without seining in the lower lagoon.

Fish Sampling in Stream Habitat

Juvenile steelhead were sampled annually by D.W. ALLEY & Associates (with funding from the Cambria Community Services District (CCSD)) using electrofishing throughout the mainstem Santa Rosa Creek by electrofishing in 1994–2006, and steelhead habitat was evaluated (**Figure A13**) (**Alley 1995a-2007a**). In the dry year of 1994, fish sampling began at Reach 1 above the fish ladder at Ferrasci Road and included 7 reaches (9 sampling sites). The stream channel in fall was dry downstream of the fish ladder. The fall stream channel was also dry for 3.9 miles from upper Reach 2 to Reach 3b. In 1995–1997, the same reaches were sampled with 6–8 sampling sites. In the wet year of 1998 and the eight succeeding years, 3 additional reaches that had become wetted were added and sampled to make a total of 10 reaches (12 sampling sites) for approximately 12.5–13 miles of wetted mainstem channel upstream to the Mora Creek confluence. Choice of sampling sites was based on their average habitat quality for each reach in terms of the amount of escape cover and water depth in pool habitat. Juvenile steelhead densities from each site were extrapolated to reach densities (**Figure A13**), with habitat proportioning from habitat-typing during survey work. One electrofishing site was sampled immediately upstream of the lagoon in early summer. CCSD staff assisted in lagoon sampling and also collected lagoon water quality and stream inflow data through this period (mostly Sean Grauel (1993–2004) and later Robert Reason and Jason Buhl). Lagoon monitoring reports were completed every other year for monitoring years 1993–2005 (**Alley 1995b–2006b**).

The assumption was that young-of-the-year steelhead would disperse downstream into less crowded habitat soon after emergence, but would spend the remainder of the growing season in the same stream/ lagoon habitat. This has been confirmed by tagging of juveniles (**Davis 1995**) and studies in Redwood Creek that indicated no movement between July and October (**Smith 1994a**) and differences in growth rate between nearby mainstem sites and tributary sites on the San Lorenzo River (**Alley 2002c**) and in Scott and Waddell creeks (**Smith 2002**). Shapovalov and Taft (**1954**) after 9 consecutive years of fish trapping on Waddell Creek detected very limited upstream juvenile steelhead movements; the relatively limited movement was mostly in the winter, perhaps after the lagoon sandbar opened and lagoon habitat was lost. Recent preliminary data from PIT-tag detectors installed by NOAA Fisheries researchers in upper Scott Creek and its tributary, Big Creek (Santa Cruz County) after PIT-tagging of estuary/lagoon- and stream-inhabiting juveniles indicated very little movement of juvenile steelhead during the months of May–November, it being insignificant at the population level (**Sean Hayes personal communication**). Hayes found that some estuary/lagoon juveniles moved upstream from the lagoon past a PIT-tag detector in the upper estuary in fall prior to sandbar opening, perhaps due to deteriorating water quality, and after sandbar opening with the loss of lagoon habitat. Our working hypothesis in relating juvenile densities to habitat conditions has been that juvenile steelhead that are sampled in the fall are likely found where they reared for the summer.

Most steelhead juveniles (and nearly all Size Class II and III juveniles) inhabit pools in Santa Rosa Creek. Habitat conditions in pools determined the choice of sampling sites. Habitat depth and escape cover are most important in determining the density of Size Class II and III (=>75 mm Standard Length (SL) juvenile steelhead in small central coast streams. Based on habitat typing and habitat assessment of the entire mainstem's reaches in 1994 and ½-mile segments of reaches at four-year intervals after that (1998, 2002 and 2006) by Don Alley of D.W. ALLEY & Associates (**Alley 1995a; 1999a, 2003a and 2007a**), reach averages were determined for mean and maximum pool depth, and the escape cover index was calculated for each pool in each reach. Then representative sites were chosen for sampling in 1994–2006 as having pools with approximately the reach average for mean and maximum pool depths and escape cover index.

The correlation between habitat depth, escape cover and density of smolt-sized juveniles was confirmed from a Santa Cruz County-wide sampling program of over 100 sites in 9 watersheds (**Smith 1982b**) and subsequent modeling of smolt-sized juvenile densities as a function of these habitat parameters (**Smith 1984**). Site densities of juvenile steelhead by size class and age class were determined by electrofishing. In 1994–2006, reach production of juvenile steelhead was extrapolated from site densities by multiplying densities by habitat type within the representative sites by the number of feet of each habitat type in the reach, using the habitat proportions of the reach that were determined by habitat typing. Production estimates for each reach were added together to estimate the juvenile steelhead population size.

The Santa Rosa Creek watershed was divided into the lower valley and upper canyon during fishery analyses because lower valley reaches had the capacity to grow a large proportion of YOY to smolt size their first growing season in every year. In the upper canyon, only a small proportion of YOY usually grew to smolt size, except in above average rainfall years. The lower valley consisted of the lagoon and four stream reaches with 4 sampling sites in 1998–2006 (2 stream reaches in 1994–1997 with two sampling sites, and Reaches 0a and 0b were dry in 1994) (**Figure A13**). The upper canyon consisted of the 6 reaches and 8 sampling sites in 1998–2006 (5 reaches and 6 sampling sites in 1994–97 with Reach 3a dry in 1994).

Steelhead densities were determined by electrofishing at sampling sites, using the three-pass multiple-pass depletion method. If depletion was poor in three passes, a fourth pass was made and the number of steelhead captured was considered a total count. In some cases the same low number were captured on the first two passes, with none captured on the third. The total count was deemed more accurate than the depletion model estimate. The concern was to prevent overestimate of juvenile densities. These judgments have been made consistently over the past 13 years of sampling. The depletion model was applied separately for size classes and age classes in each habitat type. Therefore, total population estimates were slightly different after adding up the size classes compared to age classes. Three passes were made in nearly every habitat, which had been blocked off with nets. In a few shallow habitats with no cover where no fish were captured in two passes, the third pass was cancelled.

Measuring Juvenile Steelhead Densities at Stream Sampling Sites

In the work by D.W. ALLEY & Associates, depletion estimates of steelhead density were applied separately to two age-classes in each habitat type at each site. The densities of young-of-the-year (YOY) fish were estimated separately from yearling (1+) and older juveniles (2+). Depletion estimates were also applied separately to size classes of steelhead. The number of fish in each age and size class was recorded for each pass. The age-class boundary was determined for each sampling site, based on the length frequency histogram of fish captured at the site. The dividing line between age classes was a break in the length-frequency distribution of fish lengths that had been lumped into 5 mm groupings. Age class information was used to determine annual juvenile production.

In this and other juvenile steelhead studies in which sampling occurred in the fall, a size-class boundary was chosen at 75 mm (3 inches) Standard Length (SL) for two reasons. One was that fish smaller than this would probably spend another spring, summer and fall in the stream before smolting and entering the ocean the following winter and spring. The other reason for the size class boundary was that fish captured at larger than 75 mm SL would probably migrate downstream to enter the ocean as smolts during the late winter and spring following fall sampling. These probable behaviors were based on the size distributions of juvenile fish captured throughout Santa Cruz County (**Smith 1982b**) and the sizes of down-migrant smolts captured in the San Lorenzo River. It was found that although some fish larger than 75 mm SL stayed a second year in the stream, the large majority of fish captured during fall sampling that were larger than 75 mm SL smolted the very next spring to enter the ocean. (**Smith 1993** (AFS presentation). The 75 mm SL cut-off for smolt size was based on scale samples analyzed by Dr. Jerry Smith for juvenile steelhead smolts trapped as they moved toward the sea in the San Lorenzo River in 1987-89 and determining smolt size at the first annulus. Most fish of 75 mm SL size or larger would grow sufficiently in the following spring to smolt. Fish below that size very rarely smolted the following spring. It was found that 97% of 1+ smolts were 76mm SL or longer. In addition, in the 1987-89 data years, 75% (240 of 320) of fish sampled that were 76mm SL or longer at their first annulus smolted the following spring. This meant that an estimated 75% of the juveniles that had reached 76 mm SL by the end of their first growing season smolted by the following spring. It also meant that nearly all of the 1+ juveniles (those that had taken two seasons to reach smolt size) were at least 76 mm SL.

The second size-class boundary was set at 150 mm SL, which is the typical size above which stream-reared steelhead in Waddell Creek are 2+ years old (**Smith, pers. comm.**). These three size-classes coincided with the age-class boundaries used in the Dettman model to estimate adult returns from juvenile production (**Kelley et al. 1987**).

The depletion method was used to estimate the number of fish in each sampled habitat type in two size categories; those less than (<) 75 mm SL (3 inches) (Size Class 1) and those equal to or greater than (=>) 75 mm SL (Size Classes 2 and 3). Once the number estimate was determined for Size Classes 2 and 3 combined, the proportion of each of these two larger size classes in the group of captured fish was calculated. These proportions of captured fish were multiplied by the number estimate for all steelhead in Size Classes 2 and

3 to obtain separate estimates for each size class in the habitat. These larger size classes were entered separately into the Dettman population model (**Kelley et al. 1987**) to predict number of returning adults. The 0+ age class, 1+ age class and 2+ age class for Waddell Creek steelhead in the model corresponded to our Size Classes 1, 2 and 3, respectively. In comparisons of size class densities between sampling sites, densities of Size Classes 2 and 3 were combined.

Measuring Juvenile Steelhead Densities in Reaches

For each reach, the number of juvenile steelhead estimated by size class and age class per foot of stream in each sampled habitat type was multiplied by the number of feet of that habitat type in the reach. Then the number of fish estimated in each habitat type of the reach was added to the number of fish in the other habitat types to obtain reach totals. The depletion model was applied separately for size and age classes in each habitat type. Therefore, total population estimates were slightly different after adding up the size classes compared to age classes.

Estimating the Adult Index

The predicted number of returning adults was based on survival rate of different size classes of juveniles returning as adults to Waddell Creek during the period, 1933-42 (**Shapovalov and Taft 1954**). It was found that steelhead survival rate to spawning adults increased exponentially with increasing size of steelhead smolts (**Shapovalov and Taft 1954; Bond 2006**). Dave Dettman (**Kelley et al. 1987**) developed a model based on the Waddell Creek relationship of average size of each age class as smolts and survival to returning adult. He estimated survival of juveniles from a reasonable estimate of densities in Waddell Creek in the fall to the down-migrant smolt stage for the different age classes. The relationship derived from Waddell Creek data was:

$$\text{Fraction of Survival} = (0.067)\, e^{(0.025)(\text{Fork length of smolt})}$$

The input required in the Dettman model was an estimate of juvenile steelhead densities by age class in the fall of the year. The size classes were divided according to year class sizes typically found in Waddell Creek, based on Dr. Jerry Smith's experience. Young-of-the-year fish were up to 75 mm Standard Length. Yearlings were from 75 mm to 150 mm Standard Length. Steelhead were included in the 2+ age class if larger than 150 mm Standard Length.

Number of juvenile steelhead by age/size class per foot of each habitat type in each reach was inputted to the Dettman model to predict number of returning adults, using the Waddell Creek rate of return during the 1933-42 period. Returning adults consisted of two categories. One category was first time spawners. The other was the total number of returning adults expected with a 20% repeat spawning rate. The model emphasized the increased survival rate expected for larger size classes of juvenile steelhead.

To make a more realistic estimate of returning adults from juveniles present in Santa Rosa Creek, estimates derived from the Dettman model were reduced by 50%, based on an estimate of returning adult steelhead to Waddell Creek in 1991-92 (**Smith 1992**). Smith estimated that roughly 248 adults returned to spawn, based on his trapping of up-migrating adult steelhead, tagging, sampling upstream of the trap for recaptures, and trapping down migrants for recaptures. This estimate was approximately half of the average return of 432 adults during the 1933-42 Shapovalov and Taft study (**1954**). An assumption was that the reduction in returns in 1992 resulted from reduced ocean survival. Another underlying assumption in the 50% reduction of survival rate was that rearing habitat in Waddell Creek is currently capable of producing 1930's levels of juvenile smolts over the long term. This assumption was judged likely by Dr. Smith (**personal communication**).

Smith added that the adults returning in 1991-92 on Waddell Creek came from juvenile production primarily in 1988-90, during a five-year drought. Further, additional streamflow reduction and habitat degradation came from summer water diversion that did not exist in the 1930's. Therefore, the juvenile production leading to adults in 1991-92 was probably much less than the average juvenile production during the 1930's. It follows that the average return estimate of 432 adults in the 1930's may be higher than one would expect from juvenile production during drought years of the 1930's. Limited supporting evidence is the following. The first recorded water year on the San Lorenzo River (record beginning in 1937) that produced similar acre-feet of streamflow as the drought years of 1987-92 was water year 1938-39. The adult return estimate from primarily juveniles produced in that water year was 377 adults in 1941-42.

The range of estimated adult returns during the earlier study was 373-539 adults. A less conservative reduction factor, but perhaps a more realistic one, may be 0.33 (1 - 248/373) or 33% instead of 50%, using the ratio of Smith's estimated adult return divided by the lowest estimated adult return during the 1932-42 period. This is still probably a high reduction factor because during drought in 1989-90 there was a surface water diversion reducing juvenile production that was absent during 1930's drought.

Whether the reduction factor should be 50% or 33% or something else, the model provides an annual adult index for comparison. It is important to note that our annually applied model uses the same constant survival rates from juveniles to adults, and our correction factor is also constant. However, there are annual fluctuations in ocean survival that are impossible to account for. Therefore, the estimate of adult returns using the Dettman model is only an index and not an annual prediction of adult returns. This index is valuable because it is a way to express and compare the annual value of juvenile production by size class with other years in terms of potential adult returns if all factors are kept constant.

The aforementioned method of estimating an index of returning adult steelhead was the only practical one. Estimates of adult numbers from numbers of smolts captured by down-migrant smolt trapping would be prohibitively expensive and inefficient because down-migrant smolt trapping would require nightly trapping activities over a period of at least two months in the spring. Smolt trapping would be very inefficient during stormflows when down-migration would increase. Unless a very permanent trapping facility was constructed, the fish trap would be very ineffective during storm events. Down-migrant adult trapping would give an inaccurate indication of adult up-migration because many adults do not survive to down-migrate after spawning. Trapping of down- migrant adults would require the same expensive, intensive effort required for down-migrant smolt trapping, with the associated ineffectiveness during stormflows. An added negative aspect would be potentially high fish mortality unless the trap was emptied daily.

RESULTS

Juvenile Steelhead Site Densities, Juvenile Population Estimates and Adult Indices

YOY densities at sampling sites were generally higher in the upper canyon than the lower valley (individually and on average) except in 2002 (**Figures A2 and A4**). Two wet years, 1998 and 2005, had the lowest YOY densities in the lower valley. In another wet year, 1995, although YOY densities were not determined, total juvenile densities were low in the lower valley, indicating that YOY densities were also low that year (**Figure A1**). In some drier years (1994, 1997 and 2002–2004), YOY densities were relatively higher in the lower valley than other years, and relatively lower in the upper canyon. These patterns indicated that in wetter years, adults had better passage opportunities through the estuary and lower valley to access the upper canyon and spawn more YOY. It also indicated that more habitat was available in the upper canyon in wetter years due to higher streamflow and presumed greater insect drift and food supply. Whereas in drier years, spawners likely had a shorter spawning opportunity due to earlier sandbar closure (**Table A13**) and shallower passage conditions related to smaller stormflows. This likely caused more spawning effort in the lower valley with less spawning and YOY production in the upper canyon. In drier years, habitat in the upper canyon likely supported fewer fish with reduced streamflow and reduced insect drift. The fact that annual site densities of YOY (or total juveniles when YOY densities were not determined) sometimes fluctuated mostly in the same direction at all sites in either the lower valley or upper canyon (1995–1999 and 2005 in the lower valley; 1998–1999 and 2001–2004 in the upper canyon), added support to the notion that passage and food supply may have been an important limiting factors in the upper canyon (**Figures A1–A4**). In 2002 when YOY densities in the upper canyon were very low, it rained very little in January–May the previous winter/spring, with only one storm event in January totaling more than one inch in precipitation at the CCSD wastewater plant near the creekmouth. The sandbar closed in mid-April. The earthquake of December 2003 brought cementing of the streambed and likely poor water quality with heavy seepage of hydrogen sulfide into the stream at Sites 7a and 7b in 2004–2005 (**Alley 2005a; 2006a**). This likely contributed to lower YOY densities than normal there.

In 1995, 1996, 1998 and 2005, most YOY fish at the lower 4 sites (lower valley) grew into the larger Size Class 2 by fall, thus leading to the small Size Class 1 number in those years. However, in the years with less baseflow, 1994, 1997, 1999 and 2000–2004, fewer did (**Alley 2006a**). In 2005 in Reaches 0a through 2 in the lower valley, approximately 99% of YOY's reached Size Class 2 compared to 44% in 2004 and 47% in 2003 (calculated from **Tables 27b and 28c**). In 2005 in upper canyon Reaches 3a through 7, approximately 38% of the YOY's grew into Size Class 2 compared 1% in 2004 and none in 2003. In the upper canyon, the growth rate of YOY's was less than that in the lower valley in all years, even in particularly high-baseflow years like earthquake-influenced 2004 and 2005. This underscored the importance of higher spring flows in wetter years that influenced growth much more than higher baseflows through the summer and fall.

Figure A1. Annual total Juvenile Steelhead Densities at Lower Valley Santa Rosa Creek Sites, 1994-2006.

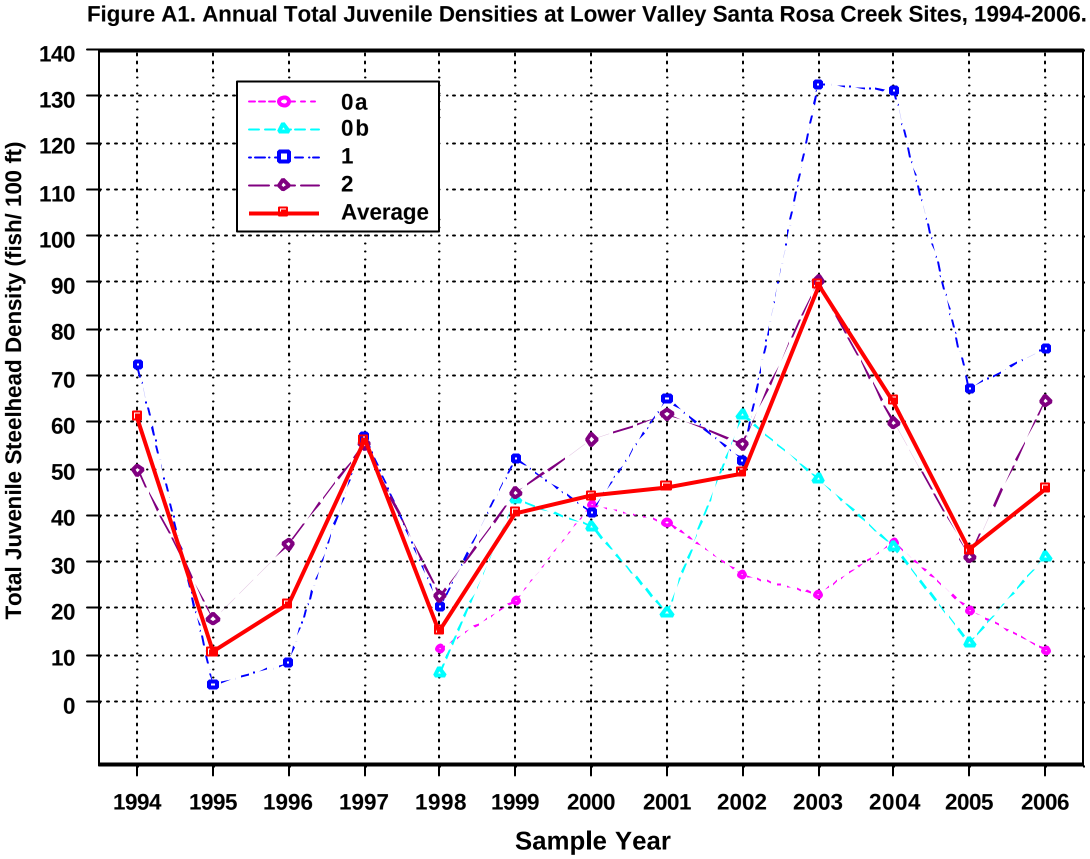


Figure A2. Annual Young-of-the-Year Steelhead Densities at Lower Valley Santa Rosa Creek Sites, 1997-2006.

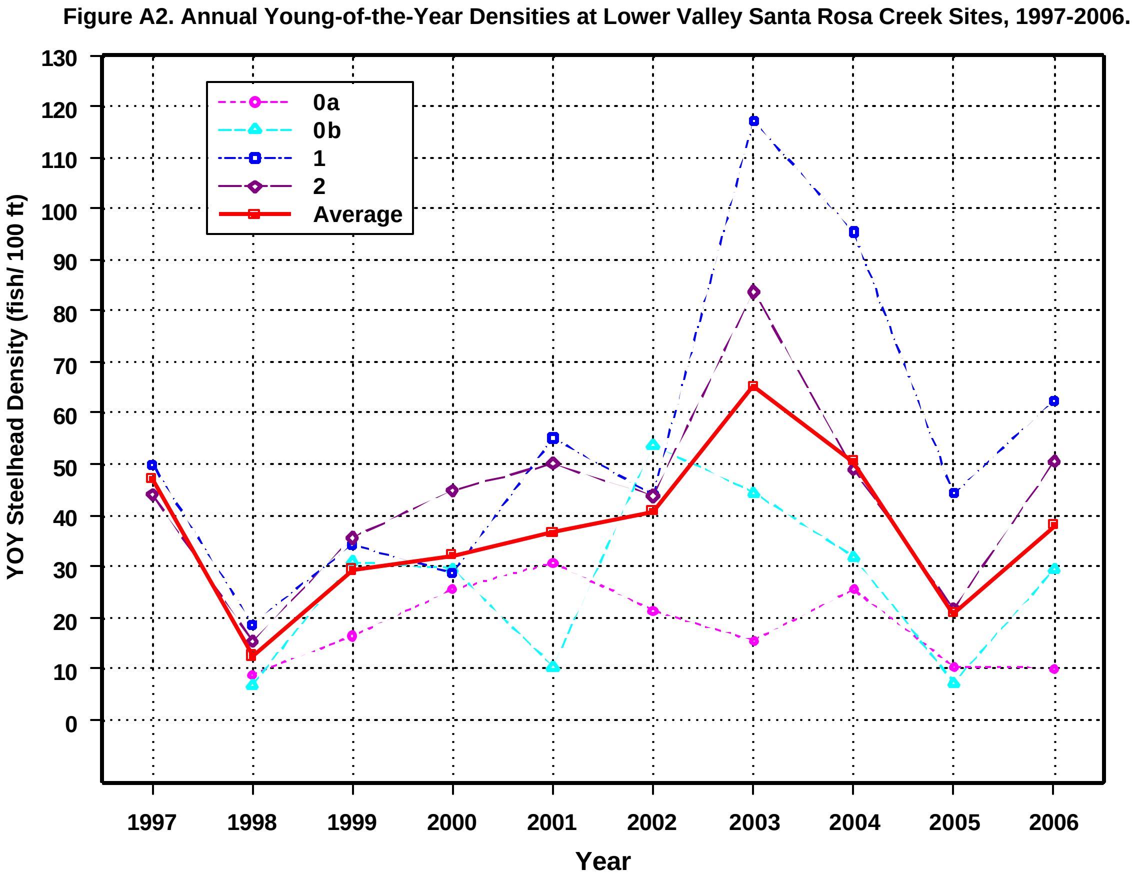


Figure A3. Annual Total Juvenile Steelhead Densities at Upper Canyon Santa Rosa Creek Sites, 1994-2006.

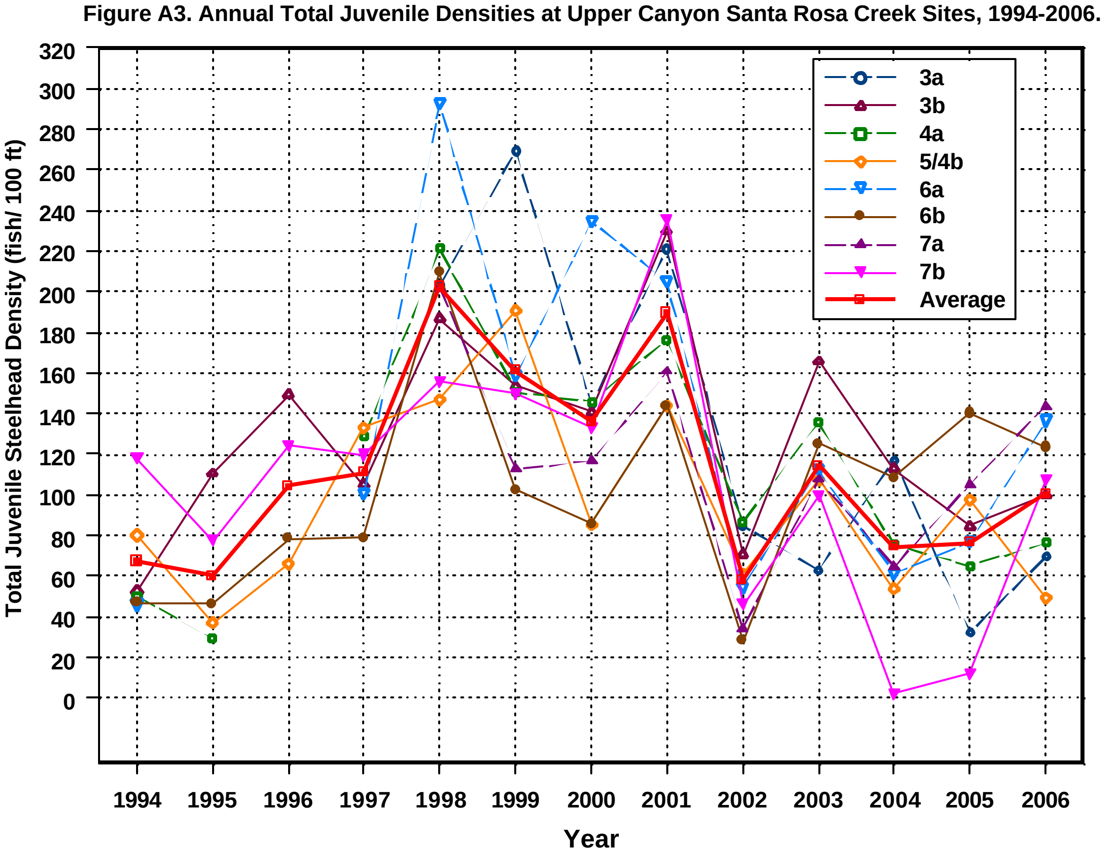
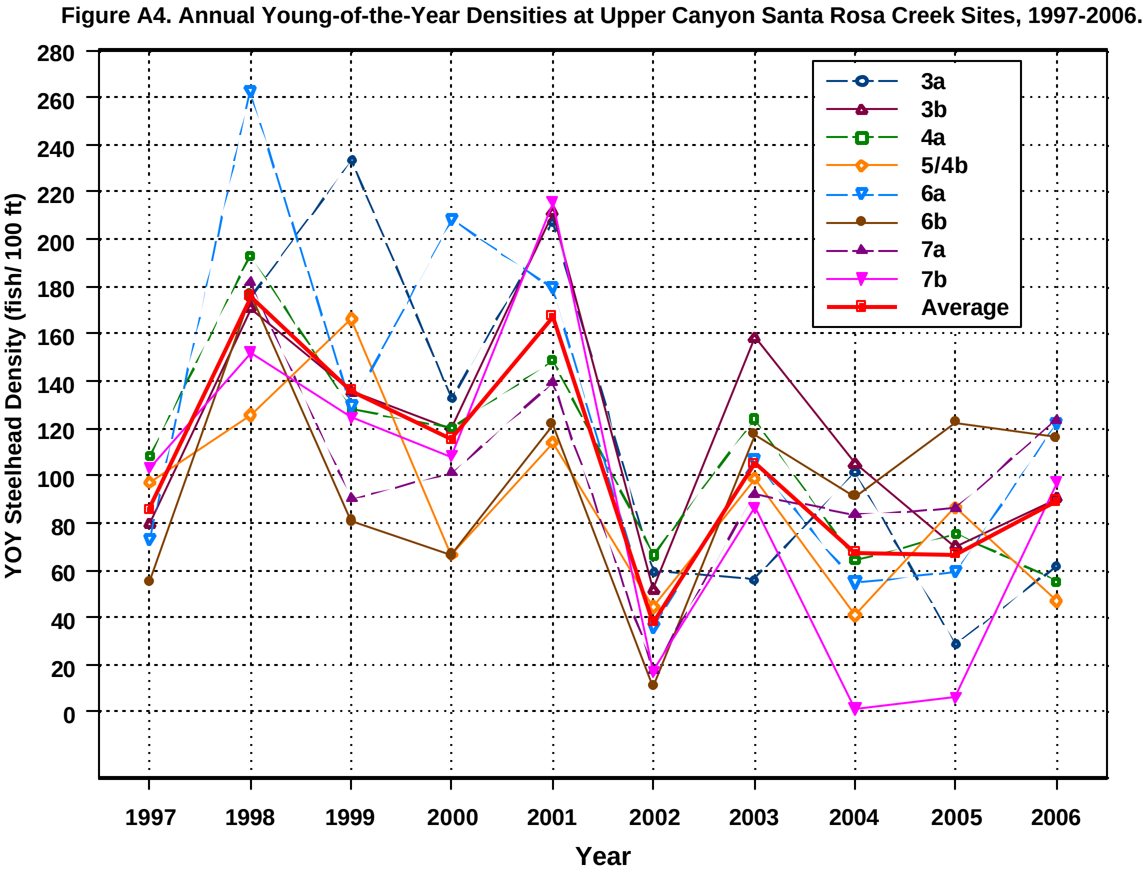


Figure A4. Annual Young-of-the-Year Steelhead Densities at Upper Canyon Santa Rosa Creek Sites, 1997-2006.



Site densities of Size Class II and III (smolt size) juveniles were higher in the lower valley than the upper canyon or similar in many years (**Figures A5–A7**). In some wet years with large storm events (1995 and 1998), densities of these larger fish were relatively low in the lower valley, likely due to the reduced YOY densities and reduced yearling survival over the winter (**Figure A8**). However, in other above-average rainfall years (1997, 2000 and 2005), Size Class II and III steelhead densities were relatively high in the lower valley, likely because of higher proportions of YOY reaching smolt size their first growing season with the higher spring/ early summer flows when growth is fastest. Then in drier years (or years when few storms came late in the spawning season and the sandbar closed early, like 1997), when more spawning effort likely occurred in the lower valley, densities of these larger fish (with large YOY) were also relatively high (1997, 2000, 2003 and 2004). As a general trend, Size Class II and III densities in the lower valley fluctuated up and down annually in 1994–2002 but increased in 2003 and remained relatively high in 2003–2006. Site 1 had especially high densities in 2003–2006 with high densities of fast growing YOY and high densities of large yearlings. This stretch of the creek also changed ownership, which corresponded to an absence of cattle along the creek afterwards and heavy streamside growth of willows at the sampling site (**Alley 2004a**). In the upper canyon, Size Class II and III densities generally increased from 1994 to 1998 and then decreased steadily to lows in 2003 and 2004, with a large increase in the wet year of 2005 (except at Site 7b that was still suffering from earthquake-related poor water quality) and then a decline in the close to normal rainfall year of 2006 **(Figure A8**). Again, the effects of the December 2003 earthquake likely contributed to low survival of yearlings in this larger size class at Sites 7a and 7b in 2004–2005.

Figure A5. Annual Size Class II/III Steelhead Densities at Lower Valley Santa Rosa Creek Sites, 1994-2006.

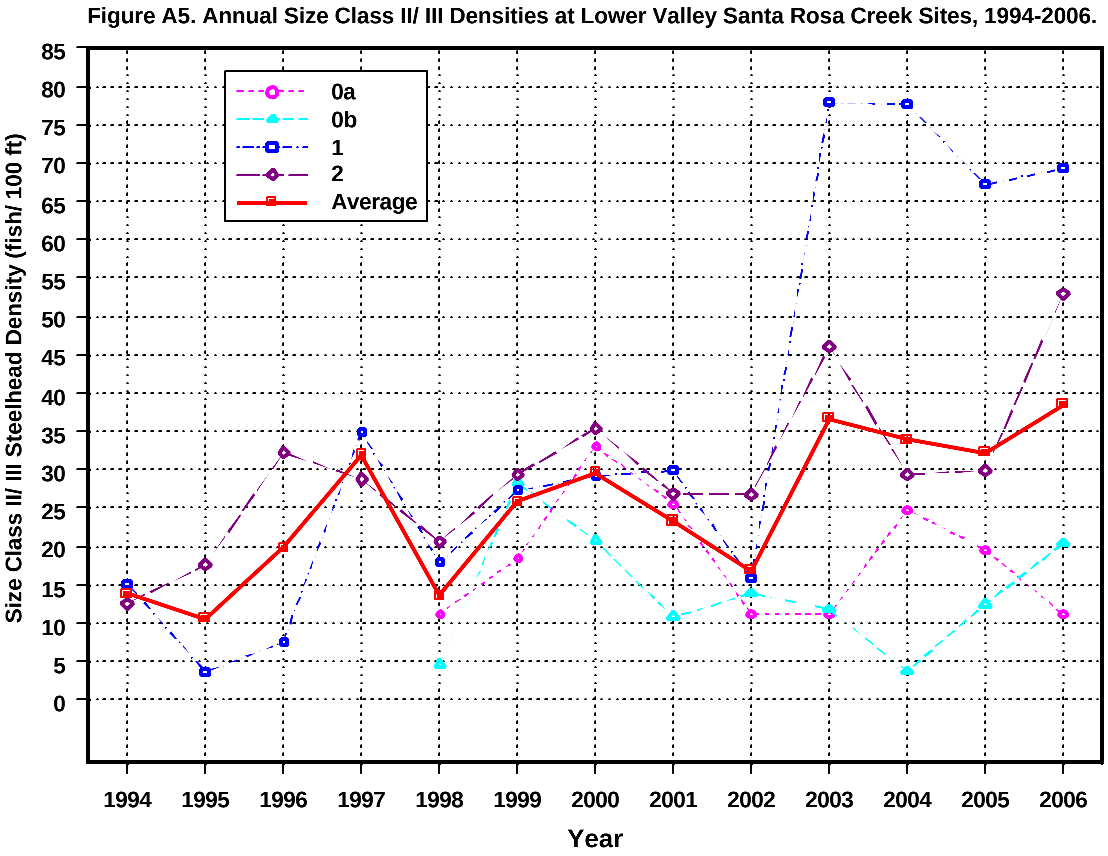


Figure A6. Annual Size Class II/III Steelhead Densities at Upper Canyon Santa Rosa Creek Sites, 1994-2006.

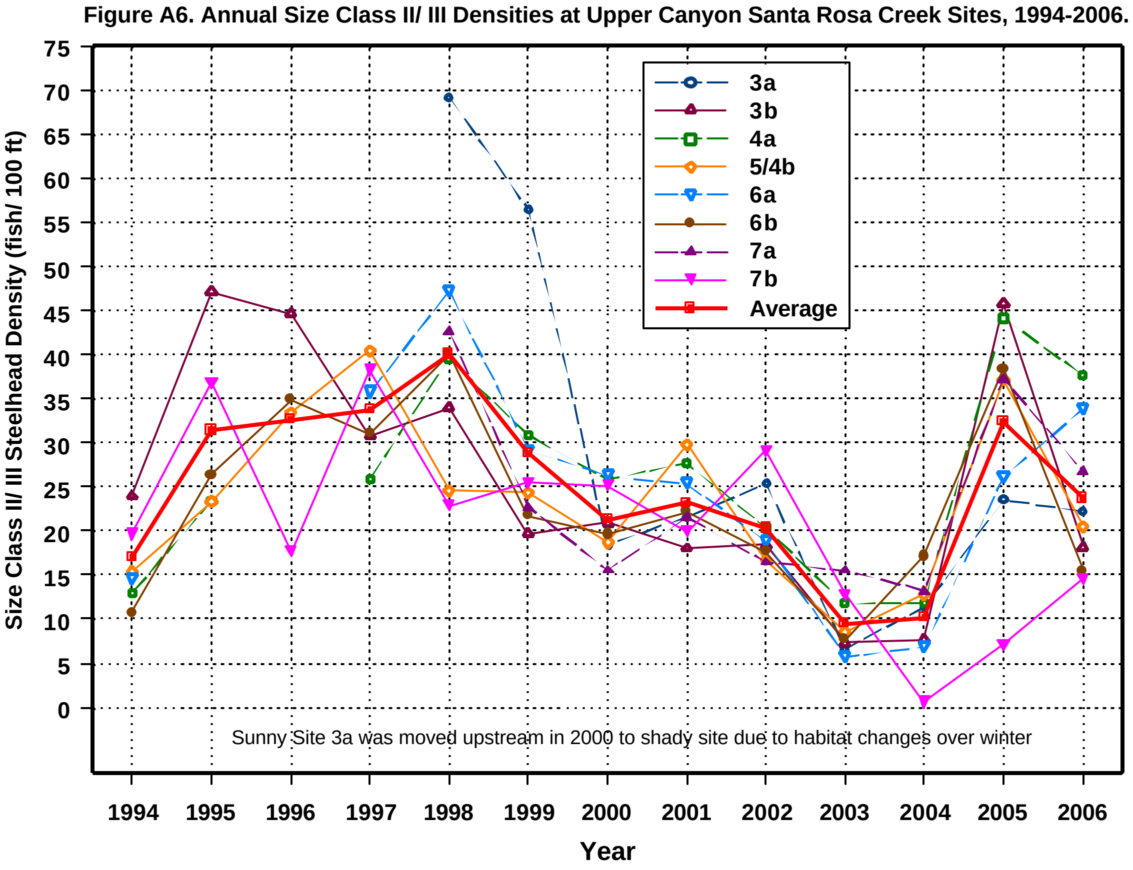


Figure A7. Average Site Density for Size Class II/III Steelhead Juveniles in the Lower Valley and Upper Canyon of Santa Rosa Creek, 1995-2006.

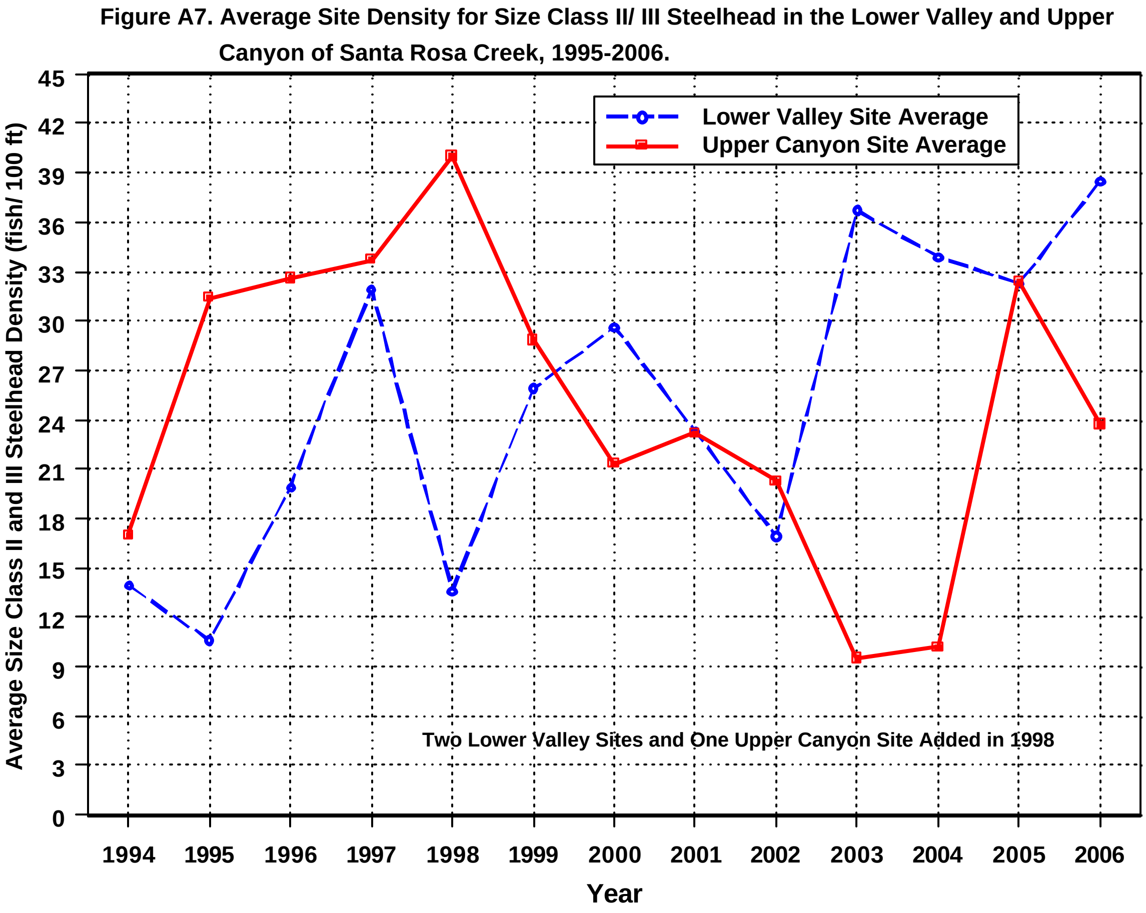
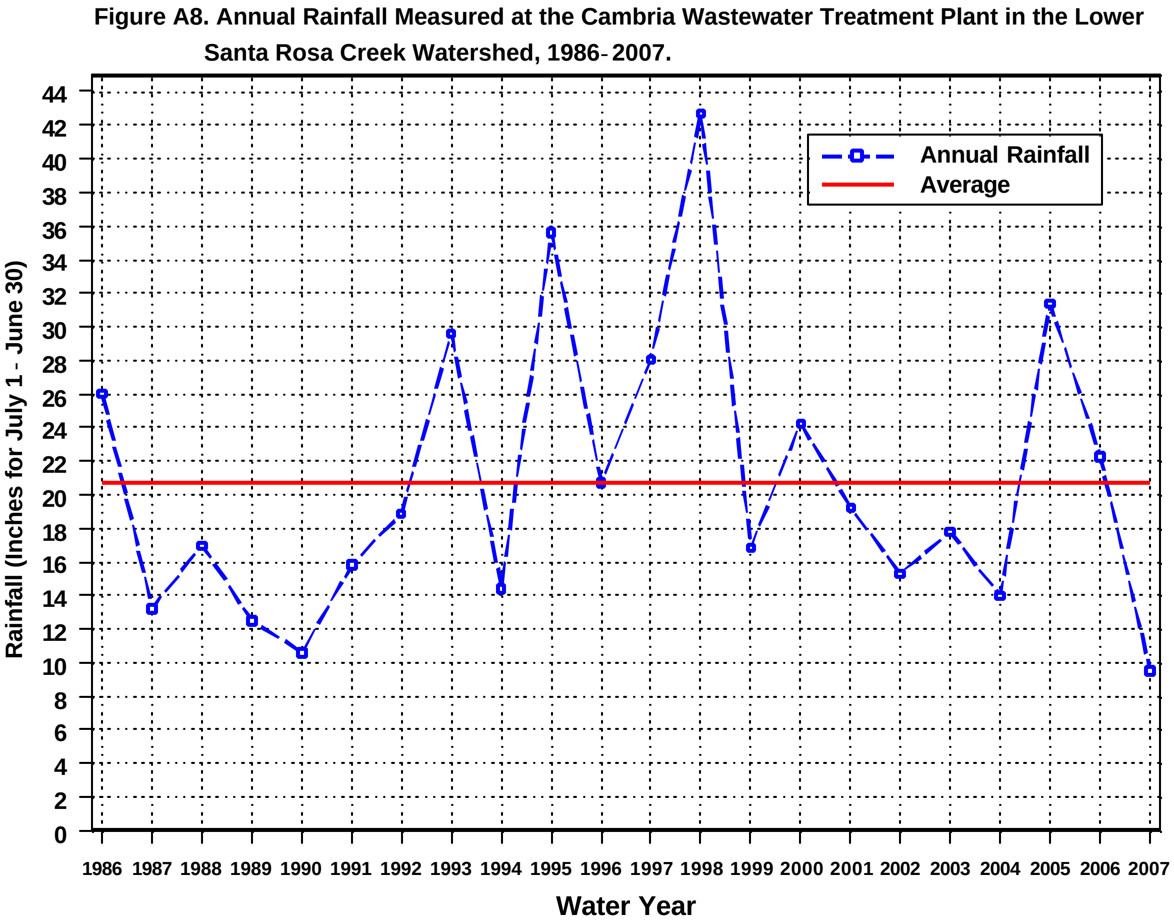


Figure A8. Annual Rainfall Measured at the Cambria Wastewater Treatment Plant in the Lower Santa Rosa Creek Watershed, 1986-2007.



Regarding total juvenile densities at sampling sites, patterns were similar to those of YOY steelhead because most of the population was YOY (**Figures A1–A4 and A9–A10**). However, more years of total density data were available. In the 1994–1998 period, the impact of the 10 March 1995 flood and good upper watershed spawning access in 1998 were evident. Total densities were very low in the lower valley in 1995 likely due to the flood washing away spawning redds, recently emerged YOY and yearlings. Total densities in the upper canyon in 1995 were also less than in 1994, on average, likely due to flood impacts similar to those in the lower valley. However, late spawning in the upper watershed likely followed the flood and YOY survival was likely greater with less yearling competition. Then in 1998, total densities declined in the lower valley and increased in the upper canyon, likely due to good spawning access to the upper canyon and greater spawning effort with numerous stormflows during the 1997/1998 winter. Survival of YOY was probably high with less competition, as well.

Figure A9. Average Site Density for Total Juvenile Steelhead in the Lower Valley and Upper Canyon of Santa Rosa Creek, 1995-2006.

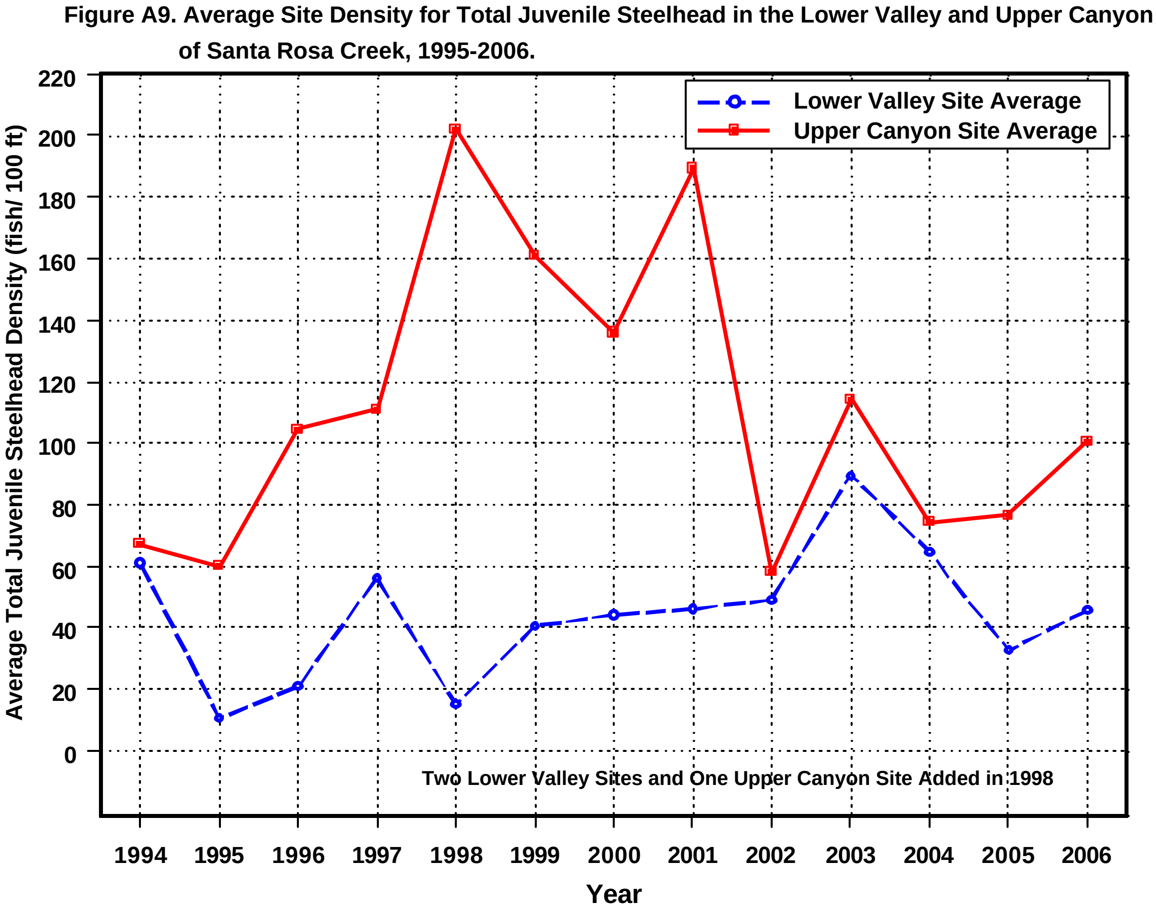
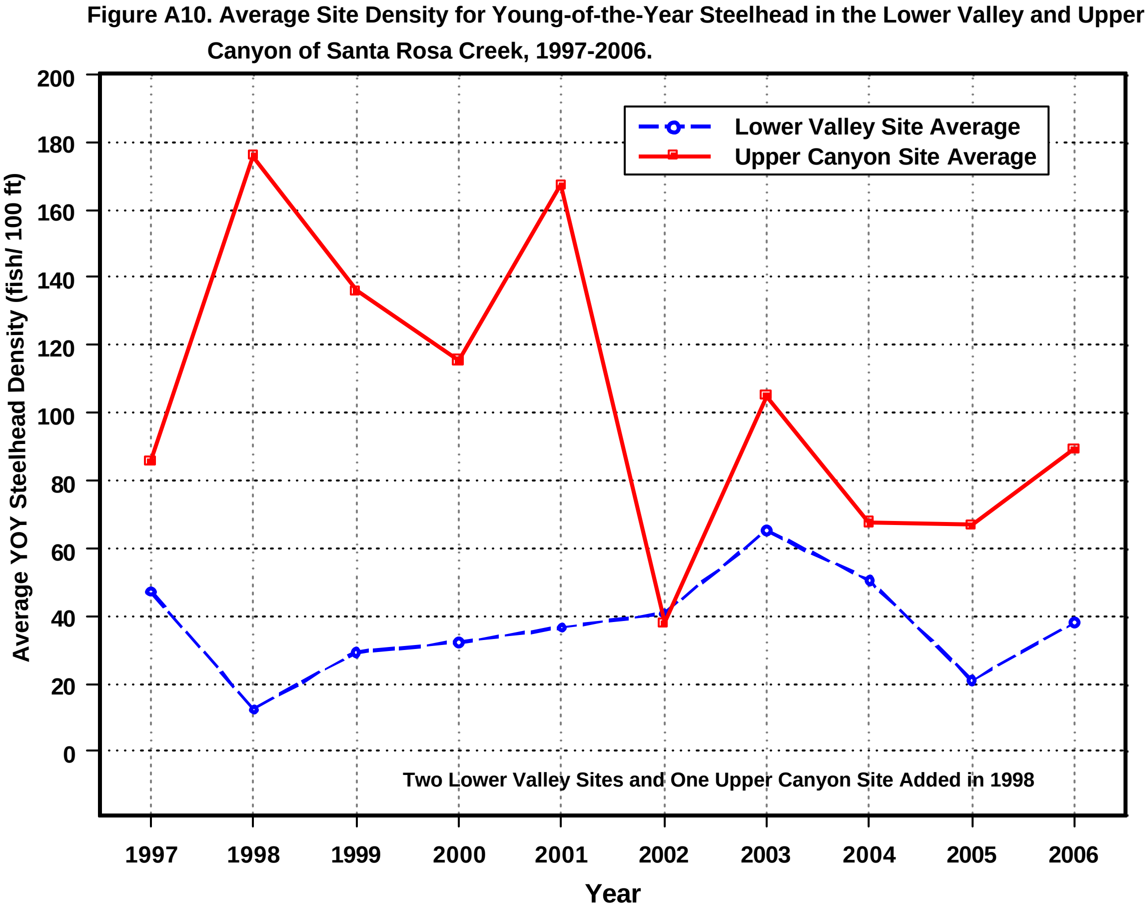


Figure A10. Average Site Density for Young-of-the-Year Steelhead in the Lower Valley and Upper Canyon of Santa Rosa Creek, 1997-2006.



Santa Rosa Creek juvenile densities in 2006 (a year with moderate total, YOY and Size Class II densities and after a near-average rainfall year in Santa Rosa Creek (**Figures A7 and A9–A11**) were compared to those in other watersheds along the Central California Coast (**Table A2 from Alley 2007a**). Santa Rosa Creek had the highest average site densities in most age and size classes and total juveniles.

Table A2. Average Juvenile Steelhead Densities in Multiple Watersheds Along the Central California Coast in 2006 (from Alley 2007a).

Watershed (Listed from South to North)	Number of Sites	Avg. YOY Density*	Avg. Yearling Density*	Avg. Size Class II and III Density*	Avg. Total Density*
Santa Rosa	14	67	10	26	77
San Simeon	3	57	6	16	63
Corralitos	7	44	17	18	61
Aptos	4	26	6	11	32
Soquel	6	17	1	5	18
San Lorenzo	16	26	2	11	28
Scott	10	48	7	–	55
Waddell	9	20	2	–	22
Gazos	8	19	5	–	24

* Density measured in fish/ 100 ft.

When the 14 sampling sites in 2006 were rated according to Size Classes II and III steelhead densities, 1 site was rated “excellent” (Site 1); 3 sites were rated “very good” (Sites 2, 4a and 6a); 5 sites were rated “good” (Sites 0b, 3a, 3b, 4b and 7a); and 4 sites were rated “fair” (Sites 0a-1, 0a-2, 6b and 7b) (**Table A3**). These ratings were given according to categories developed from sampling conducted in the early 1980s throughout Santa Cruz County (**Smith 1982b**) (**Table A4)**. This 1981 study was the only large-scale comparison of juvenile steelhead densities (100+ streams and 9 watersheds) from which categories could be developed.

Table A3. Santa Rosa Creek Sampling Sites Rated by Fall Density of Smolt-Sized (=>75 mm SL) Steelhead Juveniles in 2004–2006.

Site	2004 Density (fish/ 100 ft)	2004 Habitat Rating	2005 Density (fish/ 100 ft)	2005 Habitat Rating	2006 Density (fish/ 100 ft)	2006 Habitat Rating
0a-1	24.8	Good	19.6	Good	11.1	Fair
0a-2					14.6	Fair
0b	3.7	**Poor**	12.5	Fair	20.4	Good
1	77.7	Excellent	67.2	Excellent	69.3	Excellent
2	29.4	Good	29.9	Good	53.0	Very Good
3a	11.4	Fair	23.5	Good	22.2	Good
3b	7.6	**Below Avg.**	45.7	Very Good	18.2	Good
4a	11.8	Fair	44.1	Very Good	37.6	Very Good
5/ 4b*	12.7	Fair	37.1	Very Good	20.5	Good
6a	6.8	**Below Avg.**	26.1	Good	33.8	Very Good
6b	17.1	Good	38.4	Very Good	15.5	Fair
7a	13.2	Fair	37.2	Very Good	26.8	Good
7b	0.6	**Very Poor**	7.1	**Below Avg.**	14.6	Fair

*Site 5 was moved downstream to Site 4b in 2006 due to access problems.

Table A4. Rating of Steelhead Rearing Habitat For Small Central Coast Streams.*

Very Poor - less than 2 smolt-sized** steelhead per 100 feet of stream.

Poor - from 2 to 4 " " "

Below Average - 4 to 8 " " "

Fair - 8 to 16 " " "

Good - 16 to 32 " " "

Very Good - 32 to 64 " " "

Excellent - 64 or more " " "

* Drainages included the Pajaro, Soquel and San Lorenzo systems and other smaller Santa Cruz County coastal streams totaling more than 100 sampling sites in 1981 (**Smith 1982b**).

** Smolt-sized fish (meaning they would be smolt size by spring) were at least 75 mm (3 inches) Standard Length.

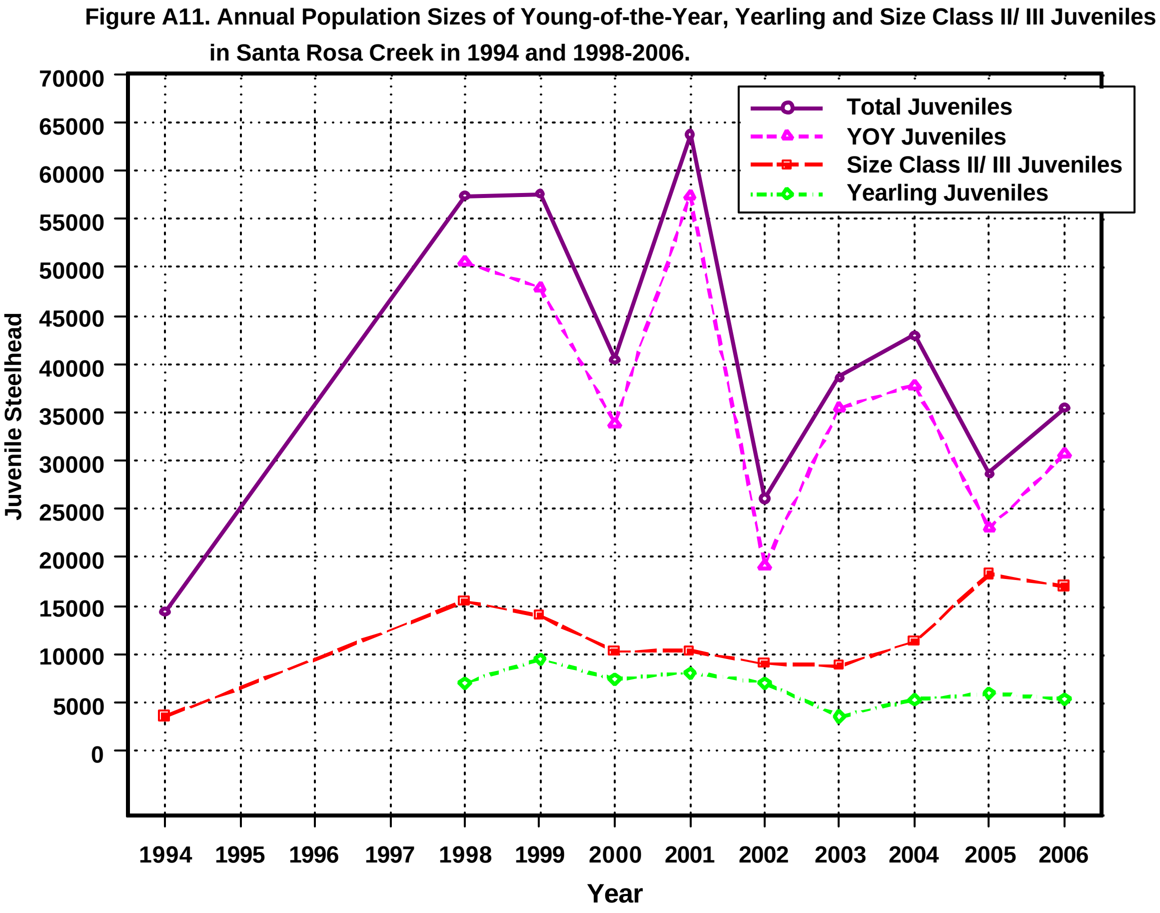
Trends in annual population size for age classes, size classes and total juveniles indicated that 1994 represented a low point in the 13-year monitoring period (**Table A5 Figure 11**). In 1994, Reaches 0a and 3a were dry and Reach 0b was partially dry with very few juvenile steelhead after an especially mild winter that had caused early sandbar closure (**Table A5** (**Alley 1995b**). The steelhead population had expanded by 1998 and 1999, with relatively large YOY and Size Class II and III populations (**Figure A11**). In 2000, the population dropped due largely to the smaller YOY population. Habitat conditions were poorer in 2000 compared to 1999 with regard to less escape cover and lower baseflow, which also likely resulted in the smaller yearling population (**Alley 2001a**). This 2000 decline in population size corresponded with declines in other monitored central coast watersheds in Santa Cruz and San Mateo Counties (Soquel, San Lorenzo and Gazos). Reduced YOY populations in 2000 may have partially been caused by poor spawning success and/or fewer spawners resulting from events associated with the El Nino period beginning in 1998. Over-winter survival of juveniles in 1997/1998 may have been reduced during large El Niño stormflows. Oceanic conditions for juvenile survival to adulthood may have been abnormally difficult for juvenile smolts entering the ocean during the 1997/1998 winter and spring. The El Niño began in summer 1997, peaked in fall and winter of 1997-98, and persisted through spring and summer of 1998. Unusually warm surface sea temperatures (SST's), low macronutrient levels and low chlorophyll and primary production characterized this event (**Michisaki et al. 2001**). This likely caused poor ocean survival of smolts entering the ocean in 1997 and 1998 due to high competition for limited food under warm water conditions that increased food demand. In smaller watersheds that did not have a reduced YOY population in 2000 (San Simeon, Scott and Waddell), there may have been sufficient adult spawners to saturate the limited YOY habitat. The one large watershed that did not show a reduced 2000 YOY population, the Carmel River, provided refuge for yearlings and YOY in Los Padres Reservoir (and less so in San Clemente Reservoir) during the El Niño storms of 1998.

Table A5. Summary Table of Steelhead Size Class Site Densities, Reach Densities, Juvenile Production and Adult Indices in Mainstem Santa Rosa Creek, 1994–2006.

Year	Size Class 1 (<75 mm SL) Avg Site Density / 100 ft	Size Class 1 Avg. Reach Density / 100 ft	Size Classes 2 & 3 (=>75 mm SL) Avg. Site Density / 100 ft	All Sizes Avg. Site Density / 100 ft	Size Classes 2 & 3 Avg. Reach Density / 100 ft	Size Classes 2& 3 Creek-Wide Density / 100 ft	Size Classes 2& 3 Upper Canyon-Wide Density / 100 ft	All Sizes Avg. Reach Density / 100 ft	All Sizes Creek-Wide Density / 100 ft	Size Class 1 Production	Size Class 2 & 3 Production	Total Juvenile Production	Adult Index
1994	51.3		15.8	67.1					47.3	10,800	3,500	14,300	203
1995	28.7		26.5	45.9					30.8	4,400 partial*	4,900 partial	9,300 partial	253 partial
1996	48.2		28.4	76.6					52.3	9,800 partial	6,000 partial	15,800 partial	317 partial
1997	64.1	51.0	33.2	97.3	23.1	25.8		74.1	76.0	15,800 partial	7,800 partial	23,600 partial	409 partial
1998	111.7	100.6	32.0	***143.6***	30.1	***28.6***	***47.6***	***130.7***	106.1	42,000	15,400	57,400	836
1999	92.9	102.9	27.8	120.7	26.4	25.8	35.8	129.7	106.4	43,700	14,000	57,600	775
2000	81.3	62.2	24.1	105.3	19.1	18.9	19.8	81.0	74.8	30,300	10,300	40,500	566
2001	***118.4***	***111***	23.3	141.6	19.1	19.0	21.9	130.1	***117.6***	***53,400***	10,300	***63,700***	658
2002	35.9	35.3	19.2	55.1	18.4	17.6	21.3	55.9	51.0	17,100	9,000	26,100	462
2003	73.9	72.2	18.6	100.8	15.9	17.1	9.2	88.2	71.9	29,900	8,800	38,700	498
2004	53.1	54.3	18.1	71.1	14.8	17.1	11.3	69.1	65.1	31,700	11,300	43,000	615
2005	29.4	27.1	***32.4***	61.9	***31.5***	***28.6***	33.1	58.6	45.1	10,400	***18,200***	28,700	***886***
2006	49.6	41.3	27.5	77.1	25.5	26.8	22.9	66.8	55.9	18,500	17,000	35,500	832
Avg.	64.5	65.8	25.2	89.6	22.7	22.6	24.8	88.4	69.3	24,400	10,500	34,900	562

* Reaches in 1995–1997 conformed to wetted reaches in 1994. However, in 1995–1997, downstream reaches (0a and 0b) also had perennial flow to varying degrees but were not sampled until 1998 and afterwards.

Figure A11. Annual Population Sizes of Steelhead Young-of-the-Year, Yearling and Size Class II/III Juveniles in Santa Rosa Creek in 1994 and 1998-2006.

