Coastal Watershed
Planning & Assessment
Program

San Luis Rey River Basin Assessment

April
2010

State of California

Governor, Arnold Schwarzenegger

California Department of Fish & Game

Director, John McCamman

Pacific States Marine Fisheries Commission

Executive Director, Randy Fisher

San Luis Rey River Watershed Assessment

Prepared through a cooperative effort by

California Department of Fish and Game

Pacific States
Marine Fisheries Commission

Coastal Watershed Planning and Assessment Program

April, 2010

California Department of Fish and Game

Coastal Watershed Planning and Assessment Program

Participants:

California Department of Fish and Game
Director, John McCamman

Pacific States Marine Fisheries Commission
Senior Manager, Stan Allen

Coastal Watershed Planning and Assessment Program
Program Manager, Scott T. Downie
Senior Biologist Supervisor

San Luis Rey River Watershed Assessment Contributors:

CWPAP Team Leader: Scott Downie
Primary Author: David Kajtaniak
Senior Biologist Supervisor: Mary Larson
GIS Specialist: Kim Pettit
Geologist: Dave Heaton
Data Technician/Technical Editor: Vikki Avara-Snider
Programmer: Karen Wilson
Environmental Scientist: Holly Sheradin
Fisheries Technicians: Ken Snyder and Christian Delgado

Acknowledgements: Mission Resource Conservation District, City of Oceanside, NMFS, Vista Irrigation District, Golden State Flycasters/Trout Unlimited, San Diego Trout, Pala Band of Mission Indians, SLR Watershed Council

Suggested Citation:

Kajtaniak, David and Downie, Scott T. 2010. San Luis Rey River Watershed Assessment. Coastal Watershed Planning and Assessment Program. Department of Fish and Game.

Table of Contents

List of Figures

List of Tables

California Coastal Watershed Planning and Assessment Program

Introduction and Overview

The Coastal Watershed Planning and Assessment Program (CWPAP) is a program of the California Department of Fish and Game (CDFG) based in Fortuna, CA. CDFG's large scale assessment efforts began in 2001 as a component of the North Coast Watershed Assessment Program (NCWAP), an interagency effort between the California Resources Agency and the Environmental Protection Agency. Due to budget constraints, the NCWAP was discontinued in 2003, but CDFG decided to continue large scale watershed assessments along California's coast to facilitate fishery improvement and recovery efforts.

The 560 square mile San Luis Rey (SLR) River Basin, which is located in northern San Diego County was selected as a CWPAP assessment area because of its potential to support anadromous southern California steelhead populations. Southern California Coast Steelhead are federally listed as endangered. The National Marine Fisheries Service (NMFS) originally designated this listing in 1997 and has since developed a Southern California Steelhead Recovery Plan (*Draft* 2009) to help restore population numbers of this Distinct Population Segment (DPS) of steelhead. The CDFG produced the Steelhead Restoration and Management Plan for California (1996), which is also intended to assist the recovery of steelhead populations. These recovery plans were utilized considerably in the production of this report.

This assessment report was guided by following the outlines, methods, and protocols detailed in the NCWAP Methods Manual (Bleier et al., 2003). The program's assessment is intended to provide answers to six guiding assessment questions at the basin, subbasin, and tributary scales.

Program Guiding Questions

- What are the history and trends of the size, distribution, and relative health and diversity of salmonid coastal populations?
- What are the current salmonid habitat conditions; how do these conditions compare to desired conditions?
- What are the effects of geologic, vegetative, fluvial, and other endemic watershed attributes on natural processes and watershed and stream conditions?
- How has land use affected or disturbed these natural attributes, processes, and/or conditions?
- As a result of those attributes, natural processes, and land use disturbances, are there stream and habitat elements that could be considered to be factors currently limiting steelhead production?
- If so, what watershed management and habitat improvement activities would most likely lead toward more desirable conditions for steelhead in a timely, reasonable, and cost effective manner?

These questions systematically focus the assessment procedures, data gathering and provide direction for syntheses, including the analysis of factors affecting anadromous salmonid production. The questions progress from the relative status of the steelhead resource, to an assessment of the watershed context by looking at processes and disturbances, and lastly to the resultant conditions encountered directly by the fish– flow, water quality, nutrients, and instream habitat elements, including free passage at all life stages. The watershed products delivered to streams shape the stream and create habitat conditions. Thus, watershed processes and human influences determine salmonid health and production and help identify what improvements could be made in the watershed and its streams.

CWPAP assessments do not address marine influences on the ocean life cycle phase of anadromous salmonid populations. While these important influences are outside of the scope of this program, we recognize their critical role upon sustainable salmonid populations and acknowledge that good quality fresh water habitat alone is not adequate to ensure sustainability. However, freshwater habitat improvements benefit their well being and survival during their two freshwater life cycle phases and thus can create stronger year classes to the ocean.

Goals

- Organize and provide existing information and develop limited baseline data to help evaluate the effectiveness of various resource protection programs over time;
- Provide assessment information to help focus watershed improvement programs, and to assist landowners, local watershed groups, and individuals in developing successful projects. This will help guide support programs, such as the CDFG Fishery Restoration Grants Program (FRGP), toward those watersheds and project types that can efficiently and effectively improve freshwater habitat and lead to improved salmonid populations;
- Provide assessment information to help focus cooperative interagency, nonprofit, and private sector approaches to protect watersheds and streams through watershed stewardship, conservation easements, and other incentive programs;
- Provide assessment information to help landowners and agencies better implement laws that require specific assessments such as the State Forest Practice Act, Clean Water Act, and State Lake and Streambed Alteration Agreements.

Southern California Coast Steelhead, Stream, and Watershed Issues

Southern California Coast anadromous steelhead trout (*Oncorhynchus mykiss*) hatch in freshwater, migrate to the ocean as juveniles where they grow and mature, and then return as adults to freshwater streams to spawn (Figure 1). This general anadromous salmonid life history pattern is dependent upon a high quality freshwater environment at the beginning and end of the cycle. Steelhead stocks utilize diverse inter-specific and intra-specific life history strategies to increase the odds for survival of species encountering a wide range of environmental conditions in both the freshwater and marine environments. These strategies include the timing and locations for spawning, length of freshwater rearing, juvenile habitat partitioning, a variable estuarine rearing period, and different physiologic tolerances for water temperature and other water quality parameters.

It has been common practice to refer to individuals completing their entire life-history cycle in freshwater as rainbow trout, while classifying those emigrating to and maturing in the ocean before returning to reproduce in freshwater as steelhead. However, this terminology may not capture the complexity of the life-history cycles of native *O. mykiss* (NMFS 2007). Resident and anadromous forms may exist in the same stream system, and individuals can complete their life-history cycle completely in freshwater, or they can migrate to the ocean after one to three years, and spend two to four years in the marine environment before returning to freshwater rivers and streams to spawn. Switching between the freshwater and an anadromous life-history cycle is probably widespread (NMFS 2007). Moreover, the resident populations presumably interbreed with anadromous fish (USFWS 1998 and NMFS 2007); therefore, resident trout appear to play a vital role in the sustainability of the anadromous steelhead population.

Steelhead trout thrive or perish during their freshwater phases depending upon the availability of cool, clean water, free access to migrate up and down their natal streams, clean gravel suitable for successful spawning, adequate food supply, and protective cover to escape predators and ambush prey. These life requirements must be provided by diverse and complex instream habitats as the fish move through their life cycles. If any life requirements are missing or in poor condition at the time a fish or stock requires it, fish survival can be impacted. These life requirement conditions can be identified and evaluated on a spatial and temporal basis at the stream reach and watershed levels. They comprise the factors that support or limit salmonid stock production.

The specific combination of these factors determines the carrying capacity for salmonids in each particular stream. The carrying capacity can thus be changed if one or more of the factors are altered. The importance of individual factors in setting the carrying capacity differs with the life stage of the fish and time of year. All of the important factors for salmonid health must be present in a suitable, though not always optimal, range in streams where fish live and reproduce (Bjorrn and Reiser 1991). Varying slightly from northern stocks of steelhead, the Southern California Coast Steelhead Distinct Population Segment (DPS), depending on water quantity and quality, available access and suitability of instream habitat conditions, are more likely to stray to other streams as opposed to their stream of origin. This may allow for re-colonizing streams that have been extirpated for some years due to prolonged drought, devastating fires, or other adverse effects (Swift 2003).

Figure 1. Photo of adult steelhead observed in the lower SLR River near Oceanside, May 2007

Within the range of anadromous salmonid distribution, historic stream conditions varied at the regional, basin and watershed scales. The majority of studies involving steelhead ecology has been conducted on northern populations and only recently have studies been published about the ecological requirements of southern steelhead. Despite the lack of technical data, it has been widely observed that wild southern steelhead evolved with their streams shaped in accordance with the inherent, biophysical characteristics of their parental watersheds, and stochastic pulses of fires, landslides, and climatic events. In some reaches of southern California vegetation may be naturally sparse; nonetheless, riparian vegetation generally plays an important role in the overall ecosystem of streams. In forested streams, trees grew along the stream banks contributing shade, adding to bank stability, and moderating air and stream temperatures during hot summers and cold winter seasons. The streams contained fallen trees and boulders, which created instream habitat diversity and complexity. The large mass of wood in streams provided important nutrients to fuel the aquatic food web. During winter flows, sediments were scoured, routed, sorted, and stored around solitary pieces and accumulations of large wood, bedrock, and boulders forming pools riffles and flatwater habitats. In southern California large instream boulders or canyon walls may provide shade and cover in the absence of woody material.

Two important watershed goals are the protection and maintenance of high quality fish habitats. In addition to preservation of high quality habitat, reparation of streams damaged by poor resource management practices of the past is important for anadromous salmonids. Science-based management has progressed significantly and "enough now is known about the habitat requirements of salmonids and about good management practices that further habitat degradation can be prevented, and habitat rehabilitation and enhancement programs can go forward successfully" (Meehan 1991).

Through the course of natural climatic events, hydrologic responses and erosion processes interact to shape freshwater salmonid habitats. These processes influence the kind and extent of a watershed's vegetative cover and act to supply nutrients to the stream system. When there are no large disturbances, these natural processes continuously make small changes in a watershed. Managers must constantly judge these small natural changes as well as changes made by human activity. Habitat conditions can be drastically altered when major disruptions of these small interactions occur (Swanston 1991).

Major watershed disruptions can be caused by catastrophic events, such as the flood events that occurred along the south coast in 1980 and 1993. These floods were system reset events. They can also be created over time by multiple small natural or human disturbances. These disruptions can drastically alter instream habitat conditions and the aquatic communities that depend upon them. Thus, it is important to understand the critical, interdependent relationships of steelhead with their natal streams during their freshwater life phases, and their streams' dependency upon the watersheds within which they are nested, and the energy of the watershed processes that binds them together.

In general, natural disturbance regimes like landslides and wildfires do not impact larger basins like the 560 square mile SLR River in their entirety at any given time. Rather, they normally rotate episodically across the entire basin as a mosaic composed of the smaller subbasin, watershed, or sub-watershed units over long periods. This creates a dynamic variety of habitat conditions and quality over the larger basin (Reice 1994).

The rotating nature of these relatively large, isolated events at the regional or basin scale assures that at least some streams in the area will be in suitable condition for salmonid stocks. A dramatic, large-scale example occurred in May 1980 in the Toutle River, Washington, which was inundated in slurry of debris and ash when Mt. St. Helens erupted. The river rapidly became unsuitable for fish. In response, returning salmon runs avoided the river that year and used other nearby suitable streams on an opportunistic basis, but returned to the Toutle two years later as conditions improved. This return occurred much sooner than had been initially expected (Quinn et al. 1991; Leider 1989).

Human disturbance sites, although individually small in comparison to natural disturbance events, usually are spatially distributed widely across basin level watersheds (Reeves et al. 1995). For example, a rural road or building site is an extremely small land disturbance compared to a forty-acre landslide or wildfire covering several square miles. However, when all the roads in a basin the size of the SLR River are looked at collectively, their disturbance effects are much more widely distributed than a single large, isolated landslide that has a high, but relatively localized impact to a single sub-watershed.

Human disturbance regimes collectively extend across basins and even regional scales and have lingering effects. Examples include water diversions, conversion of near stream areas to urban usage, removal of large mature vegetation, widespread soil disturbance leading to increased erosion rates, construction of levees or armored banks that can disconnect the stream from its floodplain, and the installation of dams and reservoirs that disrupt normal flow regimes and prevent free movement of salmonids and other fish. These disruptions often develop in concert and in an extremely short period of time on the natural, geologic scale.

Human disturbances are often concentrated in time because of newly developed technology or market forces, such as the California Gold Rush or the significant increase in dam construction and water diversions post-WWII in southern California. The intense human land use of the last century including agriculture, urbanization, silviculture, mining, dewatering, channelization of creeks, man-made barriers, combined with the introduction of exotic fish and riparian plants and extended climatic dry cycles, created stream habitat impacts at the basin and regional scales. The result of these recent combined disruptions has overlain the pre-European disturbance regime process and conditions.

Consequently, stream habitat quality and quantity are generally depressed across most of the South Coast region. It is within this widely impacted environment that both human and natural disturbances continue to occur, but with vastly fewer habitat refugia lifeboats than were historically available to steelhead. Thus, the near extirpation of steelhead stocks can at least partially be attributed to this impacted freshwater environment.

Factors Affecting Anadromous Steelhead Production

A main component of the program is the analyses of the freshwater factors in order to identify whether any of these factors are at a level that limits production of anadromous steelhead in South Coast basins. This limiting factors analysis (LFA) provides a means to evaluate the status of a suite of key environmental factors that affect anadromous salmonid life history1*. These analyses are based on comparing measures of habitat components such as water temperature and pool complexity to a range of reference conditions determined from empirical studies and/or peer reviewed literature. If a component's condition does not fit within the range of reference values, it may be viewed as a limiting factor. This information will be useful to identify underlying causes of stream habitat deficiencies and help reveal if there is a linkage to watershed processes and land use activities.

Steelhead trout utilize headwater streams, larger rivers, estuaries, and the ocean for the different facets of their life history cycles. There are several factors necessary for the successful completion of an anadromous salmonid life history. This report will focus on the brackish (estuary) and freshwater phases. In these phases, adequate flow, suitable water quality, free passage, suitable stream conditions, and functioning riparian areas are essential for survival. These are explained in more detail in the following sections.

---

[1]* The concept that fish production is limited by a single factor or by interactions between discrete factors is fundamental to stream habitat management (Meehan 1991). A limiting factor can be anything that constrains, impedes, or limits the growth and survival of a population.

Water Quantity

Stream flow is a major limiting factor for steelhead, affecting fish passage, and quantity and quality of spawning, rearing, and refugia areas. For successful salmonid production, stream flows should follow the undisturbed hydrologic regime of the basin. Habitats with increased current velocity and turbulence usually contain higher dissolved oxygen and food levels; if accessible, steelhead prefer such habitat, particularly under conditions of oxygen stress at higher temperatures (Stoecker and Coast Project Conception 2002). Adequate instream flow during low flow periods is essential for fish passage in the summer time, and is necessary to provide juvenile salmonids free forage range, cover from predation, and utilization of localized temperature refugia from seeps, springs, and cool tributaries. That is not to discount the importance of intermittent streams or intermittent reaches. Studies have shown *O. mykiss* to use intermittent streams successfully for both spawning and rearing activities, in some instances as frequently as perennial streams (Boughton et al. 2009). Concerning adult movement, it has been reported that 7 inches is the minimum depth required for successful migration of adult steelhead (Thompson 1972, as cited in Stoecker and Coastal Project 2002), however, the distance fish must swim through shallow water areas is also critical. A natural hydrologic regime also plays an important role in the fluvial transport of sediments providing important habitat components for freshwater species as well as natural sand replacement for southern California beaches.

Numerous South Coast streams and rivers once contained year-round surface flows and allowed adult steelhead to access potential spawning grounds, provided rearing habitat, and facilitated downstream juvenile emigrations to reach the estuary and hence the ocean. Alterations within these watersheds like dam construction, development of water diversions on mainstems and tributaries, and overdrafting of underground aquifers have resulted in severely reduced, or in some cases, the complete elimination of stream flows. Salmonids evolved with the natural hydrograph of coastal watersheds, and changes to the timing, magnitude, and duration of low flows and storm flows can disrupt the ability of fish to follow life history cues. Consequently, in recent decades there have been an inadequate number of opportunities for steelhead to utilize many streams and rivers in the south coast region, including the SLR River Basin.

Water Quality

Important aspects of water quality for anadromous salmonids are water temperature, turbidity, sediment load, and water chemistry. Beginning with the significance of water temperature, a collaborative report by NMFS, the U.S. Fish and Wildlife Service (USFWS) and the Environmental Protection Agency (EPA) (Spence et al. 1996) stated: "stream temperatures influence virtually all aspects of salmonid biology and ecology, affecting development, physiology, and behavior of fish, as well as mediating competitive, predator-prey and disease-host relationships." Additionally, cool water holds more oxygen, and salmonids require high levels of dissolved oxygen in all stages of their life cycle. Accordingly, the NMFS and Kier Associates' *Guide to the reference values used in south-central/southern California Coast Steelhead conservation action planning (CAP) workbooks* (2008) proposed maximum weekly maximum temperature (MWMT) interim reference values for Southern Coast California Steelhead DPS. The report states how recent studies helped determine temperature suitability of *O. mykiss*: "Temperature thresholds are set to reflect findings that steelhead in the region may persist in water temperatures above 25°C (Spina, 2006; 2007)." Proposed interim reference values for MWMT for South Coast California steelhead are as follows: < 17°C = Very Good, 17 -22.5°C = Good, 22.5-25°C = Fair, > 25.0°C = Poor.

A second important aspect of water quality is turbidity. Fine suspended sediments (turbidity) affect nutrient levels in streams that in turn affect primary productivity of aquatic vegetation and insect life (i.e. macroinvertebrates). This eventually reverberates through the food chain and affects salmonid food availability. Additionally, high levels of turbidity interfere with a juvenile salmonids' ability to feed and can lead to reduced growth rates and survival (McBain & Trush personal communication).

A third important aspect of water quality is stream sediment load. Salmonids cannot successfully reproduce when forced to spawn in streambeds with excessive silt, clays, and other fine sediment. Eggs and embryos suffocate under excessive fine sediment conditions because oxygenated water is prevented from passing through the egg nest, or redd. Additionally, high sediment loads can cap the redd and prevent emergent fry from escaping the gravel into the stream at the end of incubation. High sediment loads can also cause abrasions on fish gills, which may increase susceptibility to infection. At extreme levels, sediment can clog the gills causing death. Additionally, materials toxic to salmonids can cling to sediment and be transported through downstream areas.

Water chemistry is also an integral component of evaluating water quality and the overall health of the aquatic environment. Water chemistry interacts with basic trophic levels affecting the production and availability of food for aquatic organisms. Nutrients are often limiting factors in the biological capacity of a stream yet a proper balance is needed to prevent eutrophication. Pollutants are a concern where they interfere with the biological function of aquatic organisms, or can be a threat to those that consume them. Large sources of nutrients and pollutants are commonly associated with urban runoff from the MS4, industrial wastewater facilities, storm runoff, and agricultural operations. Naturally occurring nutrients and heavy metals are often found in much smaller concentrations. In a recent paper published in the December 2009 issue of the journal *Ecological Applications*, biologists examined the effects of pesticides in rivers and basins on the growth and size of wild salmon populations. The study results indicated that short-term (i.e. four-day) exposures that are representative of seasonal pesticide use, such as diazinon and malathion, may be sufficient to reduce the growth and size at ocean entry of juvenile chinook (Baldwin et al 2009). The paper concluded that exposures to common pesticides may place important constraints on the recovery of ESA-listed salmon species. Considering the widespread use of pesticides including insecticides, herbicides and fungicides that are usually applied to agricultural and urban landscapes throughout the Basin this may be an issue to consider while performing and tracking water quality monitoring results.

Fish Passage

Free passage describes the absence of barriers to the free instream movement of adult and juvenile salmonids. Free movement in streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can disrupt steelhead trout's ability to complete the various stages of their lifecycle.

Instream Habitat Conditions

Complex habitat is important for all lifecycle stages of salmonids. Habitat diversity for steelhead trout is created by a combination of deep pools, riffles, and flatwater habitat types. Pools, and to some degree flatwater habitats, provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas; if they are of sufficient depth, pools provide necessary cover and refuge from high summer water temperatures. They are also necessary for adult resting areas. A high level of fine sediment fills pools and flatwater habitats. This reduces depths and can bury complex niches created by large substrate and woody debris. Riffles provide clean spawning gravels and oxygenate water as it tumbles across them. Steelhead fry use riffles during rearing. Flatwater areas often provide spatially divided pocket water units (Flosi et al. 1998) that separate individual juveniles, which helps promote reduced competition and successful foraging.

Estuarine areas can be a critical component of juvenile salmonids transition from a freshwater to saltwater environment. Previous estuarine studies have shown that growth rates are greater in juvenile steelhead utilizing the estuarine environment (Shapovalov and Taft 1954; Smith 1994), which, in turn, increases the chance for marine survival and may define adult production from the watershed (Hayes et al. 2008). The NMFS Southern Steelhead Recovery Plan (2009 *Draft*) designated estuarine areas that provide uncontaminated water and substrates; food and nutrient sources to support growth and development; and connected shallow water areas and wetlands to cover and shelter juveniles as critical habitat essential to the recovery of steelhead.

Riparian Zone

A functional riparian zone helps to control the amount of sunlight reaching the stream, provides vegetative litter, and contributes invertebrates to the local salmonid diet. These contribute to the production of food for the aquatic community, including salmonids. Tree roots and other vegetative cover provide stream bank cohesion and buffer impacts from adjacent uplands. Near-stream vegetation eventually provides large woody debris and complexity to the stream (Flosi et al. 1998).

Riparian zone functions are important to anadromous salmonids for numerous reasons. Riparian vegetation helps keep stream temperatures in the range that is suitable for salmonids by maintaining cool stream temperatures in the summer and insulating streams from heat loss in the winter. Larval and adult macro-invertebrates are important to the salmonid diet and are dependent upon nutrient contributions from the riparian zone. Additionally, stream bank cohesion and maintenance of undercut banks provided by riparian zones in good condition maintain diverse salmonid habitat, and help reduce bank failure and fine sediment yield to the stream. Lastly, the woody debris provided by riparian zones shapes channel morphology, helps retain organic matter and provides essential cover for salmonids (Murphy and Meehan 1991).

Therefore, excessive natural or man-caused disturbances to the riparian zone, as well as directly to the stream and/or the basin itself can have serious impacts to the aquatic community, including anadromous salmonids. Generally, this seems to be the case in streams and watersheds in the south coast of California. This is a significant component of the relatively recent decision to list Southern California Coast Steelhead trout stocks under the Endangered Species Act.

Disturbance and Recovery of Stream and Watershed Conditions

Natural and Human Disturbances

The forces shaping streams and watersheds are numerous and complex. Streams and watersheds change through dynamic processes of disturbance and recovery (Madej 1999). In general, disturbance events alter streams away from their equilibrium or average conditions, while recovery occurs as stream conditions return towards equilibrium after disturbance events. Given the program's focus on anadromous salmonids, an important goal is to determine the degree to which current stream and watershed conditions in the region are providing salmonid habitat capable of supporting sustainable populations of anadromous salmonids. To do this, we must consider the habitat requirements for all life stages of salmonids. We must look at the disturbance history and recovery of stream systems, including riparian and upslope areas, which affect the streams through multiple biophysical processes.

Disturbance and recovery processes can be influenced by both natural and human events. A disturbance event such as sediment from a natural landslide can fill instream pools providing steelhead habitat just as readily as sediment from a road failure. On the recovery side, natural processes (such as small stream-side landslides) that replace instream large woody debris washed out by a flood flow help to restore salmonid habitat, as does large woody debris placed in a stream by a landowner as a part of a restoration project.

Natural disturbance and recovery processes, at scales from small to very large, have been at work on south coast watersheds since their formation millions of years ago. Recent major natural disturbance events have included large flood events such as occurred in 1969, 1980, and 1995; ground shaking and related tectonic uplift associated with the 1992 Landers earthquake; and the wildfires of 2003 and 2007 that burned extensive areas in southern California.

Major human disturbances (e.g., post-European development, dam construction, water diversions and extractions, agricultural and residential conversions, and the methods of sand mining practices used particularly before the implementation of the 1972 Clean Water Act and provisions that followed) that occurred over the past 150 years have adversely altered stream habitat conditions for salmonids. Salmonid habitat also was degraded during parts of the last century by well-intentioned but misguided restoration actions such as removing large woody debris from streams (Ice 1990). More recently, efforts at watershed restoration have been made both on a local level with more watershed groups and councils emerging and creating watershed restoration plans as well as on a regional scale with federal and state agencies developing recovery plans for salmonid species. Localized restoration efforts include riparian tree plantings, water quality monitoring, river clean-ups, and minor dam removal from some streams to clear barriers allowing adults access to spawning grounds and facilitating movement of juvenile anadromous fish. For a thorough treatment of stream and watershed recovery processes, see the publication by the Federal Interagency Stream Restoration Working Group (FISRWG 1998).

Defining Recovered

There is general agreement that improvements in a condition or set of conditions constitute recovery. In that context, recovery is a process. One can determine a simple rate of recovery by the degree of improvement over some time period, and from only two points in time. One can also discuss recovery and rates of recovery in a general sense. However, a simple rate of recovery is not very useful until put into the context of its position on a scale to the endpoint of recovered.

In general, recovered fish habitat supports a suitable and stable fish population. Recovered not only implies, but necessitates, knowledge of an endpoint. In the case of a recovered watershed, the endpoint is a set of conditions deemed appropriate for a watershed with its processes in balance and able to withstand perturbations without large fluctuations in those processes and conditions. However, the endpoint of recovered for one condition or function may be on a different time and geographic scale than for another condition or function.

Some types and locations of stream recovery for salmonids occur more readily than others. For example, in headwater areas where steeper source reaches predominate, suspended sediment such as that generated by a streamside landslide or a road fill failure may start clearing immediately, while coarser sediments carried as bedload tend to flush after a few years (Lisle 1981a; Madej and Ozaki 1996). Broadleaf riparian vegetation can return to create shading, stabilize banks, and improve fish habitat within a decade or so. In contrast, in areas lower in the watershed where lower-gradient response reaches predominate, it can take several decades for deposited sediment to be transported out (Madej 1982; Koehler et al. 2001), for widened stream channels to narrow, for aggraded streambeds to return to pre-disturbance level, and for streambanks to fully re-vegetate and stabilize (Lisle 1981b). Lower reach streams will require a similar period for the near-stream trees to attain the girth needed for recruitment into the stream as large woody debris to help create adequate habitat complexity and shelter for fish, or for deep pools to be re-scoured in the larger mainstems (Lisle and Napolitano 1998).

Factors and Rates of Recovery

Contrasting several changes have allowed the streams and aquatic ecosystems to move generally towards recovery in North Coast streams, the majority of South Coast streams have had additional impacts that prevent or even deteriorate the overall health of aquatic ecosystems. Over the past quarter-century, the North Coast region has seen the rate of timber harvest decline while timber harvest practices have greatly improve, stream protections have increased, and numerous, diverse restoration projects have been implemented. While in South Coast streams pressure on available water sources have increased, water quality is impaired in many streams and rivers, fish passage problems are widespread, exotic flora and fauna are common, and restoration activities intended to assist steelhead recovery have only recently taken hold.

While land use activities and urban development are continuously increasing at a fairly rapid pace in the South Coast region, some efforts have been employed to minimize the effects of these activities and protect the aquatic ecosystems of the region. Municipal areas have developed stormwater pollution plans to monitor water quality; agricultural producers have implemented Best Management Practices (BMPs) to reduce soil erosion and prevent pesticides from entering waterways; these producers have also increased their irrigation efficiency with producers taking significant measures to conserve water usage; similarly, BMPs have been developed for extractive activities, such as sand mining in the SLR River; and public awareness programs have been initiated for exotic flora and fauna, pest management, water quality, and water conservation.

In addition to the contributions made to recovery through better land management practices and natural recovery processes, increasing levels of stream and watershed restoration efforts are also contributing to recovery. Examples of these efforts include release of seasonally appropriate water flows, road upgrade and decommissioning, removal of dams and road-related fish passage barriers, eradication operations of exotic species, monitoring and research of existing Southern California Coast Steelhead DPS, etc. Some of these activities to recovery have resulted in important contributions to restoring steelhead populations.

Continuing Challenges to Recovery

Considering that the South Coast region is the most developed and populated area along the Pacific Coast, combined with having a relatively arid climate, it is not too surprising that the estimated, current Southern California Coast Steelhead DPS is approximately 1% of its historical size. In order to identify a basic strategy for recovering the two listed steelhead populations in the South-Central/Southern California Steelhead Recovery Planning Domain (Planning Domain) the National Marine Fisheries Service produced the Federal Recovery Outline for the Distinct Population Segment of Southern California Coast Steelhead (2007). The preparation of this outline, which is a preliminary step in the development of a Recovery Plan (a public review draft of the recovery plan was released in July, 2009), was supported by a Recovery Team consisting of NMFS staff from the Long Beach and Santa Rosa field offices, Technical Recovery Team members, the California Department of Fish and Game, other resource agencies, and a biological consultant. The outline identified eight principal threats to the destruction, modification or curtailment of the habitat or range of the endangered Southern California Steelhead Coast DPS (NMFS 2007). These threats present ongoing challenges to the recovery of steelhead in SLR River Basin as well as in the South Coast region. The list of threats and portions of the explanations of why each is a principal factor contributing to the decline of the listed species are taken directly from NMFS Federal Recovery Outline (2007) and are presented below:

Alteration of Natural Stream Flow Patterns:

- Stream flows are necessary to breach the sand bar at the mouth of coastal estuaries, and to allow for both upstream migrations of adults to spawning and rearing reaches in headwater streams, and for the downstream emigration of juvenile fish (smolts) to the ocean. Naturally variable flow regimes also perform important functions such as maintain naturally complex channel morphology, recruit spawning gravels, flush fine sediments, rejuvenate riparian habitats, and support rearing juvenile steelhead;

- Water developments (e.g., water wells, water diversions, and dams) have reduced the frequency, duration, timing, and magnitude of river and stream flows, which affect migratory behavior, and have altered the breaching patterns at the mouths of coastal estuaries.

Physical Impediments to Fish Passage:

- Structures within river and stream channels (e.g. road crossings, culverts, water diversions, and dams) impede or completely block both upstream and downstream migration of adult and juvenile fish within the watershed, as well as between the ocean and freshwater habitats.

Alteration of Floodplains and Channels:

- Riparian areas provide shade to maintain suitable water temperatures, filter out pollutants (including fine sediments) and provide essential habitat for food organisms to support rearing juvenile steelhead. Natural channel forming processes facilitate migration, and in some cases sustain over-summering habitat for juvenile steelhead in mainstem habitats;
- Agriculture, industrial, (including aggregate extraction), and residential developments have encroached upon, fragmented, degraded, or eliminated riparian habitat along most of the major southern California river systems (particularly the lower mainstems). Encroachment has also led to the modification of river and stream channels (e.g., construction of levees, concrete channelization, and periodic channel clearing) to protect development from erosion or inundation associated with periodic high flows.

Sedimentation:

- Road construction, residential development, clearing of vegetative cover (particularly on steep slopes and adjacent to the riparian stream corridor) principally for agricultural purposes, has accelerated the rate, type, and amount of erosion and sedimentation with rivers and streams;
- Elevated levels of sedimentation as a result of watershed developments has degraded spawning and rearing habitat by smothering eggs, reducing the amount of bottom dwelling insects, and filling in pools that provide refugia habitat for juvenile steelhead during low flow periods.

Urban and Rural Waste Discharge:

- Municipal and industrial point waste discharges and urban and agricultural non-point waste run-off are widespread, and have altered the quantity and quality of flows in southern California streams, particularly mainstems;
- Urban and rural waste discharges have altered naturally seasonal changes in flow patterns, and degraded water quality through the introduction of chemical contaminants, nutrients, and thermal pollution. The effects of these waste discharges include reduced living space, direct mortality, lower reproduction, and reduced growth rates, and increased habitats for non-native aquatic species which compete with native species, including juvenile steelhead.

Spread and Propagation of Exotic Species:

- California watersheds naturally support a relatively small suite of native fish and amphibians which compete with rearing juvenile steelhead. A number of non-native species, particularly fish and amphibians such as bass and bullfrogs have been introduced and spread widely. Some of these non-native fish and amphibians species prey upon rearing juvenile steelhead, compete with juvenile steelhead for living space, cover, and food, and can also act as vectors for non-native diseases. Additional invasive invertebrates, such as New Zealand mud snail, have been recently introduced and pose a potential threat to benthic habitat and associated native species;
- Invasive plants such as giant reed (*Arundo donax*) and tamarisk (*Tamarix spp.*) have heavily infested many major watersheds. These plant species displace extensive areas of native riparian vegetation in some cases can reduce surface flows through the uptake of large amounts of groundwater. Non-native plants can also reduce the natural diversity of insects that are an important food source for rearing juvenile steelhead.

Loss of Estuarine Habitat:

- Coastal estuaries are used by adult and juvenile steelhead to acclimate to the fresh and salt water phases of their life-history, and can also serve as important nursery areas for rearing juvenile steelhead. Many estuaries have been lost or substantially reduced in size and physical complexity through filling and the elimination of distributary and side-bar channels to accommodate agricultural, residential, recreational, and industrial development, as well as road crossings (particularly Highway 1 and U.S. Interstate 5. Over 90% of coastal estuarine acreage of southern California has been lost or substantially degraded;
- Remaining estuarine habitat has been further degraded as a result of alteration of natural flow regimes, point and non-point sources of pollution, and artificial breaching of sand-bars which temporarily dewaters estuaries and unnaturally alters their salinity regimes.

Stocking of Hatchery Reared Salmonids and Other Game Fishes:

- Stocking of non-native strains of trout (and other games species such as small mouth bass, bullhead catfish, and carp) is widespread. Non-native species compete with native juvenile steelhead for living space, cover, and food, as well as serve as vectors for infectious diseases. Stocking of non-native strains of trout has also led to reliance on hatchery cultured and reared fish to support put-and-take fisheries as a substitute for the maintenance of natural, eco-systems which support self-sustaining native fish stocks.

Climatic changes have exacerbated the problems associated with degraded and altered riverine and estuarine habitats. Periodic drought conditions have reduced already limited spawning, rearing and migration habitat. Large changes in the climate are projected by the end of the century and perhaps even mid-century (NMFS 2007). Direct effects of climate change has been the higher surface temperatures and evapotranspiration, with complex, potentially negative effects on summer habitat of *O. mykiss*. Indirect effects include changes in precipitation and temperature patterns; and attendant changes to disturbance regimes, watershed conditions, and stream hydrographs (NMFS 2007). Moreover, climate change has seemed to have resulted in decreased ocean productivity which, during more productive periods, may help offset degraded freshwater habitat conditions (Busby et al. 1996; 1997).

Key questions for landowners, agencies, and other stakeholders revolve around whether the trends toward stream recovery will continue at their current rates, and whether those rates will be adequate to allow salmonids to recover their populations in an acceptable time frame. Clearly, the potential exists for new impacts from both human activities and natural disturbance processes to compromise recovery rates to a degree that threatens future salmonid recovery. To predict those cumulative effects will likely require additional site-specific information on stream flows, water quality, sediment generation and delivery rates, fish passage barriers, and additional risk analyses of other major disturbances. Also, our discussion here does not address marine influences on anadromous salmonid populations. While these important influences are outside of the scope of this program, we recognize their importance for sustainable salmonid populations and acknowledge that good quality freshwater habitat alone is not adequate to ensure sustainability.

Policies, Acts, and Listings

Several federal, state, and county statutes have significant implications for watersheds, streams, fisheries, and their management. Here, we present only a brief listing and description of some of the laws.

Federal Statutes

One of the most fundamental of federal environmental statutes is the *National Environmental Policy Act* (NEPA). NEPA is essentially an environmental impact assessment and disclosure law. Projects contemplated or plans prepared by federal agencies or funded by them must have an environmental assessment completed and released for public review and comment, including the consideration of more than one alternative. The law does not require that the least impacting alternative be chosen, only that the impacts be disclosed.