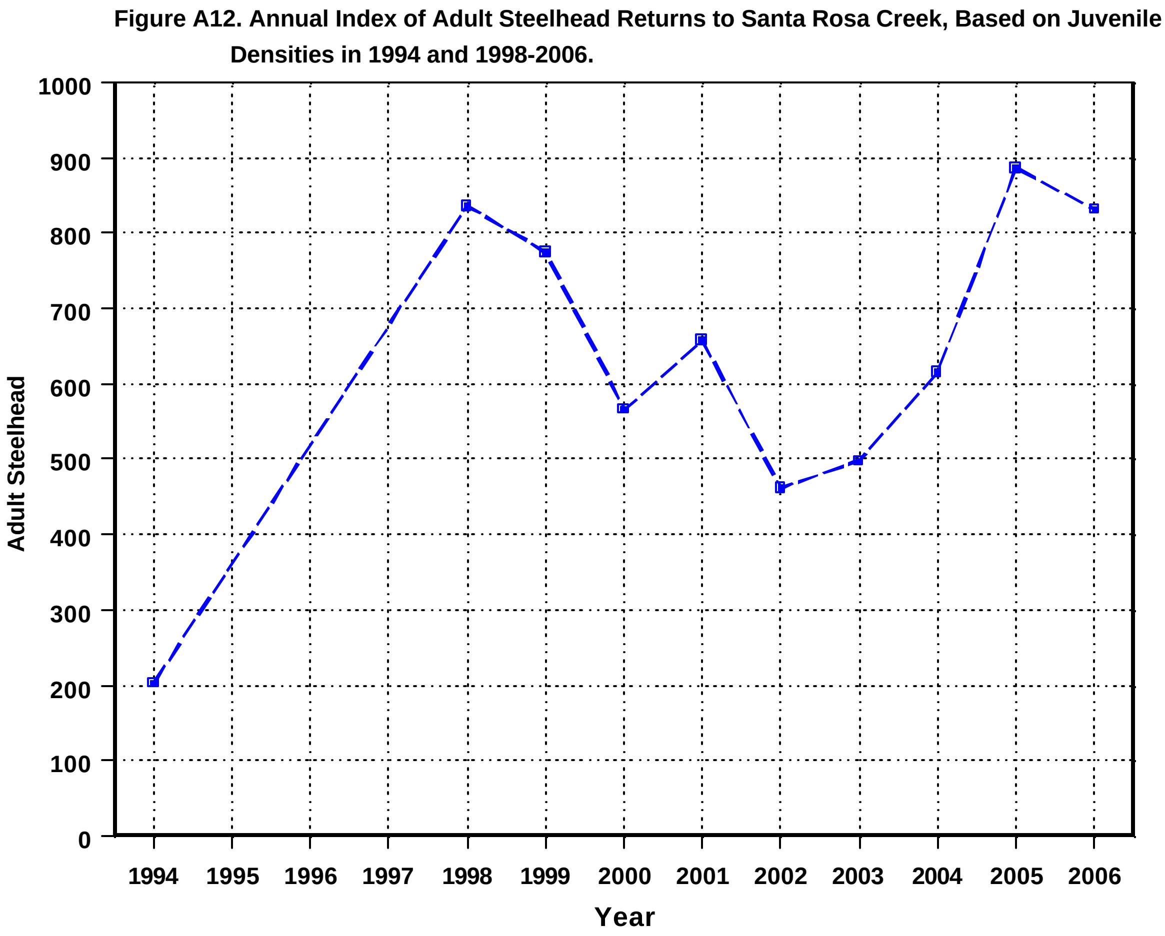


The juvenile population bounced back in 2001, only to plummet in 2002, after a winter that offered few storms with likely poor passage through the sandbar and early final sandbar closure (**Table A13**). This resulted in poor adult passage into the upper watershed, where YOY are usually most abundant. In the continued drier years of 2003 and 2004, the population size was intermediate, relying more heavily on YOY production in the lower valley. The total juvenile population in 2005 was smaller than the 2 previous years, and it was below average. This probably resulted from a smaller adult population spawning the previous winter. Seven of the 8 monitored watersheds along the Central California Coast experienced YOY and total population reductions in 2005. After the wet winter of 2004/2005, spawning access to the upper watershed was good but the YOY population did not increase over 2004 levels there and it declined in the lower valley, even though habitat conditions were improved in 2005 (**Alley 2006a)**. Beneficially, YOY growth rate in 2005 was relatively high with the higher spring flows, and the Size Class II and III population increased substantially from 2004 to 2005. In 2005, an estimated 55% of YOY (12,500) reached Size Class II compared to 16% (6,100) in 2004. This same trend was detected in the San Lorenzo River and Soquel Creek (**Alley 2006c; 2006d**). In

2006, the juvenile population increased modestly in Santa Rosa Creek after a near-average rainfall winter. However, the YOY and yearling population estimates were below average, consistent with other watersheds (San Simeon, San Lorenzo, Soquel) and low YOY densities in Scott, Waddell and Gazos creeks. This may have been the second year in a row with relatively below average adult returns and the third in the 5-year period of 2002–2006.

The trend in the annual adult steelhead index that was generated from the juvenile population, was most affected by the trend in the annual size of the Size Class II and III portion of the juvenile population. Consequently, the adult index could increase even if the total juvenile population decreased, if the Size Class II/ III population increased at the same time. The adult index increased by four times from 1994 to 1998 (**Figure A12**). Then it declined in 1999 and 2000 coincident with smaller Size Class II/ III populations when lower spring flows reduced the growth rate of YOY compared to 1998 (**Figure A11**). The adult index increased in 2001 due to a greatly increased YOY population and despite a no larger Size Class II/ III population during a drier year that did not promote very rapid YOY growth in the lower valley. In 2002 the adult index was the lowest in the 9-year period, 1998–2006, with relatively small YOY and Size Class II/III populations after a mild spring that offered poor growing conditions. The next 2 years, 2003 and 2004, afforded limited spawning and growth opportunities but YOY populations increased over 2002 levels, although the Size Class II/III population decreased in 2003 and then increased modestly in 2004. Accordingly, the adult index increased in 2003 and 2004. The juvenile population was relatively small in 2005, but habitat conditions were good and spring flows were likely relatively high after a wet winter. As a result, YOY growth rate was high in the lower valley and resulted in a substantial increase in the Size Class II/ III population, an increase in the yearling population in the upper canyon and the highest adult index during the monitoring period. In 2006, the YOY population increased during a near-average rainfall year, with adequate growth of YOY in the lower valley to maintain a relatively high Size Class II/ III population and a high adult index, despite the relatively low total juvenile population size (**Figures A11 and A12**).

Figure A12. Annual Index of Adult Steelhead Returns to Santa Rosa Creek, Based on Juvenile Densities in 1994 and 1998-2006.



Trends in Habitat Change Between 1994 and 1998

A very large flood event occurred in March 1995 (estimated as a 90-year event by Questa Engineering (**2005**)). A conservative estimate of streamflow on 10 March 1995 was 16,000 cfs, estimated by Greg Martin, hydraulic engineer at San Luis Obispo County, based on the stream gage operated by the CCSD (at Highway 1) and older stage vs. flow tables. It was more than double the previously highest flow of 7,900 cfs recorded in 1986, since the gage was installed in 1976. Questa Engineering (**2005**) estimated the 100-year storm to be 18,159 cfs. Streambank erosion was extensive from the March 1995 flood. Much of the streambank erosion one observes today actually occurred from of that one storm event or from delayed effects from that storm event. There was downcutting of the channel in the upper canyon. The entire riparian corridor, with all of its trees, was washed away for miles in the lower valley during that one stormflow. Many tree-less vertical banks were left afterwards, even in the straight-aways. The Windsor Boulevard Bridge in Cambria was nearly lost. The following summer, California Conservation Corps crews were brought in to cut up the valuable instream wood through Cambria. Private landowners cut it up elsewhere. Most wood soon left the system.

Santa Rosa Creek has a narrow gap between the upper canyon and lower valley where the creek also makes a rather sharp bend to the south (**Figure A13**). That bend has required considerable stabilization to protect the road above on the outside of the bend. The culverts at the Curti Creek mouth are perched several feet, just upstream of that bend. In 1998, after another wet winter/spring, Reaches 0a, 0b and 3a were added because they contained continuous surface flow and high baseflow after the wet winter of 1997/1998 (**Figure A14**). In the years 1994–1997, Reach 0a downstream of the Perry Creek confluence and the high school went dry through Cambria to varying degrees, although streamflow into the lagoon continued except in October and November 1994.

The lower valley (Reaches 0a–2) had a lower stream gradient than the upper canyon (Reaches 3a–7) and more extensive streambank erosion to contribute sediment to pools in 1998. Also, there were less bedrock outcrops and large boulders to scour pools in the lower valley. Most pools in the lower valley were scoured by tree rootwad masses and instream wood. Overhanging willows were the primary source of escape cover in Reaches 0a and 0b (pool escape cover in Reach 0a = 0.122).

In Reach 1 in 1998, 12 of 20 analyzed pools were formed by scour caused by instream wood (downed tree trunks and limbs). In 1994, the reach consisted of mostly pools and glides, with very little low gradient riffle habitat. Pools were relatively shallow. In 1998, pools made up a smaller proportion of habitat, with much glide habitat becoming run and riffle habitat compared to 1994. In 1998, all habitats were deeper, on average and for maximum depth (**Figures A15 and A16**). Maximum pool depth was 0.3 feet greater in 1998, indicating increased scouring. However, average pool depth was only 0.1 foot deeper, it being accounted for by higher streamflow and indicating a similar level of pool sedimentation to 1994. Escape cover in Reach 1 was primarily from instream wood and overhanging willows in 1998 (pool escape cover index = 0.153).

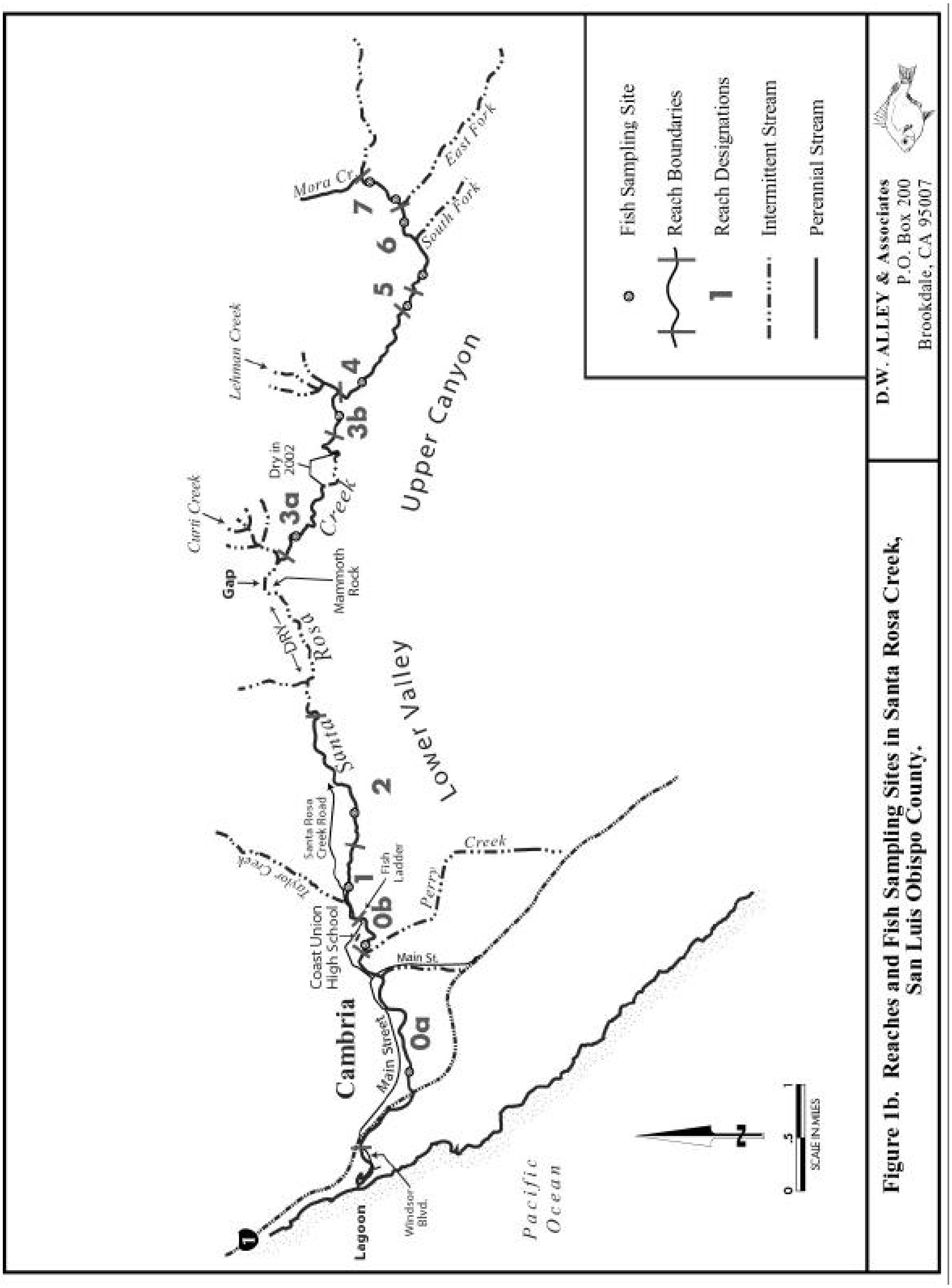


Figure A13. Reaches of Santa Rosa Creek, San Luis Obispo County.

Figure A14. Measured Streamflow in Fall at Sampling Sites in Santa Rosa Creek, 1998-2006.

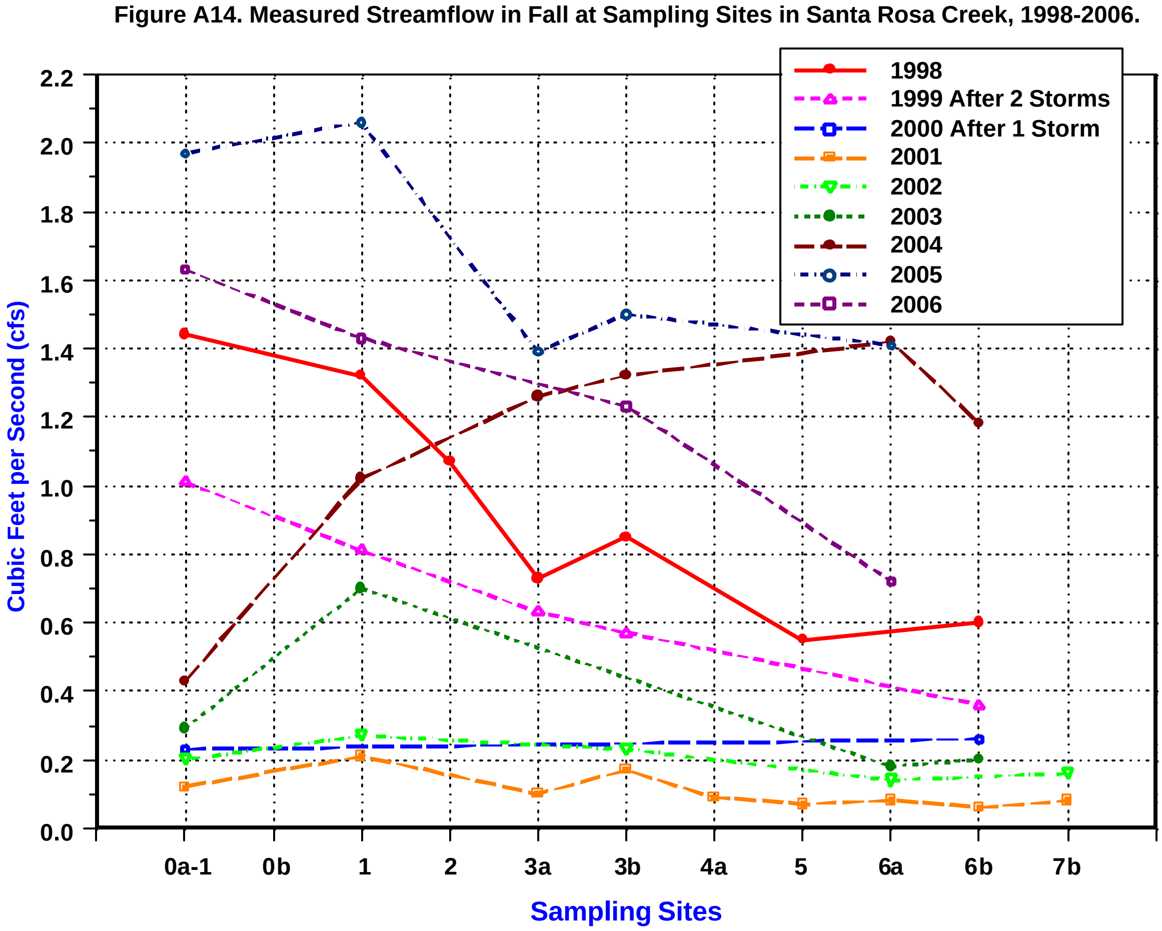


Figure A15. Average Mean Pool Depth in Habitat Typed Segments of Reaches in Santa Rosa Creek at Four-Year Intervals, 1994-2006.

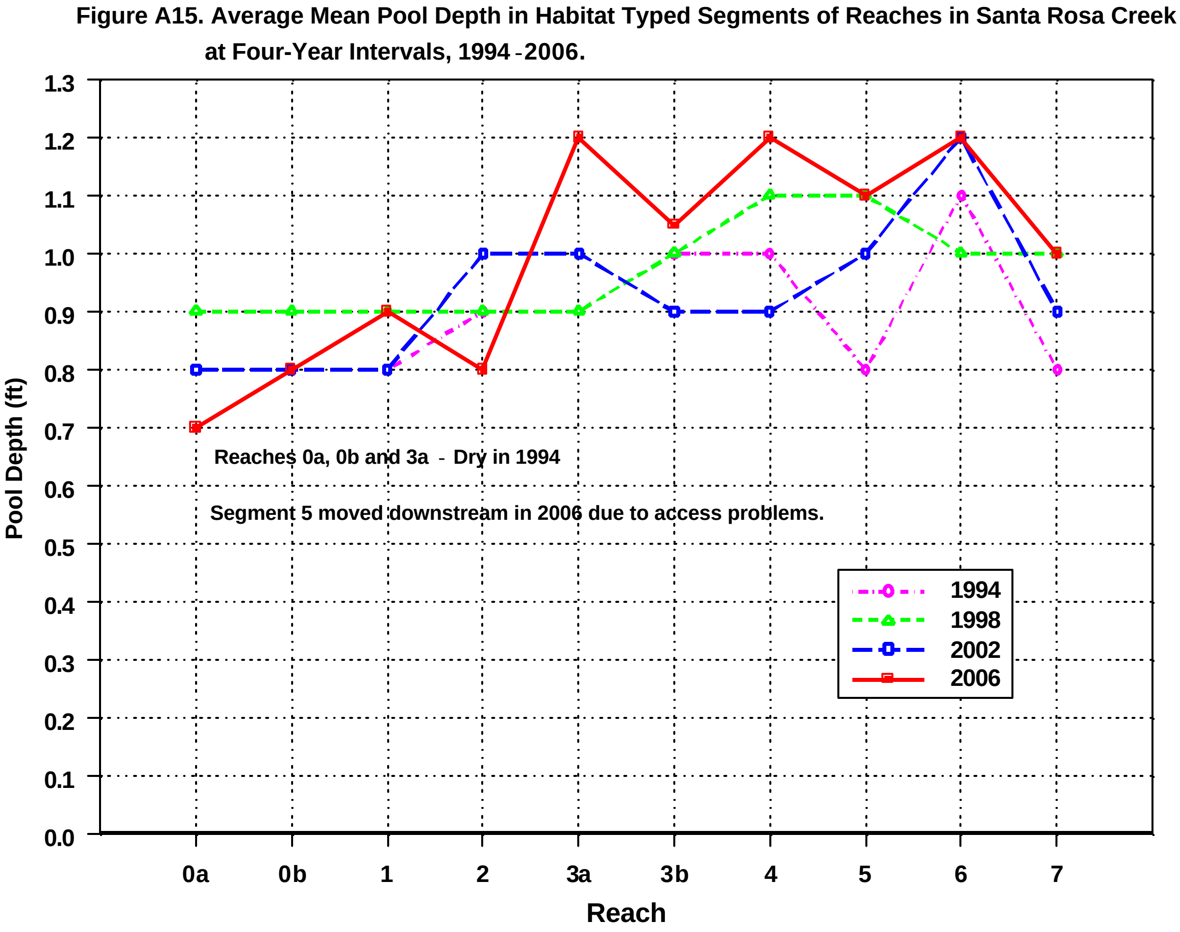
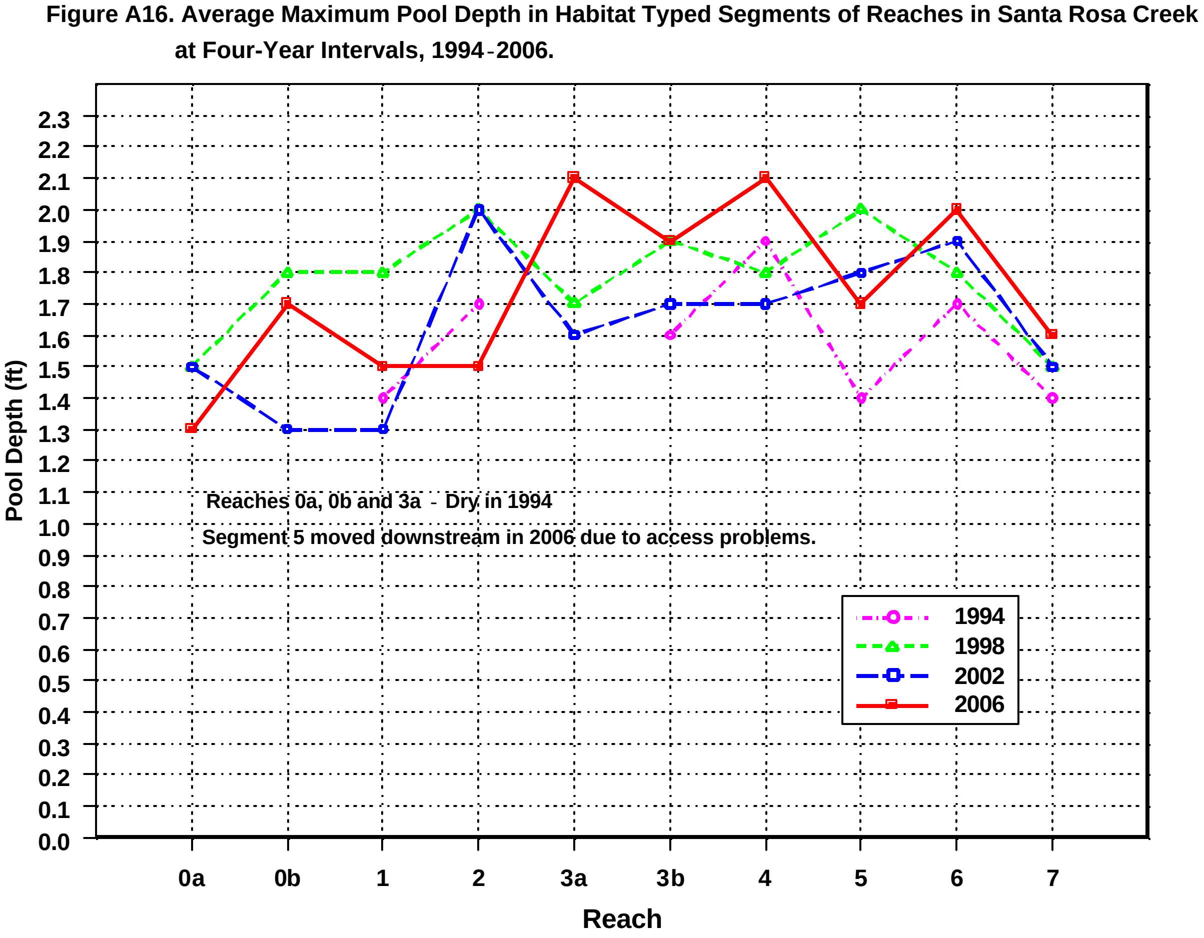


Figure A16. Average Maximum Pool Depth in Habitat Typed Segments of Reaches in Santa Rosa Creek at Four-Year Intervals, 1994-2006.



In Reach 2 in 1998, it was noted that it was separated from Reach 1 at a large bedrock outcrop where pool development and gradient began to increase in Reach 2. Average maximum pool depth was greater in Reach 2 than Reach 1, while average pool depth remained equal in 1998 (**Figures A15 and A16**). The habitat typed segment in Reach 2 was dominated by instream wood pools (9 of 17 analyzed pools), with bedrock pools becoming more common than in Reach 1. The proportion of pools increased in 1998, and glides converted to more riffles and runs as in Reach 1. Habitat lengths were longer than in 1994. As in Reach 1, escape cover in 1998 was primarily from overhanging willows with some instream wood and an occasional tree root mass (pool escape cover index = 0.127).

Reaches 3a–7 (upper canyon) were separated from Reach 2 by 2.2 miles of mostly dry streambed in 1998. Reach 3a was dominated by pools, followed by runs riffles and step-runs. Pools in the habitat typed segment were equally scoured by rootwads (7 pools), very large boulders (6 pools) and bedrock (6 pools), with fewer instream wood pools (3 pools). In addition, pools were scoured at bends having streambanks of hard clay (5 pools).

Average pool depth was the same as downstream reaches (0.9 feet), and average maximum pool depth was similar to Reaches 0a, 0b and 1 (**Figures A15 and A16**). Escape cover in 1998 was primarily submerged, living tree roots along the margins (not undercut banks), secondarily boulders and thirdly, overhanging willows (pool escape cover index = 0.142).

Reach 3b had a more closed riparian canopy and passed through a deeper canyon than downstream reaches, and the habitat typed segment was dominated by boulder pools (8) followed by rootwad pools (6) and bedrock pools (3) in 1998. Average and maximum pool depth was deeper than downstream reaches (**Figures A15 and A16**). As in Reach 2, maximum pool depth was deeper than in 1994 but average pool depth was unchanged. Substantial cover was provided by undercut banks in 1998 (unlike downstream reaches), with unembedded boulders also very important (pool escape cover index = 0.143).

Reaches 3b and 4 were separated by the confluence of the perennial tributary, Lehman Creek. In 1998, the habitat typed segment in Reach 4 was predominately pools scoured by rootwads (10), boulders (10) and bedrock (6). This was a change over 1994, when step-runs were more prevalent. Compared to downstream reaches, average pool depth increased (**Figure A15**). All habitat depths in Reach 4 increased in 1998 compared to 1994, especially in step-runs (**Figure A16**). Most of the increase was probably due to increased streamflow (**Figure A14**). As in Reaches 3a and 3b, escape cover in Reach 4 in 1998 was primarily undercut banks and unembedded boulders (pool escape cover index = 0.118).

The short Reach 5 was demarcated at its lower end by a failing canyon slope, eroding into the channel. Reach 5 was lower gradient than reaches below and above. In 1998 there was a habitat shift to more and deeper pool habitat (**Figures A15 and A16**). Escape cover was more abundantly provided under boulders and by undercut banks than in reaches above and below (pool escape cover index = 0.248)

Reach 6 began with increasing gradient and consisted of mainly pools (51%) and step-runs (41%). In the habitat typed segment, most pools were scoured primarily by rootwads (13), followed by boulders (7) and bedrock (4). In 1998, average pool depth had decreased slightly and maximum pool depth had increased slightly, resulting in not much change from 1994 (**Figures A15 and A16**). As in Reach 4, step-run depth had increased greatly over 1994. In 1998, escape cover was primarily undercut banks, unembedded boulders and submerged roots bordering the margins (pool escape cover index = 0.172).

Reach 7 began upstream of the large, dry tributary from the south (the East Fork) and a bridge crossing. Reach 7 ended at the Mora Creek confluence from the north. Large boulders dominated the streambed in this reach. In 1998, Reach 7 was primarily step-runs and pools, with a large shift from glides, runs and riffles in 1994 to step-runs in 1998. In the habitat typed segment, pools were primarily scoured by boulders (13) and rootwads (6). In 1998, maximum pool depth declined and average pool depth was unchanged from 1994 (**Figures A15 and A16**). Escape cover in 1998 was primarily under large, unembedded boulders with fewer undercut banks, providing overall good cover (pool escape cover index = 0.213).

Trends in Habitat Change Between 1998 and 2002

Santa Rosa Creek sometimes went dry through Cambria in summer prior to 1998 downstream of the High School in much of Reach 0a. Yates and Van Konyenburg (**1998**) modeled the Santa Rosa Creek groundwater basin for 1988-89, producing a calibration simulation that predicted the stream between the High School (Reach 0b) and the Highway 1 Bridge (Reach 0a) was dry from July through mid-December when agricultural and municipal pumping were included in the model. Without agricultural pumpage, but with municipal pumpage retained in the model for 1988, the simulation predicted that a trickle of baseflow emerged near well 27S/9E-19H2 and flowed continuously in all months except October when a short reach near well 27S/8E-27H1 (near Highway 1) went dry. In 1998-2006, surface flows continued through Reaches 0a and 0b to the lagoon.

Habitat quality in Reach 0a improved from 1998 to 2002, excluding the reduced flow in 2002. In 2002, Reach 0a was again dominated by long shallow pools with shallow glides and runs. Compared to 1998 conditions, conditions in 2002 indicated similar pool scour because despite the much lower streamflow in 2002, averaged mean pool depth was nearly as deep (0.8 feet vs. 0.9 feet) and equally deep for averaged maximum depth (1.5 feet) (**Figures A15 and A16**). Other habitat types were naturally shallower in 2002. Tree canopy had increased since 1998 (42% vs. 33%), and the escape cover index was slightly increased (0.133 vs. 0.122) with more overhanging willows in 2002 (**Figures A17 and A18**). Most of the cover was in pools. Pools were scoured by tree rootwads (7), woody material (3), boulders (1), riprap (1) and one hard earthen bank. In 2002 there were more of all kinds of habitats except riffles. It appeared that some run habitat in 1998 scoured more and became pool habitat in 2002. Percent fines increased in riffles in 2002.

Habitat quality declined in Reach 0b from 1998 to 2002. Consistent with Reach 0a, in Reach 0b that began at the Perry Creek confluence (**Figure A13**) there were more and shorter habitats in 2002 except for runs. Glides appeared. In Reach 0b it appeared that run habitat in 1998 scoured and became shallow pool habitat by 2002. Pool lengths in Reach 0b were much shorter than in Reach 0a, consistent with pool lengths upstream. In 2002, pools were scoured by tree rootwad (4), riprap (3), boulders (2), woody material (2) an earthen bank and a concrete road crossing with culvert. Runs were much shorter in 2002.

Compared to 1998, in 2002 mean pool depth was slightly shallower (0.8 feet vs. 0.9 feet) and maximum pool depth was much shallower (1.3 feet vs. 1.8 feet) (**Figures A15 and A16**). This indicated increased sedimentation in this reach or scour of runs to make shallow pools that made the overall pool depth less. The escape cover index decreased in 2002 (0.138 vs. 0.188) while tree canopy increased (61% vs. 40%) (**Figures A17 and A18**). Overhanging willows and instream wood were important escape cover factors. Percent fines in riffles were similar in 1998 and 2002.

Figure A17. Escape Cover Index for Pool Habitat in Habitat Typed Segments of Reaches in Santa Rosa Creek at Four-Year Intervals (1998-2006).

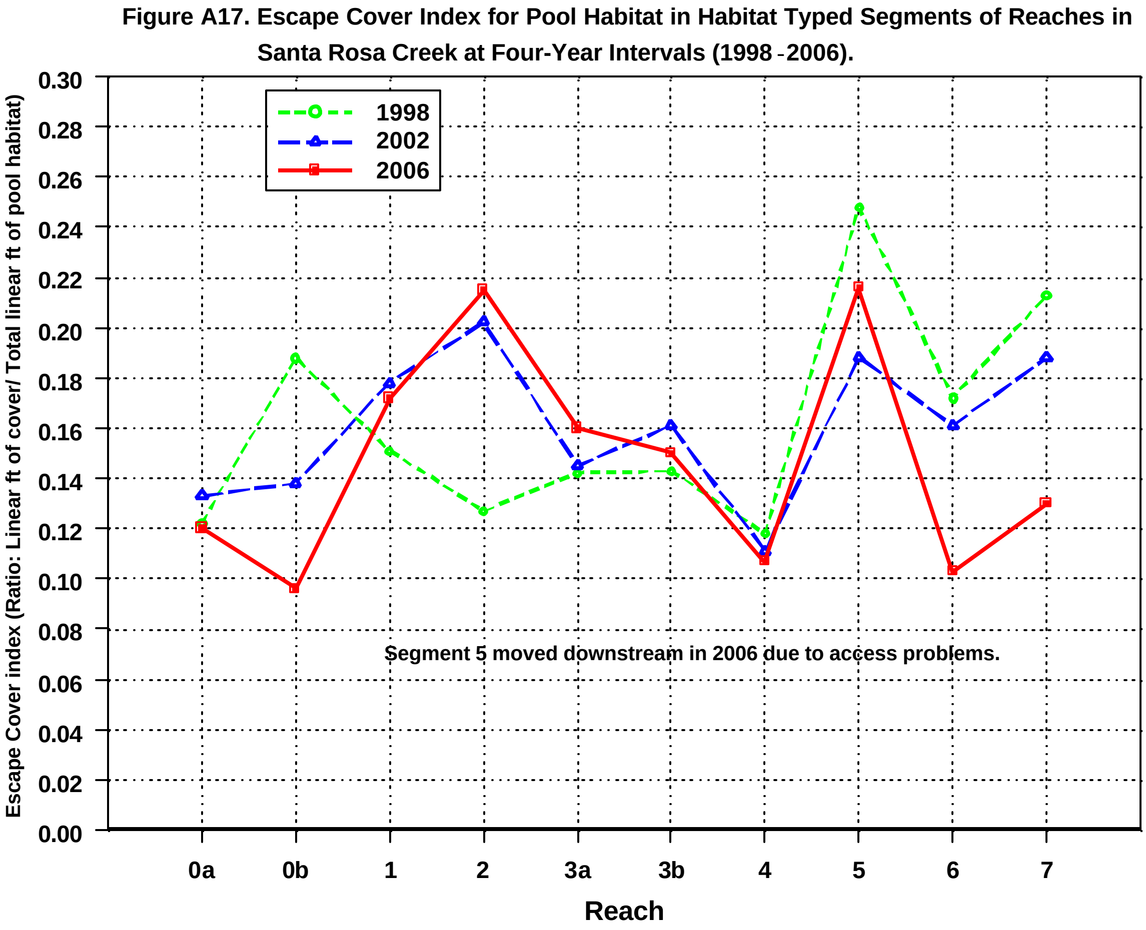
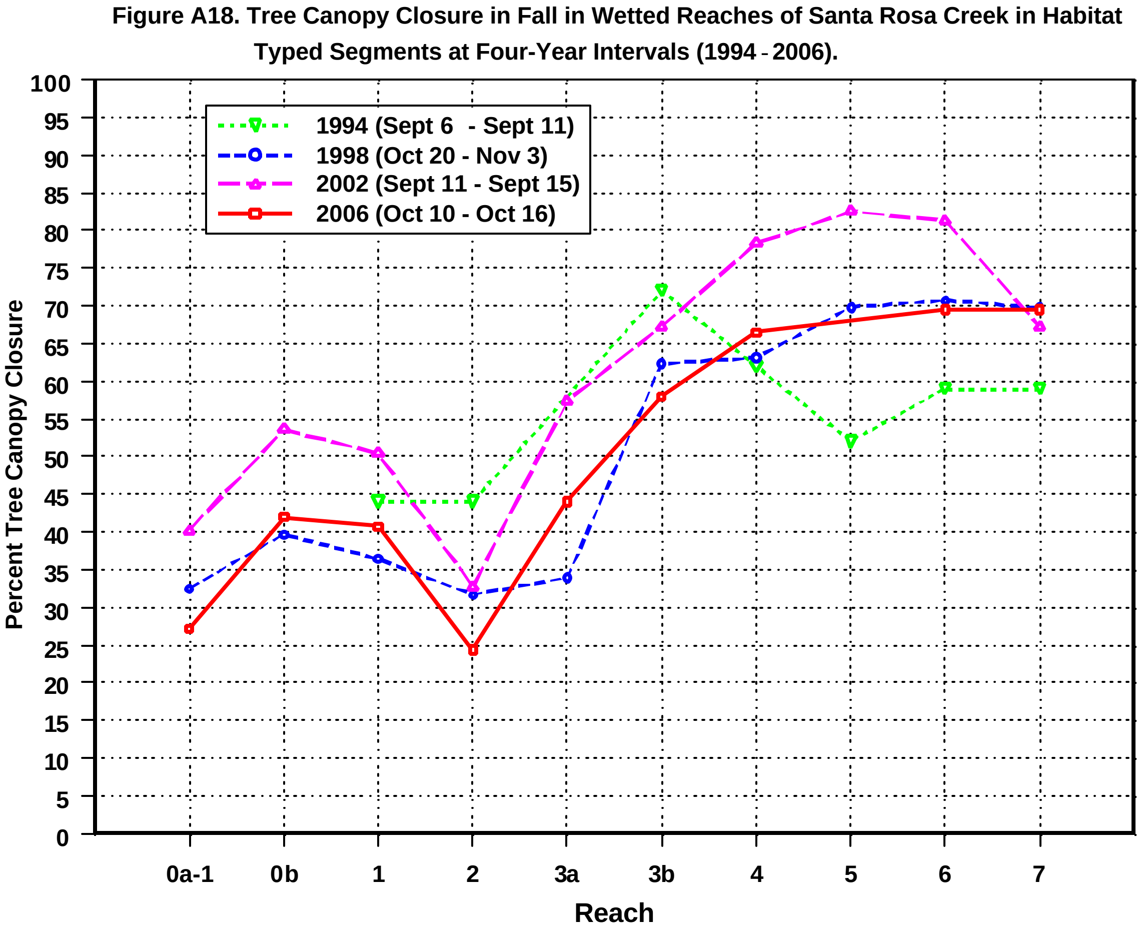


Figure A18. Tree Canopy Closure in Fall in Wetted Reaches of Santa Rosa Creek in Habitat Typed Segments at Four-Year Intervals (1994-2006).



Habitat quality in Reach 1 improved from 1998 to 2002, excluding the reduced flow in 2002 (**Figure A14**). In Reach 1 (beginning at the fish ladder) (**Figure A13**), habitat lengths were all shorter in 2002. Most pools were scoured by wood (10), followed by tree rootwads (7), boulders (2) and bedrock (1). Compared to 1998, in 2002 averaged pool depth trends were consistent with Reach 0b. Averaged pool depth was slightly shallower (0.8 feet vs. 0.9 feet in 1998), while averaged maximum pool depth was much shallower (1.3 feet vs. 1.7 feet in 1998). Pool depth in 1994 was similar to 2002, with averaged mean and maximum depth of 0.8 feet and 1.4 feet (**Figures A15 and A16**). The shallowing from 1998 to 2002 indicated either pool sedimentation or scour of runs to make shallow pools that resulted in a lower overall average pool depth. In 2002, the escape cover index increased (0.178 vs. 0.151 in 1998) (**Figure A17**) with increased tree canopy closure (53% vs. 36% in 1998) (**Figure A18**). Escape cover was primarily from instream wood and overhanging willows. There were many more riffles in 2002. Riffle embeddedness (small particle size) and percent fines in riffles were less in 2002.

Habitat quality in Reach 2 improved from 1998 to 2002, excluding the reduced flow in 2002 (**Figure A14**). Reach 2 was separated from Reach 1 at a bedrock outcrop (**Figure A13**) where pool development and gradient increased. As in downstream reaches, the habitat frequency increased for all types except runs. As in Reach 1, most pools were scoured by wood (11), followed by bedrock (5), tree rootwads (4) and boulders (1). Despite reduced streamflow in 2002, averaged pool depth was deeper than in 1998 (1.0 feet vs. 0.9 feet in 1998) and averaged maximum depth was equal in both years (2.0 feet). Averaged mean and maximum pool depth in 1994 were shallower than 2002 (0.9 and 1.7 feet, respectively) (**Figures A15 and A16**). Pool escape cover increased in 2002 (0.202 vs. 0.127 in 1998) (**Figure A17**) and tree canopy closure had increased (**Figure A18**). Riffle embeddedness declined in 2002, but particle size in riffles was small and percent fines were similar to 1998.

Habitat quality in Reach 2 improved from 1998 to 2002, excluding the reduced flow in 2002 (**Figure A14**). Reach 2 was separated from Reach 1 at a bedrock outcrop (**Figure A13**) where pool development and gradient increased. As in downstream reaches, the habitat frequency increased for all types except runs. As in Reach 1, most pools were scoured by wood (11), followed by bedrock (5), tree rootwads (4) and boulders (1). Despite reduced streamflow in 2002, averaged pool depth was deeper than in 1998 (1.0 feet vs. 0.9 feet in 1998) and averaged maximum depth was equal in both years (2.0 feet). Averaged mean and maximum pool depth in 1994 were shallower than 2002 (0.9 and 1.7 feet, respectively) (**Figures A15 and A16**). Pool escape cover increased in 2002 (0.202 vs. 0.127 in 1998) (**Figure A17**) and tree canopy closure had increased (**Figure A18**). Riffle embeddedness declined in 2002, but particle size in riffles was small and percent fines were similar to 1998.

The upper canyon (Reaches 3a through 7) was separated from Reach 2 by 2.2 miles of mostly dry streambed in 1998 and 2002 that extended upstream of the Curti Creek confluence (**Figure A13**). Habitat quality in Reach 3a was similar in 1998 and 2002, except for reduced flow in 2002. In 2002, Reach 3a continued to be dominated by pools (60%), followed by runs, riffles, glides and step-runs. Pools were scoured mostly by rootwads (15), followed by boulders (9), bedrock (5) and woody material (3). Despite reduced baseflow in 2002 (**Figure A14**), averaged pool depth was greater in 2002 (1.0 feet vs. 0.9 feet) and only slightly less as averaged maximum pool depth (1.6 feet vs. 1.7 feet) (**Figures A15 and A16**). From 1998 to 2002, the escape cover index was similar (**Figure A17**), riffle embeddedness was less, and percent fines were similar. As in downstream reaches, percent canopy closure improved (55% vs. 34%) (**Figure A18**).

Habitat quality in Reach 3b declined in 1998 and 2002. Reach 3b had a more closed riparian canopy than downstream reaches, and pools were the most common habitat (55%). In descending order of frequency, rootwad scour pools were most common (9), followed by boulder pools (8), bedrock pools (2) and log-scoured pools (1) in 2002. Pool depth averaged less in 2002 than in 1998 (averaged mean = 0.9 feet vs. 1.0 feet in 1998 and averaged maximum = 1.7 feet vs. 1.9 feet in 1998) (**Figures A15 and A16**), presumably due at least partially from reduced streamflow (**Figure A14**). Pool depths were similar in 1994 (averaged mean = 1.0 feet and averaged maximum = 1.6 feet). The pool escape cover index was somewhat higher in 2002 (0.161 vs. 0.143 in 1998) and tree canopy closure was increased (72% vs. 63% in 1998) (**Figures A17 and A18**). Riffle substrate was more highly embedded (48%) and contained more percent fines (36%). It appeared that riffle habitat in 1998 became step-run habitat in 2002 with considerably less escape cover (2002 index of 0.016 vs. 0.074 in 1998) with similar embeddedness (45%) and percent fines (29%) (**Figures A19 and A20**). Step-run depth was 0.1-foot shallower with reduced flow in 2002.

Figure A19. Substrate Embeddedness in Step-Runs and Runs in Reaches of Santa Rosa Creek at Four-Year Intervals (1998-2006).

Figure A19. Substrate Embeddedness in Step-Runs and Runs in Reaches of Santa Rosa Creek at Four-Year Intervals (1998- 2006).

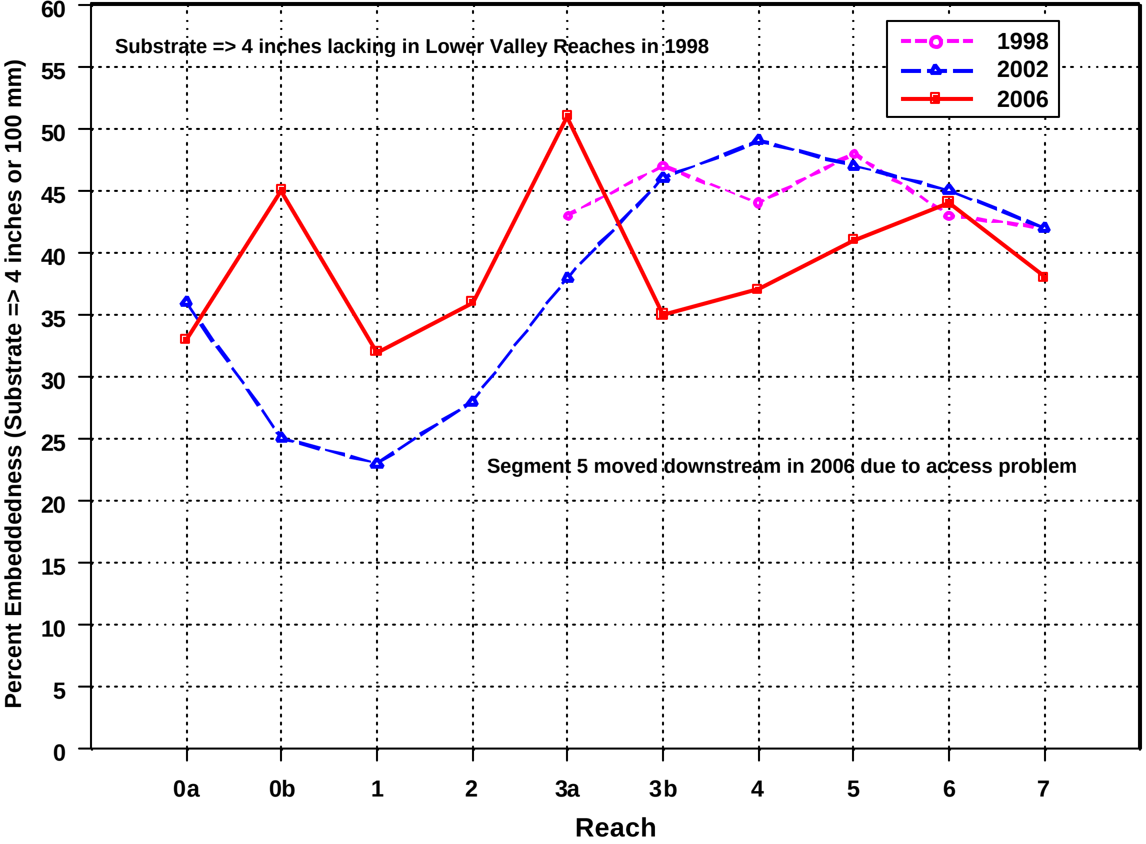
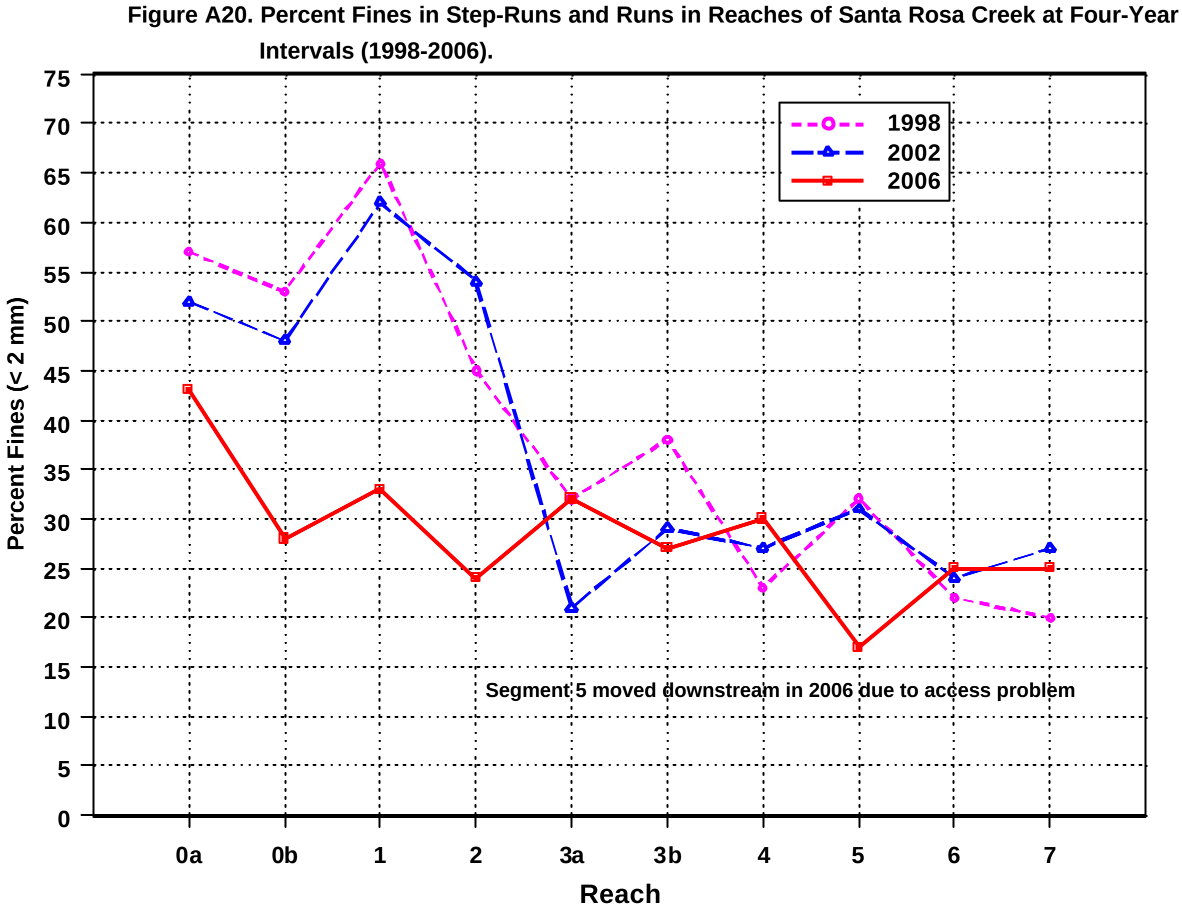


Figure A20. Percent Fines in Step-Runs and Runs in Reaches of Santa Rosa Creek at Four-Year Intervals (1998-2006).



Habitat quality in Reach 4 was similar in 1998 and 2002, except for reduced flow in 2002 (**Figure A14**). Reach 4 had changed in habitat proportions in 2002, with more pool habitat, less step-run habitat and more run habitat. Habitat value was lost with the loss of step-run habitat. Both averaged mean depth (0.9 feet vs. 1.1 feet in 1998) and maximum depth (1.7 feet vs. 1.8 feet in 1998) declined in 2002 compared to 1998 partially due to reduced streamflow (**Figures A15 and A16**). Compared to 1994, pool depth was shallower in 2002. However, more habitat was surveyed in 1994, making comparisons weaker. Pool escape cover was very similar between 1998 and 2002 (0.111 vs. 0.118 in 1998), and tree canopy increased (77% vs. 63% in 1998) (**Figures A17 and A18**). Undercut banks and unembedded boulders were the primary sources of escape cover in Reach 4. Riffle and step-run habitat had very similar levels of embeddedness and percent fines (**Figures A19 and A20**).

The short, lower gradient Reach 5 was demarcated at its lower end by a failing canyon slope, eroding into the channel and had a wood jam near its upper end with the horizontal-trunked sycamore (**Figure A13**). Habitat quality in Reach 5 was lower in 2002 compared to 1998, but perhaps better than in 1994. Regarding habitat proportions in Reach 5, pools dominated (59%), step-run habitat was less (14%) and riffle habitat increased (9%). This reach was unusual in that it had a higher proportion of wood-scoured pools and boulder pools compared to reaches above and below. Several boulder pools were formed by old riprap along the road. As in downstream reaches, averaged pool depth was less in 2002 compared to 1998, (1.0 foot vs. 1.1 feet in 1998) (**Figure A15**). So was averaged maximum depth in pools (1.8 feet in 2002 vs. 2.0 feet in 1998) (**Figure A16**). Reduced streamflow played a part (**Figure A14**). However, pool depth was less in 1994 (0.8 feet for averaged mean depth and 1.4 feet for averaged maximum depth). Pool escape cover in 2002 was high (0.188) relative to other reaches, but was less than in 1998 (0.248) (**Figure A17**). Step-runs in 2002 were considerably shallower and had much less escape cover than in 1998, although embeddedness and percent fines were somewhat less (**Figures A19 and A20**). Riffle embeddedness and percent fines were similar between the years. Canopy closure increased from 70% in 1998 to 80% in 2002 (**Figure A18**).

Habitat quality in Reach 6 had improved since 1998, excluding consideration of the reduced baseflow in 2002 (**Figure A14**). As in other reaches of the upper canyon, step-run habitat was reduced in Reach 6 while run and riffle habitat increased, likely due to reduced baseflow. Reach 6 began with increasing gradient and consisted of primarily pools (50%) and step-runs (32%). Pools were deeper in 2002 than 1998 (1.2 feet vs. 1.0 foot for averaged mean depth in 1998 and 1.9 vs. 1.8 feet for averaged maximum depth in 1998) despite the reduced streamflow (**Figures A15 and A16**). Pools in 2002 were also deeper than in 1994. As in 1994 and 1998, most pools in 2002 were rootwad-scoured (14). In 2002, less frequent pools were bedrock pools (8) and boulder pools (5). Pool escape cover was similar (0.161 in 2002 vs. 0.172 in 1998), and tree canopy closure increased some (71 to 77%) (**Figures A17 and A18**). Step-runs remained similar in depth, escape cover, embeddedness and percent fines (**Figures A19 and A20**). Riffle embeddedness was similar, but percent fines in riffles were somewhat less in 2002.

Habitat quality in Reach 7 in 2002 appeared similar to 1998 conditions except for reduced baseflow (**Figure A14**). Reach 7 began at the confluence of the East Fork and ended at the Mora Creek confluence (**Figure A13**). Pools had similar depths between 1998 and 2002 (averaged mean depth = 0.9 in 2002 vs. 1.0 foot in 1998 and averaged maximum depth = 1.5 feet in both years) (**Figures A15 and A16**). Most pools were boulder scoured in 2002 (8), followed by bedrock (4), rootwad (2) and wood-scoured (1). Pools dominated the reach (58%) followed by step-runs (37%), though the proportion of step-runs decreased as in other upper canyon reaches. Pool escape cover was similar (0.188 in 2002 vs. 0.213 in 1998) (**Figure A17**). Escape cover was similar in step-runs, as was embeddedness and percent fines. Tree canopy closure was similar (74% in 2002 vs. 70% in 1998) (**Figure A18**). Step-run depth was greater in 1998 probably due to increased flow that year.

Trends in Habitat Change Between 2002 and 2006

Habitat conditions in Reach 0a [beginning at Windsor Drive Bridge (**Figure A13**)] declined from 2002 to 2006, excluding the higher baseflow in 2006. In 2006, Reach 0a was again dominated by long shallow pools runs and glides. Habitat typing in segment 0a-1 in 2006 indicated pool filling because, despite the higher streamflow in 2006 (**Figure A17**), the averaged mean pool depth was shallower (0.7 vs. 0.9 feet in 2002), as was averaged maximum depth (1.3 vs. 1.5 feet in 2002) (**Figures A15 and A16**). Pool length increased slightly as it did in all reaches in 2006. Other habitat types were shallower in 2006. Tree canopy was reduced in 2006 (27 vs. 42% in 2002), and the escape cover index decreased slightly (0.120 vs. 0.133 in 2002), with fewer overhanging willows in 2006 (**Figures A17 and A18**). Most of the cover was in pools. Pools were scoured by tree rootwads (9), bedrock (1), riprap (1) and one hard earthen bank. In 2006, the number of riffles increased while the number of runs and glides declined though lengthened. There was one fewer pool in 2006. Embeddedness was similar between 2002 and 2006 in all habitat types (**Figures A19 and A21**). Percent fines remained high and the same in pools (80%) (**Figure A22**) and lessened in other habitat types in 2006 (**Figure A20**).

Habitat conditions in Reach 0b declined overall in 2006 from 2002, despite the higher maximum pool depths and higher baseflow that increased the depth of fastwater habitat (runs and riffles). In Reach 0b [beginning at Perry Creek confluence (**Figure A13**)] the averaged mean pool depth remained the same and averaged maximum pool depth increased in 2006 (1.7 vs. 1.3 ft) (**Figures A15 and A16**). The main factor that reduced habitat quality was the reduced pool cover index in 2006 (0.096 vs. 0.138) (**Figure A17**). Run escape cover also declined. In 2006, pools in the Reach 0b were scoured by artificial boulder riprap (5), tree rootwads (3), woody material (1), an earthen bank and a concrete road crossing with a culvert and fish ladder. Pool length increased slightly as it did in all reaches in 2006. The percent of run habitat increased in 2006 while glide habitat decreased, consistent with higher baseflow. Tree canopy closure decreased (42 vs. 61%), as it did in all repeated stream segments (**Figure A18**). Overhanging willows and woody debris were important escape cover factors. Embeddedness and percentage of fines increased in pools and runs in 2006 compared to 2002, indicating sedimentation (**Figures A19–A21**).

In Reach 1 [beginning at the fish ladder (**Figure A13**)], habitat conditions improved in 2006 over 2002 primarily due to increased mean pool depth (0.9 vs. 0.8 ft) and maximum pool depth (1.5 vs. 1.3 ft) and increased baseflow (**Figures A14–A16**). Evidence of cattle using the riparian corridor appeared absent in 2006. The pool escape cover index was similarly high in 2002 (0.178) and 2006 (0.172) (**Figure A17**) while run escape cover index declined in 2006 (0.022) from 2002 (0.054). Most pools were scoured by tree rootwads with overhanging limbs (11), followed by wood (2), boulders (2) and bedrock (1) and a mudstone wall. In 2006, average embeddedness increased in pools and runs while average percent fines decreased (**Figures A19–A22**). Canopy closure decreased in Reach 1 in 2006 (42 vs. 61%) as in all repeated habitat typed segments (**Figure A18**).

Figure A21. Substrate Embeddedness in Pools in Reaches of Santa Rosa Creek at Four-Year Intervals (1998-2006).

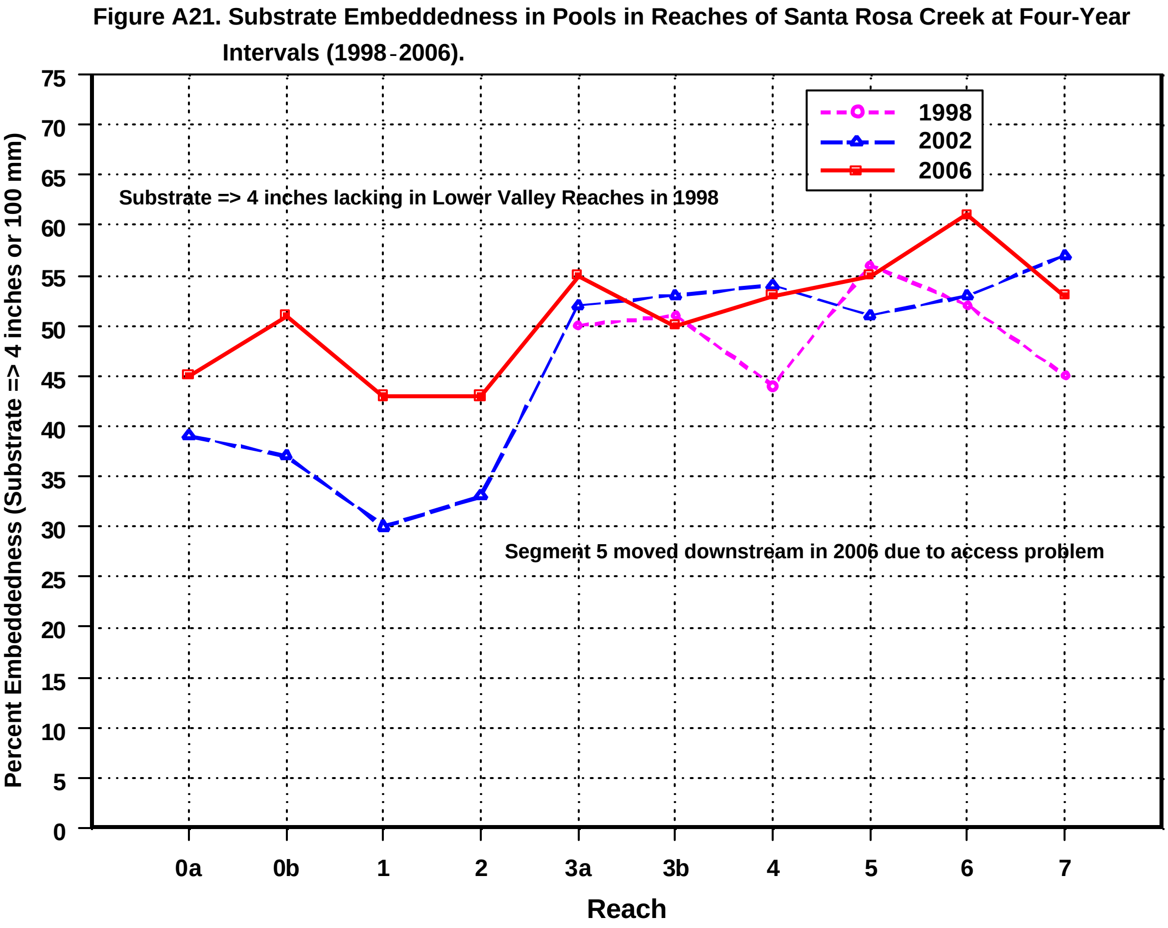
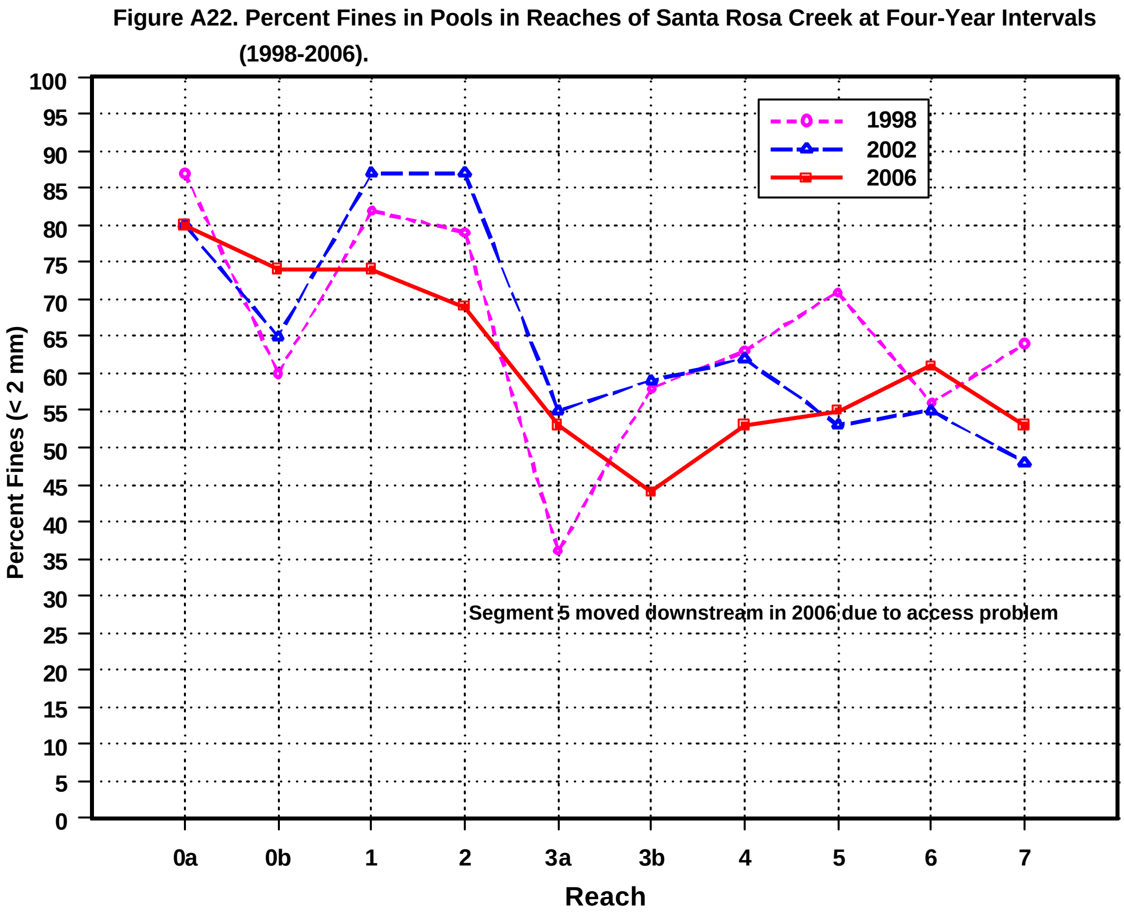


Figure 22. Percent Fines in Pools in Reaches of Santa Rosa Creek at Four-Year Intervals (1998-2006).



Habitat conditions in Reach 2 declined from 2002 to 2006 primarily due to pool shallowing, although pool escape cover increased slightly despite less tree canopy closure. Reach 2 was separated from Reach 1 at a bedrock outcrop, where pool development and gradient increased (**Figure A13**). In 2006, averaged mean pool depth declined (0.8 vs. 1.0 ft in 2002), averaged maximum pool depth declined substantially (1.5 vs. 2.0 ft in 2002) and tree canopy closure declined considerably (24 vs. 54% in 2002), while the pool escape cover index increased slightly (0.215 vs. 0.202 in 2002) and baseflow was higher compared to 2002 (**Figures A14–A18**). As in Reach 1, most pools were scoured by tree rootwads (wood (8), followed by wood (6), bedrock (3), mud banks (2) and boulders (1). As in Reach 1, embeddedness increased slightly in all habitat types while percent fines decreased (**Figures A19–A22**).

The upper canyon (Reaches 3a through 7) was separated from Reach 2 in 2006 by 0.25 miles of mostly dry streambed downstream of the Curti Creek confluence (**Figure A13**). Reach 3a improved in habitat quality in 2006 compared to 2002. Pools deepened, escape cover increased and baseflow increased. In 2006, averaged mean pool depth increased

(1.2 vs. 1.0 ft in 2002), averaged maximum pool depth increased (2.1 vs. 1.6 ft in 2002), pool escape cover increased (0.160 vs. 0.145 in 2002), run cover increased (0.018 vs. 0 in 2002) and baseflow increased substantially after the earthquake in 2003 (**Figures A14–A18**). In 2006, Reach 3a continued to be dominated by pools (50%), but riffles increased in proportion (9% in 2002 to 28% in 2006) at the expense of pools and runs, primarily. Pools lengthened in 2006, and there were much fewer of them. This was partially due to a shorter habitat-typed section. Pool embeddedness and percent sand in pools and runs were similar in 2002 and 2006, although run embeddedness increased in 2006 (**Figures A19–A22**). As in other repeated reach segments, percentage canopy closure decreased (44 vs. 55% in 2002) (**Figure A18**). Pools were formed primarily by tree rootwads (10), followed by bedrock (4), boulders (4) and wood (2).

Habitat conditions in Reach 3b improved overall in 2006 compared to 2002. Along with increased baseflow, water depth increased in all habitat types, as did escape cover in step-run habitat in 2006. In 2006, averaged mean pool depth increased (1.05 vs. 0.9 ft in 2002), averaged maximum pool depth increased (1.9 vs. 1.7 ft in 2002), averaged run mean depth and maximum depth increased by 0.2 ft, averaged step-run mean depth increased by 0.2 ft and maximum depth by 0.3 feet, step-run escape cover increased (0.059 vs. 0.016 in 2002) and baseflow was much greater (1.23 vs. 0.23 cfs in 2002) (**Figures A14–A18**). While pool embeddedness was similar in 2002 and 2006, embeddedness in other habitat types declined and percent fines decreased in all habitat types (**Figures A19–A22**). The only decline in habitat conditions in 2006 occurred with a slight decline in pool escape cover (0.150 vs. 0.161 in 2002) (**Figure A17**). Pools were formed by scour against boulders (9), tree rootwads (7) and bedrock (1).

Reach 4 [beginning at the Lehman Creek confluence (**Figure A13**)] showed net decrease in habitat quality in 2006 compared to 2002 primarily due to the proportion of pool habitat greatly decreasing (45 vs. 67% in 2002), it being converted with step-run habitat to riffle habitat in 2006 (37 vs. 4% in 2002). Riffle habitat does not provide much habitat compared to pools, particularly for larger juveniles. The quality of pool habitat improved in 2006, as averaged mean pool depth increased (1.2 vs. 0.9 ft in 2002) and averaged maximum pool depth increased (2.1 vs. 1.7 ft in 2002) (**Figures A15 and A16**). Averaged mean and maximum run depth also increased. Pool escape cover was very similar between 2006 and 2002 (0.107 vs. 0.111 in 2002), and tree canopy decreased (67 vs. 77% in 2002) (**Figures A17 and A18**). Undercut banks and unembedded boulders were the primary sources of escape cover in Reach 4. Pool embeddedness was similar to 2002, though percent fines was less in pools in 2006 (**Figures A21 and A22**). Embeddedness lessened in riffles and runs while percent fines were similar between years (**Figures A19 and A20**). Pools were primarily scoured by tree rootwads (9) followed by boulders (4), bedrock (3) and wood (1).

After being denied access to the short, lower gradient Reach 5 by new landowners in 2006, a new segment was substituted in upper Reach 4, immediately downstream of Reach 5. This new 4b segment had slightly better habitat conditions in 2006 than the previous Reach 5 in 2002. As in lower Reach 4 in 2006, riffle habitat increased in proportion but at the expense of run and step-run habitat. The proportion of pool habitat was very similar between years. Habitat improvement was primarily due to more pool escape cover in 2006 (0.216 vs. 0.188 in 2002) and more streamflow in the upper canyon (**Figures A14 and A17**). Averaged mean pool depth was deeper in 2006 (1.1 vs. 1.0 ft in 2002), but averaged maximum pool depth was less in 2006 (1.7 ft vs. 1.8 ft in 2002) (**Figures A15 and A16**). Pools in segment 4b were scoured primarily by tree rootwads (7) followed by bedrock (5) and boulders (3). Embeddedness and percent and in pools were similar between years (**Figures A21 and A22**). Percent sand and embeddedness in other habitat types were similar between years except percent fines were reduced in runs in 2006 (**Figures A19 and A20**). Canopy closure was similar in segment 4b in 2006 (85%) and in Reach 5 in 2002 (80%) (**Figure A18**).

Overall habitat conditions in Reach 6 declined in 2006 compared to 2002 primarily due reduced pool escape cover (0.103 vs. 0.161 in 2002) (**Figure A17**), although step-run escape cover increased (0.074 vs. 0.041 in 2002). The number and proportion of pool habitat increased in 2006, but more habitat was typed in 2006. Pool depths were similar with slightly deeper averaged maximum pool depth in 2006 (2.0 vs. 1.9 ft in 2002) (**Figures A15 and A16**). Pools were primarily scoured by tree rootwads (26) followed by bedrock (9) and boulders (4). Other habitat types were deeper in 2006 partially due to increased streamflow (**Figure A14**). Pool embeddedness increased in 2006 while percent fines in pools decreased (**Figures A21 and A22**). Embeddedness in riffles and step-runs were similar between years with more percent sand in riffles and similar amounts in step-runs (**Figures A19 and A20**). Embeddedness increased in runs with similar percent fines between years. Tree canopy closure was similar (70% in 2006 vs. 77% in 2002) (**Figure A18**).

Overall habitat conditions in Reach 7 [beginning at the confluence of the East Fork (**Figure A13**)] declined in 2006 compared to 2002 primarily due to reduced pool escape cover (0.130 vs. 0.188 in 2002) (**Figure A17**), although step-run escape cover increased (0.088 vs. 0.062 in 2002). Pools slightly deepened with averaged mean depth increased (1.0 vs. 0.9 ft in 2002) and averaged maximum depth increased (1.6 vs. 1.5 ft in 2002) (**Figures A15 and A16**). Most pools were scoured by boulders (14), followed by tree rootwads (8), bedrock (6), and wood (2). Tree canopy closure was similar (68% in 2006 vs. 74% in 2002) (**Figure A18**). Water depth in all other habitat types increased partially due to increased baseflow in the upper canyon (**Figure A14**). Embeddedness declined in all habitat types while percent sand diminished in pools and riffles and remained similar in step-runs and runs, indicating reduced overall sedimentation (**Figures A19–A22**).

Comparison of Habitat Conditions in Reaches Between 1994 and 2006

In comparing habitat conditions in 2006 to those in 1994 in the lower valley, Reach 1 had similar conditions with slightly deeper pools (mean and maximum) in 2006 (**Figures A15 and A16**), which may have been partially due to higher baseflow in 2006 (**Figure A14**), and similar tree canopy closure (**Figure A18**). Reach 2 conditions had worsened by 2006, with shallower pools (mean and maximum) in 2006 despite higher baseflow. Tree canopy closure in Reach 2 was the lowest in the 13-year period and had not recovered to 1994 levels after the 1995 flood. In comparing 2006 to 1994 in the upper canyon, habitat conditions had improved in 2006 with deeper pools (mean and maximum depth) in all reaches (3b, 4, 5, 6 and 7). Tree canopy was very similar in 1994 and 2006 in the upper canyon. Escape cover could not be compared due to the change to better methods in 1998 that were used thereafter.

Changes in Tree Canopy Closure Between 1994 and 2006

Comparisons of tree canopy closure in fall at four-year intervals was not clear-cut because data in1994 and 2002 were collected approximately a month earlier than in 1998 and 2006. Data in 1994 and 2002 were collected after below average rainfall winters (perhaps hastening earlier leaf drop), and data in 1998 and 2006 were collected after above average rainfall winters (perhaps delaying leaf drop). Despite these ambiguities, tree canopy closure in lower valley reaches was trending in a negative direction since the 1995 flood, as it was in the 2 lower reaches of the upper canyon (Reaches 3a and 3b) (**Figure A18**). The upper 4 reaches of the upper canyon had somewhat more tree canopy than prior to the 1995 flood. In 2006, the lower valley and Reach 3a in the upper canyon had relatively lower tree canopy closure (25–45%), while the remainder of the upper canyon had relatively higher closure (55–70%).

In looking at the details, it appeared that tree canopy in the lower valley decreased from 1994 to 1998, after the devastating flood of spring 1995 and 2 wet winters of 1995 and 1998 (**Figures A8 and A18**). Tree canopy also decreased in Reach 3b of the upper canyon in 1998, was unchanged in Reach 4 and had increased in the upper Reaches 5, 6 and 7 since 1994. From 1998 to 2002, with average to below average rainfall winters, tree canopy in Reach 1 of the lower valley had increased to slightly above the 1994 level, but Reach 2 (which had sustained such major streambank erosion in 1995) had remained at the low 1998 level. In the upper canyon, Reaches 3b, 4, 5, and 6 increased by 2002, while Reach 7 was similar to the 1998 level. From 2002 to 2006, tree canopy closure decreased back to near 1998 levels in 9 of 10 reaches (except in Reach 7 where canopy closure had been stable since 1998), with continued reduction in Reach 2. Winter of 2005 was especially wet.

Water Temperature Monitoring at Stream Sites in 2003–2006 and Management Guidelines

Since the December 2003 earthquake that increased summer baseflow, the proposed temperature guidelines were met at upper canyon temperature monitoring sites in 2004–2006 except for short periods. Once summer baseflows return to pre-earthquake levels, more water temperature monitoring will indicate if the guidelines are still being met. Water temperature was monitored for only the latter part of the summer in 2003, prior to the baseflow-augmenting effects (**Figure A14**) of the December 2003 earthquake. However, for the month of September in 2003 vs. 2004, daily maximum water temperatures were very similar at lower valley Sites 0a and 1 and within 1°F at the upper Site 6a (slightly cooler in 2004), despite the increased baseflow in 2004 (**Alley 2004a and 2005a**). Monitoring of water temperature in 2003 and the post-December 2003 earthquake era (2004–2006) indicated that the upper canyon was cooler than in the lower valley (about 5 °F cooler in 2006 for the maximum daily water temperature) (**Table A6**). However, the maximum 7-day rolling average at Site 6a in 2006 was equal to that at Site 0a (20.4 °C (68.8 °F); 19 July to 28 July) between 1 July and 10 September. In all years, the daily water temperature varied more between days in the upper canyon but the diurnal (daily) variation in water temperature was greatest in the lower valley (**Tables A6–A8**). It is significant to note that although the baseflow in 2004 was much less at Site 0a than in 2005 and 2006 (**Figure A14**), water temperature was cooler there in 2004 than in the two succeeding years. When the 7-day rolling average was examined for each year at Site 0a for the months of July and August, the range for 2004 was 17.6–19.3 °C (63.6–66.7 °F) (**Figure A23**). In 2005 and 2006 during the same period, the 7-day rolling average ranges were 17.4–19.6 °C (63.4–67.3 ºF) and 17.2–20.4 °C (63.0–68.8 ºF), respectively (**Figures A27 and A31**). Therefore, the degree of persistence of fog and overcast nearer the coast during the summer (and their effect on air temperature) may be more important in maintaining cooler water temperature than higher streamflow (within the ranges of streamflow in 2004–2006). The common range of daily maximum water temperature was higher in 2005 than 2004 despite the generally higher baseflow in 2005. The common range of daily maximum temperature in the lower valley (Sites 0a and 1) between 1 July and 10 September in 2005 was 70–75.5 ºF (71–74 ºF in 2004). In the upper canyon (Sites 3b and 6) it was 65–71 ºF (63–70 ºF in 2004). This likely resulted from warmer afternoon air temperature in 2005.

Table A6. Comparison of Dry-Season Water Temperatures at Lower Valley and Upper Canyon Fish Sampling Sites from <u>1 July through 10 September 2006</u> Using, Continuous 30-Minute Interval Measurements.

Fish Sampling Site	Range of Daily Max. Temp. ºF (ºC)	Common Range of Daily Max. Temp. °F (° C)	Temp. Range on Day with Coolest Max. Temp. ºF (ºC) (Date)	Temp. Range on Day with Warmest Max. Temp. ºF (ºC) (Date)	Max. 7-Day Rolling Average	Avg. Site Tree Canopy	Fall Streamflow (cfs)
0a Lower Valley	64.5-76.7 (17.9-24.8)	70-74 (21-23.3)	61-64.5 (16.1-17.9) 8 Sep	63.3-76.7 (17.4-24.8) 19 July	68.8 (20.4) 19-25 July	28	1.63
1 Lower Valley	63.8-75.7 (17.7-24.1)	69-72 (20.6-22.2)	60.4-64.1 (15.6-17.7) 8 Sep	62.7-75.7 (17.1-24.1) 22 July	67.2 (19.6) 22-28 July	36	1.43
3b Upper Canyon	–	–	–	–	–	–	1.23
6a Upper Canyon	61.8-74.5 (16.6-23.6)	65.3-68.8 (18.5-20.3)	59.5-61.8 (15.1-16.6) 8Sep	65.6-74.5 (18.7-23.6) 22 July	68.8 20.4 22-28 July	76	0.72

Table A7. Comparison of Dry-Season Water Temperatures at Lower Valley and Upper Canyon Fish Sampling Sites from 1 July through 10 September 2005 Using, Continuous 30-Minute Interval Measurements.

Fish Sampling Site	Range of Daily Max. Temp. ºF (ºC)	Common Range of Daily Max. Temp. ºF (ºC)	Temp. Range on Day with Coolest Max. Temp. ºF (ºC) (Date)	Temp. Range on Day with Warmest Max. Temp. ºF (ºC) (Date)	Max. 7-Day Rolling Average	Avg. Site Tree Canopy	Fall Streamflow (cfs)
0a Lower Valley	65.9–76.1 (18.8–24.5)	70–75.5 (21.1–24.2)	61.9–65.9 (16.6–18.8) (15 Aug)	62.2–76.1 (16.8–24.5) (23 July)	67.2 (19.6) 8-14 July	26	1.97
1 Lower Valley	65.9–75.7 (18.8–24.3)	71–75 (21.7–23.9)	61.0–65.9 (16.1–18.8) (15 Aug)	61.3–75.7 (16.3–24.3) (23 July)	66.5 (19.2) 9-15 July	48	2.06
3b Upper Canyon	62.1–70.9 (16.7–21.6)	65–70 (18.3–21.1)	59.8–62.1 (15.5–16.7) (15 Aug)	62.4–70.9 (16.9–21.6) (23 July)	65.2 (18.4) 19-25 July	74	1.50
6a Upper Canyon	62.6–71.7 (17.0–22.1)	65–71 (18.3–21.7)	59.7–62.6 (15.4–17.7) (15 Aug)	62.6–71.7 (17.0–22.1) (23 July)	65.4 (18.6) 19-25 July	73	1.41

Table A8. Comparison of Dry-Season Water Temperatures at Lower Valley and Upper Canyon Fish Sampling Sites from 1 July through 10 September 2004, Using Continuous 30-Minute Interval Measurements.

Fish Sampling Site	Range of Daily Max. Temp. ºF (ºC)	Common Range of Daily Max. Temp. ºF (ºC)	Temp. Range on Day with Coolest Max. Temp. ºF (ºC) (Date)	Temp. Range on Day with Warmest Max. Temp. ºF (ºC) (Date)	Temperature Range ºF (ºC) on 24 July at All Sites	Max. 7-Day Rolling Average	Avg. Site Tree Canopy	Fall Stream-flow (cfs)
0a Lower Valley	67.4–74.6 (19.7–23.6)	71–73 (21–22)	62.7–67.4 (17.1–19.7) (30 Aug)	63.9–74.6 (17.7–23.6) (24 July)	63.9–74.6 (17.7–23.6)	66.7 (19.3) 19-25 July	41%	0.43
1 Lower Valley	68.5–73.5 (20.3–23.1)	71–74 (21–23.3)	62.4–68.5 (17.5–20.3) (8 July)	63.5–73.5 (17.5–23.1) (24 July)	63.5–73.5 (17.5–23.1)	67.0 (19.4) 18-24 July	67%	1.02
3b Upper Canyon	63.8–70.3 (17.7–21.3)	63–69 (17.2–20.6)	60.7–63.8 (15.9–17.7) (8 July)	62.1–70.3 (16.7–21.3) (20 July)	62.1–68.2 (16.7–20.1)	64.9 (18.3) 16-22 July	69%	1.32
6a Upper Canyon	64.0–71.1 (17.8–21.7)	64–70 (17.8–21.1)	60.6–64.0 (15.9–17.8) (8 July)	62.6–71.1 (17.0–21.7) (20 July)	61.5–68.4 (16.4–20.2)	65.4 (18.6) 16-22 July	67%	1.42

According to laboratory work, water temperatures would ideally not rise above 20ºC (68ºF) to balance steelhead/ rainbow trout scope of activity and metabolic demands. Refer to the literature review in **Appendix B**. However, despite the increased food demand at higher temperatures, if food supply is adequate, YOY steelhead can grow to smolt size the first year at water temperatures above 20ºC, though they select habitats where food is abundant, such as lagoons (**Smith 1990**) and fastwater habitat (**Smith and**

Li 1983; Moyle et al. 1982). YOY steelhead grow rapidly to smolt size in one growing season in central coast streams (lower mainstem of San Lorenzo River and Soquel Creek in Santa Cruz County) where summer water temperatures regularly rise above 20ºC (**Alley 2008b**), as in the lower valley reaches of Santa Rosa Creek (**Alley 2007a**), in lower San Luis Obispo Creek downstream of the treated effluent outfall (**Alley 2008a**), in Soquel Creek lagoon (**Alley 2008c**).

The recommended water temperature guideline during the important growth period of April and May for steelhead in stream of Santa Rosa Creek, upstream of the lagoon, is to maintain stream temperature below 20ºC (68ºF.

The recommended water temperature guideline for lower valley reaches of Santa Rosa Creek to protect steelhead habitat should be to maintain the average daily temperature at 20ºC (68ºF) or less, with a 23ºC (73.4ºF) daily maximum from June 1 to October 15.

These summer/fall guidelines were based on 1) consideration of the SYRTAC guidelines, 2) steelhead sampling at lower valley sites 1994–2006, 3) the high densities of smolt-sized juveniles (many of which were fast-growing YOY), 4) the measured summer water temperatures in summer 2004–2006 and late summer 2003 and 5) the Hokanson et al. (**1977**) conclusions.

From June 1 to October 15 in the lower valley reaches of Santa Rosa Creek, divergence from the proposed guidelines of the Santa Ynez River Technical Advisory Committee (SYRTAC) for the Santa Inez River are appropriate. The SYRTAC had proposed guidelines with upper limits of 20ºC average daily temperature and 25ºC daily maximum as providing acceptable habitat conditions for steelhead in the Santa Ynez River (**SYRTAC 2000**). The SYRTAC (**2000**) decided that a mean daily temperature of 22ºC may be the threshold between acceptable and unsuitable from a long-term perspective. This was based on studies by Hokanson et al. (**1977**) who concluded that the highest constant temperature at which the effects of growth and mortality balance out was 23ºC.

By comparison with our temperature guidelines, an average daily water temperature requirement that was more restrictive than ours was determined for upper Big Sulphur Creek (Russian River drainage) in the Geysers Geothermal Region. For Big Sulphur Creek, it was concluded that stations which had temperatures greater than 20ºC for less than 50% of the time in any one month were not expected to cause significant sub-lethal effects in that month, unless that station reached a marginal or lethal maximum temperature (25.8ºC for fish acclimated to 20ºC) (**Kubicek and Price 1976**).

More restrictive guidelines than those for the lower valley should be followed in the upper canyon of Santa Rosa Creek, where baseflow was less. To protect steelhead habitat in the upper canyon, the average daily water temperature should have upper limits of 20ºC (68ºF) and the maximum daily temperature should not rise above 22ºC (71.6ºF).

This summertime goal was based on electrofishing data that indicated the upper canyon Santa Rosa Creek reaches that met these guidelines produced relatively high densities of yearling juveniles and were typically cool enough to allow juvenile steelhead to inhabit more than just fastwater habitat in pools.

In 2004–2006, our recommended temperature guidelines regarding average daily water temperature were likely met at lower valley sites regarding average daily temperature except for a 10-day period in July 2006, based on the 7-day rolling average. Refer to **Figures 21–31** for continuous temperature probe data in 2004–2006. The 7-day rolling average was less than 20°C in all three years. In 2004, the temperature guidelines regarding daily maximum temperature were met at Site 0a except for a small number of days but less so at Site 1. In 2005, the guidelines were approached less at Site 0a for maximum daily temperature than at Site 1, with exceedence about a third of the days at each site. In 2006, the maximum daily temperature guideline was not met much of July and half of August at Site 0a and for a warm 10-day period in July at Site 1. The increased baseflow effects from the December 2003 earthquake (**Figure 14**) may have promoted cooler water temperatures in the lower valley than under pre-earthquake baseflow conditions.

In 2004–2006, the temperature guidelines regarding average daily temperature and daily maximum were likely met at monitored upper canyon sites except for a six-day period in mid-July 2006. These guidelines will allow steelhead to grow and thrive without water temperature being a significant limit factor. Once summer baseflows return to pre-earthquake levels, more water temperature monitoring will indicate if the guidelines continue to be met.

Regarding temperature optima, Moyle (**2002**) stated, "The optimal temperatures for growth of rainbow trout are around 15-18ºC, a range that corresponds to temperatures selected in the field when possible. Thus in a section of the Pit River containing a thermal plume from an inflowing cold tributary, rainbow trout selected temperatures of 16-18ºC. However, many factors affect choice of temperatures by trout (if they have a choice), including the availability of food." Optimal temperature for rainbow trout in higher elevation mountain streams of the Sierra Nevada or Cascades may be lower than what is optimal for juvenile steelhead along the central Coast. According to Smith (**2003**), "The optimum temperature for steelhead very much depends upon factors other than temperature of the habitat. The ideal habitat conditions would be moderately cool and sunny, with the sunny conditions providing higher algae and invertebrate abundance (fish food). In the Sierra or other northern or higher elevation habitats this combination is possible. However, along the Central Coast, most cool habitats are heavily shaded and unproductive and most sunny habitats are relatively productive, but warm. Because the interactions that control survival and growth of steelhead in warmer and/or productive habitats are fairly complex, the best way to determine the suitability of the habitat and the optimum temperature is to **sample the fish to determine their densities, microhabitat use and growth rates.** If fish are abundant and fast growing in warm lagoons or warm stream reaches having fastwater feeding areas, then the warmer temperatures are being compensated for by increased food supply and may be facilitating high growth rates. In these reaches, higher temperatures are optimum. In small tributaries where fish grow slowly, then cooler temperatures are required, and overwintering habitat and habitat for yearling fish are likely to be the major habitat concern."

Figure A23. Santa Rosa Creek Water Temperature (Degrees C) at Site 0a, May–October 2004.

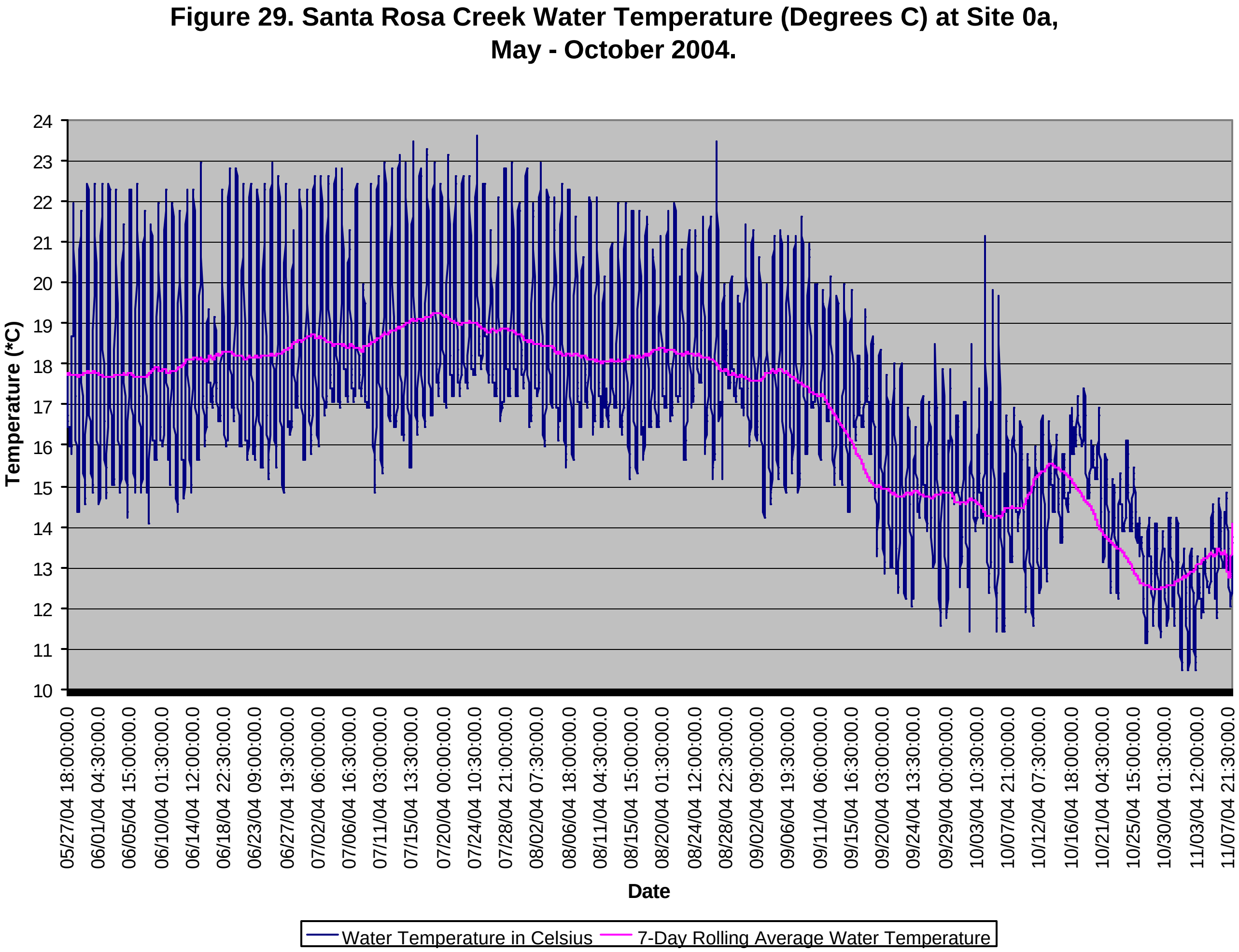


Figure A24. Santa Rosa Creek Water Temperature (Degrees C) at Site 1, May–October 2004.

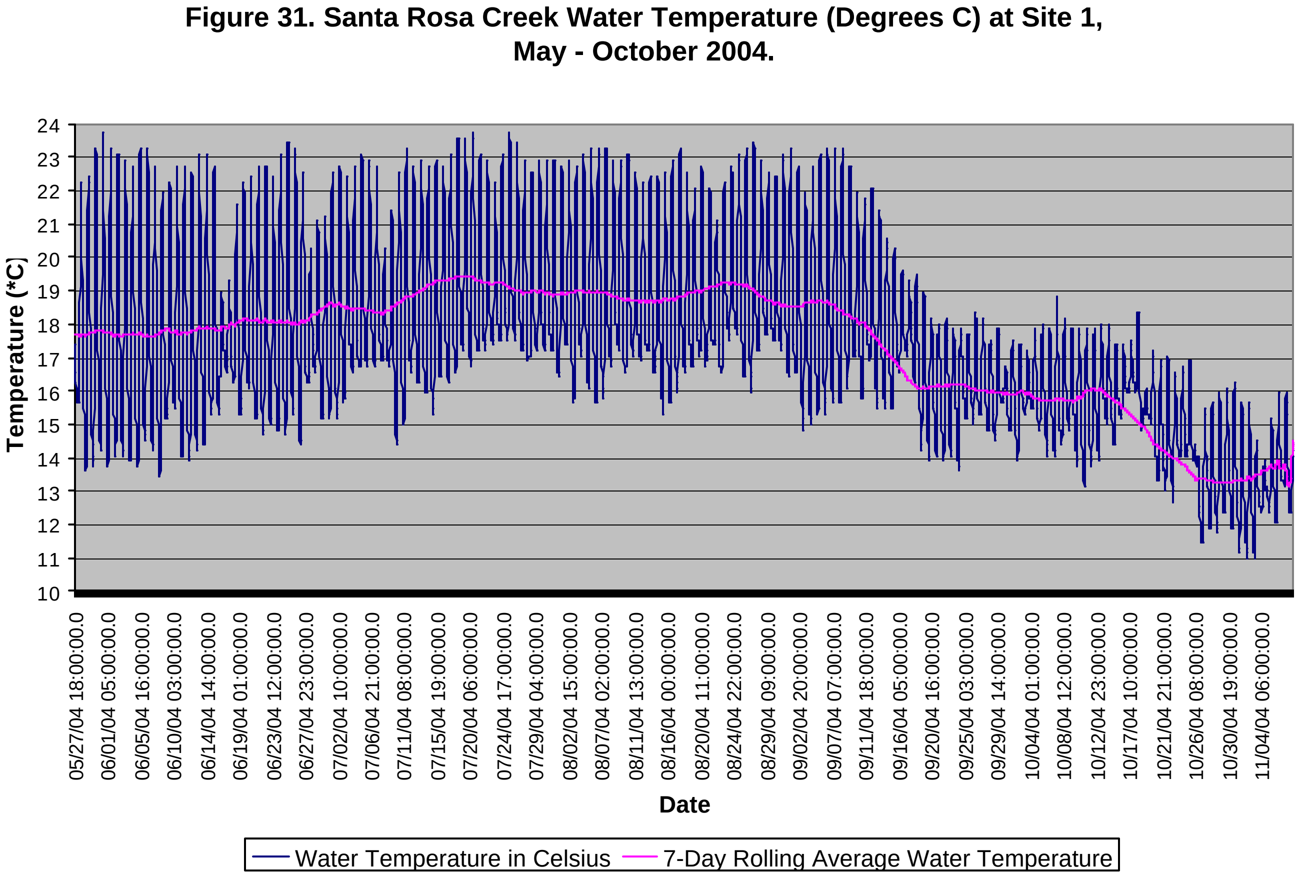


Figure A25. Santa Rosa Creek Water Temperature (Degrees C) at Site 3b, May–October 2004.

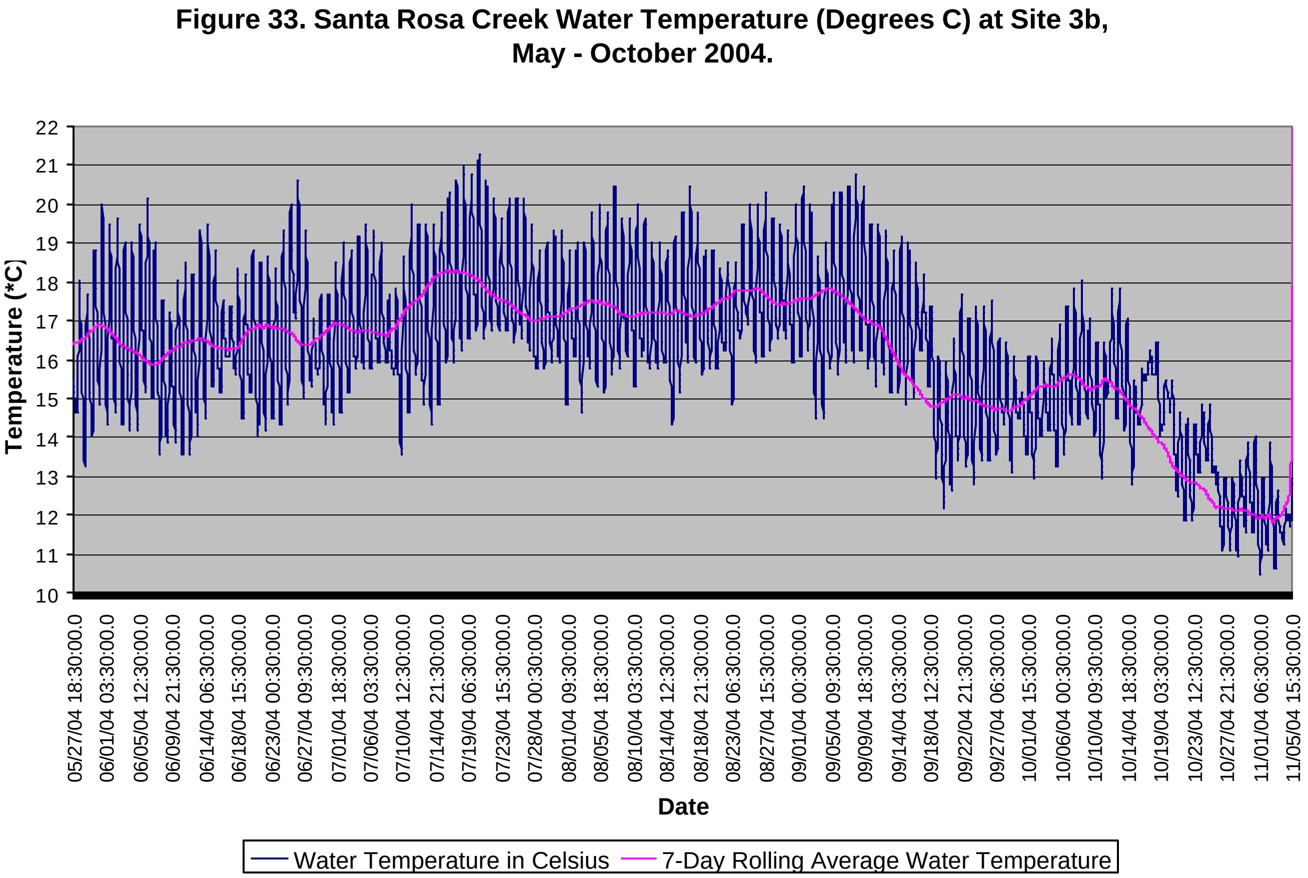


Figure A26. Santa Rosa Creek Water Temperature (Degrees C) at Site 6a, May–October 2004.

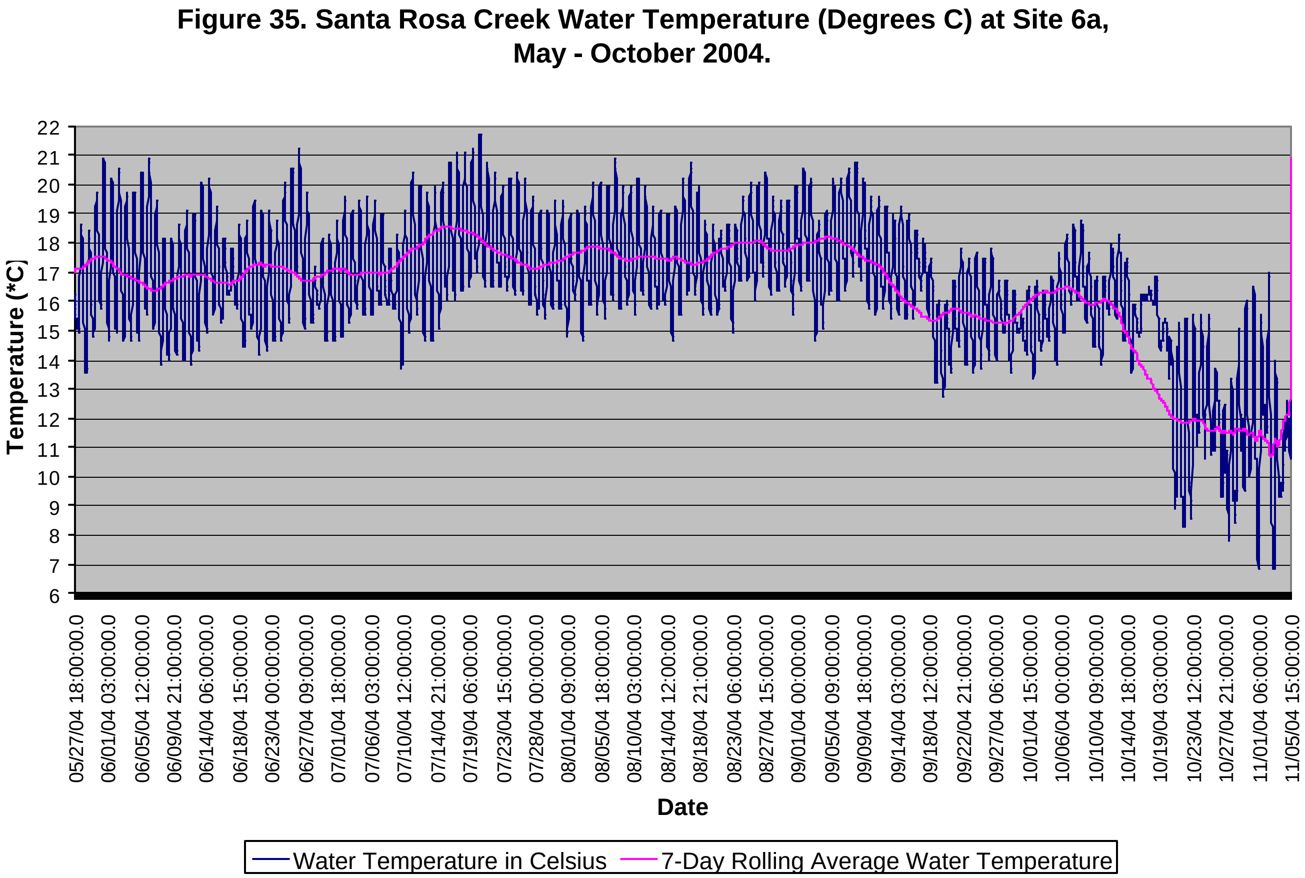


Figure A27. Santa Rosa Creek Water Temperature (Degrees C) at Site 0a, June–October 2005.

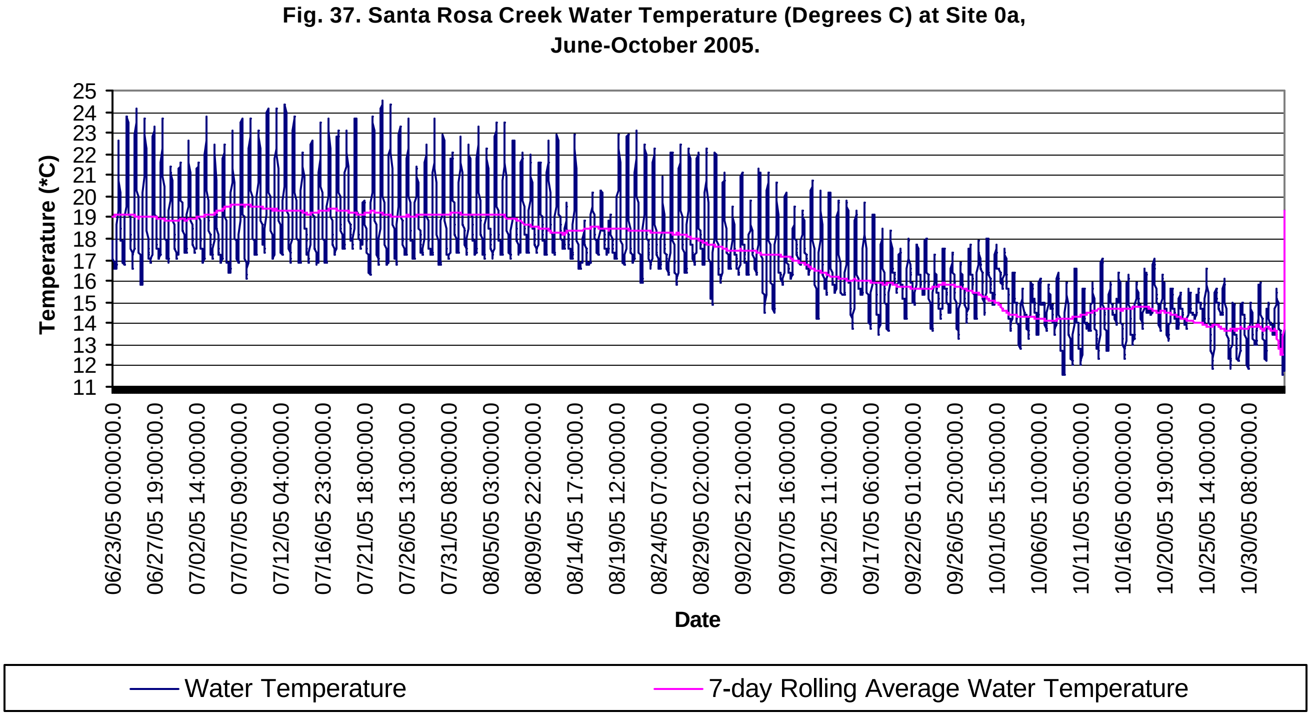


Figure A28. Santa Rosa Creek Water Temperature (Degrees C) at Site 1, June–October 2005.

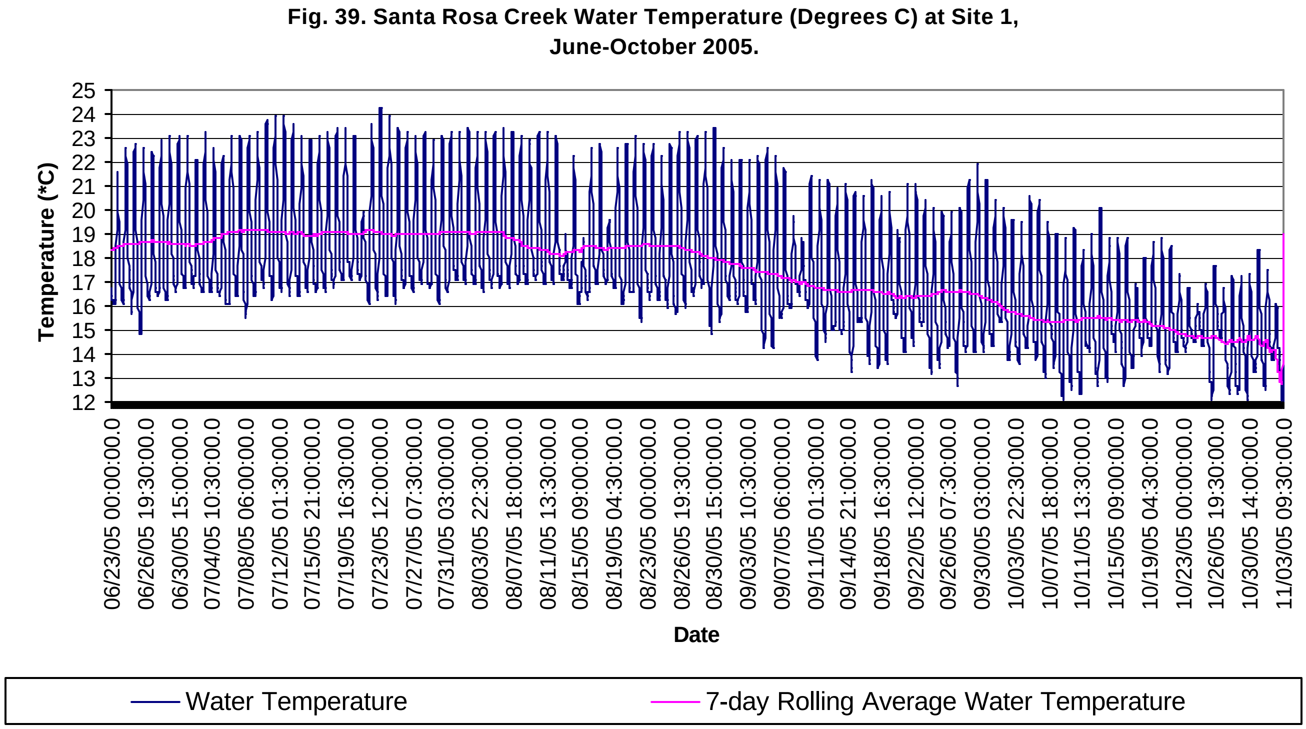


Fig. 39. Santa Rosa Creek Water Temperature (Degrees C) at Site 1, June-October 2005.

Figure A29. Santa Rosa Creek Water Temperature (Degrees C) at Site 3b, June–October 2005.

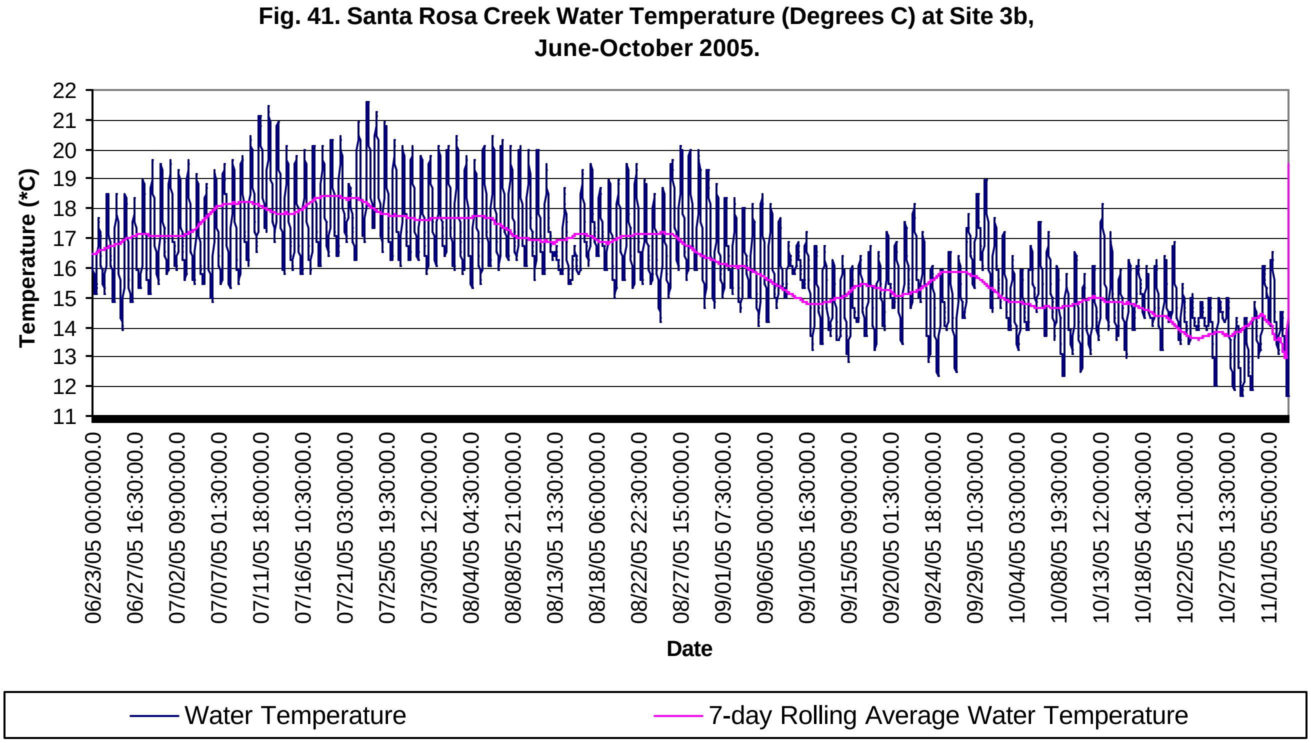


Figure A30. Santa Rosa Creek Water Temperature (Degrees C) at Site 6a, June–October 2005.

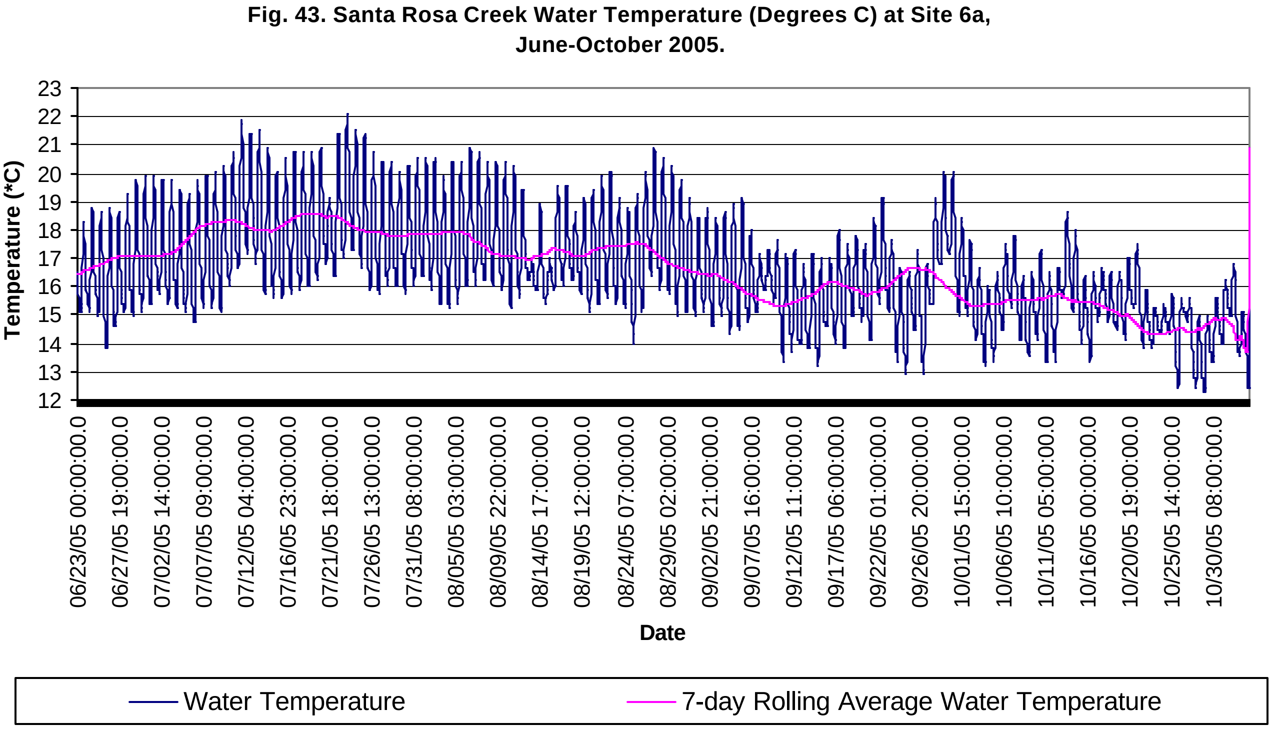


Fig. 43. Santa Rosa Creek Water Temperature (Degrees C) at Site 6a, June-October 2005.

Figure A31. Santa Rosa Creek Water Temperature (Degrees C) at Site 0a, June–October 2006.

Figure 45. Santa Rosa Creek Water Temperature (Degrees C) at Site 0a, June-October 2006.

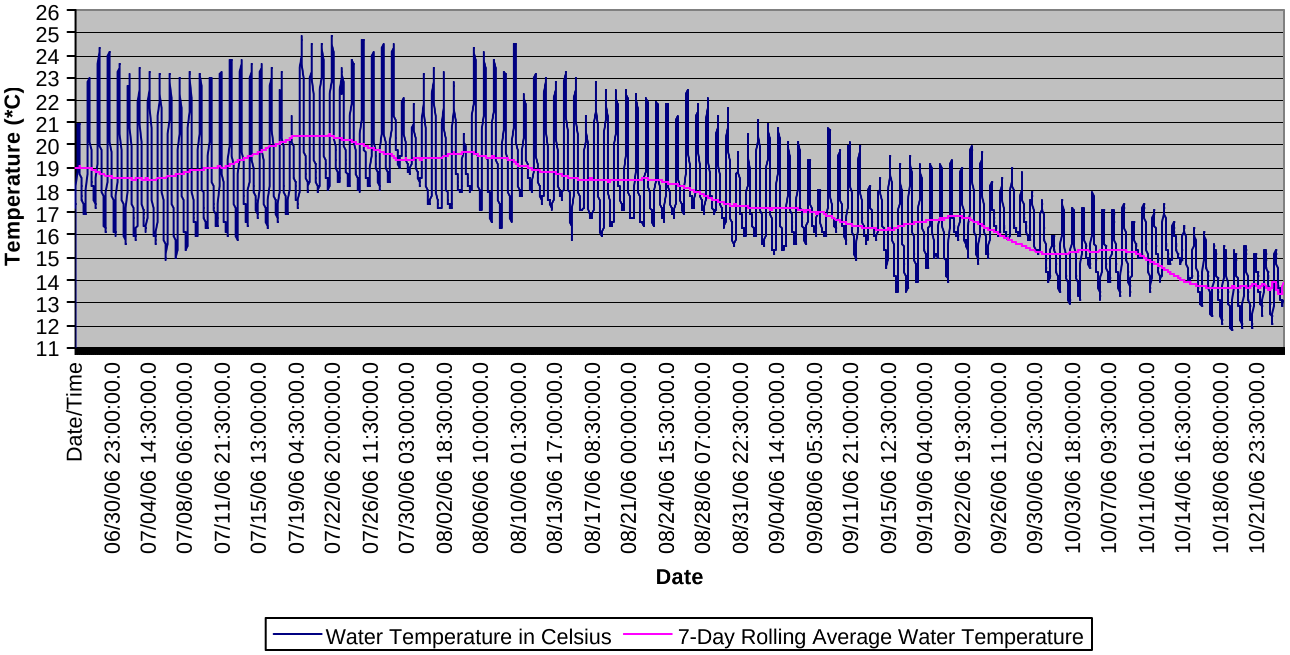


Figure A32. Santa Rosa Creek Water Temperature (Degrees C) at Site 1, June–October 2006.

Figure 47. Santa Rosa Creek Water Temperature (Degrees C) at Site 1, June-October 2006.

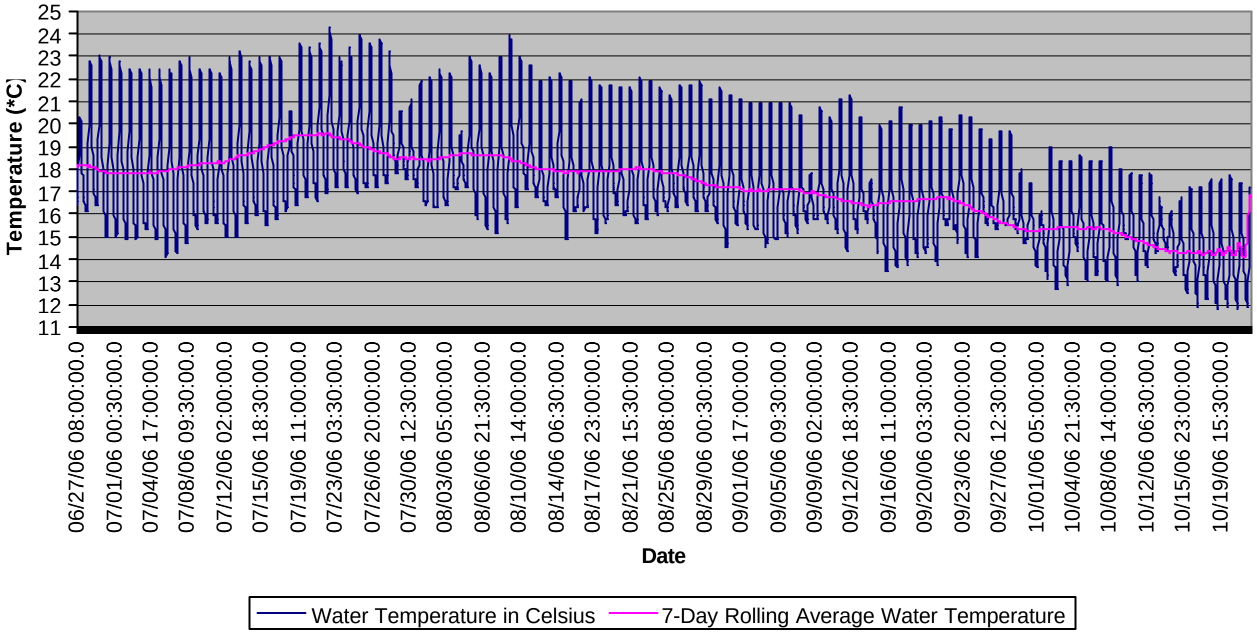
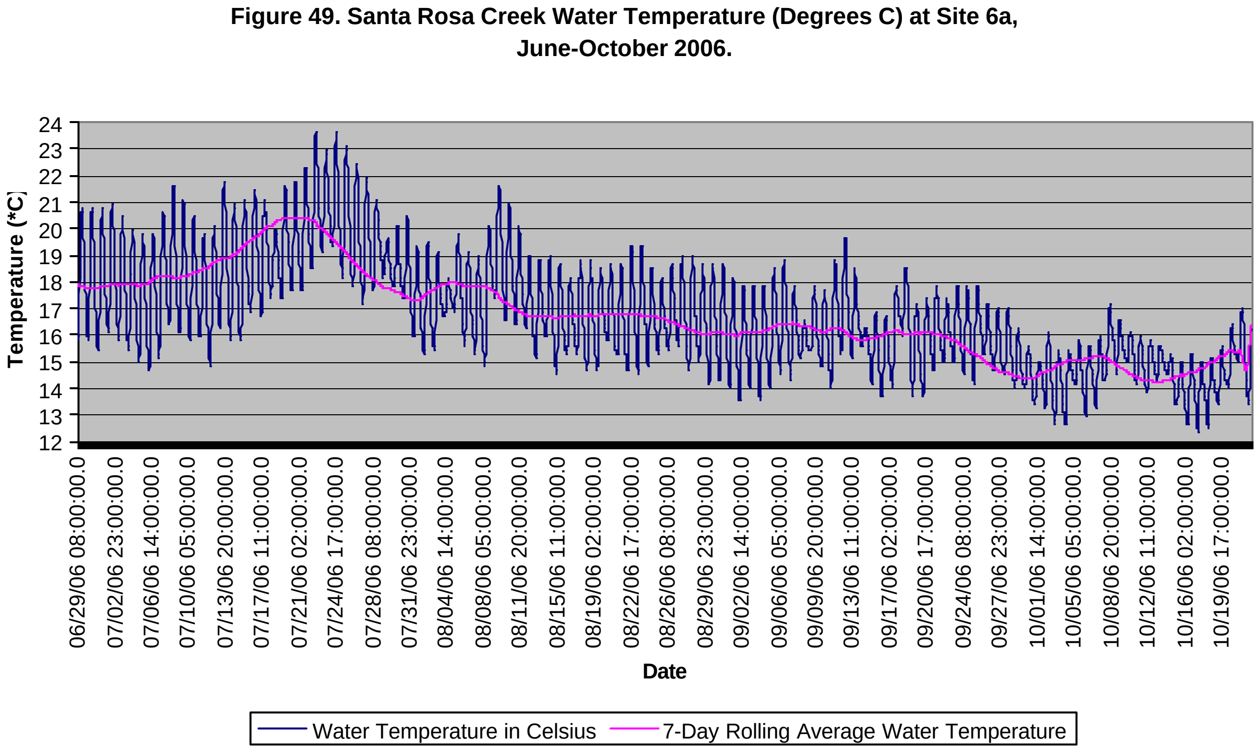


Figure A33. Santa Rosa Creek Water Temperature (Degrees C) at Site 6a, June–October 2006.



Lagoon Water Temperature Monitoring and Management Guidelines

Regarding Santa Rosa Lagoon for the period of sandbar closure, the water temperature guidelines to provide steelhead habitat are as follows:

- *The 7-day rolling average water temperature within 0.25 m of the bottom should be 19°C or less.*
- *Maintain the daily maximum water temperature below 25ºC (77°F).*
- *If the maximum daily water temperature should reach 26.5ºC (79.5ºF), it may be lethal and should be considered the lethal limit.*
- *Water temperature at dawn near the bottom for at least one of the two monitoring stations (adjacent Moonstone parking lot or Shamel Park) should be 16.5°C (61.7°F) or less on sunny days without morning fog or overcast and 18.5°C (65.3°F) or less on days with morning fog or overcast.*

These recommended guidelines are based on 1) SYRTAC **(2000**) recommendations for temperature maxima, 2) our continuous temperature monitoring data and two-week temperature monitoring in Soquel Creek Lagoon during the period of sandbar closure in 2007 when it supported and estimated 6,000+ juvenile steelhead (**Figures A34–A36)**

(**Alley 2008a**), 3) our continuous temperature monitoring data from Santa Rosa Lagoon during periods of sandbar closure (**Alley 2006**), 4) the maximum daily fluctuation of 10°C observed in four years of Santa Rosa Lagoon data subtracted from 26.5°C (considered the lethal limit) and 5) the maximum common daily fluctuation of 8°C from four years of data subtracted from 26.5°C.

Figure A34. Water Temperature (°C) Above the Trestle in Soquel Lagoon, 0.5 feet from the Bottom, 29 May-30 September 2007.

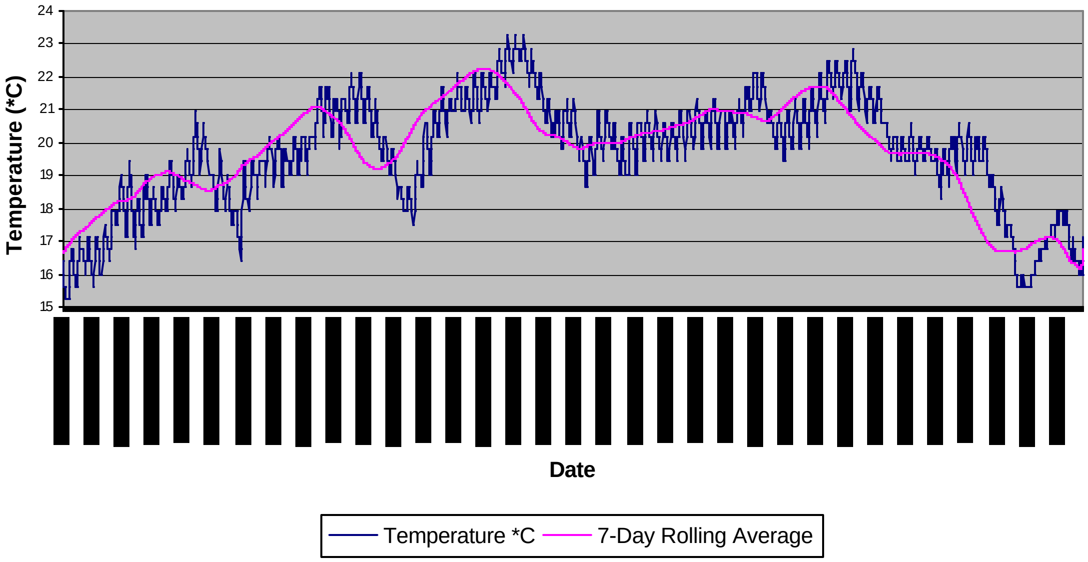


Figure 4a. Water Temperature (*C) Above Trestle, 0.5 ft from Bottom, 29 May- 30 September 2007 (30-minute interval).

Figure A35. Water Temperature at Dawn at Four Lagoon Stations Near the Bottom and Upstream in Soquel Creek in 2007.

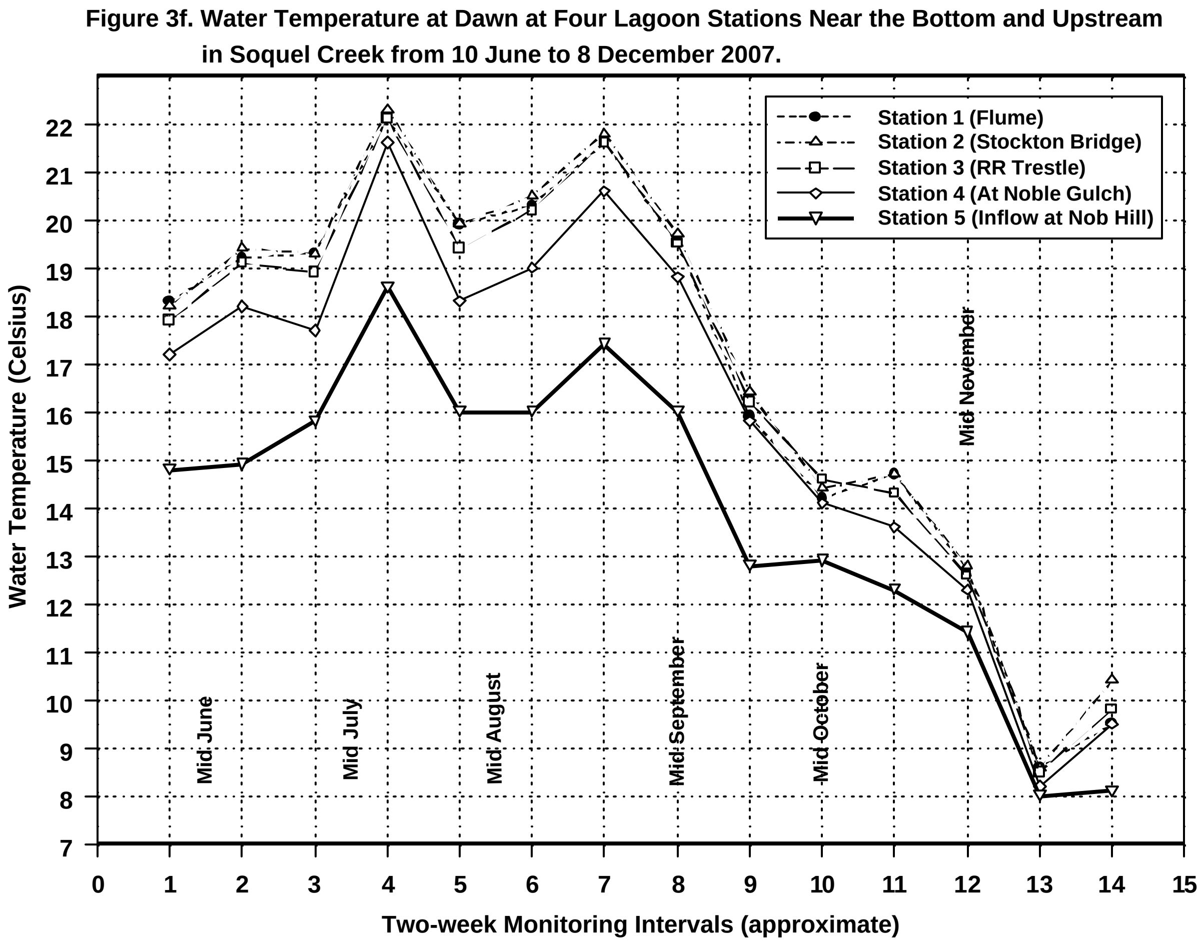


Figure A36. Water Temperature in the Afternoon at Four Soquel Lagoon Stations Near the Bottom in 2007.