Evolving, in part, in response to water quality protection requirements established by the 1972 amendments to the federal *Clean Water Act*, the US Environmental Protection Agency (EPA) provided for significant measures to protect watersheds, watershed function, water quality, and fishery habitat. Section 208 deals with non-point source pollutants, including cumulative impacts that could arise from a variety of land uses, such as agriculture, silviculture, mining and construction activities. States are required to develop Best Management Practices (BMPs) for these large-scale land uses, as well as an implementation schedule. Section 303 deals with water bodies that are impaired to the extent that their water quality is not suitable for the beneficial uses identified for those waters. For water bodies identified as impaired, the EPA or its state counterpart (locally, the San Diego Regional Water Quality Control Board (SDRWQCB) and the State Water Resources Control Board must set targets for Total Maximum Daily Loads (TMDLs) of the pollutants that are causing the impairment. Section 404 deals with the alterations of wetlands and streams through filling or other modifications; the U.S. Army Corps of Engineers' (Corps) issues Section 404 permits, but the EPA has veto power over Corps permits.

The federal *Endangered Species Act* (ESA) addresses the protection of animal species whose populations are dwindling to critical levels. Two levels of species risk are defined. A threatened species is any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. An endangered species is any species that is in danger of extinction throughout all or a significant portion of its range. Southern California steelhead are currently listed as endangered. In general, the law forbids the take of listed species. Taking is defined as harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting a species or attempting to engage in any such conduct.

A take of a species listed as threatened may be allowed where specially permitted through the completion and approval of a *Habitat Conservation Plan* (HCP). An HCP is a document that describes how an agency or landowner will manage their activities to reduce effects on vulnerable species. An HCP discusses the applicant's proposed activities and describes the steps that will be taken to avoid, minimize, or mitigate the take of species that are covered by the plan. Many of California's salmon runs are listed under the ESA, including Southern California Coast Steelhead DPS found in the SLR River Basin (NMFS 2001).

State Statute

The state analogue of NEPA is the *California Environmental Quality Act* (CEQA). CEQA goes beyond NEPA in that it requires the project or plan proponent to select for implementation the least environmentally impacting alternative considered. When the least impacting alternative would still cause significant adverse environmental impacts, a statement of overriding considerations must be prepared.

The *Porter-Cologne Water Quality Control Act* establishes state water quality law and defines how the state will implement the federal authorities that have been delegated to it by the US EPA under the federal Clean Water Act. For example, the US EPA has delegated to the state certain authorities and responsibilities to implement TMDLs for impaired water bodies and NPDES (national pollution discharge elimination system) permits to point-source dischargers to water bodies.

Sections 1600 et seq. of the Fish and Game Code are implemented by the Department of Fish and Game. These agreements are required for any activities that alter the beds or banks of streams or lakes or divert water from a stream. A 1600 agreement typically would be involved in a road project where a stream crossing was constructed. While treated as ministerial in the past, the courts have more recently indicated that these agreements constitute discretionary permits and thus must be accompanied by an environmental impact review per CEQA.

The *California Endangered Species Act* (CESA) (Fish & Game Code §§ 2050, et seq.) generally parallels the main provisions of the Federal Endangered Species Act and is administered by the California Department of Fish and Game (CDFG). Southern California steelhead in the SLR River Basin is not listed as endangered under CESA. However, other species, such as the southwestern willow flycatcher (*Empidonax traillii extimus*) and least Bell's vireo (*Vireo bellii pusillus*) that inhabit the riparian areas along the SLR River are listed as endangered under CESA.

County Statute

The County of San Diego with local governments initiated a *Multiple Species Conservation Program* (MSCP) to develop regional plans to protect the long-term survival of sensitive plant and animal species and conserve the native vegetation found throughout San Diego County. In order to create a regional preserve system and provide Endangered Species Act coverage for all of the unincorporated areas, the County of San Diego divided the unincorporated area into three planning areas. Each area will have its own MSCP plan prepared and approved. The North County MSCP is the second of three parts of the County's MSCP. A Public Review Draft of the North County MSCP text was released on February 19, 2009 (http://www.co.san-diego.ca.us/dplu /mscp/nc.htm).

Currently, there are 61 species of sensitive plants, mammals, birds, amphibians, reptiles, and invertebrates to pursue for coverage (receive an incidental take permit) in the North County MSCP. Many of these species occur or could potentially occur in the watershed. In order to develop this list the County considered numerous factors such as species distribution, life history, sensitivity and vulnerability to human activities, viability, dependence on conservation, current listing status and its likelihood to be listed as rare, threatened or endangered in the future under the state or federal endangered species acts (http://www.co.sandiego. ca.us/dplu/mscp/nc. html).

Assessment Strategy and General Methods

The NCWAP developed a Methods Manual (Bleier et al. 2003) that identified a general approach to conducting a watershed assessment, described or referenced methods for collecting and developing new watershed data, and provided a preliminary explanation of analytical methods for integrating interdisciplinary data to assess watershed conditions. CWPAP continues to use the NCWAP approach in order to conduct its watershed assessments.

This section provides brief descriptions of data collection and analysis methods used. The reader is referred to the Methods Manual for more detail on methods, data used in the assessment, and assessments of the data.

Watershed Assessment Approach in the SLR River Basin

The steps in a large-scale assessment include:

- Conduct scoping and outreach workshops. Three public presentations were held in conjunction with the monthly SLR Watershed Council meetings to identify issues and promote cooperation;
- Determine logical assessment scales. The SLR River Basin assessment delineated the basin into five subbasins (Coastal, Southern, Northern, Middle, and Upper) for assessment and analyses purposes;
- Discover and organize existing data and information;
- Identify data gaps needed to develop the assessment;
- Collect field data. Over 38 miles of new stream data and 6 fishery surveys were performed for this assessment (in addition to previous surveys). Additional data were provided by private and agency cooperators;
- Conduct limiting factors analysis (LFA). The Ecological Management Decision Support system (EMDS) was used to evaluate factors at the tributary scale. These factors were rated to be either beneficial or restrictive to the well being of fisheries;
- Conduct refugia rating analysis. Watershed, stream, habitat, and fishery information were combined and evaluated in terms of value to salmon and steelhead;
- Develop conclusions and recommendations;
- Facilitate implementation of recommendations and monitoring of conditions.

CWPAP Products and Utility

CWPAP assessment reports and their appendices are intended to be useful to landowners, watershed groups, agencies, and individuals to help guide restoration, land use, watershed, and salmonid management decisions. The assessments operate on multiple scales ranging from the detailed and specific stream reach level to the very general basin level. Therefore, findings and recommendations also vary in specificity from being particular at the finer scales, and general at the basin scale.

Assessment products include:

- A basin level Report that includes:
    - o A collection of the SLR River Basin's historical information;
    - o A description of historic and current hydrology, geology, land use, and water quality, salmonid distribution, and instream habitat conditions;
    - o An evaluation of watershed processes and conditions affecting salmonid habitat;
    - o A list of issues developed by landowners, agency staff, and the public;
    - o An analysis of the suitability of stream reaches and the watershed for salmonid production and refugia areas;
    - o Tributary and watershed recommendations for management, refugia protection, and restoration activities to address limiting factors and improve conditions for salmonid health and productivity;
    - o Monitoring recommendations to improve the adaptive management efforts;
    - o Ecological Management Decision Support system (EMDS) models to help analyze

instream conditions;

- Databases of information used and collected;
- A data catalog and bibliography;
- Web based access to the Program's products: www.coastalwatersheds.ca.gov/, www.calfish.org, http://bios.dfg.ca.gov, www.dfg.ca.gov/biogeodata/gis/imaps.asp

Assessment Report Conventions

CalWater 2.2.1 Planning Watersheds and CWPAP Subbasins

The California Interagency Watershed Map (CalWater Version 2.2.1) is designed to be a spatial cross-reference for watershed boundaries as defined by local, state, and federal agencies (Figure 2). This hierarchy of watershed designations consists of six levels of increasing specificity: Hydrologic Region, Hydrologic Unit, Hydrologic Area, Hydrologic Sub-Area, Super Planning Watershed, and Planning Watershed (PW). PWs are used by CWPAP to delineate basins, subbasins, and drainages.

CalWater 2.2.1 PWs may not represent true watersheds. Because PWs were created using elevation data, rather than flow models, PWs may cut across streams and ridgelines, especially in less mountainous areas. Streams, such as the mainstem SLR River, can flow through multiple PWs. In addition, a stream, or administrative boundary, such as the California state border, may serve as a division between two PWs. For these and other reasons, PWs may not depict the true catchment of a stream or stream system. However, despite these potential drawbacks, the use of a common watershed map has proven helpful in the delineation of basins and subbasins.

Based on significant variance across the SLR River Basin attributes, the CWPAP assessment team delineated the basin into five subbasins for assessment and analyses purposes (Figure 3). These are the Coastal, Southern, Northern, Middle, and Upper subbasins. In general, these subbasins have distinguishing attributes common to the CalWater 2.2.1 Planning Watersheds (PWs) contained within them (Figure 2).

Variation among subbasins is a product of natural and human disturbances. Characteristics that can distinguish subbasins within larger basins include differences in elevation, geology, soil types, aspect, climate, vegetation, fauna, human population, land use and other social-economic considerations. Demarcation in this logical manner provides a uniform methodology for conducting large scale assessment. It provides a framework for the reporting of specific findings as well as assisting in developing recommendations for watershed improvement activities that are generally applicable across the relatively homogeneous subbasin area.

Hydrology Hierarchy

Watershed terminology often becomes confusing when discussing different scales of watersheds involved in planning and assessment activities. The conventions used in the SLR River Basin assessment report follow guidelines established by the Pacific Rivers Council. The descending order of scale is as follows: from the basin level (e.g., SLR River Basin) to the subbasin level (e.g., Northern Subbasin) to the watershed level (e.g., Pauma Creek) to the sub-watershed level (e.g., Doane Creek) (Figure 4).

The subbasin is the assessment and planning scale used in this report as a summary framework; subbasin findings and recommendations are based upon the more specific watershed and sub-watershed level findings. Therefore, there are usually exceptions at the finer scales to subbasin findings and recommendations. Thus, findings and recommendations at the subbasin level are somewhat more generalized than at the watershed and sub-watershed scales. In like manner, subbasin findings and recommendations are somewhat more specific than the even more generalized, broader scale basin level findings and recommendations that are based upon a group of subbasins.

Terminology

The term watershed is used in both the generic sense, as to describe watershed conditions at any scale and as a particular term to describe the watershed scale introduced above, which contains, and is made up from multiple, smaller sub-watersheds. The watershed scale is often approximately 20–40 square miles in area; its sub-watersheds can be much smaller in area, but for our purposes contain at least one perennial, un-branched stream. Please be aware of this multiple usage of the term watershed, and consider the context of the term's usage to reduce confusion.

Another important watershed term is "river mile," indicated as RM. RM is used to assign a specific, measured distance upstream from the mouth of a river or stream to a point or feature on the stream. In this report, RM is used to locate points along the SLR River and/or its tributaries (e.g. Henshaw Dam is at RM 50).

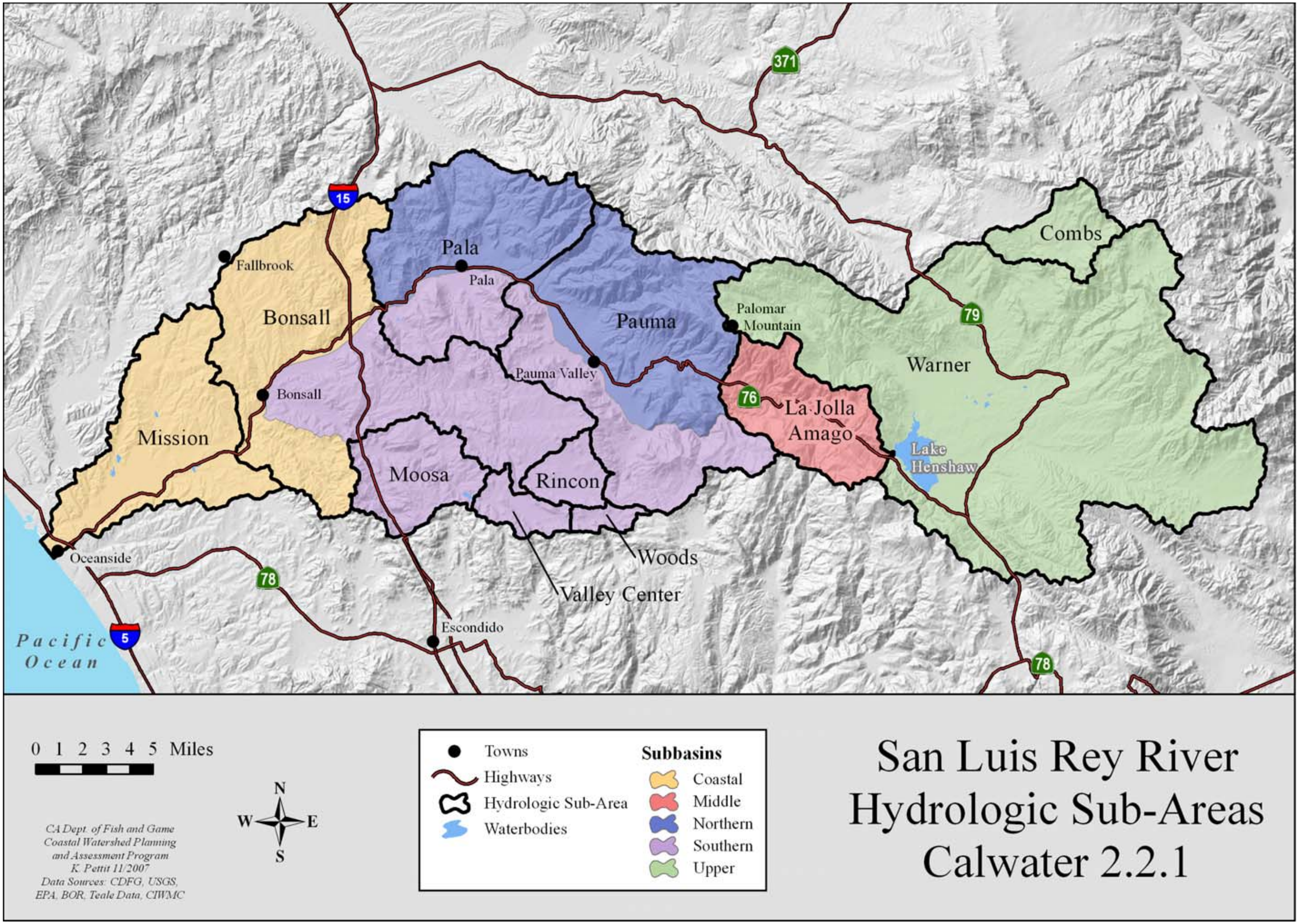


Figure 2. SLR River Hydrologic Sub-Areas CalWater 2.2.1

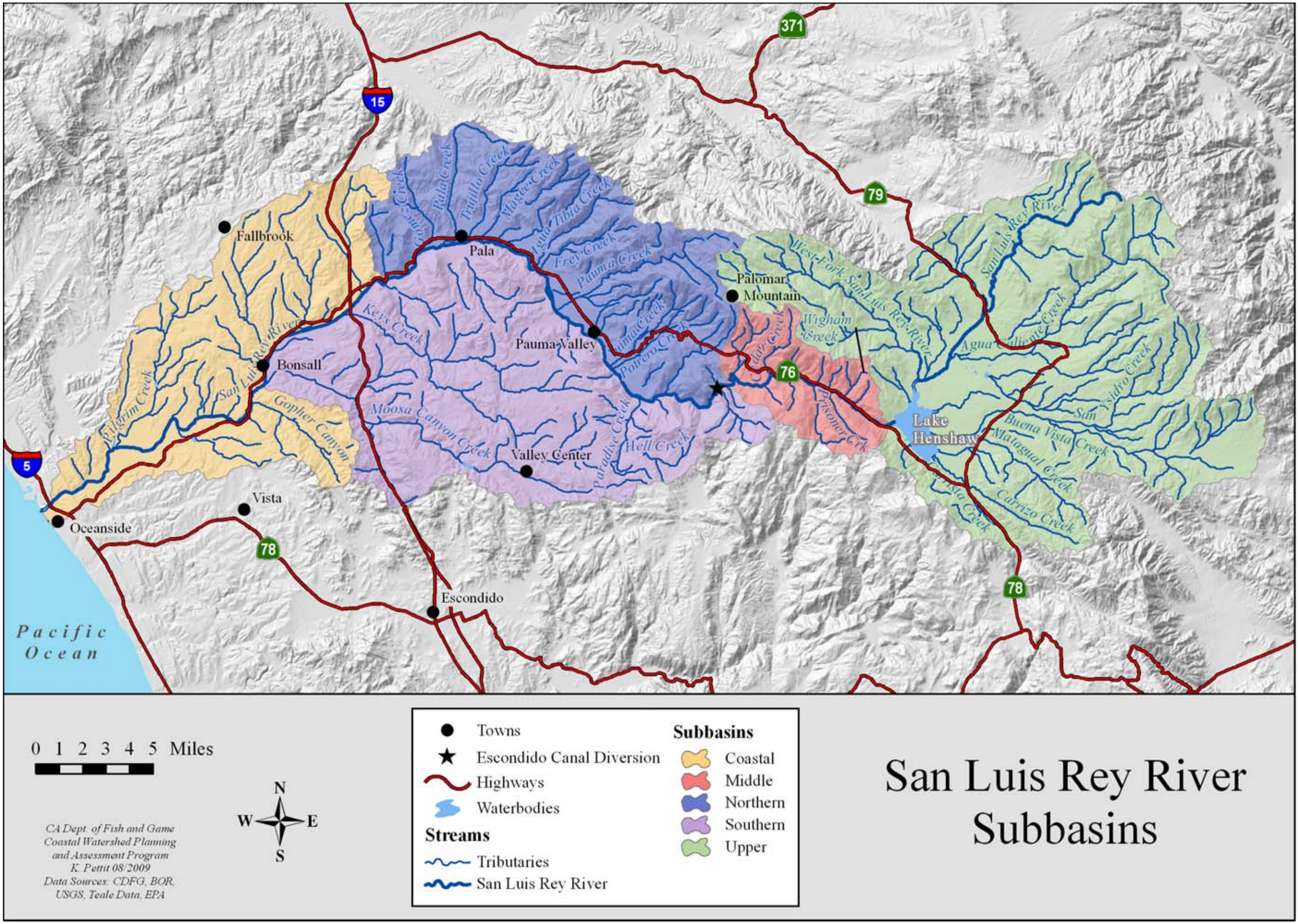
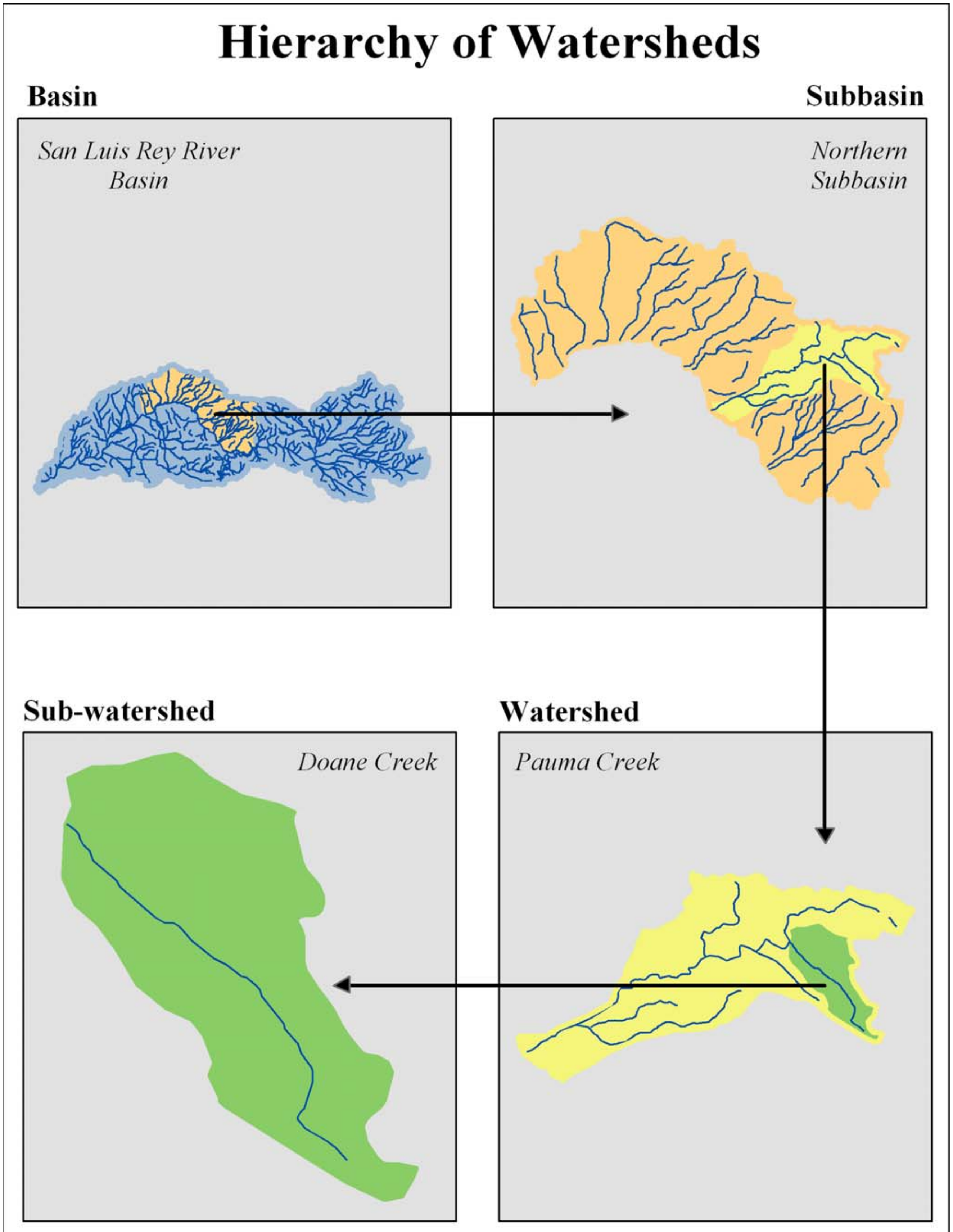


Figure 3. San Luis Rey River Basin with subbasin boundaries.



CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 02/2009
Data Sources: CDFG, CDF, CIWMC

Figure 4. Hydrography hierarchy.

Electronic Data Conventions

The early NCWPAP program collected or created hundreds of data records for synthesis and analysis purposes and most of these data were either created in a spatial context or converted to a spatial format. Effective use of these data between the four remaining partner departments required establishing standards for data format, storage, management, and dissemination. Early in the assessment process, we held a series of meetings designed to gain consensus on a common format for the often widely disparate data systems within each department. Our objective was to establish standards which could be used easily by each department, that were most useful and powerful for selected analysis, and would be most compatible with standards used by potential private and public sector stakeholders.

As a result, we agreed that spatial data used in the program and base information disseminated to the public through the program would be in the following format (see the data catalog at the end of this report for a complete description of data sources and scale):

- Data form: standard database format usually associated with a Geographic Information System (GIS) shapefile or personal geodatabase (Environmental System Research Institute, Inc. © [ESRI]). Data were organized by watershed. Electronic images were retained in their current format;
- Spatial Data Projection: spatial data were projected from their native format to Teale Albers, North American Datum (NAD) 1983;
- Scale: most data were created and analyzed at 1:24,000 scale to (1) match the minimum analysis scale for planning watersheds, and (2) coincide with base information (e.g., stream networks) on USGS quadrangle maps (used as Digital Raster Graphics [DRG]);
- Data Sources: data were obtained from a variety of sources including spatial data libraries with partner departments or were created by manually digitizing from 1:24,000 DRG.

The metadata available for each spatial data set contain a complete description of how data were collected and attributed for use in the program. Spatial data sets that formed the foundation of most analysis included the 1:24,000 hydrography and the 10-meter scale Digital Elevation Models (DEM). Hydrography data were created by manually digitizing from a series of 1:24,000 DRG then attributing with direction, routing, and distance information using a dynamic segmentation process (for more information, please see http://downloads2.esri.com/support/whitepapers/ao_/ArcGIS8.1.pdf

The resulting routed hydrography allowed for precise alignment and display of stream habitat data and other information along the stream network. The DEM was created by USGS from base contour data for the entire study region.

Source spatial data were often clipped to watershed, planning watershed, and subbasin units prior to use in analysis. Analysis often included creation of summary tables, tabulating areas, intersecting data based on selected attributes, or creation of derivative data based on analytical criteria. For more information regarding the approach to analysis and basis for selected analytical methods, see Appendix, Assessment Strategy and General Methods; and, Interdisciplinary Synthesis and Findings.

Assessment Methods

Hydrology

There are two United States Geological Survey (USGS) river gages currently operating within the basin. The longest operating one is in Oceanside under the Benet Road Bridge (RM 1.25). This gage (USGS ID 11042000) has operated from 1913-1916, 1930-1942 and 1947 to the present, measuring gage height and discharge. The other operating river gauge is located 0.07 miles south of Cole Grade Road, near Pauma Valley. This gauge (USGS ID 11036700) has been in operation since March of 2008 and is also recording river gauge height and discharge. Two other gauges recording discharge operated briefly from March 2008 to October 2008 in the Pauma Valley but have since discontinued data collection. Historically, other stream gauges were in operation, recording discharge along the SLR River. These gauges were downstream of Lake Henshaw and operated during different time periods from the early 1900’s to the 1980’s, but have since ceased operation. Some of these gauges provided a historical perspective of the stream flow in the SLR River prior to the completion of the Henshaw Dam and other major water extractions that took place in the watershed.

In order to help evaluate and categorize streams and rivers, streams are assigned a stream order classification based on the branching pattern of river systems (Strahler 1957). A first order stream is defined as the smallest un-branched tributary to appear on a 7.5-minute USGS quadrangle (1:24,000 scale) (Leopold et al. 1964). This system includes only perennial streams (i.e. those with sufficient flow to develop biota). When two first order streams join, they form a second order stream. When two second order streams join, they result in a third order stream; and as streams of equal order meet they result in a stream of the next higher order (Strahler 1957). The mainstem of the SLR River is a difficult system to designate a stream order due to the numerous diversions and lack of hydrologic connectivity in the basin. Although the river is contained in a large basin, due to the arid climate, dams, and water diversions and extractions, large sections of the river are intermittent throughout the year; therefore, the river was only given a second order classification in the Middle and Coastal Subbasin were it flows perennially. Most of the tributaries, which have also been significantly altered by anthropogenic uses, maintain only intermittent flows with sections or perennial flows and are classified accordingly.

Geology and Fluvial Geomorphology

A simplified geologic map was compiled for use in this report using published USGS maps (see Table 1 for reference maps) and limited, geologic photo-reconnaissance mapping, as well as available GIS layers. This map was then simplified combining rock types of similar age, composition, and geologic history. This was done to simplify the information so that it was more easily understandable at the scope and scale of presentation in this report. Calculations of area occupied by each rock type were based on GIS interpretation. An extensive review of existing literature was conducted to gather geologic background information presented in this report. Description and composition of soils was based on information gathered from the Natural Resources Conservation Service.

Table 1. List of USGS quadrangles covering the San Luis Rey Basin

GEOLOGIC MAP OF THE AGUANGA 7.5'QUADRANGLE SAN DIEGO AND RIVERSIDE COUNTIES, CALIFORNIA: A DIGITAL DATABASE, 2003, Tan, S.S., Kennedy M.P.
GEOLOGIC MAP OF THE BOUCHER HILL 7.5' QUANDRANGLE SAN DIEGO COUNTY, CALIFORNIA: A DIGITAL DATABASE, 2006, Kennedy, M.P.
GEOLOGIC MAP OF THE MARGARITA PEAK 7.5' QUADRANGLE SAN DIEGO COUNTY, CALIFORNIA: A DIGITAL DATABASE, 2000, Tan, S.S.
GEOLOGIC MAP OF THE MORRO HILL 7.5' QUADRANGLE SAN DIEGO COUNTY, CALIFORNIA: A DIGITAL DATABASE, 2001, Tan, S.S.
GEOLOGIC MAP OF THE OCEANSIDE 30 X 60' QUADRANGLE, CALIFORNIA, 2005, Kennedy M.P., Tan, S.S.
GEOLOGIC MAP OF THE PALA 7.5' QUADRANGLE SAN DIEGO COUNTY, CALIFORNIA: A DIGITAL DATABASE, 2000, Kennedy M.P.
GEOLOGIC MAP OF THE PECHANGA 7.5' QUADRANGLE SAN DIEGO AND RIVERSIDE COUNTIES, CALIFORNIA: A DIGITAL DATABASE, 2000, Tan, S.S., Kennedy M.P.
GEOLOGIC MAP OF THE TEMECULA 7.5' QUADRANGLE SAN DIEGO AND RIVERSIDE COUNTIES, CALIFORNIA: A DIGITAL DATABASE, 2000, Tan, S.S., Kennedy M.P.
GEOLOGIC MAP OF THE VALLEY CENTER 7.5' QUADRANGLE SAN DEIGO COUNTY, CALIFORNIA: A DIGITAL DATABASE, 1999, Kennedy M.P.

Vegetation and Land Use

The USDA Forest Service (USFS) CALVEG vegetation data were used to describe basin-wide as well as subbasin level vegetation. This classification breaks down vegetation into major "vegetative cover types." These are further broken down into a number of "vegetation types."

Land use data and statistics were derived from Riverside and San Diego Counties as well as data adopted from the SLR Watershed Council's 2000 San Luis Rey Watershed Guidelines report and from the San Diego Association of Governments (SANDAG). SANDAG is composed of the 18 cities and county governments of San Diego County as the forum for regional decision-making.

DFG personnel analyzed year 2000 census data to provide population estimates for the SLR River Basin. The 2000 data were available from the U.S. Census Bureau and SANDAG. Statistics do not exist for specific breakdowns of the watershed; therefore, Community Planning Areas (CPAs) were used to describe the various areas. Many of these areas are not located entirely within the watershed boundaries, thus the estimated population of the watershed is significantly less than the total population of the CPAs.

Regionally, San Diego County has been one of the fastest growing areas in the United States. There is a strong relationship between land use planning and the quality of watersheds. The proper planning of future land use may help to prevent and repair water quality problems. Protected areas that are mapped out in advance instead of worked in around development, are far more effective at conserving biodiversity and ecological functions.

Fish Habitat and Populations

Data Compilation and Collection

CDFG compiled existing available data and gathered anecdotal information pertaining to salmonids and the instream habitat on the SLR River and its tributaries. Anecdotal and historic information was cross-referenced with other existing data whenever possible. Where data gaps were identified, access was sought from landowners to conduct habitat inventory and fisheries surveys. Habitat inventories and biological data were collected following the protocol presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998). Throughout the 2007 year, CDFG and Pacific States Marine Fisheries Commission (PSMFC) fisheries crews inventoried 35 miles of the SLR River and 1.2 miles of Pauma Creek. Most of the inventory occurred during the spring and early summer months. Seven other tributaries, three in the Coastal Subbasin, one each in the Southern and Northern subbasins, and two in the Middle Subbasin, were examined for general habitat suitability. Based on fish passage barriers preventing upstream access and/or unsuitable habitat conditions at the time of the survey, it was agreed that steelhead were unlikely to utilize those streams; therefore, full habitat typing protocols were not performed.

Fish Passage Barriers

Twenty six structures considered partial or complete barriers to fish passage were identified below Lake Henshaw within the SLR River Basin, and reported in the Passage Assessment Database (2005). Table 2 defines partial, complete, and unknown barrier types and describes their potential impact on fish passage. The twenty six structures are split primarily between dams, water diversions, road crossings (usually in the form of culverts) and a few non-structural barriers. While dams and water diversions are most likely complete barriers, culverts can either create partial or complete barriers for adult and/or juvenile salmonids during their freshwater migration activities. Non-structural generally indicates natural waterfall and bedrock chute barriers and could fit into any barrier category depending on height of structure and/or amount and velocity of stream flows.

Table 2. Definitions of barrier types and their potential impacts to salmonids.

Barrier Category	Definition	Potential Impact
Partial	Impassable to steelhead during certain life cycle stages and certain times of the year.	Generally, partial barriers are impassible at low flow conditions, which in Southern California extend for the majority of the summer and fall months.
Complete	Impassable to all fish at all times.	Exclusion of all species from portions of a watershed.
Unknown	Fish passage status is unclear.	Due to landowner access issues or location of barrier outside of steelhead's range in the watershed these barriers were not examined.

Target Values from Habitat Inventory Surveys

Beginning in 1991, habitat inventory surveys were used as a standard method to determine the quality of the stream environment in relation to conditions necessary for salmonid health and production. In the CDFGs *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998) target values were given for each of the individual habitat elements measure (Table 3). The data collected during stream habitat inventories are compared to the target values defined in this Manual to determine if habitat conditions within the streams are limiting to salmonid production. When habitat conditions decrease below the target values, restoration projects may be proposed in an attempt to meet critical habitat needs for salmonids. Because these target values were developed for desired stream conditions in northern California, this assessment also utilized reference values that were developed in the NMFSs *Guide to the reference values used in south- central/southern California coast steelhead conservation action planning (CAP) workbooks* (NMFS and Keir and Associates 2008) to help evaluate recommended stream habitat conditions, specifically intended for the Southern California Coast Steelhead DPS.

Table 3. Habitat inventory target values.

Habitat Element	Canopy Density	Embeddedness	Primary Pool* Frequency	Shelter/Cover
Range of Values	0-100%	0-100%	0-100%	0-300 Rating
Target Values	>80%	>50% of the pool tails surveyed with category 1 embeddedness values	>40% of stream length	>100

* Primary pools are pools >2 feet deep in 1st and 2nd order streams, >3 feet deep in 3rd order streams, or >4 feet deep in 4th order streams
From the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al 1998).

Canopy Density—Eighty percent or greater of the stream is covered by canopy

Near stream forest density and composition contribute to microclimate conditions. These conditions help regulate air temperature and humidity, which are important factors in determining stream water temperature. Riparian vegetation can also help filter nutrients and pollutants, provide food for aquatic organisms, and maintain bank stability. Along with the insulating capacity of the stream and riparian areas during winter and summer, canopy levels provide an indication of the potential present and future recruitment of large woody debris to the stream channel. The 80% target value may be a little high for south coast streams as canopy measurements do not account for steep canyon walls which can provide an alternate form of shade in tributaries and in the headwaters of rivers. Lower alluvial sections of rivers in southern California are adapted to large flood events, which may greatly reduce riparian canopy. Usually, these areas are able to quickly recover. Stream restoration, such as re-vegetation projects, should bear in mind the impacts of potential flood cycles/events when considering the design and implementation of these projects.

Good spawning substrate—fifty percent or greater of the pool tails sampled are fifty percent or less embedded

Cobble embeddedness is the percentage of an average sized cobble piece, embedded in fine substrate at the pool tail. Steelhead are also known to spawn in riffles. The CDFG habitat inventory does not record embeddedness for riffle habitats; therefore, the data may not represent the condition of all potential spawning areas. The best steelhead trout spawning substrate is classified as Category 1 cobble embeddedness or 0-25% embedded. Category 2 is defined by the substrate being 26-50% embedded. Cobble embedded deeper than 51% is not within the range for successful spawning. The target value is for 50% or greater of the pool tails sampled to be 50% or less embedded. Streams with less than 50% of their length greater than 51% embedded do not meet the target value. They do not provide adequate spawning substrate conditions.

Pool depth/frequency- forty percent or more of the stream provides pool habitat

During their life history, salmonids require access to pools, flatwater, and riffles. Pool enhancement projects are considered when pools comprise less than 40% of the length of total stream habitat. The target values for pool depth are related to the stream order. Greater pool depth provides more cover and rearing space for older age (1+ and 2+) steelhead juveniles. Deeper pools may also help to stratify water temperatures, providing important cool water refugia for *O. mykiss* during the hot summer months. First and second order streams are required to have 40% or more of the pools 2 feet or deeper to meet the target values. Third and fourth order streams are required to have 40% or more of the pools 3 feet or deeper or 4 feet or deeper, respectively, to meet the target values. As mentioned in the Hydrology Section, the SLR River was evaluated as a second order stream. Considering the difficulty in categorizing the SLR River and the importance of pool depths, the Ecological Management Decision Support System (EMDS) (see below for description) model based suitability ratings on pools greater than 2.49 feet, with a slight consideration (weight) given to pools greater than 2 feet deep. A frequency of less than 40% or inadequate depth related to stream order indicates that the stream provides insufficient pool habitat.

Shelter/Cover- scores of one hundred or better means that the stream provides sufficient shelter/cover

Pool shelter/cover provides protection from predation and rest areas from high velocity flows for salmonids. Shelter/cover elements include undercut bank, small woody debris, large woody debris, root mass, terrestrial vegetation, aquatic vegetation, bubble curtain (whitewater), boulders and bedrock ledges. All elements present are measured and scored. Shelter/cover values of 100 or less indicate that shelter/cover enhancement should be considered.