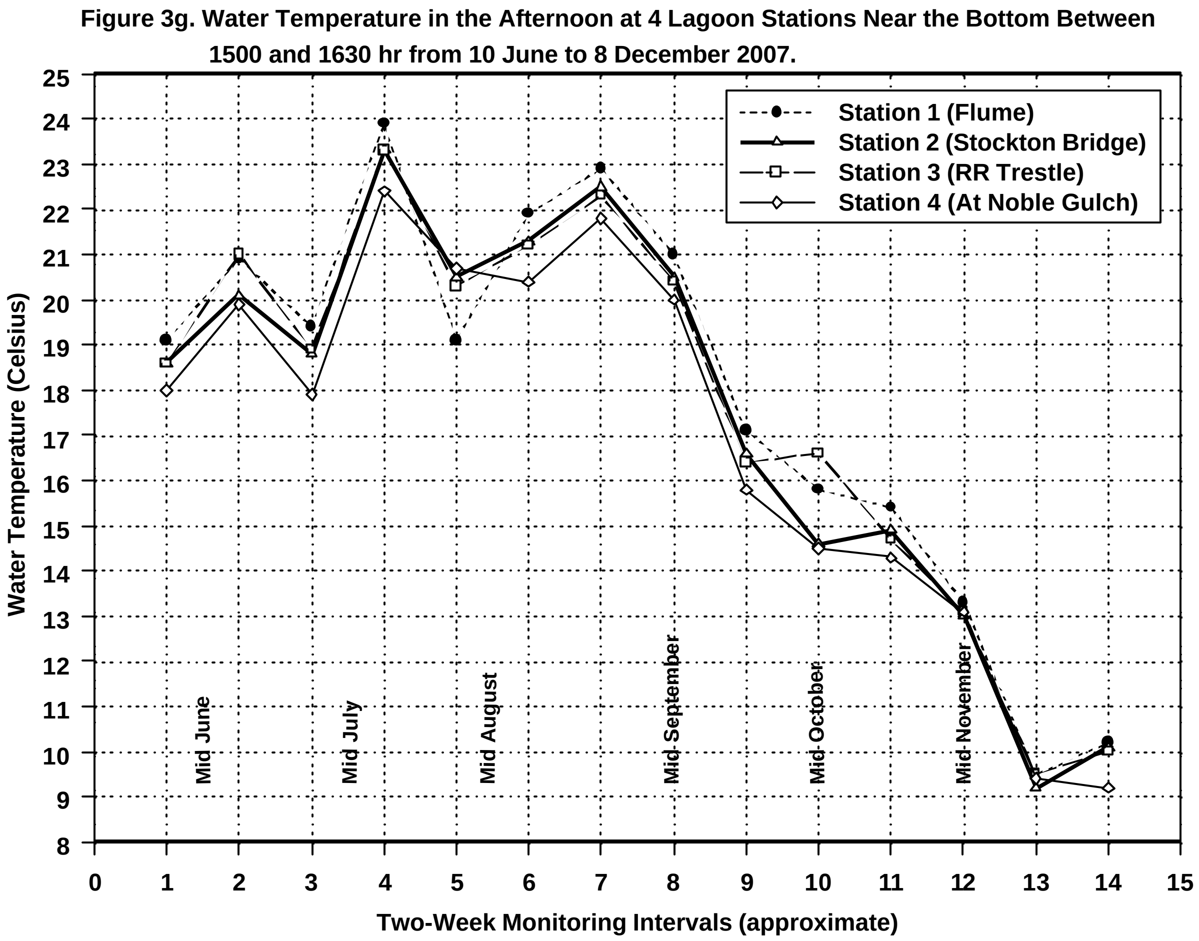


Table A9 summarizes the range in daily water temperature fluctuations in Santa Rosa Lagoon in two relatively low stream inflow years (2001 and 2002) and two relatively high stream inflow years (2005 and 2006). The summary **Table A9** was developed from temperature graphs that follow the table.

Table A9. Daily Water Temperature Fluctuations in Santa Rosa Lagoon Near the Bottom in 2001, 2002, 2005 and 2006.

Station	2001 Range in Daily Fluctuation (°C); Common Daily Fluctuation	2002 Range in Daily Fluctuation (°C); Common Daily Fluctuation	2005 Range in Daily Fluctuation (°C); Common Daily Fluctuation	2006 Range in Daily Fluctuation (°C); Common Daily Fluctuation
1-Adjacent Moonstone Parking Lot	4 – 10; 8°C	2 – 9; 6°C	4 – 7; 5°C	2 – 7; 5°C
2- Adjacent Shamel Park	4 – 9; 8°C	2 – 8; 5°C	4 – 9; 6°C	3 – 10; 8°C

In the four years when continuous water temperature data were available (2001, 2002, 2005 and 2006) Santa Rosa Lagoon did not meet temperature guidelines regarding maximum daily temperature (25°C) at either Station 1 (adjacent the Moonstone Drive parking lot) or Station 2 (adjacent Shamel Park) in any year for the annual period of monitoring (**Figures A37–A44**). Water temperature probes malfunctioned in 2003, and Sites 1 and 2 went dry in 2004 (there was a small, stagnant pool remaining near Shamel Park at Site 2, with the probe not remaining submerged). The lethal limit (26.5°C) was reached at Site 1 in every year and at Site 2 in 2006. With the 7-day rolling average calculated in 2005 and 2006, the temperature guideline for 7-day rolling average (19°C) was exceeded in both years at both stations. Thus, temperature guidelines related to the 7-day rolling average, maximum daily temperature and the lethal limit are not likely to be achieved without increased lagoon shading, increased stream inflow through the entire period of sandbar closure to deepen the lagoon and reduction in tidal overwash.

Figure A37. Water Temperature (°C) at Station 1 in Santa Rosa Lagoon in 2001.

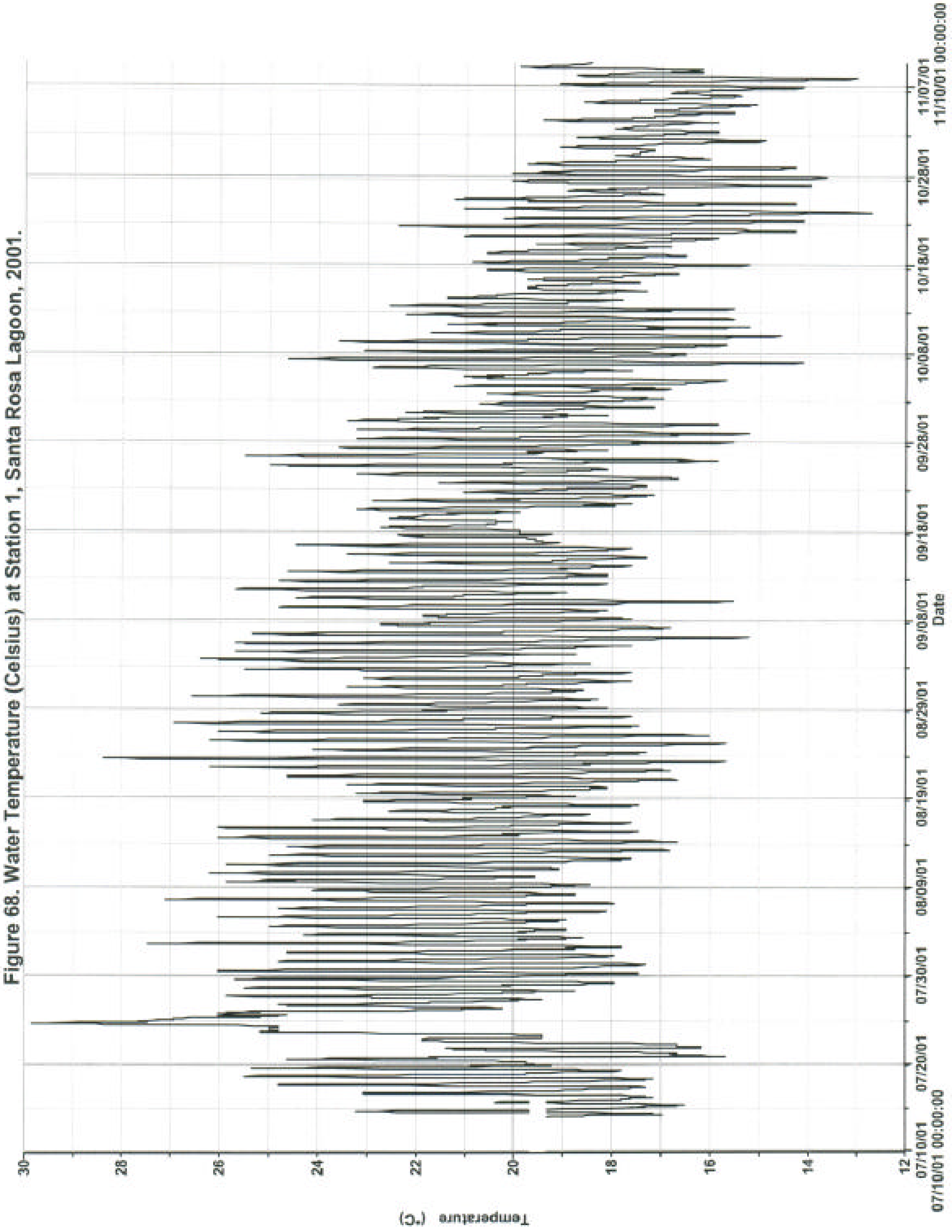


Figure A38. Water Temperature (°C) at Station 2 in Santa Rosa Lagoon in 2001.

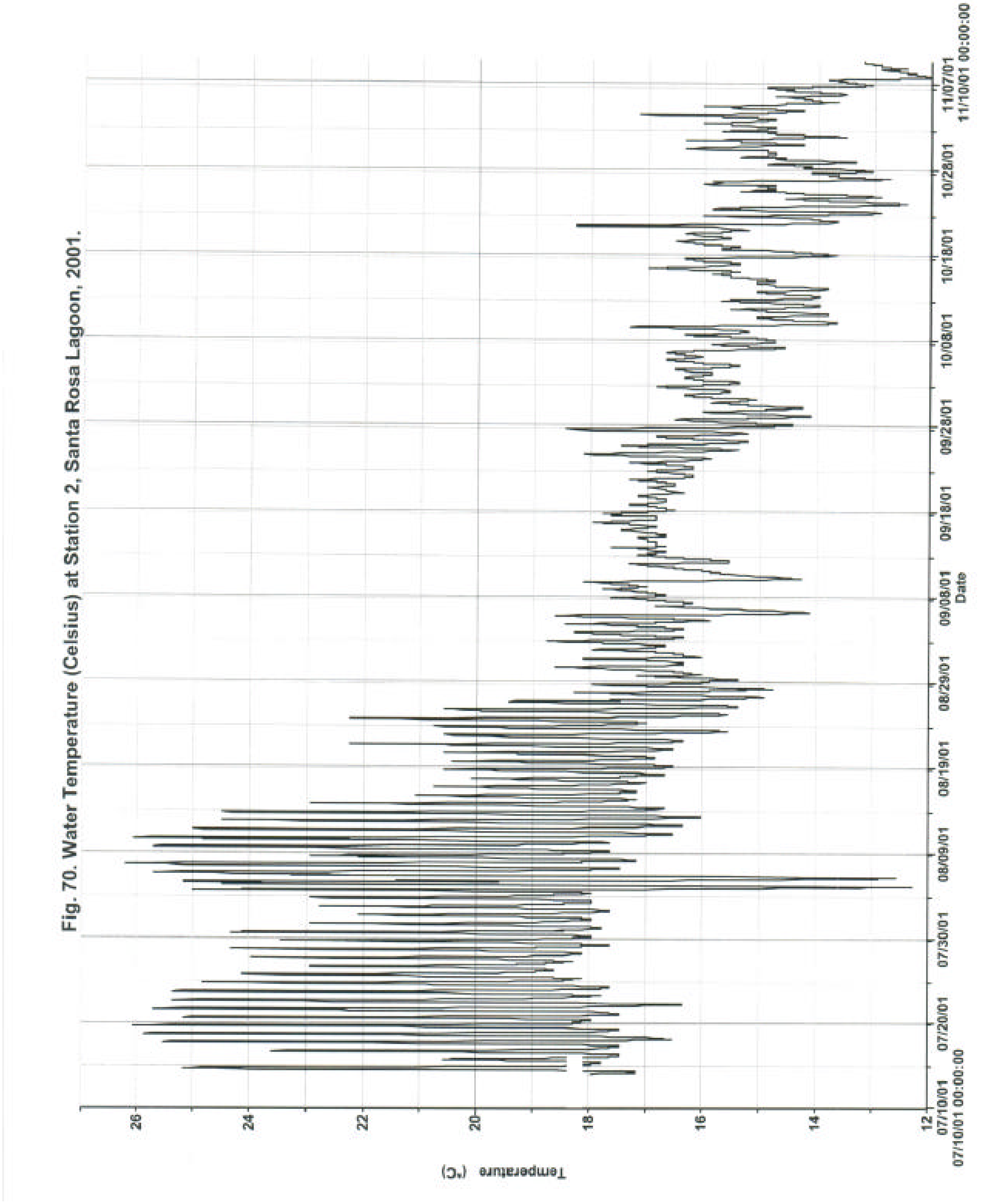


Figure A39. Water Temperature (°C) at Station 1 in Santa Rosa Lagoon in 2002.

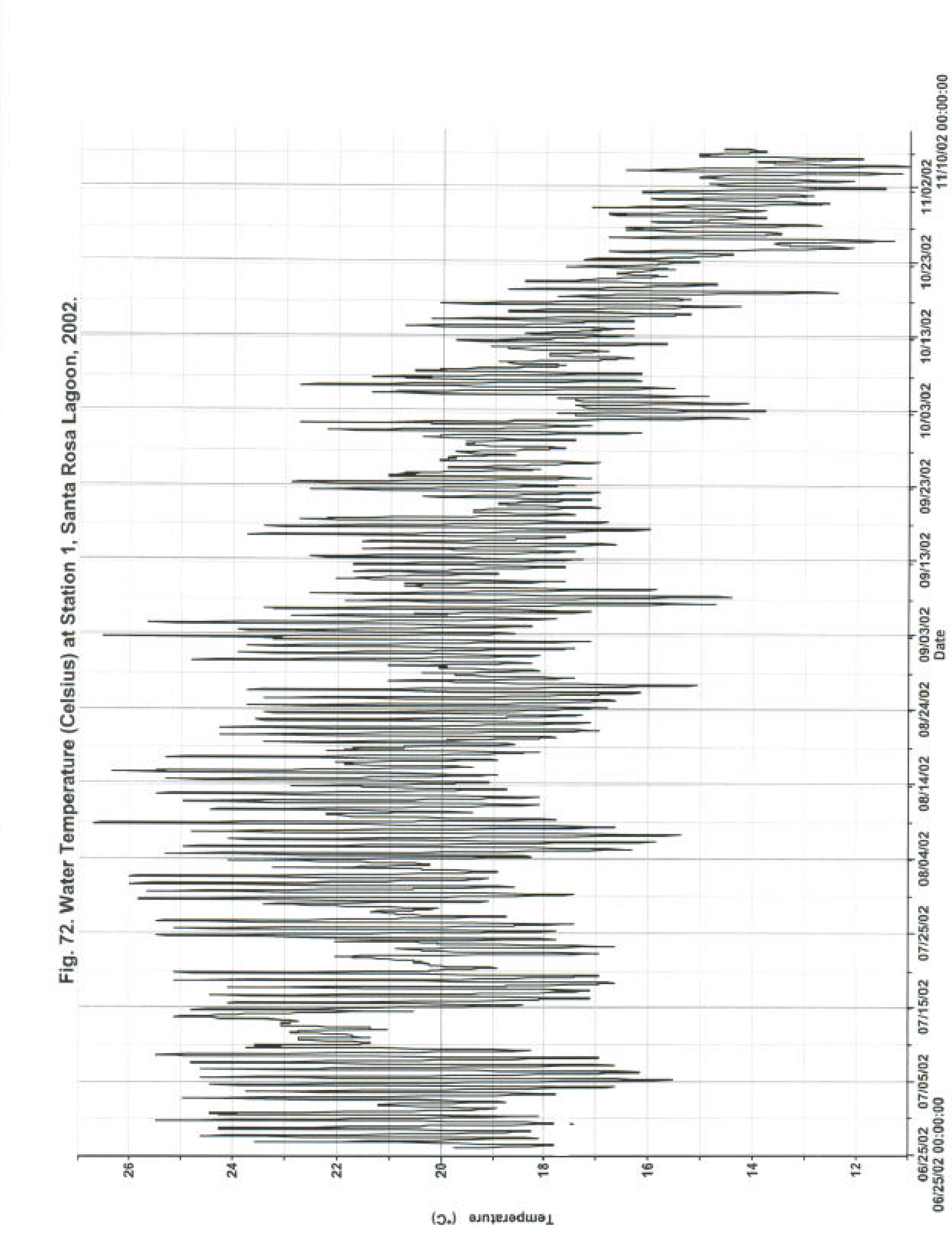


Figure A40. Water Temperature (°C) at Station 2 in Santa Rosa Lagoon in 2002.

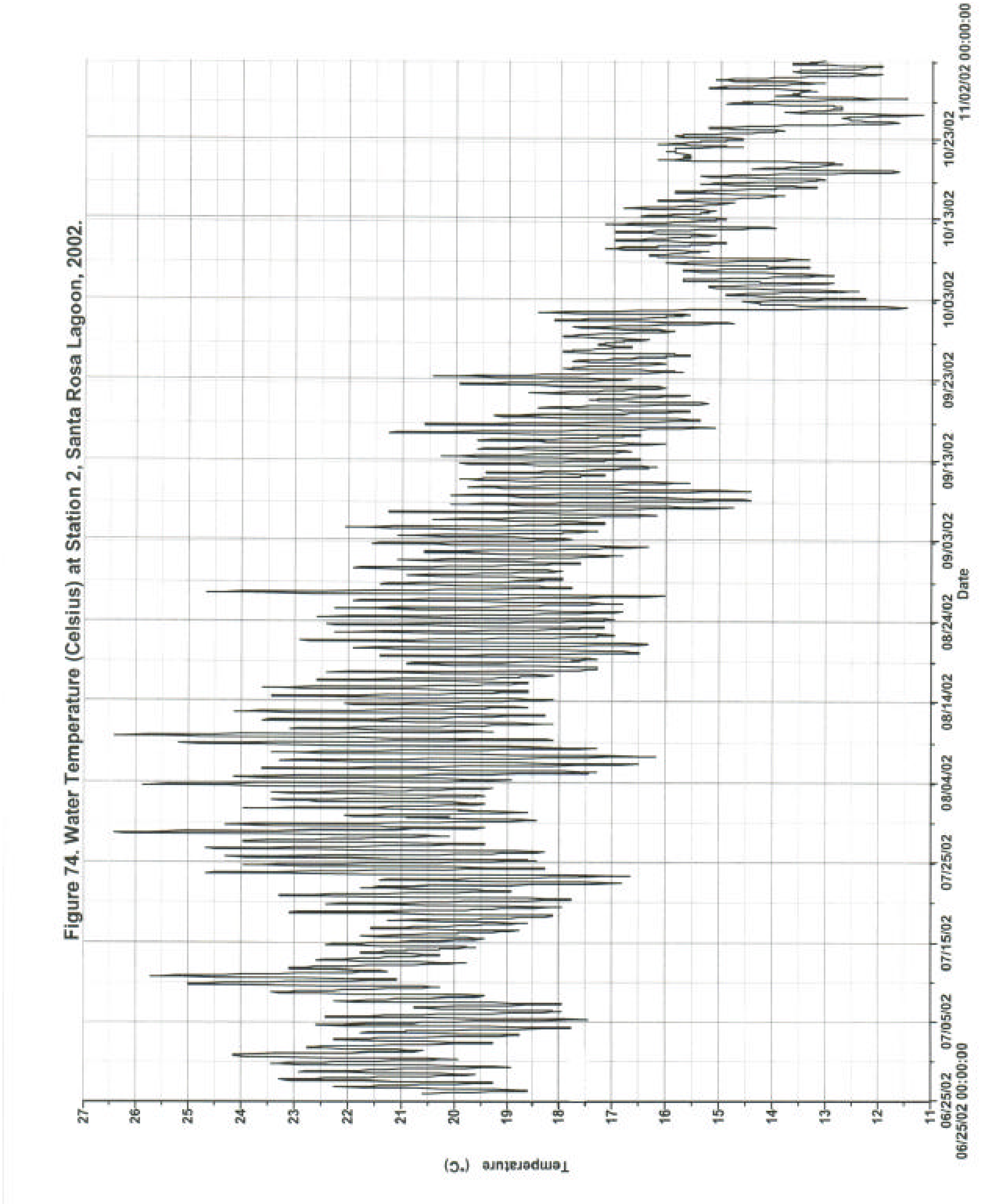


Figure A41. Water Temperature (°C) at Station 1 in Santa Rosa Lagoon in 2005.

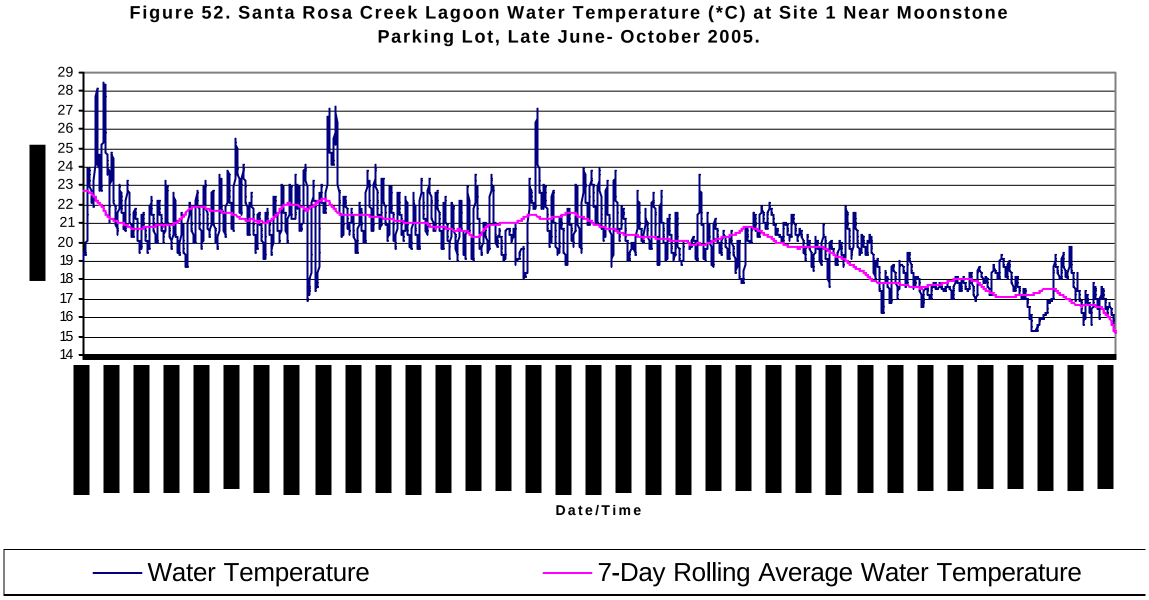


Figure 52. Santa Rosa Creek Lagoon Water Temperature (*C) at Site 1 Near Moonstone Parking Lot, Late June- October 2005.

Figure A42. Water Temperature (°C) at Station 2 in Santa Rosa Lagoon in 2005.

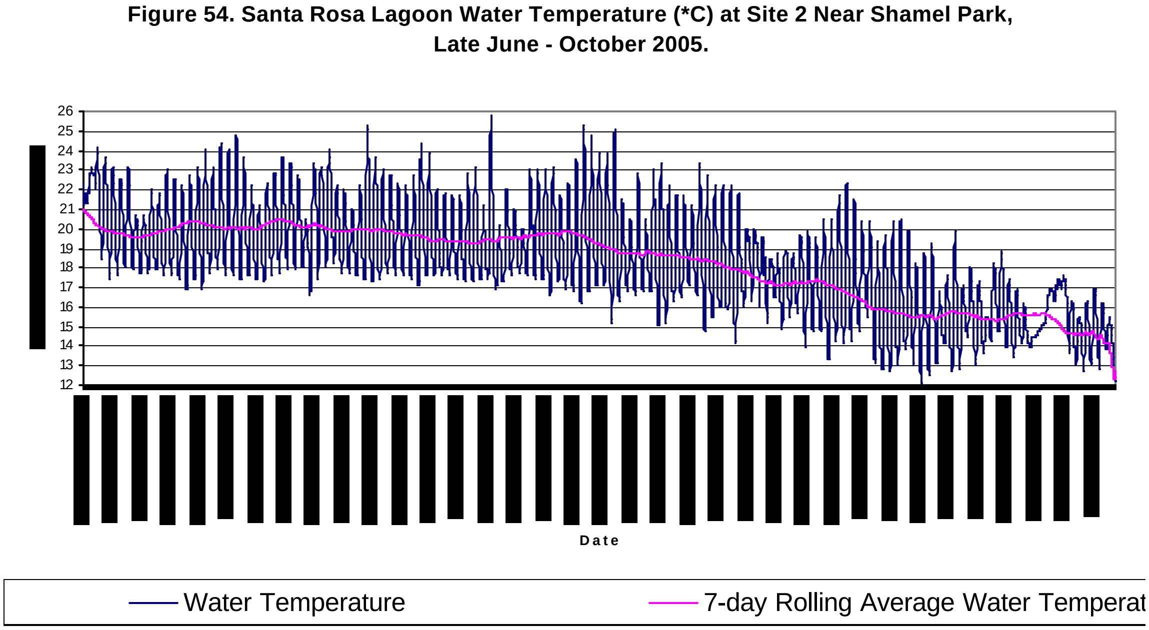


Figure 54. Santa Rosa Lagoon Water Temperature (*C) at Site 2 Near Shamel Park, Late June - October 2005.

Figure A43. Water Temperature (°C) at Station 1 in Santa Rosa Lagoon in 2006.

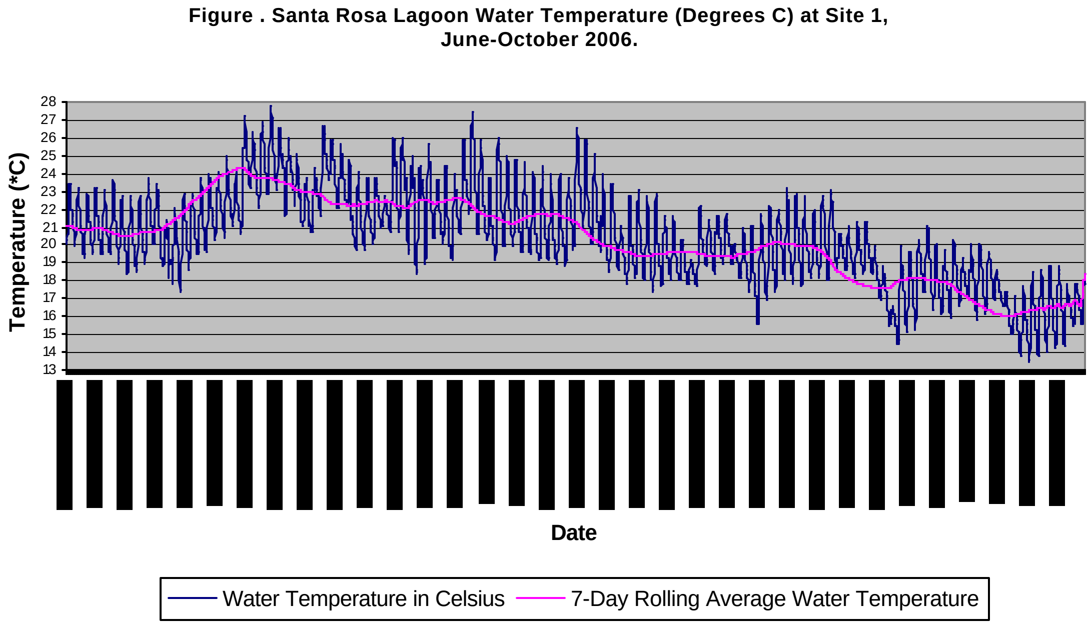
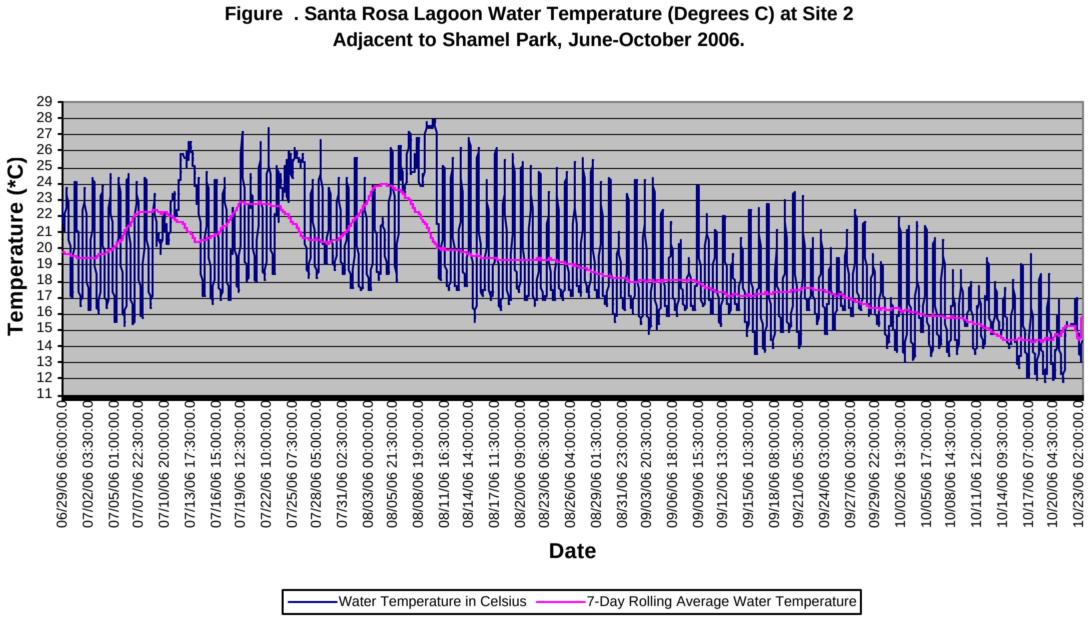


Figure A44. Water Temperature (°C) at Station 2 in Santa Rosa Lagoon in 2006.



In 2001 at Site 1 near the Moonstone parking lot, the lethal temperature limit was exceeded on 6 separate occasions and the daily maximum temperature guideline was exceeded on 32 days (38%) between 10 July and 1 October, with no rolling average calculated. Even so, steelhead were observed feeding on the surface near Site 1 as late as 20 September 2001 (**Alley 2003b**). In 2001 at Station 2 near Shamel Park, the daily maximum guideline was exceeded on 13 days (16%) between 10 July and 1 October, with no rolling average calculated. The dawn water temperature guideline for sunny days was met on only 10 days (12%) at Station 1 between 10 July and 1 October.

In 2002 at Site 1, the lethal limit was exceeded on 2 occasions and the daily maximum guideline was exceeded on 20 days (20%) between 25 June and 1 October, with no rolling average calculated. In 2002 at Site 2, the lethal limit was approached by 0.1ºC on 2 occasions and the daily maximum guideline was exceeded on 5 occasions (5%), with no rolling average calculated. The dawn water temperature guideline for sunny days (16.5 C) was met only 11 days (11%) at Station 1 between 25 June and 1 October. The dawn water temperature guideline for sunny days was met 26 days (26%) at Station 2.

In 2005, a year with the maximum stream inflow measured near the Highway 1 bridge in the nine-year period 1998–2006, none of the lagoon temperature guidelines were met for the entire period of sandbar closure. The lethal limit (26.5) was reached on 5 days at Site 1. Water temperatures at Stations 1 and 2 likely caused sub-lethal stress, leading to indirect mortality from higher vulnerability to predation and higher susceptibility to disease for Central Coast steelhead during the periods in which the 7-day rolling average was 20°C or greater (75% at Station 1 and 25% at Station 2 between 23 June and 1 October). Thus, the 2005 lagoon was a difficult location for steelhead to survive the period of sandbar closure. No juvenile steelhead were observed or captured in the fall of 2005 at the lagoon, after a wet winter when spawning near the lagoon was less likely.

At Site 1 between 23 June and 1 October, the temperature guidelines were not met on 6 days regarding the daily maximum (6%). At Station 1, the lethal limit (26.5°C) was reached on 5 days. Water temperature near the bottom reached 28.3ºC (82.9ºF) on 25 June, the warmest day of the season and 28.1ºC (82.6ºF) the previous day. The 7-day rolling average guideline (19°C) was exceeded until approximately 26 September 2005 (95% between 23 June and 1 October), after which it was met. It exceeded 20°C until approximately 5 September (75%). The 7-day rolling average went above 22ºC during 3 periods totaling approximately 6 days and was above 21ºC for more than a month during one period and more than 15 days during another. The high water temperatures near the bottom for 24 and 25 June coincided with a stagnant salinity layer on the bottom that could have been avoided by the fish seeking cooler water up in the column. No salinity measurements were available for the extremely warm temperatures above 27ºC measured on 24 and 27 July and 20 August, though saltwater overwash was likely the cause. The dawn water temperature guideline for sunny days (16.5°C) was not met at Station 1. The guideline for sunny mornings (16.5°C) was not met, while the guideline for foggy or overcast mornings (18.5°C) was not met 94 days (94%) between 23 June and 1 October at Station 1.

At Station 2 in 2005 after 23 June, the guideline for the 7-day rolling average (19°C) was not met until approximately 1 September 2005 (70% between 23 June and - October) (after which it was met). Daily maxima at Station 2 exceeded the guideline for daily maxima (25ºC) on 4 days (4%) and exceeded 24ºC) on 12 days (12%). However, the lethal limit (26.5° C) was not reached at Station 2. The 7-day rolling average never went as high as 21°C. However, there were 2 periods of 15 and 9 days (24%) each in which the 7-day rolling average was greater than 20ºC. The water temperature for the two warmest days reached 25.8ºC (78.4ºF) on 14 August and 25.2°C (77.4ºF) on 29 July, which were approaching the lethal limit. The warmest water temperatures at Station 2 did not correspond to the warmest at Station 1. Because of this lack of coincidence and the fact that the sandbar was higher adjacent to Station 2 than Station 1 (where the creek exited the beach in spring), it was unlikely that high water temperatures at Station 2 were a result of saltwater overwash in 2005. Therefore, there was likely no thermal refuge higher in the water column to avoid warm water near the bottom on the 4 isolated days with maxima above 25°C. The dawn water temperature guideline for sunny mornings (16.5°C) was not met on 70 days (70%) at Station 2 between 23 June and 1 October. The dawn water temperature guideline for foggy or overcast mornings (18.5°C) was met during the entire period at Station 2.

The lagoon was even warmer in 2006 than 2005. **N**one of the lagoon temperature guidelines were met for the entire period of sandbar closure. The lethal limit of 26.5°C was reached near the bottom on 7 days at Station 1 and 9 days at Station 2. The water temperatures at Stations 1 and 2 likely caused sub-lethal stress, leading to indirect mortality from higher vulnerability to predation and higher susceptibility to disease for Central Coast steelhead during the periods in which the 7-day rolling average was 20°C or greater (66% at Station 1 and 46% at Station 2 between 29 June and 1 October). Thus, the 2006 lagoon was a difficult, if not impossible location for steelhead to survive the period of sandbar closure. Even so, 3 juvenile steelhead were captured and approximately 20 more were observed (all likely large YOY) in the upper lagoon between Shamel Park and the Windsor Bridge.

In 2006 at Station 1 after 29 June, the lethal limit was exceeded on 7 days near the bottom and the daily maximum guideline (25°C) was exceeded on 20 days (21%). The 7-day rolling average guideline (19°C) was exceeded at Site 1 until approximately 23 September 2006 (91% between 29 June and 1 October), after which it was met. At Station 1, 7-day rolling average went to 24.3°C at one point and was greater than 20°C until approximately 30 August (66%) and the lethal limit (26.5°C) was reached on 7 days. At Station 2 in 2006 after 29 June, the lethal limit was exceeded on 9 days near the bottom during three apparent tidal overwashes, with temperatures above it for two continuous days on 2 occasions. The guideline for daily maxima was exceeded on 30 days (32%). After each of the first two tidal overwashes, there was a delayed elevation in minimum daily temperatures near the bottom at Station 1 for several days. The 7-day rolling average guideline (19°C) was exceeded at Site 2 until approximately 27 August 2006 (64% between 29 June and 1 October), after which it was met. The 7-day rolling average at Site 2 went as high as 24°C and was greater than 20°C until 11 August (46%).

Thus, the 2006 lagoon was a difficult, if not impossible location for steelhead to survive the period of sandbar closure.

During the period of lagoon monitoring in which the data were analyzed and reported (1993–2005), lagoon water temperature (Graphs for 1997-2005 in **Figures A45–A53**), salinity, dissolved oxygen and conductivity were measured through the water column at two-week intervals during sandbar closure. They were measured monthly while the sandbar was open during the period 1997–2005. Monitoring Station 1 was adjacent to the Moonstone Drive parking lot. Station 2 was adjacent to Shamel Park. The lagoon dried up to isolated puddles by September 2000, and water quality graphing was suspended. When the lower lagoon dried up in summer 2003, monitoring was suspended. The lagoon bed aggraded an estimated 2.4 feet at Station 1 in 2003, which likely facilitated the drying out. The lagoon bed at Station 2 likely aggraded as well. In 2003 and afterwards the summer lagoon extended upstream of Shamel Park to near Windsor Blvd Bridge, likely due to lagoon bed aggradation. Station 1 degraded 1.2 feet in 2004 but Station 2 likely did not. Station 1 aggraded 0.5 feet in 2005 while Station 2 degraded considerably. When Stations 1 and 2 dried up in the lower lagoon in 2004, Station 3 adjacent to original Chuck Wagon Restaurant (that became the antique store which has now been demolished and replaced) was added in 2004 after the lower lagoon dried up at Stations 1 and 2. Below are temperature graphs of temperature data near the bottom during the period, 1997–2005. Unfortunately, the degree of overcast or fog was not recorded during monitoring.

In 1993–2000 and 2003–2004, only temperature data at two-week intervals were available. Below is **Table A10**, which provides a summary of monitoring days when water temperature guidelines at dawn were not met (<=16.5 C on sunny mornings; 18.5 C on foggy or overcast mornings). When one compares these data for years when data from continuous temperature monitoring were available (2001, 2002, 2005), we see that if the temperature guideline at the dawn is not met, then the daily maximum and lethal maximum temperature guidelines may also be reached later in the day.

Table A10. Summary of Monitoring Days When Water Temperature Guidelines Near the Bottom at Dawn Not Met on Two-Week Intervals in Santa Rosa Lagoon, 1993–2004.

Year	Station 1 # Monitoring Days when Sunny Morning Temperature Guideline (<=16.5 C) Not Met	Station 1 # Monitoring Days when Foggy or Overcast Morning Temperature Guideline (<=18.5 C) Not Met	Station 2 # Monitoring Days when Sunny Morning Temperature Guideline (<=16.5 C) Not Met	Station 2 # Monitoring Days when Foggy or Overcast Morning Temperature Guideline (<=18.5 C) Not Met	# Monitoring Days at 2-Week Intervals During Closed Sandbar Period
1993	8	4	—	—	14
1994	1 (dried up during August and returned to puddle in September)	0	5	1	10 @ Sta 1 12 @ Sta 2
1995	7	1	8	7	12
1996	4	1	5	0	12
1997	9	9	10	10	12
1998	6	4	6	3	9
1999	8 (7 close)	1	1	0	15
2000	5 (puddle in Sep, dry in Oct and Nov)	2	2 (puddle in Sep, dry in Oct and Nov)	0	6
2001	5	3	3	1	11
2002	8	3	5	3	13
2003	2 (went dry)	0	3 (went dry)	2	2 @ Sta 1 3 @ Sta 2
2004	5 (went dry)	5	6 (went dry and moved to Sta 3)	0	6 @ Sta 1 11 @ Sta 2/3
2005	7 (data collected later in morning after 9 August, making it incomparable)	4	6 (data collected later in morning after 9 August, making it incomparable)	1	11

Figure A45. Two-Week Interval Water Temperature (°C) at Stations 1 and 2 in Santa Rosa Lagoon in 1997.

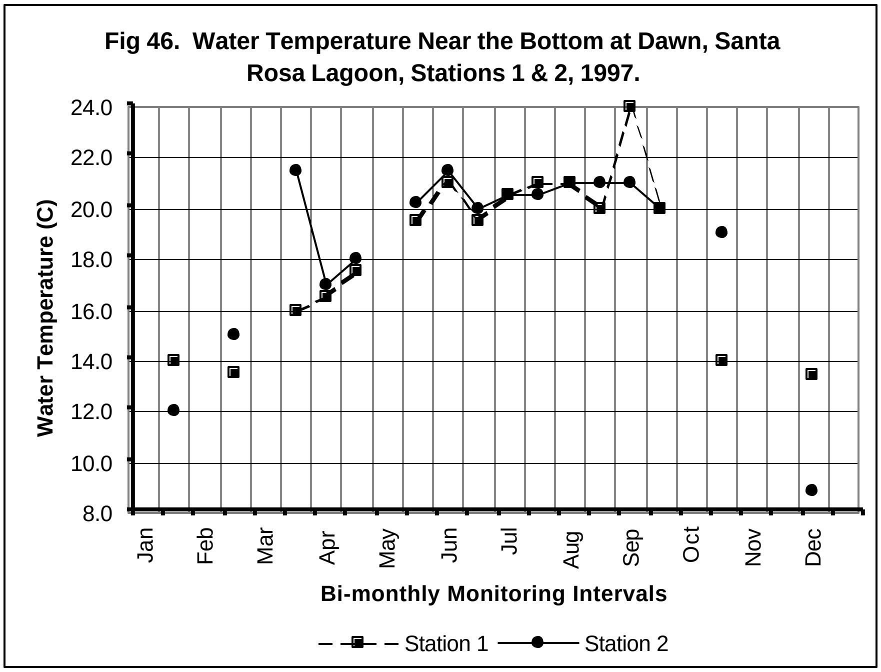


Figure A46. Two-Week Interval Water Temperature (°C) at Stations 1 and 2 in Santa Rosa Lagoon in 1998.

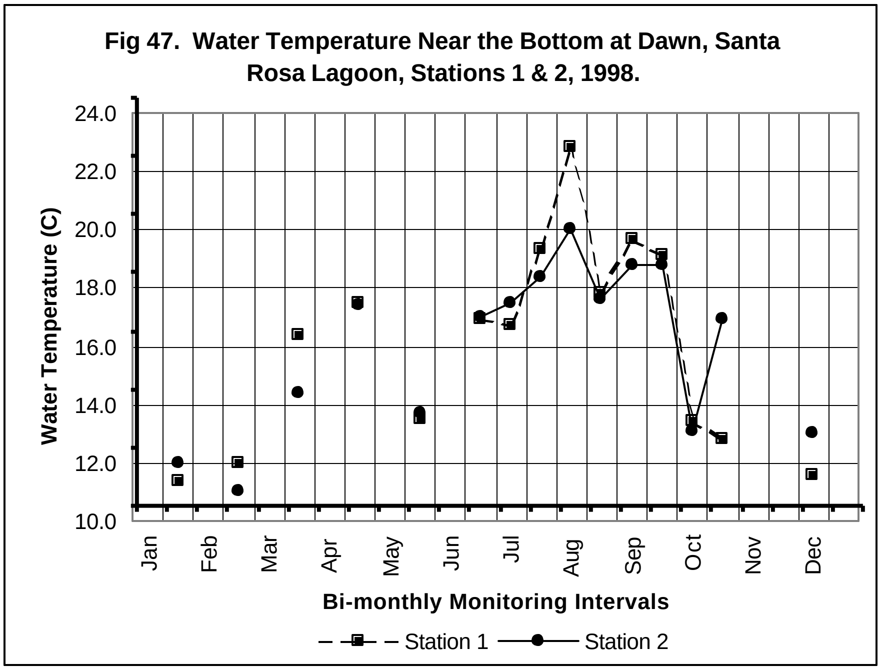


Figure A47. Two-Week Interval Water Temperature (°C) at Stations 1 and 2 in Santa Rosa Lagoon in 1999.

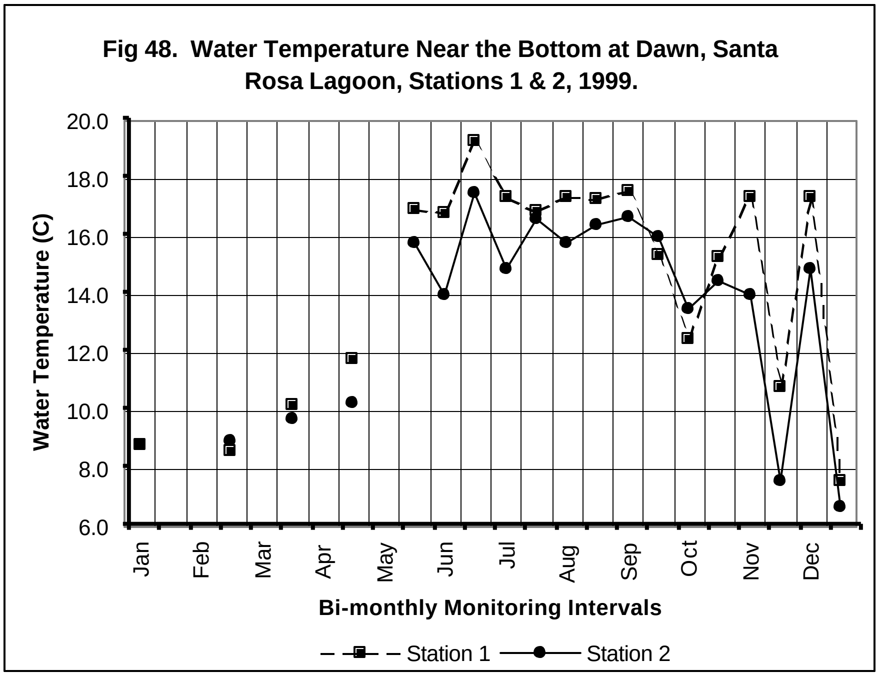


Figure A48. Two-Week Interval Water Temperature (°C) at Stations 1 and 2 in Santa Rosa Lagoon in 2000.

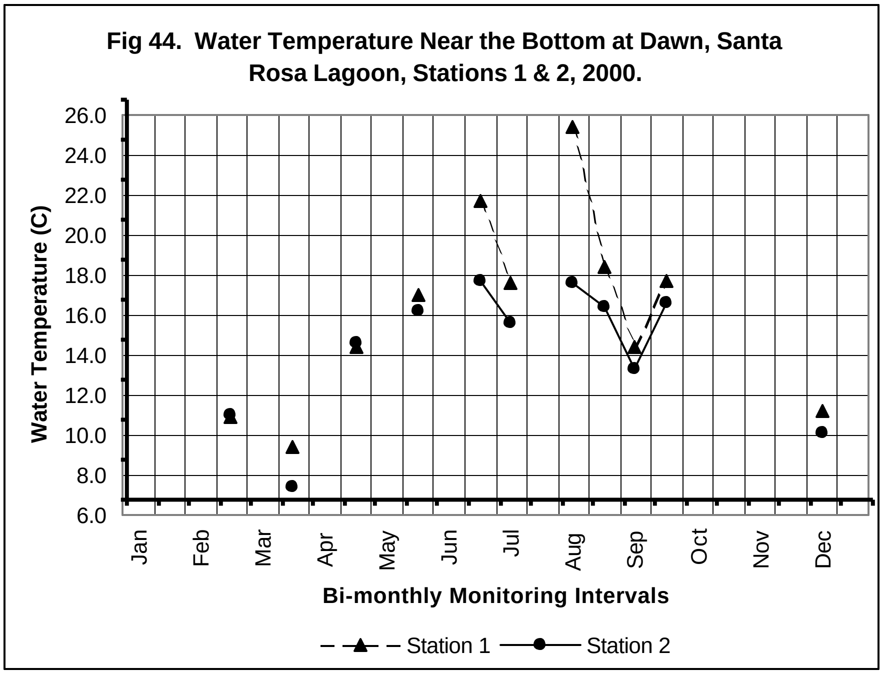


Figure A49. Two-Week Interval Water Temperature (°C) at Stations 1 and 2 in Santa Rosa Lagoon in 2001.

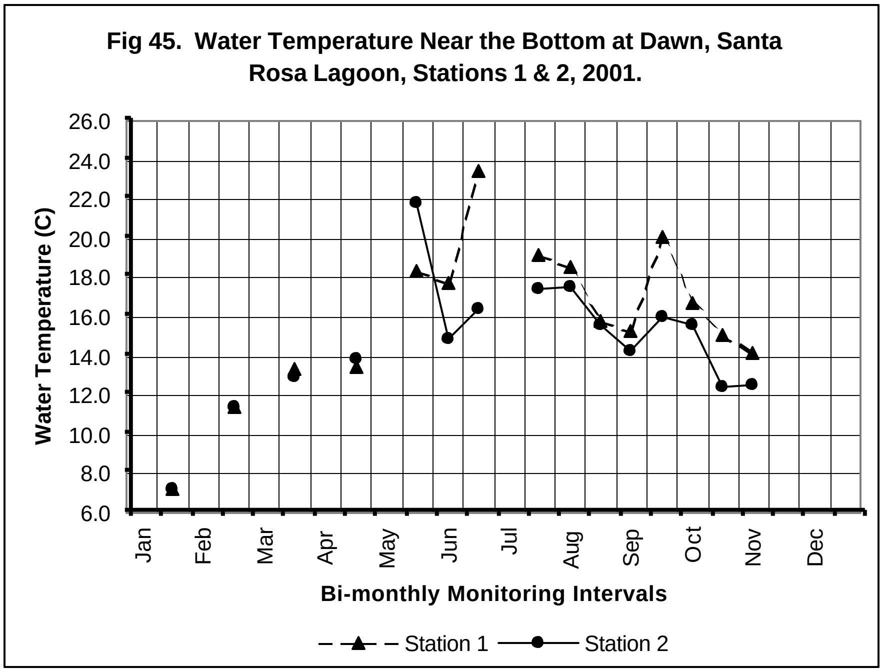


Figure A50. Two-Week Interval Water Temperature (°C) at Stations 1 and 2 in Santa Rosa Lagoon in 2002.

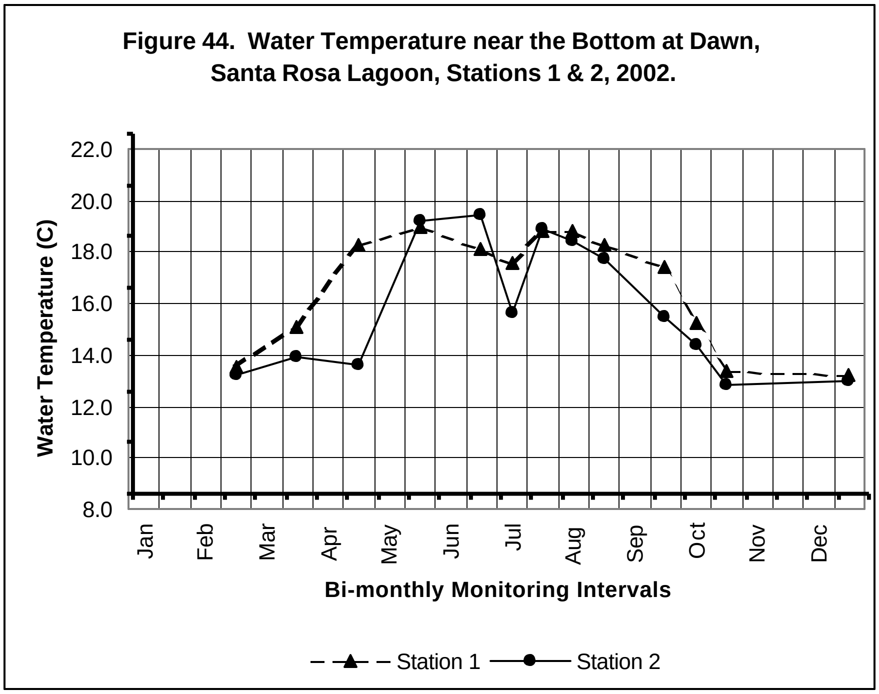


Figure A51. Two-Week Interval Water Temperature (°C) at Stations 1 and 2 in Santa Rosa Lagoon in 2003.

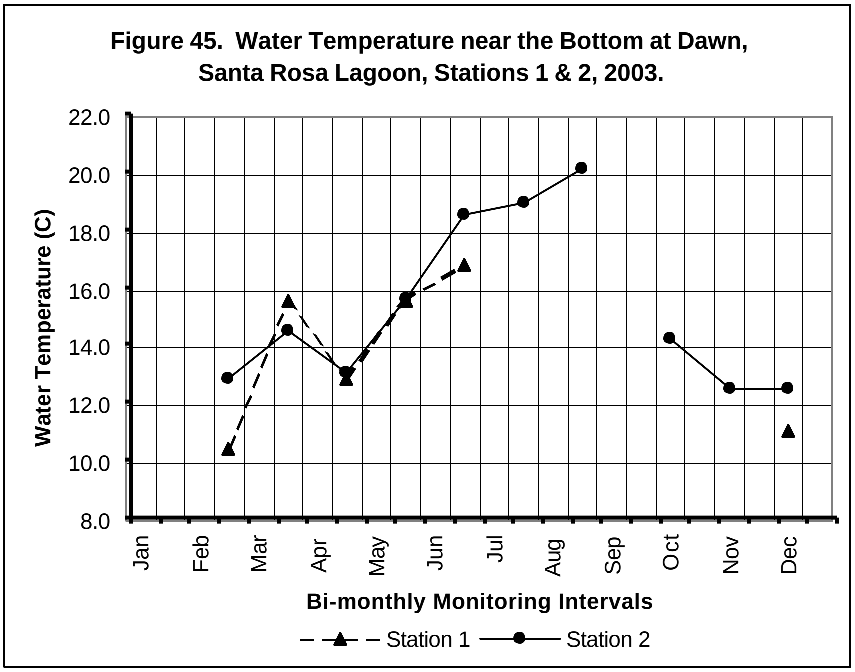


Figure A52. Two-Week Interval Water Temperature (°C) at Stations 1 and 2 in Santa Rosa Lagoon in 2004.

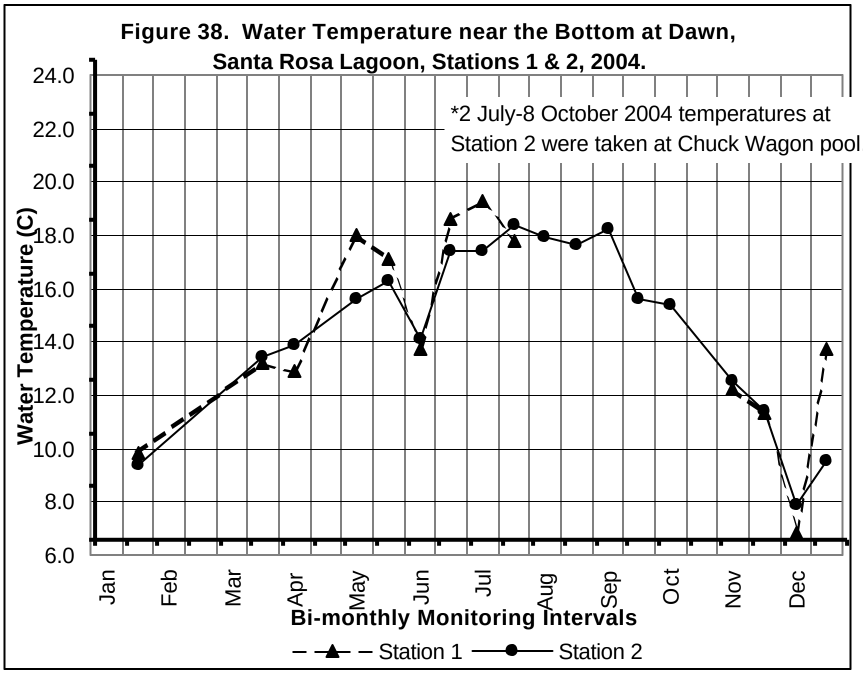
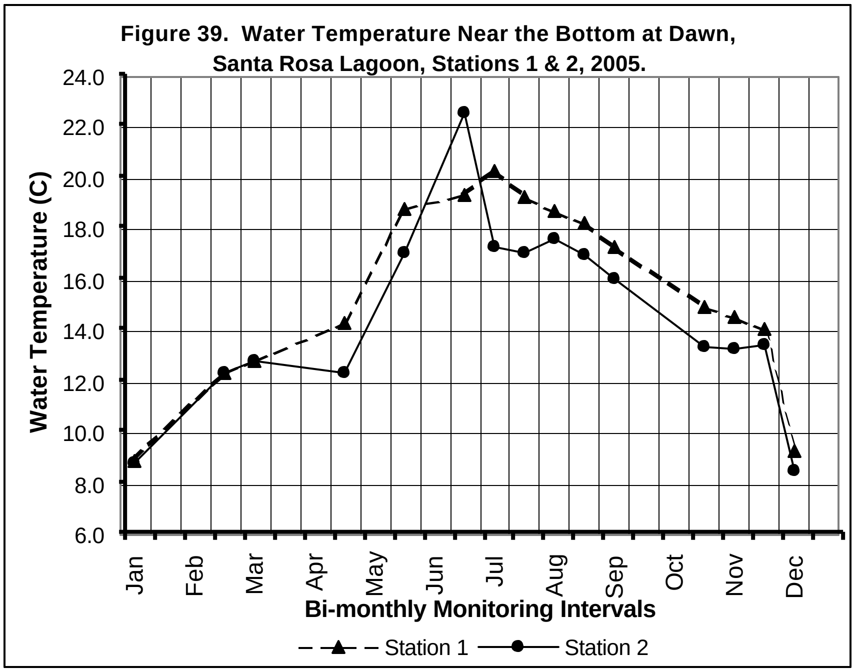


Figure A53. Two-Week Interval Water Temperature (°C) at Stations 1 and 2 in Santa Rosa Lagoon in 2005.



Effects of Stream Inflow Upon Lagoon Size, Depth and Habitat for Steelhead and Tidewater Goby, with Management Guidelines

Based on monitoring of streamflows as the lower portions of Santa Rosa Lagoon dried up in 2003 and 2004, the recommended streamflow guideline is to maintain stream inflow to Santa Rosa Lagoon at 0.9 cfs or greater through the period of sandbar closure in order to provide tidewater goby habitat in the lower lagoon, protect the tidewater goby population from extirpation and maintain steelhead habitat between Shamel Park and Windsor Bridge.

This inflow guideline has been satisfied in only 4 of the years of that 15-year period. Therefore, the likelihood of this guideline being met in the future is unlikely unless a new source of water is provided to the lagoon from treated effluent and/or less water is pumped from wells that reduce stream inflow to the lagoon.

In 2003, the lower lagoon in the vicinity of Station 1 went dry by 24 July with a stream inflow of 0.83 cfs, and the portion of the lagoon as far upstream as Shamel Park was dry by 18 September with a stream inflow of 0.3 cfs. There had been considerable sedimentation over the winter of 2002/2003, with the lagoon bed aggrading 2.4 feet at Station 1 and likely as much at Station 2. In 2004, lower portions of the lagoon began to dry up when stream inflow declined to about 0.8 cfs, with the lagoon bed at Station 1, 1.2 feet lower than 2003 conditions. The water surface elevation of the lagoon between Shamel Park and the Windsor Bridge started to decline when streamflow declined below

0.9 cfs in 2004. By 9 August 2004, when the stream inflow had declined to 0.64 cfs, Station 1 adjacent the Moonstone parking lot had completely dried up. As the lagoon shrank, tidewater goby and steelhead habitat were lost. Steelhead surface hits were observed between Shamel Park and Windsor Bridge throughout the summer of 2004, and juveniles were captured there in the fall by seining. This was the only viable steelhead habitat in the 2004 lagoon.

Tidewater gobies were detected only in very low numbers in the lagoon in fall 2003 after the lower lagoon dried up, and they appeared absent in 2004 and 2005 during both the early summer and late fall sampling and in early 2006. (They were detected in fall 2006 and June 2007 before the lagoon mostly dried up again by October 2007.) Thus, dewatering of the lower lagoon below Shamel Park had a very negative impact on the tidewater goby population, although steelhead habitat was available upstream of Shamel Park. **Table A11** provides information on minimum stream inflow to Santa Rosa Lagoon in 1993–2007.

Table A11. Streamflow Measurements Taken Immediately Upstream of Santa Rosa Lagoon (Except 2005–2006) Prior to Rainfall, Including the Minimum Measured for the Dry Season.

Date	**Streamflow (cubic feet/ second**
5 August 1993	0.47*
4 October 1993	0.62
16 June 1994	0.69
16 July 1994	**0.00 (dry)**
14 September 1995	0.52
25 September 1996	0.22
18 August 1997	0.19
16 September 1998	**1.37**
30 July 1999	0.62
7 September 2000	0.20
20 September 2000	0.40
7 September 2001	0.15
20 September 2001	0.21
30 August 2002	0.28
30 October 2002	0.37
2 October 2003	0.29
10 September 2004	0.30
24 September 2004	0.49
13 September 2005	**1.63**
23 September 2005	**1.97 (Hwy 1)**
24 October 2006	**1.63 (Hwy 1)**
12 October 2007	**0.00 (dry)**

*** All streamflow measurements taken with a Marsh McBirney Model 2000 flowmeter.**

Dissolved Oxygen Guidelines and Measurements in Santa Rosa Lagoon

The recommended lagoon guidelines for oxygen concentration within 0.25 m of the bottom are as follows:

- *Dissolved oxygen concentration at dawn should be 5 mg/l or greater*
- *Dissolved oxygen levels less than 2 mg/l at dawn should be considered critically low, close to the lethal limit and prevented, if possible.*

However, steelhead have survived in pools in the Carmel River at oxygen levels of 1–2 mg/l [parts per million (ppm)] for 1–2 hours at dawn **(David Dettman 1993, personal communication)**. We have documented steelhead survival with chronic levels of less than 2 mg/l in San Simeon Lagoon in 1997 and 1999 **(Alley 2001b).** Refer to **Appendix B** for details on oxygen tolerances of steelhead and data that relate to the oxygen guidelines.

Table A12 below, summarizes the number of monitoring days in which guidelines for oxygen concentration were not met in Santa Rosa Lagoon in 1992–2005, along with fish data from seining. Below that are graphs of oxygen concentration measured near the bottom at the two monitoring stations in Santa Rosa Creek, extracted from previous lagoon monitoring reports.

For the monitoring years 1992–2005, the 5mg/l oxygen guideline was met at one of the monitoring stations for the entire lagoon season in 3 of 14 years (1995, 1996 and 2001) (Graphs for 1997-2005 in **Figures A54–A61**). The near lethal limit of 2 mg/l oxygen was avoided at one station for the entire lagoon season in 8 of 14 years. Although oxygen levels frequently failed to meet guidelines and were likely restrictive on scope of activity, they were likely less limiting than temperature to steelhead survival in the lagoon. Some low oxygen levels are caused near the lagoon bottom within a stagnant saline layer that does not circulate with the air. Other low oxygen conditions result from high density of filamentous algae, particularly in shallow lagoon conditions that result from insufficient stream inflow to maintain lagoon depth. If tidal overwash can be minimized or prevented, low oxygen conditions resulting from saline lenses may be reduced. Lagoon depth may be maintained to prevent complete filamentous algae growth throughout the water column that prevents water circulation if lagoon inflow is maximized to ideally 0.9 cfs or more. Filamentous algae may be reduced if lagoon shading is increased.

Table A12. Record of Days When Oxygen Guidelines in Santa Rosa Lagoon Were Not Met During Two-Week Monitorings at Dawn With the Sandbar Closed, 1992–2004, and Number of Steelhead and Tidewater Gobies Captured, 1993–2007.