Water Quality

The maximum weekly average temperature (MWAT) is the maximum value of the seven day moving average temperatures. The MWAT range for “fully suitable conditions” of 10–15°C (50-60°F) was developed as an average of the needs of several cold water fish species, including steelhead trout. However, these temperature ranges were developed for northern stocks of salmonids, including steelhead. There are widespread field data from Southern California Coast Steelhead DPS streams where steelhead have been found despite water temperatures considered lethal to more northern stocks (NMFS and Kier Associates 2008). Temperature thresholds in Table 4 are set to reflect findings that steelhead in the region may persist in water temperatures above 25°C (77°F) (Spina, 2006). Proposed CAP interim reference values for MWATs for Southern California Steelhead DPS were derived from NMFS and Kier Associates (2008) (Table 4).

Table 4. Water temperature criteria.

MWAT Range	Description
< 17°C (62.6°F)	Very Good
17–22.5°C (62.6–72.5°F)	Good
22.5–25°C (72.5–77.0°F)	Fair
≥ 25°C (77°F)	Poor

Ecological Management Decision Support System

The assessment program selected the Ecological Management Decision Support (EMDS) system software to help synthesize information on stream conditions. The EMDS system was developed at the USDA-Forest Service, Pacific Northwest Research Station (Reynolds 1999). It employs a linked set of software that includes Microsoft Excel and Access, NetWeaver, the EMDS ArcView Extension, and ArcGIS™. The NetWeaver software, developed at Pennsylvania State University, helps scientists model linked frameworks of various environmental factors called knowledge base networks (Reynolds et al. 1996).

These networks specify how various environmental factors will be incorporated into an overall stream or watershed assessment. The networks resemble branching tree-like flow charts, graphically show the assessment's logic and assumptions, and are used in conjunction with spatial data stored in a Geographic Information System (GIS) to perform assessments and render the results into maps.

Development of the North Coast California EMDS Model

Staff began development of EMDS knowledge base models with a three-day workshop in June of 2001 organized by the University of California, Berkeley. In addition to the assessment program staff, model developer Dr. Keith Reynolds and several outside scientists also participated. As a starting point, analysts used an EMDS knowledge base model developed by the Northwest Forest Plan for use in coastal Oregon. Based upon the workshop, subsequent discussions among staff and other scientists, examination of the literature, and consideration of localized California conditions, the assessment team scientists then developed preliminary versions of the EMDS models.

The Knowledge Base Network

For California's north coast watersheds, the assessment team constructed a knowledge base network, the Stream Reach Condition Model. The Model was reviewed in April 2002 by an independent nine-member science panel, which provided a number of suggestions for model improvements. According to their suggestions, the team revised the original model to reflect these suggestions.

The Stream Reach Condition Model addresses stream conditions for salmonids on individual stream reaches and is largely based on data collected using CDFG stream survey protocols found in the *California Salmonid Stream Habitat Restoration Manual,* (Flosi et al. 1998). While this model and stream survey protocols were developed for north coast watersheds, the suitability ratings of the model can be modified to reflect the varying conditions and preferred habitat requirements of south California coast steelhead.

In creating these EMDS models, the team used what is termed a tiered, top-down approach. For example, the Model tested the truth of the proposition: The overall condition of the stream reach is suitable for maintaining healthy populations of native Chinook, coho, and steelhead trout. A knowledge base network was then designed to evaluate the truth of that proposition, based upon existing data from each stream reach. The Model design and contents reflected the specific data and information analysts believed were needed, and the manner in which they should be combined, to test the proposition.

In evaluating stream reach conditions for salmonids, The Model uses data from several environmental factors. The first branching tier of the knowledge base network shows the data based summary nodes on: 1) in-channel condition; 2) stream flow; 3) riparian vegetation and: 4) water temperature (Figure 5). These nodes are combined into a single value to test the validity of the stream reach condition suitability proposition. In turn, each of the four summary branch node's values is formed from the combination of its more basic data components. The process is repeated until the knowledge base network incorporates all information believed to be important to the evaluation (Figure 5).

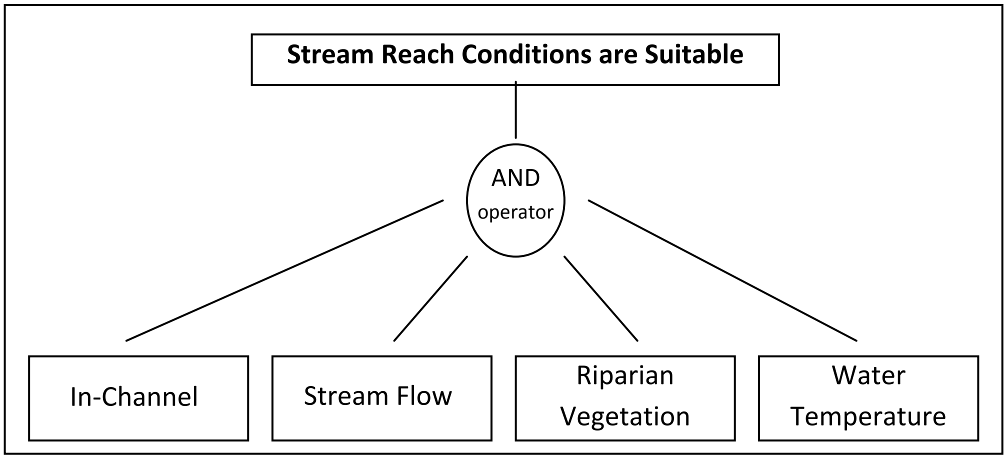


Figure 5. Tier one of the EMDS stream reach knowledge base network.

Advantages Offered by EMDS

EMDS offers a number of advantages for use in watershed assessments. Instead of being a hidden black box, each EMDS model has an open and intuitively understandable structure. The explicit nature of the model networks facilitates open communication among agency personnel and with the general public through simple graphics and easily understood flow diagrams. The models can be easily modified to incorporate alternative assumptions about the conditions of specific environmental factors (e.g., different habitat requirements of Southern California Steelhead, such as water temperature) required for suitable salmonid habitat.

Using Geographic Information System (GIS) software, EMDS maps the factors affecting fish habitat and shows how they vary across a basin. EMDS models also provide a consistent and repeatable approach to evaluating watershed conditions for fish. In addition, the maps from supporting levels of the model show the specific factors that, taken together, determine overall watershed conditions. This latter feature can help to identify what is most limiting to salmonids, and thus assist to prioritize restoration projects or modify land use practices.

Limitations of the EMDS Model and Data Inputs

While EMDS-based syntheses are important tools for watershed assessment, they do not by themselves yield a course of action for restoration and land management. EMDS results require interpretation, and how they are employed depends upon other important issues, such as social and economic concerns. In addition to the accuracy of the EMDS model constructed, the dates and completeness of the data available for a stream or watershed will strongly influence the degree of confidence in the results. External validation of the EMDS model using fish population data and other information should be done.

One disadvantage of linguistically based models such as EMDS is that they do not provide results with readily quantifiable levels of error. It is necessary to validate EMDS results with other observations. Therefore, EMDS should only be used as an indicative model, one that indicates the quality of watershed or instream conditions based on available data and the model structure. It is not intended to provide highly definitive answers, such as from a statistically based process model. It does provide a reasonable first approximation of conditions through a robust information synthesis approach; however, its outputs need to be considered and interpreted in the light of other information sources and the inherent limitations of the model and its data inputs. It also should be clearly noted that EMDS does not assess the marine phase of the salmonid life cycle, nor does it consider fishing pressures.

Program staff has identified some model or data elements needing attention and improvement in future iterations of EMDS. These currently include:

- Completion of quality control evaluation procedures;
- Adjust the model to better reflect differences between stream mainstems and tributaries, for example, the modification of canopy density standards for wide streams;
- Develop a suite of Stream Reach Model reference curves to better reflect the differences

in expected conditions based upon various geographic watershed locations considering geology, vegetation, precipitation, and runoff patterns.

Adaptive Application for EMDS and CDFG Stream Habitat Evaluations

CDFG has developed habitat evaluation standards, or target values, to help assess the condition of anadromous salmonid habitat in California streams (Flosi et al. 1998). These standards are based upon data analyses of over 1,500 tributary surveys, and considerable review of pertinent literature. The EMDS reference curves have similar standards. These have been adapted from CDFG, but following peer review and professional discussion, they have been modified slightly due to more detailed application in EMDS. As such, slight differences occur between values found in Flosi et al. (1998) and those used by EMDS.

Both habitat evaluation systems have similar but slightly different functions. Stream habitat standards developed by CDFG are used to identify habitat conditions and establish priorities among streams considered for improvement projects based upon standard CDFG tributary reports. The EMDS compares select components of the stream habitat survey data to reference curve values and expresses degrees of habitat suitability for fish on a sliding scale. In addition, the EMDS produces a combined estimate of overall stream condition by combining the results from several stream habitat components. In the fish habitat relationship section of this report, we utilize target values found in Flosi et al. (1998), field observations, and results from EMDS reference curve evaluations to help describe and evaluate stream habitat conditions.

Due to the wide range of geology, topography and diverse stream channel characteristics which occur within the North and South Coast region, there are streams that require more detailed interpretation and explanation of results than can be simply generated by EMDS suitability criteria or tributary survey target values.

For example, pools are an important habitat component and a useful stream attribute to measure. However, some small fish-bearing stream channels may not have the stream power to scour pools of the depth and frequency considered to be high value “primary” pools by CDFG target values, or to be fully suitable according to EMDS. Often, these shallow pool conditions are found in low gradient stream reaches in small watersheds that lack sufficient discharge to deeply scour the channel. They also can exist in moderate to steep gradient reaches with bedrock/boulder dominated substrate highly resistant to scour, which also can result in few deep pools.

Therefore, some streams may not have the inherent ability to attain conditions that meet the suitability criteria or target values for pool depth. These scenarios result in pool habitat conditions that are not considered highly suitable by either assessment standard. However, these streams may still be very important because of other desirable features that support valuable fishery resources. As such, they receive additional evaluation with our refugia rating system and expert professional judgment. Field validation of any modeling system’s results is a necessary component of watershed assessment and reporting.

Limiting Factors Analysis

A main objective of CDFG watershed assessment is to identify factors that limit production of anadromous salmonid populations in North and South Coast watersheds. This process is known as a limiting factors analysis (LFA). The limiting factors concept is based upon the assumption that eventually every population must be limited by the availability of necessary support resources (Hilborn and Walters 1992) or that a population’s potential may be constrained by an overabundance, deficiency, or absence of a watershed ecosystem component. Identifying stream habitat factors that limit or constrain anadromous salmonids is an important step towards setting priorities for habitat improvement projects and management strategies aimed at the recovery of declining fish stocks and protection of viable fish populations.

Although several factors have contributed to the decline of anadromous salmonid populations, habitat loss and modification are major determinants of their current status (FEMAT 1993). Our approach to a LFA integrates two habitat based methods to evaluate the status of key aspects of stream habitat that affect anadromous salmonid production- species life history diversity and the stream’s ability to support viable populations.

The first method uses priority ranking of habitat categories based on a CDFG team assessment of data collected during stream habitat inventories. The second method uses the EMDS to evaluate the suitability of key stream habitat components to support anadromous fish populations. These habitat-based methods assume that stream habitat quality and quantity play important roles in a watershed's ability to produce viable salmonid populations.

The LFA assumes that poor habitat quality and reduced quantities of favorable habitat impairs fish production. Limiting factors analysis is focused mainly on those physical habitat factors within freshwater and estuarine ecosystems that affect spawning and subsequent juvenile life history requirements during low flow seasons.

Two general categories of factors or mechanisms limit salmonid populations:

- Density independent and
- Density dependent mechanisms.

Density independent mechanisms generally operate without regard to population density. These include factors related to habitat quality such as stream flow and water temperature or chemistry. In general, fish will die regardless of the population density if flow is inadequate, or water temperatures or chemistry reach lethal levels. Density dependant mechanisms generally operate according to population density and habitat carrying capacity. Competition for food, space, and shelter are examples of density dependant factors that affect growth and survival when populations reach or exceed the habitat carrying capacity.

The program's approach considers these two types of habitat factors before prioritizing recommendations for habitat management strategies. Density dependent mechanisms currently do not play an integral role in the South Coast region because of the extremely depressed numbers of steelhead runs in the region. Hence, priority steps are given to preserving and increasing the amount of high quality (density independent) habitat in a cost effective manner. More details of the LFA are presented in the CDFG Appendix.

Restoration Needs/Tributary Recommendations Analysis

In 2007, CDFG inventoried the mainstem SLR River and one of its tributaries, Pauma Creek, using protocols in the *California Salmonid Stream Habitat Restoration Manual* (Flosi 1998). Seven other tributaries, three in the Coastal Subbasin, one each in the Southern and Northern subbasins, and two in the Middle Subbasin, were examined for general habitat suitability. Based on fish passage barriers preventing upstream access and/or unsuitable habitat conditions at the time of the survey, it was agreed that steelhead were unlikely to utilize those tributaries; therefore, full habitat typing protocols were not performed. The surveyed area of the mainstem SLR River and Pauma Creek were composed of 13 stream reaches, defined as Rosgen channel types. The stream inventories are a combination of several stream reach surveys: habitat typing, channel typing, and biological assessments. An experienced Biologist conducted quality assurance/quality control (QA/QC) on field crews and collected data, performed data analysis, and determined general areas of habitat deficiency based upon the analysis and synthesis of information.

CDFG/PSMFC biologists then selected and ranked recommendations for each of the inventoried streams, based upon the results of these standard CDFG habitat inventories, and updated the recommendations with the results of the stream reach condition, EMDS, and the refugia analysis (Table 5). It is important to understand that these selections are made from stream reach conditions that were observed at the times of the surveys and do not include upslope watershed observations other than those that could be made from the streambed. They reflect a single point in time and do not anticipate future conditions. However, these general recommendation categories have proven to be useful as the basis for specific project development, and provide focus for on-the-ground project design and implementation. Bear in mind that stream and watershed conditions change over time and periodic survey updates and field verification are necessary if watershed improvement projects are being considered.

The following paragraphs describe the stream habitat recommendation categories and their importance to steelhead recovery/production:

Stream flow and water quality are integral in supporting steelhead during their freshwater phase and need to be addressed in order to restore/improve other habitat functions for salmonids.

Providing suitable water temperatures for salmonids usually go hand in hand with having sufficient canopy cover along streams and rivers. Moderating stream water temperatures may be achieved by improving the overall canopy along the stream.

Instream improvement recommendations are usually a high priority in streams that reflect watersheds in recovery or good health. Improving pool habitat by increasing the number of pools, pool depth, and available cover in pool habitats are all important components in increasing overall stream habitat suitability. Various project treatment recommendations can be made concurrently if watershed and stream conditions warrant.

Table 5. List of stream habitat recommendation categories and how they relate to desired conditions for steelhead.

Recommendation	Explanation
Stream Flow	Flow is limited or lacking due to anthropogenic activities and usage
Water Quality	Water quality is impaired throughout the watershed
Temperature	Summer water temperatures were measured to be above optimum for steelhead
Canopy	Shade canopy is below CDFG target values
Pool	Pools are below CDFG target values in quantity and/or quality
Cover	Escape cover is below CDFG target values
Spawning Gravel	Spawning gravel is deficient in quality and/or quantity
Bank	Stream banks are failing and yielding fine sediment into the stream
Roads	Fine sediment is entering the stream from the road system
LDA	Large debris accumulations are retaining large amounts of gravel and could need modification
Livestock	There is evidence that stock is impacting the stream or riparian area and exclusion should be considered
Fish Passage	There are barriers to fish migration in the stream

In general, the recommendations that involve erosion and sediment reduction by treating roads and failing stream banks, and riparian and near stream vegetation improvements precede the instream recommendations in reaches that demonstrate disturbance levels associated with watersheds in current stress. Erosion and sediment reduction projects as well as large debris accumulation modifications will most likely improve spawning gravel conditions.

Fish passage problems, especially in situations where favorable stream habitat reaches are being separated by a man-caused feature (e.g., culvert), are usually a treatment priority. Good examples of these are the recent and successful Santa Barbara County/CDFG culvert replacement projects in tributaries to the Pacific Ocean. In these regards, the program's more general watershed scale upslope assessments can go a long way in helping determine the suitability of conducting instream improvements based upon watershed health. As such, there is an important relationship between the instream and upslope assessments.

Additional considerations must enter into the decision process before these general recommendations are further developed into improvement activities. In addition to watershed condition considerations as a context for these recommendations, there are certain logistic considerations that enter into a recommendation's subsequent ranking for project development. These can include work party access limitations based upon lack of private party trespass permission and/or physically difficult or impossible locations of the candidate work sites. Biological considerations are made based upon the propensity for benefit to multiple or single fishery stocks or species. Cost benefit and project feasibility are also factors in project selection for design and development.

Potential Salmonid Refugia

Establishment and maintenance of salmonid refugia areas containing high quality habitat and sustaining fish populations are activities vital to the conservation of our anadromous salmonid resources (Moyle and Yoshiyama 1992; Li et al. 1995; Reeves et al. 1995). Protecting these areas will prevent the loss of the remaining high quality salmon habitat and salmonid populations. Therefore, a refugia investigation project should focus on identifying areas found to have high salmonid productivity and diversity.

The concept of refugia is based on the premise that patches of aquatic habitat provide habitat that retains the natural capacity and ecologic functions to support wild anadromous salmonids in such vital activities as spawning and rearing. Anadromous salmonids exhibit typical features of patchy populations; they exist in dynamic environments and have developed various dispersal strategies including juvenile movements, adult straying, and relative high fecundity for an animal that exhibits some degree of parental care through nest building (Reeves et al. 1995). Conservation of patchy populations requires conservation of several suitable habitat patches and maintaining passage corridors between them.

Potential refugia may exist in areas where the surrounding landscape is marginally suitable for salmonid production or altered to a point that stocks have shown dramatic population declines in traditional salmonid streams. If altered streams or watersheds recover their historic natural productivity, through either restoration efforts or natural processes, the abundant source populations from nearby refugia can potentially re-colonize these areas or help sustain existing salmonid populations in marginal habitat. Protection of refugia areas is noted as an essential component of conservation efforts to ensure long-term survival of viable stocks, and a critical element towards recovery of depressed populations (Sedell 1990; Moyle and Yoshiyama 1992; Frissell 1993, 2000).

Refugia habitat elements include the following:

- Areas that provide shelter or protection during times of danger or distress;
- Locations and areas of high quality habitat that support populations limited to fragments of their former geographic range, and;
- A center from which dispersion may take place to re-colonize areas after a watershed and/or sub-watershed level disturbance event and readjustment.

Identified areas should then be carefully managed for the following benefits:

- Protection of refugia areas to avoid loss of the last best salmon and steelhead habitat and populations. The focus should be on protection for areas with high productivity and diversity;
- Refugia area populations which may provide a source for re-colonization of salmonids in nearby watersheds that have experienced local extinctions, or are at risk of local extinction due to small populations;
- Refugia areas provide a hedge against the difficulty in restoring extensive, degraded habitat and recovering imperiled populations in a timely manner (Kaufmann et al. 1997).

Basin Profile and Synthesis

Table of Contents

List of Figures

List of Tables

Basin Profile and Synthesis

The San Luis Rey River (SLR River) is located in Southern California, along the northern border of San Diego County. The river's terminus into the Pacific Ocean at the City of Oceanside is approximately 38 miles north of San Diego at latitude 33° 22' N, longitude 117° 36' W. The San Luis Rey River watershed (Figure 1) lies entirely in San Diego County, and it is bordered to the north by the Santa Margarita watershed and to the south by the Carlsbad and San Dieguito River watersheds. It is the third largest watershed in San Diego County with a drainage area of 560 square miles (PBSJ 2003) of which 342 square miles are situated below Henshaw Dam located at River Mile 50 (RM 50).

The SLR River originates in the Palomar and Hot Springs Mountains, as well as several other mountain ranges in the Cleveland National Forest along the western border of the Anza Borrego Desert State Park. It is approximately 60 miles in length from its headwaters to the Pacific Ocean. Henshaw Dam and the Escondido Canal diversion dam (RM 40) are the primary hydrologic controls of the river. The San Luis Rey River receives flow from 242 tributaries - adding up to 759 miles of perennial and intermittent stream. Elevations on the mainstem range from sea level to over 4,600 feet at the headwaters. A few of the tributaries' headwater areas extend above 5,000 feet. Principle tributaries located below the Escondido Canal diversion dam include: Paradise Creek, Pauma Creek, Frey Creek, Agua Tibia Creek, Gomez Creek, Keys Creek, Moosa Canyon Creek, and Pilgrim Creek. These tributaries flows have all been altered by anthropogenic (i.e. human) uses.

The SLR River gets its current namesake from the Franciscan Mission established by Spanish settlers in 1798 near the City of Oceanside. The Native Americans who inhabited the watershed were primarily divided between the Cupeños Indians who occupied the upper watershed and the Luiseño Indians (Spanish derived names for the tribes) who were located along the coast and river valleys. These tribes referred to the river as "Quechla" (http://www.nps.gov/history/history/onlinebooks/5views/5views 1h67.htm).

Steelhead (*Oncorhynchus mykiss*) is a salmonid species native to the North Pacific Ocean and in North American coastal streams extending from Alaska south to northwestern Mexico (NMFS 2007). In the SLR River steelhead runs were reportedly sufficient enough to provide a major food supply for the Luiseño Indians as late as the 1890s and early 1900s (USFWS 1998). As more settlers populated the SLR watershed during the late 1800s and early 1900s, increased demands were placed on the available water resources, particularly the mainstem of the river. This eventually led to the construction of the Escondido Canal in 1895, followed by the Henshaw Dam in 1922, which also coincided with groundwater extraction along the river and its tributaries. The completion of these projects greatly altered the hydrologic connectivity of the watershed and adversely affected the lifecycle requirements for steelhead production. By the 1ate 1930s steelhead populations in the SLR River became severely depleted (USFWS 1998).

Steelhead encountered additional adverse estuarine and freshwater conditions as an extended dry cycle from the mid 1940s through the late 1970s was accompanied with expanding human settlement and on-going water resources development. Surface flows in the river and its tributaries were greatly reduced or eliminated altogether. Limited surface flows, poor water quality, numerous fish passage barriers on the SLR River and its tributaries, the introduction of exotic flora and fauna, and loss of estuarine habitat have been identified as the leading factors in the decline of steelhead. Since the 1940s annual field surveys have not been conducted to appropriately determine the overall presence of steelhead in the SLR River Basin. However, during the spring of 2007, an adult steelhead, approximately 21-24 inches in length (Figure 25), was observed by California Department of Fish and Game (CDFG)/Pacific States Marine Fisheries Commission (PSMFC) personnel approximately 7 miles upstream of the river's mouth. Additionally, self-sustaining populations of native rainbow trout are present in Pauma Creek (RM 30) and WF SLR River (RM 50.5).

The National Marine Fisheries Service (NMFS) in 1997, federally listed the Southern California Coast Steelhead Evolutionary Significant Unit (ESU) as Endangered from Point Conception south to Malibu Creek. Subsequent to this original listing, two small populations of steelhead were documented south of Malibu Creek (Topanga and San Mateo Creek) and included in the southern range extension, thus extending the range to include all steelhead found in drainages south to the U.S.-Mexican border (NMFS 2007). In 2006 NMFS determined that the ESU designation of steelhead populations was not appropriate and reclassified the steelhead populations within the state as Distinct Population Segments (DPS). In July 2009, NMFS released a public review draft of the Southern California Steelhead Recovery Plan and will finalize the plan in the near future.

Agriculture crop production, along with urban runoff from developed areas, has introduced many pollutants into the river resulting in degraded water quality. According to the San Diego Regional Water Quality Control Board, the river shows high levels of chloride and total dissolved solids. High levels of bacteria have also been observed at the mouth of the river, near the Pacific Ocean.

Current efforts to restore the San Luis Rey River focus on the implementation of watershed management guidelines developed through the San Luis Rey Watershed Management Project and the Watershed Urban Runoff Management Plan (WURMP) for the San Luis Rey Watershed. The WURMP identifies tasks related to urban runoff that all jurisdictions in the SLR Watershed are committed to implementing in order to improve water quality. The San Luis Rey Watershed Council (2000) also identified twelve priority issues with consideration to long term planning within the watershed. Some of these issues are as follows: water quality and quantity, heavy industrial uses, invasive plant species management, flood plain management and flood plain warning, and wetlands protection and restoration (see Restoration Programs, pp. 73-74 for the entire list of issues). Furthermore, the Mission Resource Conservation District (RCD) has taken an active role in invasive plant species management along the SLR River and its tributaries and in conjunction with the Natural Resource Conservation Service (NRCS) has worked with local landowners on Best Management Practices (BMPs). Steelhead recovery in the SLR River is consistent with many of these and other ongoing activities intended to protect and/or restore ecosystem functions within the watershed.

Subbasin Scale

The complexity of large basins like the SLR River makes it difficult to address watershed assessment and recommendation issues except in very general terms. In order to be more specific and of value to planners, managers, and landowners, it is useful to subdivide the larger basin into smaller subbasin units whose size is determined by the commonality of many geographic attributes (Table 1).

For purpose of assessment and analysis, the San Luis Rey Basin was divided into five subbasins: Coastal, Southern, Northern, Middle, and Upper (Figure 2). These comprise a total of 11 CalWater 2.2.1 Planning Watersheds (PWs). Subbasins were designated based on several attributes, including locations of dam and water diversions, hydrology, geography, geology, and land use. Original PW boundaries were edited to more accurately reflect the drainage patterns and watershed processes within the SLR Basin when defining subbasins.

The Coastal Subbasin is the western portion of the SLR River, and includes the estuary. It is 102 square miles in area and includes approximately 22 miles of the mainstem from the river's mouth to Gomez Creek, as well as 133 miles of predominantly intermittent streams. From the lagoon to approximately 7.2 miles upstream, the river's channel has been concrete-lined but retains a natural streambed with riparian and wetland habitats. Due to the high water table and groundwater recharge, this portion of the mainstem remains flowing nearly year round. This subbasin

Table 1. General attributes of the SLR River Basin.

Attribute	Coastal Subbasin	Southern Subbasin	Northern Subbasin	Middle Subbasin	Upper Subbasin
Area	102mi2	134mi2	92mi2	26mi2	206mi2
Percent of Basin	18.2%	24.0%	16.4%	4.6%	36.8%
Miles of Stream (permanent + intermittent)	133.0mi	167.4mi	127.9mi	41.0	290mi
Principal Communities	Oceanside, Fallbrook, Vista, & Bonsall	Pauma Valley	Pala and Pauma Indian Tribes	La Jolla and Rincon Indian Tribes	Warner Springs
Predominant Geology	Mesozoic Granitic	Mesozoic Granitic	Mesozoic Granitic	Mesozoic Granitic	Mesozoic Granitic
Predominant Vegetation	Crop production & Grassland	Chaparral, Scrub oak, & crop production	Chaparral & Oak woodland	Oak woodland	Grassland & Oak woodland
Predominant Land use	Urban & Agriculture	Urban & Agriculture	Agriculture, Tribal lands, & Recreation	Tribal lands & Recreation	Grazing, Agriculture, Tribal lands, & Recreation
Salmonid species*	Steelhead	None	Rainbow Trout	None	Rainbow Trout

*Annual field surveys have not been conducted in any of the subbasins, which are necessary to confirm the presence or absence of steelhead/trout. In recent years, limited surveys have been conducted in Pauma Creek, French Creek, and Doane Creek in the Northern Subbasin and in the West Fork of the SLR River in the Upper Subbasin to assess populations of native, self-sustaining rainbow trout.

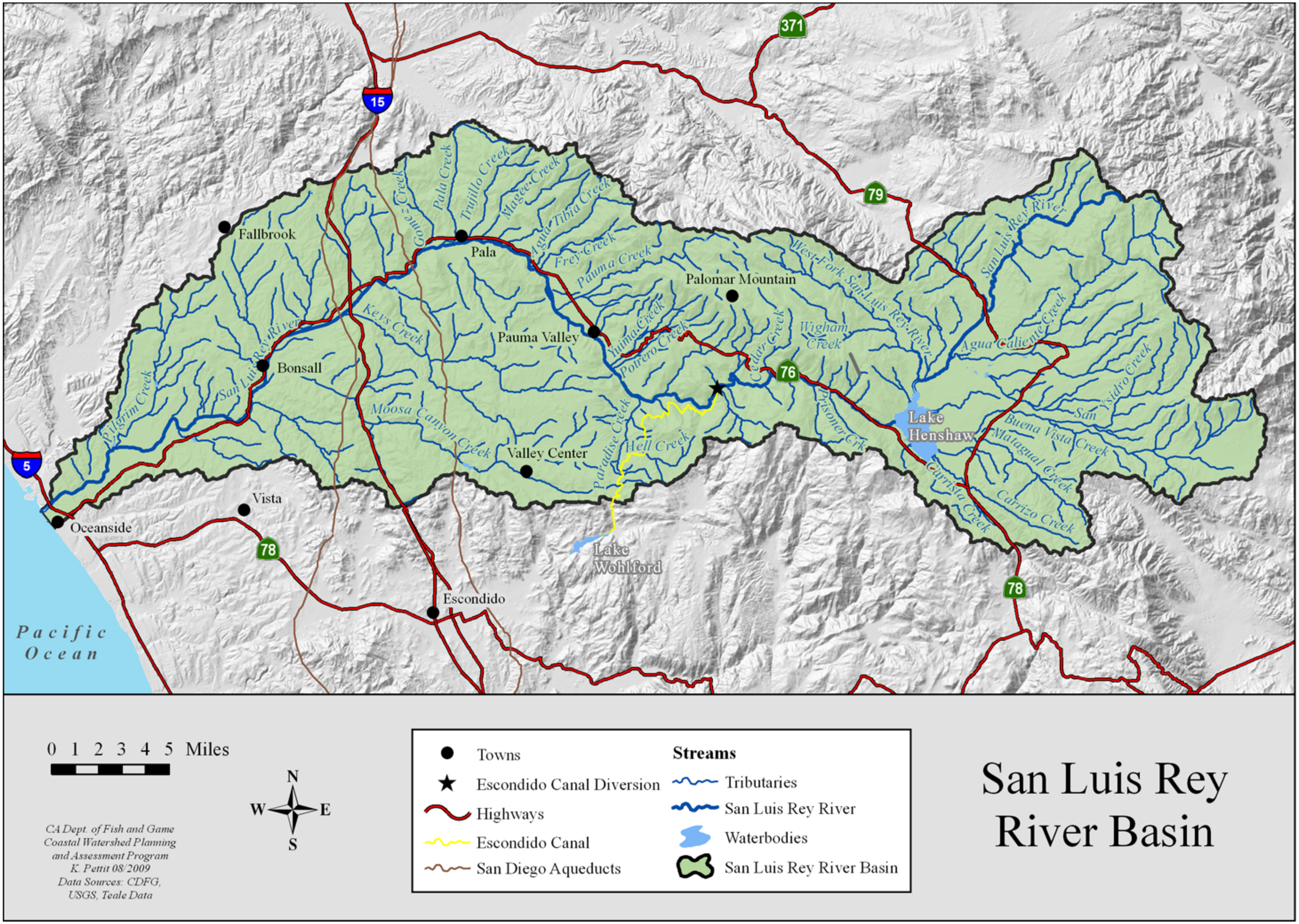


Figure 1. The SLR River Basin.

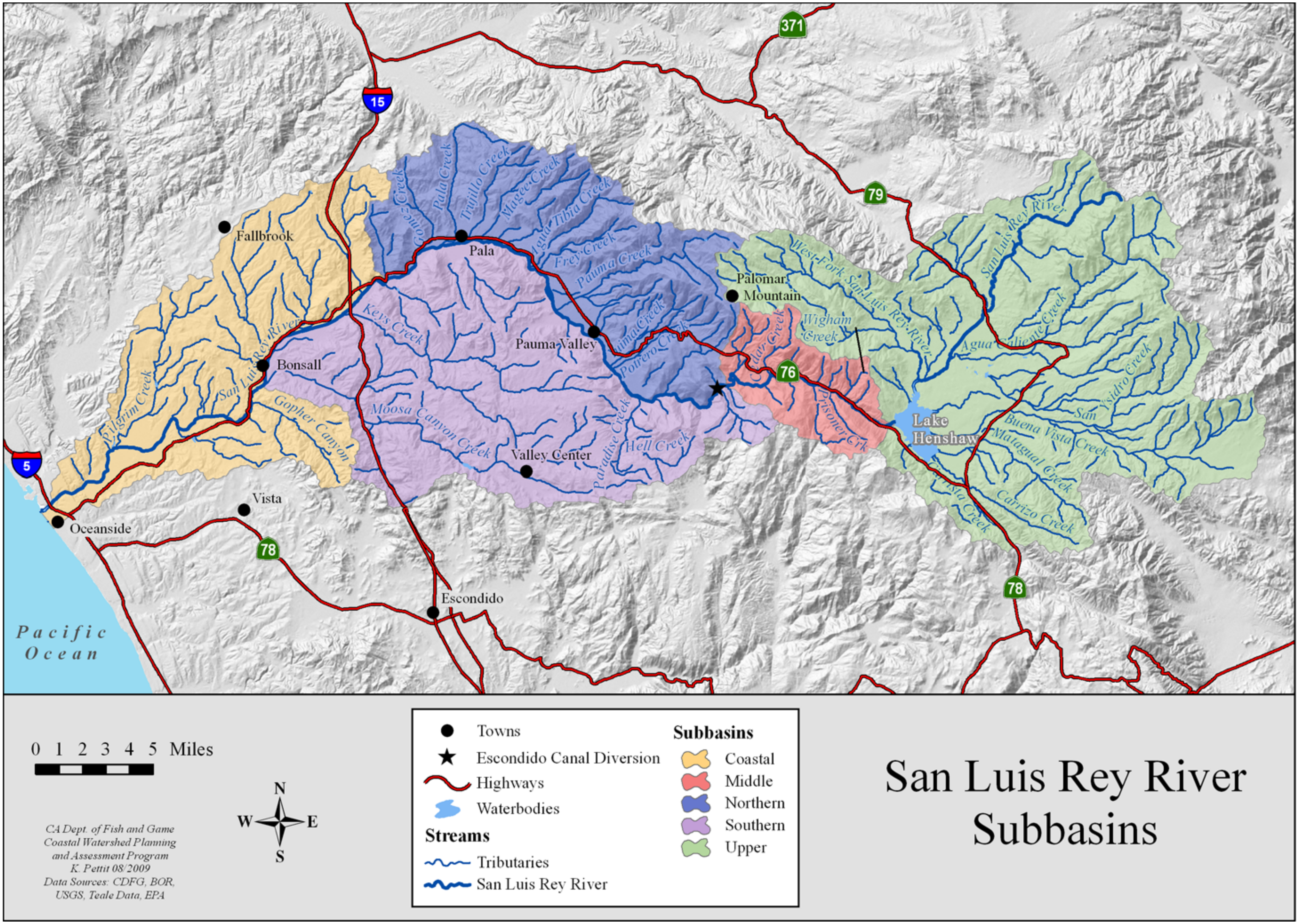


Figure 2. San Luis Rey River Subbasins, delineated using CalWater 2.2.1.

contains the largest human population, with the principle community of Oceanside. In addition to urban development, light industry, tourism and Camp Pendleton Marine Corps Base, agriculture also plays an integral role in the local and regional economy.

The SLR estuary in the Coast Subbasin has been significantly altered by human development and has been degraded from historical conditions. Once a sprawling estuary with native vegetation, sloughs, side channels, and connectivity with the Santa Margarita lagoon to the north, it currently functions primarily as a marina. Despite the decrease in the lagoon size, presence of non-native predatory fish species and overall poor quality of habitat, biological sampling conducted in the spring of 2000 and summer of 2003 demonstrated a typical subset of estuarine fishes that have marine adult or larval stages (MBC Applied Environmental Sciences 2003).

The Southern Subbasin is the second largest subbasin with approximately 134 square miles and contains the SLR River and its southern tributaries primarily between Interstate 15 and the Escondido Canal diversion dam (RM 40). This diversion dam is located 10 miles downstream of Lake Henshaw, near the eastern end of the Southern Subbasin. The 12 foot high, concrete dam spans the entire river channel and continuously diverts the majority of river water into the canal. Between the Escondido Canal diversion and the numerous unregulated wells associated with extensive agricultural production, the majority of the SLR River within the subbasin remains dry for most of the year. Surface flows generally only occur during or immediately after significant rain events. The exception being in the SLR River canyon, downstream of the diversion, where year round surface flows are most likely maintained by rising ground water and small side tributaries and springs (M. Capelli, NMFS, personal communication 2009). This area, RM 37 to RM 39.5 (approximately), represents the best potential steelhead trout habitat within the subbasin and could serve as important refugia within the basin. Several man-man, partial barriers to steelhead/trout movement are located downstream of canyon along the SLR River that would hinder access into the canyon.