Year	Station 1 # Monitorings with Oxygen Concentration < 5 mg/l	Station 1 # Monitorings with Oxygen Concentration < 2 mg/l	Station 2 # Monitorings with Oxygen Concentration < 5 mg/l	Station 2 # Monitorings with Oxygen Concentration < 2 mg/l	# Monitoring Days at 2-Week Intervals With Closed Sandbar	# Steelhead Observed or Captured in Fall (except 1993-1996 and 2007)	# Tidewater Goby Captured in Fall (except 1993-1996 and 2007)
1992	4	0	—	—	11	—	—
1993	7	3	—	—	14	0 (**June**- with snorkeling)	9 (**June**)
1994	4 (dried up during August and returned to puddle in Sep.)	0	4	2	10 @ Sta 1 11 @ Sta2	16 (all stranded smolts at Shamel Park only) (**June**)	3 (sampled Shamel Park only) (**June**)
1995	2	0	0	0	12	0 (**June**)	12 (**June**)
1996	0	0	6	0	12	7 (5 stranded smolts) (**June**)	2,200+ (**June**)
1997	2	0	1	1	12	0	223
1998	1	0	4	0	9	3 (surface hits observed until September)	10
1999	5	1	3	0	15	0 (surface hits observed until September)	7
2000	1 (dried up after 20 September)	0	0 (dried up after 20 September)	0	6	0	32
2001	0	0	2	0	11	0	1,200+
2002	5	1	4	1	13	0	165
2003	0 (dried up by July)	0	2 (dried up by September)	0	2 @ Sta 1 3 @ Sta 2	0	9
2004	2 (dried up by 9 August)	1	8 (Station 2 dried up by July and was moved to Station 3)	2	6 @ Sta 1 11 @ Sta 2 and 3	69 YOY (between Shamel Park and Windsor Bridge)	0
2005	1 (data collected by CCSD later in morning after 5 August- not comparable)	0	1	0 (data collected by CCSD later in morning after 5 August- not comparable)	1	0 (surface hits observed into November)	0
2006	—	—	—	—		23 YOY (between Shamel Park and Windsor Bridge)	480+
2007	Small isolated		Small isolated			15-20	463

	pool in October		pool and dry upstream to Windsor Bridge in October			stranded adults and 20 smolts observed, only 1 stranded smolt captured * (**June**)	(**June**)

*Informed by local resident that smolts were rescued from the lagoon and placed in the Monterey Bay prior to our sampling.

Figure A54. Two-Week Interval Oxygen Levels at Station 1 at Dawn in Santa Rosa Lagoon, 1997–1999.

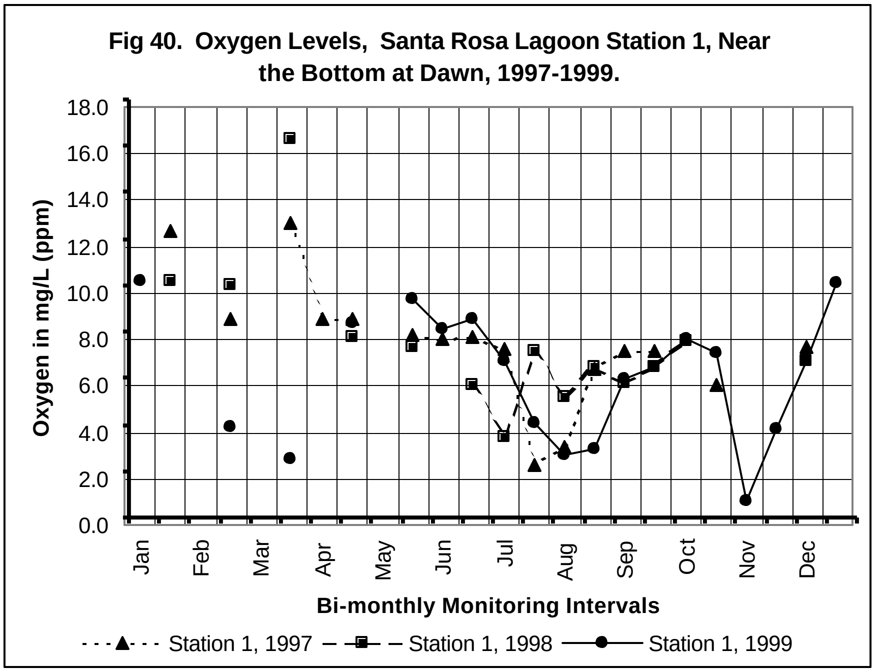


Figure A55. Two-Week Interval Oxygen Levels at Station 2 at Dawn in Santa Rosa Lagoon, 1997–1999.

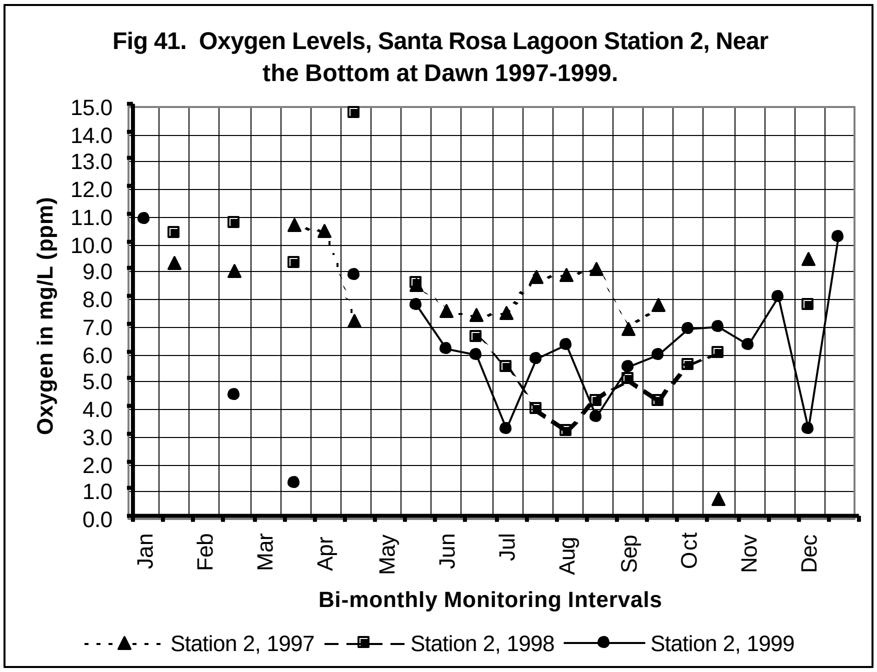


Figure A56. Two-Week Interval Oxygen Levels at Station 1 at Dawn in Santa Rosa Lagoon, 2000–2001.

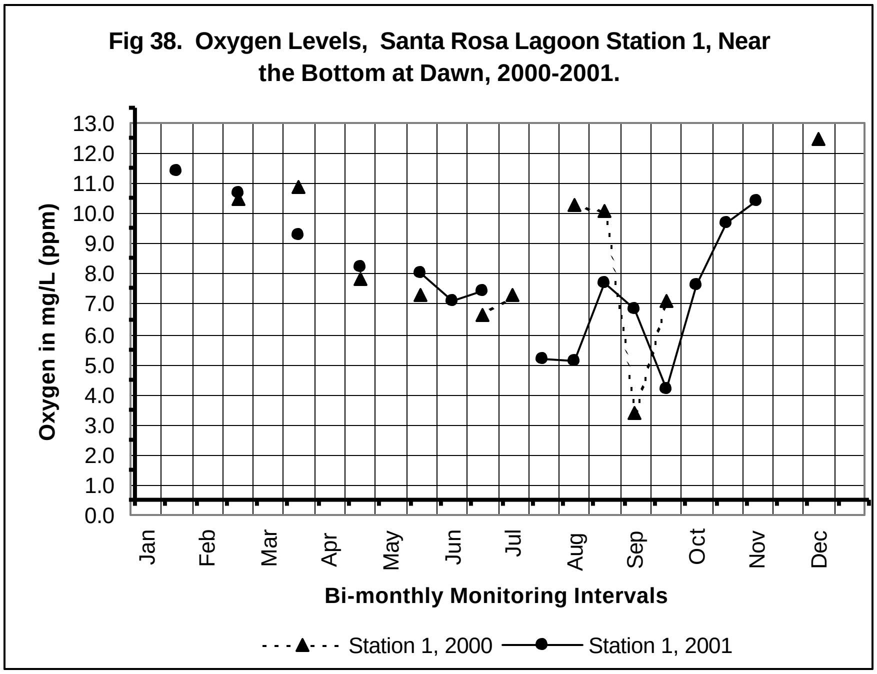


Figure A57. Two-Week Interval Oxygen Levels at Station 2 at Dawn in Santa Rosa Lagoon, 2000–2001.

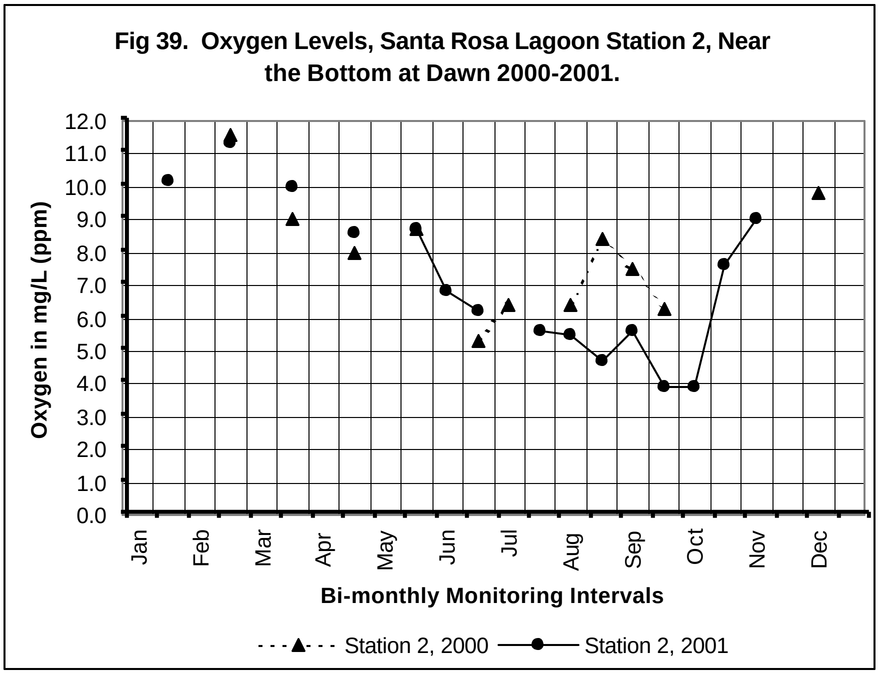


Figure A58. Two-Week Interval Oxygen Levels at Station 1 at Dawn in Santa Rosa Lagoon, 2002–2003.

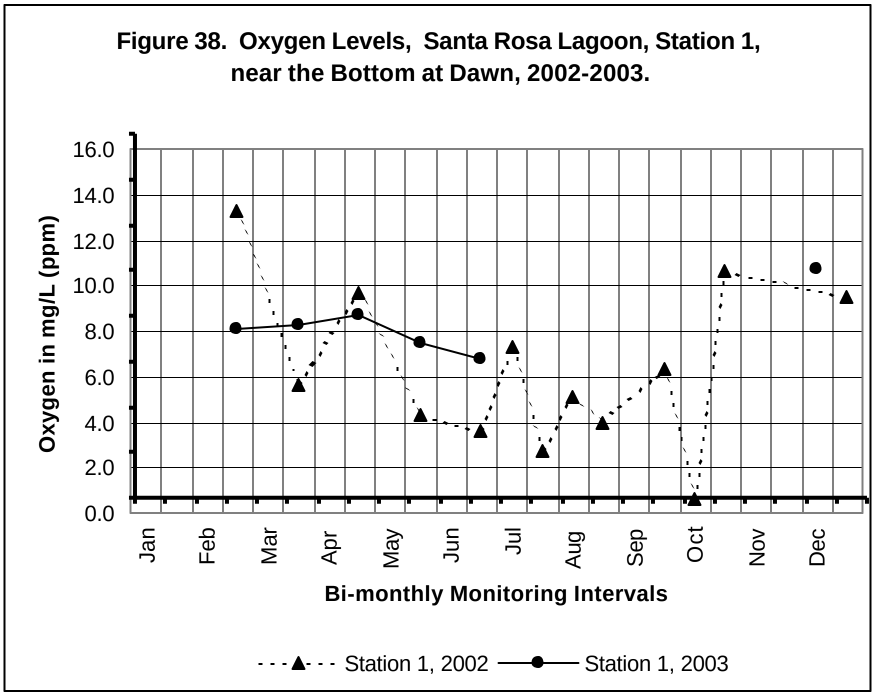


Figure A59. Two-Week Interval Oxygen Levels at Station 2 at Dawn in Santa Rosa Lagoon, 2002–2003.

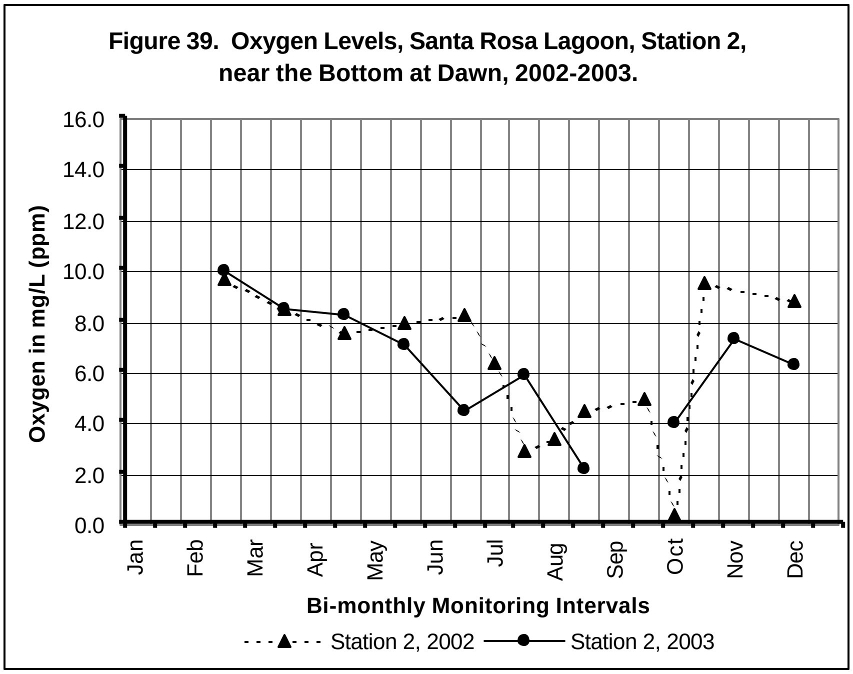


Figure A60. Two-Week Interval Oxygen Levels at Station 1 at Dawn in Santa Rosa Lagoon, 2004–2005.

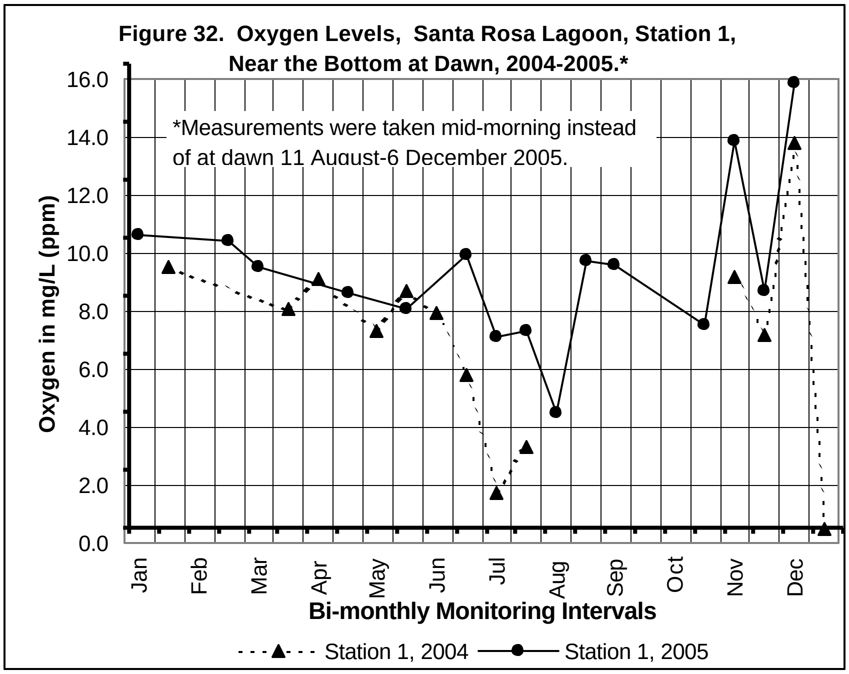
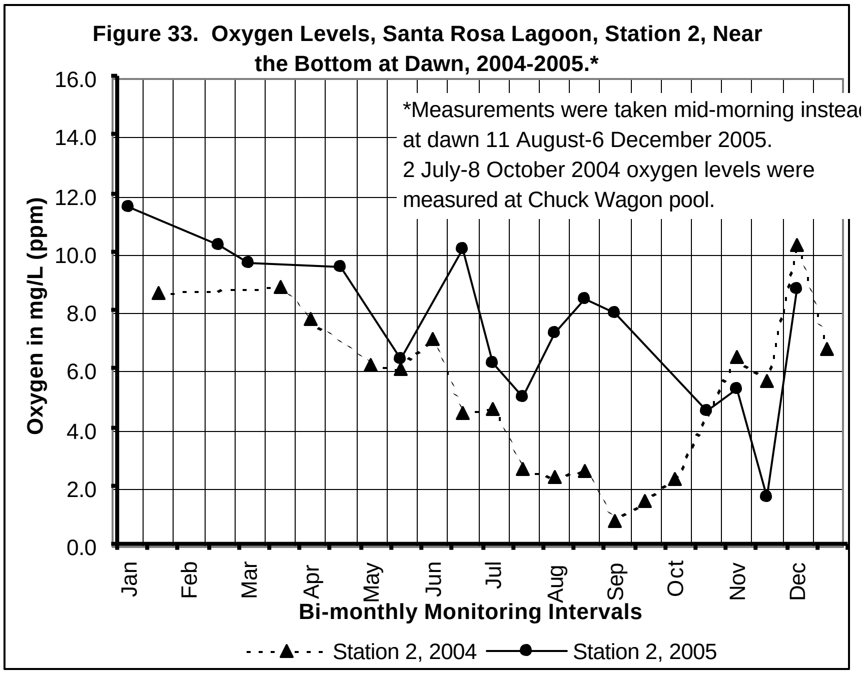


Figure A61. Two-Week Interval Oxygen Levels at Station 2 at Dawn in Santa Rosa Lagoon, 2004–2005.



Adult Steelhead Passage With Streamflow Management Guidelines

Since passage over many riffles in the mainstem is flow dependent, steelhead are more vulnerable to shallow passage conditions in drier years. If winter storms are delayed or drought conditions exist, flows may be inadequate to allow adult steelhead migration over certain critically wide riffles. Judging by the pattern of higher YOY production in the lower valley in drier years and higher YOY production in wetter years (see pervious section on juvenile densities), shallow riffles impede adult passage into the upper canyon in some years. The opening and closing of the sandbar at the creek mouth determines the spawning period during the wet season. If storms are delayed, the sandbar remains closed longer. If storms come early and are largely absent in the spring, then the sandbar closes early, thus preventing adults from entering the creek afterwards and stranding kelts trying to return to the ocean after spawning.

Regarding minimum bypass flows downstream of the Perry Creek confluence and until more current IFIM data are collected, the following management guidelines are recommended:

- *In order to promote upstream adult steelhead spawning migration during the primary spawning season of January 1 – April 15, any water diversion or well extraction capable of reducing surface flow should be interrupted during stormflow episodes when streamflow between Perry Creek confluence and Main*

Street Bridge is less than 60 cfs and streamflow between Main Street Bridge and the bay is less than 35 cfs.

- *In dry fall/ winters in which no storms have occurred by January 1, any water diversion or well extraction capable of reducing surface flow should be interrupted from January 1 until the first stormflow. After that, follow the guideline listed above.*

- *In order to promote out-migration of post-spawning steelhead kelts, water diversion or well extraction capable of reducing surface flow should not resume after a stormflow until the baseflow between storm events is shown to be greater than 15 cfs at the Highway 1 Bridge until May 1, and water extraction should be discontinued until May 1 if streamflow declines below 15 cfs between the first storm event and May 1.*

D.W. ALLEY & Associates performed a steelhead passage study in Reach 0a in lower Santa Rosa Creek in 1993 (**Alley 1993b**). With limited data at that time, it was estimated that a minimum bypass flow of 7 cfs would be necessary at the Windsor Bridge to prevent sandbar closure and to insure sandbar passage for kelts and smolts to the ocean. Later data on lagoon closure times and streamflow confirmed this initial estimate to be correct. Regarding upstream spawning migration, it was determined that a minimum bypass of 60 cfs was required at the critical riffle # 1upstream of Main Street (channel mile 2.80) and 35 cfs downstream through Cambria to negotiate the critical riffle # 2 at the concrete apron under the Burton Street Bridge (channel mile 2.16) (now removed), critical riffle # 3 a short distance downstream of Highway 1 (channel mile 1.19) and critical riffle # 4 just downstream of the CCSD lift station (channel mile 1.0). The Thompson rule was used, requiring 25% of the top (surface) width of the stream channel or 10% of continuous (contiguous and unbroken) top stream width be at least 0.6 feet deep. An additional condition placed on the passage criteria was that a minimum of 5 continuous feet of channel width most be at least 0.6 feet deep if the channel width was narrowed to less than 50 feet. It was determined that 25 cfs was required to maintain a minimum depth of 0.4 feet over a width of 4 feet for kelt (post-spawner) downstream passage at critical riffle # 1 and 13-15 cfs for critical riffles downstream. It was determined that 17 cfs was required to maintain a minimum depth of 0.3 feet over a width of at least 5 feet for downstream passage of juvenile smolts over critical riffle # 1 and 5.8 to 8 cfs for critical riffles downstream. However, probably a more realistic minimum of 6 cfs was required to maintain a minimum depth of 0.2 feet over a width of at least 5 feet at critical riffle # 1 and 0.2-0.3 feet depth over the other critical riffles for downstream passage of juvenile smolts, yearlings and YOY.

Extent of Anadromy

Updated survey work for barriers to steelhead anadromy was beyond the scope of this report. Road crossings and potential steelhead barriers were mapped by CDFG in 2005 (refer to **Appendix C**). When the mainstem of Santa Rosa Creek was surveyed to the Mora Creek confluence in fall 1994, no passage impediments were observed. However, sometime after the 1995 flood, a potential passage impediment was observed in upper

Reach 2. This was a stretch where an instream project had been completed, and the streambed had been graded into a wide, flat configuration between vertical, unvegetated streambanks. The stream thalweg had been destroyed, causing a critically shallow cross section during winter stormflows until a thalweg was re-established. This location was not re-visited, and the thalweg likely reformed during the wet winter of 1998. The concrete ford with laddered culvert at Ferracsi Road between Reaches 0b and 1 in the lower valley is a potential passage impediment if instream wood collects on the upstream entrance to the culvert and inside during stormflows. Sean Grauel, formerly of the Cambria CSD, Don Alley (D.W. ALLEY & Associates) and Dave Highland of CDFG have cleared wood multiple times that has collected at the culvert through the years. However, Don Alley has no observations of this culvert being completely impassable, and sampling data collected by D.W. ALLEY & Associates for juvenile densities upstream of the culvert has indicated that the culvert was passable to spawning adults for the entire period of sampling (1993–2006).

Although perennial flow exists in Mora Creek (**Figure A13**), judging from the topography, the gradient rapidly increases and passage impediments likely exist. There may be as much as ¼ -mile of spawning and rearing habitat on lower Mora Creek. A resident on the East Fork (**Figure A13**) reported observations of adults and juveniles in that tributary at times. However, this tributary was dry at its mainstem confluence in every year of fish sampling 1994–2006, and the gradient steepened quickly not far from its confluence with the mainstem. There may be ¼-mile of spawning habitat on the East Fork. It is unknown if perennial habitat exists in the East Fork. Lehman Creek has perennial flow at its mouth and is accessible to adult steelhead (**Figure A13**). Judging by the topography, Lehman Creek may have ¼-mile of spawning and rearing habitat. Curti Creek (**Figure A13**) likely is inaccessible to adult steelhead due to a perched culvert at its mouth under Santa Rosa Creek Road. It has been ephemeral at its mouth during past sampling and likely has no rearing habitat. Taylor Creek in the lower valley (**Figure A13**) is likely inaccessible to adult steelhead due to a perched culvert. This drainage is usually intermittent at best and dry in many years, making it unlikely to provide rearing habitat if adult passage was improved. Perry Creek and its tributary, Green Valley Creek, are accessible to adult steelhead and would provide juvenile rearing habitat in perennial stretches. However, we are unfamiliar with that sub-watershed and do not know if perennial habitat exists there. Lower Perry Creek was dry in 1994 when the Santa Rosa Creek mainstem was first surveyed.

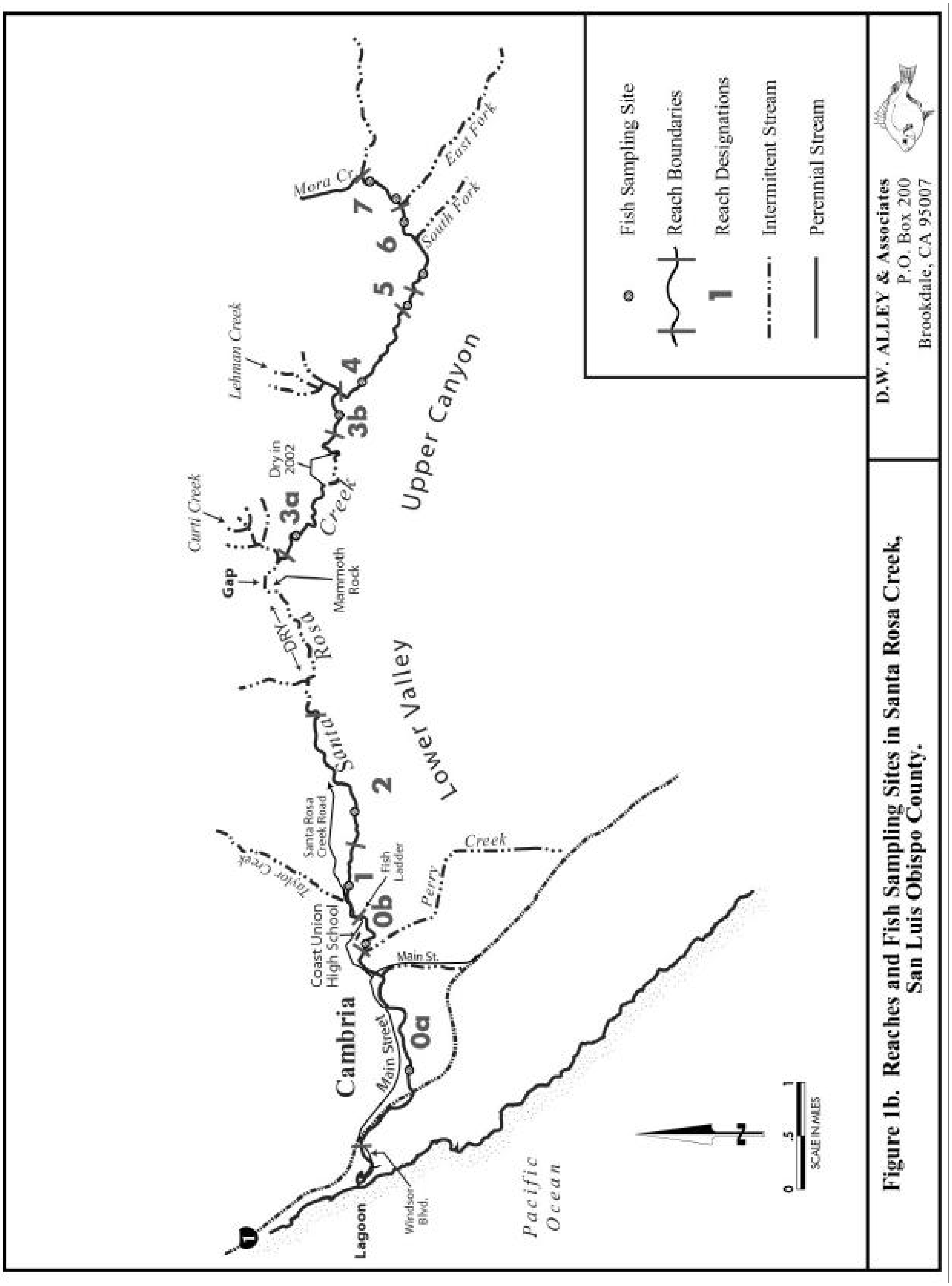


Figure 1b. Reaches and Fish Sampling Sites in Santa Rosa Creek, San Luis Obispo County.

Figure A13. Reaches of Santa Rosa Creek, San Luis Obispo County.

Timing of Lagoon Sandbar Closure and Its Effect on Out-Migration of Steelhead Smolts, with Management Guidelines

The recommended guideline to insure adequate steelhead smolt passage to the Monterey Bay is to discontinue any water extraction that affects surface flow if inflow to the Santa Rosa Creek estuary declines to 7 cfs or less during the typical wet season until at least 15 May.

Smolt out-migration by steelhead occurs primarily from March through May, but may happen earlier if large storms occur earlier and juveniles are large enough. The primary limiting factor on movement of smolts from rearing habitat to the ocean is the early closure of the sandbar at the mouth due to limited spring stormflows and resulting low streamflow into the estuary. Refer to **Table A13** for a record of annual sandbar closure. Based on streamflow data collected at or near the time of sandbar closure, the sandbar at Santa Rosa Creek mouth has closed at streamflows between 2 and approximately 13 cfs. However, most sandbar closures occurred in the 3–6.3 cfs range. Evidence of steelhead smolts that were stranded in the lagoon after sandbar closure indicated that most smolt migration was over by mid-May. Based on data regarding streamflow at the time of sandbar closure and data on stranded smolts after sandbar closure, the recommended guideline for insuring sufficient smolt passage to the Monterey Bay is to maintain stream inflow to the estuary at 7 cfs or greater until at least 15 May.

Table A13. Historical Record of Sandbar Closure at Santa Rosa Lagoon (1993–2007) and San Simeon Lagoon (1991–1992).

Year	**Date of First Sandbar Closure Detection After Winter/Spring Rainy Season**	**Evidence of Smolts in the Lagoon or Immediately Upstream After Sandbar Closure**	**Stream Inflow Cubic feet/ second (cfs)**
1991 (San Simeon Lagoon)	Before 2 April 1991	–	–
1992 (San Simeon Lagoon)	10 Jan (opened 8 Feb) 29 April 1992	–	4.35 2.75
1993	24 May 1993 closed (Re-opened after light rain on 25 May 1993) 11 June 1993 (or sooner)	Yes (few)	7.9 4.15 on 11 June
1994	**28 March 1994**	**Yes (many)**	**2.49 on 29 April**
1995	28 May 1995	Yes (few upstream only)	-
1996	3 June 1996	Yes (very few upstream only)	5.13 on 29 May 2.98 on 12 June
1997	**23 March 1997**	**Yes (many)**	**12.60 on 26 March**
1998	13 July 1998	Yes (very few upstream only)	4.65 on 15 July
1999	28 May 1999	No (upstream not sampled)	6.18
2000	31 May 2000	No (upstream not sampled)	3.00 on 15 June
2001	14 May 2001	No (upstream not sampled)	4.40 on 23 May
2002	**14 April 2002**	**Yes (many)**	**2.14 on 28 Feb. 2.11 on 28 March**
2003	9 June 2003	No	1.50 on 3 July
2004	7 May 2004	Yes (few upstream only)	2.69 on 21 May
2005	27 May 2005	Yes (few upstream only)	6.25 on 16 June
2006	Between 24 May and 26 June 2006	No	18.67 on 24 May 3.23 on 12 July
2007	**15 March 2007**	**Yes (many)**	**21.94 on 1 March**

APPENDIX B. WATER TEMPERATURE AND OXYGEN TOLERANCES FOR CENTRAL COAST STEELHEAD

Water Temperature Considerations

The relationship between water temperature and metabolic rate (measured as oxygen consumption) is basic to fish physiology and important in understanding fish distribution and ecology. Fish being ectotherms (cold-blooded), their body temperatures increase along with metabolic rate as water temperature increases. At higher temperatures, steelhead oxygen requirements and food demands increase, and steelhead are forced to fastwater habitat or other sources of abundant food. References that indicate that oxygen consumption by fishes increases with water temperature include Fry (**1947**), Beamish (**1964**) and Beamish (**1970**). Many fisheries textbooks refer to this relationship. An example is The Chemical Biology of Fishes by Malcolm Love (**1970**). The positive relationship between water temperature and metabolic rate in fishes leads to higher oxygen requirements as water temperature increases (**Nikolsky 1963**).

Brett (**1956**) defined lethal temperature theoretically as that temperature at which 50% of a fish population could withstand for an infinite time. At the lethal temperature and beyond, there is a period of tolerance before death, known as the resistance time (**Fry 1947**). Because of the resistance time, fish are able to tolerate diurnal fluctuations exceeding lethal temperatures (**Fry et al. 1946**). Between the upper and lower lethal temperatures is found the preferred temperature for each species. Fry (**1947**) defined the preferred temperature as the temperature range in which a given fish population will congregate when given the choice of an infinite range of temperatures.

Lethal temperature limits and the preferred temperature of a species can be altered through acclimation to changing environmental temperatures. As the acclimation temperature increases, the lethal and preferred temperatures progressively increase (**Brett 1956**). This process allows a species to survive over an extended temperature range. A review of the literature concerning the effects of high temperature on steelhead-rainbow trout shows considerable variation in results between different researchers. This was partially due to differences in laboratory conditions under which the studies were conducted. Uncontrolled variables such as water chemistry, season, day length, acclimation level, physiological condition, size, age, sex, reproductive condition, nutritional state and genetic history of tested fish may influence their response to water temperature levels.

Sub-lethal effects of high temperatures on salmonids include increased metabolic rates and decreased scope for activity, decreased food utilization and growth rates, reduced resistance to disease and parasites, increased sensitivity to some toxic materials, interference with migration, reduced ability to compete with more temperature resistant species and reduced ability to avoid predation.

A review of the literature indicates that temperatures below 20ºC (68ºF) are best suited for the success and production of steelhead-rainbow trout (**Kubicek and Price 1976**). Snyder and Blahm (**1971**) reporting on the work of Brett (**1959**) stated that steelhead could exist at temperatures above 20ºC (68ºF), but only at the expense of feeding, growth, maturation and migration. Mantelman (**1958**) indicated that the range of 12 to 20ºC was most favorable for food consumption and growth of rainbow trout. Coche (**1967**) concluded that, for his stock of juvenile steelhead, temperatures between 20ºC (68ºF) and 24ºC (75.2ºF) were responsible for high maintenance requirements and low conversion efficiency of food into growth. Dickson and Kramer (**1971**) reported that the scope for activity of hatchery and wild rainbow trout was maximum at 15ºC (59ºF) and 20ºC (68ºF), respectively, and slightly less at 25ºC (77ºF). Baltz et al. (**1987**) reported that optimal temperatures for growth of rainbow trout to be around 15-18ºC, a range that corresponded to temperatures selected in Sierran streams when possible. Baltz et al. (**1987**) found that rainbow trout selected temperatures of 16-18ºC in the Pit River (southern Cascades of Northeast California) when they had a choice. However, Moyle (**2002**) stated that many factors affect choice of temperatures by trout, including food availability. The applicability of temperature data collected on Sierran/Cascade trout populations has limited applicability to Central Coast steelhead populations and temperature preferences. In higher elevation Sierran streams, there are conditions of cool and sunny, productive conditions. We do not have that on the Central Coast. Cool habitat here is unproductive in terms of food because it is heavily shaded. Sunny habitat on the central coast is warm and productive in terms of food. Therefore, we have warmer stream habitats that are more optimal for steelhead growth and densities than cool, heavily shaded habitats.

At sub-lethal levels water temperature is largely a food availability issue. If food is scarce, low temperatures (10-14ºC or less) would be optimal, because they reduce basal metabolic rate, reducing food needs and resulting in lower summer weight loss (if food is very scarce). If food is moderately abundant higher temperatures (14-18ºC) would be optimal, because metabolic rate would not be too high, and swimming performance and digestive rate would allow for active feeding and growth. If food is very abundant and available, then warmer temperatures (18-22ºC) might be optimal, because rapid digestion would allow the fish to quickly assimilate the abundant food and growth rate would be high.

In the upper canyon of Santa Rosa Creek, summer and the summer/ fall 7-day rolling average water temperature is typically 1–1.5 C (1.8–2.7 F) cooler and the daily maximum is typically 2–4 C (3.6–7.2 F) cooler than the lower valley (**Alley 2007a**). However, YOY steelhead grow faster in the lower valley and more reach Size Class 2 their first growing season than in the upper canyon. Food supply in the lower valley is evidently greater to offset the added metabolic cost of living there. Higher temperatures increase food demands and restrict steelhead to faster habitats for feeding in these lower reaches, especially above 21ºC (70ºC) (**Smith and Li 1983).** Streamflow is higher in the lower valley in spring when feeding and growth are maximized and during the summer months. The lower valley is less shaded with more light to stimulate photosynthesis and insect productivity. More light makes visual feeding more effective. In conclusion, in central coast streams, optimal habitat is not the coolest habitat.

Kubicek and Price (**1976**) concluded that although temperatures less than 26.5ºC (79.7ºF) were not assumed to directly cause steelhead mortality in the Big Sulphur Creek drainage (tributary to the Russian River, Mendocino County), temperatures consistently above 20ºC (68ºF) were assumed to cause sub-lethal stress that could result in decreased fish production and indirect mortality. They noted that juvenile steelhead disappeared from a section of Big Sulphur Creek when hot springs caused summer temperatures to rise above 26ºC. *They assumed in their monitoring that stations that had temperatures greater than 20ºC (68ºF) for less than 50% of the time in any one month were not expected to cause significant sub-lethal effects in that month, unless that station reached a marginal or lethal maximum temperature.*

Charlon (**1970**) found that steelhead acclimated at 24ºC (75.2ºF) experienced a lethal temperature of 26.35ºC (79.4ºF). Alabaster (**1962**) found steelhead acclimated to 20ºC (68ºF) to experience a lethal temperature of 26.6ºC (79.9°F). McAfee (**1966**) found steelhead lethal temperatures in the range of 24-29ºC (75.2º- 84.2ºF) with unspecified acclimation temperatures.

Supporting Evidence For High Temperature Tolerance in Steelhead

There are many central coast examples of steelhead surviving and growing well at water temperatures above 21ºC. Many of these come from coastal lagoons (**Alley 2002b**) and lower reaches of unshaded drainages, such as lower Soquel Creek (**Alley 2002c**) and the lower San Lorenzo River (**Alley 2002d**), but only where food is abundant. When food is abundant, growth is actually better at warmer water temperatures because digestive rate is increased, allowing fish to consume and process more food and grow more quickly.

The Soquel Creek Lagoon is inhabited by juvenile steelhead each summer and is valuable nursery habitat. As a typical example, on 22 July 1988 at 0820 hr the minimum lagoon temperature was 20.8º C, and by 1449 hr the minimum lagoon temperature was 22-23º C at all stations throughout the water column, (**Alley et al. 1990**). Large, fast-growing steelhead were collected from this lagoon in fall, 1988, indicating their survival well above 21º C. In late July 1989, Smith observed 300+ steelhead juveniles at the mouth of Noble Gulch in Soquel Lagoon where the water column temperature ranged from 21.4 to 22.4º C at 1555 hr.

On 21 July 1992 in Soquel Lagoon, the minimum temperature measured at 4 sites before 0700 hr was 21.2º C (**Alley 1993c**). At 3 of the 4 monitoring sites the minimum was 23º C. By 1700 hr on that day, the minimum water temperature measured was 25.2º C at one site and 26º C at the other monitored site. These sites were representative of the entire lagoon. Large, fast-growing steelhead were collected in abundance in Soquel Lagoon in fall, 1992, after these warm summer conditions.

On two occasions (August and September) in Soquel Lagoon in 1993, steelhead juveniles fed at the surface in early morning with minimum water temperature above 20.6 º C (**Alley 1994**). Water temperature was likely to increase at least 2º C through the day. More than 1,100 juvenile steelhead were captured in the lagoon in fall 1993.

Steelhead have been detected at water temperatures as high as 26º C in Pescadero Creek Lagoon (San Mateo County) and at 24º C on a regular basis in Pescadero and San Gregorio Lagoons (San Mateo County) (**Smith 1990**) and Uvas Creek in Santa Clara County (**J. Smith, personal observation**).

It has been reported that rainbow trout (same species as steelhead but with a freshwater life history pattern) survive temperatures from 0 to 28ºC, provided that they are gradually acclimated to higher temperatures and that saturated oxygen conditions exist (**Moyle 1976**). Rainbow trout in Big Sulphur Creek, tributary to the Russian River, are often exposed to stream temperatures in excess of 20ºC (**Price et al. 1978**). This is particularly the case in Big Sulphur Creek below Little Geysers Creek where daily minimum temperatures sometimes exceed 20ºC. Daily stream temperatures fluctuate up to, and perhaps greater than 28ºC in Big Sulphur Creek in summer rainbow trout habitat (**Price et al. 1978**). Steelhead inhabited the Creek, downstream of where these data were collected. More than 100 rainbow trout/ steelhead were observed during snorkeling in pools, runs and riffles on 24 July 1976 in Deer Creek, Tehama County, where water temperature fluctuated daily between 19 and 24º C (**Alley 1977**).

Oxygen Considerations for Steelhead

Steelhead can likely survive oxygen levels in the cooler, early morning as low as 2 mg/l. However, the water quality goal for Santa Rosa Creek should be to maintain oxygen levels above 5 mg/l because activity is likely restricted at lower oxygen levels. Research with YOY rainbow trout (same species as steelhead) acclimated for 5 days at 15°C were provided oxygen levels of 1 and 3 mg/1 for a maximum 48-hour period (**Dean and Richardson 1999**). Mortality occurred at both 1 mg/l (100% mortality) and 3 mg/l (14.3% mortality after 36 hours and none thereafter) oxygen concentrations. Surfacing behavior to gulp air was also observed at these oxygen concentrations. However, no mortality or surfacing behavior was observed at 5 mg/l. The USEPA (**1986**) concluded that if salmonid exposure time was less than 84 hours (3.5 days), and temperatures were between 10 and 20°C, dissolved oxygen concentrations of at least 3 mg/l should not produce any direct mortality in salmonids. They considered salmonids to be moderately impaired at 5 mg/l oxygen and acute at 3 mg/l. This was a general recommendation based on a combination of data from multiple species. The 5 mg/l minimum oxygen goal is easily met in flowing stream habitat where riffle turbulence recharges oxygen to full saturation or close to it. However, oxygen may readily fall below 5 mg/l at greater depths in the lagoon if considerable filamentous algae is present at night after a foggy/ overcast day to use up oxygen or if saltwater has been trapped by sandbar closure without sufficient lagoon inflow after mild winters with low summer baseflow to flush the stagnant saltwater lens through the sandbar.

Supporting Evidence for Low Oxygen Tolerance by Steelhead

Steelhead have been observed at oxygen levels below 4 mg/l in many locations along the central coast. Steelhead were captured from isolated pools (stream discontinuous) at 3-4 mg/l oxygen and 16º C water temperature in 1988 in Waddell and Redwood creeks in

Santa Cruz and Marin counties, respectively (**J. Smith, pers. observation).** In August 1989 on the Carmel River, juvenile steelhead were observed in pools at three different sites where oxygen ranged from a minimum of 2-4 mg/l at the different sites before dawn to a maximum of 14-15.5 mg/l (super saturation) in the afternoon, with water temperature ranging from 61º F (16.1º C) in the morning to 72º F (22.2º C) in late afternoon (**D. Dettman 2003, pers. communication**).

In San Simeon Creek Lagoon in 1993, steelhead survived to at least mid-August, despite morning oxygen levels in the 1.7-2.8 mg/l range (**Alley 1995b**). Juvenile steelhead were observed on 10 June, and 29 July 1993 at the same location (**Alley, pers. observation**). On 11 June the maximum oxygen concentration at that station was 2.7 mg/l at 0603 hr (at the surface), with water being 14º C (**Alley 1995b**). On 8 July the maximum oxygen level was 1.7 mg/l with water at 16º C at 0525 hr (**Alley 1995b**). On 29 July the oxygen concentration was at a maximum of 2.8 mg/l with water temperature of 17.5º C at 0530 hr (**Alley 1995b**). An adult steelhead was observed in the lagoon during sampling on 10-11 August (**J. Nelson 1993, personal communication**).

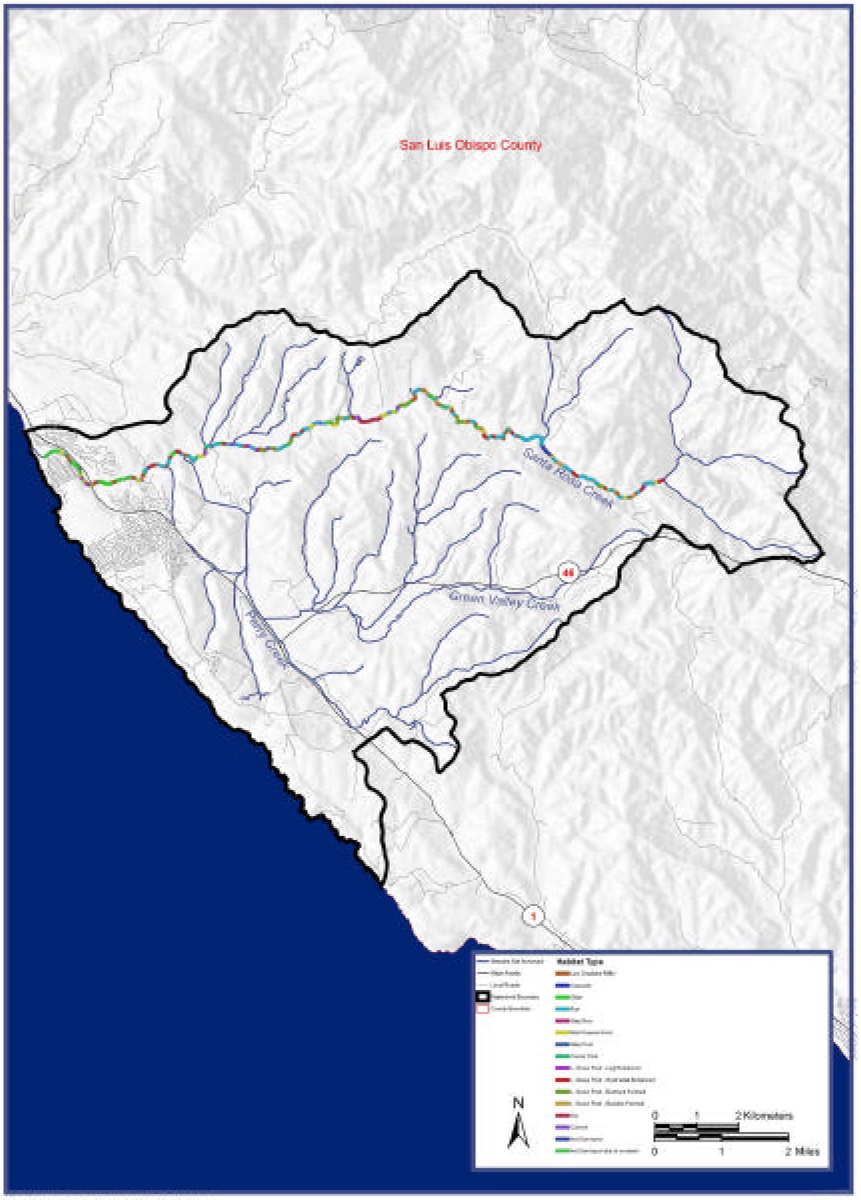
At low water temperatures, it was reported that rainbow trout withstand oxygen concentrations of 1.5 to 2 mg/l (**Moyle 1976**). Rainbow trout were found in Penitencia Creek (Santa Clara County) at 3 mg/l oxygen and 20º C water temperature (**J. Smith 2003, personal communication**).

APPENDIX C. HABITAT MAPS FROM THE CDFG BASIN PLANNING AND HABITAT MAPPING PROJECT.

http://ccows.csumb.edu/scdp/data.htm

California Department of Fish and Game
Central Coast Region South District Basin Planning

Santa Rosa Creek Watershed
Habitat Type



Map produced by Julie Casagrande and Fred Watson (Central Coast Watershed Studies, Watershed Institute, California State University Monterey Bay) in collaboration with the California Department of Fish and Game. The data presented in map were collected during the CDFG Salmonid Habitat Surveys (Summer 2005). The basemap layer is a shaded relief raster derived from the USGS National Elevation Dataset using TNT Mips software. The watershed boundaries layer was derived from the California Interagency Watershed Map of 1999 (Calwater 2.2.1, updated May 2004) by merging HSA (Hydrologic Sub-Area) level boundaries.

California Department of Fish and Game
Central Coast Region South District Basin Planning

California Department of Fish and Game
Central Coast Region South District Basin Planning

Santa Rosa Creek Watershed
Primary Pools

Map produced by Julie Casagrande and Fred Watson (Central Coast Watershed Studies, Watershed Institute, California State University Monterey Bay) in collaboration with the California Department of Fish and Game. The data presented in map were collected during the CDFG Salmonid Habitat Surveys (Summer 2005). The basemap layer is a shaded relief raster derived from the USGS National Elevation Dataset using TNT Mips software. The watershed boundaries layer was derived from the California Interagency Watershed Map of 1999 (Calwater 2.2.1, updated May 2004) by merging HSA (Hydrologic Sub-Area) level boundaries.

California Department of Fish and Game
Central Coast Region South District Basin Planning

California Department of Fish and Game
Central Coast Region South District Basin Planning

Santa Rosa Creek Watershed
Embeddedness

Map produced by Julie Casagrande and Fred Watson (Central Coast Watershed Studies, Watershed Institute, California State University Monterey Bay) in collaboration with the California Department of Fish and Game. The data presented in map were collected during the CDFG Salmonid Habitat Surveys (Summer 2005). The basemap layer is a shaded relief raster derived from the USGS National Elevation Dataset using TNT Mips software. The watershed boundaries layer was derived from the California Interagency Watershed Map of 1999 (Calwater 2.2.1, updated May 2004) by merging HSA (Hydrologic Sub-Area) level boundaries.

California Department of Fish and Game
Central Coast Region South District Basin Planning

California Department of Fish and Game
Central Coast Region South District Basin Planning

Santa Rosa Creek Watershed
Riparian Canopy Density

Map produced by Julie Casagrande and Fred Watson (Central Coast Watershed Studies, Watershed Institute, California State University Monterey Bay) in collaboration with the California Department of Fish and Game. The data presented in map were collected during the CDFG Salmonid Habitat Surveys (Summer 2005). The basemap layer is a shaded relief raster derived from the USGS National Elevation Dataset using TNT Mips software. The watershed boundaries layer was derived from the California Interagency Watershed Map of 1999 (Calwater 2.2.1, updated May 2004) by merging HSA (Hydrologic Sub-Area) level boundaries.

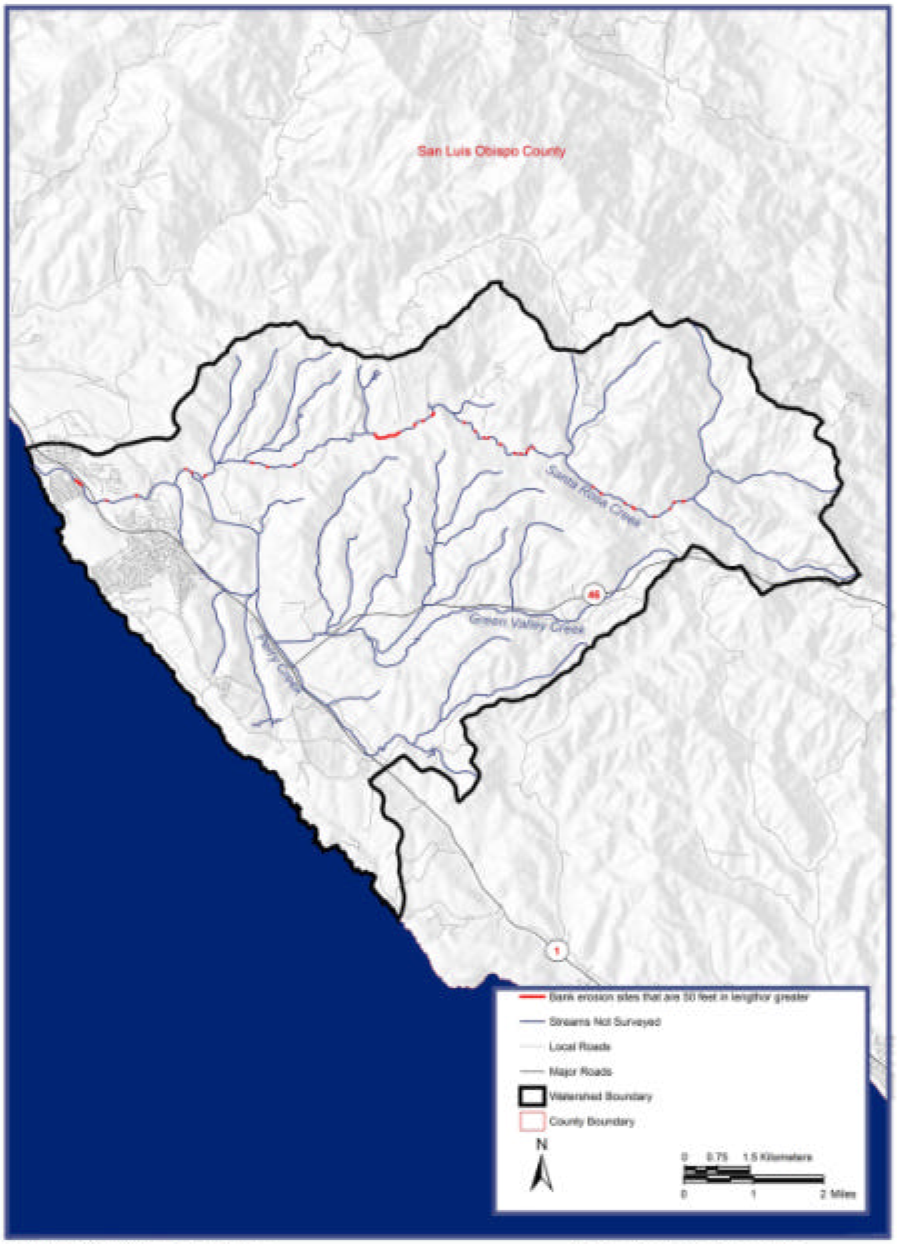
California Department of Fish and Game
Central Coast Region South District Basin Planning

CCoWS

Monterey Bay

California Department of Fish and Game
Central Coast Region South District Basin Planning

Santa Rosa Creek Watershed
Left Bank Erosion Sites



Map produced by Jessica Watson, William Perry, and Fred Watson (Central Coast Watershed Studies, Watershed Institute, California State University Monterey Bay) in collaboration with the California Department of Fish and Game. The basemap layer is a shaded relief raster derived from the USGS National Elevation Dataset using TNT Mips software.
The bank erosion data layer
was created from Crossing Inventory and Fish Passage Evaluation for California Department of Fish and Game.
The watershed boundaries layer was derived from the California Interagency Watershed Map of 1999 (Calwater 2.2.1, updated May 2004) by merging HSA (Hydrologic Sub-Area) level boundaries.

California Department of Fish and Game
Central Coast Region South District Basin Planning

California Department of Fish and Game
Central Coast Region South District Basin Planning

Santa Rosa Creek Watershed
Right Bank Erosion Sites

Map produced by Jessica Watson, William Perry, and Fred Watson (Central Coast Watershed Studies, Watershed Institute, California State University Monterey Bay) in collaboration with the California Department of Fish and Game. The basemap layer is a shaded relief raster derived from the USGS National Elevation Dataset using TNT Mips software.
The bank erosion data layer
was created from Crossing Inventory and Fish Passage Evaluation for California Department of Fish and Game.
The watershed boundaries layer was derived from the California Interagency Watershed Map of 1999 (Calwater 2.2.1, updated May 2004) by merging HSA (Hydrologic Sub-Area) level boundaries.

California Department of Fish and Game
Central Coast Region South District Basin Planning

California Department of Fish and Game
Central Coast Region South District Basin Planning

Santa Rosa Creek Watershed
Stream Structures & Potential Barriers

Map produced by Julie Casagrande and Fred Watson (Central Coast Watershed Studies, Watershed Institute, California State University Monterey Bay) in collaboration with the California Department of Fish and Game. The basemap layer is a shaded relief raster derived from the USGS National Elevation Dataset using TNT Mips software. The stream structures and potential barriers data layer was extracted from the PAD GIS dataset - California Fish Passage Assessment Database Project (January, 2006). The watershed boundaries layer was derived from the California Interagency Watershed Map of 1999 (Calwater 2.2.1, updated May 2004) by merging HSA (Hydrologic Sub-Area) level boundaries.

California Department of Fish and Game
Central Coast Region South District Basin Planning

APPENDIX D. SCALE ANAYSIS FOR STEELHEAD FROM SANTA ROSA CREEK, SAN LUIS OBISPO COUNTY, OCTOBER 2006.

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11 July 2008 Revised

Aging Methods

True annuli were recognized by cutting over of scale circuli that was not near the edge of the scale and was usually accompanied by tighter spacing of circuli before the annulus. This reflected slowing growth and the major loss of body girth (and scale erosion) during the poor growth period in fall and winter.

False annuli also occurred in many fish. False annuli were recognized by cutting over of circuli near the edge of the scale, but with no change in circuli spacing. This occurs when previously fast-growing, “plump” fish lose weight in late summer due to high stream temperatures and/or reduced stream flow that results in insufficient feeding to maintain weight. False annuli can even occur in hatchery-reared fish of known age, when the normally fast growth is interrupted briefly.

Sizes of fish at true annuli were back-calculated based upon projected scale length versus projected length to annuli and using 25 mm Standard Length (SL) as the fish length at the time of scale formation (a + bx, where a = fish size at scale formation).

Diagnosis of Age and Growth Results from Scales

All but one of the 15 fish samples from Sites 0A and 0A2 were young-of-year, despite standard lengths of 108 to 152 mm SL. The 175 mm SL fish was a yearling.

For Sites 1 and 2, all but 1 of 15 fish samples between 108 and 131 mm SL long were young-of-year. All 10 fish samples with lengths 132 – 156 mm SL were yearlings. The 175 mm SL fish from Site 2 was probably a yearling, also, but may have been a 2-year old with negligible growth in 2006. A 267 mm SL fish from Site 1 was at least 3 years old (all scales were regenerated to some degree). It may have been a resident (male) fish.

The majority of young-of-year fish at all sites showed false annuli near the edge of the scale (so did the majority of yearlings, also those false annuli were not noted in Table 1). They lost weight in late summer during a period of no growth, probably due to very low stream flows and higher water temperatures in late August or September. Growth resumed later as temperatures cooled and/or stream flows increased with leaf drop. The occurrence of false annuli in 2006 (a wet spring) indicates that in drier years, the growth period would shrink and fish sizes at the end of summer would be significantly smaller.

The back-calculated sizes at annuli for yearling fish from sites 1 and 2 were generally small compared to the scale-sampled fish that were young-of-year at sites 1 and 2. This may be because most of the larger young-of-year will smolt as yearlings, and the smaller fish make up most of those which remain for a second year. Alternatively, the smaller size may reflect generally poorer conditions for growth in 2005 or growth by those fish further upstream in 2005.

Table 1. Ages of fish from Santa Rosa Creek, San Luis Obispo County, for 2006 with back-calculated lengths at annuli.

Length (mm) Standard / Fork	Age	Projected Image Length Scale	Projected Image Length Annulus	Back-calculated Standard Length at Annulus
Site 0A1- 20 Oct 06				
108 / 121	0+	23	21 false	
128 / 144	0+	30	26 false	
130 / 143	0+	26	22 false	
130 / 144	0+	28		
131 / 147	0+	30		
132 / 146	0+	35	29 false	
132 / 148	0+	29.5	25 false	
137 / 153	0+	33	28 false	
138 / 151	0+	33	26 false	
142 / 161	0+	35.5	30 false	
146 / 163	0+	34.5	30 false	
152 / 167	0+	30	23 false	
175 / 193	1+	31	21	126
Site 0A2- 20 Oct 06				
120 / 135	0+	26	22 false	
121 / 136	0+	27		
Site 1- 18 Oct 06				
97 / 108	0+	18		
113 / 125	0+	20	16 false	
117 / 133	0+	28	22 false	
120 / 133	1+	29	15.5	76
122 / 136	0+	22	18.5 false	
131 / 145	0+	26	22.5	

Length (mm) **Standard / Fork**	**Age**	**Projected Image Length** **Scale**	 **Annulus**	**Back-calculated Standard Length at Annulus**
132 / 148	1+	27	19	
133 / 151	1+	25	11	73
138 / 156	1+	27	12	75
152 / 168	1+	32	20	104
267 / 298	3+ or more	50	regen,22,31,42	131, 175, 228

Site 2- 17 Oct 06

89 / 101	0+	22	20 false	
101 / 113	0+	22		
101 / 113	0+	18		
101 / 115	0+	25	20.5 false	
107 / 120	0+	19		
108 / 120	0+	22	20 false	
113/ 123	0+	25	21 false	
116 / 130	0+	29	24 false	
122 / 137	0+	24.5	21 false	
132 / 148	1+	29	13	73
142 / 161	1+	37	18	80
143 / 160	1+	26	14.5	91
143 / 161	1+	31	12.5	73
148 / 166	1+	27.5	17	101
156 / 174	1+	26	11	80
175 / 196	1+/2+?	39	13, 36 false	75, 163?

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APPENDIX M

NORTH COAST AREA PLAN ENVIRONMENTAL GOALS

County of San Luis Obispo (revised, 2008)

NORTH COAST AREA PLAN ENVIRONMENTAL GOALS

Environmental goals defined in the North Coast Area Plan (revised, 2008) are to maintain and protect a living environment that is safe, healthful and pleasant for all residents by:

- Assuring the protection of coastal resources such as wetlands, coastal streams, forests, marine habitats, and wildlife, including threatened and endangered species.
- Conserving nonrenewable resources and replenishing renewable resources.
- Balancing the capacity for growth allowed by the Area Plan with the sustained availability of resources.
- Avoiding or mitigating to the maximum extent feasible, any adverse impacts from development using the best available methods.
- Preserving and protecting the air quality by seeking to attain and maintain state and federal ambient air quality standards by determining, and mitigating where feasible, potential adverse air quality impacts of new residential, commercial, and recreational development.
- Preserving and protecting water quality by avoiding and mitigating, potential adverse water quality impacts of new residential, commercial, and recreational development, among other ways through the implementation of low impact site designs that protect natural drainage courses, maximize opportunities for on-site percolation or detention and reuse of stormwater, and treat and filter runoff as necessary to remove sediments and contaminants.
- Supporting the efforts of the Monterey Bay National Marine Sanctuary, or future local marine sanctuaries.
- Protecting cultural, archaeological, and paleontological resources.
- Avoiding new development in hazardous areas and, where feasible, removing development threatened by hazards.

Other general goals in the North Coast Area Plan (2007) that relate to the goals of the Santa Rosa Creek Watershed Conservation Plan (Conservation Plan) include:

- Orderly Development-Establish a growth rate consistent with the protection of coastal resources.
- Residential Design in Cambria- Preserve the native forest ecosystem; maximize onsite-percoloation of stormwater, or detention and reuse of stormwater; and provide adequate setbacks and open space to implement water best management practices both during and after construction.
- Parking and Access – Minimize impervious surfaces and hardscapes.
- Landscape Design – Renew the urban forest and use California Central Coast native plants and drought and fire-resistant vegetation.
- Public Services, Parks and Facilities – Plan new development using Management Systems and Growth Management Strategies to ensure resource demands do not exceed existing and planned capacities.

- Open Space - Encourage collaboration among governmental agencies, landowners, and non-profit organizations for the preservation of open space.
- Resource Use and Energy Conservation – Recognize the impacts of land use and water consumption activities that are inappropriate for semi-arid climates.

"North Coast Rural Land Use" category standards significant to the Conservation Plan include:

- Site Design and Building Construction – New development shall not be visible from State Highway 1. Development shall be on moderately sloped terrain, leaving steep slopes visible from public roads undeveloped.
- Building Height – Structures on the east side of State Highway 1 cannot exceed 22 feet, unless a maximum height exceeding this level is required to meet a specific building standard.

Standards applied to all lands within the Cambria Urban Reserve Line that are of importance to the Conservation Plan include:

- Marine Habitat Protection –Projects with Point-Source Discharge – Water Quality Enhancement – In-stream habitat for sensitive species including steelhead, red-legged frog, and tidewater goby, cannot be affected by water temperature and quality at discharge locations.

Standards applied to land use categories in and adjacent to Santa Rosa Creek and are significant to this Conservation Plan include:

- Biological Viability – Proposed development must maintain Santa Rosa Creek's ecologic viability.
- Channelization or Filling in Floodways – Channelization or filling of the channel or floodplain is prohibited unless action is consistent with Coastal Act Section 30236.
- Creek Setbacks and Habitat Protection – A 100 foot buffer between the upland edge of riparian vegetation and new development must be maintained unless consistent with the Coastal Zone Land Use Ordinance Section 23.07.174d.2. Recreational trails cannot be constructed within riparian vegetation.
- Limitations on Residential Construction – No more than 125 residential building permits will be issued each year.
- Limitations on Development – Supplemental Water Supply Standards – Creek Withdraws- Services District water withdraws from the Santa Rosa Creek and San Simeon Creek must maintain a level to protect adequate in-stream flows for sensitive species and riparian/wetland habitats; groundwater aquifers; and agricultural resources.