In the upper end of the SLR River canyon a natural waterfall barrier is located approximately a half a mile below the diversion dam at RM 39.5 (the La Jolla Tribe refers to this area by its Luiseño place name "Kye"). While the overall height of the waterfall is about 50 feet, it is broken up into a series of steps, with the largest lowermost step approximately 13 feet, and a narrow steeped crevasse above the first step extending to the top of the waterfall (M. Capelli, personal communication 2010). Under most flow conditions steelhead are very unlikely to navigate through this feature. In recent years, steelhead have not been identified in the Southern Subbasin; however, field surveys utilizing appropriate protocols have not been employed to confirm the presence or absence of steelhead/trout.

The Northern Subbasin is located a few miles east of Interstate 15 and is composed solely of the north slope draining tributaries of the SLR River. Beginning with Rice Canyon, it contains all the tributaries north of the mainstem upstream to the Escondido Canal diversion dam. In its 92 square miles, it contains 127 miles of predominantly intermittent streams. These streams typically are of steeper gradient than the rest of the basin and flow from the highest mountain ranges within the basin. The Northern Subbasin provides potential spawning and rearing habitat for steelhead/trout, located primarily in a few tributaries, such as Pauma Creek, Gomez Creek, Pala Creek, Agua Tibia Creek, and Frey Creek. However, the majority of the potential suitable habitat is not accessible in these tributaries due to man-made fish passage barriers and/or water diversions/ groundwater pumping that decrease seasonally appropriate stream flows. Located centrally within the subbasin, a healthy population of self-sustaining rainbow trout persists in the Pauma Creek watershed. Genetic sampling of these fish concluded that, “it seems more than likely that these fish are part of a native coastal *O. mykiss* lineage” (NOAA 1999). This genetic analysis report went on to state, “these populations may be reasonable choices to consider in efforts to re-establish anadromous runs in their respective streams.” However, fish passage into and out of Pauma Creek is completely blocked by a box culvert, located under Highway 76.

The Middle Subbasin is the smallest subbasin in the assessment area with 26 square miles. The subbasin and river are demarked by the Henshaw Dam on its eastern boundary and the Escondido Canal diversion dam (RM 40) on its western boundary (the subbasin’s boundary is just upstream of the diversion). The natural flow regime in this subbasin has been significantly altered by the timing and volume of flow released from Henshaw Dam, which is determined by water right agreements with La Jolla and Rincon Indian Tribes, Vista Irrigation District, and the amount of water stored in Lake Henshaw. Potential steelhead/trout spawning and rearing habitat exists in the subbasin, but steelhead trout access to the subbasin is restricted due to the altered flow regime and downstream fish passage barriers, including the diversion dam and the natural waterfall at RM 39.5.

Rainbow trout were initially planted in the SLR River beginning in the late 1800/early 1900s by local landowners. Subsequently, during the 1940s the California Department of Fish and Game (CDFG) initiated a stocking program in order to support the demand for a local recreational fishery. Rainbow trout were planted in the SLR River downstream of Lake Henshaw and on the La Jolla Indian Reservation. This stocking program continued until the early 2000s. While trout are no longer present in the Middle Subbasin, exotic warm water game fish, such as largemouth bass, channel catfish, bluegill, etc. are now abundant in the SLR River, especially in upper portions of this subbasin. These fish are transported downstream from Lake Henshaw during flow releases.

The Upper Subbasin is the largest subbasin occupying approximately 206 square miles. This subbasin contains Lake Henshaw and all its tributaries (including the upper SLR River) that flow into the lake. Henshaw Dam, in conjunction with the Escondido Canal diversion dam, are the hydrologic controls in the basin as well as being permanent barriers to upstream fish passage. The Vista Irrigation District releases flows from the lake, typically in the late spring and continuing into early summer. The Upper Subbasin holds populations of resident native rainbow trout and arroyo chub, a native fish of southern California. Prior to any introduction of hatchery fish, the Upper Subbasin contained trout (Cooper 1874) and genetic sampling on trout taken from the West Fork SLR River concluded that, "…. it seems likely that the West Fork population is composed predominantly of native fish to the region" (Thorgaard 1979). This is strong evidence of ocean-run steelhead once accessing and populating the Upper Subbasin. Lake Henshaw and the area surrounding the lake provide regionally significant recreational hunting and fishing opportunities. Numerous species of exotic warm water game fish inhabit the lake and are inadvertently released downstream into the SLR River during seasonal flow releases.

Climate

The SLR River basin is representative of a Mediterranean climate with dry, warm to hot summers and relatively cool, moist winters. Climatic variations within the watershed are the result of coastal influence and elevation. The dry season along the coast, May through October, is usually defined by morning fog and cloudiness. On average, about 266 days out of the year are clear, with the remaining 99 days being either cloudy or partly cloudy. The average winter minimum temperature near the coast is 46°F with cooler inland temperatures that range from 30°F in the Upper Subbasin with an occasional snowfall, to 37°F in the valleys of the Northern and Middle subbasins. The average summer temperature along the coast is about 69°F, with temperatures inland that frequently exceed 90°F. (http://www.wrcc.dri.edu/). A majority of the precipitation falls during the months of November through April with snow occurring in the higher elevations of the Agua Tibia, Palomar, and Hot Springs mountains.

The Western Regional Climate Center has precipitation data for Oceanside, from water years (WY) 1953-2005; Lake Henshaw and Palomar Mountain WY 1948 to 2005 (Figure 3). Along the coast, Oceanside receives a mean annual precipitation of approximately 12 inches, while higher elevations inland, Lake Henshaw and Palomar Mountain, receive 26 and 33 inches respectively. An isohyetal contour map (Figure 5) of the SLR River Basin reflect these figures as mean annual precipitation and is lowest in the Coastal Subbasin and highest in the upper elevations of the Northern Subbasin. Palomar Mountain stands isolated from the rest of the Agua Tibia Mountain Range. Its location and high elevation of 6,126 feet is such that it intercepts many storms from the coast making it one of the wettest locations in Southern California. In 1993, Palomar Mountain collected a record 97 inches of precipitation (http://www.fs.fed.us/r5/cleveland/).

Considering precipitation records for the basin are limited from the late 1940s to the present, one has to examine recorded data for downtown San Diego to gain a further historical perspective of precipitation trends in the area. Precipitation records for downtown San Diego date back to the mid 1800s. These trends, displayed in Figure 4, indicate that the region went through a dry period between the mid 1940s to the mid 1970s; subsequently, precipitation increased to levels that resembled those prior to this dry spell (http://www.wrcc.dri.edu/). However, in recent years, rainfall totals have decreased and on-going drought conditions have existed for much of this past decade.

Projections of future climate conditions, conducted by nineteen different climate modeling groups around the world and using different climate models, show widespread agreement that the southwestern U.S.—including southern California—are going to become increasingly arid as a consequence of rising greenhouse gases (Seager et al., 2007). According to these models, the transition to a hotter, more arid climate in the southwestern U.S becomes marked early this century. Regional climate projections for southern California Coast Ranges suggest a future of longer, hotter summers, more extreme heat waves and droughts, perhaps drier rainy seasons, reduced snowfall in mountainous regions, and perhaps more intense precipitation events in some areas (NMFS 2009 *Draft*).

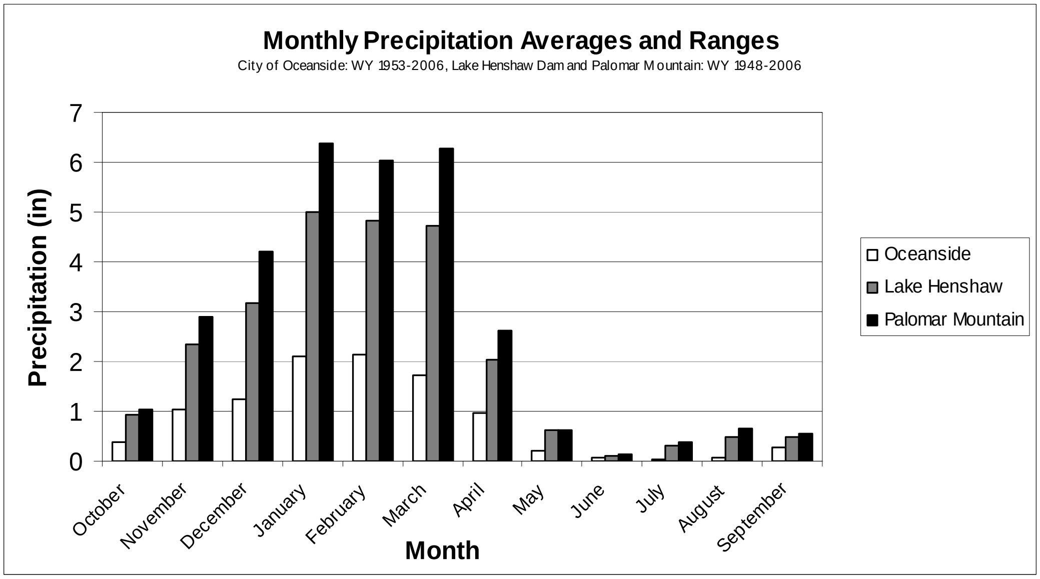


Figure 3. Average monthly precipitation within various locations of the SLR Basin.
(Western Regional Climate Center website, http://www.wrcc.dri.edu/).

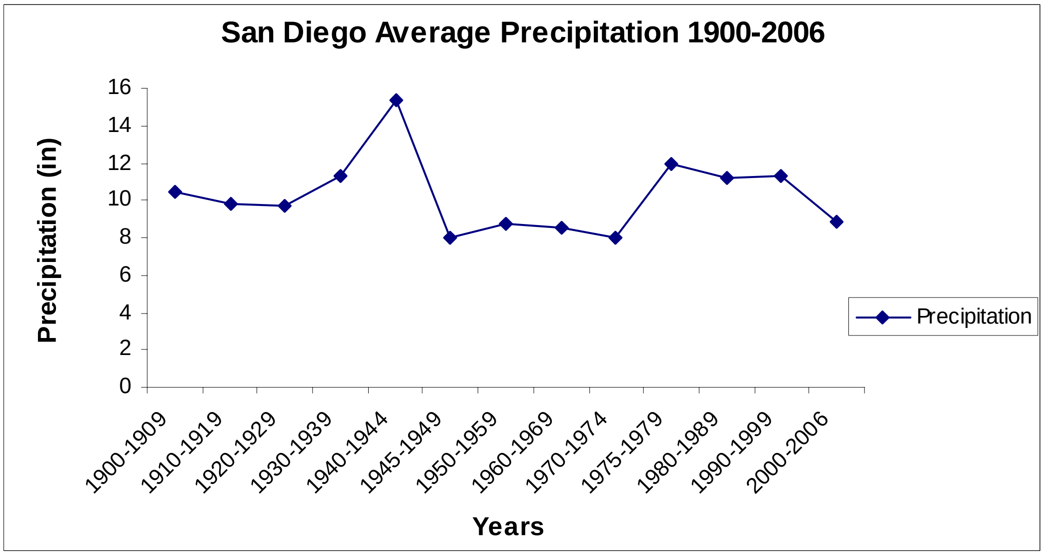


Figure 4. Yearly precipitation statistics over the period of record in downtown San Diego.
(Western Regional Climate Center website, http://www.wrcc.dri.edu/).

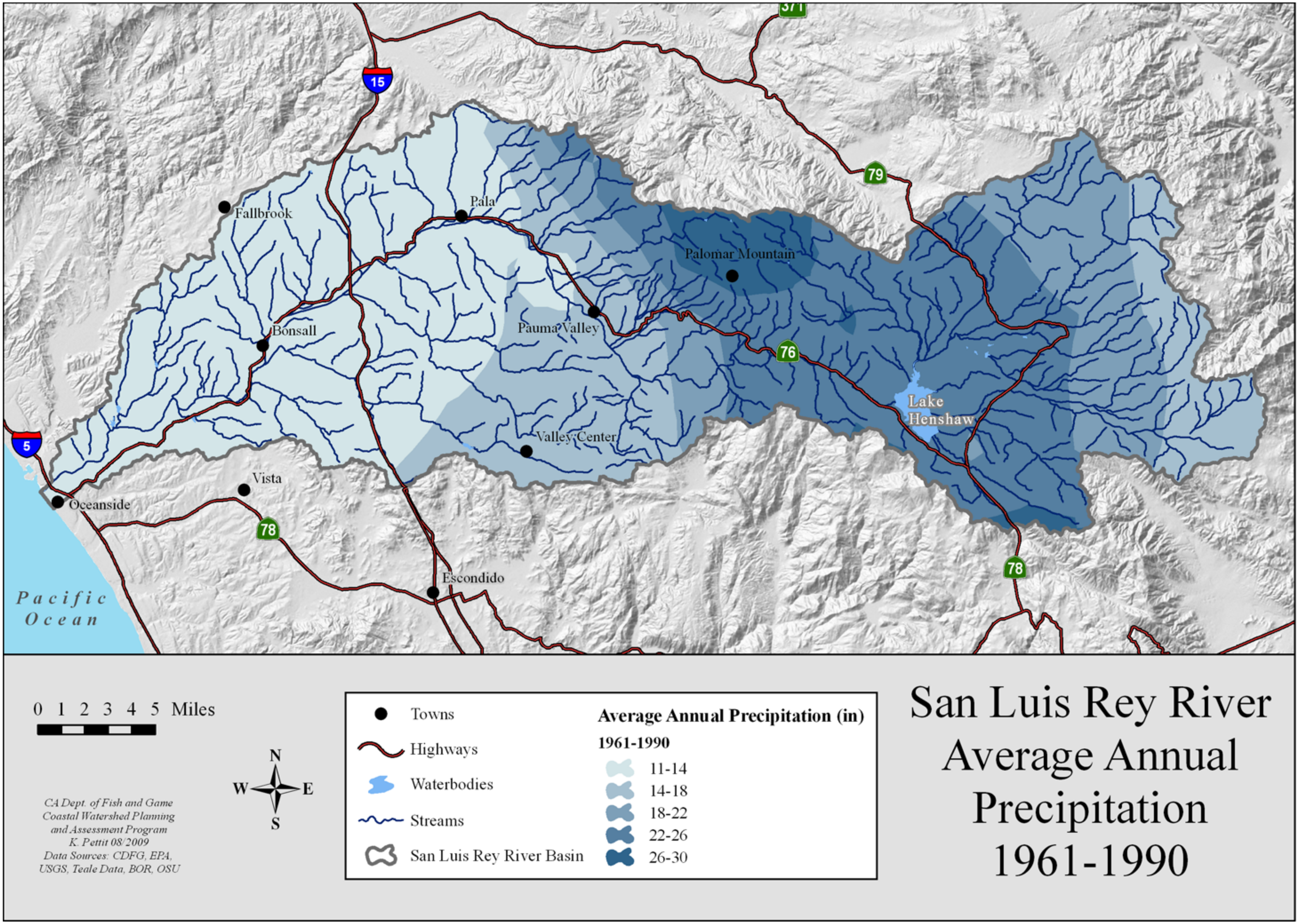


Figure 5. San Luis River Basin average annual precipitation.

San Luis Rey River Timeline

The San Luis Rey Basin has undergone significant changes and modification since the establishment of Spanish missions along the basin's coast approximately 215 years ago to its current state of multiple uses and an increasingly populated area throughout the watershed. Many of the modifications have had unforeseen cumulative ecological and hydrological impacts. The significant changes in the system during this period have drastically altered the hydrologic function of the watershed.

Pre-1769s: The San Luis Rey Basin is inhabited by the Luiseño Indians who occupy villages along the coast and streams in narrow valleys and the Cupeños Indians who reside in Agua Caliente Village near what is now Warner Springs in the eastern part of the watershed. Cupeños Indians were eventually evicted from their lands in 1903;

1769: Spanish settlers arrive and attempt to convert local Indians to Christianity;

1798: Spanish settlers establish Mission San Luis Rey in what is now Oceanside;

1829: Mission San Luis Rey is expanded;

1846-1848: Mexican-American War;

1850: California becomes 31st state;

1862: Trout observed in headwaters of the SLR River in the Warner's Pass area (Cooper 1874);

1883: California Southern Railways finished linking San Diego with San Bernardino;

1888: Cities of Oceanside and Escondido are incorporated;

1891: Fallbrook Irrigation District is organized; Mission Indian Relief Act signed making the Rincon, La Jolla, Pauma, Pala, San Pasqual, and Yuma reservations permanent;

1895: Escondido Irrigation District completes Escondido Canal bringing water from the SLR River on the La Jolla Indian Reservation to what is now known as the City of Escondido;

1909: U.S. Highway 101 defined from San Diego to Oceanside, which later becomes Interstate 5;

1916: Largest recorded flood with maximum discharges of 95,600 cfs (recorded at Oceanside), kills four people and washes out City of Oceanside bridges;

1922: Completion of the Henshaw Dam on Warner Ranch with the intent to divert water for irrigation and municipal uses;

1923: Vista Irrigation District (VID) is formed;

1926: First water deliveries from Lake Henshaw to Lake Wohlford via the Escondido Canal. This water was then made available for service area of what is now Vista;

1928: Metropolitan Water District of Southern California is incorporated;

1938: FPUD buys Fallbrook Irrigation District, thus acquiring a permit for 2,500 acre-feet of water from the SLR River;

1942: Upper San Luis Rey Resource Conservation District is organized; U.S. purchases Rancho Margarita and Las Flores property for Camp Pendleton;

1944: Mission Resource Conservation district is formed; San Diego County Water Authority formed under the County of Water Authority Act;

1946: Vista Irrigation District purchases all of the stock of the San Diego County Water Company and acquires ownership of Henshaw Dam and 43,000 acres of land in the Warner's Basin; San Diego County Water Authority (SDCWA) partners with Metropolitan Water District;

1947: SDCWA begins delivering imported water from the Colorado River into San Diego County;

1953-55: Rainbow Valley Center and Vallecitos Water Districts are formed;

≈1960: Sand mining operations begin in the San Luis Rey riverbed;

1962: Pauma Valley Water District is formed;

1969: The Indian Tribes of Pauma, Pala, Rincon, La Jolla, and San Pasqual (the Bands) sue the City of Escondido and the Vista Irrigation District (Local Entities) charging that the U.S. law protecting Indian reservation water rights was violated and the Secretary of Interior exceeded his authority in reaching water agreements on behalf of the Indian Bands;

1980: Largest flood event since the completion of Henshaw Dam (peak discharge of 25,000 cfs at Oceanside) causes 2.23 million in property damage;

1988: San Luis Rey Indian Water Rights Settlement Act recognized that the Federal government had in effect given away the right to the SLR River water twice to the Bands. Furthermore, it recognized "The inadequacy of the San Luis Rey River to supply the needs of both the Bands and the Local Entities…" and authorized and directed the Secretary of the Interior to "provide a supplemental water supply for the benefit of the Bands and the Local Entities." (J. Membrino, Special Counsel, San Pasqual Band of Mission Indians, personal communication 2009);

1989: U.S. Army Corps of Engineers begins construction on seven mile flood control project considered to be a grouted rip-rap control channel, with concrete covered boulder sides and a natural bed of the SLR River in the City of Oceanside;

1993: Large flood event (25-year flood event) which caused extensive damage to property and various infrastructure;

1994: Oceanside constructs a demineralization plant creating a local water supply;

1995: Large flood event (25-year flood event) which also caused extensive damages to property and infrastructure;

1997: Federal listing of Southern California Steelhead ESU (Santa Maria River south to Malibu Creek) as "endangered" under the Endangered Species Act;

1997: San Luis Rey Watershed Council is organized;

1999: U.S. Army Corps of Engineers completes SLR River flood control project in City of Oceanside;

2000: California voters end years of debate and legal battles over casino-style Indian gaming by enacting Proposition 1A, a constitutional amendment removing the legal impediment resulting in the overturn of Proposition 5 (a gaming initiative enacted in 1998 but overturned by the California Supreme Court). Shortly afterwards, Pala, Pauma, and Rincon Indian Tribes develop casino-style gaming facilities on their respective tribal lands;

2001: Implementation Agreement provided for the delivery by the Secretary of the Interior for the benefit of the Indian Bands and the Local Entities of up to 16,000 acre feet of water conserved by the lining of the All-American Canal and its Coachella Branch (J. Membrino, personal communication 2009);

2002: NMFS extends range of Southern California Coast Steelhead ESU to the U.S.-Mexican border;

2002: Rosemary Mountain Quarry permit approved. Lawsuits challenging permit were stuck down in 2004. After the projected completion of the Highway 76 road widening in 2009 and development of the plant, the quarry is projected to commence operations in 2010 and sell 1 million tons of sand and gravel a year for 20 years;

2003: Three water agencies and the state of California finalize the Quantification Settlement Agreement to settle longstanding disputes concerning Colorado River water. This agreement provides California a transition period to implement water transfers and supply programs that will reduce California's dependence upon the Colorado River and reduce the state's draw to its 4.4 million acre-foot basic annual apportionment;

2005: The Fenton Sand Mine near Pala ends operations, ending the last operating sand mine on the SLR River;

2006: NMFS determined that the ESU designation of steelhead populations was not appropriate and reclassified the steelhead populations within the state as Distinct Population Segments (DPS);

2008: U.S. Army Corps of Engineers begins a long-term Operation and Maintenance Plan to remove riparian vegetation along the SLR River in Oceanside in order to maintain a flood capacity of 71,200 cfs.

Hydrology

The SLR River Basin includes numerous tributaries from the Peninsular Ranges, which include the Agua Tibia, Palomar, Hot Springs, and Volcan Mountains to the Pacific Ocean. The length of the mainstem from Henshaw Dam to the ocean is approximately 50 miles with an additional 10 miles of mainstem above the dam. There are approximately 757 miles of intermittent and perennial stream miles within the SLR River Basin. Lengths of individual streams and river mile locations are detailed in the subbasin sections.

In order to help evaluate and categorize streams and rivers, streams are assigned a stream order classification based on the branching pattern of river systems (Strahler 1957). A first order stream is defined as the smallest un-branched tributary to appear on a 7.5-minute USGS quadrangle (1:24,000 scale) (Leopold et al. 1964). This system includes only perennial streams (i.e. those with sufficient flow to develop biota). When two first order streams join, they form a second order stream. When two second order streams join, they result in a third order stream; and as streams of equal order meet they result in a stream of the next higher order (Flosi et al. 1998). The mainstem of the SLR River is a difficult system to designate a stream order due to the numerous diversions and lack of hydrologic connectivity in the basin. Although the river is situated in a large basin with numerous contributing streams, the arid climate combined with significant water diversions and extractions create predominantly intermittent conditions with only a few first order tributaries. Consequently, the mainstem SLR River was classified as a second order stream in the Coastal and Middle subbasins, and mostly intermittent in the Southern and Upper subbasins.

The San Luis Rey River is located in an area where anthropogenic (i.e., human) actions have greatly altered the hydrology and water quality of the river. These anthropogenic influences include:

- The completion of the Henshaw Dam at RM 50 in 1922 - limiting surface flows in the river to surfacing groundwater and precipitation for extended portions of the year;
- The Escondido Canal diversion - located at RM 40 (ten miles below Henshaw Dam), diverts practically all flows out of the river into the canal, usually leaving the river dry immediately downstream of the diversion and drastically reducing water flow to the rest of the basin;
- Thousands of wells are located throughout the SLR River Basin, some of which are drawing water directly from tributaries and from the shallow aquifer of the SLR River, which, in turn, greatly reduces overall surface flows of the SLR River and lowers the groundwater table;
- Use of imported Colorado River water, allowed groundwater aquifers to recharge from years of over pumping and thus returned perennial surface flows in the Coastal and lower Southern subbasins the late 1960s;
- Increased salt loads entering the groundwater from urban runoff (via irrigation flows), which is heavily supplemented with Colorado River water (Colorado River water contains a higher salt content than local water sources).

Stream Flow

Stream flow data are an important component in determining the historic and existing conditions and assisting assessment, restoration, and management activities in South Coast basins. Stream flow can be a limiting factor for anadromous fisheries, affecting passage and the quantity and quality of spawning, rearing, and refugia areas. Stream flow also has a direct effect on other factors such as water temperature, dissolved oxygen, and sediment and chemical transport.

The SLR River Basin receives varied precipitation and has extremely altered runoff rates. Stream flow discharge is typified by peaks in the winter, including flood flows, and very low flows in the summer. In addition to precipitation, flows in the SLR River have been and continue to be influenced by dams, water diversions/extractions along the river and its tributaries, and the geologic/hydrologic conditions, including the surface water and shallow, alluvial aquifer relationship in the basin. These alluvial groundwater aquifers exist adjacent to and along the riverbed and extend from the eastern edge of Oceanside upstream to Pauma Valley (Figure 6). Another large aquifer is located in the area surrounding Lake Henshaw. Depending on the amount of withdrawal, the aquifers have provided potential base flow to the river for most of the year (PBSJ 2003). These aquifers have been and continue to be used throughout the watershed for agricultural, industrial, municipal, and tribal water supplies. For example, the Lake Henshaw area aquifer’s production is utilized by the settlement parties in the San Luis Rey Settlement Agreement (J. Membrino, personal communication 2009).

There are two currently operating United States Geological Survey (USGS) river gauges recording

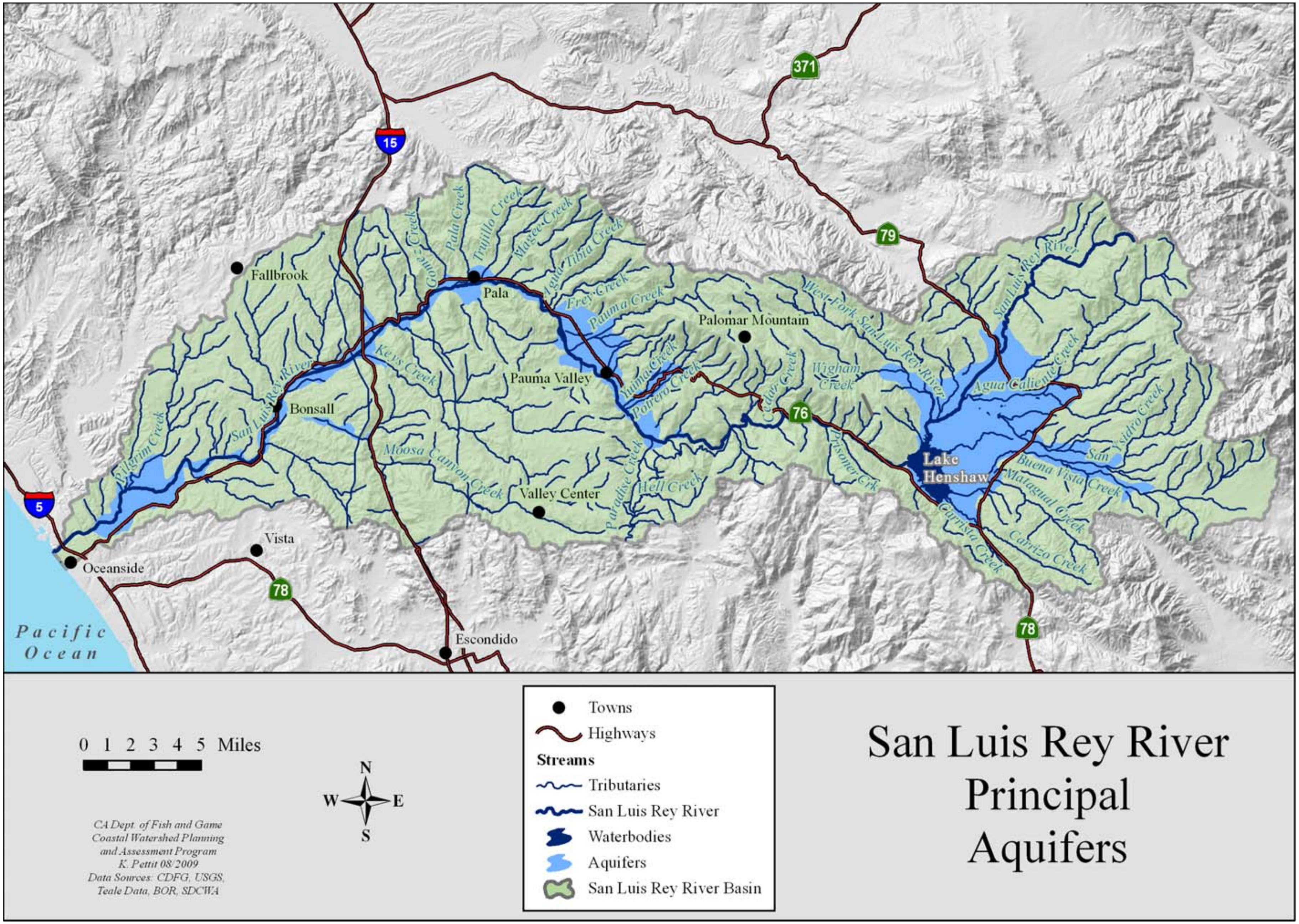


Figure 6. Aquifers of the SLR River Basin.

stream flow data within the basin. The oldest and most complete records are from the gauge operating in Oceanside, under the Benet Road Bridge (RM 1.25). The Oceanside gauge (USGS ID 11042000) measures gauge height and discharge (in cubic feet per second) (http://www.usgs.gov/). This gauge has operated from 1913-1916, 1930-1942 and 1947 to the present. The other operating river gauge is located 0.07 miles south of Cole Grade Road, near Pauma Valley. This gauge (USGS ID 11036700) has been in operation since March of 2008 and is also recording river gauge height and discharge. Two other gauges recording discharge operated briefly from March 2008 to October 2008 in the Pauma Valley but have since discontinued data collection. Historically, additional stream gauges were located along the SLR River and recorded stream flow data during different time periods from the early 1900s to the 1980s. The data recorded from these gauges is discussed in more detail in the following section.

Historical Stream Flows

Sufficient data exists to indicate that prior to the completion of Escondido Canal diversion dam in 1895 and subsequently Lake Henshaw Dam in 1922 the SLR River contained perennial stream flows in most years, from near its headwaters downstream to the Pacific Ocean. Historical stream gauge data, previous studies, aerial photos, and sufficient anecdotal accounts support this statement. Kondolf and Larson (1995) reviewed some these factors and others in a case study on the SLR River and thus concluded: “under natural conditions, flow was probably perennial in most years. Surface flow may have ceased in dry years, but the alluvial water table probably remained high, supporting riparian vegetation and maintaining deep pools as refugia for aquatic organisms.”

Data recorded at formerly operating USGS river gauges in the Southern and Middle/Upper subbasins indicated year-round surface flows throughout the SLR River in the early 20th century. In the upper SLR River, an USGS river gauge, stationed at the current location of Henshaw Dam (RM 50), recorded stream flow data from 1912 to 1922. During this period, minimum monthly summer/early fall flows averaged above 1.4 cubic feet per second (cfs), while minimum monthly winter and spring flows averaged above 8 cfs (Hazel et al. 1976 in Jones and Stokes 1976). Mean monthly flows were significantly greater and reached as high as 254 cfs during winter months (see Middle Subbasin, Figure 5, p. 11). Similarly, in the Southern Subbasin, flow data recorded in Wilderness Gardens County Park at RM 27, (approximately 8 miles east of Highway 15), from the period of 1909 to 1915, indicated mean monthly discharges of at least 1.5 cfs during the dry late summer/early fall and substantially higher flows the rest of the year (Figure 7).

Reviewing San Diego precipitation records indicates these rain years (1909-1915) ranged from above normal precipitation to below normal precipitation (http://www.wrcc.dri.edu/); therefore, the perennial flows recorded at the Wilderness Gardens location cannot merely be attributed to a period of increased rainfall. Rather, these measurable flows were most likely the result of continuous river flows in the Southern Subbasin, and its close proximity to perennial flowing tributaries such as Pauma Creek, Frey Creek, and Agua Tibia Creek, which drained into the SLR River just upstream of the Gardens. These contributing tributaries had yet to have been significantly impacted by anthropogenic activities and uses.

The historical operation of the first mill in northern San Diego County at the present-day Wilderness Gardens County Park provides additional evidence of perennial river flows in the Southern Subbasin in the late 1800s. This grist mill required a flowing water supply in order to turn the grinding stones for grinding corn and wheat into flour. From 1881 till the early 1890s the Sickler Brothers operated this highly profitable mill, year-round, serving farmers throughout the region. Operations ceased when no one came forward to continue its operation (Jones 2006 and County of San Diego 2005).

Anecdotal accounts of local historians and elderly tribal members described how the SLR River flowed freely down to Pauma Valley. Leo Calac, a Rincon elder whose grandfather grew crops stated: “There was enough water every year for those who wanted to farm, the riverbed was full of sycamores and willows... The old-timers say in Pauma Valley that steelhead used to come up from Oceanside” (Soto 2008). Henry Rodriguez (former tribal leader of the La Jolla Indians) also affirmed, “There was running water in the San Luis Rey River, with large pools, even down at Rancho Corrido (Pauma Valley) and the narrows - these pools held fish” (http://www.sandiegotrout.org/indians.html).

These nearly perennial flows disappeared from the river due to the lack of water released below the Escondido Canal diversion dam, an extended, climatically dry period between the mid-1940s and mid-1970s, and increased groundwater withdrawals throughout the Northern, Southern, and Coastal subbasins, which resulted in a lowering of groundwater levels. The SLR River (in the Coastal and Southern subbasins) became completely devoid of surface flows, except during or immediately after significant rain events, from the mid 1940s to the late 1960s (Table 2).

The dry riverbed in the mid to lower river varied from the river's flow conditions in the Upper and Middle subbasins where the aquifer at Lake Henshaw has been used since the 1950s to supplement surface flows for use by the Local Entities (City of Escondido and VID) (J. Membrino, personal communication 2009).

By the early 1950s, the extensive lowering of groundwater levels in the Coastal Subbasin and lack of hydrologic connectivity to the middle and upper watershed enabled a trough of seawater to extend for a distance of two to six miles inland from the coast (U.S. Geological Survey 1976). In the Southern Subbasin, the water table level dropped as much as 85 feet, forcing the abandonment of some wells, and giving rise to increased pumping costs (http://www.yuimamwd.com/).

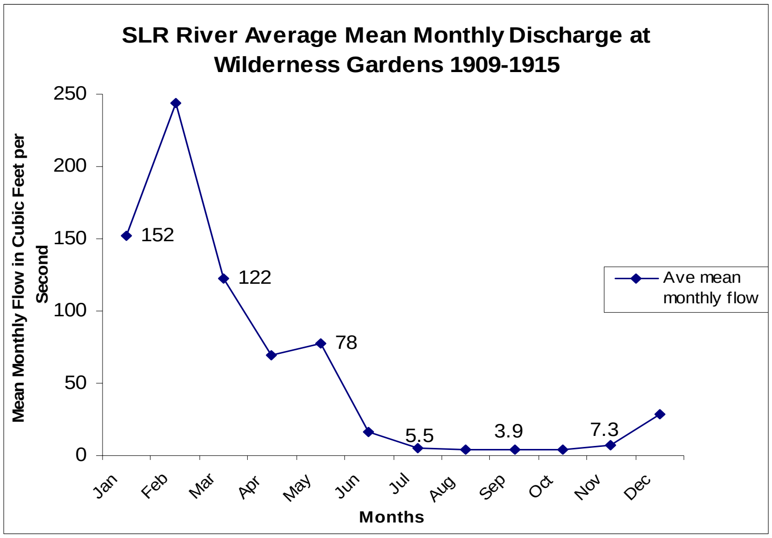


Figure 7. SLR River average mean monthly flow recorded at Wilderness Gardens from 1909-1915 (USGS website).

Table 2. Median monthly flow (cubic feet per second) for SLR River at Oceanside by decade (USGS website).