APPENDIX N

CAMBRIA COMMUNITY SERVICES DISTRICT

CALIFORNIA MUNICIPAL CODE

Edited with supplementation by

Matthew Bender & Company, Inc., 2004

(Downloaded online: http://www.municode.com/resources/gateway.asp?pid=16102&sid=5)

CAMBRIA COMMUNITY SERVICES DISTRICT

CALIFORNIA MUNICIPAL CODE

Chapter 4.08: Waste of Water – Eliminate waste of potable water within district boundaries and encourage the use of nonpotable water for activities such as irrigation and construction. Water waste is defined as any of the following activities:

1. The watering of grass, lawns, ground-cover, shrubbery, open ground, crops and trees herein after collectively called "landscape or other irrigation," in a manner or to an extent which allows excess water to run-off the area being watered. Every water user is deemed to have under his or her control at all times his or her water distribution lines and facilities and to know the manner and extent of his or her water use and excess run-off;

2. The watering of grass, lawns, ground-cover, shrubbery, open ground, crops or trees or other irrigation within any portion of the district in violation of the following schedule and procedures:

    a. Watering shall be accomplished with a person in attendance;

    b. Watering shall not take place between the hours of ten a.m. and six p.m.; and

    c. Watering shall be limited to the amount of water necessary to maintain landscaping.

3. The washing of sidewalks, walkways, driveways, parking lots, windows, buildings and all other hard-surfaced areas by direct hosing;

4. The escape of water through breaks or leaks within the water user's plumbing or distribution system for any substantial period of time within which such break or leak should reasonably have been discovered and corrected. Water must be shut off within two hours after the water user discovers such leak or break, or receives notice from the district of such leak or break, which ever occurs first. Such leak or break shall be corrected within an additional six hours;

5. The serving of water to customers by any eating establishment except when specifically requested;

6. Except as approved in advance in writing by the general manager of the district, the use of water by governmental entities or agencies for: (1) routine water system flushing for normal maintenance, (2) routine sewer system flushing for normal maintenance, and (3) fire personnel training;

7. Washing vehicles by use of an unrestrained hose. Use of a bucket for washing a vehicle and rinsing with a hose with a shutoff at the point of release is permitted subject to non-wasteful applications. Vehicle is defined as any mechanized form of transportation including, but not limited to, passenger cars, trucks, recreational vehicles (RVs), campers, all terrain vehicles (ATVs), motorcycles, boats, jet skis, and off-road vehicles;

8. Use of potable water from the district's water supply system for compacting or dust control purposes;

9. Using unmetered water from any fire hydrant, except as required for fire suppression;

10. It is unlawful for any consumer to remove, replace, alter or damage any water meter or components thereof.

Chapter 4.12: Emergency Water Conservation Program – Provide the structure where the board of directors may restrict water use when water demands necessitate water conservation strategies.

Stage 1 Water Conservation Program – Drought Watch Condition: Reduce consumption through voluntary actions by seven percent. A drought watch condition may be declared and the Stage 1 water conservation program may be placed into effect using the procedures set forth in Section 4.12.060, under any of the following circumstances:

1. If, at any time, the results of the water supply and demand model indicate that groundwater levels may be insufficient to meet the ordinary demands and requirements of the water consumers;

2. Once seasonal streamflow in San Simeon Creek ceases to flow to the Pacific Ocean, if the results of the water supply and demand model indicate that groundwater levels may be insufficient to meet the ordinary demands and requirements of the water consumers; or

3. If, at any time, water delivery capabilities are impaired such that the water supply or delivery system is incapable of meeting the ordinary demands and requirements of the water consumers.

Stage 2 Water Conservation Program – Water Shortage Condition:

Reduce water consumption by 15 percent. A water shortage condition may be declared and the Stage 2 water conservation program may be placed into effect using the procedures set forth in Section 4.12.060, under any of the following circumstances:

1. If, at any time, results of the water supply and demand model indicate groundwater levels will be insufficient to meet ninety-three (93) percent of the ordinary demands and requirements of the water consumers; or

2. If, at any time, water delivery capabilities are impaired such that the water supply or delivery system is incapable of meeting ninety-three (93) percent of the ordinary demands and requirements of the water consumers.

Stage 3 Water Conservation Plan – Water Shortage Emergency Condition: Conserve water supply for human consumption, fire protection, and sanitation. A Stage 3 water shortage emergency condition may be declared using the procedures set forth in Section 4.12.060, under any of the following circumstances:

1. If, at any time, results of the water supply and demand model indicate groundwater levels will be insufficient to provide water for human consumption, sanitation and fire protection; or

2. If, at any time, water delivery capabilities are impaired such that the water supply or delivery system is incapable of providing sufficient water for human consumption, sanitation and fire protection; or

3. If, at any time, the board of directors finds and determines that the ordinary demands and requirements of water consumers cannot be satisfied without depleting the water

supply of the district to the extent that there would be insufficient water for human consumption, sanitation and fire protection.

Chapter 4.16: Water Conservation Devices – Reduce the consumption of potable water within the Cambria Community Services District through installations of water-saving plumbing and fixtures and the prohibition of use of high water consumptive devices and fixtures.

All new construction shall be equipped with water conserving fixtures and plumbing exclusively. (Ord. 3-88 § III)

Within 90 days from the supplemented Code chapter's activation, all motels, hotels, recreational vehicle parks, and campgrounds must be retrofitted with water conserving plumbing and fixtures where high water consuming plumbing and fixtures exist. (Ord. 3-88 § IV)

All residential, commercial, industrial, and public authority structures shall be retrofitted with water conserving plumbing and fixtures, if not already so, when a change in ownership occurs. (Ord. 3-88 § V)

All residential, commercial, public authority, and industrial reconstruction, remodels or additions that add or change bathroom plumbing fixtures, and/or increase floor area by 20 percent or greater of the existing floor area must have low water-use plumbing fixtures for the entire facility, including retrofitting of existing plumbing fixtures as identified in Section 4.16.030. (Ord. 3-88 § VI)

Prior to the close of escrow, the new owner/applicant must successfully meet the district's inspection to show compliance with retrofit requirements. Prior to the change of use of any commercial, industrial, or public authority buildings, the owner must certify in writing compliance with all plumbing fixture retrofitting requirements to the Cambria Community Services District. (Ord. 6-2005 § 1: amended during 2004 codification; Ord. 3-88 § VII)

APPENDIX O

LAND USE CODE DESCRIPTIONS

Original Land Use Code descriptions provided by the
County of San Luis Obispo
Assessor's Office

LAND USE CODE DESCRIPTIONS

LUC	LAND USE	LAND USE DEFINED
008	Unknown	Unknown
018	Residential	Retired
019	Residential	Water List
020	Residential	Transition Structure
033	Residential	Residual Land Segment
039	Open Space	Open Space Easement
050	Unknown	Misc
051	Residential	Urban Residential
102	Vacant	Urban Vacant
110	Residential	Residential
115	Residential	Residential
130	Residential	Mobile Home
160	Residential	Residential
200	Residential	Vacant Income Residential
201	Residential	Duplex
210	Residential	Apartments
309	Residential	Residence on Commercial
310	Commercial	Retail
321	Commercial	Restaurant
330	Business	Office
331	Business	Office
332	Business	Office
333	Business	Office
338	Business	Office/Condo
361	Commercial	Motel
381	Commercial	Automotive
390	Commercial	Banks
515	Commercial	Mini Storage
520	Industrial	Warehouseing
613	Agriculture	Oranges
650	Graze	Graze
810	Church	Church
854	Recreational	Government/Recreational
857	Government	Government
860	Public Utility	Public Utility
SUB	Residential	Subdivision
	None	None

APPENDIX P

STREAM RESTORATION
MANAGEMENT MEASURES AND PRACTICES

STREAM RESTORATION MANAGEMENT MEASURES AND PRACTICES

The following descriptions and typical drawings provide conceptual guidance for a selection of the stream restoration techniques presented in Section 5 of the report. All of the text and typical drawings were obtained from Environmentally-Sensitive Streambank Stabilization (ESenSS), authored by Salix Applied Earthcare and funded by the National Cooperative Highway Research Program.

Biotechnical Engineering

Coconut Fiber (Coir) Roll
Erosion Control Blankets
Large Woody Debris Structures
Live Brushlayering
Live Brush Mattress
Live Fascine
Live Gully Fill Repair
Live Pole Drain
Live Siltation
Live Staking
Turf Reinforcement Mats
Veg. Mech. Stabilized Earth
Willow Posts and Poles

Stream Corridor Habitat Improvement

Boulder Clusters
Meander Restoration
Newbury Rock Riffles
Rootwad Revetment
Vegetated Floodways

River Training Structures

Bendway Weirs
Cross Vanes
Longitudinal Stone Toe Protection

Rock Vanes
Rock Vanes with J-Hooks
Spur Dikes
Stone Weirs

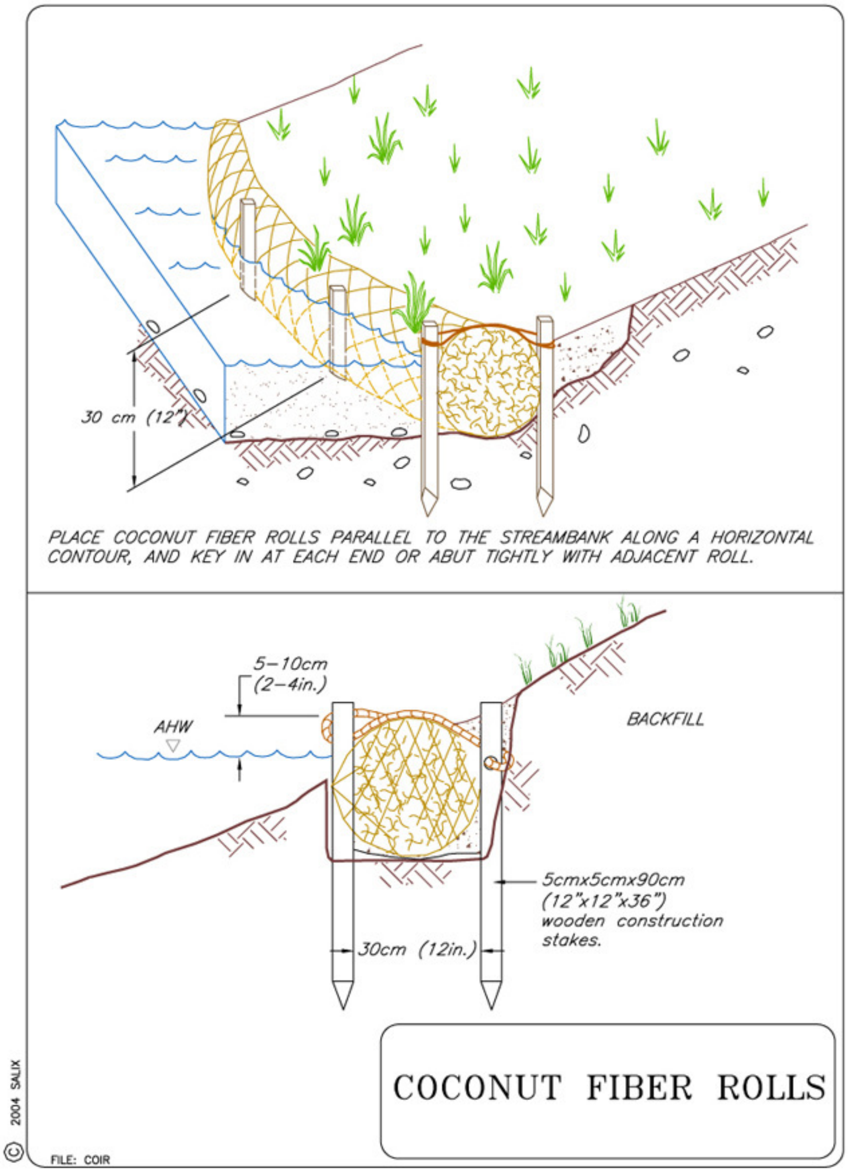
Structural Streambank Stabilization

Cobble or Gravel Armor
Geocellular Confinement System
Live Cribwall
Slope Flattening
Trench Fill Revetment
Vegetated Articulated Concrete Blocks
Vegetated Gabions
Vegetated Gabions Mattress
Vegetated Riprap
Stone-Fill trenches

BIOTECHNICAL ENGINEERING

Coconut Fiber Rolls

Coconut fiber (coir) rolls are manufactured, elongated cylindrical structures that are placed at the bottom of stream banks to help prevent erosion and scour. The coconut husk fibers are bound together with geotextile netting with 35 cm or 40 cm (12 in or 18 in) diameters and lengths of 6 meters (20 ft). Coir is fairly long-lasting, typically 5-7 years, but must be designed with riparian revegetation to attain permanent solutions. Proper anchoring is critical and generally coir rolls are not recommended for areas with high velocities and shear. Brushlayering and Live Stakes are good candidates for combining with coconut fiber rolls.

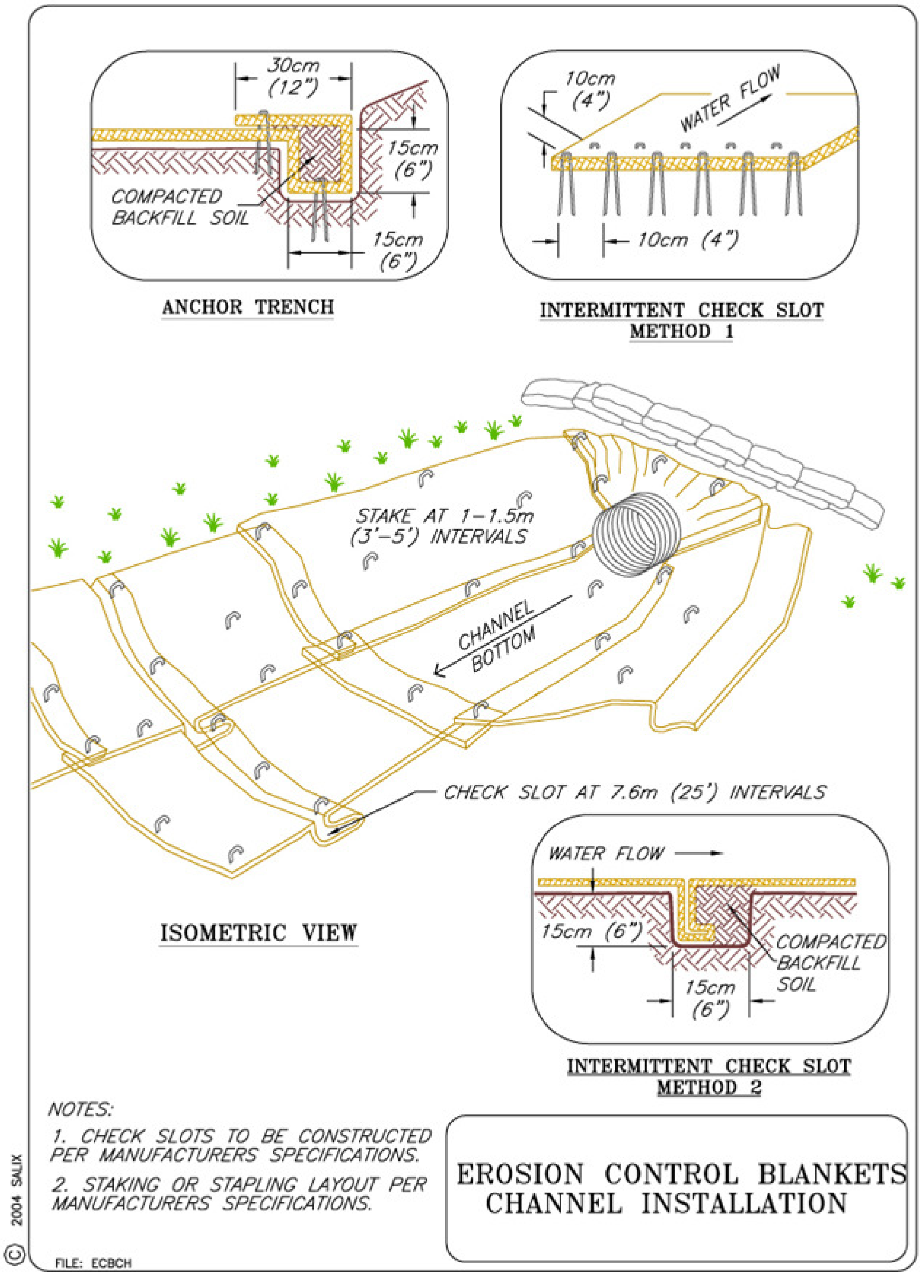


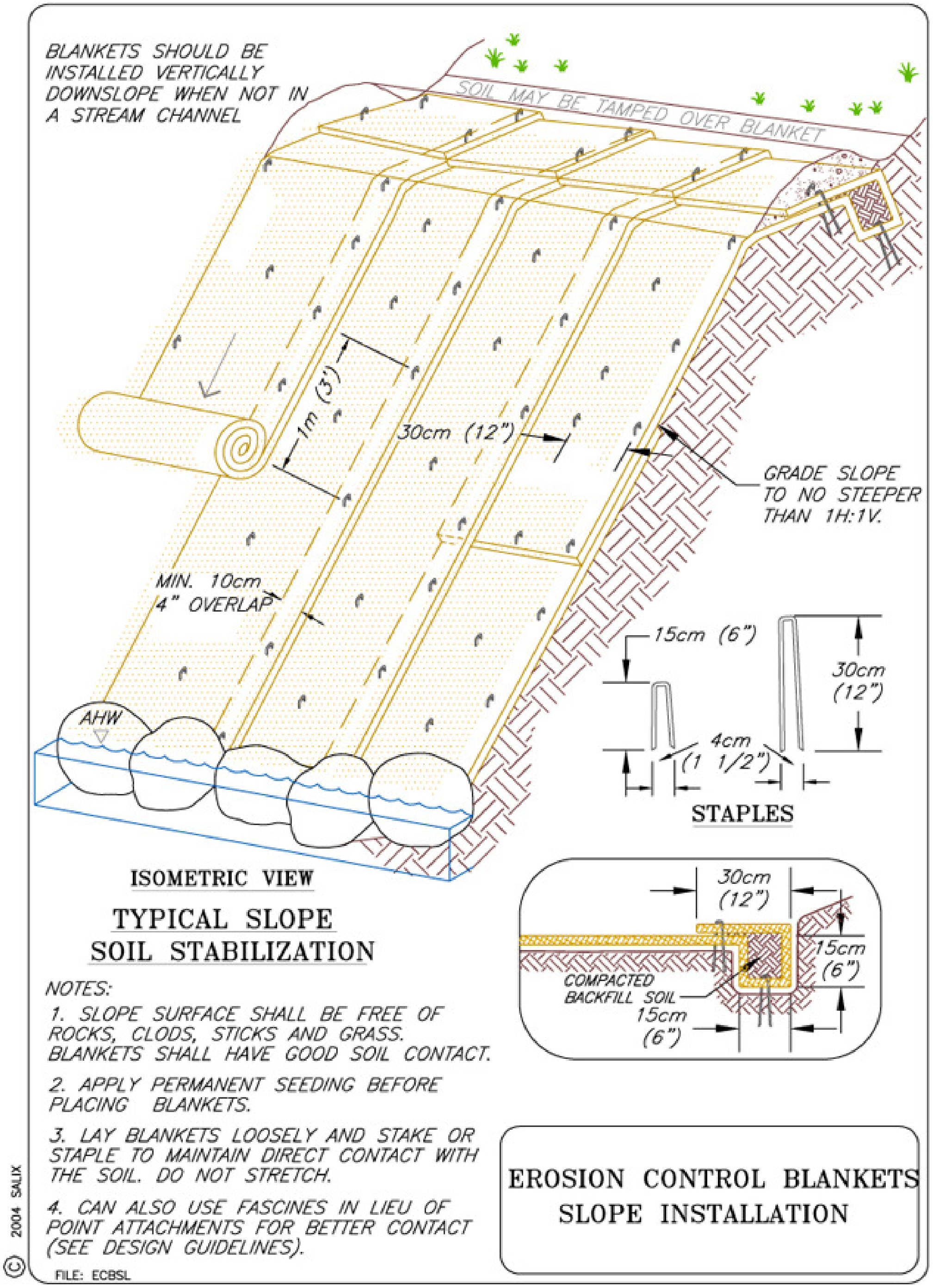
PLACE COCONUT FIBER ROLLS PARALLEL TO THE STREAMBANK ALONG A HORIZONTAL CONTOUR, AND KEY IN AT EACH END OR ABUT TIGHTLY WITH ADJACENT ROLL.

COCONUT FIBER ROLLS

Erosion Control Blankets, Channel and Slope Installation

Erosion Control Blankets (ECBs) are a temporary rolled erosion control product consisting of flexible nets or mats, manufactured from both natural and synthetic materials, which can be brought to a site, rolled out, and fastened down on a slope. ECBs are typically manufactured of fibers such as straw, wood, excelsior, coconut, or a combination, and then stitched to or between geosynthetic or woven natural fiber netting. Various grades of biodegradable fibers and netting can be specified depending on required durability and environmental sensitivity.





TYPICAL SLOPE SOIL STABILIZATION

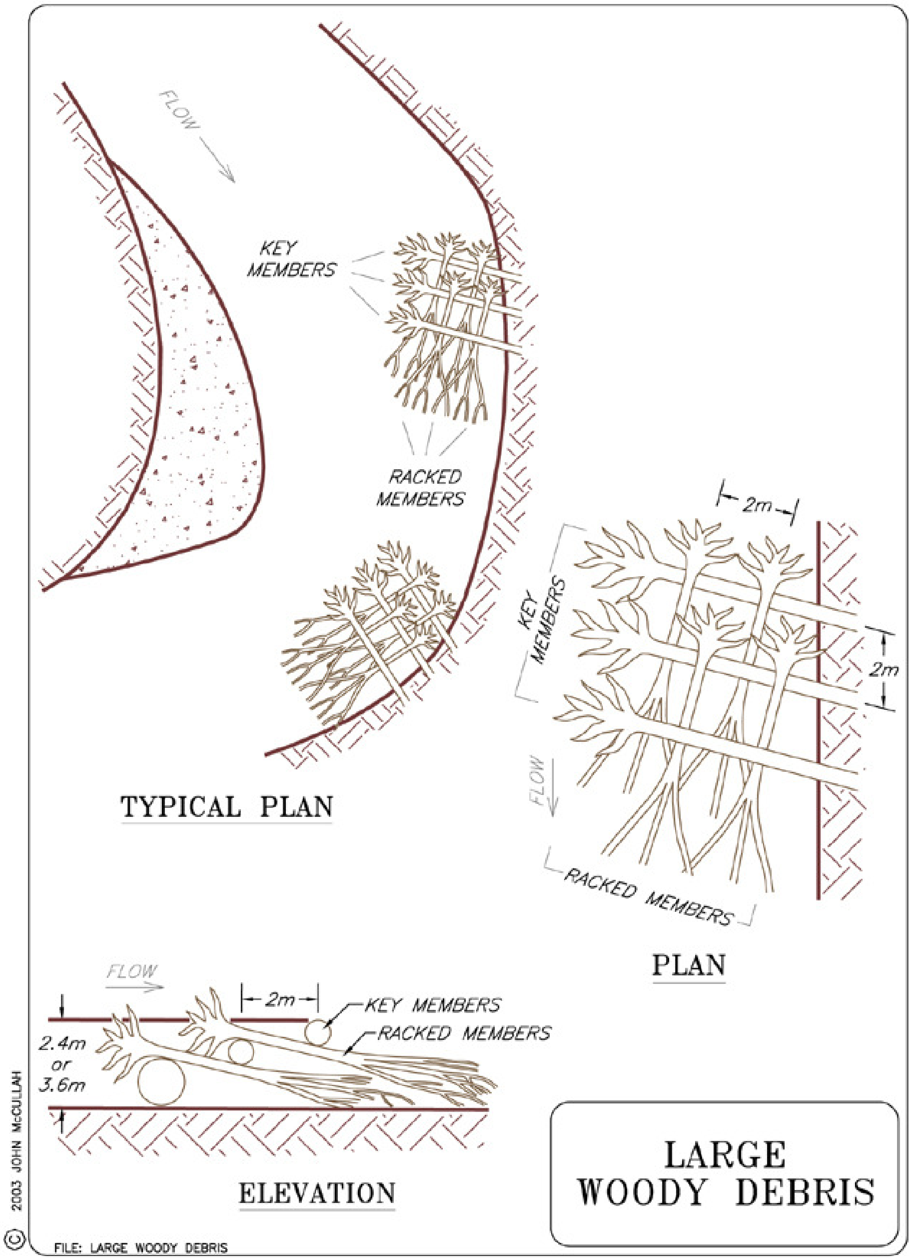
NOTES:

1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. BLANKETS SHALL HAVE GOOD SOIL CONTACT.
2. APPLY PERMANENT SEEDING BEFORE PLACING BLANKETS.
3. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.
4. CAN ALSO USE FASCINES IN LIEU OF POINT ATTACHMENTS FOR BETTER CONTACT (SEE DESIGN GUIDELINES).

EROSION CONTROL BLANKETS SLOPE INSTALLATION

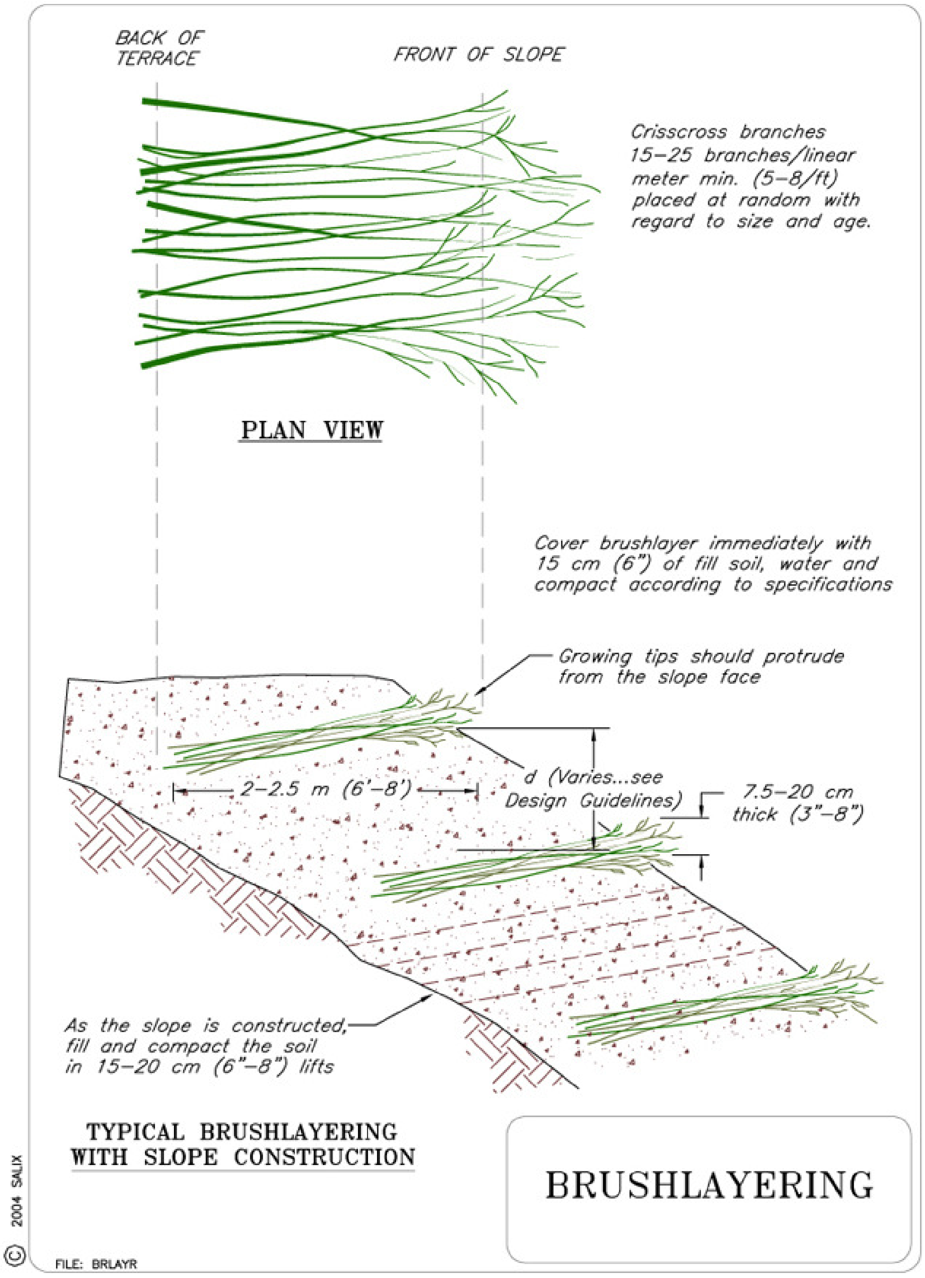
Large Woody Debris Structures

Large woody debris (LWD) structures (aka engineered log jams) made from felled trees may be used to deflect erosive flows and promote sediment deposition at the base of eroding banks. Root wads, consisting of a short section of trunk and attached root bole, can also be used or incorporated into the structures. Using the classical spur design criteria and methods, the placement of LWD can be designed to achieve optimum benefit for both aquatic habitat and bank protection.



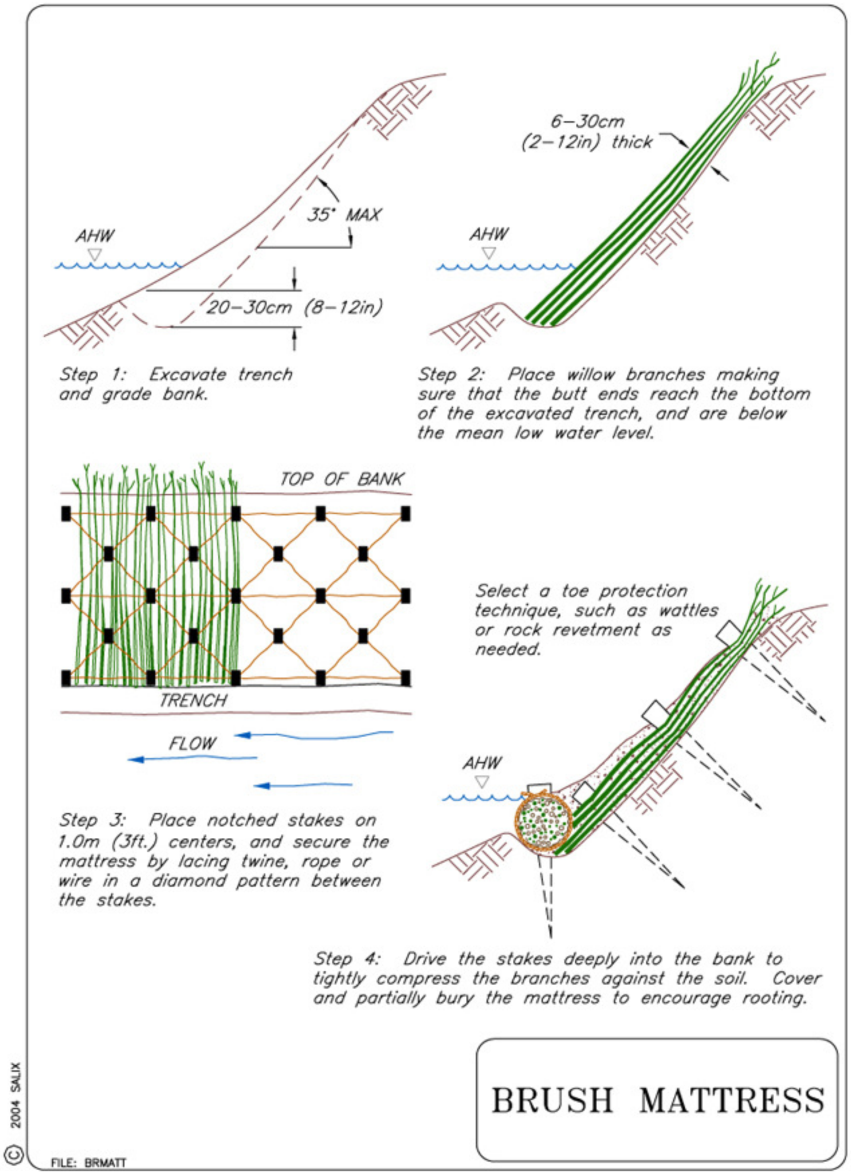
Live Brushlayering

Live brushlayers are rows of live woody cuttings that are layered, alternating with successive lifts of soil fill, to construct a reinforced slope or embankment. Vertical spacing depends on slope gradient and soil conditions. Live Brushlayering provides enhanced geotechnical stability, improved soil drainage, superior erosion control and is one of the most effective ways to establish vegetation from live cuttings. Live brushlayering is an excellent candidate for combining with other streambank stabilization measures.



Live Brush Mattress

A live brush mattress is a thick blanket (15-30 cm (6-12 in)) of live brushy cuttings and soil fill. The mattresses are usually constructed from live willow branches or other species that easily root from cuttings. Brush mattresses are used to simultaneously revegetate and armor the bank. The dense layer of brush increases roughness, reducing velocities at the bank face, and protecting it from scour, while trapping sediment and providing habitat directly along the waters' edge. Brush mattresses are an excellent candidate for combining with structural techniques such as rock toe protection.



Step 1: Excavate trench and grade bank.

Step 2: Place willow branches making sure that the butt ends reach the bottom of the excavated trench, and are below the mean low water level.

Step 3: Place notched stakes on 1.0m (3ft.) centers, and secure the mattress by lacing twine, rope or wire in a diamond pattern between the stakes.

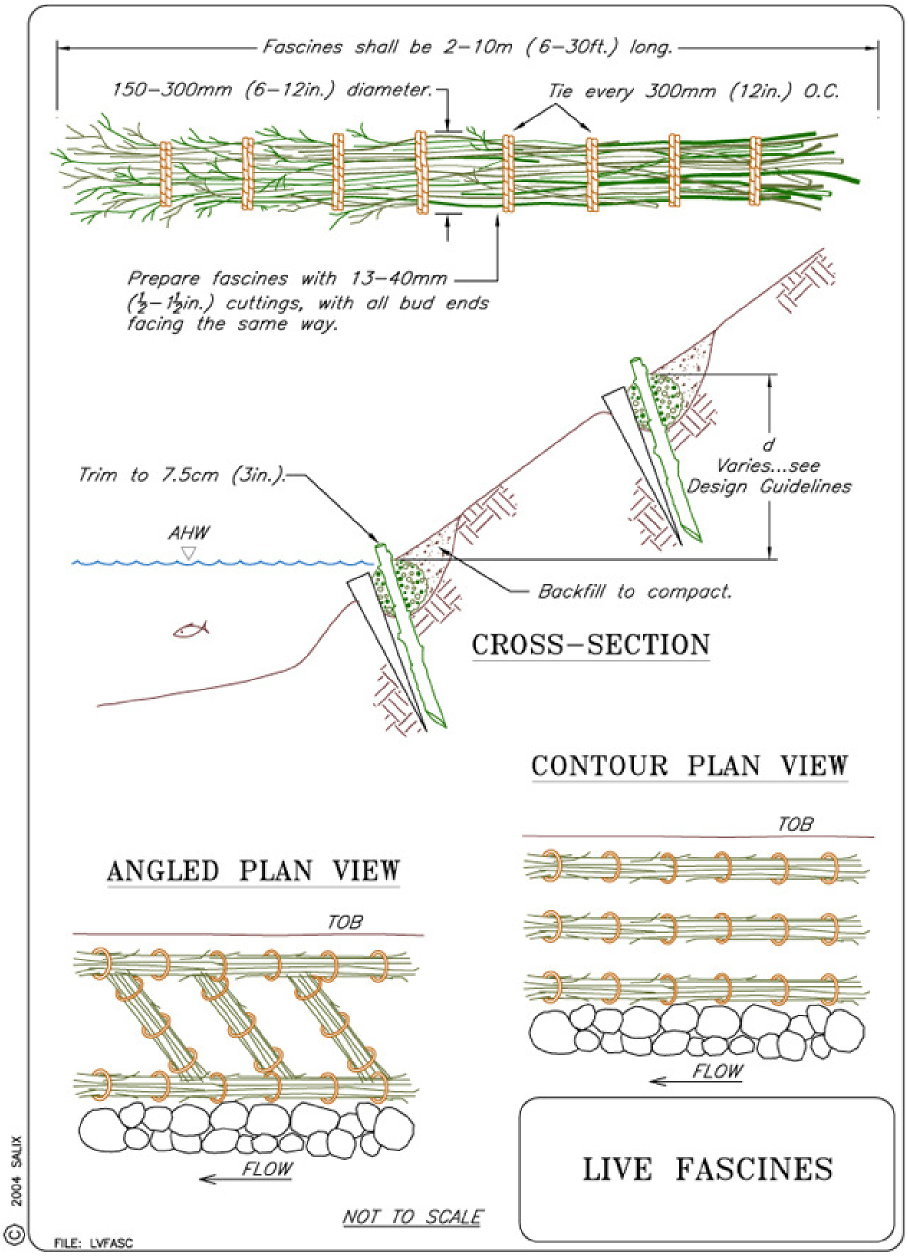
Select a toe protection technique, such as wattles or rock revetment as needed.

Step 4: Drive the stakes deeply into the bank to tightly compress the branches against the soil. Cover and partially bury the mattress to encourage rooting.

BRUSH MATTRESS

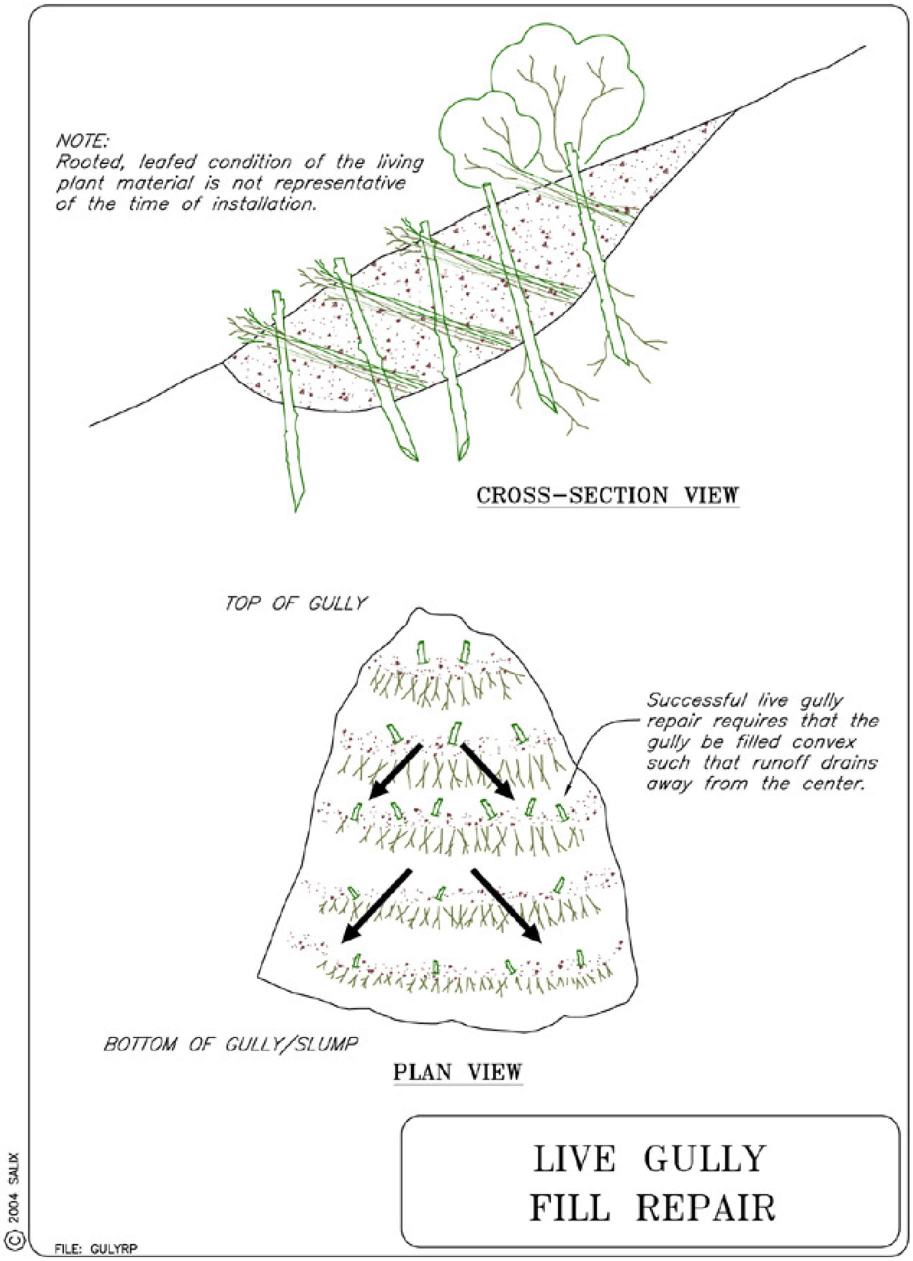
Live Fascines

Live fascines are bundles of live (and non-living) branch cuttings placed in long rows in shallow trenches across the slope on contour or at an angle. Fascines are intended to grow vegetatively while the terraces formed will trap sediment and detritus, promoting vegetative establishment. Fascines can be utilized as a resistive measure at the stream edge and for erosion control on long bank slopes above annual high water. Fascines are also an effective way to anchor Erosion Control Blankets (ECBs) and Turf Reinforcement Mats (TRMs).



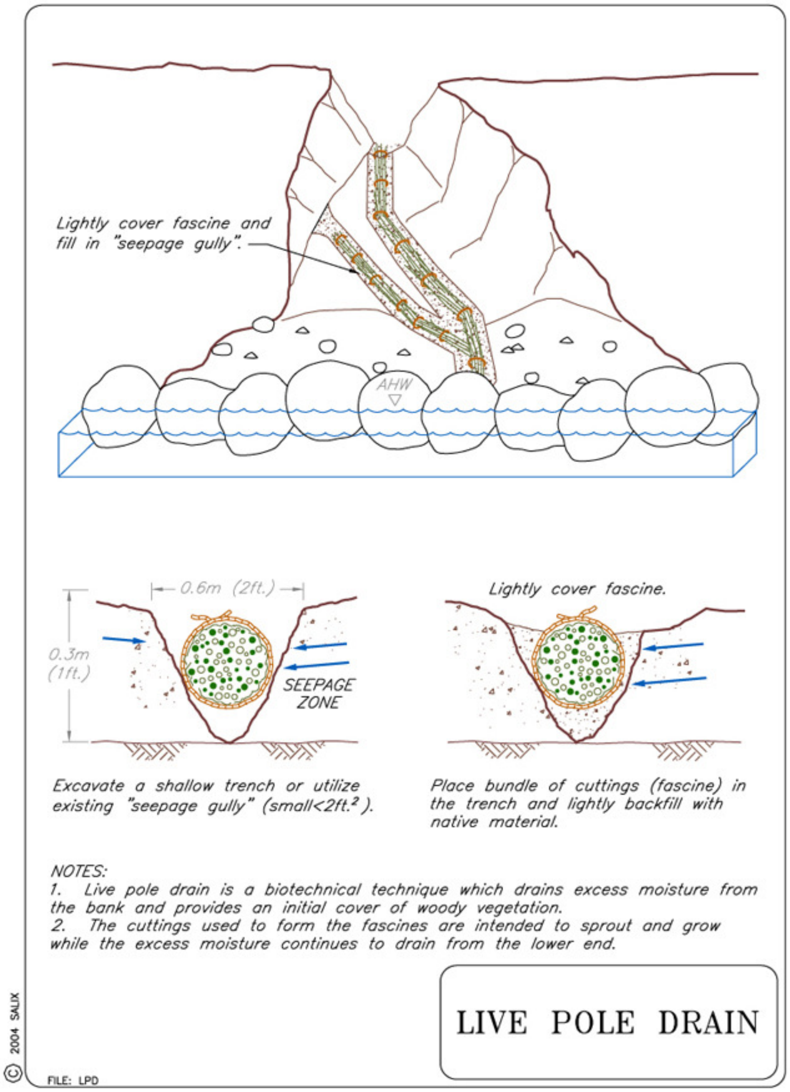
Live Gully Fill Repair

Live Gully Fill Repair consists of alternating layers of live branch cuttings and compacted soil. This reinforced fill can be used to repair small gullies. The method is similar to branch packing (a method for filling small holes and depressions in a slope), but is more suitable for filling and repairing elongated voids in a slope, such as gullies. Gully treatment must include correcting or eliminating the initial cause of the gully as well as the gully itself. Gullies are likely to have tributary gullies that also require treatment.



Live Pole Drain

Live pole drains are live, growing and often long-lived drainage systems composed of bundles (fascines) of live branches (commonly willow). Live pole drains placed in areas where excess soil moisture results in soil instability. They are also used to treat small drainage gullies. Live Pole Drains collect subsurface drainage and concentrated surface flow and channel it to the base of the bank. Once established, their drainage function is increased, as the plants absorb much of the water that is conducted along their stems. Because they are long and fibrous, the bundles act like a conduit. As the fascines begin to root and sprout the root system acts like a filter medium, stabilizing fine particles and reducing piping and sapping. Live pole drains provide drainage and stabilization immediately after installation, and once established, produce roots, which further stabilize bank and levee slopes.



Excavate a shallow trench or utilize existing "seepage gully" (small<$2ft.^2$).

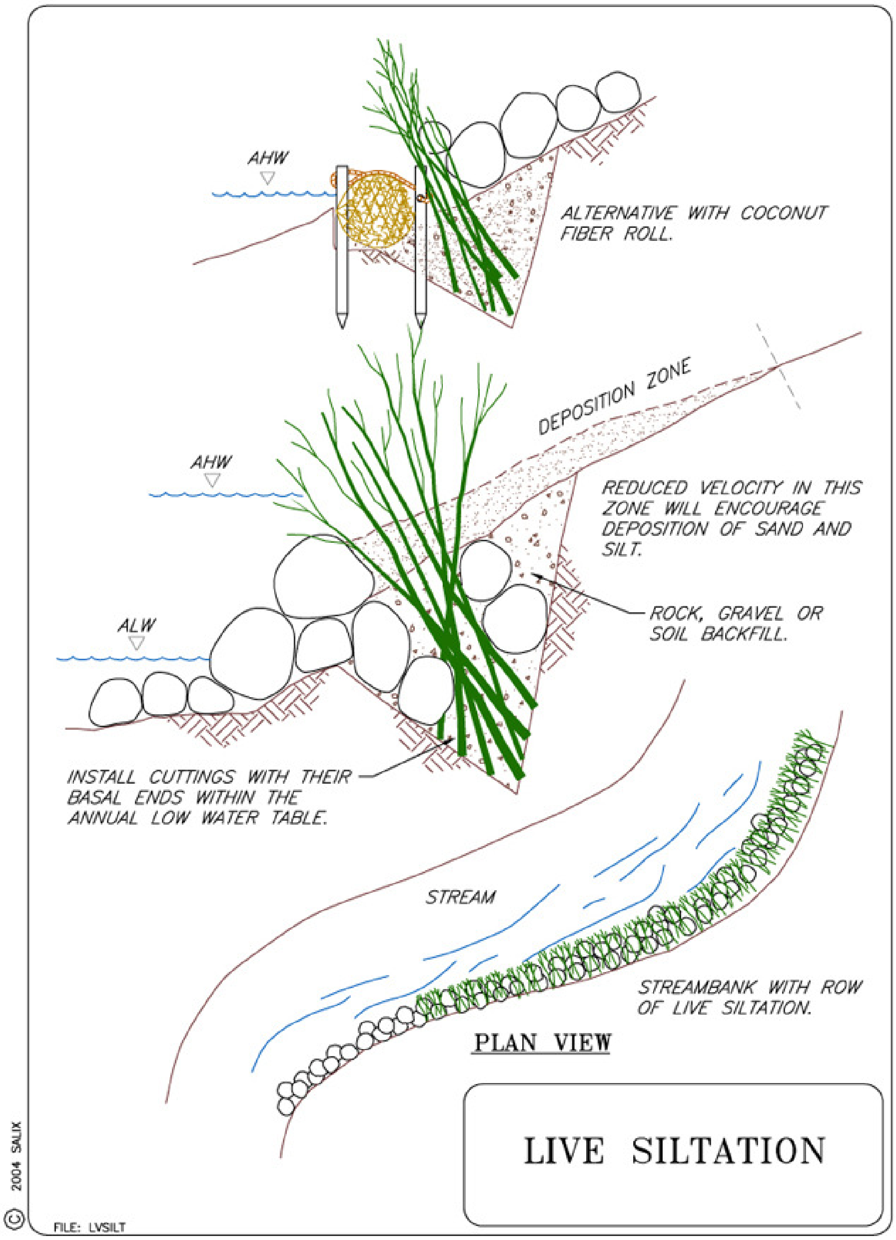
Place bundle of cuttings (fascine) in the trench and lightly backfill with native material.

NOTES:
1. Live pole drain is a biotechnical technique which drains excess moisture from the bank and provides an initial cover of woody vegetation.
2. The cuttings used to form the fascines are intended to sprout and grow while the excess moisture continues to drain from the lower end.

LIVE POLE DRAIN

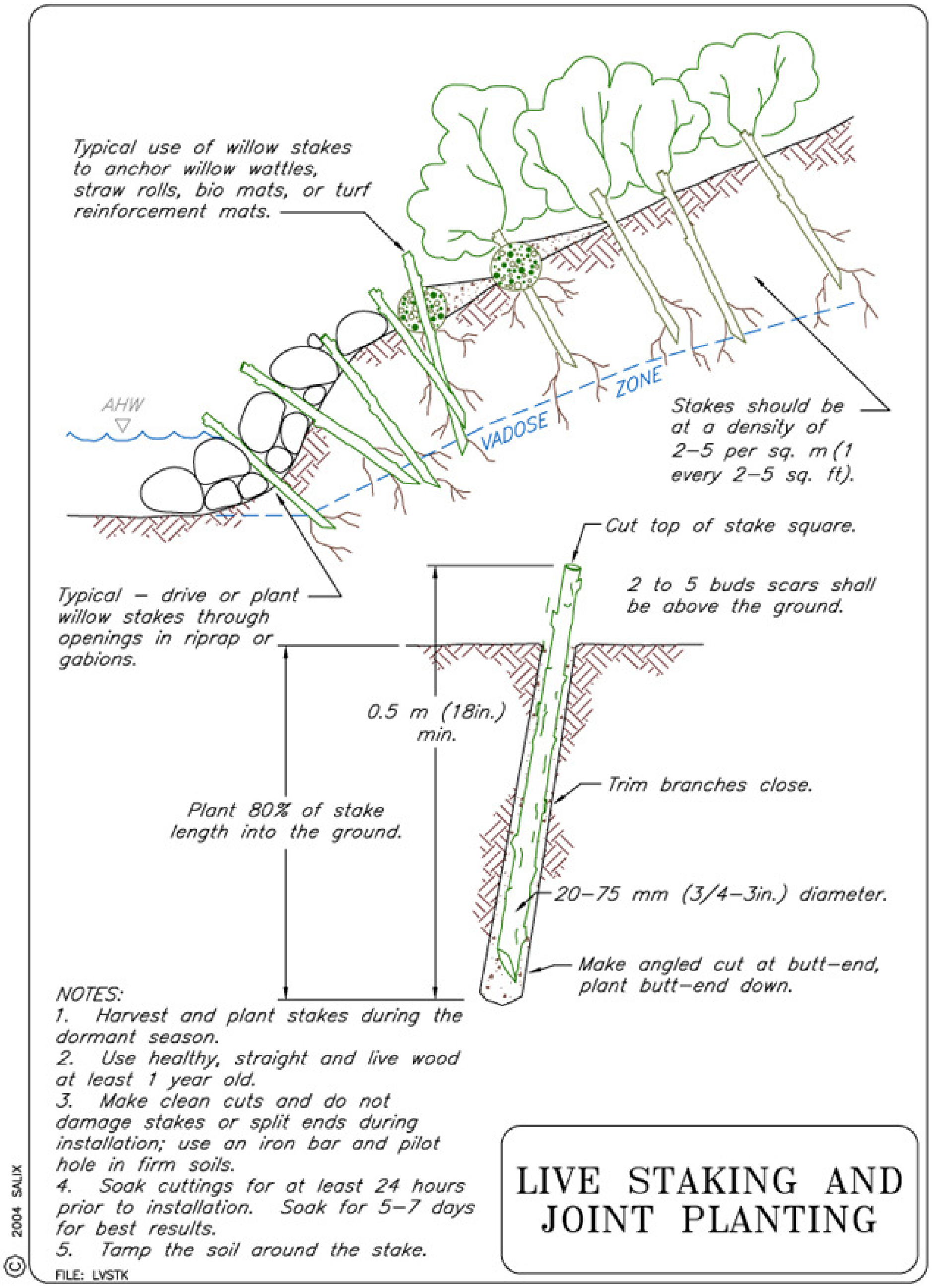
Live Siltation

Live siltation is a bioengineering technique involving the installation of a living or a non-living brushy system at the water's edge. Willow cuttings are the most common. Live siltation construction is intended to increase roughness at the stream edge thereby encouraging deposition and reducing bank erosion. The embedded branches and roots also reinforce the bank, reduce geotechnical failure while the branches and leaves provide cover, aquatic food sources and organic matter.



Live Staking

Live stakes are very useful as a revegetation technique, a soil reinforcement technique, and as a way to anchor erosion control materials. They are usually cut from the stem or branches of willow species and the stakes are typically 0.5-1.0 m (1.5 – 3.3 ft) long. The portion of the stem in the soil will grow roots and the exposed portion will develop into a bushy riparian plant. This technique is referred to as Joint Planting when the stakes are inserted into or through riprap. Live staking is an excellent candidate for combination with other techniques.



Typical use of willow stakes to anchor willow wattles, straw rolls, bio mats, or turf reinforcement mats.

Stakes should be at a density of 2-5 per sq. m (1 every 2-5 sq. ft).

Typical – drive or plant willow stakes through openings in riprap or gabions.

Cut top of stake square.

2 to 5 buds scars shall be above the ground.

Plant 80% of stake length into the ground.

Trim branches close.

20-75 mm (3/4-3in.) diameter.

Make angled cut at butt-end, plant butt-end down.

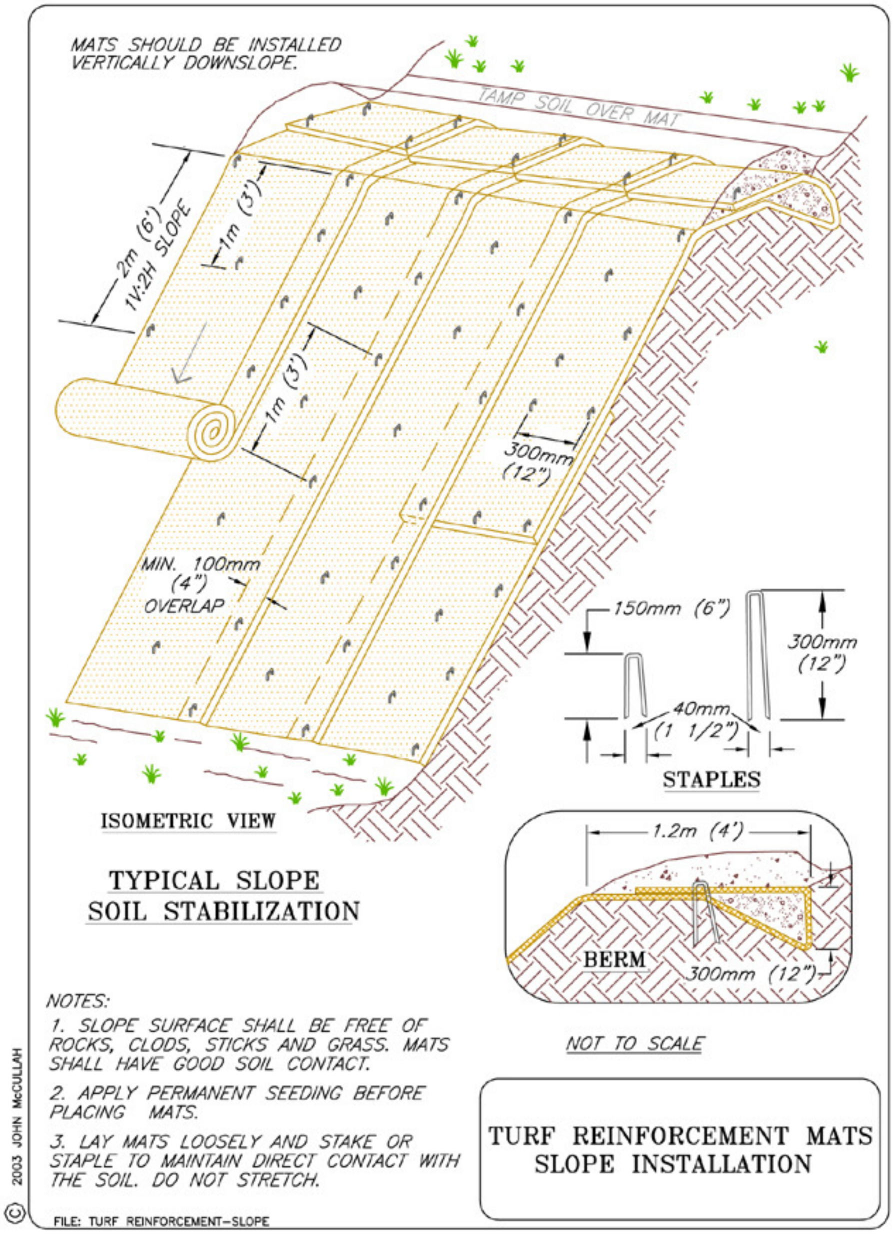
NOTES:

1. Harvest and plant stakes during the dormant season.
2. Use healthy, straight and live wood at least 1 year old.
3. Make clean cuts and do not damage stakes or split ends during installation; use an iron bar and pilot hole in firm soils.
4. Soak cuttings for at least 24 hours prior to installation. Soak for 5-7 days for best results.
5. Tamp the soil around the stake.

LIVE STAKING AND JOINT PLANTING

Turf Reinforcement Mats

Turf Reinforcement Mats (TRMs) are similar to Erosion Control Blankets, but they are more permanent, designed to resist shear and tractive forces, and they are usually specified for banks subjected to flowing water. The mats are composed of ultraviolet (UV) stabilized polymeric fibers, filaments, and/or nettings, integrating together to form a three-dimensional matrix 5 to 20 mm (.2 to .79 in) thick. TRMs are a biotechnical practice, intended to work with vegetation (roots and shoots) in mutually reinforcing manner. As such, vegetated TRMs can resist higher tractive forces than either vegetation or TRMs can alone.



TYPICAL SLOPE SOIL STABILIZATION

NOTES:

1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. MATS SHALL HAVE GOOD SOIL CONTACT.
2. APPLY PERMANENT SEEDING BEFORE PLACING MATS.
3. LAY MATS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.

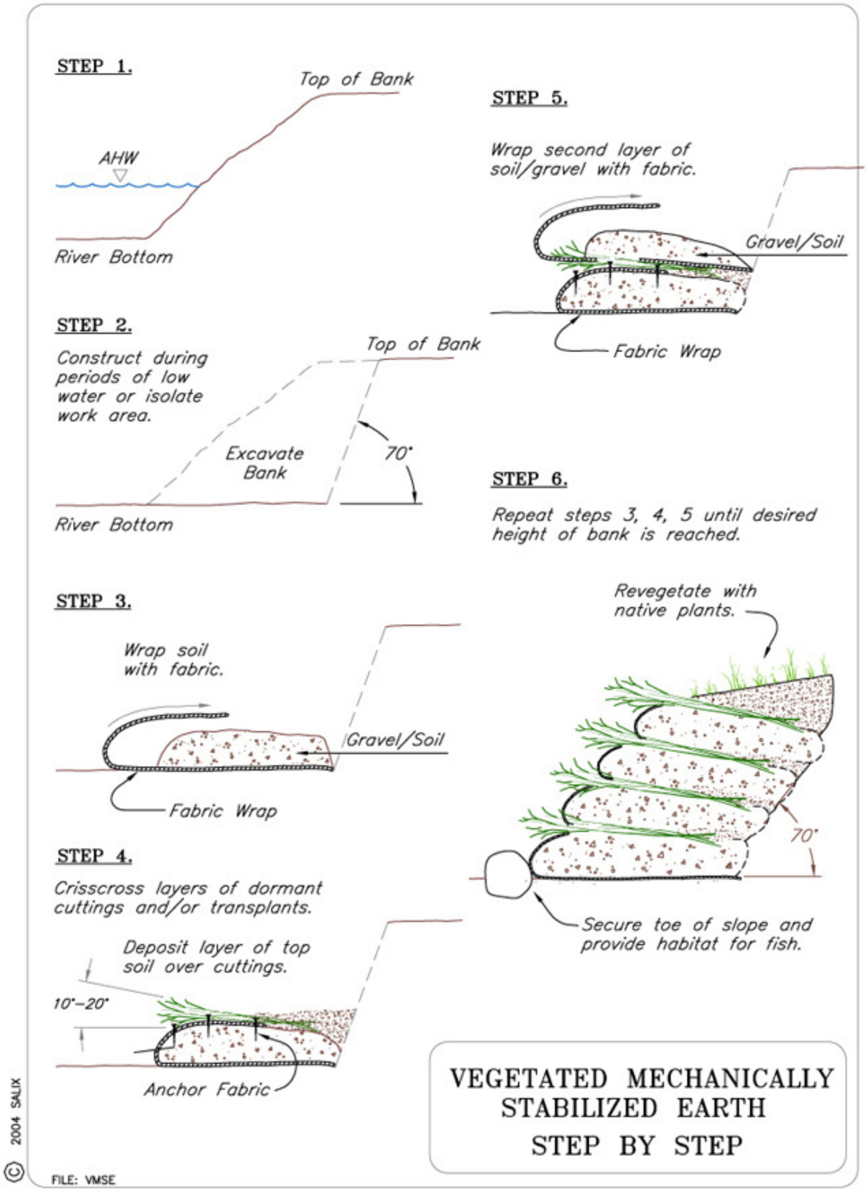
NOT TO SCALE

TURF REINFORCEMENT MATS SLOPE INSTALLATION

FILE: TURF REINFORCEMENT–SLOPE

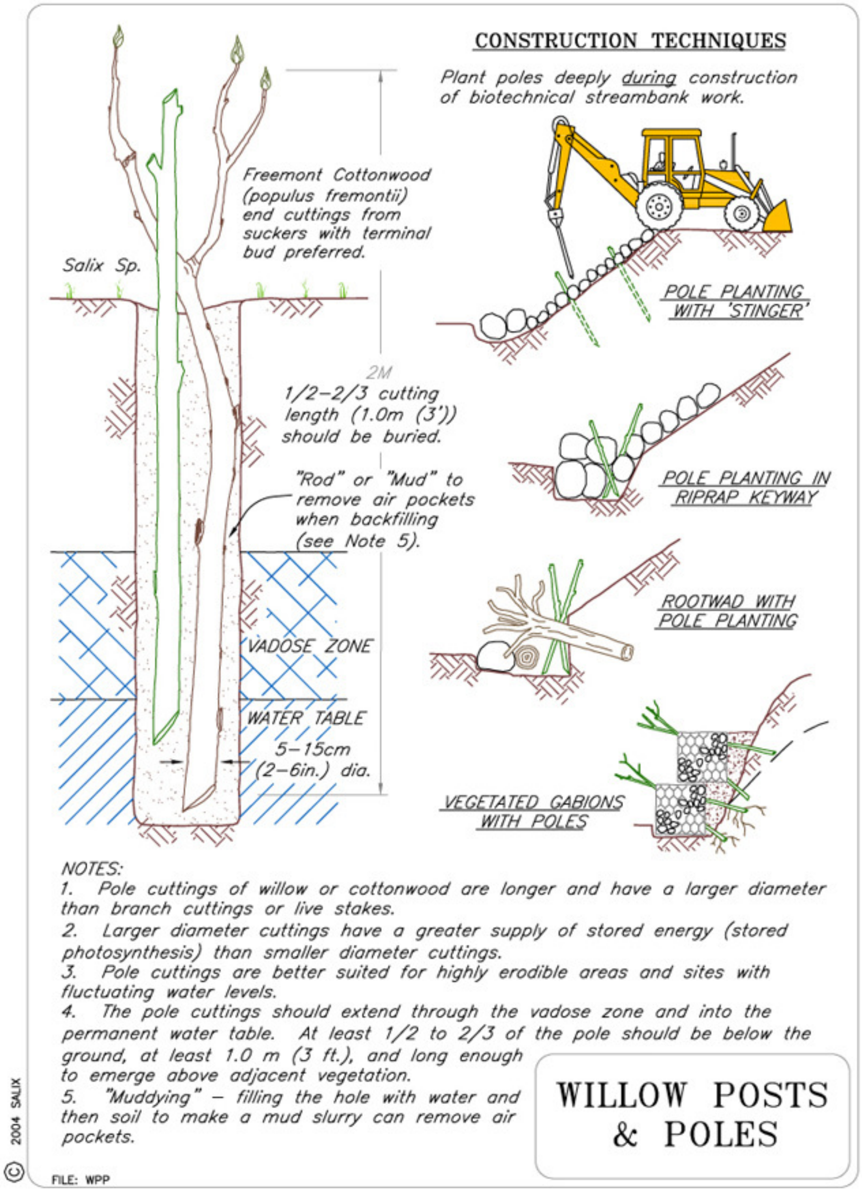
Vegetated Mechanically Stabilized Earth (Soil Wraps)

This technique consists of live cut branches (brushlayers) interspersed between lifts of soil wrapped in natural fabric, e.g., coir, or synthetic geotextiles (Turf Reinforcement Mats (TRMs) or Erosion Control Blankets (ECBs)) or geogrids. The live brush is placed in a crisscross or overlapping pattern atop each wrapped soil lift in a manner similar to conventional brushlayering (see Technique: Live Brushlayering). The fabric wrapping provides the primary reinforcement in a manner similar to that of conventional mechanically stabilized earth (MSE). The live, cut branches eventually root and leaf out providing vegetative cover and secondary reinforcement as well.