Decade	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1930s	22.8	209.4	222.0	45.2	19.4	2.3	0	0	0	0	0	9.6
1940s[1]	14.5	27.5	111.7	82.2	21.3	4.3	0.28	0	0	0.89	5.6	10.2
1950s	0.06	0	1.6	4.6	0	0	0	0	0	0	0	0
1960s	6.7	31.4	6.0	1.9	0.7	0.4	0.4	0.2	0.1	0.4	1.2	8.1
1970s	82.3	78.1	140.0	75.6	34.8	23.6	9.9	3.3	3.5	4.9	11.5	27.6
1980s	111.2	276.7	295.4	128.9	82.7	47.8	29.4	28.1	14.5	15.5	34.3	60.9
1990s[2]	85.5	67.9	230.9	68.2	44.0	18.7	8.4	4.6	3.6	3.4	8.5	15.5
2000s[3]	287.1	170.8	105.3	53.0	26.5	12.5	5.5	3.0	2.9	21.2	14.0	26.5

[1] No data recorded from 1942-1945
[2] No data recorded from October 1992 to September 1993 and November 1997 to May 1998
[3] No data available from October 2001 to October 2003

Influence of Imported Water Supplies on Stream Flows

With expanding agriculture production, an increasing population in the San Diego region, and overtaxed groundwater supplies it was imperative that the area acquire outside water sources. These sources were made available by importing Colorado River water beginning in the late 1940s and further supplemented by the State Water Project in the early 1970s, which brought in northern California water supplies. Colorado River water is transported from Lake Havasu, Arizona, through the Colorado River Aqueduct to Lake Mathews in Riverside County. Before reaching Lake Mathews, a portion of the water is delivered through the San Diego Canal to Lake Skinner, the primary storage facility for San Diego where it is treated. In some years, the Colorado River Aqueduct has supplied as much as 90% of all the water used in San Diego County (http://www.doi.gov/). The San Diego Canal also transports State Project water to Lake Skinner. Water from this source is transported via the 444-mile California Aqueduct from the delta at the confluence of the Sacramento and San Joaquin Rivers to Lake Perris, in Riverside County. It is then blended in the San Diego Canal with Colorado River water and flows into Lake Skinner from which deliveries are made to MWDs member agencies in southern Riverside County and San Diego County through the San Diego Aqueducts. These aqueducts distribute water across the region, including the SLR River Basin, through a network of pipelines (http://www.yuimamwd.com/).

The MWD and the San Diego County Water Authority (Water Authority) determines how much water is available for these deliveries throughout San Diego County. The Water Authority takes delivery of water from MWD in five pipelines buried in two rights of way called the San Diego Aqueducts (http://www.yuimamwd.com/). These aqueducts run north to south parallel to Interstate 15. The First Aqueduct is on the east side of the Interstate and Aqueduct 2 is just west of the Interstate (Figure 9). The delivery points are located about six miles south of the Riverside-San Diego County line. From there, water is distributed through more than 245 miles of pipeline to the Water Authority's 23 member agencies through 88 service connections to serve 2.6 million residents in San Diego County (http://www.yuimamwd.com/).

After the completion of the first San Diego Aqueduct in 1947, imported Colorado River water became available for use in the region. This, in combination with the completion of the second San Diego Aqueduct in the early 1960s, slowly allowed groundwater recharge to occur within the basin. The amount of imported water increased to meet escalating water demands and water availability for applied uses (agricultural and municipal). Meanwhile, the volume of groundwater extraction decreased, thus allowing a recovery of groundwater levels to historical levels by the early 1970s. In turn, the volume of river flow increased significantly and by the late 1960s the SLR River was considered a perennial river in the vicinity of Oceanside. The mean annual flow of the SLR River at Oceanside went from 0.6cfs between the years 1947 to 1967 (SLR Watershed Council 2003) to a mean annual flow of 52cfs between the years 1967 to 2006. Mean monthly discharge during this latter period has ranged from approximately 0 to 1,858cfs (Table 3). Expanding urbanization, which decreases infiltration of precipitation and increases surface runoff, most likely also contributed to the increased discharge rates (Hawkins et al. 1997).

Table 3. Statistics of mean monthly discharge and maximum and minimum monthly discharges in their respective year(s) for SLR River at Oceanside over the period of record, Water Year (WY) 1967 to 2006. Data from USGS (2006).

Month	Mean Monthly Discharge (cfs)	Maximum Mean Monthly Discharge (cfs) and Associated WY	Minimum Mean Monthly Discharge (cfs) and Associated WY
October	9	86 / (2004)	0 / (1967)
November	15	144 / (1983)	0 / (1967)
December	30	196 / (1978)	0.3 / (2000)
January	103	1,347 / (2005)	3 / (1968)
February	131	1,858 / (1980)	0.5 / (1967)
March	170	1,211 / (1995)	0.7 / (1967)
April	72	431 / (1980)	3 / (1967)
May	24	346 / (1980)	0.1 / (1967)
June	13	292 / (1980)	0 / (1967)
July	13	206 / (1980)	0 / (1967)
August	6	213 / (1980)	0 / (1967[1])
September	9	85 / (1980)	0 / (1967[2])

[1] Also includes water years 1997 & 2004

[2] Also includes water years 1996, 1997, 2000, & 2004

Current Stream Flow Conditions

Mean annual discharge in the SLR River exhibits patterns typical of Mediterranean climates, with most discharge occurring during the winter and early spring and the least during late summer and early fall. As discussed previously, the overall hydrology of the SLR River is largely controlled by the Henshaw Dam and then downstream at the Escondido Canal diversion dam. These dams along with groundwater extraction and precipitation patterns over several years greatly influence river flows throughout the basin.

Currently, the SLR River maintains perennial stream flows for approximately only half of its length, split up between various reaches, from the Pacific Ocean to the Henshaw Dam, RM 50. The remaining river miles are mostly intermittent and generally only flow between the winter and spring months. The following discussion and accompanying map (Figure 9) describes the typical flow conditions in the SLR River and its tributaries. Bear in mind that perennial and intermittent flows in certain sections of the river as well as in tributaries are not necessarily static and may vary year to year depending on precipitation patterns and anthropogenic water extractions.

The SLR River contains perennial stream flows through the majority of the Middle Subbasin between Henshaw Dam and the Escondido Canal diversion, RM 40. Immediately downstream of the Escondido Canal diversion dam, stream flow is usually absent unless there is water being released from the dam. However, approximately ¼ of mile downstream of the dam, water flow commences and most likely remains perennial through the majority of the SLR River canyon. Surface flows subside near the canyon mouth and the streambed runs dry through the Pauma and Pala areas to just upstream of Rice Canyon's confluence with the SLR River, RM 21. At this point, the river usually contains perennial surface flows downstream to just east of the old Bonsall Bridge, RM 11, where the river once again becomes mostly intermittent for approximately 5 stream miles. Perennial flows are generally re-established from Oceanside's eastern city limits, RM 6, to the ocean. Surface flows in the lower river during dry weather are directly related to groundwater levels (City of Oceanside et al. 2008).

Tributaries in the Northern Subbasin contain the greatest number of perennial stream miles as they are benefited by higher rainfall totals occurring in the Agua Tibia and Palomar Mountains. However, similar to the majority of the basin, diversions and groundwater pumping have also reduced overall stream flows in these streams. In the Southern Subbasin, Keys Creek and Moosa Canyon Creek contain large sections of perennial flows aided by agricultural runoff. The Coastal and Middle subbasins maintain limited perennial flows in portions of a few streams.

Floods

Disturbance due to flooding is a natural process important to the long-term functioning of the floodplain ecosystem (Hawkins et al. 1997). In southern California, riparian areas rely on annual flooding, channel migration, and occasional large flood events to maintain a cycle of succession and therefore sustain a mosaic of diverse natural communities (Gregory et al. 1991). Floods also redistribute sediment, inundate riparian zones, and recharge aquifers (Jansson et al. 2007). In the SLR Basin, flood patterns have been modulated by dams, urbanization and other land-use changes.

Despite the hydrologic controls of Henshaw Dam and the Escondido Canal diversion dam, the SLR River is still subject to occasional episodic flood events. Infrequent periods of intensive or extensive rain during the winter or early spring months in conjunction with extremely altered runoff rates may result in short periods of flood flows. Several events have occurred in the past 50 years that have rearranged the active floodplain and vegetation (Olson and Harris 1997). Although this episodic flooding is usually required for ecosystem maintenance, riparian vegetation within the river's floodplain is generally at high risk of damage from large floods; this risk is exaggerated in areas with high urban development (Hawkins et al. 1997).

The largest recorded flood event in the SLR River occurred in 1916. With a maximum discharge of 95,500 cfs (measured in Oceanside), this flood killed four people and caused significant infrastructure damage in Oceanside. After the completion of Henshaw Dam the largest flood event was the flood of 1980, which peaked at 25,000 cfs and caused 2.23 million dollars in damage. The floods of 1980, 1993, 1995, and 2005 significantly impacted the basin and caused most of the sediment transport and stream channel changes in recent years (SLR Watershed Council 2003). Figure 8 represents the peak stream flows (floods) that have occurred in the SLR River, measured in Oceanside (RM 1.25) during the period of 1913 to 2005 (gaps in data are noted below). The major floods of 1916, 1938, 1980, 1993, 1995, and 2004 are distinctive on this graph.

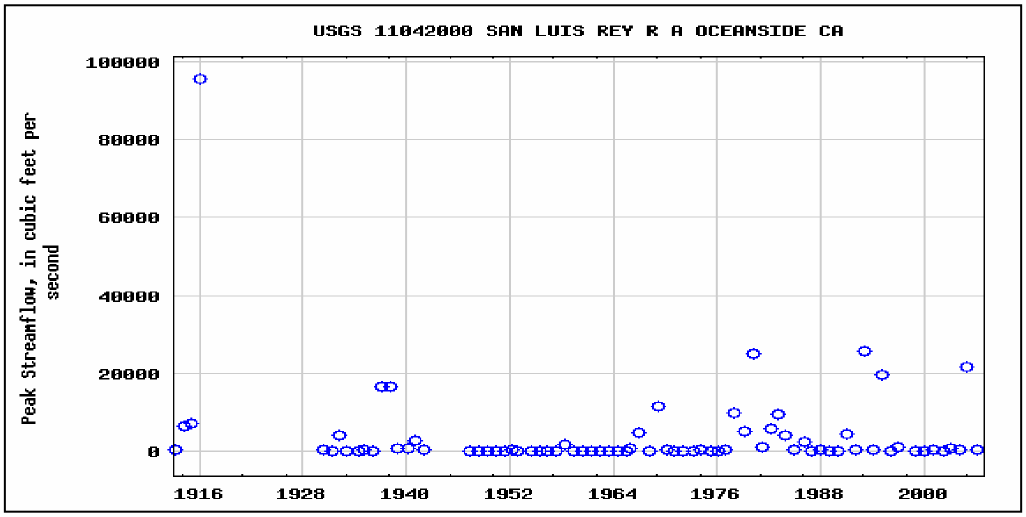


Figure 8. Annual peak stream flows for the SLR River at Oceanside (RM 1.25) 1913-2005. Gaps in data collection occurred from 1917 to 1929 and from 1943 to 1946 (http://www.usgs.gov/).

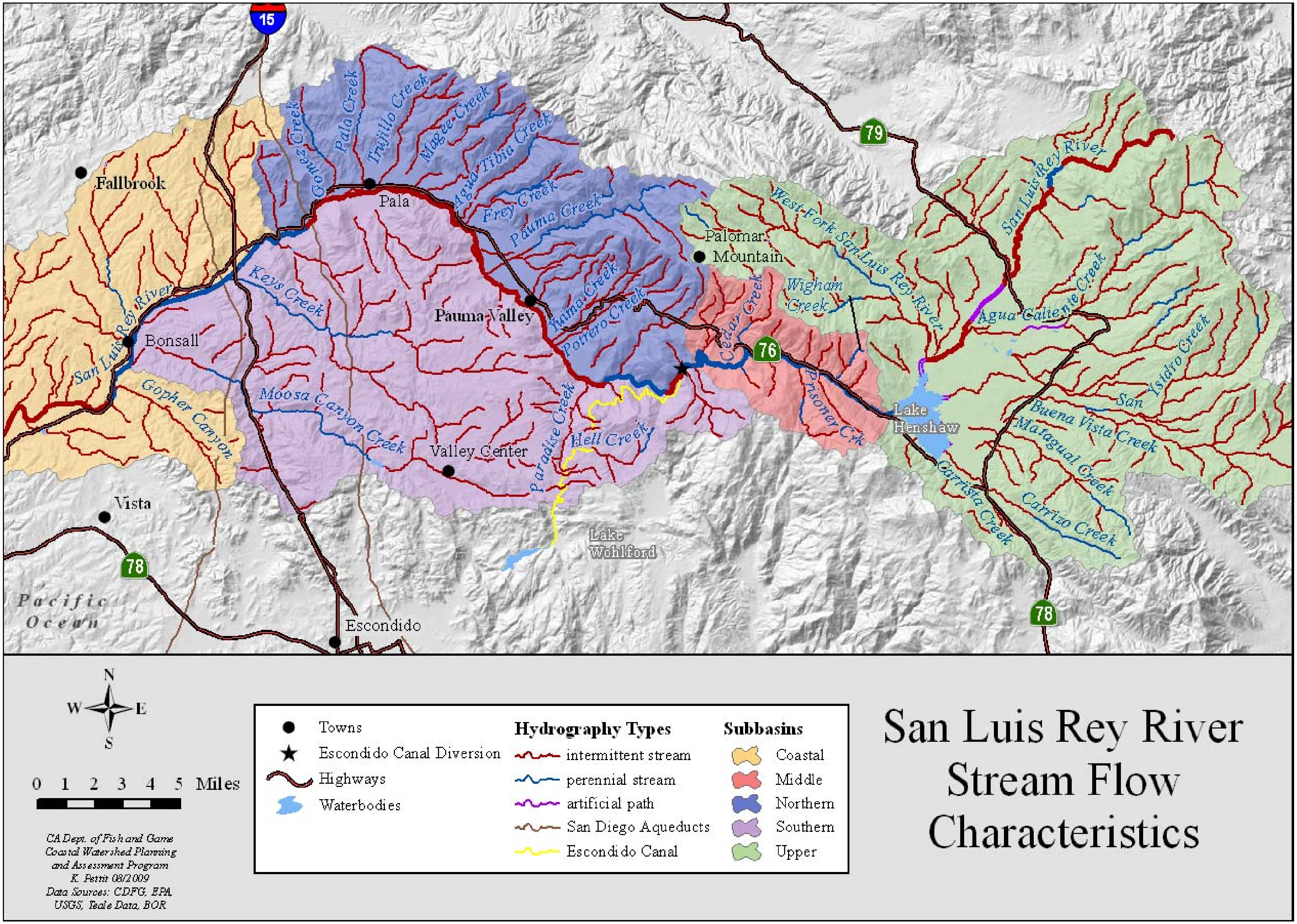


Figure 9. SLR River Basin Stream Flow Characteristics.*

* Intermittent and perennial stream hydrography type delineations are approximate and can vary year to year depending on precipitation patterns over several years and anthropogenic water withdrawals.

Geologic Overview

The San Luis Rey River is located in the Peninsular Ranges of southern California. The basin is predominately underlain by plutonic rock types of the Peninsular Range Batholith that intruded into much older sedimentary, marine rock types between 90 and 140 million years ago and have subsequently been exposed by tectonic uplift and erosion. Intrusion of the Peninsular Range Batholith as well as regional tectonics has caused some of the marine, sedimentary rocks to undergo metamorphosis.

Erosion has exposed the batholith leaving behind mountains of granitic rock with remnants of the sedimentary rocks into which it intrudes. Weathering of the granitic rocks has created younger unconsolidated sediments that are very susceptible to enhanced erosion and mass movement such as landslides and debris-flows. These sediments have been deposited in a series of alluvial fans, marine and river terraces, as well as active channel deposits. These sedimentary deposits range from partially consolidated sandstone, siltstone, mudstone, and shale to unconsolidated sand and gravel (Figure 10).

Rock Types

The rock types depicted in the geologic map (Figure 9) presented in this report have been combined from various other published source maps. Like rock types based on similar age, composition, genesis, origin, and geologic history have been combined to help simplify the information presented herein. General descriptions of the geologic units presented in the map and in Table 4 follow.

Mesozoic Granitic

Granitic rocks make up the majority of the basin. They occupy approximately 70% of the watershed. They are predominantly Cretaceous (154.5 million through 65.5 million years ago) in age. These rocks are very hard and resistant to erosion, however, they do tend to exfoliate to some extent in exposed surfaces and preferentially weather at structural joints. Over long periods of time granitic rocks tend to decompose, become "soft" and are much less resistant to erosion producing "decomposed granite." In more advanced forms the minerals within the granite disaggregate and form "Arkosic Sand" which is made of individual mineral grains disaggregated from the granitic parent rock. These sands are predominantly comprised of quartz and feldspar. This material is highly susceptible to erosion, sliding, and fluvial transport.

Granitic bedrock in this region usually produces a landscape that is typified by large outcroppings of spheroidally weathered rocks and steep, bare inner gorge canyons (Figure 11).

Quaternary Alluvium

Alluvium is the next most extensive rock type covering about 13% of the basin. It consists of unconsolidated sediments that range from clay to boulders. Alluvium is transported and deposited by the streams and makes up most of the bed and banks of the streams. Units of alluvium delineated by the geology map (Figure 10) include sediment currently being acted upon by the streams and bank and flood-plain deposits occasionally acted upon by the streams. If the alluvium within the stream channel is of sufficient depth it can readily transport water via the subsurface pore-spaces allowing stretches of the stream to run dry.

Alluvium is generally deposited in low lying areas and in flood plains producing a relatively flat landscape (Figure 12).

Quaternary Alluvial Fan Deposits

Fan deposits make up about 1% of the basin and consist of unconsolidated sediments ranging from clay to boulders. They wash out of canyons on high slopes and are usually deposited where there is a significant change of slope. They are not usually transported far from their source and therefore consist of sediments made from the bedrock of the mountains from which they come.

Sedimentary Rock Types

Sedimentary rock types within the basin typically produce a landscape characterized by rugged, sharp-crested mountains with steep inner-gorge canyons. Rock outcrops appear blockier than the rounded exposures of granite.

Mesozoic Sedimentary

Mesozoic sedimentary rocks make up around 6% of the basin and consist mostly of siltstone, sandstone and conglomerate and were deposited some 65.5 to 225 million years ago. The original deposition of the sediments that make up these rock types occurred in environments ranging from marine to terrestrial. Some of these rock types have subsequently undergone metamorphism especially in areas in contact with granitic rock types. These sedimentary rock types are generally more susceptible to erosion than granitic rock types.

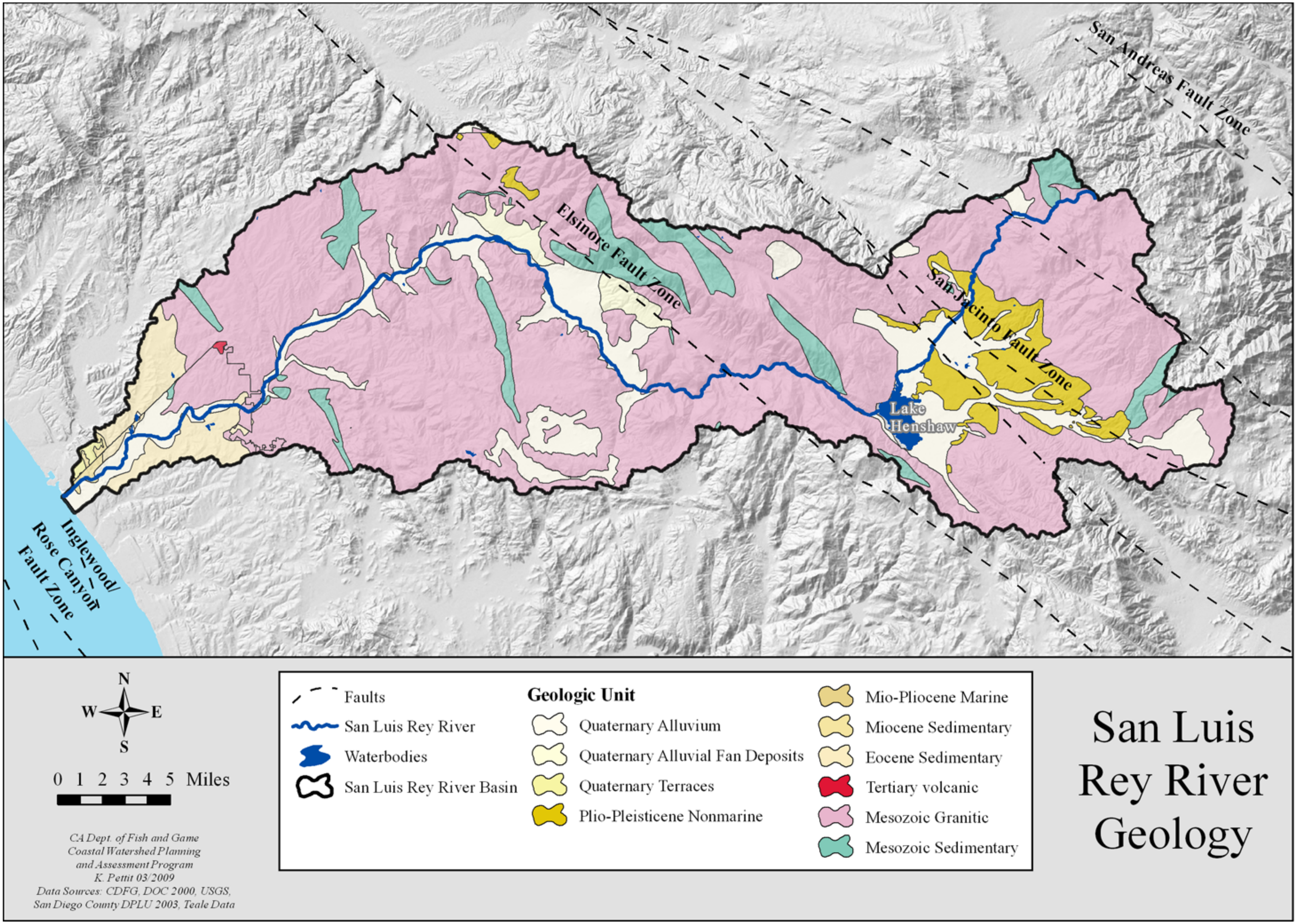


Figure 10. Geology of the San Luis Rey River.

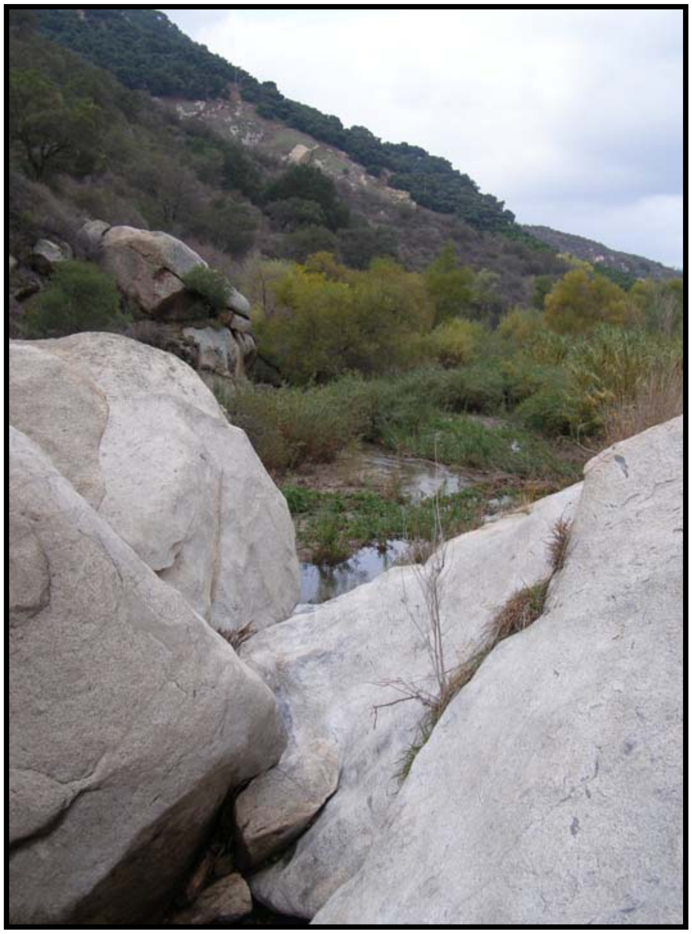


Figure 11. Granitic bedrock in the foreground and within the distant hillsides.

Figure 12. Alluvium floodplain of the SLR River in the Southern Subbasin.

Plio-Pleisticene Nonmarine

This unit occupies about 5% of the basin. It is composed of sedimentary rocks ranging in composition from siltstone through conglomerate. The sediments that make up these rock types were deposited on land between 11 thousand and 5 million years ago. The sediments of these rock types range from siltstone through conglomerate and from poorly consolidated to well indurated.

Eocene Sedimentary

This rock type makes up about 3% of the basin and occurs in the Coastal Subbasin. It contains sedimentary rocks ranging in composition from siltstone through conglomerate. The sediments that make up these rock types were deposited on land between 56 and 34 million years ago. The sediments of these rock types range from siltstone through conglomerate and from poorly consolidated to well indurated.

Miocene Sedimentary

This rock type makes up less than 1% of the basin and occurs in the Coastal Subbasin. It consists of sedimentary rocks ranging in composition from siltstone through conglomerate. The sediments that make up these rock types were deposited on land between 23 and 5 million years ago. The sediments of these rock types range from siltstone through conglomerate and from poorly consolidated to well indurated.

Tertiary Volcanic

This rock type makes up less than 1% of the basin and occurs in the Coastal Subbasin. This unit consists of volcanic flows of dacitic composition that were deposited between roughly 65 through 2 million years ago.

Mio-Pliocene marine

This rock type makes up less than 1% of the basin and occurs in the Coastal Subbasin. It is made out of sedimentary rocks ranging in composition from siltstone through conglomerate. The sediments that make up these rock types were deposited on land between roughly 23 and 2 million years ago. The sediments of these rock types range from siltstone through conglomerate and from poorly consolidated to well indurated.

Table 4. Percentage of rock types in the SLR River Basin.

Lithologic Unit	% Basin
Mesozoic Granitic	70.64
Quaternary Alluvium	12.86
Mesozoic Sedimentary	6.20
Plio-Pleisticene Nonmarine	4.85
Eocene Sedimentary	3.16
Quaternary Alluvial Fan Deposits	1.32
Miocene Sedimentary	0.22
Quaternary Terraces	0.15
Tertiary Volcanic	0.03
Mio-Pliocene marine	0.01

% area of basin represents a rough approximation based on GIS mapping.

Soils

Broadly, the soils within the SLR River watershed range from excessively drained gravelly sands to well drained clays, and include areas of rough broken land, alluvial fans, terrace escarpments, and steep gullied land. Many of the soil series defined by the U.S. Department of Agriculture have characteristics that can have a significant effect on water quality related issues. There are many properties and qualities that affect soil erodability. These factors include slope, surface layer texture, restricted permeability, and the grade structure in the surface layer. Since severely erodible soils comprise 95% of the watershed, prudent planning must be incorporated when developing land use plans and implementing grading ordinances (PBSJ 2003). Probable development areas, built on highly erodible soil, pose a potential threat to the water quality and sediment management of the watershed.

Other important soil characteristics include infiltration rate (the rate at which soil absorbs precipitation), and the shrink-swell factor (the amount of water a soil can hold and how quickly water can be released). Both of these characteristics affect how quickly precipitation is transformed into surface runoff and how long subsurface flows will continue into the dry season. Soils that have a slow infiltration rate and a high shrink-swell factor are likely to generate surface runoff sooner, but also continue to discharge subsurface flows longer than a soil with a fast infiltration rate and a low shrink-swell factor (PBSJ 2003). On average, the watershed requires 6 inches of precipitation to raise the groundwater levels sufficiently and enable the river to have surface flows (Vic Smothers personal comm.).

The soils within the watershed vary in their physical and chemical properties according to differences in parent material, mode of formation, and age and degree of development if alleviated (Department of Public Works 1956). The predominant material on hillsides adjacent to the SLR River is decomposed granite. The bed material in the river below Lake Henshaw in the Middle Subbasin and western portion of the Southern Subbasin is a mixture of sand and gravel, with an insignificant amount of silt or other finer materials. The size of bed material decreases along the river channel but becomes fairly uniform from Pala to the ocean. The dominant material below Pala (lower Southern Subbasin) is median sand, which is highly transportable during floods.

The stability of the soils within the basin is affected by:

- Land use practices–grazing, crop production, and development, etc;
- The terrain–soils rest on steep slopes;
- Climate–some soils are easily erodible by sustained and heavy rain;
- Wildfires–frequency, timing, duration, and intensity of wildfires all affect soil stability;
- Seismic activity–seismic events, including uplift,

can have a significant alter soil structure and stability.

Considering the drier climate in the watershed, with fewer periods of heavy precipitation, most of the changes in the SLR River substrate composition are limited to infrequent storms during the winter months. During years of little precipitation, including the 2006-2007 water year, minimal changes occur in the SLR River and its tributaries.

Erosion

Decomposed Granite

Decomposed granitic rock is relatively porous allowing it to become saturated with water during storms. In steep slopes when the pore pressure exceeds the rock strength debris-flows are typically initiated. Sedimentary deposits derived from decomposed granite are susceptible to enhanced erosion including debris-flow. The severity of erosion may increase as a result of land disturbance from construction or wildfires (Wagner 1991).

Steep Slopes

Quaternary deposits made up of loosely consolidated sediments are prone to sliding and enhanced erosion. The internal friction between grains in a sediment deposit dictates the slope angle at which sliding or raveling will likely initiate (generally around 30-40° for loose to moderately consolidated sand). Other than the steepness of the slope and the influence of gravity saturation of the sediments by water will tend to reduce the angle at which they slide by increasing the pressure in pore spaces thus reducing the friction between grains. The amount of vegetation cover also influences the stability of loose sediments. Vegetation cover protects the surface from surface erosion as well as trapping sediments that do wash out. It also intercepts some precipitation reducing the amount of saturation within the sediment. Live roots furthermore increase the stability by increasing the tensile strength of the sediment. Within this basin loosely consolidated sedimentary deposits are mostly confined to low lying areas with relatively flat topography such as within stream channels and their associated flood plains. Most steep slope related sediment movement is associated with stream bank erosion of flood plains and stream terrace deposits.

Wildfires

Wildfires can, and usually will enhance the erodability of a region by burning off the duff layer and organic matter that helps to bind the soil together, as well as intensively drying it leaving behind a waxy coating around soil particles (http://www.nrcs.usda.gov/). The waxy coating causes soils to become "hydrophobic" reducing the amount of infiltration from rainfall and allowing them to repel water. This increases relative runoff from the hill slope and allows for increased surface erosion and transport of sediments to the stream channels (Ryan 2002). Sometimes this hydrophobic layer can persist for years, especially if it is relatively thick. Eventually as plants regenerate and growth resumes, plant roots, soil microorganisms, and soil fauna will break down the hydrophobic layer.

The intense heat can also cause minerals within the underlying bedrock to expand. Greater thermal expansion of quartz relative to other minerals causes granitic rock to fracture. The fracturing of the rock can increase the permeability of the rock and initiate mass wasting of the hill slope or debris-flows.

In addition to changing the soil and rock composition, wildfires contribute erosion through the reduction or elimination of vegetation. On steep slopes, vegetation can form organic dams, successfully retaining sediment that originates upslope; when fire incinerates this vegetation, sediment that was impounded behind it is released and can be quickly mobilized downslope by dry ravel (rolling, bouncing, and sliding of individual particles down a slope) and overland flow (http://www.santaclarariverparkway.org/theriver/fireflood). Incineration of vegetation by fires can also accelerate erosion by exposing surfaces to more efficient erosion by rain impact.

The 2007 wildfires that occurred within the SLR Basin burned almost 55,000 acres of land in the Coastal, Southern, Northern, and Middle subbasins. In addition to the loss of homes and other structures, the principal concern with these recent fires and future fires is their potential to increase runoff and erosion. In order to categorize the post-fire erosion potential and identify potentially problematic areas in the SLR Basin the California Department of Forestry's Fire and Resource Assessment Program (FRAP) employed the Revised Universal Soil Loss Equation (RUSLE) in a post-wildfire environment. RUSLE, which is used for agricultural soil loss, was adapted by FRAP for estimating wildland post-fire erosion based on the interaction of fire threat and vegetation cover. The resulting soil loss estimates are grouped into three erosion classes (Low, Moderate, and High). Figure 13 (p. 24) depicts the post-fire erosion potential in the SLR River Basin based on these three erosion classes. These estimates were derived from data prior to 2005;

therefore, they do not take into account the results of the more recent fires and other potential land use activities which may or may not have affected the erosion potential. Post-fire erosion potential has been estimated as moderate to low erosion potential for the majority of the SLR River Basin (Table 5). The Middle and Northern subbasins have the highest post-fire erosion potential ratings. These subbasins contain the highest fuel capacities, the steepest slopes, the most rugged terrain, and soil types that are more prone to erosion, resulting in higher ratings. A more detailed discussion of the 2007 wildfires, their impacts to the watershed, and other fire management issues is located in the Fire History and Management section (p.35).

Table 5. Percentage of post-fire erosion potential for the SLR River Basin and individual subbasins.

	Post-fire erosion potential					
Percentage	**San Luis Rey Basin**	**Coastal Subbasin**	**Middle Subbasin**	**Northern Subbasin**	**Southern Subbasin**	**Upper Subbasin**
High	10	<1	29	23	8	8
Moderate	35	13	55	43	25	47
Low	28	28	15	18	26	36

% area of basin represents a rough approximation based on GIS mapping and only includes data prior to 2005. Figures do not equal 100% because they do not account for percentage of Urban/Water and No fuels rank categories. See Figure 13 for these mapped areas.

Tectonics and Faulting

The San Luis Rey River Basin is located on the eastern edge of the Pacific Plate near its margin with the North American Plate along the San Andreas Fault system (Kondolf and Larson 1995). As a result, the region is tectonically and seismically active. This fault system is composed of a series of faults that run through this area (Figure 10). The faults trend northwest and tend to have a right lateral, oblique strike-slip. They are associated with the Pacific Plate/North American Plate boundary.

There are basically three types of plate boundaries: convergent, divergent and transform. Of these three, the effects of the transform plate boundary between the Pacific Plate and the North American Plate are the most influential. The San Andreas Fault is arguably the most famous fault resulting from this plate boundary. Divergent plate action may also affect the San Luis Rey River Basin. To the southeast of the basin the Gulf of California is spreading apart and encroaching northward along the Salton Trough via the shearing and transform/spreading tectonics of the East Pacific Rise (Schmidt 1990).

The fault zones depicted on the map include:

- Newport-Inglewood-Rose Canyon Fault Zone;
- The Elsinore Fault Zone;
- San Jacinto Fault Zone; and
- San Andreas Fault Zone.

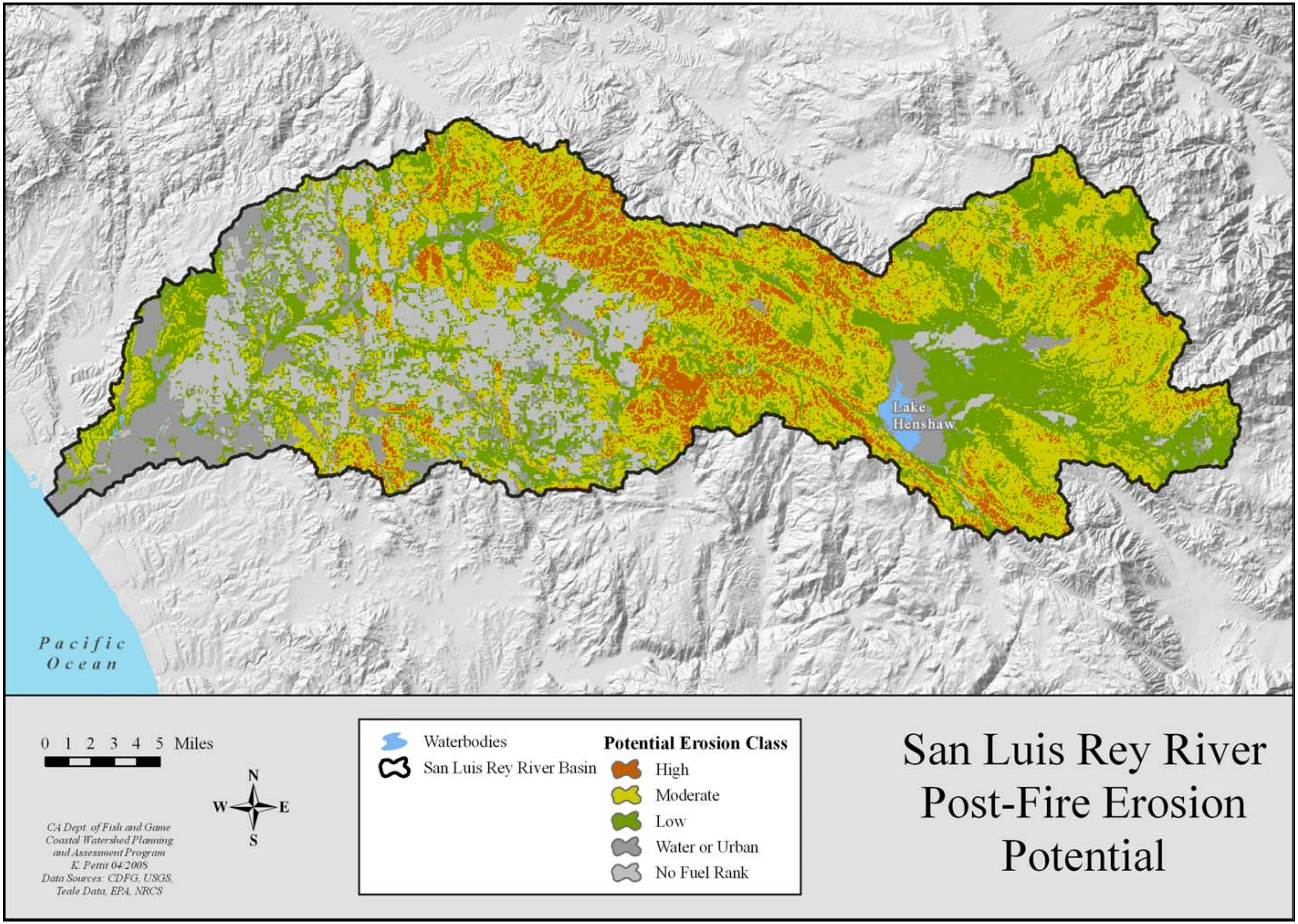
Fault zones, rather than individual faults, were depicted on the map due to the scale and the scope of this report. All of the faults shown on this map have had seismic movement within the Holocene (last 11,000 years) and many of them within the last century or decade. These faults are capable of creating earthquakes of large magnitude (M). The Elsinore Fault Zone generated an earthquake of M7 in 1892 and has a recurrence interval of approximately 250 years. The Newport-Inglewood-Rose Canyon Fault Zone generated an earthquake of M6.3 in 1933. Most recently, the San Jacinto Fault Zone produced a M6.5 quake in 1968 (http:// www.data.scec.org/index.html).

Large seismic events especially when coupled with large storm events can trigger large landslides and mudflows increasing sediment delivery to the streams and altering their hydrologic condition. In coastal areas seismic events may produce Tsunami capable of re-depositing sediments filling channels and initiating even more landsliding.

Hydrologists and thus water users have noted the occurrence and movement of groundwater in the basin is significantly tied to the occurrence of the fault zones and adjacent joint systems. Groundwater aquifers, for example, on the La Jolla Indian Reservation are primarily found in fractured bedrock (Tierra Environmental Services 2006).

Uplift

This area has undergone tectonic uplift that has created a series of marine and river terraces. The uplift in this area is most likely a result of compressive forces generated by the interaction of the Pacific and North American Plates. As the land undergoes uplift the ocean and local streams respond by incising through sediment layers that they had



CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 04/2008
Data Sources: CDFG, USGS,
Teale Data, EPA, NRCS

Figure 13. Post-fire erosion potential of the San Luis Rey River Basin, California.

once deposited. This tends to leave behind loosely consolidated sediments perched steeply above the active stream channels and along the coastline above the ocean. Bank erosion and land sliding along the streams and sea cliffs is usually enhanced in these areas. Uplift rates for this area have been estimated at .13 mm/year (Kennedy et al. 2005).

Fluvial Geomorphology

Fluvial geomorphology is the study of stream processes and channel forms. River channel dimensions and form reflect the prevailing flow and sediment transport regime (Kondolf and Larson 1995). These independent variables may change as a result of human actions including, but not limited to: dam construction, land use changes in the drainage basin, and transfer of water from one basin to another. These changes typically induce changes in dependent variable of cross-sectional form, bed configuration, planimentic form and channel slope (Knighton 1989), with important implications for restoration planning and design. For example, reservoirs can trap all gravel and sand transported from upstream and (depending on reservoir size, its location, and operation) usually reduces the magnitude of floods downstream. Consequently, as in the case of the SLR River, downstream reaches can be deprived both of a supply of gravel critical for salmonid spawning and reduce the frequency and degree of ecologically important periodic disturbance provided by floods.

Sediment delivery of the SLR River was studied by Brownlie and Taylor (1981) and by the U.S. Army Corps of Engineers (1988). It has been estimated that the suspended load - sediment that it is fully entrained in the moving water column, contains, on average 25% sand. The percentage of bedload (coarser material that rolls or bounces along the stream bed) to the overall suspended load is, on average, 10%. For the study period of 1920 to 1985, the natural average yield of sand and gravel at the river mouth has been reduced from about 61,600 tons per year to about 14,600 tons per year, or by approximately 75% (Lettieri-McIntyre & Associates 1995). Dams, water diversions, urbanization, and sand and gravel mining has created a sediment deficit of approximately 3 million tons of sand and gravel over the 65-year period. This has resulted in a loss of beach sand and accelerated coastal erosion and property damage.

In addition to supplying necessary beach sand, floods are also important to the overall ecological function of riverine areas. Floods inundate riparian zones and recharge aquifers. While floods may cause mortality to various species by drowning and physical disturbance, they also create opportunities for establishment of pioneer species. From a landscape perspective, floods create a mosaic of patches with specific geomorphology and hydrologic conditions, supporting different types of vegetation, contributing to spatial heterogeneity and high diversity (Jansson et al. 2007). Release of water from the dams in the basin in flood pulses may enhance establishment of riparian species such as *Populus* (cottonwoods) and *Salix* (willows), in cohorts that may survive for decades (Jansson et al. 2007). In other watersheds in the southwestern U.S., restoring base flows, using only a small proportion of total flow had large influence on riparian vegetation (Stromberg et al. 2007).

Although anthropogenic activities have led to diminished stream flows, the SLR River has remained subject to large floods that periodically rearrange the active floodplain and vegetation (Olson and Harris 1997). The SLR basin's probable max flood (pmf), as defined by the U.S. Army Corps of Engineers, is between 177,000 and 224,000 cfs. This is approximately twice that of the 1916 flood, which had a maximum discharge of 95,600 cfs in the City of Oceanside (Figure 8). Since the completion of the Lake Henshaw Dam in 1922, flood flows have been much smaller, but potential for flood damage has greatly increased with the urban development along the floodplain of the SLR River. Three significant flood events, considered to be 25-year events, have occurred since the early 1990s (1993, 1995, and 2005). These floods resulted in washed out bridges, crossings and altered the soil cover of the San Diego Aqueduct and several other pipelines resulting in millions of dollars in damage. They also caused most of the sediment transport and stream channel changes in recent years (SLR Watershed Council 2003).

Considering the encroachment of development along many streams and rivers in southern California, including the SLR River and some of its tributaries, measures have been taken to alter or reduce the magnitude of flood flows. In the mid 1990s, the United States Army Corps of Engineers (USACE) undertook a channelization project along the lower 7.2 miles of river to provide flood protection in this area. The flood levees, considered to be a grouted, rip-rap control channel, have concrete-covered boulder sides and a natural bed, initially allowing for more natural flows and riparian and wetland habitat to exist between the concrete sides. However, the USACE is responsible for maintenance of the flood control channel and are in the process of removing native and non-native vegetation along the entire 7.2 mile channelized riverbed (see Flood Control Project, pp. 30-31, for further discussion).

Stream Gradient and Reach Classification

Stream gradients determine patterns of sediment transport and accumulation in the stream network. Stream classification is based in part on gradient. The CWPAP channel classification was modified from Montgomery and Buffington (1993) to be more compatible with the stream classification of Rosgen (1996). Montgomery and Buffington (1993) described three general categories of stream reaches as follows:

- Source reaches are transport-limited, sediment storage sites subject to intermittent debris flow scour;
- Transport reaches are morphologically resilient, high-gradient, supply-limited channels that rapidly convey increased sediment inputs;
- Response reaches are low-gradient, transport-limited channels in which significant morphologic adjustment occurs in response to increased sediment supply.

Montgomery and Buffington (1993) stated that the "…cumulative effects of upstream increases in sediment supply are magnified in a response reach where longer time and/or significant morphological change is required to transport the additional sediment." They further stated that response reaches "are of fundamental concern for aquatic resource management because of the associated habitat values."

The lower gradient response reaches of the SLR River in the Coastal Subbasin could potentially be where steelhead rear and to a lesser extent spawn, but the accumulation of sediment in these response reaches over decades has impacted potential fish habitat.

Most of the mainstem channel of SLR River and its tributaries in the Coastal and Southern subbasins are shallow response reaches, less than 4% in gradient (Figure 14). These areas accumulate sediment and may hold it for decades if the basin is devoid of large, flushing flow events. In contrast, tributary channels in the Northern and Middle Subbasin contain more transport reaches, reaches with gradients between 4% and 20%. The eastern part of the mainstem in the Southern Subbasin also has some transport reaches as it winds through the SLR River canyon in the La Jolla and Rincon Indian Reservations. This canyon contains several natural waterfalls, including one that has an overall height of approximately 50 feet but is broken up by a series of steps, with the largest lowermost step of about 13 feet. The Upper Subbasin contains mostly response reaches with some transport reaches located within the mountainous regions.

Vegetation

The USDA Forest Service (USFS) CALVEG vegetation data were used to describe basin-wide vegetation. This classification breaks down vegetation into major "vegetative cover types." These are further broken down into a number of "vegetation types" (Table 6).

The predominant vegetative cover type in the SLR Basin is mixed sagebrush/chaparral at 45%. Of this cover type, 46% is described as lower montane mixed chaparral, 21% is California sagebrush, and with red shanks chaparral and chamise vegetation types each composing 13%. The remaining acres consist primarily of buckwheat, upper montane mixed chaparral, and manzanita chaparral. Mixed sagebrush/chaparral occurs in every subbasin and is the dominant vegetation category in the Northern, Middle, and Upper subbasins.

Agricultural land composes the second largest area of land with a little more than 13% of the Basin, with the majority of it occurring in the Southern and Coastal subbasins. Agriculture land, as defined by the USFS, is that which is used to produce food and fiber. Within the San Luis Rey Basin, pastures used for grazing of livestock may not be included in this vegetation designation since land use is often difficult to remotely ascertain. For this reason, it can be assumed that areas mapped as annual grasslands may also be agricultural in nature. Grasslands that are not mapped as agricultural are given the classification of herbaceous vegetation, also composing 13% of the land area, the third most abundant category in the basin. An example of this is in the Upper Subbasin, where much the area around Lake Henshaw is used as grazing land, but is displayed as herbaceous vegetation in Figure 15. The majority of the herbaceous category is located in the Upper and Coastal subbasins, respectively.

Most of the inland areas are made up of chaparral or oak woodland vegetation. Coastal areas contain more sensitive habitats such as coastal sage scrub and southern maritime chaparral.

This USFS classification describes current vegetation as of the mid 2000s. Vegetation in the SLR Basin has changed considerably over time. As a result of these changes, large areas of natural vegetation communities have been lost or replaced. The county-wide reduction of these types of communities has resulted in the need to preserve these now Sensitive Communities. Sensitive Communities such as beach/strand, coastal sage scrub, alluvial fan scrub, marshes, native grasslands, vernal pools, oak woodlands and forests, riparian woodlands and forests, and conifer forests are all represented within the watershed (Figure 15).

Table 6. USFS classification of vegetation of the SLR River Basin.

Vegetative Cover Type	Percent of Basin	Primary Vegetation Type	Percent of Cover Type
Chaparral/Scrub	45.9	Basin Sagebrush	0.37
		Buckwheat	2.54
		California Sagebrush	21.94
		Ceanothus Mixed Chaparral	0.63
		Chamise	12.88
		Lower Montane Mixed Chaparral	46.11
		Manzanita Chaparral	0.59
		Red Shanks Chaparral	13.21
		Upper Montane Mixed Chaparral	1.24
		Other	0.49
Agriculture	13.1	Agriculture	8.37
		Orchard Agriculture	75.14
		Pastures and Crop Agriculture	16.49
Herbaceous	13.0	Annual Grasses/Forb Alliance	58.51
		Non-Native/Ornamental Grass	4.52
		Perennial Grasses and Forbs	36.89
Hardwood Forest/Woodland	9.4	Black Oak	14.04
		California Sycamore	0.39
		Canyon Live Oak	15.64
		Coast Live Oak	53.23
		Engelmann Oak	6.44
		Eucalyptus	1.0
		Interior Mixed Hardwood	4.79
		Non-native/Ornamental Hardwood	4.23
Urban/Development	7.8	Urban/Development	100
Mixed Conifer/Woodland	4.0	Bigcone Douglas–Fir	27.99
		Coulter Pine	33.23
		Mixed Conifer–Fir	5.90
		Mixed Conifer–Pine	4.51
		White Fir	19.54
		Nurseries	8.83
Barren/Rock	2.7	Barren (includes area burned by previous fires)	73.29
		Tilled Earth	8.71
		Urban-related Bare soil	18.01
Riparian	1.7	Baccharis (Riparian)	16.55
		Fremont Cottonwood	0.90
		Riparian Mixed Hardwood	33.73
		Riparian Mixed Shrub	17.0
		Willow (Tree and Shrub)	31.82
Wetlands	1.0	Tule–Cattails	6.61
		Wet Meadows	93.39
Water	0.7	Water	100
Scrub Oak	0.6	Scrub Oak	99.29
		Tucker/Muller Scrub Oak	0.71
Conifer Forest/Woodland	0.2	Bigcone Douglas-Fir	16.37
		Coulter Pine	37.13
		Mixed Conifer–Fir	39.25
		White Fire	7.25

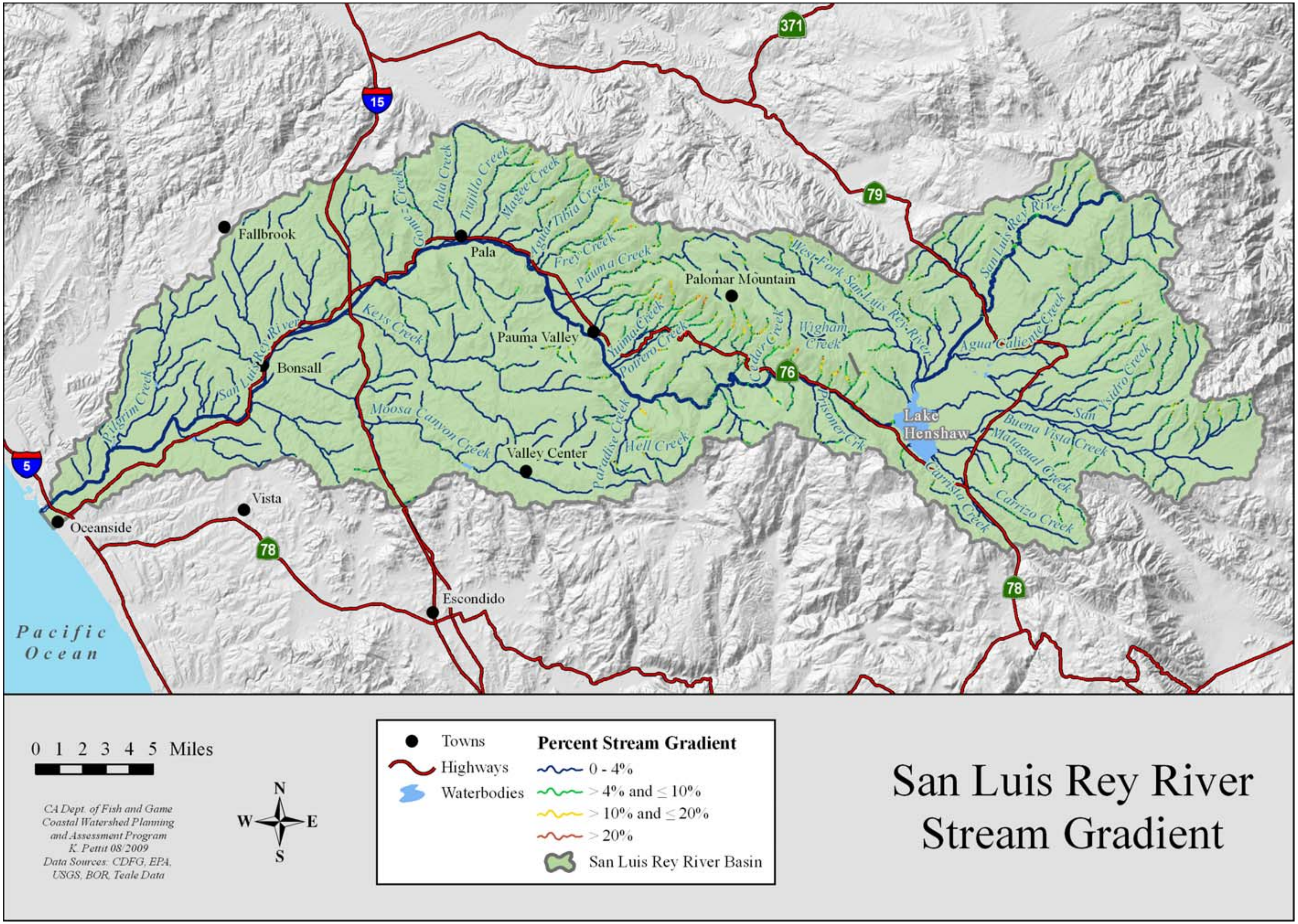


Figure 14. Stream gradient of the SLR River Basin.

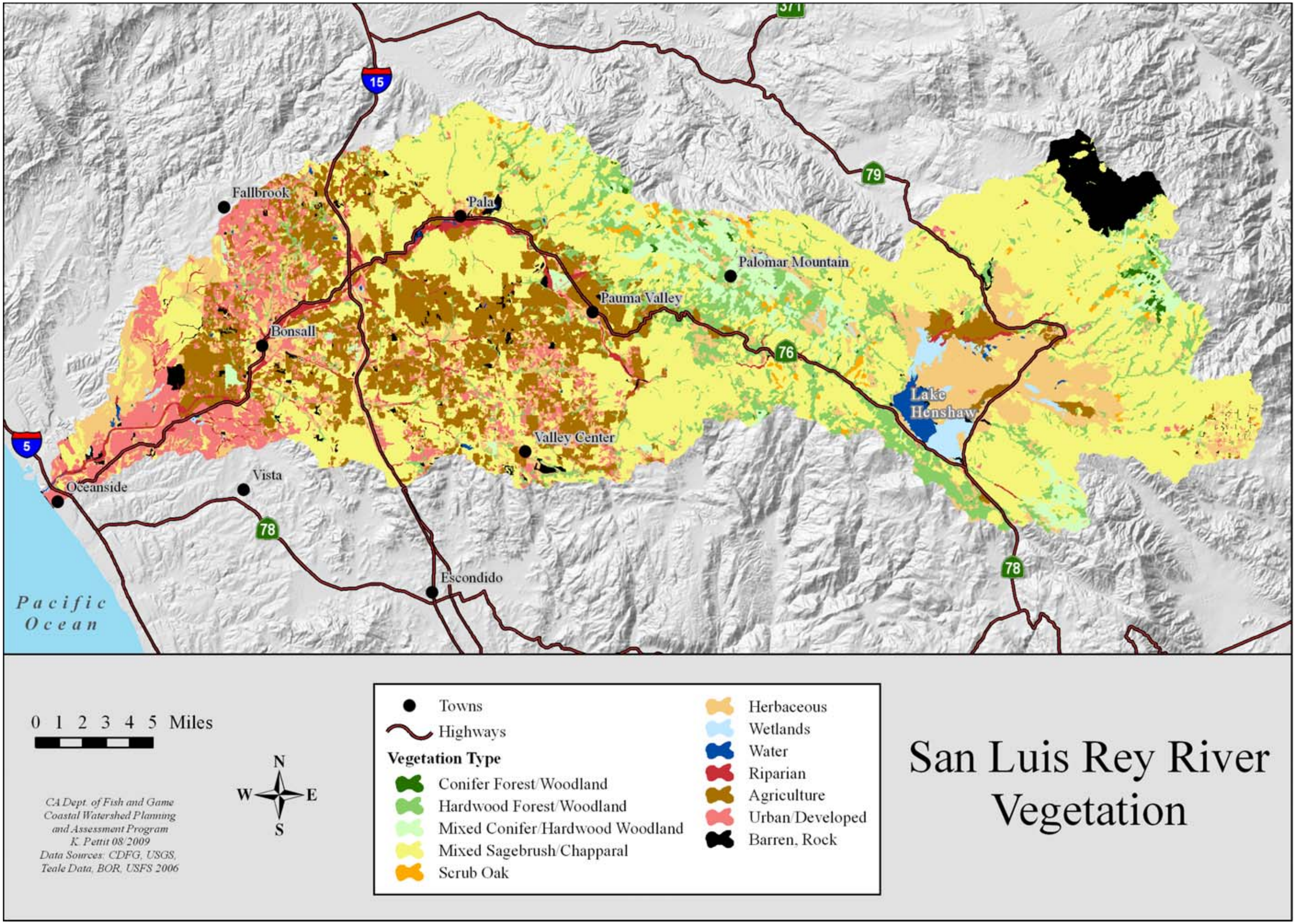


Figure 15. Vegetation of the SLR River Basin, California.

Flood Control Project and Channel Maintenance Plan

The U.S. Army Corps of Engineers' (Corps) completed the San Luis Rey Flood Control Project (the Project) in the lower seven miles of the SLR River in 2000. This Project was designed to provide 71,200 cubic feet per second (CFS) of flood capacity, which is equivalent to a 175-year flood event (L. Thibodaux, City of Oceanside, personal communication 2009). In order to maintain this flood capacity the Corps is implementing a long-term Operation and Maintenance Plan (O & M Plan) within the Project area. The focus of the O & M Plan is vegetation manipulation (meaning the mowing/chipping/ shredding and/or removal of riparian and exotic vegetation) and the removal of sediment. The initial O & M Plan will be accomplished in phases over an estimated eight-year period. The first phase of implementation began in September 2008 near the Oceanside Harbor and was scheduled to move upstream depending on weather and stream flow conditions. All work must occur outside the bird breeding season (breeding season extends from March 15th to September 15th) in order to protect a variety of riparian-dependent bird species, including several endangered species such as the least Bell's vireo (*Vireo bellii pusillus*) and the southwestern willow flycatcher (*Empidonax traillii extimus*). The total project area consists of 7.2 contiguous river miles (estuary to College Avenue), encompassing approximately 549 acres of channelized and unchannelized reaches of the SLR River. The implementation and completion of this Plan most likely will have a significant impact on sensitive flora and fauna communities as substantial areas of riparian vegetation will be removed and wetlands will be disturbed or altered (Figure 16).

Phase1 will be implemented during the first year of the Project and aims to reach the target flow capacity of 53,000cfs (estimated 100-year flood event). The project proposes to minimize the loss of riparian habitat throughout the project area by incorporating as much as possible: (a) open water/freshwater marsh where bendable vegetation less than 0.5 inches diameter at breast height (DBH) can be left in the channel, and (b) establishing a 10-foot wide "buffer" zone on each side of the active channel. Within this zone, no emergent aquatic vegetation or native riparian vegetation shall be removed except for the following: 50% of existing riparian trees 5 inches or greater DBH may be removed in alternating sections based on the on-site biological monitor's recommendations on either side of the channel. This buffer zone will help retain some vegetation around key areas. Even if these measures are adhered throughout the project, there will be significant loss of wetland/riparian areas that provide important habitat to many species of flora and fauna, including but not limited to, the endangered arroyo southwestern toad (*Bufo microscaphus californicus*), least Bell's vireo, and southwestern willow flycatcher.

Ocean-run steelhead utilization of the project area would depend largely on the different phases of their lifecycle stages. Migrating adult steelhead would primarily use the project area as a migration corridor to more suitable spawning habitat located in Northern Subbasin tributaries. Juvenile trout could potentially utilize the area as rearing habitat during downstream migration to the estuary and eventually the ocean. While the removal of dense stands of giant reed (*Arundo donax*) and other non-native species will benefit the ecology of the area, the disruption of native riparian and near stream forest can have serious impacts to the aquatic habitat. These near stream forests provide overstory shade moderating air and water temperature, a critical component for steelhead trout rearing conditions; supply necessary cover from predation; contribute to pool formation, which offer adults and juveniles resting holes during migration; function as the base of the food chain for biological stream life, contribute to macro-invertebrate production, a necessary food supply for juvenile fish and other organisms; and stabilize banks, contributing to soil cohesion.

The riparian corridor along the river serves more than just important habitat for numerous species. In a time of dwindling water resources, the riparian and surrounding wetlands increase groundwater storage during the rainy season. This ecosystem also functions as a clean water filter, helping maintain higher water quality. Research has shown that a riparian system is one of the best ecological systems for removing sediment – and therefore for removing pollution-causing nutrients from water (Riley 1998 and Jenkins 2007). Studies have identified riparian vegetation to be just as effective a filter in urban areas as in agricultural areas and riparian buffer areas as narrow as 20 feet are valuable in contributing to water quality (Riley 1998). This is especially pertinent to the water quality of the SLR River as it receives both agricultural and urban runoff. The development and clearing of riparian areas not only represents a loss of the water treatment capabilities of those areas, but may turn such damaged environments into sources of nonpoint pollution with the release of stored sediments and nutrients that have been deposited over many years. Disturbance and erosion would allow these sediment and nutrients back into the watershed (Riley 1998). As Oceanside looks to become less reliant on dwindling and expensive outside water sources, and meeting high standards of water quality, the river, accompanied by a functional riparian is essential to maintaining water quality and local groundwater supplies.

Considering the housing and other commercial development that has occurred within the lower SLR River floodplain, vegetation and sediment removal will continue to be an on-going issue in the Oceanside area. Future maintenance projects must strike a balance between flood protection and ecological protection of the many riverine resources, including clean, potable water.

Figure 16. Riparian vegetation removal along SLR River in Oceanside.

SLR River is forked but the main channel is to the right of remaining trees. Photo taken March, 2008.

Invasive Plant Species Management

The SLR Basin contains several problematic, highly invasive, non-native plant species. These invasive plant species have detrimental impacts to native habitats and species, crop and rangelands, alter nutrient cycling, use large quantities of water, contribute to erosion and flood damage, and increase the frequency and intensity of wildfires. Invasive plants alter ecological and hydrological processes. The differing growth structure and growth patterns of invasive versus the native species they replace can alter flooding patterns, accelerate sediment deposition, and produce large amounts of biomass during flood events. Native plants often support “10 to 50 times as many species of native wildlife as nonnative plants,” noted biologist Philip Rundel, a California plant specialist at UCLA (Anton 2008). The loss of native habitat to invasive species is one of the leading causes of species extinction in San Diego County (SLR Watershed Council 2000).

Invasive plant species are difficult to control because of the properties that allow them to be successful invaders. These species tend to have rapid, tenacious growth rates, spread easily and swiftly, and can grow in a variety of conditions. These non-native plant species generally out-compete the native species and may completely eliminate natives from certain areas. Examples of native vegetation displacement in the SLR Basin by non-natives are the salt cedar (*Tamarisk spp*.) and perennial pepperweed (*Lepidium latifolium*) along lower reaches of the SLR River and in the estuary. These species have the ability to elevate topsoil salinity by excreting salts or pumping salt from below ground, which then discourages native plant growth. Very few native plants are currently present in the SLR estuary.

Any activity that disturbs or spreads soil generally distributes invasive plant seed or plant parts that can grow new individuals. Numerous activities along the SLR River such as channel clearing, the building of flood control structures, gravel mining, and agricultural practices could have easily contributed to the proliferation of exotics. In addition, as a result of the Escondido Canal diversion, the flood regime has been altered which may have exacerbated the situation by reducing native plant post-flood establishment. The high levels of disturbance and habitat modification tend to favor a non-native flora (Stephenson and Calcarone 1999). Eradication is rarely achieved with one treatment, thus requiring a multi-year effort which is costly and requires accuracy and thoroughness in completing follow-up treatments and monitoring.

Currently, there are two plant species that represent the greatest threat to the watershed in terms of area occupied, potential to spread, impact to the quality and quantity of native habitat, and problems they pose to land managers: giant reed (*Arundo donax*) and salt cedar (*Tamarisk spp.*). Giant reed, also known as *Arundo*, has numerous negative impacts on the riparian and stream habitat. *Arundo* increases sediment input by having a weak root system that is susceptible to under-cutting by stream flows; it creates a monoculture that is difficult to penetrate and excludes native plant species; in areas of heavy *Arundo* concentrations, it reduces all forms of wildlife, including the federally endangered species of the least Bell's vireo, southwestern willow flycatcher, and arroyo southwestern toad; when grown along main stream channels, it provides less shade than native riparian trees because it grows vertically instead of arching over the water channel; riverine areas dominated by *Arundo* have warmer water temperatures, which results in lower oxygen concentrations and lower diversity of aquatic animals (Bell 1997); and increases both the frequency of fires and the intensity of fires when they occur (SLR Watershed Council 2000). Moreover, in order to supply its incredible growth rate, *Arundo* uses extraordinary amounts of water. In short, every acre of *Arundo* consumes about 5.62 acre-feet of water per year. On average, native species use only one-third this amount; 1.87 acre-feet per year (Iverson 1998). The amount of water lost to evapotranspiration has detrimental effects on overall surface flows and the supply of the groundwater aquifer in the SLR River Basin.

Non-native grasses are also problematic, specifically in the Coastal and Upper subbasins. Similar to many other areas of California, non-native annual grasses and forbs have displaced perennial native grasses throughout the basin. Non-native grasses, displace wildlife, outcompete native species of plants, deplete soil resources, increase fire frequency, and type conversion of shrub-dominated habitats to grassland (Stephenson and Calcarone 1999). Once alien grasses become established it is difficult for native vegetation to recover. Other invasive plant species of concern within the basin are as follows (in descending order of concern): perennial pepperweed, bridal bloom (*Retama monosperma*), German ivy (*Delairea odorata*), pampas grass (*Cortaderia selloana*), Castor bean (*Ricinus communis*), artichoke thistle (*Cynara cardunculus*), and periwinkle (*Vinca major*) (SLR Watershed Council 2000).

In order to combat the spread of invasive, non-native plants and the risks they impose, the San Luis Rey Watershed Council has assisted in mapping the distribution of these plants within the watershed (Figure 17) and has supported the formation of the Santa Margarita and San Luis Rey Watersheds Weed Management Area. The Weed Management Area plan has been actively treating the invasive plants in the basin since the fall of 2000 (Figure 18). Most of this work has focused on treating *Arundo*, the most widespread species. According to the Weed Management Area website, as of August 1, 2007, approximately 292 of 507 acres of *Arundo* had been treated in the watershed, mainly in the mainstem and some tributaries. Another 100 acres is slated for treatment during the 2007/2008 season, mostly along lower Keys Creek. Due to the Corps flood control project the total number of non-native plant removals will significantly increase with the completion of the multiple phases of the project in the lower seven miles of the river in Oceanside (see Flood Control Project section, pg. 30). The majority of the invasive plants are located in the Coastal Subbasin and treatment recommendations are discussed further in the Coastal Subbasin section. It is important to note that some treatments have also been administered in the Southern Subbasin; further eradication efforts are needed in this subbasin and to a lesser degree in the Northern Subbasin to prevent the continuous supply of seeds and plants downstream to the Coastal Subbasin.

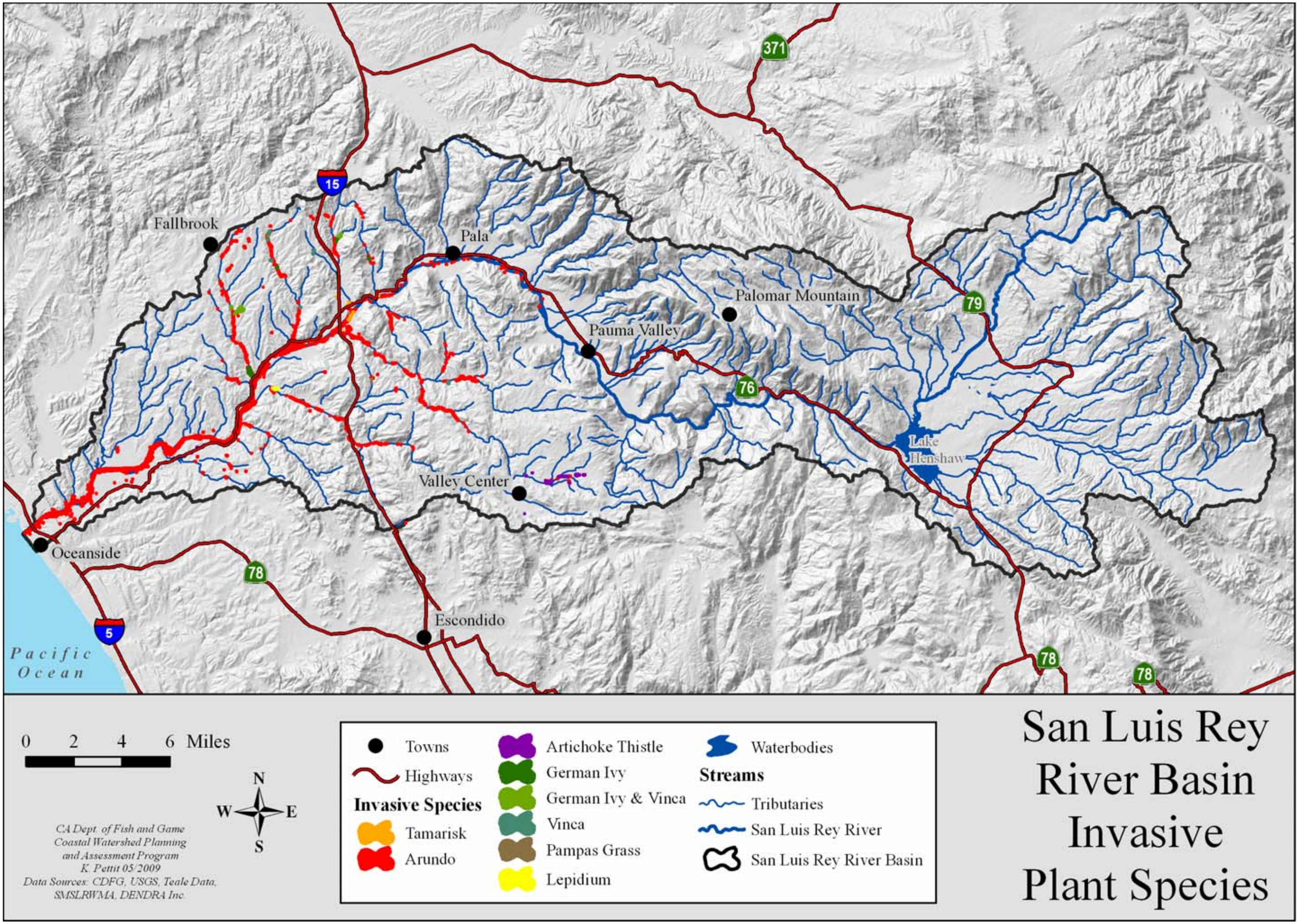
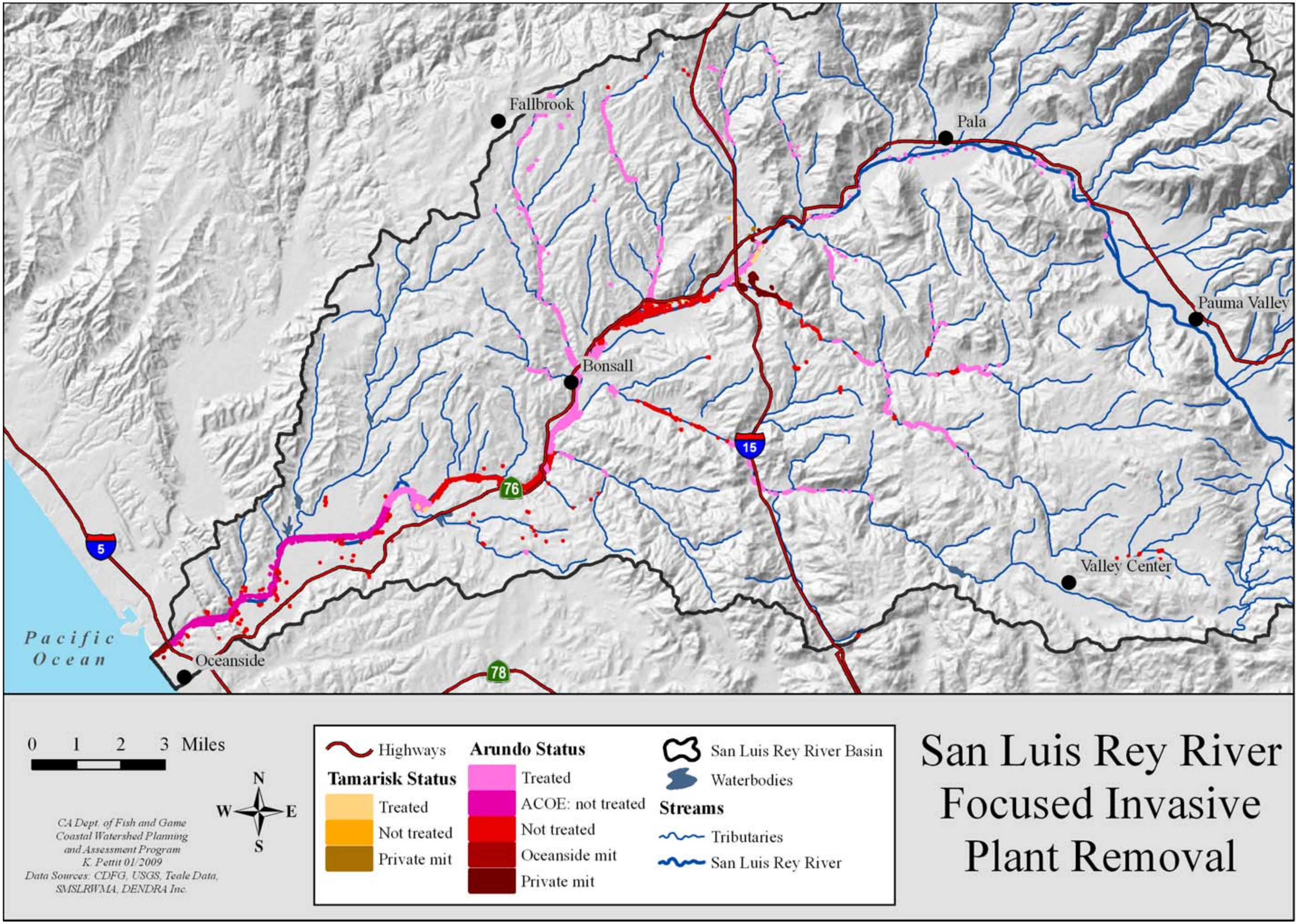


Figure 17. Invasive Plant Species of the SLR River Basin.