Willow Posts and Poles

Posts and pole plantings are methods intended to provide mechanical bank protection. Willow and cottonwood species are recommended for their ability to root and grow, particularly if they are planted deep into the streambanks. Larger and longer than live stakes, the posts and poles can provide better mechanical bank protection during the period of plant establishment. Dense arrays of posts or poles can reduce velocities near the bank or bed surface, and long posts or poles reinforce banks against shallow mass failures or bank slumps. Posts and poles are also excellent candidates for combination with other structural methods e.g., LWD Structures, Vegetated Gabion Baskets, Live Cribwall, and Cross Vanes.



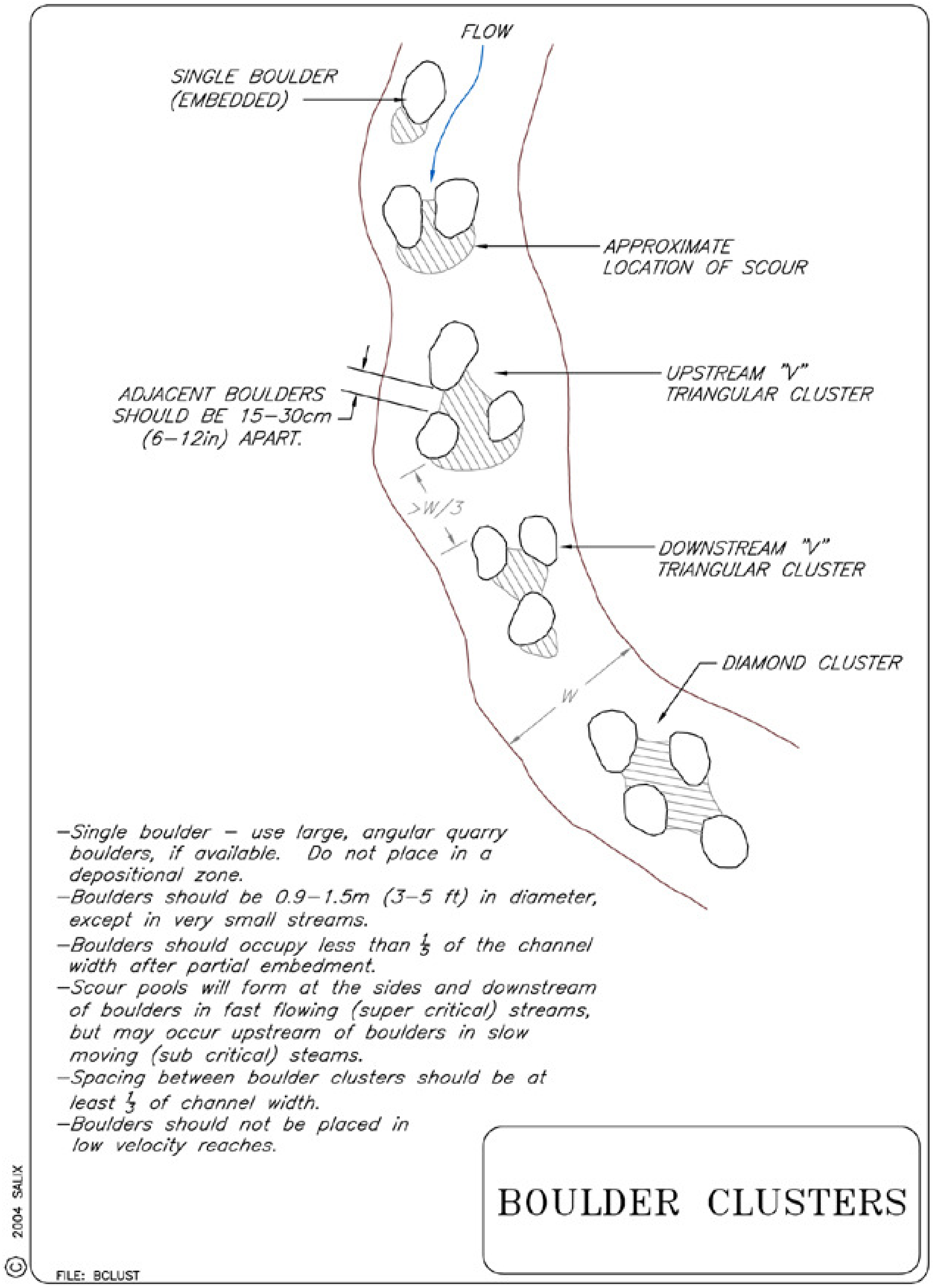
NOTES:

1. Pole cuttings of willow or cottonwood are longer and have a larger diameter than branch cuttings or live stakes.
2. Larger diameter cuttings have a greater supply of stored energy (stored photosynthesis) than smaller diameter cuttings.
3. Pole cuttings are better suited for highly erodible areas and sites with fluctuating water levels.
4. The pole cuttings should extend through the vadose zone and into the permanent water table. At least 1/2 to 2/3 of the pole should be below the ground, at least 1.0 m (3 ft.), and long enough to emerge above adjacent vegetation.
5. "Muddying" – filling the hole with water and then soil to make a mud slurry can remove air pockets.

STREAM CORRIDOR HABITAT IMPROVEMENT

Boulder Clusters

Large boulders may be placed in various patterned clusters within the base flow channel of a perennial stream. Natural streams with beds coarser than gravel often feature large roughness elements like boulders that provide hiding cover and velocity shelters for fish and other aquatic organisms. If a constructed or modified channel lacks such features, adding boulder clusters may be an effective and simple way to improve aquatic habitat.

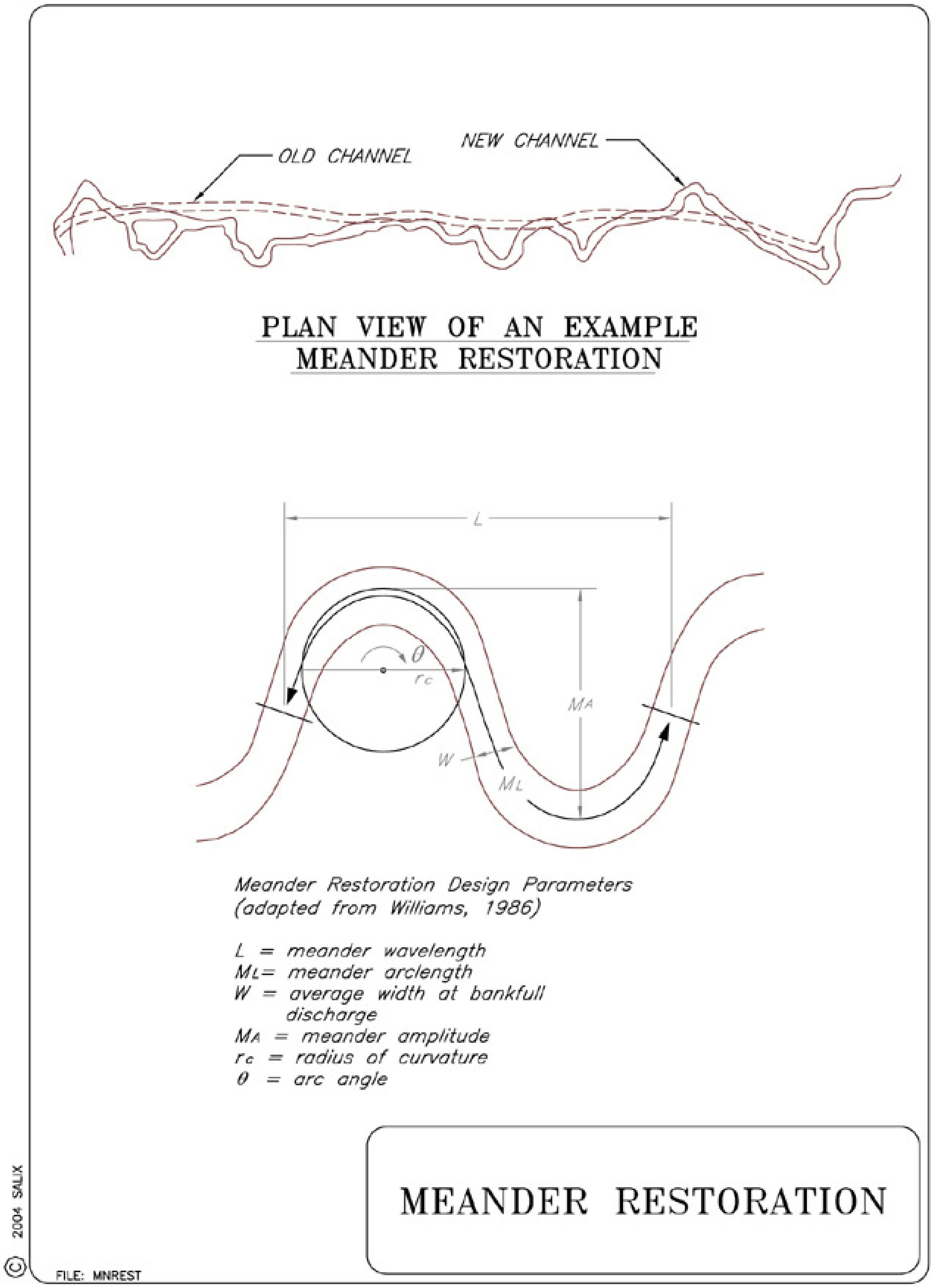


- –Single boulder – use large, angular quarry boulders, if available. Do not place in a depositional zone.
- –Boulders should be 0.9–1.5m (3–5 ft) in diameter, except in very small streams.
- –Boulders should occupy less than ⅕ of the channel width after partial embedment.
- –Scour pools will form at the sides and downstream of boulders in fast flowing (super critical) streams, but may occur upstream of boulders in slow moving (sub critical) steams.
- –Spacing between boulder clusters should be at least ⅓ of channel width.
- –Boulders should not be placed in low velocity reaches.

BOULDER CLUSTERS

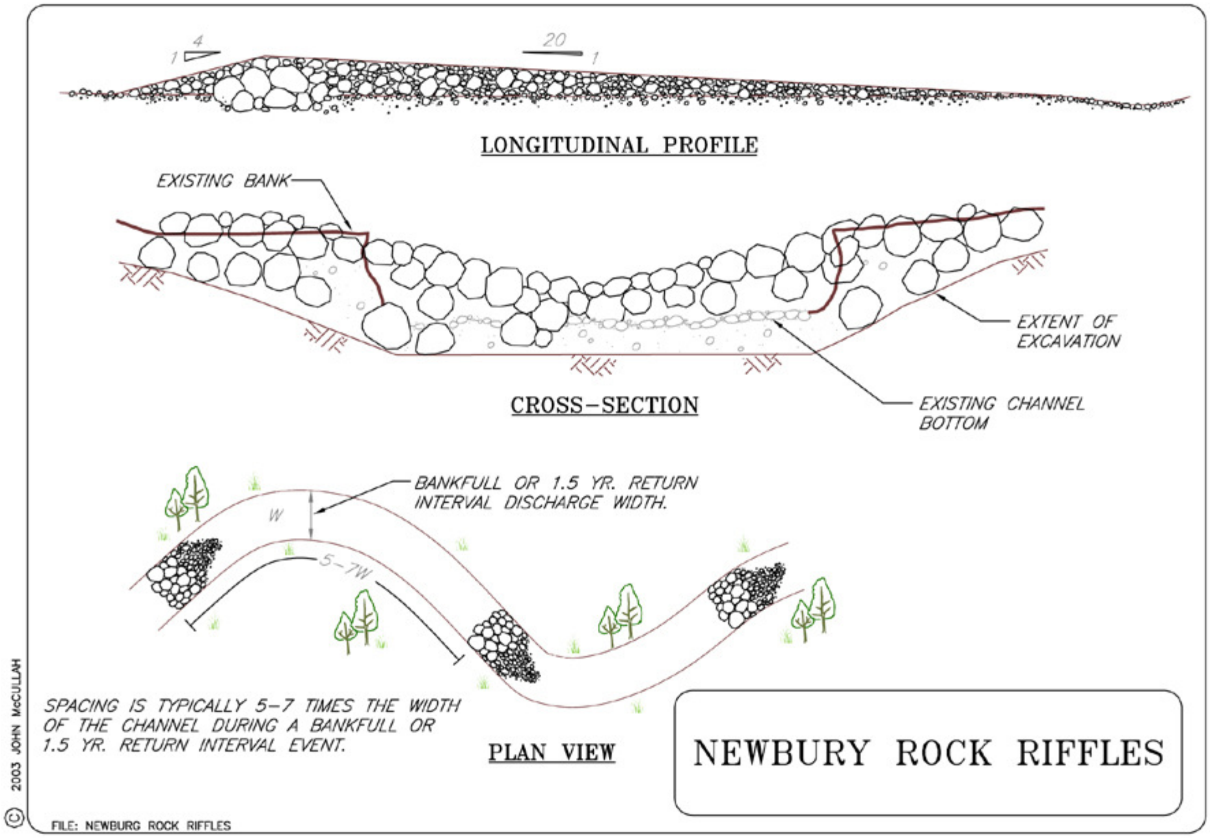
Meander Restoration

Meanders are broad, looping (sinuous) bends in a stream channel. Meandering is a form of slope adjustment with more sinuous channel paths leading to decreased reach gradient. Fluvial and ecological functions are integrally related to the highly diverse spatial and temporal patterns of depth, velocity, bed material and cover found in meanders. Generally speaking, streams with natural meander bends do not require grade control measures. Meander restoration consists of reconstructing meandering channels that have been straightened or altered by man.



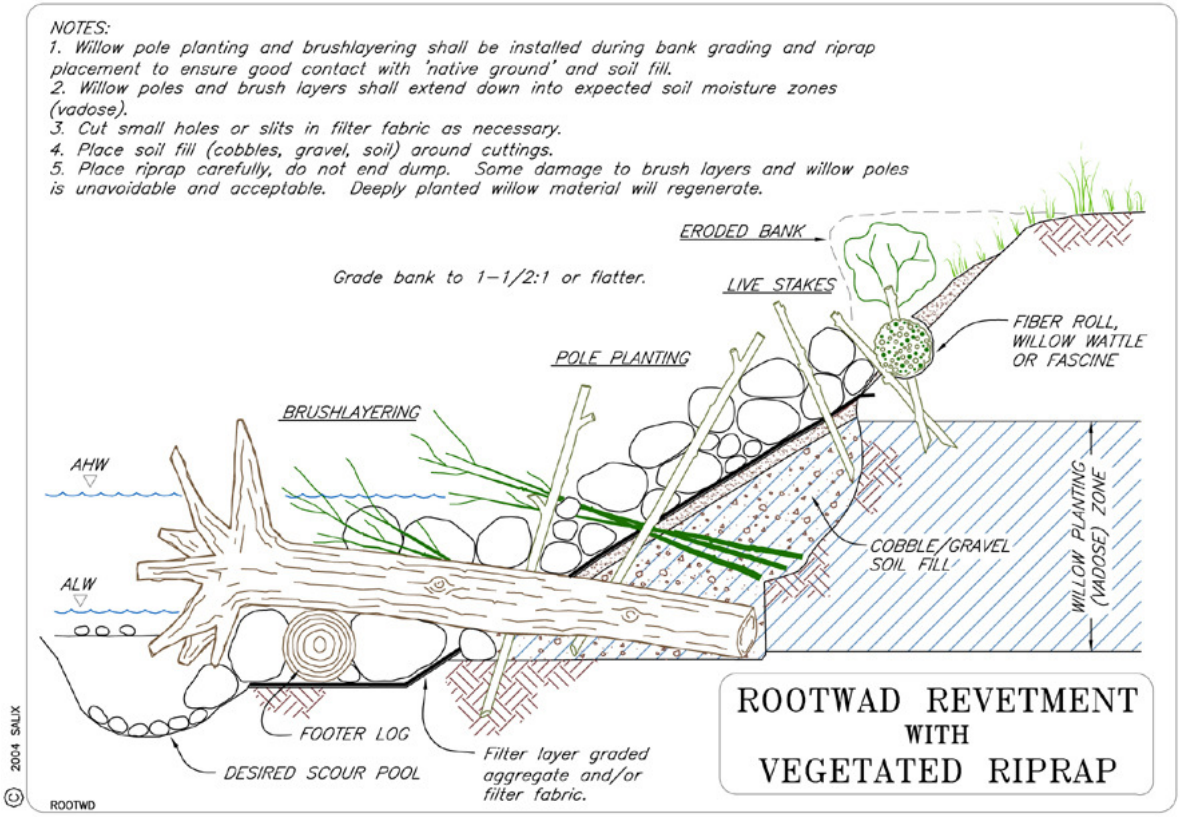
Newbury Rock Riffles

Newbury rock riffles are ramps or low weirs with long aprons made from riprap or small boulders that are constructed at intervals along a channel approaching natural riffle spacing (5 to 7 channel widths). The structures are built by placing rock fill within an existing channel. The upstream slope of the rock fill is typically much steeper than the downstream slope, which creates a longitudinal profile quite similar to natural riffles. These structures provide limited grade control, pool and riffle habitat, and visual diversity in otherwise uniform channels.



Rootwad Revetments

Rootwad and tree revetments are structures constructed from interlocking tree materials. These structures are continuous and resistive type methods, distinguishable from discontinuous and redirective methods such as Large Woody Debris (LWD) structures or rootwad deflectors. Rootwad revetments and tree revetments are primarily intended to resist erosive flows and are usually used on the outer bank of a meander bend when habitat diversity is desirable and tree materials are available and naturally-occurring.



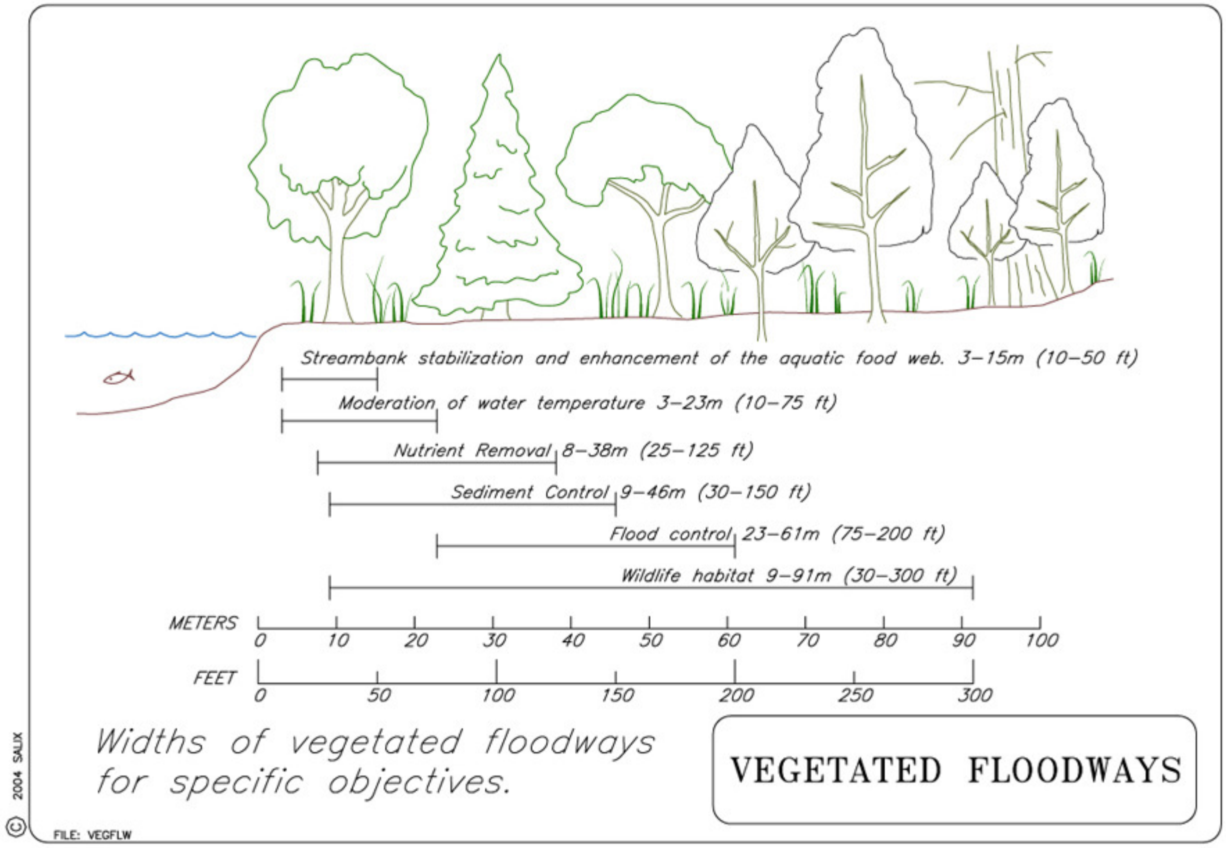
NOTES:
1. Willow pole planting and brushlayering shall be installed during bank grading and riprap placement to ensure good contact with 'native ground' and soil fill.
2. Willow poles and brush layers shall extend down into expected soil moisture zones (vadose).
3. Cut small holes or slits in filter fabric as necessary.
4. Place soil fill (cobbles, gravel, soil) around cuttings.
5. Place riprap carefully, do not end dump. Some damage to brush layers and willow poles is unavoidable and acceptable. Deeply planted willow material will regenerate.

Grade bank to 1-1/2:1 or flatter.

ROOTWAD REVETMENT
WITH
VEGETATED RIPRAP

Vegetated Floodways

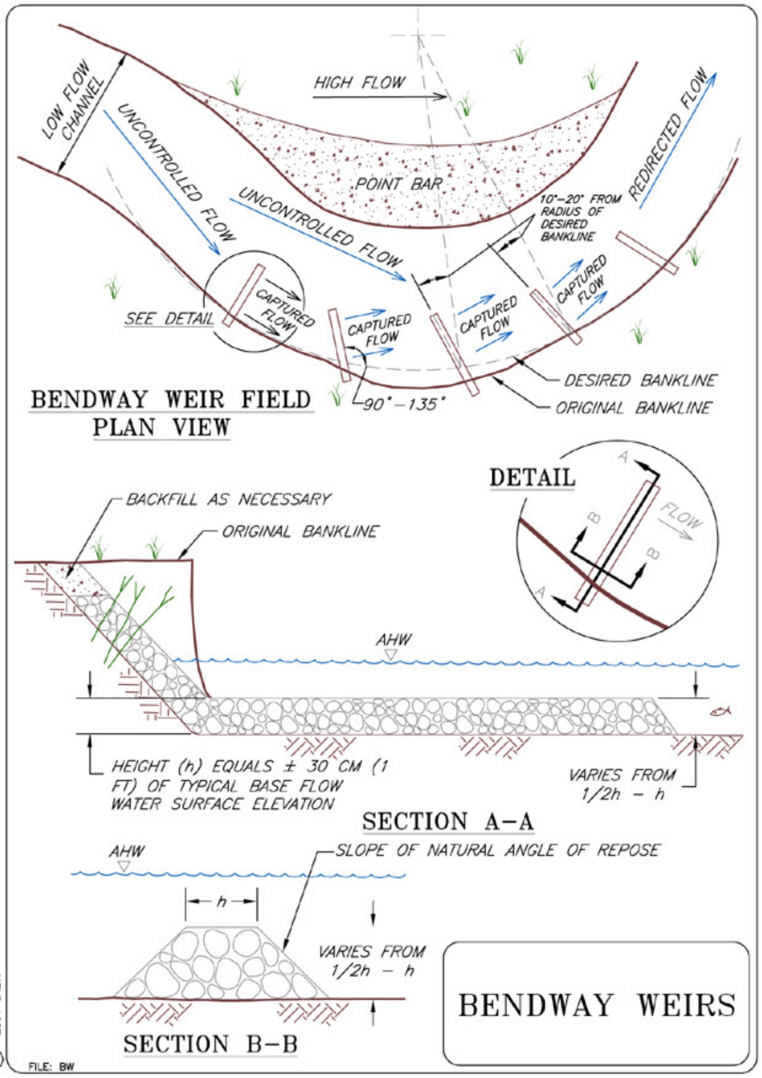
Confining floodwaters to a broad floodway bordered by levees or topographic highs is attractive because the portion of the floodway not normally inundated can support vegetation and thus provide wildlife habitat or recreational opportunities. Floodways may be created by constructing levees, floodwalls, or by excavation. Excavation consists of creating terraces or benches along an existing channel or a completely new flood channel (bypass). Roadway embankments sometimes serve a dual purpose by defining a floodway.



RIVER TRAINING STRUCTURES

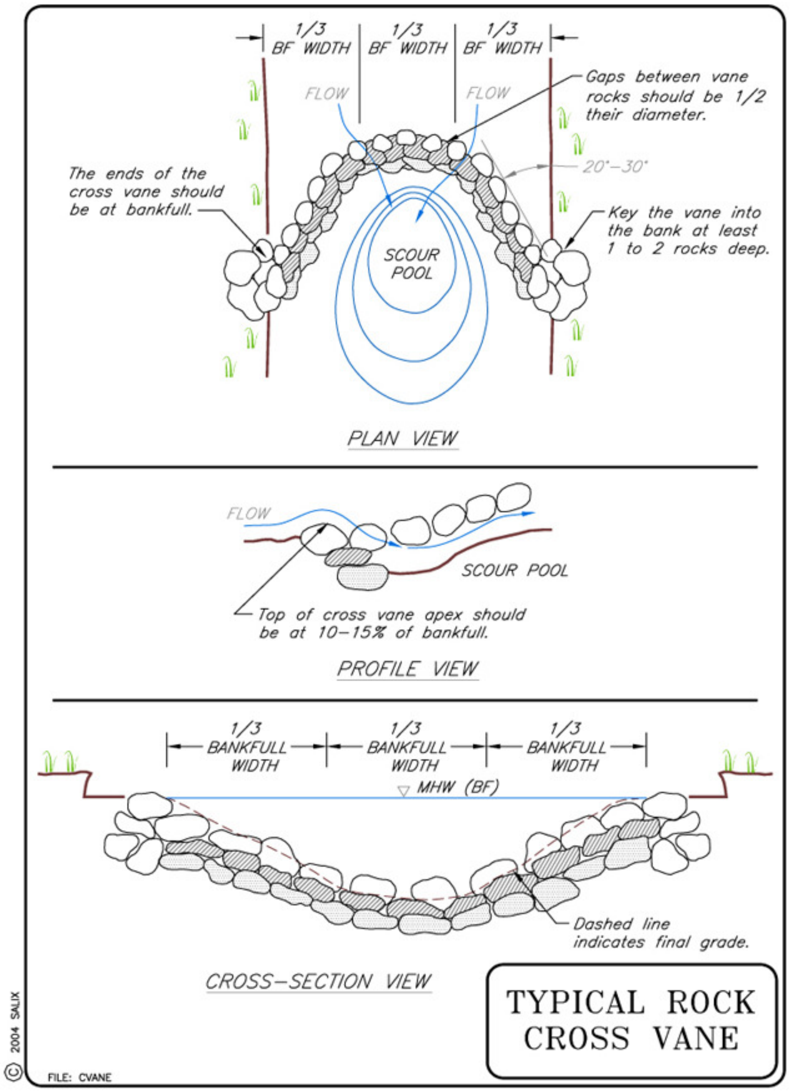
Bendway Weirs

Bendway weirs are discontinuous, redirective, structures usually constructed of rock, designed to capture and then safely direct the flow through a meander bend. A minimum of five structures are typically placed in series (the series are known as “weir fields”) along straight or convex bank lines. Bendway weirs differ from spurs and vanes in that they form a control system that captures and directs the streamflow through the weir field, usually all the way through the bend (hence the name bendway weirs). Bendway weirs are generally longer (1/3 – 1/2 stream width) and lower than barbs or spurs, flat crested and are designed to be continuously submerged or at least be overtopped by the design flows. Transverse river training structures often provide pool habitat and physical diversity.



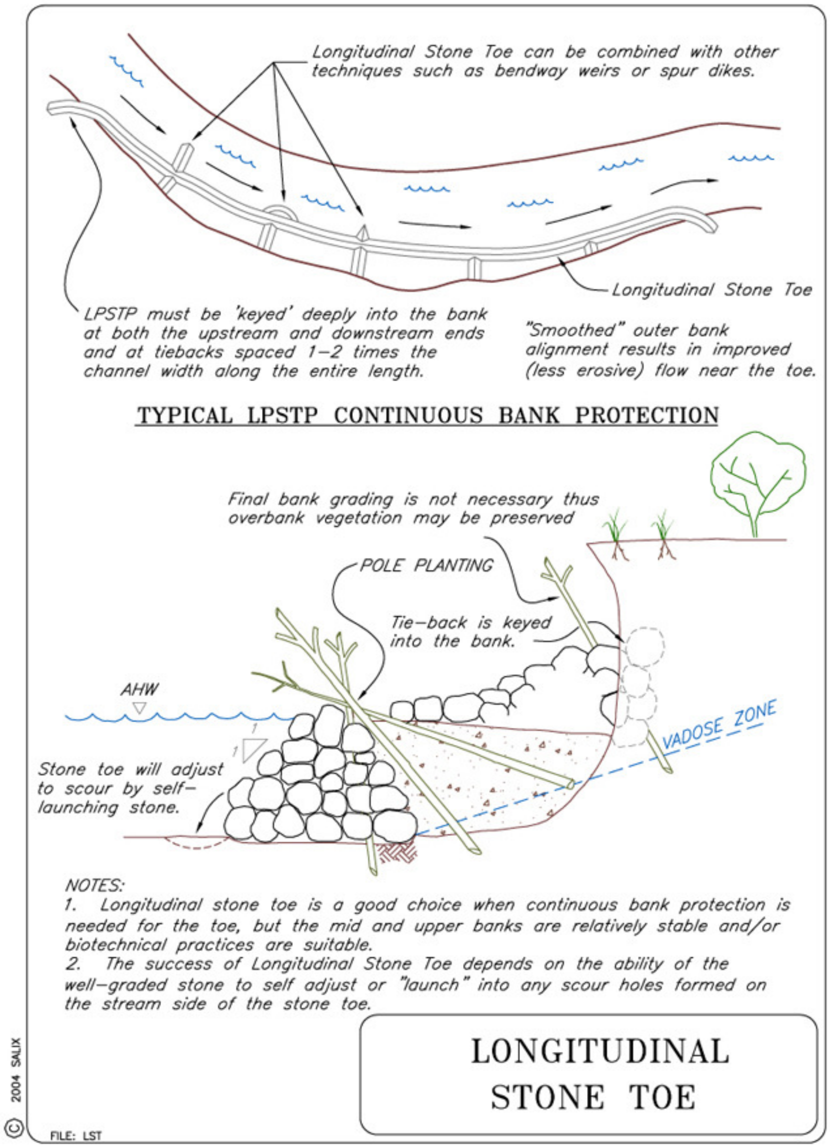
Cross Vanes

Cross vanes (aka. vortex weirs) are "V" shaped, upstream pointing, rock structures stretching across the width of the stream. Cross vanes redirect water away from the streambanks, and into the center of the channel. This serves to decrease shear stress on unstable banks, as well as create aquatic habitat in the scour pools formed by the redirected flow. Cross vanes are designed to be overtopped at all flows. The lowest part of the structure is the vortex of the "V", which is at the point farthest upstream. The crests are sloped 3-5% with the ends of the vanes keyed into the streambanks at an elevation approximate to annual high water or bankfull stage. This shape forms a scour pool inside of the "V". Cross vanes are particularly useful for modifying flow patterns, enhancing in-stream habitat, substrate complexity and providing in grade control. Double cross vanes (W weirs) are a variation suitable for wider channels.



Longitudinal Stone Toe

A longitudinal stone toe (aka longitudinal peaked stone toe protection (LPSTP)) is continuous bank protection consisting of a stone dike placed longitudinally at, or slightly streamward of the toe of an eroding bank. The cross section of the stone toe is usually triangular in shape. The success of this method depends upon the ability of stone to self-adjust or "launch" into scour holes formed on the stream side of the revetment. The stone toe does not need to follow the bank toe exactly, but should be designed and placed to form an improved or "smoothed" alignment through the stream bend. Longitudinal stone toes usually require much less bank disturbance and the bank landward of the toe may be revegetated by planting or natural succession. Brushlayering and Willow Post and Poles are excellent candidates for use with this technique.

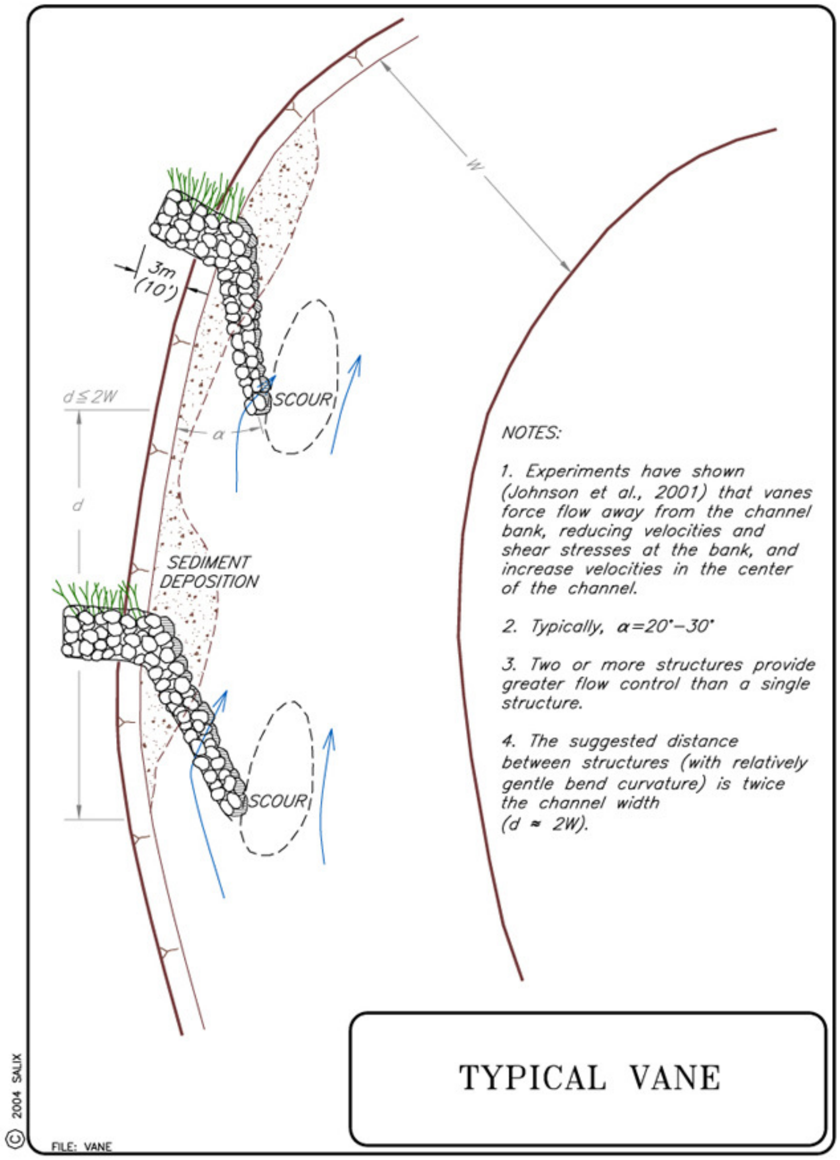


NOTES:
1. Longitudinal stone toe is a good choice when continuous bank protection is needed for the toe, but the mid and upper banks are relatively stable and/or biotechnical practices are suitable.
2. The success of Longitudinal Stone Toe depends on the ability of the well–graded stone to self adjust or "launch" into any scour holes formed on the stream side of the stone toe.

LONGITUDINAL STONE TOE

Rock Vanes

Rock vanes are discontinuous, redirective structures angled upstream 20 to 30 degrees. Generally, two or three vanes are constructed along the outer bank of a bend in order to redirect flows near the bank to the center of the channel. Typically, vanes project 1/3 of the stream width. The riverward tips are at channel grade, and the crests slope upward to reach bankfull stage elevation at the key. Rock vanes can preclude the need for rock armor and increase vegetative techniques as the high flows are redirected away from the bank. Vanes can increase cover, backwater area, edge or shoreline length, and the diversity of depth, velocity and substrate. Variations include Cross Vanes and Rock Vanes with J-hooks.



NOTES:

1. Experiments have shown (Johnson et al., 2001) that vanes force flow away from the channel bank, reducing velocities and shear stresses at the bank, and increase velocities in the center of the channel.

2. Typically, $\alpha = 20^\circ - 30^\circ$

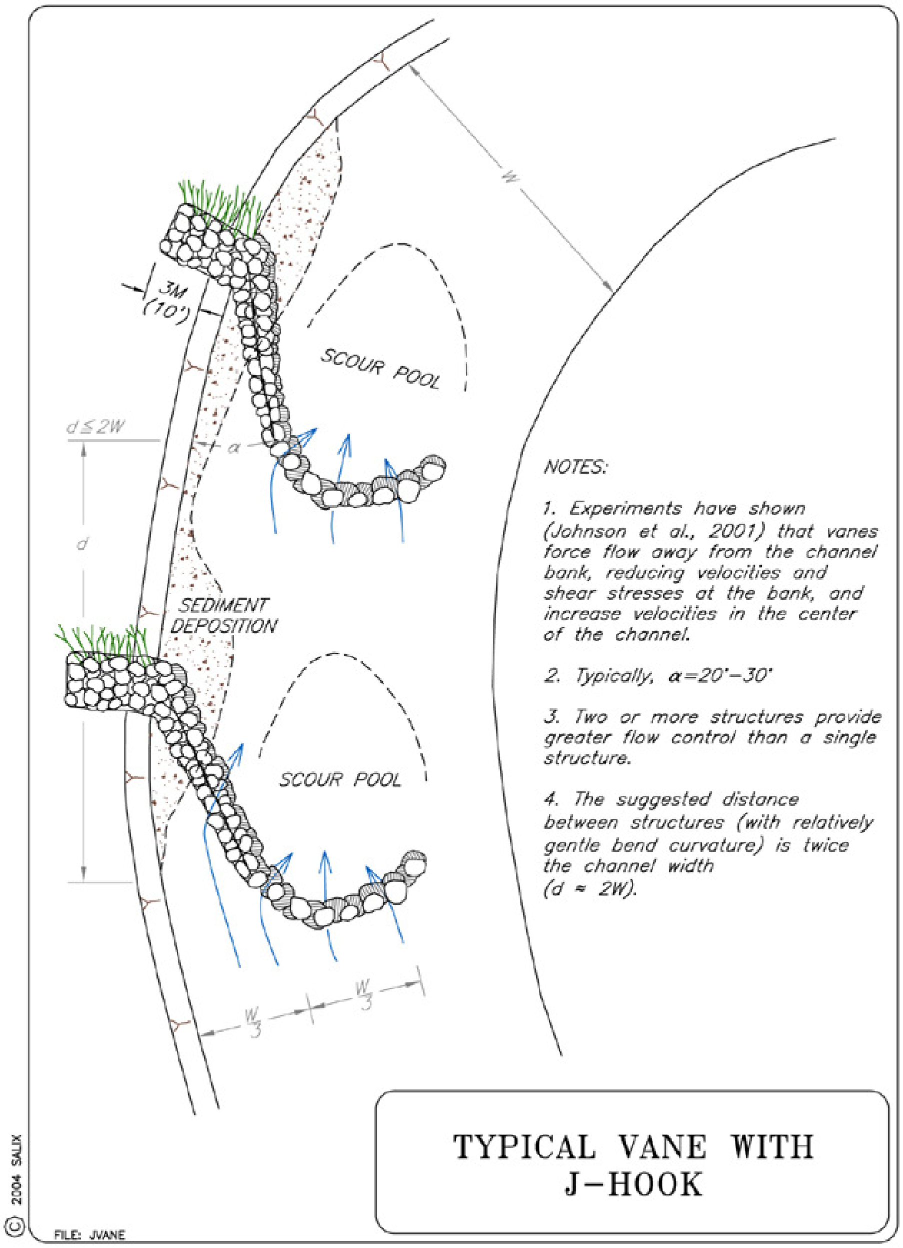
3. Two or more structures provide greater flow control than a single structure.

4. The suggested distance between structures (with relatively gentle bend curvature) is twice the channel width ($d \approx 2W$).

TYPICAL VANE

Rock Vanes with J Hook

Vanes with J-Hooks are actually rock vanes modified to enhance the instream habitat benefits. They are redirective, upstream-pointing deflection structures whose tip is placed in a “J” configuration and partially embedded in the streambed so that they are submerged even during low flows. The rock vanes have demonstrated effectiveness in reducing near-bank velocities by redirecting the thalweg toward the center of the channel. The “J” structures are intended to create scour pools and thereby improve substrate complexity. The scour usually results in a “tail out” deposition of gravel (riffle) which may provide spawning habitat.



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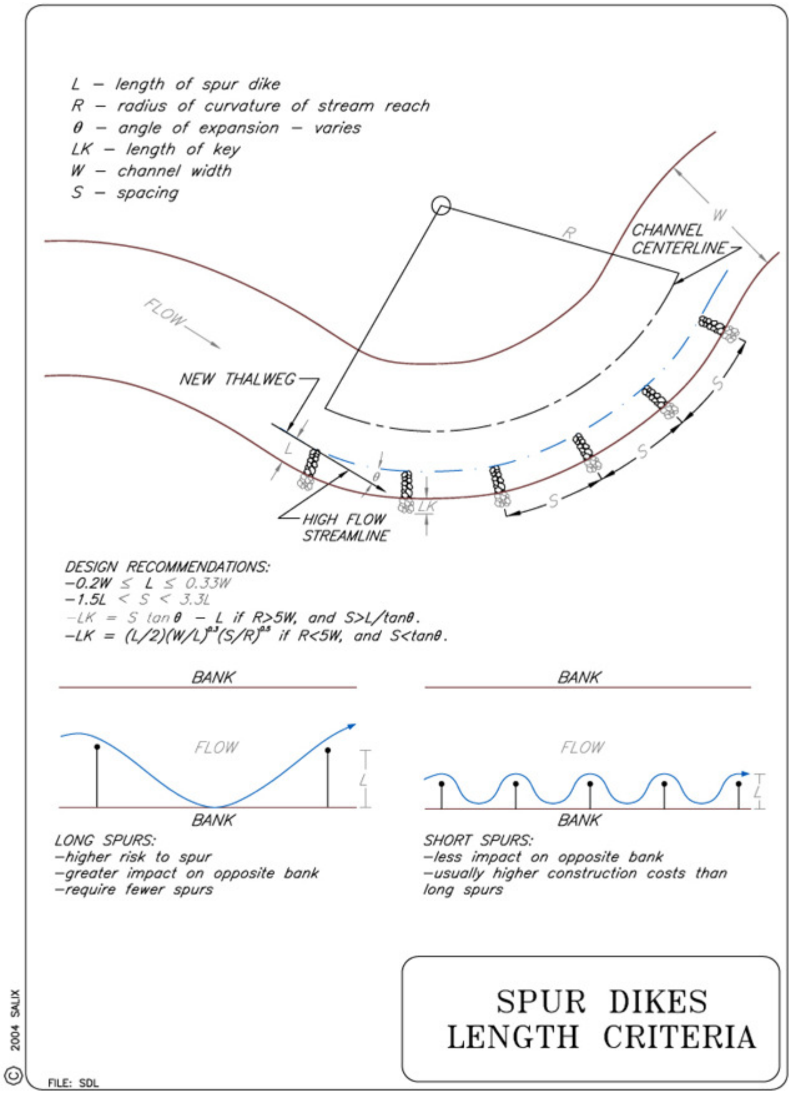
TYPICAL VANE WITH
J–HOOK

Spur Dikes

Spur dikes, deflectors or groins are transverse structures that extend into the stream from the bank and reduce erosion by deflecting flows away from the bank. Transverse river training structures often provide pool habitat and physical diversity. Two to five structures are typically placed in series along straight or convex bank lines where flow lines are roughly parallel to the bank. Spurs, groins, and deflectors have no specific design criteria regarding crest height, crest slope or upstream angle and therefore differ from vanes and bendway weirs. Earthen core spur dikes are groins constructed with a soil core armored by a layer of stone. Deflectors can also be constructed from natural materials, such as large woody debris (LWD), or LWD embedded with rock, and designed to provide biologic benefits and habitat restoration. Stone spurs capped with a prism of earth reinforced with live fascines are referred to as "live booms."



L – length of spur dike
R – radius of curvature of stream reach
θ – angle of expansion – varies
LK – length of key
W – channel width
S – spacing

DESIGN RECOMMENDATIONS:
–$0.2W \leq L \leq 0.33W$
–$1.5L < S < 3.3L$
–$LK = S \tan\theta - L$ if $R>5W$, and $S>L/\tan\theta$.
–$LK = (L/2)(W/L)^{0.3}(S/R)^{0.5}$ if $R<5W$, and $S<\tan\theta$.

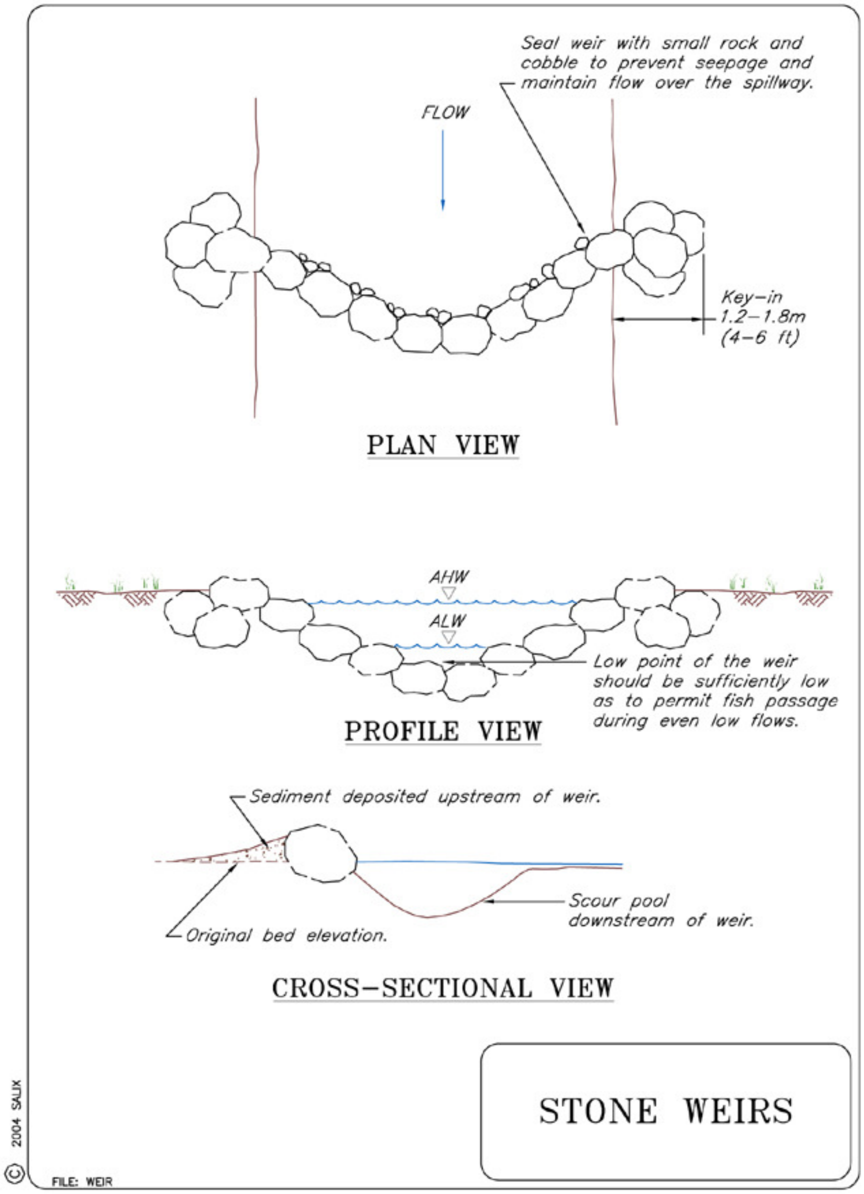
LONG SPURS:
–higher risk to spur
–greater impact on opposite bank
–require fewer spurs

SHORT SPURS:
–less impact on opposite bank
–usually higher construction costs than long spurs

SPUR DIKES
LENGTH CRITERIA

Stone Weirs

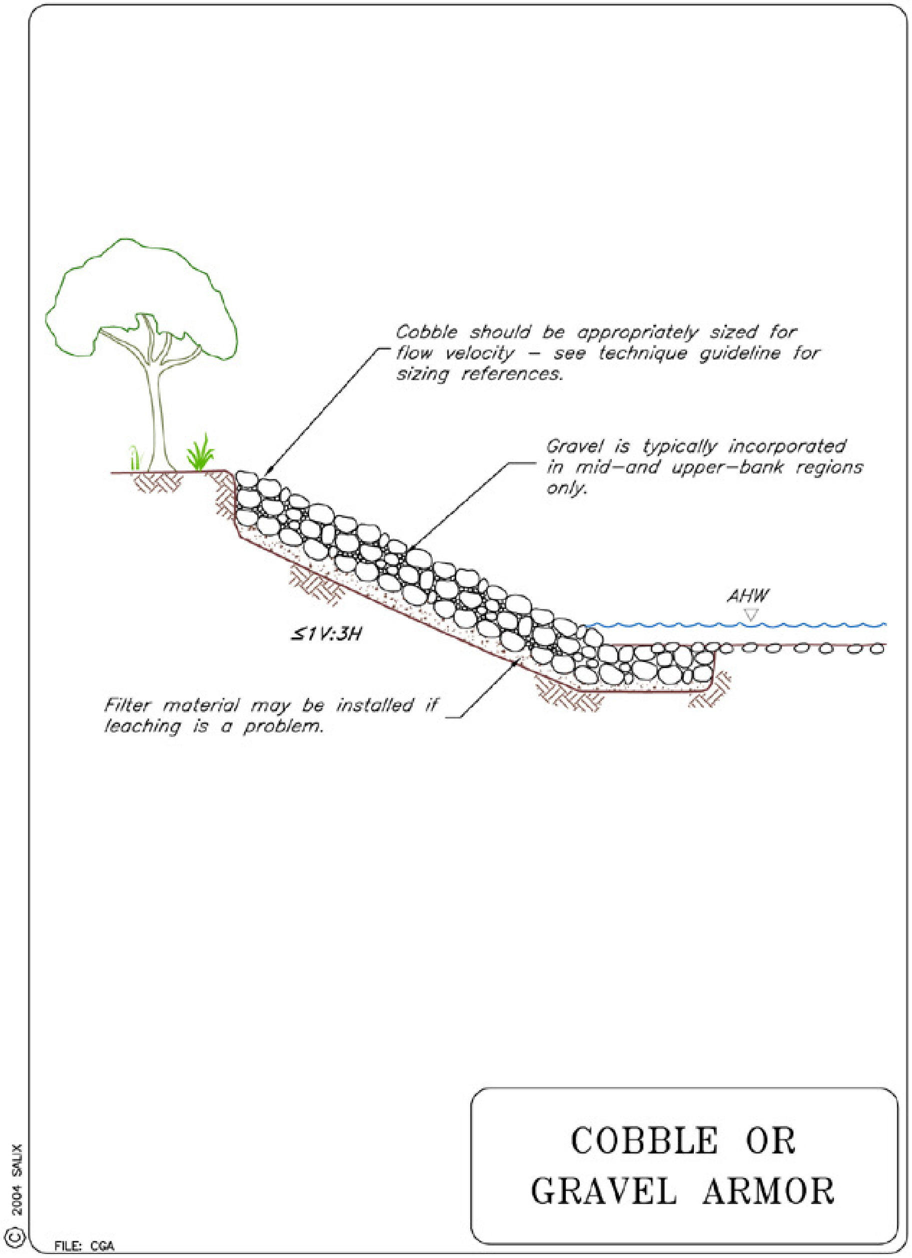
Stone weirs are structures that span the stream and produce a drop in the water surface elevation. These structures are frequently made of angular quarried stone, but logs, sheet piling, concrete, boulders and masonry are also quite common. Well-constructed stone weirs can prevent or retard channel bed erosion and upstream progression of "knickpoints" and headcuts, as well as providing pool habitats for aquatic biota. Stone weirs or similar grade control structures are often intended to raise or elevate the bottom of incised channels, with the ultimate goal of elevating a dropping water table. Variations on stone weirs that have additional habitat benefits are Newbury Rock Riffles and Cross Vanes.



STRUCTURAL STREAMBANK STABILIZATION

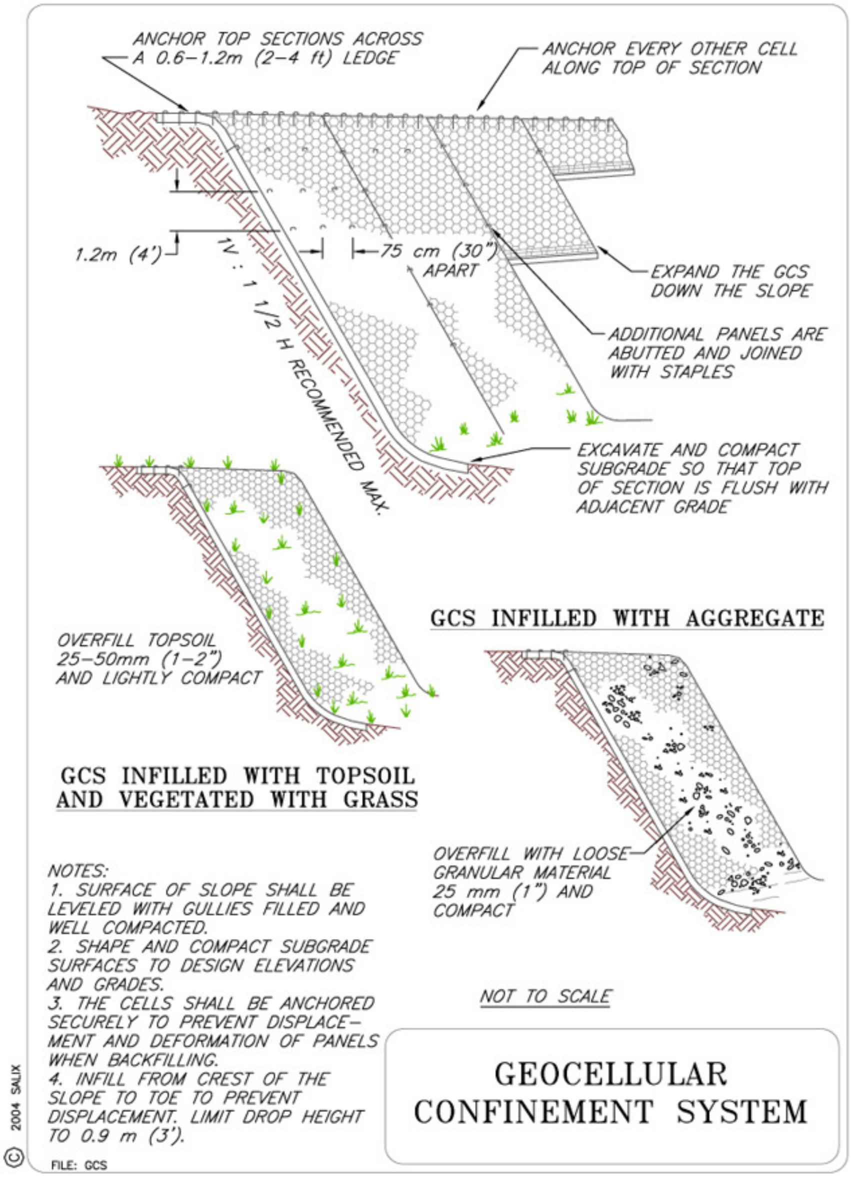
Cobble or Gravel Armor

Cobble or gravel armor is a resistive technique, similar to riprap revetment that uses naturally-occurring rock. Cobbles are natural stones larger than 6.5 cm (2.5 in) in diameter that have been rounded by the abrasive action of flowing water, while gravel is material smaller than cobble, but larger than sand (larger than about 5 mm(0.2 in)). Rounded river cobble or gravel blanket presents a more natural appearance, and can be as effective as riprap revetment for areas with relatively lower tractive forces and velocities.



Geocellular Containment Systems

Geocellular Containment Systems (GCS) are flexible, three-dimensional, high density polyethylene (HDPE) honeycomb-shaped earth-retaining structures that can be expanded and backfilled with a variety of materials to mechanically stabilize surfaces. They can be used flat, as channel or slope lining, or stacked to form a retaining wall. Maximum slope for walls is generally 2V:1H, although they have been installed as steep as 0.5V:1H and even 1V:1H in some cases. GCS provide very little habitat enhancements alone, therefore these systems must be combined with vegetation to be considered environmentally-sensitive. Live staking and joint planting are excellent choices for combining techniques.

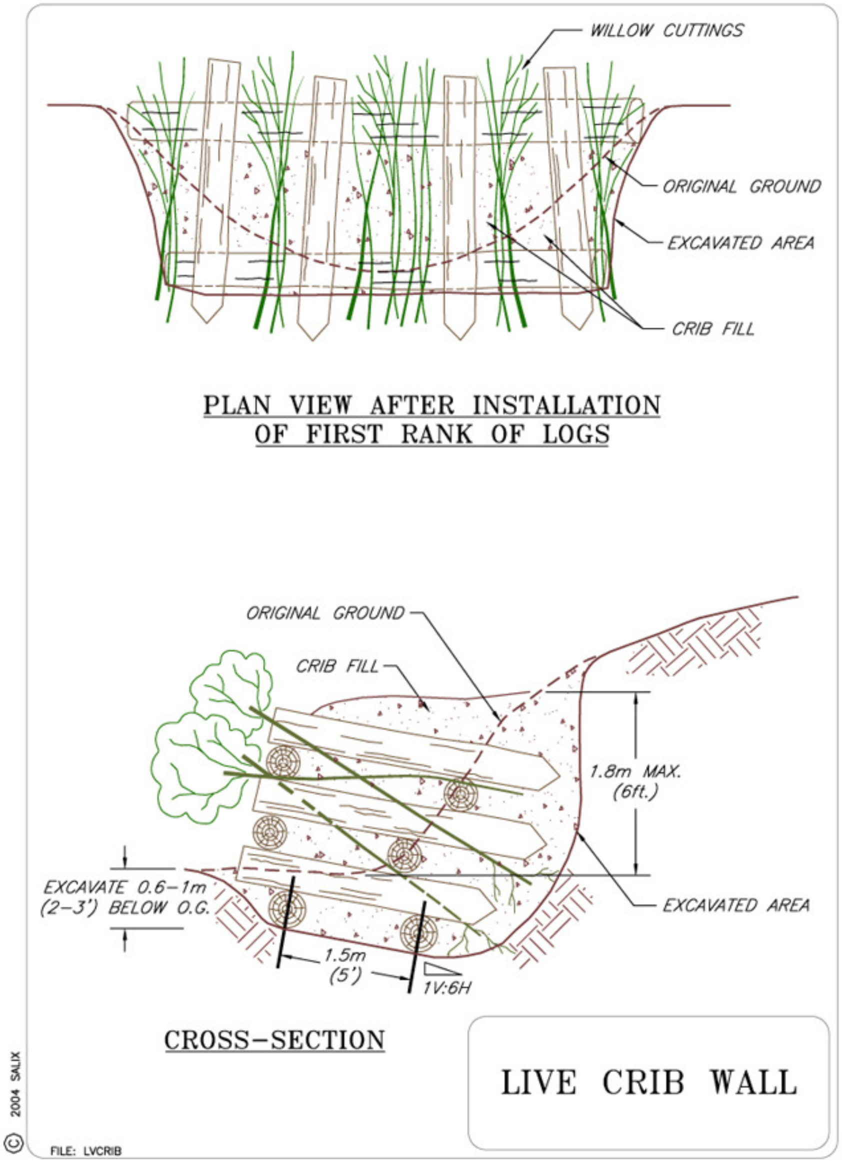


NOTES:
1. SURFACE OF SLOPE SHALL BE LEVELED WITH GULLIES FILLED AND WELL COMPACTED.
2. SHAPE AND COMPACT SUBGRADE SURFACES TO DESIGN ELEVATIONS AND GRADES.
3. THE CELLS SHALL BE ANCHORED SECURELY TO PREVENT DISPLACEMENT AND DEFORMATION OF PANELS WHEN BACKFILLING.
4. INFILL FROM CREST OF THE SLOPE TO TOE TO PREVENT DISPLACEMENT. LIMIT DROP HEIGHT TO 0.9 m (3').

GEOCELLULAR CONFINEMENT SYSTEM

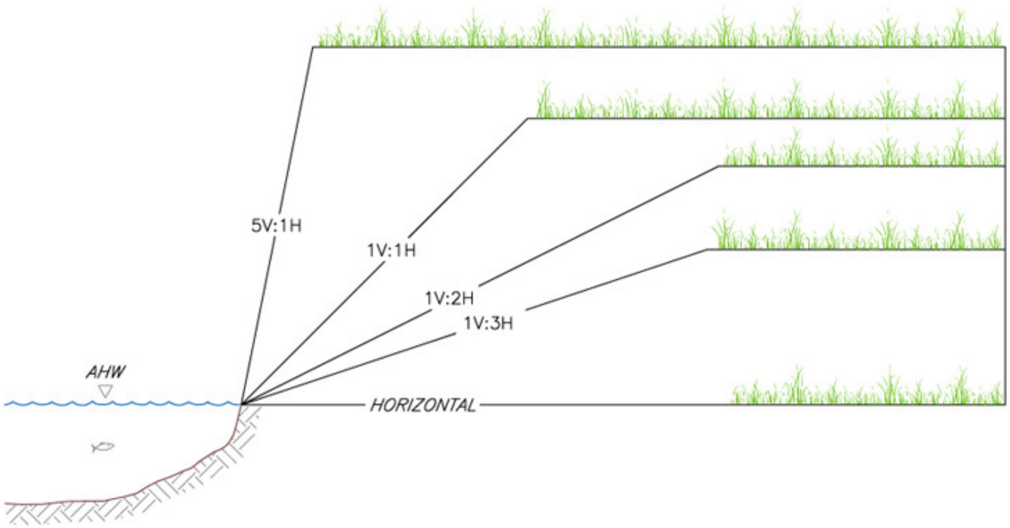
Live Cribwall

A cribwall is a gravity retaining structure consisting of a hollow, box-like inter-locking arrangement of structural beams (e.g., logs). The interior of the cribwall is filled with rock or soil. In conventional cribwalls, the structural members are fabricated from concrete, wood logs, and dimensioned timbers (usually treated wood). In live cribwalls, the structural members are usually untreated log or timber members. The structure is filled with a suitable backfill material and live branch cuttings are inserted through openings between logs at the front of the structure and imbedded in the crib fill. These cuttings eventually root inside the fill and the growing roots gradually permeate and reinforce the fill within the structure.



Slope Flattening

Flattening or bank reshaping stabilizes an eroding streambank by reducing its slope angle or gradient. Slope flattening is usually done in conjunction with other bank protection treatments, including installation of toe protection, placement of bank armor, re-vegetation or erosion control, and/or installation of drainage measures. Flattening or gradient reduction can be accomplished in several ways: 1) by removal of material near the crest, 2) by adding soil or fill at the bottom, or 3) by placing a toe structure at the bottom and adding a sloping fill behind it. Right-of-way constraints may limit or preclude the first two alternatives because both entail either moving the crest back or extending the toe forward.



- 1V:3H – Maximum suggested slope angle for establishing plantings or seedlings, when used alone.
- 1V:3H – IV:2H – Optimal slope angle range for soil bioengineering.
- 1V:3H or steeper – Roughen stairstep or terrace slope if planting.
- 1V:2H – Maximum suggested slope angle for unreinforced fills.
- 1V:2H or steeper – Biotechnical techniques (combination of stabilization structures, soil bioengineering and geotechnical methods) often needed.
- 1V:1H – Maximum suggested slope angle for unreinforced cuts in clay soil.
- 5V:1H – Typical face angle for rockeries, gabions, crib walls, etc.