San Luis Rey River Focused Invasive Plant Removal

CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 01/2009
Data Sources: CDFG, USGS, Teale Data, SMSLRWMA, DENDRA Inc.

Figure 18. Focused invasive plants removal in the SLR River Basin.

Fire History and Management

Analysis of land management in the SLR River Basin cannot be comprehensive without addressing issues of fire. Fire is a primary agent of change in vegetation patterns across the southern California landscape (Stephenson and Calcarone 1999). The distribution, composition, and structure of almost all plant communities in the SLR River Basin are influenced by fire. With the urbanization of many portions of the basin, fire management has become an increasing concern as the cost of damage to homes and personal property has reached millions of dollars per year. The 2007 Poomacha Fire that burned 44,412 acres in the Middle, Southern and Northern subbasins had an estimated cost of 21 million dollars, which may actually increase over time (State of California 2007).

There is little argument that the fire regime in southern California has changed as human populations have grown and fire suppression practices have become increasingly effective. There are, however, widely divergent opinions among researchers regarding historic patterns of fire frequency, size, and intensity. Fire frequency appears to have significantly increased only in ignition-prone areas near the urban interface, where there are many more opportunities for fire ignition with the increased population and usually high proportions of scrub and grass vegetation that facilitate rapid fire spread (Stephenson and Calcarone 1999) (See Figures 19-21). The expansion of urbanized areas in the region has created fragmented patches of shrublands that are losing connectivity to other natural areas. Fires in these areas may cause local extinction of plant or animal populations, which leads to the increase invasion of exotic species and little to no hope of re-colonization of native species. In addition to on-going expansion of urban areas in southern California, modeling of global climate change predicts wildfire frequency and magnitude will most likely continue to increase over the next few decades (Cannon and DeGraff 2009).

Generally, the greater the intensity of the fire results in the greater the impact on the landscape and natural resources. Hotter fires consume organic matter that binds soils, creating an increase in erosion potential, or in the worst case, can volatilize minerals in the soil causing it to become hydrophobic (Wells 1985). In San Mateo Creek, 18 miles to the north of the SLR River, Higgins (1992) noted that soils became hydrophobic after an intense wildfire and deposited more than a foot of sediment in pools surveyed.

While recovery of herbaceous vegetation after a fire is usually rapid and abundant, as in the case of the 1989 Vail Fire in the Palomar Ranger District (Winter 2000), high recurrence of fires in coniferous forests in southern California may cause conversion to chaparral, which can greatly alter hydrologic conditions (NMFS & Kier Associates 2008). Similarly, in lower elevations, coastal sage scrub and chaparral that burns frequently (less than 20-year reoccurrence) may result in the establishment of non-native grasses. Because non-native grasses are shallow rooted, compared to deep-rooted shrubs or even native grasses, they are less effective at stopping erosion, which increases sediment pollution into creeks and rivers. Typically, once these native species have been replaced by alien grasses, they are unable to recover (Zedler et al. 1983 & Rogers and Lee 2007). This, in turn, displaces native fauna, which depend on the native vegetation communities.

Depending on the intensity of the fire, wildfires in the short-term can be extremely detrimental to fish habitat. Wildfires increase the wet-season runoff, with the consequence that dry-season baseflow will decrease, and fires increase fine sediment input, which may bury spawning gravels and fill in rearing pools (Shapovalov 1944, cited in Boughton et al. 2007). Moreover, wildfires may lead to direct fish kills through sediment input and debris flows, which can dramatically decrease instream dissolved oxygen levels. Conversely, wildfires can have long-term benefits for fish habitat, such as producing influxes of spawning gravels to the stream (Boughton et al. 2007).

In addition to adverse impacts to native habitats, fires in urban areas can pose further impact to water quality, and in turn, humans and biological resources that rely on these resources. According to a recent report by federal geologists, ash from wildfires in southern California's residential neighborhoods poses a serious threat to people and ecosystems because it is extremely caustic and contains high levels of arsenic, lead and other toxic metals. It is a known feature of ash to generate alkalinity and thus increase pH levels in water. Although the alkalinity will diminish over time and be diluted by heavy rain, it is unknown how quickly it will neutralize. High-alkaline water could be poisonous to wildlife and vegetation essential to its survival. Some ash collected in residential areas after the October 2007 fires (Grass Valley Fire and Witch Fire) registered a pH of 12.7, a level more caustic than ammonia and nearly as caustic as lye (Cone 2007).

In the fall of 2007 the Poomacha and Rice Fires burned large portions of the Basin. The principal concern with the aftermath of these recent fires is an increase in the potential for in-channel floods, debris torrents, debris flows, and headward expansion of gullies. The increased runoff and erosion will result in higher than usual peak flows along stream channels. Ash and other sediment/ nutrient loads will be washed and blown into ephemeral and perennial streams, increasing the Total Maximum Daily Loads (TMDLs) for total nitrogen and phosphorus, Total Dissolved Solids (TDS), and Total Suspended Solids (TSS) within the water courses. This will cause short term water quality impacts that could impact aquatic species. A more detailed description of the recent fires and areas impacted in the watershed is provided below.

2007 Poomacha Fire

The 2007 Poomacha Fire started October 23rd as a structure fire on the La Jolla Indian Reservation and spread through Pauma Valley to the lower slopes of Palomar Mountain, the northern slopes of Bouchar Hill, and to Doane Valley (see Figure 21) (County of San Diego 2007). It burned a total of 49,410 acres (44,412 acres in the SLR Basin) and destroyed 138 homes before being fully contained on November 9th (State of California 2007). Aided by Santa Ana winds, this was a quick moving fire that spread rapidly. The fire burned throughout chaparral, oak woodland/forest, grassland, riparian, and other wetland vegetation communities. This fire burned over a third of the area located in the Middle and Northern subbasins. Approximately 15,100 acres of the fire overlapped with the 2003 Paradise Fire burn area (State of California 2007).

According to the Interagency State Burned Area Emergency Response (BAER) Report, dated November 17th, 2007, described the burn within coastal sage and grassland as low to moderate in severity and in chaparral, oak woodlands/forests, and conifer forests as low to high severity. It went on to state the riparian habitat along the SLR River burned "at moderate intensity with patches of high severity." The report summarized its findings in the following paragraph:

> *"In the San Luis Rey/Paradise Creek area, the primary concern is the moderate burn on north facing slopes that flow into the SLR River. Anticipated impacts include burn debris and sediment flowing to the SLR River. It is also likely that aquatic species will be affected by poor water quality resulting from mobilized debris and sediment. Due to extremely high burn severity within the upper watershed of Plaisted and Cedar creeks, it is likely that there will be highly mobilized ash and sediment. Possible effects to water quality could extend to other downstream riparian areas. In general, it is likely that the extent of these burn areas will have effects to downstream aquatic biota, as well as an increase in large woody debris throughout and beyond the burn area."*

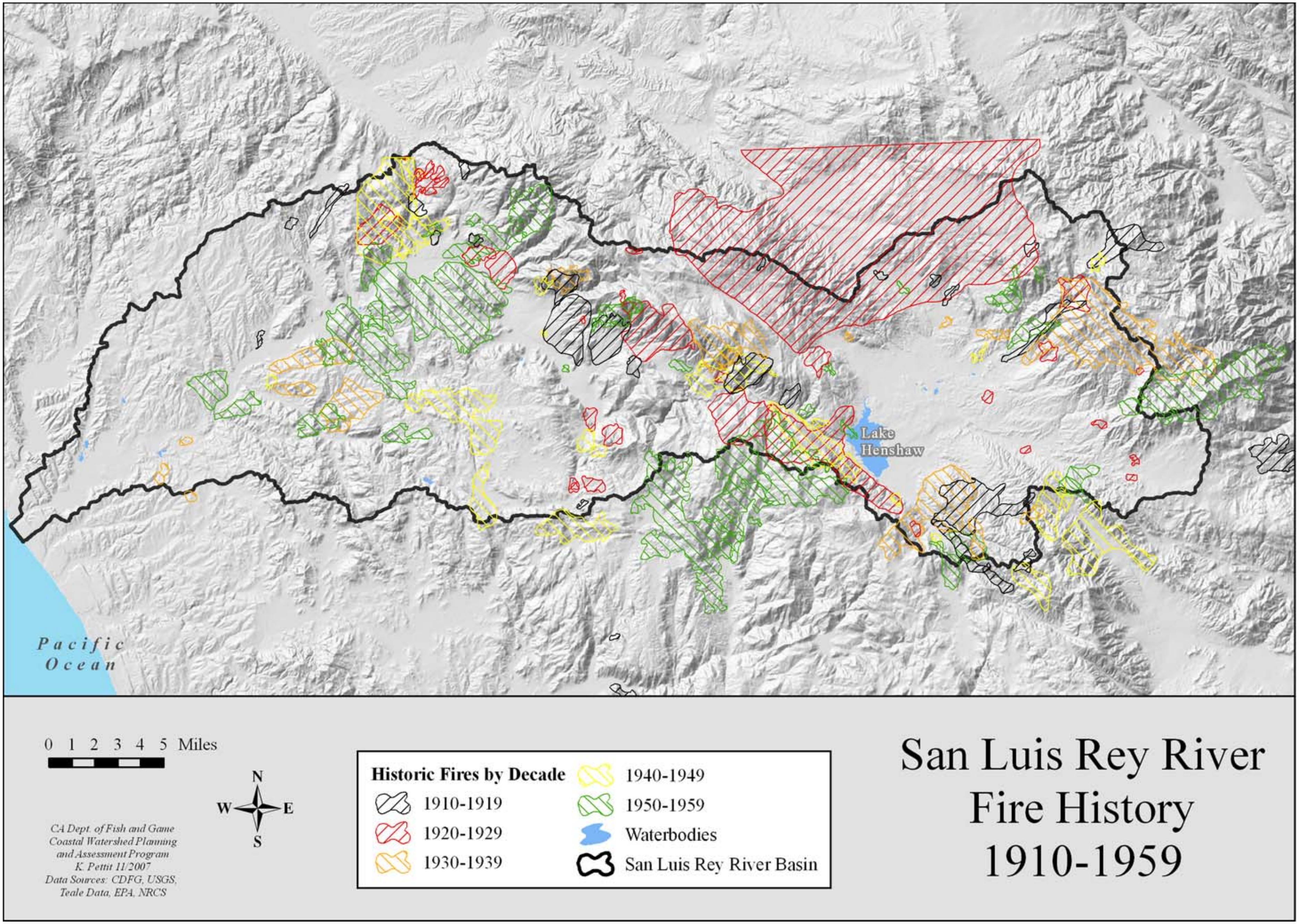
The magnitude of the potential post-fire damage became a reality when major storm events hit the area in late November/early December of 2007, releasing large amounts of precipitation. Large debris flows occurred in some of the tributaries to the SLR River, particularly those that flowed out of the Palomar Mountain region, which received the greatest rainfall totals and contained the watershed's highest post-fire erosion potential (Figure 13).

CDFG fisheries biologists conducted a reconnaissance level stream survey in upper Pauma Creek to assess the habitat conditions and status of the fisheries resources after the Poomacha Fire. The biologists agreed that while some fish mortality would occur, it was extremely unlikely, almost impossible, for the trout population to be extirpated from the watershed, due to impacts related to the fire. The conditions of Pauma Creek watershed and observations from this survey are discussed further in the Northern Subbasin section.

2007 Rice Fire

The Rice Fire began on October 22 and was fully contained one week later on October 29. The fire area is located in both the Santa Margarita River watershed to the north and the SLR River watershed to the south (Figure 21). Similar to the Poomacha Fire, the Rice Fire, aided by Santa Ana winds, burned very rapidly and produced mostly low and moderate burn severity with large areas of unburned land within the fire perimeter. The entire fire area encompassed 9,472 acres, of which 6.9% was rated as high burn severity, 26.0% as moderate severity, 19.8% as low severity, and 47.3% was unburned (within the burn perimeter) (State of California 2007).

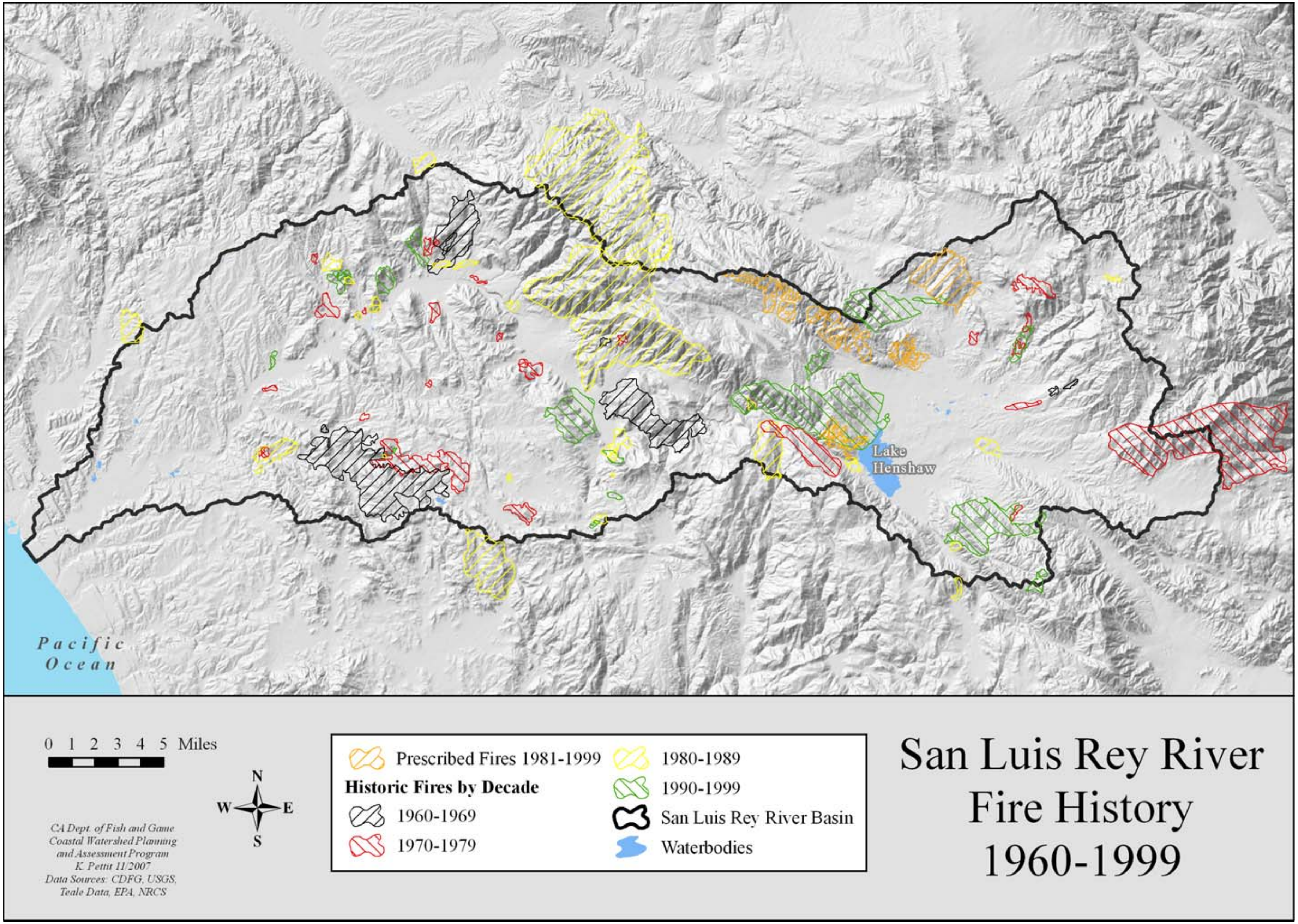
The Rice Fire was located almost entirely within the northeastern corner of the Coastal Subbasin. Ten percent, or 6,758 acres, of this subbasin was impacted by the fire. The fire primarily burned in the Stewart Canyon sub-watershed. Almost half, 46%, of this sub-watershed was burned. Only a slight portion, 1%, of the Upper Rice Canyon sub-watershed was burned (State of California 2007). Based on the low to moderate burn severity of the fire and considering the large areas within the fire perimeter that were not burned, the Rice Fire BAER report concluded that potential changes to peak flows would not be extreme. "For peak discharges that occur on average every two years, flow rates are estimated to increase 1.0 and 1.5 times for these watersheds respectively."



San Luis Rey River Fire History 1910-1959

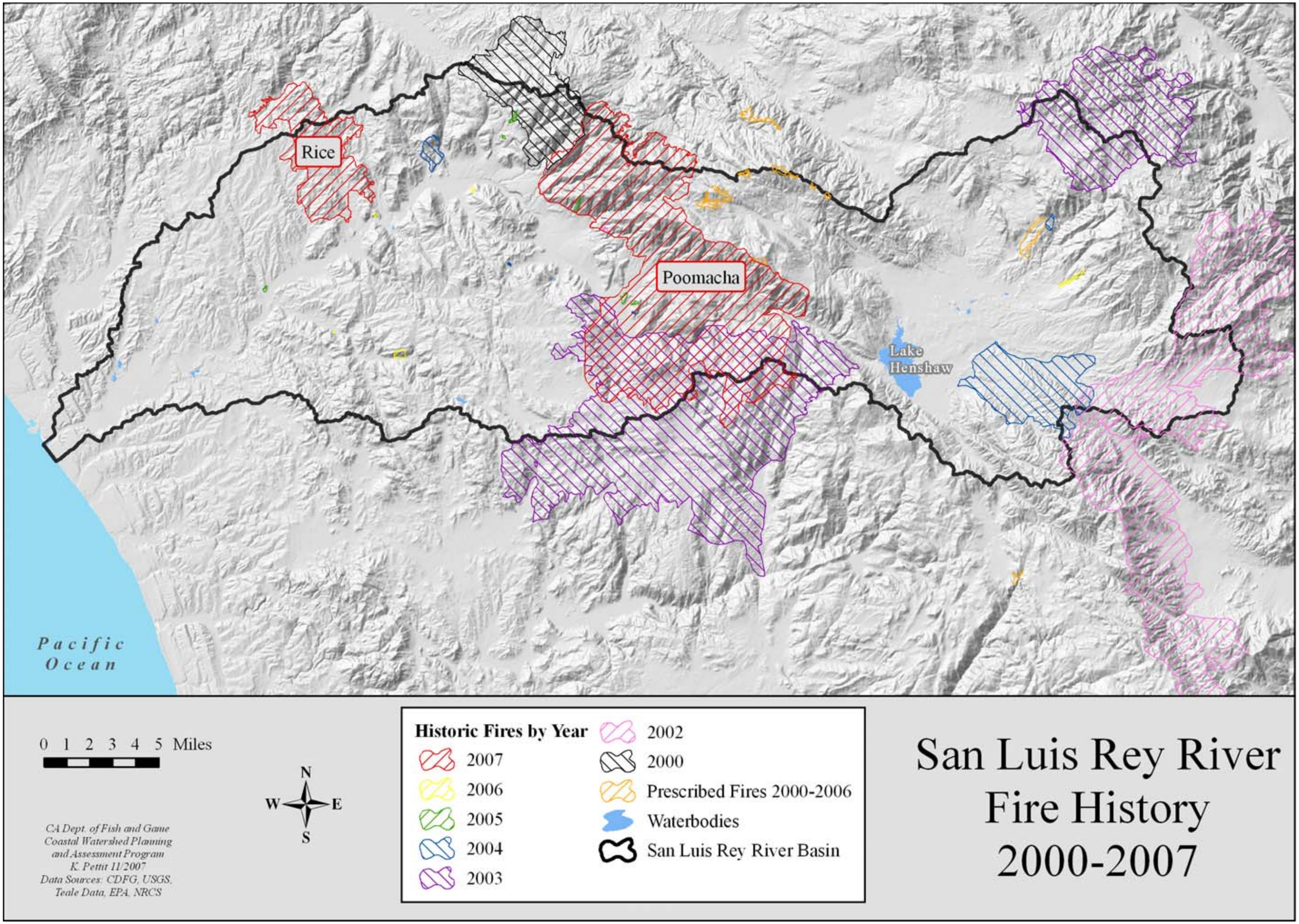
CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 11/2007
Data Sources: CDFG, USGS,
Teale Data, EPA, NRCS

Figure 19. Burned areas of the SLR River Basin 1910 to 1959.



CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 11/2007
Data Sources: CDFG, USGS,
Teale Data, EPA, NRCS

Figure 20. Burned areas of the SLR River Basin 1960 to 1999.



CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 11/2007
Data Sources: CDFG, USGS, Teale Data, EPA, NRCS

Figure 21. Burned areas of the SLR River Basin 2000 to 2007.

Numerous post-fire studies have documented that a significant percentage of sediment can be expected to occur immediately following the fire (MacDonald et al. 2004). Using a computer modeling program, the report predicts a significant increase in sediment production rate, 8.5 times higher than normal in the Stewart Canyon watershed. Roughly half of the additional sediment will occur during the first over wintering period (State of California 2007). Upper Rice Canyon is expected to have only a slight increase in its sediment production rate.

Land and Resource Use

Pre-European Settlement

The earliest inhabitants in San Diego County are identified as the San Dieguito Complex/Tradition, which are typified as hunter and gatherer society. This group of people may have migrated from drying inland lakes of the present California desert to San Diego County circa 9000 years ago based on the artifact assemblage at several archeological sites in San Diego County (Lettieri-McIntyre 1995). The early occupants made use of coastal and inland resources of plants, animals, shellfish, and fish.

The next period of human occupation in the region spanned approximately 7,000 years as the San Dieguito people assimilated with the inland La Jollan people. These people utilized a diverse range of resources from coastal and inland ecozones and developed an artifact assemblage to exploit these diverse resources (Lettieri-McIntyre 1995).

Approximately 2,000 years ago, Yuman speaking people intruded from the Gila/Colorado River drainages and the La Jollans may have either assimilated with, or were displaced by the Yumans. About 1,000 years ago, the Yuman and Shoshonean groups migrated to the northern San Diego area. The Shoshonean group belongs to the Takic language family of Uto-Aztecan, and comprised the Luiseño (name derived from the Franciscan Friars who later established the Missions), Cahuilla, and the Cupeños tribal groups (http://www.library.ca.gov/).

The Luiseño tribal territory was roughly bound on the south by Agua Hedionda and Escondido, on the east by Lake Henshaw, on the west by the Pacific Ocean and extended north into Riverside County. The SLR River was a prominent natural feature of the Luiseño territory providing the residents with subsistent food sources that included ocean and freshwater fish and shellfish, a wide variety of plants and seeds, birds and small to large mammals available in the riparian habitat and from surrounding areas (Lettieri-McIntyre 1995).

The Cahuilla and the Cupeños tribal groups were located primarily in the Upper Subbasin region. The Cupeños were one of the smallest Native American tribes living in California. They once occupied a territory of 10 square miles in the mountainous region at the headwaters of the SLR River in the valley of San Jose de Valle (http://www.palatribe.com/about/history/), what is now Warner Springs. They lived relatively undisturbed until the arrival of the first Europeans, the Spanish, in the early 1800s. Gradually, as more Spanish, Mexicans, and later American settlers moved into the region, the Cupeños territory and way of life became altered. In 1903, the Cupeños were forced to make a 40-mile journey from their land to what is now called the Pala Reservation.

The Cahuilla people were a larger, more widespread tribal group located throughout Riverside County and Northern San Diego County. Prior to European settlement, their group consisted of 6,000 to 10,000 tribal members. The Cahuilla people have since been divided into multiple tribes located in Riverside and Northern San Diego County. Of these tribes, only the Los Coyotes Indian Reservation is located in the SLR Basin (Upper Subbasin).

European Settlement

Shortly after arriving in the region, Spaniards established the Mission San Luis Rey de Francia (1769) in the heart of the Luiseño territory, adjacent to the SLR River in what is now the City of Oceanside. The missions "recruited" the Luiseño to use as laborers and converted them to Catholicism (Tierra Environmental Services 2006). This was the earliest European settlement in the area. With the location of the mission in the broad San Luis Rey valley, the settlers had access to fresh water and fertile soil, allowing the mission and other Spanish settlements in the region to become very productive in the raising of crops and grazing of cattle, sheep, and horses. However, as introduced annual grasses and forbs by the Spaniards became established on the range, livestock numbers declined. After catastrophic losses to cattle occurred in the late 1800s, grazing as an economic enterprise was limited to the grasslands around Lake Henshaw and some Native American lands (SLR Watershed Council 2000).

Spanish, Mexican, and American settlers continued to migrate into the region, accompanied by their increased demands for territorial and resource rights, often located in tribal territories. A series of Executive Orders were eventually followed by the Mission Indian Relief Act of 1891, which resulted in the creation of Indian reservations (SLR Watershed Council 2000). The La Jolla, Rincon, San Pasqual, Santa Ysabel, Pala, Pauma/Yuima, Mesa Grande, and eventually the Los

Coyotes Indian Reservations were set aside in the SLR River Basin, and Native American tribes were forced to move from their ancestral lands onto these reservations.

The increase in the basin's population and subsequent land development and applied uses required access to reliable water resources. This led to the development of water storage facilities. From 1893 to 1895, the Escondido Irrigation District constructed the thirteen mile long Escondido Canal that brought SLR River water by gravity flow from the canal's intake on the La Jolla Indian Reservation into the adjacent watershed to what is now Lake Wohlford. Shortly afterwards, Vista Irrigation District's predecessors, William Henshaw and San Diego County Water Company, obtained water rights along the SLR River and completed the construction of Henshaw Dam (1922), located approximately ten miles upstream from the intake of the Escondido Canal. The dam's primary purpose at the time of construction was to provide water for downstream agricultural needs (Hazel et al. 1975). The dam began the delivery of water to the city of Escondido's predecessor in 1925 and the Vista Irrigation District (VID) in 1926 (SLR Watershed Council 2000).

As these local water supplies were developed, agricultural practices switched from dryland crops (hay and grains) to more profitable, water-dependent crops. Citrus orchards (mostly oranges and lemons) were established in Pauma Valley, Fallbrook, and Valley Center in the 1920s. These orchards were expanded and partly replaced by avocados after 1940 (SLR Watershed Council 2000). The Vista area became known as the "Avocado Capital of the World" with six avocado packing plants in the area (http://www.vid-h2o.org/aboutus/ourhistory.asp). After the completion of the first San Diego Aqueduct in 1947, imported Colorado River water became available for use in the region. These imported water supplies have provided the basis for many intensive agricultural enterprises in the basin, including truck crops, flowers, and nurseries.

Present Land Use

Due to the large percentage of publicly owned land, Indian reservations, and physical features such as steep slopes or floodplains, the majority of the SLR River Basin, 54%, has remained undeveloped (Table 7). Of the developed lands, residential areas have recently replaced agriculture as the dominant land use. A little over 15% of current land use is dedicated to residential areas with most of the region's developable acres slated for future residential development. Many of these residential developments are planned for densities of less than one home per acre and in rural areas dependent upon scarce ground water supplies (PBSJ 2003). Agricultural production, varying from cattle grazing to a wide variety of croplands, occupies approximately 14.5% of the land within the watershed. Less than 10% of the basin land remains in parks and open space, which is a slight increase over the past decade. The types of development that can be expected in the SLR Basin are shown in Table 8 (note that these planned land use categories have been generalized from land use elements of local jurisdictions).

There is a strong relationship between land use planning and the quality of watersheds. The proper planning of future land use may help to prevent and repair water quality problems. Depending on the type and magnitude of water quality problems that occur in surface water bodies and groundwater basins, the acreage of undeveloped land and its planned land use can provide an indication as to the types of water quality problems that may be expected to occur in the future so that they may be addressed (SANDAG 2004). Protected areas that are mapped out in advance instead of worked in around development, are far more effective at conserving biodiversity and ecological functions.

An example of potentially effective land planning is the future development of the San Luis Rey River Park along the 8.5-mile stretch of the San Luis Rey River corridor between I-15 and the old Bonsall Bridge. Once complete, this park will provide passive and active recreational amenities for the Fallbrook and Bonsall community areas, as well as a habitat preserve and multi-use trail system serving the larger region. The park's Master Plan Goals include: the protection and enhancement of critical habitat for several threatened and endangered species within the river corridor and identification and removal of invasive, non-native species (Hargreaves Associates 2005). The riparian protection and potential stream habitat improvement projects could be very beneficial to steelhead upstream and downstream migrations.

Table 7. Existing land uses in the SLR Watershed.

Land Uses	Acres[1]	Percent of Total[2]
Vacant/Undeveloped	195,593	54.3
Residential	54,842	15.2
Agriculture	52,092	14.5
Parks and Open Space	31,854	8.9
Commercial/Industrial	13,,739	3.8
Freeway Roads	7,225	2.0
Recreation	3,325	0.9
County of Riverside	649	0.2
Military	600	0.2
Schools	567	0.2
Total	**360,485**	

Source: City of Oceanside, City of Vista and County of San Diego 2008 and SANDAG 1998 and 2006. Values provided in table are for general purposes only.

[1] Due to rounding, values do not equal total.

[2] Due to rounding, values do not equal total.

Table 8. Planned land use (in acres) of vacant/undeveloped land in the SLR River Watershed.

Total Vacant/ Undeveloped	Constrained	Constrained Pct.	Total	Residential	Commercial/ Office	Industrial	Schools	Future Roads/Freeways
199,709	121,037	61%	78,672	77,878	499	196	45	54

Source: SANDAG 2004

Population

Although the SLR River watershed is the third largest of the San Diego region watersheds, its population is one of the smallest. This may be attributed to its northeastern location in the county, which is comprised of unincorporated communities that are less developed than coastal cities. The 2000 population of the SLR watershed was 142,402. However, the population is expected to increase approximately 63% by 2030 to 231,797, which is the third largest percent increase of the San Diego County watersheds (SANDAG 2004). This growth is expected to occur mostly within vacant land in the unincorporated areas of the watershed; however, the City of Oceanside will also contribute significantly to the growth. Within the unincorporated areas of the watershed, the communities of Fallbrook and Valley Center are anticipated to produce the greatest population increases (SLR Watershed Council 2000).

The major population centers in the watershed are located in the Coastal Subbasin, where over two-thirds of the watershed population resides. The City of Oceanside and Vista (near the coast) and the community of Fallbrook, located in the north central portion of the Coastal Subbasin, contain a majority of the population in this subbasin. The second most populous subbasin is the Southern Subbasin which includes the community of Valley Center and the Rincon Indian Tribe. The remaining subbasins are mostly rural and contain sparse populations.

Table 9 has been adopted from the SLR Watershed Council's 2000 San Luis Rey Watershed Guidelines report and from the San Diego Association of Governments (SANDAG 2004). SANDAG is composed of the 18 cities and county governments of San Diego County as the forum for regional decision-making. This Association attempts to build consensus, obtain and allocate resources, and provide information on a broad range of topics pertinent to the region's quality of life. Statistics do not exist for specific breakdowns of the watershed; therefore, Community Planning Areas (CPAs) were used to describe the various areas. Many of these areas are not located entirely within the watershed boundaries, thus the estimated population of the watershed is significantly less than the total population of the CPAs.

Regionally, San Diego County has been one of the fastest growing areas in the United States. Table 9 and Table 10, derived from SANDAG and the U.S. Census Bureau, detail the growth of the region, and provide future growth prediction.

Table 9. 2000 Cities population and 2020 forecast populations; 1995 developable areas and 2020 forecast vacant development areas.

Areas	2000 Population	2020 Population	1995 Vacant Developable Areas	2020 Vacant Developable Areas
Pendleton D.L. CPA	36,927	38,046	9,691	9,524
City of Oceanside	161,029	202,592	3,028	335
City of Vista	89,857	103,316	2,002	0
Bonsall CPA	8,864	17,224	6,070	30
Fallbrook CPA	39,585	50,012	7,830	6,796
Rainbow CPA	1,843	2,800	4,159	3,754
Pala-Pauma CPA	6,156	6,908	26,090	24,910
Valley Center	15,639	33,006	12,359	5,156
N. Mountain SRPL**	2,619	5,280		
No. County Metro SRPL**	28,914	52,967	2,266	89
City of Escondido	133,559	143,228	20,317	5,313
SLR watershed	148,201	242,069	N/A	N/A

Data from U.S. Census Bureau, SLR Watershed Council 2000, and SANDAG 2002.

*Community Planning Areas (CPAs) are defined geographical areas located in unincorporated areas of San Diego County utilized for community and regional planning efforts.

**The North Mountain and North County Metro Sub-regional Planning Areas are comprised of many non-contiguous "island" areas interspersed among the cities of Escondido, San Diego, San Marcos, Vista, and Oceanside with the most easterly portion adjacent to Valley Center. The North County Metro Sub-region includes the communities of Hidden Meadows and Twin Oaks.

Table 10. San Diego County population trends since 1980.

San Diego County Population Totals	
1980 Census	1,861,846
1990 Census	2,498,016
2000 Census	.2,813,833
2010 Forecast	.3,437,697
2020 Forecast	3,853,297

The growth rate, however, is slowing and that trend is predicted to continue. By the mid-2020s, San Diego County's growth rate will fall below the national rate of about 1%. The primary drivers of this trend are declining fertility rates and the aging and eventual death of the disproportionately large baby boom generation. Currently, the surrounding counties of Riverside and Imperial counties are growing faster than San Diego County (SANDAG 2004).

Ownership

Land ownership in the basin is primarily privately owned (48%). Over a third (36%) of the land is publicly owned and the remaining 14% consists of numerous Indian reservations within the watershed (Figure 22). The privately owned land dominates the western portion of the watershed (Coastal Subbasin and the western portions of the Northern and Southern subbasins). Moving eastward, more public land is apparent with the Cleveland National Forest comprising large areas in the Northern, Middle, and Upper subbasins. A majority of Indian Reservation lands are also located in the Northern, Middle, and Upper subbasins. The Vista Irrigation Water District (area near Lake Henshaw) is the single largest landholder in the watershed (SLR Watershed Council 2000).

Agriculture

Agriculture is the fourth largest industry in San Diego County and is extremely important to the regional economy of the SLR River Basin (SLR Watershed Council 2000). As previously discussed, agriculture occupies almost a quarter of the land in the basin. Most of the larger scale agricultural use in the basin occurs east of Interstate 15, but there are a few large producers and a considerable number of small scale growers in the Coastal Subbasin. Tomatoes and herb farms compose some of these larger producers in the Coastal Subbasin. West of Interstate 15, citrus, avocado, nursery, and flower crops are the dominant agricultural use of land. The nursery and flower industry comprises the largest economic component of the San Diego County agricultural industry, with 68% of the dollars generated (County of San Diego 2007).