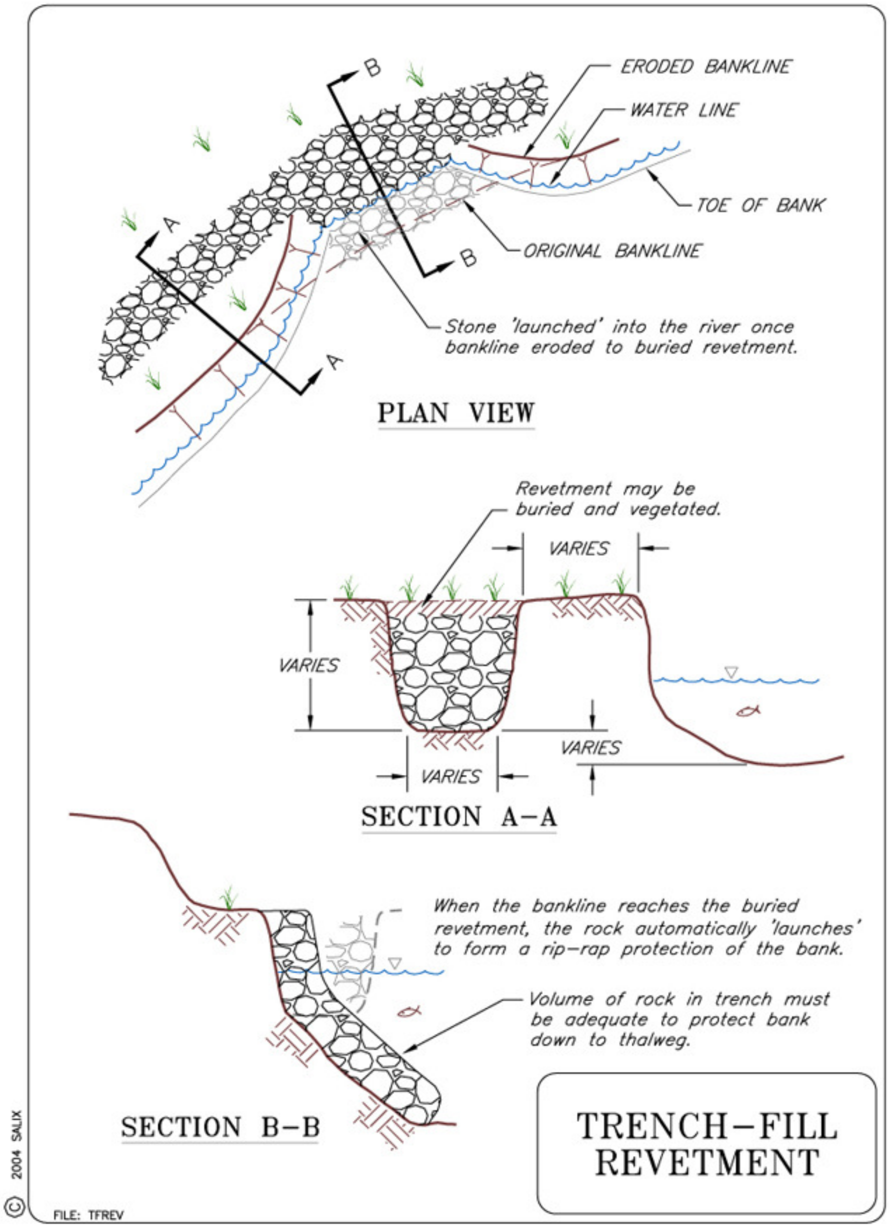
FILE: SFLT

SLOPE FLATTENING

(adapted from FISRWG, 1998)

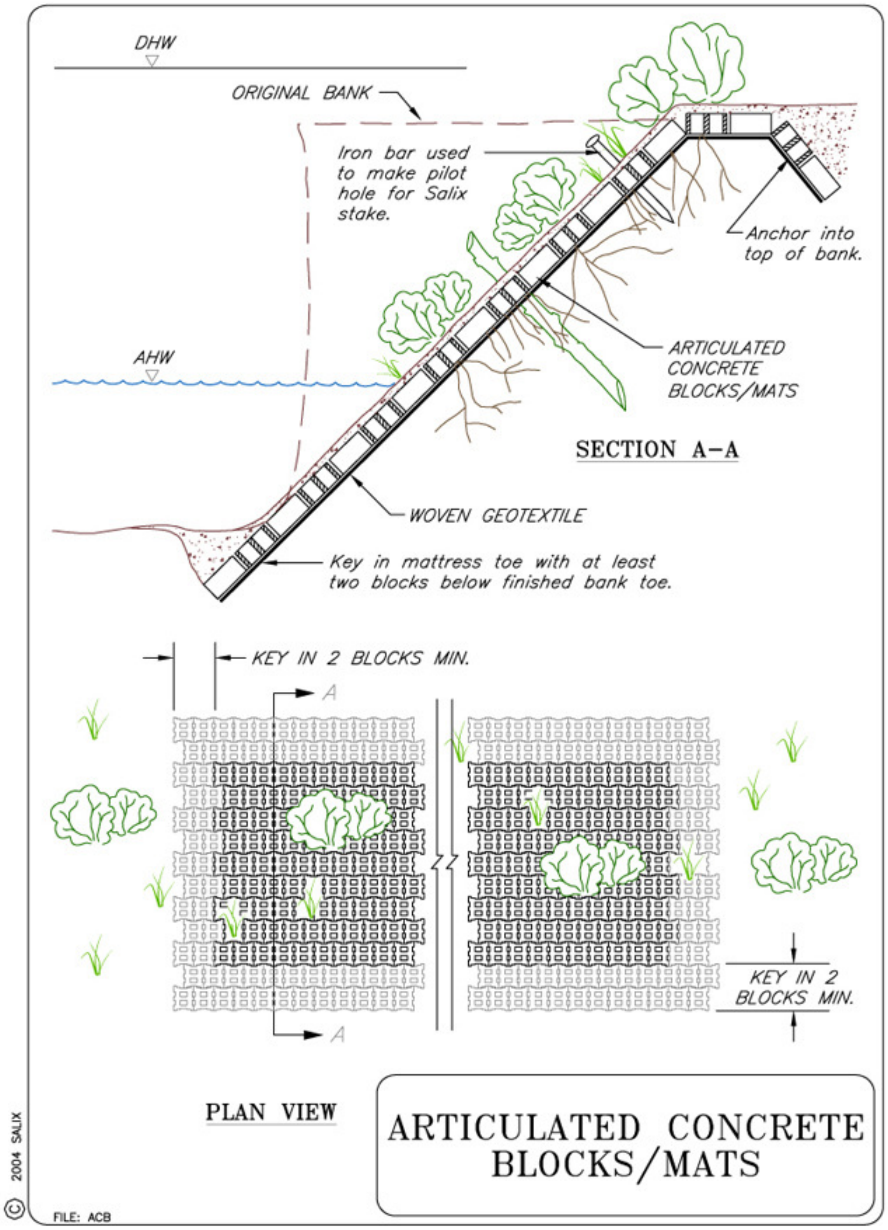
Trench Fill Revetment

Trench fill revetments are constructed by excavating a trench along the top of the bank and placing stone riprap in the trench. As the bank erodes, the stone is undercut and “launches” down the bank line, resulting in a more gradual, protected slope. Earth removed for excavation of the trench may be used to cover the riprap, thus completely concealing it until it is launched. This technique might be chosen if access to the stream reach is restricted due to legal or environmental issues.



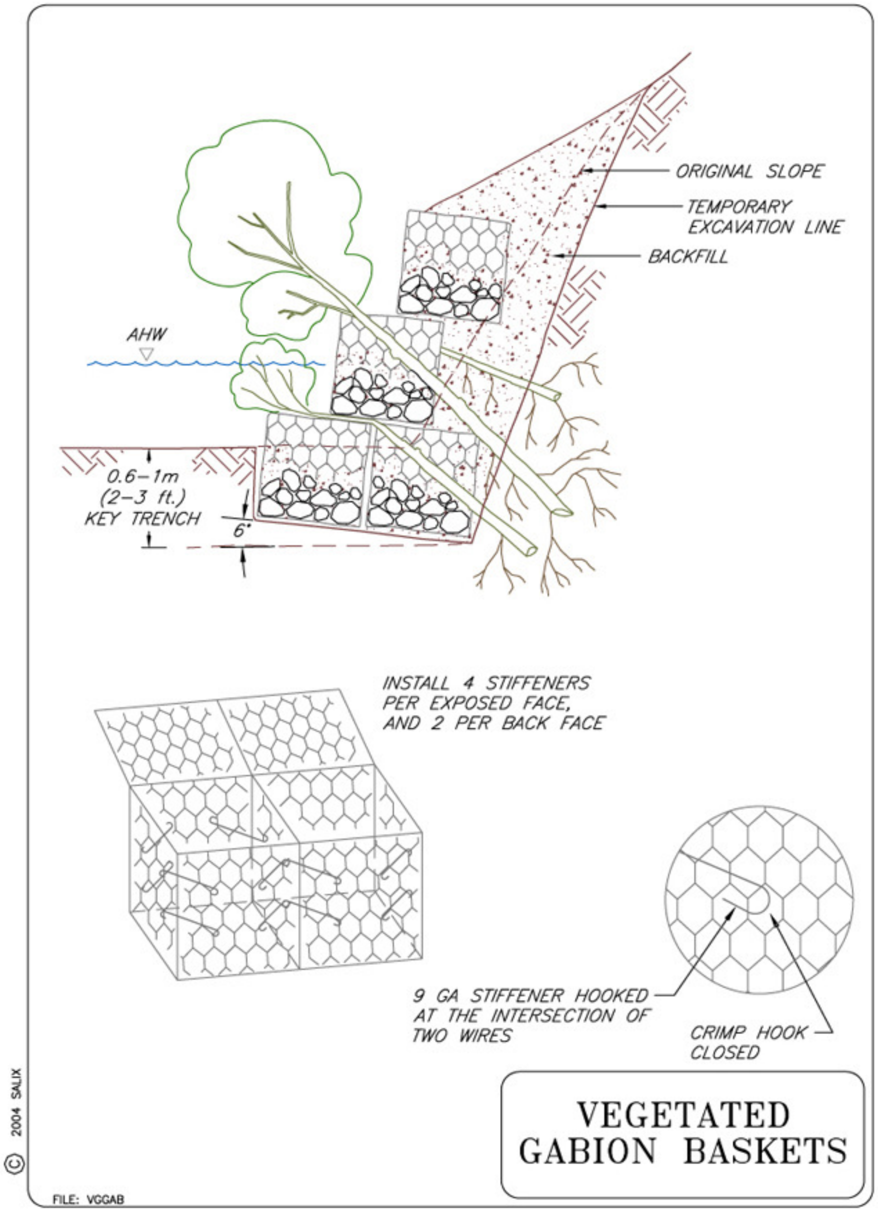
Vegetated Articulated Concrete Blocks

An Articulated Concrete Block (ACB) system consists of durable concrete blocks that are placed together to form a matrix overlay or armor layer. Articulated block systems are flexible and can conform to slight irregularities in slope topography caused by settlement. The blocks are placed on a filter course (typically a geofabric) to prevent washout of fines through the blocks. ACBs provide very little habitat enhancements alone, therefore these systems must be combined with vegetation to be considered environmentally-sensitive. Vegetation in the form of live cuttings or grass plugs is inserted through openings in the blocks into the native soil beneath the blocks.



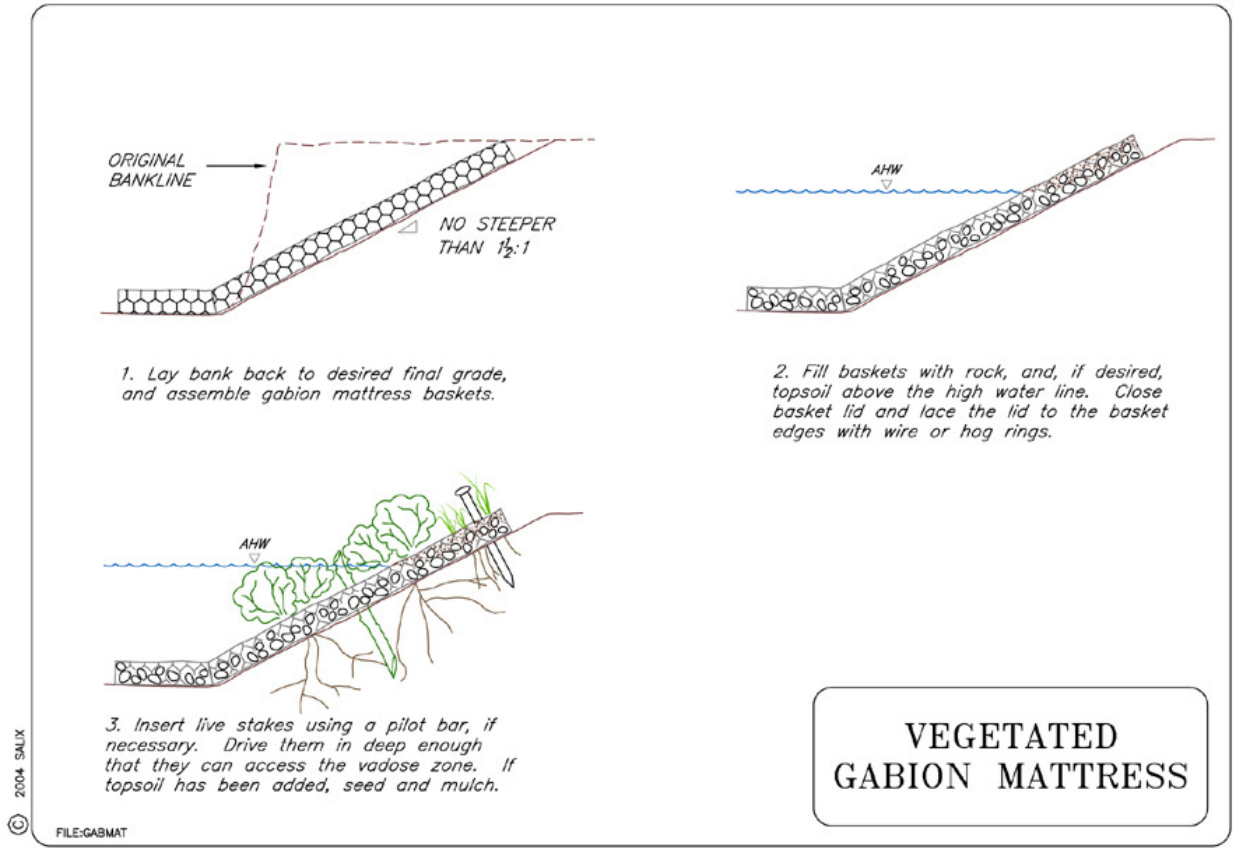
Vegetated Gabion Baskets

Gabions are rectangular baskets made of twisted or welded-wire mesh that are filled with rock. These flexible and pervious structures can be used individually or stacked like building blocks to reinforce steep banks. Used alone, rock-filled gabions provide insufficient habitat benefit. However, woody vegetation, such as brushlayering, post and poles, can be incorporated by inserting the cuttings all the way through the basket during filling, and penetrating the native subsoil. The woody vegetation can provide additional reinforcement and longevity to the structure while helping to mitigate for loss of habitat.



Vegetated Gabion Mattress

Gabion mattresses differ from gabion baskets as they are shallow, (0.5-1.5 m (20-60 in)) deep, rectangular containers made of welded wire mesh, and filled with rock. Gabion mattresses are not stacked but placed directly and continuously on the prepared banks. They are intended to protect the bed or lower banks of a stream against erosion. A gabion mattress can be used as either a revetment to stabilize a streambank, or when used in a channel, to decrease the effects of scour. Live cuttings are introduced through the rock filled mattress and inserted into native soil beneath.



1. Lay bank back to desired final grade, and assemble gabion mattress baskets.

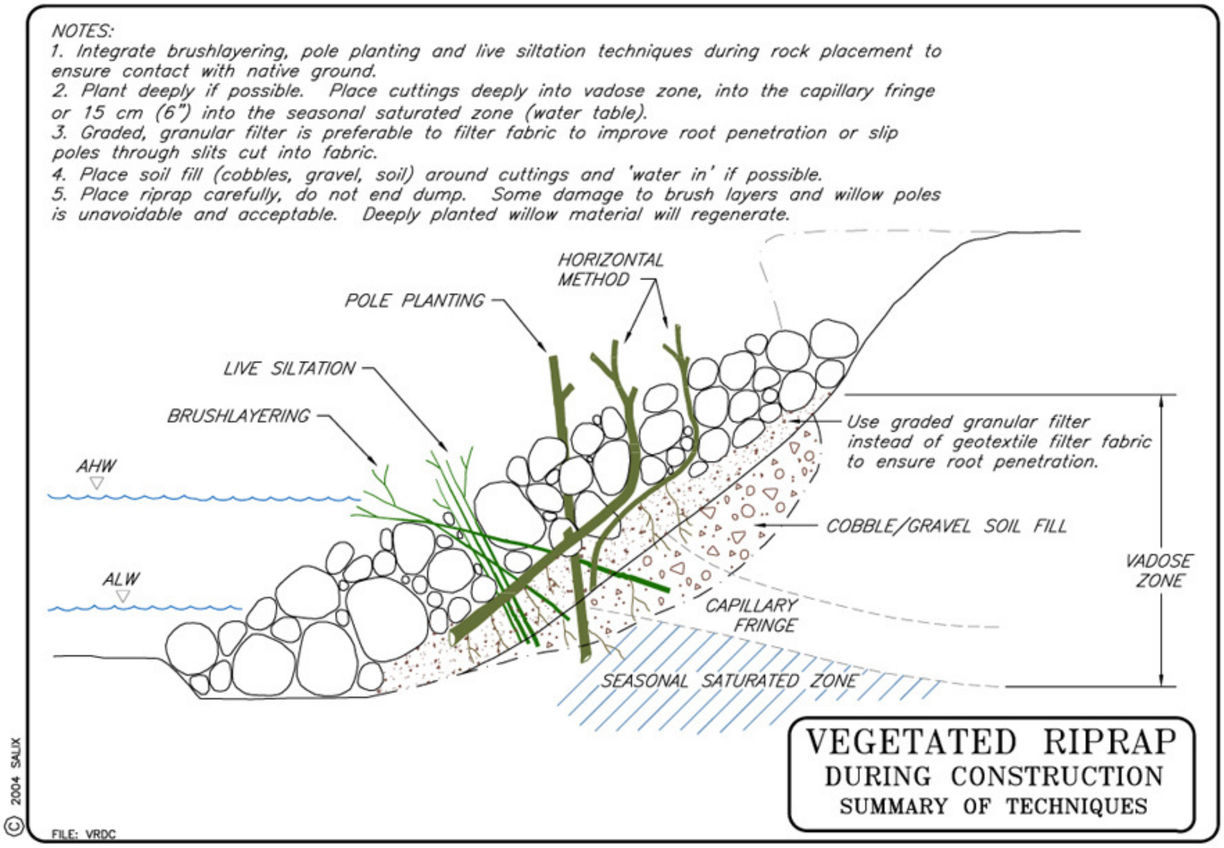
2. Fill baskets with rock, and, if desired, topsoil above the high water line. Close basket lid and lace the lid to the basket edges with wire or hog rings.

3. Insert live stakes using a pilot bar, if necessary. Drive them in deep enough that they can access the vadose zone. If topsoil has been added, seed and mulch.

VEGETATED GABION MATTRESS

Vegetated Riprap

A layer of stone and/or boulder armoring that is vegetated, optimally during construction, using pole planting, brushlayering, and live-staking techniques. The goal of this method is to increase the stability of the bank, while simultaneously establishing riparian growth within the rock and overhanging the water, to provide shade, water quality benefits, and fish and wildlife habitat. Vegetative riprap combines the widely accepted, resistive and continuous rock revetment techniques with deeply-planted biotechnical techniques.



NOTES:
1. Integrate brushlayering, pole planting and live siltation techniques during rock placement to ensure contact with native ground.
2. Plant deeply if possible. Place cuttings deeply into vadose zone, into the capillary fringe or 15 cm (6") into the seasonal saturated zone (water table).
3. Graded, granular filter is preferable to filter fabric to improve root penetration or slip poles through slits cut into fabric.
4. Place soil fill (cobbles, gravel, soil) around cuttings and 'water in' if possible.
5. Place riprap carefully, do not end dump. Some damage to brush layers and willow poles is unavoidable and acceptable. Deeply planted willow material will regenerate.

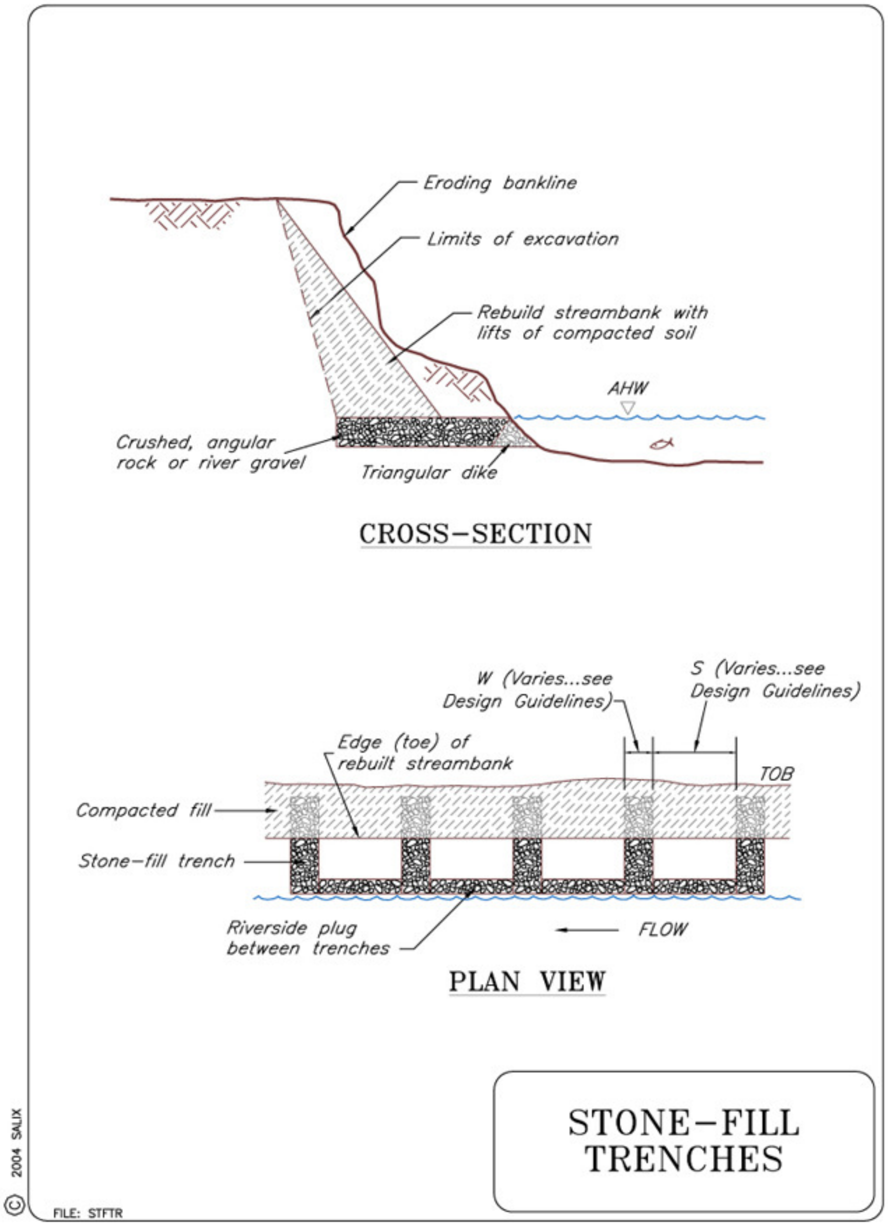
VEGETATED RIPRAP
DURING CONSTRUCTION
SUMMARY OF TECHNIQUES

© 2004 SALIX

FILE: VRDC

Stone-Fill Trenches

Stone-fill trenches are rock filled trenches placed at the base of a streambank, usually within a failed section of the toe. A series of trenches are excavated at or within the toe of the slope in a direction perpendicular to the stream. The trenches are backfilled with crushed rock or stone. The toe of the slope is then reconstructed by placing and compacting earthen fill within and atop the stone-fill trenches. A small, longitudinal riverside plug or stone dike should be used between the stone trenches to help contain and protect the toe of the earthen fill placed between and atop the stone trenches.



APPENDIX Q

EXISTING INFORMATIVE RESOURCES FOR THE SANTA ROSA CREEK WATERSHED

SANTA ROSA CREEK WATERSHED INFORMATIVE RESOURCES

REFERENCE #	SUBJECT	TITLE	DATE	AUTHOR
1	Agriculture	2006 Annual Report	2006	San Luis Obispo County Department of Agriculture Weight & Measures
2	Agriculture	Agriculture & Open Space Element SLO County General Plan	October 22, 1998	
3	Agriculture	Agriculture & Open Space Element SLO County General Plan	September 4, 1992	
4	Assessment	Affordable Housing Ordinances EIR	2007	County of San Luis Obispo
5	Assessment	An Environmental Assessment on Golf Course Development		
6	Assessment	Bio-monitoring Report of the Cambria Cross-Town Trail Project	March 16, 2005	
7	Assessment	Biotic Assessment, Santa Rosa Creek, Cross-Town Trail Project	1999	Assegued & Associates
8	Assessment	Biotic Resources Assessment for the Cambria Community Services District Proposed Santa Rosa Creek Trail and Stream Bank Restoration Project	March, 2003	Rincon Consultants, Inc.
9	Assessment	Cross Town Trail Initial Study/Mitigated Negative Declaration	1999	RBF Consulting
10	Assessment	Drainage Study	2004	County of San Luis Obispo
11	Assessment	East-West Ranch Management Plan Initial Study/Mitigated Negative Declaration	2002	Rincon Consultants, Inc.
12	Assessment	East-West Ranch Resource Inventory and Constraints Report	2002	Rincon Consultants, Inc.
13	Assessment	Environmental Assessment Programmatic Habitat Conservation Plan	December 18, 1991	
14	Assessment	Preliminary Geotechnical Study, San Simeon Creek Diversion/Recharge and Off-Stream Dam Project: for Cambria Community Services District, Cambria, California	August, 1988	McClelland Engineers, Inc.
15	Assessment	Preliminary Site Assessment & Instream Flow Study Plan Santa Rosa Creek	May 25, 1990	Tenera
16	Assessment	Resource Inventory and Constraints Report	March 1, 2002	
17	Assessment	San Simeon & Santa Rosa Creeks Watershed Sanitary Survey	January 1, 1996	
18	Assessment	San Simeon Creek Diversion/Recharge and Off-Stream Storage Project: Preliminary Design Evaluation	September, 1988	Boyle Engineering Corporation
19	Assessment	Watershed Sanitary Survey	October 1, 1997	
20	Biology	A Manual of California Vegetation	1995	John O. Sawyer and Todd Keeler-Wolf
21	Biology	A Technical Bibliography on the Natural History of the San Simeon Area, San Luis Obispo County, California: Including coastal basins from Santa Rosa Creek north to San Carpoforo Creek	April 1, 2000	Galen B. Rathbun and Susan Wright
22	Biology	California Invasive Plant Inventory	2006	California Invasive Plant Council
23	Biology	California Salmonid Stream Habitat Restoration Manual	1998	Flosi, et al

REFERENCE #	DESCRIPTION	WEBSITE	OTHER SOURCE
1		http://www.slocounty.ca.gov/Assets/AG/croprep/2006+Crop+Report.pdf	
2			CCSD resource #227; Bookcase B; Shelf 5
3			CCSD resource #250; Bookcase C; Shelf 2
4	Includes water, biological, geological and historical resources for the county.	http://www.slocounty.ca.gov/planning/environmental/EnvironmentalNotices/Environmental_Impact_Reports_2007.htm	
5			CCSD resource #196; Bookcase B; Shelf 4
6			CCSD resource #224; Bookcase B; Shelf 5
7			
8			
9			
10			
11			
12			
13			CCSD resource #176; Bookcase B; Shelf 3
14	Water storage, Water supply, Water diversion, Dams		Cal Poly State University-Reference Section
15			CCSD resource #35; Bookcase A; Shelf 2
16			CCSD resource #226; Bookcase B; Shelf 5
17			CCSD resource #354; Bookcase D; Shelf 1
18	Water storage, Water supply, Water diversion		Cal Poly State University-Reference Section
19			CCSD resource #467; Bookcase D; Shelf 4
20	Vegetation series descriptions		Kennedy Library, Cal Poly State University
21		http://www.greenspacecambria.org/Documents/NaturalHistoryBibliography.pdf	
22	Non-native invasive plant species for the Central Western Floristic Province.	http://www.cal-ipc.org/ip/inventory/pdf/Inventory2006.pdf	
23			

REFERENCE #	SUBJECT	TITLE	DATE	AUTHOR
24	Biology	CDFG Basin Planning and Habitat Mapping Project		Central Coast Watershed Studies Team
25	Biology	Comparison of Juvenile Steelhead Densities in 1994-96	January 1, 1997	DW Alley & Associates
26	Biology	Comparison of Juvenile Steelhead Densities in 1994-97	July 1, 1998	DW Alley & Associates
27	Biology	Comparison of Juvenile Steelhead Densities Santa Rosa Creek 1994-1997	July 1, 1998	DW Alley & Associates
28	Biology	Comparison of Juvenile Steelhead Densities Santa Rosa Creek 1994-98	September 1, 1999	
29	Biology	Comparison of Juvenile Steelhead Production in 1994-1999 for Santa Rosa Creek, San Luis Obispo County, California, With Habitat Analysis and an Index of Adult Returns	2000	DW Alley & Associates
30	Biology	Comparison of Juvenile Steelhead Production in 1994-98	September 1, 1999	DW Alley & Associates
31	Biology	Comparison of Juvenile Steelhead Production Santa Rosa Creek 1994-98	September 1, 1999	DW Alley & Associates
32	Biology	Determination of Juvenile Steelhead Densities Santa Rosa and San Simeon Crees	February 5, 1995	DW Alley & Associates
33	Biology	Draft Recovery Plan for the Tidewater Goby (Eucyclogobius newberryi)	2004	US Fish and Wildlife Service
34	Biology	Fisheries-Steelhead Trout Management Tasks (Coastal Watersheds)	2008	California Department of Fish and Game
35	Biology	History and Status of Steelhead in California Coastal Drainages South of San Francisco Bay	1994	Titus, Erman and Snider
36	Biology	History and Status of Steelhead in California Coastal Drainages South of San Francisco Bay	2000	Titus, Erman and Snider
37	Biology	Invasive Plants of California Wildlands	2000	Bossard, Randall and Hoshovsky
38	Biology	Listed, Proposed and Candidate Species Which May Occur in San Luis Obispo County		US Department of the Interior, Fish and Wildlife Service
39	Biology	Misc. Articles, Reports, etc. about Steelhead Fish Monitoring	1997	
40	Biology	Monitoring Report San Simeon & Santa Rosa Creeks 1992-93	November 18, 1993	DW Alley & Associates
41	Biology	Monitoring Report San Simeon and Santa Rosa Creeks, 1992-93	November 18, 1993	DW Alley & Associates
42	Biology	Monitoring Report San Simeon and Santa Rosa Creeks, 1993-94	March 22, 1995	DW Alley & Associates
43	Biology	Monitoring Results for Lower San Simeon and Santa Rosa Creeks 2000-01	November 1, 2003	DW Alley & Associates
44	Biology	Monitoring Results for Lower San Simeon and Santa Rosa Creeks 2002-03	August 1, 2004	DW Alley & Associates
45	Biology	Monitoring Results for Lower San Simeon and Santa Rosa Creeks, 1997-99	June 1, 2001	DW Alley & Associates
46	Biology	Monitoring Results for San Simeon and Santa Rosa Creeks	1995-1996	DW Alley & Associates

REFERENCE #	DESCRIPTION	WEBSITE	OTHER SOURCE
24	GIS data of stream structures and potential barriers, riparian canopy denisty, embeddedness, geology, habitat level, habitat type, land cover, primary pools, restoration projects, slope, water temperature, erosion of right bank, erosion of left bank, and spawning.	http://ccows.csumb.edu/scdp/data/SantaRosa/index.htm	
25			CCSD resource #138; Bookcase B; Shelf 1
26			CCSD resource #140; Bookcase B; Shelf 1
27			CCSD resource #172 Bookcase B; Shelf 2
28			CCSD resource #216; Bookcase B; Shelf 4 (may be a duplicate)
29			CCSD resource #142; Bookcase B; Shelf 1
30			CCSD resource #135; Bookcase B; Shelf 1
31			CCSD resource #263; Bookcase C; Shelf 3
32			CCSD resource #147; Bookcase B; Shelf 1
33			
34	Prioritized land management tasks	http://nrm.dfg.ca.gov/steelhead/steelhead_tasks.aspx	
35			
36			
37		Blackgold.org	
38	Not an official list	http://www.fws.gov/ventura/esprograms/listing_ch/spplists/species_slo.cfm	
39			CCSD resource #175; Bookcase B; Shelf 3
40			CCSD resource #173 Bookcase B; Shelf 2
41			CCSD resource #143; Bookcase B; Shelf 1
42			CCSD resource #167; Bookcase B; Shelf 2
43			CCSD resource #552; Bookcase F; Shelf 3
44			CCSD resource #230; Bookcase C; Shelf 1
45			CCSD resource #134; Bookcase B; Shelf 1
46			CCSD resource #117; Bookcase B; Shelf 1

REFERENCE #	SUBJECT	TITLE	DATE	AUTHOR
47	Biology	Monitoring Results for San Simeon and Santa Rosa Creeks in 1995 and 1996: Water Quality Conditions in Lagoons, Streamflow Measurements, Fish Sampling in Lagoons and Steelhead Censusing in the Upper Watersheds, San Luis Obispo County, California	1997	DW Alley & Associates
48	Biology	Passage Requirements for Steelhead in Santa Rosa Creek, 1993	July 10, 1993	DW Alley & Associates
49	Biology	Santa Rosa Creek Trail and Stream Bank Restoration Project - Biological Assessment of Existing Conditions, Potential Impacts and Mitigations for the Following Sensitive Aquatic Species: California Red-legged Frog, Southwestern Pond Turtle, Steelhead and Tidewaer Goby	2003	DW Alley & Associates
50	Biology	Special Animals (848 taxa)	October, 2007	California Department of Fish and Game
51	Biology	Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest)-Steelhead	1986	R.A. Barnhart
52	Biology	State and Federally Listed Endangered and Threatened Animals of California	February, 2008	California Department of Fish and Game
53	Biology	State and Federally Listed Endangered, Threatened, and Rare Plants of California	January, 2008	California Department of Fish and Game
54	Biology	Status and Ecology of Sensitive Aquatic Vertebrates in Lower San Simeon and Pico Creeks, San Luis Obispo, California	1993	Rathburn, et al
55	Biology	Status of Declining Aquatic Reptiles, Amphibians and Fish in Lower Santa Rosa Creek	February 1, 1996	
56	Biology	Summary of Steelhead Population and Habitat Sampling, Santa Rosa Creek, San Luis Obispo County, 1993	July 29, 1994	Jennifer Nelson
57	Biology	Technical Bibliography on Monterey Pine, Pinus radiata	October 23, 1998	Rathburn, et al
58	Biology	The Status of Steelhead Populations in CA in Regards to the Endangered Species Act	February 1, 1995	Cramer/Alley et al
59	Biology	Trends in Juvenile Steelhead Production in 1994-2000 for Santa Rosa Creek, San Luis Obispo County, California, with Habitat Analysis and an Index of Adult Returns	2001	DW Alley & Associates
60	Biology	Trends in Juvenile Steelhead Production in 1994-2001 for Santa Rosa Creek, San Luis Obispo County, California, with Habitat Analysis and an Index of Adult Returns	2002	DW Alley & Associates
61	Biology	Trends in Juvenile Steelhead Production in 1994-2002 for Santa Rosa Creek, San Luis Obispo County, California, with Habitat Analysis and an Index of Adult Returns	2003	DW Alley & Associates

REFERENCE #	DESCRIPTION	WEBSITE	OTHER SOURCE
47			CCSD resource #174 Bookcase B; Shelf 2
48			CCSD resource #139; Bookcase B; Shelf 1
49			
50	California Natural Diversity Database (CNDDB)		
51	U.S. Fish and Wildlife Service Biological Report 82 (11.60); U.S. Army Corps of Engineers, TR EL-82-4		
52	California Natural Diversity Database (CNDDB)		
53	California Natural Diversity Database (CNDDB)		
54		http://www.werc.usgs.gov/pb/rathbun1.pdf	
55			CCSD resource #177; Bookcase B; Shelf 3
56			Greenspace
57	A compilation of reports held by the Piedras Blancas Field Station, Western Ecological Research Center, USGS, in San Simeon.	www.greenspacecambria.org/Documents/MontereyPinesBibliography.pdf	
58			CCSD resource #266; Bookcase C; Shelf 3
59			CCSD resource #170 Bookcase B; Shelf 2
60			CCSD resource #217; Bookcase B; Shelf 4 (may be a duplicate)
61			

REFERENCE #	SUBJECT	TITLE	DATE	AUTHOR
62	Biology	Trends in Juvenile Steelhead Production Santa Rosa Creek 1994-2003	August 1, 2004	DW Alley & Associates
63	Biology	Trends in the Juvenile Steelhead Population in 1994-2006 for Santa Rosa Creek, San Luis Obispo County, California with Habitat Analysis and an Index of Adult Returns	June 2007	DW Alley & Associates
64	Biology			
65	Biology			
66	Biology			National Oceanic and Atmospheric Administration
67	Biology		1998	
68	Biology			
69	Forestry	Cambria Forest Management Plan	April 1, 2002	Cambria Forest Committee
70	Forestry	Cambria Monterey Pine Forest Management Plan	April 6, 2001	
71	Geology	California Landscape: Origin and Evolution		Mary Hill
72	Geology	California's Changing Landscapes: a Guide to the Geology of the State	1971	Gordon B. Oakeshott
73	Geology	CaliforniaSerpentines: Flora, Vegetation, Geology, Soils, and Management Problems	1984	Arthur Kruckeberg
74	Geology	Cretaceous Geology of the California Coast Ranges West of the San Andreas Fault: Pacific Coast Paleogeography Field Guide No 2	1977	Howell, Vedder and MacDougall
75	Geology	Drought and Ground Deformation, Cambria, San Luis Obispo, California	1980	G.B. Cleveland
76	Geology	Earthquake Basics Brief No. 1: Liquefaction		Earthquake Engineering Research Institute
77	Geology	Franciscan and Related Rocks and their Significance in the Geology of Western California	1964	Edgar Herbert Bailey
78	Geology	Geologic Map of the Adelaida Quadrangle, San Luis Obispo County, California.	1968	David L. Durham
79	Geology	Geologic Map of the Cambria Region, San Luis Obispo County, California	1974	Calrence Hall
80	Geology	Geologic Map of the San Luis Obispo-San Simeon Region, California	1979	Hall and others
81	Geology	Geology of California	1976	Robert Norris & Robert Webb
82	Geology	Introduction to the Geology of Southern California and its Native Plants	2007	Clarence Hall
83	Geology	Mercury Rising	Volume 23, Issue 52, 2009	Colin Rigley
84	Geology	Preliminary Observations on the December 22, 2003 San Simeon Earthquake	March, 2004	Earthquake Engineering Research Institute

REFERENCE #	DESCRIPTION	WEBSITE	OTHER SOURCE
62			CCSD resource #231; Bookcase C; Shelf 1
63			Greenspace
64	California Department of Fish and Game California Natural Diversity Database	http://www.dfg.ca.gov/biogeodata/cnddb/	
65	California Native Plant Society Inventory of Rare and Endangered Plants, by topo quad	http://cnps.web.aplus.net/cgi-bin/inv/inventory.cgi/BrowseAZ?name=quad	
66	Central California Coast Steelhead DPS	http://swr.nmfs.noaa.gov/recovery/Steelhead_CCCS.htm	
67	Endangered Species List and Descriptions for Santa Barbara and San Luis Obispo Counties	http://www.essexenv.com/endangered_species/	
68	Wieslander Vegetation Type Mapping Project. Search historic photographs and maps by quads. Includes vegetation data associated wth historic photographs.	http://vtm.berkeley.edu/	
69		CCSD website	CCSD resource #25; Bookcase A; Shelf 2
70			CCSD resource #26; Bookcase A; Shelf 2
71		Blackgold.org	Cal Poly State University Library
72			
73			Cal Poly State University; Physics Department
74			
75			
76	Liquefaction: What it is and what to do about it	http://www.eeri.org/cds_publications/earthquake_basics_series/LIQ1.pdf	
77		Blackgold.org	
78	GQ-768		Cal Poly State University; Physics Department
79	Miscellaneous Field Studies. 1:24000. Map MF-599		Cal Poly State University; Physics Department
80	Miscellaneous Investigations Series, 1:48,000. Map I-1097		Cal Poly State University; Physics Department
81		Blackgold.org	
82			Cal Poly State University; Physics Department
83	Cleaning up mercury mining sites in the Central Coast, including Oceanic Mine, in Cambria.	http://www.newtimesslo.com/cover/2994/mercury-rising/	Print
84		http://www.eeri.org/lfe/pdf/usa_san_simeon_eeri_preliminary_report.pdf	

REFERENCE #	SUBJECT	TITLE	DATE	AUTHOR
85	Geology	Preliminary Report and Geologic Guide to Franciscan Melanges of the Morro Bay-San Simeon Area, California	1976	K. Jinghwa Hsu
86	Geology	Quaternary Deformation of the San Luis Range, San Luis Obispo County, California	1994	Lettis, et al
87	Geology	Roadside Geology of Northern and Central California	2000	David Alt
88	Geology	San Luis Obispo Geology Field Trip		Al Stevens
89	Geology	Seismotectonics of the Central California Coast Ranges	1994	
90	Geology	Special Publication 117: Guidelines for Evaluating and Mitigating Seismic Hazards in California	March 13, 1997	State Mining and Geology Board
91	Geology	The Geology of San Luis Obispo County: a Brief Description and Field Guide		David Chipping
92	History	12,000 Years of Cultural Change Along the Central Coast		Parker & Associates Archeological Research
93	History	400 Years of Central California Precipitation Variability Reconstruted from Tree-Rings	1987	Michaelson, Halston and Davis
94	History	Cambria		Gayle Baker
95	History	Cambria Treasures: Interviews with Noteworthy Cambrians		Darren Wetlund
96	History	Captain Portola in San Luis Obispo County	1721-1782	Juan Crespi
97	History	Chronicles of the Cambria Pioneers	1946	Marcus Waltz & Delmar Herbert Williams
98	History	Chumash Place Names. Journal of California Anthropology	1974	Richard Applegate
99	History	Cultural Resourcs Inventory Assessment for Preliminary Environmental Assessment	May 1, 1998	
100	History	Dominion Over Palm and Pine: Paul Squibb and His Students	2001	Gary Lewis
101	History	Emerging from the Ice Age: early Holocene Occupations on the California Central Coast: a Compilation of Research in Honor of Roberta Greenwood	2004	San Luis Obispo County Archaeological Society
102	History	Guide to Historic Cambria		Carol Adams
103	History	History of San Luis Obispo County, California, with Illustrations and Biographical Sketches of its Prominenet Men and Pioneers	1883	Myron Angel
104	History	Inventory and Assessment of Historic Properties for the Santa Rosa Creek Trail Project	March, 2003	Gibson's Archaeological Consulting
105	History	Memories of Cambria		Marjan Swantek
106	History	Memories of the Land: Place Names of San Luis Obispo County	1994	Mark Hall-Patton
107	History	Obispeño and Purismeño Chumash	1978	Roberta Greenwood
108	History	Our Cambria: Intimate Glimpses of a Rare Town		Irina Wilson

REFERENCE #	DESCRIPTION	WEBSITE	OTHER SOURCE
85			
86	Seismotectonics of the Central California Coast Ranges		
87		Blackgold.org	
88		Blackgold.org	
89	Special Paper 292		Cal Poly State University; Physics Department
90			
91		Blackgold.org	
92		http://www.tcsn.net/sloarchaeology/12,000.pdf	
93			
94		Blackgold.org	Cal Poly State University Library-Special Collections
95		Blackgold.org	Cal Poly State University Library-Special Collections
96		Blackgold.org	
97			Cal Poly State University Library-Special Collections
98		Blackgold.org	
99			CCSD resource #11; Bookcase A; Shelf 1
100			Cal Poly State University Library-Special Collections
101		Blackgold.org	
102		Blackgold.org	
103		Blackgold.org	
104			
105		Blackgold.org	
106		Blackgold.org	
107	In R.F. Heizer, vol. ed., Handbook of North American Indians. Vol. 8: California.		
108		Blackgold.org	

REFERENCE #	SUBJECT	TITLE	DATE	AUTHOR
109	History	Russ Leadabrand "sez"	1991	
110	History	The Cambria Forest: Reflections on its Native Pines and its Eventful Past		Taylor Coffman
111	History	The Cambrian		
112	History	The Names and Locations of Historic Chumash Villages (assembled by Thomas Blackburn)	1975	Chester King
113	History	Vision Revision: from Cambria	1981	Paul Squibb
114	History	Where the Highway Ends: A History of Cambria, San Simeon and the Ranchos		Geneva Hamilton
115	Hydrology	Analysis of Borehole Extensometer Data from Central California	1969	F.S. Riley
116	Hydrology	Cambria Drainage and Flood Control Study	November 1, 2003	
117	Hydrology	Cambria Drainage and Flood Control Study	February 1, 2004	
118	Hydrology	Draft Report for Flood Mitigation in the West Village of Cambria	February 16, 2000	
119	Hydrology	Groundwater Recharge Project	December 1, 1991	
120	Hydrology	High School Well	1979	
121	Hydrology	Hydrogeology, Water Quality, Water Budgets, and Simulated Responses to Hydrologic Changes in Santa Rosa and San Simeon Creek Ground-Water Basins, San Luis Obispo County, California	1998	Eugene B. Yates and Kathryn M. Van Konyenburg
122	Hydrology	Hydrologic and Hydraulic Analysis for FEMA CLOMR Application, Cambria, California	September 2005	Questa Engineering Corporation
123	Hydrology	Hydrologic Evaluation of Design and Impacts of CCSD Proposed Groundwater Recharge Project	November 25, 1991	
124	Hydrology	Rainfall Data 1973	1973	
125	Hydrology	San Luis Obispo County Hydrologic Report, Water Years 2001-02 and 2002-03	May 16, 2005	County of San Luis Obispo
126	Hydrology	San Luis Obispo County Investigation	1958	State of California Department of Water Resources Division of Resources Planning
127	Hydrology	SWRCB-CA Division of Water Rights San Simeon & Santa Rosa Creek Underflow	May 19, 1987	
128	Hydrology	The Role of Ground Water in Generating Streamflow in Headwater Areas and in Maintaining Base Flow	February, 2007	Thomas C. Winter
129	Hydrology	Water Supplies for the Central California Coastal Area	May 1, 1969	
130	Hydrology	Water Well Completion Report for CCSD Well SR4	January 1, 2001	
131	Hydrology	WWTP Rain Gage Data	1985-86	
132	Land Use	2006 Management Practice Checklist Update Summary Report	June, 2007	Regional Water Quality Control Board

REFERENCE #	DESCRIPTION	WEBSITE	OTHER SOURCE
109			Cal Poly State University Library-Special Collections
110		Blackgold.org	Cal Poly State University Library-Special Collections
111			Cal Poly State University Library
112			
113			Cal Poly State University Library-Special Collections
114		Blackgold.org	
115			
116			CCSD resource #322; Bookcase C; Shelf 4
117			CCSD resource #323; Bookcase C; Shelf 4
118			CCSD resource #534; Bookcase F; Shelf 3
119			CCSD resource #156; Bookcase B; Shelf 2
120			CCSD resource #446; Bookcase D; Shelf 3
121	Water-Resources Investigations Report 98-4061		Greenspace
122	Creek bypass channel to reduce flooding in West Village.		
123			CCSD resource #159; Bookcase B; Shelf 2
124			CCSD resource #456; Bookcase D; Shelf 3
125		http://www.slocountywater.org/site/Water%20Resources/Reports/Hydrologic%20Report%202002.pdf	
126		Blackgold.org	
127			CCSD resource #352; Bookcase D; Shelf 1
128		http://www.blackwell-synergy.com/doi/abs/10.1111/j.1752-1688.2007.00003.x	
129			CCSD resource #355; Bookcase D; Shelf 1
130			CCSD resource #371; Bookcase D; Shelf 1
131			CCSD resource #457; Bookcase D; Shelf 3
132		http://www.waterboards.ca.gov/centralcoast/AGWaivers/documents/2007_6_11_ChecklistReport_000.pdf	

REFERENCE #	SUBJECT	TITLE	DATE	AUTHOR
133	Land Use	Annual Resource Summary Report	2006	San Luis Obispo County Department of Planning and Building
134	Land Use	Cambria Prks, Recreation and Open Space Needs Assessment	October 11, 1992	
135	Land Use	Coastal Zone Land Use Ordinance - Title 23 of the San Luis Obispo County Code	January, 2006	County of San Luis Obispo
136	Land Use	Draft Environmental Impact Report for Growth Management Ordinance Amendments	June, 2005	County of San Luis Obispo
137	Land Use	Final EIR for Land Use Element & Local Coastal Plan SLO County General Plan	December 10, 1996	
138	Land Use	Final Environmental Impact Report: Cambria Ranch Grading Permit and Development Plan: ED87-41/ED88-127 (D870020D)	May, 1989	QUAD Consultants
139	Land Use	Inactive Metal Mines in Four San Luis Obispo County Watershed	June, 1999	
140	Land Use	Land Use Element - Circulation Element - San Luis Obispo County General - Annual Resource Summary Report	2006	San Luis Obispo County Department of Planning and Building
141	Land Use	Land Use Element & Local Coastal Plan-North Coast Planning Area	April, 1988	San Luis Obispo County Planning Department
142	Land Use	Land Use Ordinance - Title 22 of the San Luis Obispo County Code	January, 2008	County of San Luis Obispo
143	Land Use	North Coast Area Plan	March 1, 1988	
144	Land Use	Surface Water Degradation in North West San Luis Obispo County, California	December, 1993	
145	Land Use			
146	Plan	2005 Fire Management Plan	2005	California Department of Forestry and Fire Protection/San Luis Obispo County Fire Department
147	Plan	2006 North Coast Transit Plan: Cambria Component	January 18, 2007	San Luis Obispo Council of Governments
148	Plan	A General Plan for the Community of Cambria	1964	San Luis Obispo County Planning Department
149	Plan	California Noxious and Invasive Weed Action Plan	September, 2005	California Department of Food and Agriculture and California Invasive Weed Awareness Coalition
150	Plan	California Water Plan Update	2005	Department of Water Resources
151	Plan	Cambria 2010 Community Plan	1989	Cambria Community Services District
152	Plan	Cambria Community Services District Code	August 27, 2006	Cambria Community Services District
153	Plan	Cambria Design Plan Public Review Draft	January 7, 2000	
154	Plan	Cambria Residential Design Plan	May 9, 2002	
155	Plan	Cambria Village Center, Cambria, California: Draft Supplemental Environmental Impact Report	February, 1994	Morro Group, Inc.
156	Plan	Cambria Village Center: Draft Additional Information	March, 1990	Morro Group, Inc.

REFERENCE #	DESCRIPTION	WEBSITE	OTHER SOURCE
133		http://www.slocounty.ca.gov/Assets/PL/pdfs/Annual+Resource+Summary+Report.pdf	
134			CCSD resource #190; Bookcase B; Shelf 3
135		http://www.slocounty.ca.gov/planning/General_Plan__Ordinances_and_Elements/Land_Use_Ordinances.htm	
136			
137			CCSD resource #228; Bookcase B; Shelf 5
138	Highway engineering, Real estate development, Land use, Regional planning, Environmental impact statements, Cambria ranch		Cal Poly State University-Reference Section
139	Surface water quality impact and remedial options		David Schwartz
140			
141			
142		http://www.slocounty.ca.gov/planning/General_Plan__Ordinances_and_Elements/Land_Use_Ordinances.htm	
143			CCSD resource #62; Bookcase A; Shelf 3
144	Santa Rosa Creek Inactive Metal Mining Report		David Schwartz
145	San Luis Obispo Planning and Building Department Website. CEQA, land use, environmental, planning and other pertinent information for local watershed plans.	http://www.slocounty.ca.gov/planning.htm	
146		http://cdfdata.fire.ca.gov/fire_er/fpp_planning_plans_details?plan_id=91	
147			
148			Cal Poly State University-Reference Section
149		http://www.cdfa.ca.gov/phpps/ipc/noxweedinfo/pdfs/noxious_weed_plan.pdf	
150		http://www.waterplan.water.ca.gov/index.cfm	
151			
152		http://municipalcodes.lexisnexis.com/codes/cambria/	
153			CCSD resource #212; Bookcase B; Shelf 4
154			CCSD resource #327; Bookcase C; Shelf 5
155	City Planning, Land Use		Cal Poly State University-Reference Section
156	City Planning, Land Use		Cal Poly State University-Reference Section

REFERENCE #	SUBJECT	TITLE	DATE	AUTHOR
157	Plan	Cambria Village Center: Draft Environmental Impact Report	1988	Morro Group, Inc.
158	Plan	Cambria Village Center: Draft Subsequent Environmental Impact Report	December, 1999	Morro Group, Inc.
159	Plan	Cambria Village Center: Final Environmental Impact Report	1989	Morro Group, Inc.
160	Plan	Cambria Village, Special Report	June, 1972	County of San Luis Obispo Planning Department
161	Plan	Draft Environmental Impact Report, Fiscalini Ranch Development Plan	1981	Envicom Corporation
162	Plan	Draft Environmental Impact Report: Cambria Ranch Grading Permit and Development Plan: ED87-41/ED88-127 (D870020D)	December, 1988	QUAD Consultants
163	Plan	East-West Ranch Public Access and Resource Management Plan	2002	Rincon Consultants, Inc.
164	Plan	General Plan and Land Use Element Draft EIR	1994	San Luis Obispo County Department of Planning and Building
165	Plan	Master Development Plan	November 20, 1995	
166	Plan	Master Development Plan	May 23, 1994	
167	Plan	Mid-State Bank Cambria Development Plan Draft Subsequent Environmental Impact Report	August, 2001	Douglas Wood & Associates
168	Plan	North Coast Area Plan	January 5, 1998	
169	Plan	North Coast Area Plan & Draft EIR		
170	Plan	North coast Area Plan Project Description	January 1, 2000	
171	Plan	North Coast Area Plan Update	January 15, 1998	
172	Plan	Parks & Recreation Master Plan	August 2, 1988	
173	Plan	Parks, Recreation & Open Space Master Plan	November 21, 1994	
174	Plan	Periodic Review of the San Luis Obispo County Local Coastal Plan	February 2, 2001	California Coastal Commission
175	Plan	Policy Statement	October, 1976	Cambria Advisory Council
176	Plan	San Luis Obispo County Master Water Plan	1998	County of San Luis Obispo
177	Plan	SLO County North Coast Area Plan Update Vol. I & II	January 13, 1998	
178	Plan	Supplemental Environmental Impact Report: Cambria Village Center, Cambria, California	June, 1994	Morro Group, Inc.
179	Plan	Water Master Plan		RBF Consulting
180	Plan	Water Resources and Land Use Planning: Coping with Limits in Cambria, California	1987	Kimberly Ann Hansen
181	Regulation	Growth Management Ordinance-Title 26 of the San Luis Obispo County Code	2007	County of San Luis Obispo

REFERENCE #	DESCRIPTION	WEBSITE	OTHER SOURCE
157	City Planning, Land Use		Cal Poly State University-Reference Section
158	City planning, Flood control, Land use, Environmental conditions		Cal Poly State University-Reference Section
159			Cal Poly State University
160	Historic districts, Central business districts, Regional planning, Land use		Cal Poly State University-Reference Section
161			
162	Highway engineering, Real estate development, Land use, Regional planning, Environmental impact statements, Cambria ranch		Cal Poly State University-Reference Section
163		http://www.cambriacsd.org/Library/Website/services/parks/Mgm_%20Plan_%205-22-03.pdf	
164			
165			CCSD resource #213; Bookcase B; Shelf 4
166			CCSD resource #225; Bookcase B; Shelf 5
167	City and regional planning, Land use, Environment		Cal Poly State University-Reference Section
168			CCSD resource #317; Bookcase C; Shelf 4
169			CCSD resource #313; Bookcase C; Shelf 4
170			CCSD resource #295; Bookcase C; Shelf 4
171			CCSD resource #318; Bookcase C; Shelf 4
172			CCSD resource #194; Bookcase B; Shelf 3
173			CCSD resource #189; Bookcase B; Shelf 3
174			
175	Regional planning, Land use		Cal Poly State University-Reference Section
176		http://www.slocountywater.org/site/Frequent%20Downloads/Master%20Water%20Plan/index.htm	
177			CCSD resource #185; Bookcase B; Shelf 3
178	City planning, Flood control, Land use, Environmental impact statements		Cal Poly State University-Reference Section
179	Cambria Community Services District Water Master Plan	http://www.cambriacsd.org/cm/Services/Engineering/water%20master%20plan.html	
180	Water supply, Water resource development		Cal Poly State University-Main Collection
181	County growth regulations	http://www.slocounty.ca.gov/Assets/PL/Ordinances/Title+26+-+Growth+Management+Ordinance.pdf	

REFERENCE #	SUBJECT	TITLE	DATE	AUTHOR
182	Regulation			Environmental Protection Agency
183	Regulation			Environmental Protection Agency
184	Regulation			State Water Resources Control Board
185	Regulation			Environmental Protection Agency
186	Restoration	Effluent Disposal Field & Stream Restoration Improvement Project	August 1, 1993	
187	Restoration	Santa Rosa Creek and Stream Bank Restoration Project	April 2, 203	
188	Restoration	Santa Rosa Creek Enhancement Plan 1993	1993	Prunuske Chatham, Inc.
189	Restoration	Santa Rosa Creek Streambank Protection Project	April 9, 1998	
190	Restoration	Santa Rosa Creek Trail and Stream Bank Restoration Project	April 2, 2003	RBF Consulting
191	Restoration	Steelhead Restoration and Management Plan for California	1996	D. McEwan and T.A. Jackson
192	Soils	Grading, Drainage, Erosion and Sediment Control	1998	
193	Soils	Sediment Yield Variations in Northern Santa Lucia Mountains	2000	Barry Hecht
194	Soils	Soil Characteristics of Blue Oak and Coast Live Oak Ecosystems	1996	Denise Ellen Downie
195	Soils	Soil Data Viewer		USDA, NRCS
196	Soils	Soil Survey Manual	October, 1993	US Department of Agriculture
197	Soils	Soil Survey of San Luis Obispo County, California, Coastal Part	1984	United States Department of Agriculture, Soil Conservation Service
198	Soils	Soil Survey of San Luis Obispo County, California, Paso Robles Area	1977	United States Department of Agriculture, Soil Conservation Service
199	Soils	The Influence of Annual Precipitation, Topography, and Vegetative Cover on Soil Moisture and Summer Drought in Southern California	1983	Miller, Poole and Miller
200	Transportation	Cambria Erosion and Sediment Study	Ammended June 18, 1998	USDA NRCS Watershed Planning Services, Engineering, and Resource Technology Staffs
201	Transportation	Embankment Failure Investigation of California State Highway 46 at Post Mile 4.15	2000	David Serafini
202	Transportation	Slope Stability Investigation on California Highway 46 Post Mile 0.5 East of Cambria	December, 1995	John K. Sanchez
203	Water quality	Annual Water Quality Report	1989	Cambria Community Services District
204	Water quality	County of San Luis Obispo Stormwater Pollution Prevention and Discharge Control Ordinance	2006	County of San Luis Obispo
205	Water quality	Draft Central Coast Water Quality Data Synthesis, Assessment, and Management (SAM) Project		Conley, DeBeukelaer and Hoover
206	Water quality	National Pollutant Discharge Elimination System (NPDES) Phase II Storm Water Management Plan County of San Luis Obispo	2006	County of San Luis Obispo

REFERENCE #	DESCRIPTION	WEBSITE	OTHER SOURCE
182	Endangered Species Act	http://www.epa.gov/lawsregs/laws/esa.html	
183	Federal Clean Water Act	http://www.epa.gov/lawsregs/laws/cwa.html	
184	Porter Cologne Water Quality Control Act	http://www.swrcb.ca.gov/water_laws/docs/portercologne.pdf	
185	The California Environmental Quality Act (CEQA)	http://ceres.ca.gov/ceqa/	
186			CCSD resource #160; Bookcase B; Shelf 2
187			CCSD resource #440; Bookcase D; Shelf 3
188			CCSD resource #148; Bookcase B; Shelf 1
189			CCSD resource #496; Bookcase F; Shelf 1
190			Greenspace
191			
192			CCSD resource #219; Bookcase B; Shelf 5
193		http://www.balancehydro.com/pdf/Hecht,%202000,%20Sed%20Yield%20N.%20Lucia%20Mts.,%20Balance%2099066.pdf	
194	Masters Thesis		Cal Poly State University
195	Website with supporting soils data	http://soildataviewer.nrcs.usda.gov/	
196		http://soils.usda.gov/technical/manual/	Government Printing Office (GPO)
197	In cooperation with University of California Agricultural Experiment Station		
198	In cooperation with University of California Agricultural Experiment Station		
199			
200	Erosion study, mostly of roads, in the Lodge Hill community of Cambria.		CCSD resource #151; Bookcase B; Shelf 2; USLT RCD Office
201	Senior project		California Polytechnic State University, Kennedy Library, Senior Project
202	Senior project		California Polytechnic State University, Kennedy Library, Senior Project
203			
204		http://www.slocounty.ca.gov/Assets/PW/stormwater/Draft_IDDE_Ordinance_12-07.pdf	
205	Prepared with the Monterey Sanctuary/ Sanctuary Integrated Monitoring Network		
206		http://www.slocounty.ca.gov/Assets/PW/stormwater/SWMPRev3.pdf	

REFERENCE #	SUBJECT	TITLE	DATE	AUTHOR
207	Water quality	Results of Santa Rosa Creek Visual Field Survey and Water Quality Sampling 6/2000	September 1, 2000	
208	Water quality	Results of Santa Rosa Creek Visual Field Survey and Water Quality Sampling 6/2001	April 8, 2002	
209	Water quality	Storm Water Pollution Prevention Plan	September 1, 2003	
210	Water quality	Stormwater Management Area Assessments and Maps		
211	Water quality	Surface Water Monitoring 1993-94	1994	
212	Water quality	The Role of Headwater Streams in Downstream Water Quality	2007	Alexander, et al
213	Water quality	Water 2006: Consumer Confidence Report	2006	Cambria Community Services District
214	Water quality	Water Quality Control Plan (Basin Plan) Central Coast Region	1994	Regional Water Quality Control Board
215	Water quality		2000	California State Water Resources Control Board
216	Water quality		2000	California State Water Resources Control Board
217	Water quality			
218	Water quality		2001	California State Water Resources Control Board
219	Water Rights	Administrative Final EIR for Santa Rosa Creek Water Rights Project	April 1, 1987	McClelland
220	Water Rights	Exhibit to Analysis of CCSD Water Rights in Santa Rosa Creek 1/8/01 Vol. I & II	January 8, 2001	
221	Water Rights	Final Impact Report for Santa Rosa Creek Water Rights Project	November 1, 1987	McCelland Engineers, Inc.
222	Water Treatment	Riparian Enhancement, Revegetation and Screening Program	December 1992/ Revised January 1993	
223	Water Treatment	Santa Rosa Creek Sewer Line Crossing	April 1, 1982	
224	Water Use	Assessment of Long-Term Water Supply Alternatives CCSD	April 1, 2003	
225	Water Use	CCSD Water Conservation and Sewer Study and Appendices	March 12, 1992	
226	Water Use	Drought Management Plan	March 1, 1989	
227	Water Use	Master Water Plan	August, 1998	
228	Water Use	Urban Water Management Plan	June 12, 1989	Stratford
229	Water Use	Urban Water Use in California	1983	California Department of Water Resources
230	Water Use	Vegetative Water Use in California	1975	California Department of Water Resources
231	Water Use	Water Shortage Contingency Plan	June 22, 1992	
232	Water Use			
233	Wetlands	Public Access and Wetlands: Impact of Recreational Use	1989	
234	Wetlands	Status and Trends of Wetlands in the Conterminous United States 1998 to 2004	2006	T.E. Dahl

REFERENCE #	DESCRIPTION	WEBSITE	OTHER SOURCE
207			CCSD resource #237; Bookcase C; Shelf 1
208			CCSD resource #238; Bookcase C; Shelf 1
209			CCSD resource #551; Bookcase F; Shelf 3
210		http://www.slocounty.ca.gov/Assets/PW/stormwater/appa_a.pdf	
211			CCSD resource #155; Bookcase B; Shelf 2
212		http://www.blackwell-synergy.com/doi/abs/10.1111/j.1752-1688.2007.00005.x	
213	Brochure describes water resources, water quality and conservation techniques for the area.	http://www.cambriacsd.org/Library/Website/services/water/2006%20CCR%20brochure.pdf	
214			
215	Nutrients	http://www.swrcb.ca.gov/tmdl/background.html	
216	Nutrients	http://www.swrcb.ca.gov/nps/docs/nutrient_tac.doc	
217	State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Data Management	http://www.swrcb.ca.gov/swamp/	
218	TMDL	http://www.swrcb.ca.gov/tmdl/docs/tmdl_factsheet	
219			CCSD resource #350; Bookcase D; Shelf 1
220			CCSD resource #349; Bookcase D; Shelf 1
221			CCSD resource #360; Bookcase D; Shelf 1
222			CCSD resource #87; Bookcase A; Shelf 3
223			CCSD resource #90; Bookcase A; Shelf 3
224			CCSD resource #29; Bookcase A; Shelf 2
225			CCSD resource #161; Bookcase B; Shelf 2
226			CCSD resource #258; Bookcase C; Shelf 2
227		http://www.slocountywater.org/site/Frequent%20Downloads/Master%20Water%20Plan/index.htm	
228			CCSD resource #443; Bookcase D; Shelf 3
229	Bulletin 166-3		
230	Bulletin 133-3		
231			CCSD resource #259; Bookcase C; Shelf 2
232	California Department of Water Resources California Irrigation Management Information Systems (CIMIS)	http://wwwcimis.water.ca.gov/cimis/welcome.jsp	
233			CCSD resource #191; Bookcase B; Shelf 3
234			