Due to its broad land use in the basin, agriculture has a wide range of influences within the watershed:

Water Quantity: Because of the relatively dry climate, type of crops that are grown, and lack of groundwater in the basin, many agricultural producers rely on imported water sources (Colorado River and State Water Project) to irrigate and sustain crops. The high cost of land and imported water (more than $600 per acre foot) encourages growers to produce crops with a high dollar value per acre (County of San Diego 2007). This puts added pressure on developing or retaining local sources of water, such as SLR River, its significant tributaries, and .

Water Quality: Imported water often contains high levels of Total Dissolved Solids (greater than 500 parts per million). Because of the poor quality of the water, preventing water runoff from reaching natural water sources is critical. Growers are increasingly required to reduce and capture runoff water, re-use tailwater, and utilize other best management practices to minimize the effects of agriculture on water quality and water bodies in the areas where they farm (SLR Watershed Council 2000).

Soil Erosion: Soil erosion from crops planted on steep hillsides has generally been minimized because the type of crops grown in these areas are perennial in nature and the soil under tree crops is usually covered with leaf litter or a cover crop to prevent further soil erosion. However, due to the large scale of farming operations and roads associated with these operations soil erosion is expected to still occur within the basin. Erosion from agriculture uses can result in the loss of agricultural production, and degrade important aquatic habitat. Eroded soils can bury benthic (e.g., bottom dwelling) communities, cover spawning grounds, destabilize channel banks, and fill sensitive wetland areas. Furthermore, other pollutants are often bound to eroded soils. Under certain conditions, these pollutants may be remobilized into the water column causing problems for human health, wildlife, and aquatic resources. The state and regional boards have adopted narrative standards that prohibit the impairment of aquatic habitat from erosion.

Pesticide Use: The use of pesticides in the basin is closely scrutinized by the local Agricultural Commissioner's office. Growers in the region must be aware of the effects of pesticides on water quality, endangered species, air quality, and public perceptions within close proximity of these farms that utilize pesticides. The effects of pesticides on the aquatic community are discussed further in the Adverse Conditions, Water Quality section (pp.63-67).

Habitat Issues: Some of the farmland in the Basin provides excellent habitat for a variety of species which are protected in some capacity (SLR Watershed Council

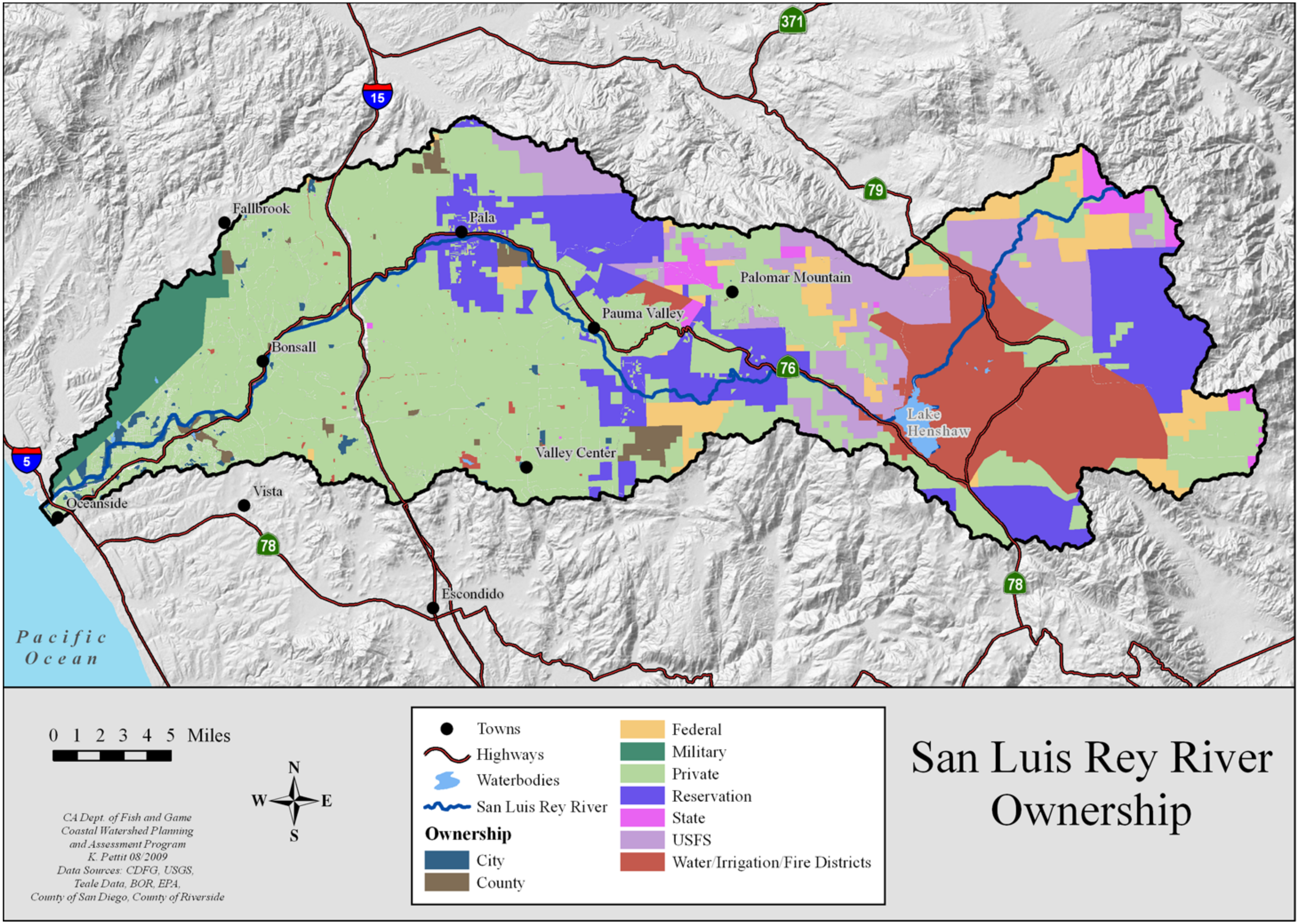


Figure 22. Generalized ownership of the SLR River Basin.

2000). Although not available for public use, agricultural lands are considered open space that would otherwise be most likely developed for housing or commercial tracts. Furthermore, San Diego County has the most registered organic growers than any other county in the nation. Research on organic farms, done over several decades, has revealed characteristics usually associated with sustainable farming, such as reduced soil erosion, lower fossil fuel consumption, less leaching of nitrate, greater carbon sequestration and little to no pesticide use (San Diego County 2007).

Conversion of Agricultural Land to Urban Development: Continuing an agricultural operation in areas of urban interface can be a difficult proposition. Agricultural operations are faced with many issues stemming from a lack of understanding of their practices. Concern over property values, health issues, traffic, and numerous other situations associated with urban encroachment contribute to growers selling agricultural property, which usually leads to further development and more housing in the area.

Forest Management

Timber harvesting does not occur within the SLR River Basin. Due to the relatively dry, warm climate the forests of the basin are limited to the higher regions of the basin and consist primarily of oak and scrub oak vegetation. Most of the merchantable timber within the basin lies protected in Palomar Mountain State Park and surrounding areas. Some commercial timber harvesting occurred in the Cleveland National Forest during peak years in the 1960s and 1970s, but it was short lived. The small volumes produced within the forest was not sufficient to support viable sawmill operations as timber had to be trucked long distances to the nearest mill (Stephenson and Calcarone 1999).

For the past couple of decades, small timber programs in Southern California forests have been concerned with forest health issues (e.g., treatment of insect and disease centers, understory thinning, and fuels reduction), administering individual permits to accommodate local demand for fuelwood, and identifying and removing hazard trees (Stephens and Calcarone 1999).

Roads and Railroads

Roads near streams contribute chronic surface erosion, and failed road crossings or segments may trigger landslides that contribute enormous amounts of sediment to streams (NMFS & Kier Associates 2008). Roads may also alter the flow regime within a watershed, increasing peak flows and decreasing summer base flows. Although there are no studies specific to southern California that document relationships between roads and degradation of steelhead streams, the widespread occurrence of erodible sandstone formations in the region make it likely that roads increase sediment supply (NMFS & Kier Associates 2008).

According to the Coastal Conservancy website, in 2001 there were 509.14 miles of near stream roads in the watershed. The vast majority of roads within the watershed are paved, maintained roads, located in the western portion of the basin (Figure 23). The central access route in the basin is California Highway 76. This heavily used road runs west - east paralleling the SLR River from near its mouth with the Pacific Ocean to Lake Henshaw. The river briefly veers away from the road in Pauma Valley only to reconnect near the La Jolla Indian Tribe reservation boundary.

The numerous roads present in the watershed result in a large number of stream crossing. Accordingly, there are 1,311 stream crossings in the watershed (http://www.scc.ca.gov/). Some of these stream crossings present fish passage problems and are in need of modification. In Oceanside, the Douglas Avenue Bridge (RM 6) contains a boulder rip-rap configuration to protect the bridge abutments but hinders fish passage during low to moderate flows. A similar boulder rip-rap configuration is located one mile upstream at College Avenue, but it is not as problematic as the extensive rip-rap at the Douglas Avenue. Further upstream, other road crossings have been loosely constructed across the river using dirt fill and small culverts that hinder fish passage. In the Southern Subbasin, an Arizona road crossing, located on Cole Grade Road, within the SLR River streambed, would prevent fish passage during low and even moderate flows. Furthermore, on the Pauma Valley Country Club, there are also two road crossings on the course that would create low flow barriers.

Roads also pose fish passage problems with a few of the tributaries that possess or may possess potential steelhead habitat. Most notable of these is the Highway 76 Bridge spanning Pauma Creek. This bridge contains box culverts that are impassible during all stream flow conditions to any potential steelhead migrating up Pauma Creek to spawn. After significant winter and spring storms, resident, naturally reproducing rainbow trout are occasionally carried downstream from the canyon and are unable to migrate downstream of the bridge to the SLR River (see Fish Habitat Relationship section, pp.51-53, for further discussion of relationship between 'anadromous', sea to freshwater life history, and resident rainbow trout). These trout become stranded and are easily susceptible to predation and the stresses associated with low flow conditions. See Barriers (pp. 68-70) for a more detailed discussion of fish passage problems throughout the watershed.

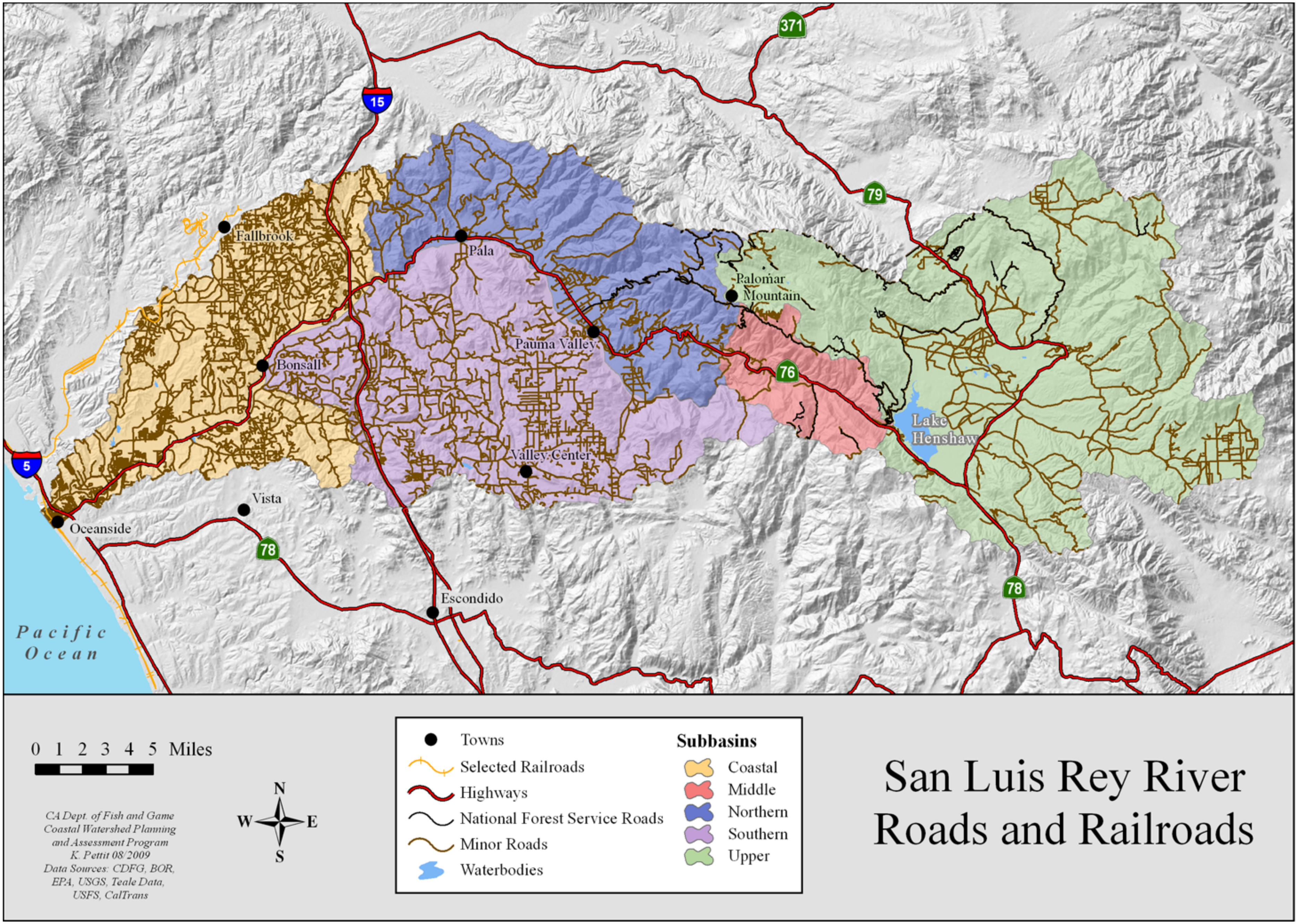


Figure 23. Roads and railroads in the SLR River Basin.

In addition to fish passage issues and a major source of sediment in watersheds, roads potentially degrade water quality from point and non-point pollution sources. Sources of contamination from Highway 76 and other roads that parallel the river and its tributaries may include: pavement wear and asphalt surface leachate, tire wear (e.g., lead oxide filler material, lubricating oil and grease, bearing wear), spills, leaks or blow-by of motor lubricants, antifreeze and hydraulic fluids and roadside application of fungicides and insecticides.

On a positive note, in the fall of 2008, the City of Oceanside completed the Pacific Street reconfiguration and bridge replacement project. Prior to completion of this project Pacific Street crossed the mouth of SLR River, utilizing two large corrugated metal, cylindrical culverts that allowed the continuous exchange of freshwater with ocean water. The culverts and or road would occasionally be displaced by heavy flows of the SLR River. The project removed the culverts, reconfigured the road, and built a bridge to cross the river approximately 800 feet upstream. While preventing the displacement of the road, the reconfiguration/bridge replacement should also improve fish passage and could enhance overall estuary conditions.

There is only one railroad in the basin and it crosses the estuary, just upstream of the new Pacific Street Bridge, in a north-south direction. This railroad is used by passenger trains as well as freight trains.

Mining

Although there is no on-going extractive mining occurring in the watershed, gravel mining operations have been important industry in the Basin. The SLR River has provided the San Diego region with a major source of sand, gravel, and aggregate. The river contains particularly valuable deposits of quality sand that require little processing because the river's fluvial processes have ground and sorted the material (Micheli 1994). This sand has been used by the construction industry for a variety of concrete and asphalt applications. Sand mining has long caused major disagreements in the watershed and was a dominant factor in the initiation of a general resource plan for this area. Beginning with the H.G. Felton Materials Company, which in 1969 was issued the first Major Use Permit for a sand mining operation on the SLR River, multiple sand mining operations have been active on the river, from just east of Bonsall to Pala.

As development in San Diego County increased, including the housing construction boom during the 1980s, sand and gravel mining became the most economically important industry in the watershed (SLR Watershed Council 2000). At one time, there were 13 active mining operations. Of more recent significance was the termination of the Felton Mine site operated by Hansen Aggregates. This was an in-stream mine that encompassed 225 acres and mined an average of 600,000 tons of sand per year during the late 1990s and early 2000s. This sand accounted for about 20% of all the concrete use in San Diego County (Chester 2000). Their Major Use permit expired in 2005 and the site was dedicated as open space. The reclamation and mitigation that occurred is mostly in the form of several large ponds just east of Pala on the south side of Highway 76.

The proposed rock quarry at Rosemary Mountain, one-half mile east of Interstate 15, immediately adjacent to the river on State Highway 76, is a more recent development that has been the subject of lawsuits and considerable disagreement between the developer and the local residents. The 94-acre mine, of which 38-acres will be mined, is set to begin operations in 2009/2010 and is projected to sell one million tons of sand and gravel a year for 20 years (Pfingsten 2008). The mine will increase vehicle traffic on Highway 76 with a projected 452 daily truck trips added to the already busy highway (Pfingsten 2008). To compensate for the additional traffic the mining company, Granite Construction, will be widening and straightening 1.3 miles of the highway. While the quarry will provide the area with what some state officials say are needed aggregate supplies within areas of nearby development (Jones 2007), the quarry is located adjacent to the SLR River and there is a concern of its operations affecting the air quality, sediment input and water quality of the river.

The current condition of the SLR River in the Coastal and Southern subbasins demonstrates that the previous traditional approaches to regulating in-stream mining have failed to adequately protect river resources over the long term. The extraction of sand and aggregates has contributed to a range of significant environmental impacts. The cumulative effect of the mining operations has been to lower the overall bed elevation of the river (Micheli 1994). The process of channel degradation was accelerated by upstream and downstream erosion due to excavation of deep pits, some 80 feet in depth, in the active river channel. The mining contributed to a shift in channel morphology from a shallow and braided channel, sinuating back and forth across the broader portions of the floodplain as it deposits sand and creates scrub-shrub habitat, to a channel that is now in some places deeply incised with steep erodible walls (Micheli 1994). This channel degradation and streambed erosion has compromised bridge supports and exposed buried water and natural gas lines. Biologically, the degraded streambed causes: lowering of groundwater levels, loss of riparian vegetation due to erosion and die-offs from the lack of water, a minimal low-flow channel that implicates a loss of deep holding pools for adult and juvenile migration, loss of cover, and complex habitat for juvenile steelhead.

In addition to effecting riverine ecosystems, sand mining also contributes to a reduced supply of sand transported through the mouth to replenish the beaches of Oceanside (Kondolf 1993). Combining the effects of the Henshaw Dam impounding sediment, the mining produced an even larger sediment deficit. According to Kondolf (1997), the five gravel mines that were in operation in the 1990s, within 8 km of the Highway 395 Bridge, extracted a permitted volume of approximately 300,000 m^3/yr. This was about 50 times greater than the estimated post-dam bedload sediment yield, further exacerbating the coastal sediment deficit.

The SLR River is one of several key locations in the county that can provide the sand and gravel resource. However, sand mining has been shown to have a costly effect through infrastructure degradation, loss of beach sand and environmental resources on the watershed. If future sand mining operations were to occur in the basin some of these impacts could be minimized by stricter monitoring and compliance of permit requirements by governmental enforcement agencies and the mining operations themselves. Just as one understands the value of maintaining open space–habitat preservation, wildlife protection, water quality, scenic beauty, and recreation–maintaining sand transport to the coast must become an equally important environmental goal. The long-term costs of artificial beach replenishment should be considered in the environmental costs of development within coastal watersheds (http://coastalchange.ucsd.edu/st2challenges/sources.html).

Water Use: Dams, Diversions, and Water Rights

Stream flow can be a limiting factor for steelhead, affecting passage and the quantity and quality of spawning, rearing, and refugia areas. Stream flow also has a direct effect on other factors such as water temperature, dissolved oxygen, and sediment and chemical transport. Withdrawal of water directly from streams or by means of fluvial connected groundwater, such as for agricultural or domestic use, can result in a decrease in both peak and low flows as well as in the general pattern of flows (timing and duration).

The hydrology in the middle and upper SLR River is controlled by the Henshaw Dam and the Escondido Canal diversion dam. Henshaw Dam separates the Upper Subbasin from the Middle Subbasin, approximately 50 miles from the mouth of the river. Henshaw Dam, completed in 1922, was built with the intention of diverting river water for irrigation. The reservoir, which is owned by the Vista Irrigation District (VID), has 51,744 acre-feet of storage capacity; however, its recent water storage has rarely approached its potential capacity, fluctuating from a high of 37,900 acre-feet in 2005 to a low of approximately 2,500 acre-feet in June of 2007 (VID 2008). In addition to capturing stream flows into Lake Henshaw, the VID also utilizes 24 wells within its holdings surrounding the lake to supplement overall water supply from the lake.

The Escondido Canal diversion dam is located approximately ten miles below the Henshaw Dam (RM 40) and roughly divides the Middle Subbasin from the Southern Subbasin. The canal was constructed in 1895 for the purposes of supplying water for agricultural and municipal uses to the Vista area and what is known today as the City of Escondido areas. The City of Escondido and VID (Local Entities) historically have diverted approximately 90% of the flow of the SLR River. The remaining 10% of diverted flows is delivered to the Rincon Indian Tribe (Escondido Mutual Water Company vs. Tribes 1984 and http://www.slriwa. org/). Depending on availability of stored water, a variable amount of water is delivered yearly to the La Jolla Indian Campground for recreational uses.

This water diversion is made possible by a concrete dam approximately 150 feet long and 12 feet high across the main channel. The canal diverts up to 70 cfs, an annual average of 14,000 acre-feet, of water out of the river into a man-made canal that transports the water to Lake Wohlford. Exotic fish are sometimes transported in the diversion canal and dropped into Lake Wohlford. The lake acts as an intermediate storage and distribution reservoir located in the Escondido Creek drainage basin of the Carlsbad Watershed (PBSJ 2003). This canal diverts practically all flows from the river, typically leaving the river nearly dry below the diversion. Natural flow accounts for only 2,705 acre-feet of the average annual diversion, the remainder consisting of water stored in Lake Henshaw and water pumped from the ground-water (aquifer) basin above Lake Henshaw. Since the 1950s this aquifer has been used by the Local Entities to supplement surface supplies (J. Membrino, personal communication 2009).

Most local tribes pump water from wells, but tribal leaders have stated those sources are drying up and need to be replenished (Sifuentes 2008). In the Southern Subbasin, for example, in some areas the water table level has dropped as much as 85 feet, forcing the abandonment of some wells, having to drill new wells, and giving rise to increased pumping costs (http://www.yuimamwd.com/history.php).

The lack of bypass flows in the SLR River does not allow these wells to be recharged as well as providing inadequate amounts of moisture to maintain riparian communities along extensive reaches of the SLR River below the Escondido Canal diversion. Competing claims to the waters of the upper and middle SLR River have been highly contentious.

In 1969, the Indian Tribes of Pauma, Pala, Rincon, La Jolla, and San Pasqual (the Bands) sued the Local Entities charging that the U.S. law protecting Indian reservation water rights was violated and the Secretary of Interior exceeded his authority in reaching water agreements on behalf of the Indian Bands. On-going litigation finally resulted in the 1988 San Luis Rey Indian Water Rights Settlement Act (the Act), which recognized that the Federal Government had in effect awarded the right to the SLR River water to the Indian bands when their reservations were created and to the Local Entities through various contracts and permits. Furthermore, it recognized "The inadequacy of the San Luis Rey River to supply the needs of both the Bands and the local entities…" and authorized and directed the Secretary of the Interior to "provide a supplemental water supply for the benefit of the Bands and the Local Entities." (J. Membrino, personal communication 2009). In addition, the Act appropriated $30 million to the San Luis Rey Tribal Development Fund.

Amended in 2000, the Act identified a specific supplemental water supply for the San Luis Rey settlement. The Act required the federal government to annually and permanently provide 16,000 acre-feet of Colorado River water conserved by the lining of the All-American Canal and its Coachella Branch for the benefit of the Bands and Local Entities (J. Membrino, personal communication 2009). An acre-foot is 326,000 gallons, or enough water for two four-person households for a year (http://www.sdcwa.org/about/faqs.phtml). Most of this supplemental water is now available as the Coachella Canal Lining Project was completed in 2006 and the All-American Canal Lining Project is nearing completion.

In order for the Act to become effective, the U.S., acting through the Secretary of the Interior, the five Bands and the Local Entities must enter into a Settlement Agreement that provides for the resolution of claims, controversies and issues involved in the federal district court litigation and the administrative proceedings before the Federal Energy Regulatory Commission (FERC) (J. Membrino, personal communication 2009). The FERC regulates hydro-power facilities and requires a multi-disciplinary analysis of the project prior to approval of the relicensing. In September of 2008, a draft of the Settlement Agreement was accepted in principle by the five Bands and the Local Entities. The draft Settlement Agreement provides terms and conditions for the use of the SLR River waters above the diversion (Middle and Upper subbasins) and of the supplemental Colorado River water for the mutual benefit of the five Bands and the Local Entities. Section 109 of the Act requires that any FERC license "shall be subject to all of the terms, conditions, and provisions of the settlement agreement…. and …. shall not in any way interfere with, impair or affect the ability of the Bands, the Local Entities, and the United States to implement, perform, and comply fully with all of the terms, conditions , and provisions of the settlement agreement" (J. Membrino, personal communication 2009).

Potential relicensing issues, subject to the limitations and authority of section 109, are as follows:

- Project effect on water quality in the SLR River;
- Project effect on native fish populations in the SLR River;
- Project effect on special-status plant and wildlife species within FERC project boundary;
- The result of the project on threatened and endangered species;
- Project effect on tribal and cultural resources;
- The effect of the project on local economy.

In addition to Lake Henshaw, three small reservoirs, Guajome Lake, Hubbert Lake, and Whelan Lake are located within the watershed. These reservoirs are located in small drainage basins and consequently only have minor effects on the hydrology and the fisheries of the river.

Impacts to SLR River water flows are not limited to the Henshaw Dam and the Escondido Canal diversion in the Upper and Southern subbasins, respectively. Several shallow alluvial aquifers exist in the SLR River Basin, which contribute groundwater used throughout the watershed for agricultural, industrial, and municipal supplies (Figure 6). This groundwater is extracted through the numerous wells located throughout the watershed. For example, more than 100 wells are present in a five mile stretch between the Old Bonsall Bridge and I-15 (Helm 2008 Draft) and over 600 wells exist along the river channel in the Middle Subbasin (Hazel et al. 1975). These wells and other wells located in the Coastal, Southern and Northern subbasins are largely unregulated. As the uncertainty and costs of obtaining outside water supplies rise, demands will increase on utilizing local water resources.

Figure 24. Photo of Escondido Canal dam diversion in Southern Subbasin.

The San Diego County Water Authority (Water Authority), together with its member agencies, is developing a diversified water supply portfolio to lessen the region's dependence on imported water. In 2008, 18% of the region's water was supplied from local sources, including water conservation (8%), local surface water (5%, dry conditions), recycled water (3%), and groundwater (2%). By 2030, this figure is expected to increase to 40% by increasing each of the aforementioned resources and the addition of seawater desalination, which will comprise a quarter of this 40% figure (L. Purcell, Water Authority, personal communication 2009).

The Oceanside City Council has mandated that 50% of the City's water supply be provided through local supply (L. Thibodaux, personal communication 2009). As a means of meeting this mandate and utilizing local water supplies to offset the expected decrease in water from regional and state water sources, the Water Authority and the City of Oceanside agreed to drill two new wells near the SLR River in Oceanside. Currently the City receives about 7% of its water needs from wells in the basin. Once these new wells are up and running as well as other wells awaiting proper filtration installation, this figure will increase to about 20% of the city's needs (Burge 2007). This increase equates to pumping 2.4 million gallons per day to 8.4 million gallons per day once the proper carbon filters are installed and public health permits are granted (City of Oceanside 2007). The new wells are located approximately 4 tenths of a mile south of the river and approximately 3 miles from the river's mouth at the Pacific Ocean. These wells are situated where the river historically flowed (G. Pennell, City of Oceanside, personal communication 2009). These wells would be accessing a water supply that was established through percolation of the old riverbed. Due to the significant distance from the current riverbed, and the predicted water draw from the old location of the riverbed, it seems unlikely that these new wells will affect surface water flows of SLR River.

The City of Oceanside also operates two wells, located several miles upstream that are in closer proximity to the river. These wells have been in full production during 2007 to the present (2009) and have had no negative effects on the overall groundwater table (G. Pennell, personal communication 2009). The City of Oceanside monitors the production wells weekly and the monitoring wells monthly using a sounding device that measures the distance in feet from the surface to the top of the water in the well. This ongoing monitoring will be essential in determining alterations in water quantity in the lower portion of the SLR River and minimize the potential to impact the surrounding wetlands and riparian areas as well as prevent possible saltwater intrusion from occurring upstream of the natural tidal area.

Waste Water Treatment

The Rainbow Municipal Water District's (Rainbow MWD), which serves the unincorporated communities of Rainbow, Bonsall, and portions of Fallbrook, sewage treatment system has nearly reached capacity, leaving few options for new connections (Rainbow MWD 2006b). The Rainbow MWD has identified three possible solutions to the sewer capacity limits: (1) do not allow future projects/development rights to the sewer system, (2) construct a wastewater treatment plant for treatment of sewage, or (3) upgrade the existing Oceanside Wastewater Treatment Plant to allow for more treatment capacity (this plant currently treats Rainbow

MWD's wastewater) (Rainbow MWD 2006a). Proposals two and three would be very costly (estimated costs for a small plant and pipelines are between 20 and 50 million dollars), politically unfavorable, pose environmental concerns, and spatially limited.

The San Luis Rey Wastewater Treatment Plant, at 3950 North River Road, provides wastewater treatment and disposal for 80% of the City of Oceanside's water, essentially covering all areas east of Interstate 5. The La Salina Wastewater Treatment Plant serves all areas west of Interstate 5, downtown, and along the coast. The City of Oceanside once discharged treated wastewater into the river from the period of 1958 to 1974. After 1974, the treatment plant treated all water before its offshore discharge into the ocean (1.6 miles offshore), near Alta Loma Creek in Oceanside. As far as the City of Oceanside is aware, no treated wastewater is discharged to the river (A. Witheridge, City of Oceanside, personal communication 2009).

Fish Habitat Relationship

Historic Accounts of Steelhead Runs

The first written evidence of native trout in San Diego County comes from a note in an article by Dr. Cooper from a scientific collection expedition he conducted in 1862 in the Cuyamaca Mountains. He reported that trout and stickleback were found 15 miles north of San Felipe at Warner's Pass at the head of the San Luis Rey River (Cooper 1974). This was well before any introduction of hatchery raised fish, which did not occur until 1893 (see Stockings and Origins of Trout pp. 55-56). Additional historical reports including, "A List of Fishes of San Diego CA" (Smith 1880) and "The Fishes of San Diego California" (Eigenmann 1892), also noted native rainbow trout being "abundant in the streams rising in Smith Mountain (Mount Palomar) and draining into the SLR River". These streams include Pala and Pauma Creeks and potentially additional streams located in the Northern Subbasin.

Evidence of steelhead runs are directly related to historical fishing activities that occurred along the SLR River and some of its tributaries. Steelhead runs were reportedly sufficient enough to provide a major food supply for the local Native American tribes (Luiseño Indians) as late as the 1890s and early 1900s (USFWS 1998). San Diego anthropologist, Dr. Florence Shipek, has testified before the Indian Claims Commission and the San Diego Regional Water Quality Control Board (SDRWQCB) that the SLR River did support steelhead runs prior to the construction of Henshaw Dam (1922) and that Native Americans caught steelhead by various means including nets, weirs, and hook and line (USFWS 1998). USFWS (1998) also cited a report compiled by CDFG, the San Diego Coast Regional Commission, and Charles Swartz of the University of California Sea Grant Program which stated, "…anadromous fish runs were observed in San Diego County as late as 1945-50…. In San Diego County, steelhead occurred in De Luz Creek (tributary to Santa Margarita River) in about 1950-52, and reports of steelhead in the lower San Luis Rey River as late as 1940-41." Moreover, an account from Dr. Hubbs' (1946) early fishery investigations, reported local anglers catching fish, thought to be steelhead trout in San Luis Rey River prior to the mid-1940s. In 1947, Dr. Hubbs, along with Dr. Brody and Carl Johnson, found steelhead in the SLR River up to the Mission, approximately 6.4km (4 miles) upstream from the mouth (USFWS 1998).

Anecdotal accounts from a Pauma Indian Tribal elder spoke of annual runs and ceremonies associated with large fish, presumably steelhead, on SLR River (USFWS 1998). In a 1996 interview of Mauricio "Sonny" Magante, former leader of the Pauma Band, conducted by Ruth Held of the Sand Diego Historical Society's oral history program, Mr. Magante recalled that his ancestors told him salmon (presumably steelhead) used to run up the San Luis Rey River (SDHS in USFWS 1998). Leo Calac, a Rincon elder discussing the historical conditions of the SLR River stated: "There was enough water every year for those who wanted to farm, the riverbed was full of sycamores and willows... The old-timers say in Pauma Valley that steelhead used to come up from Oceanside" (Soto 2008).

However, with expanding human settlement, development of the basin, and a prolonged dry period from the mid-1940s to the mid-1970s, native runs of steelhead became nearly extirpated from the basin by the late 1940s. The SLR River is currently closed to all fishing below Lake Henshaw Dam.

Fishery Resources

The SLR Basin currently maintains self-reproducing native rainbow trout populations in Pauma Creek and the West Fork SLR River. The basin has the potential to support the Southern California Coast Steelhead DPS, but it would require watershed improvement measures to provide sufficient habitat for all life history stages of this imperiled species. Changes that occurred within the watershed since European contact have drastically altered the historical conditions of the SLR River and its tributaries, thus adversely affected the lifecycle requirements for steelhead production. Currently, potential habitat for all phases of their life cycle is limited to portions of the mainstem as well as tributaries in the Northern and Upper subbasins.

Comprehensive descriptions of this species' habitat needs are described in the Program Introduction & Overview with further information located in the Adverse Conditions Affecting Steelhead Recovery section of the Basin Profile pp.61-71. Species descriptions of steelhead and other native fish that were historically present within the basin are described below.

Southern California Coast Steelhead, *Oncorhynchus mykiss*

The Southern California Coast Steelhead DPS is a unique anadromous form of rainbow trout (*O. mykiss*) that include all populations south of Point Conception, historically into Baja California. This population of steelhead is one of the most distinct steelhead in terms of both genetics and life history (Moyle 2003). Nielsen (1994) suggests southern steelhead represent the earliest form of coastal rainbow and steelhead populations, which radiated from their southern range northwards. They are, however, the most jeopardized of all of California's steelhead population. Of the 92 streams in the six south coastal counties in which it historically spawned, steelhead may be absent from as many as 39 (Moyle 2003). The present distribution in southern California has been reduced to perhaps 1% of the stream miles they formerly inhabited (Gerstung 1989 in Moyle et al. 1995). Due to their drastic reduction in numbers, the National Marine Fisheries Service (NMFS) in 1997 federally listed the Southern California Steelhead Evolutionary Significant Unit (ESU) as Endangered from Point Conception, Santa Maria River in Santa Barbara County, south to Malibu Creek. Subsequent to this original listing, two small populations of steelhead were documented south of Malibu Creek (Topanga and San Mateo Creek) and included in the southern range extension, thus extending the range to include all steelhead found in drainages south to the U.S.-Mexican border (NMFS 2007). In 2006 NMFS determined that the ESU designation of steelhead populations was not appropriate and reclassified the steelhead populations within the State as Distinct Population Segments (DPS). These fish persist in streams that have warm, dry lower reaches on the coastal plain, but typically spawn and rear in habitats near or in the headwaters. This usually presents substantial migration passage problems as indicative of the SLR River basin.

In southern California, adult steelhead enter freshwater streams after winter storms breach sand bars allowing open access to the river, which typically occurs December through April. Although in the case of the SLR River, atypical conditions existed in the lagoon for decades as the Pacific Street Bridge culverts provided year-round tidal exchange and thus access to the river. The street and its culverts were removed in Oct., 2008.

In Malibu Creek, currently the southernmost self-sustaining steelhead population, peak spawning activity occurs mid-February to mid-March in the upper mainstem or tributaries having suitable spawning gravels and cool, well oxygenated water (CDFG 1996). Redd location commonly occurs at the top of a riffle or downstream edge of a pool where current velocity increases (Barnhart 1990). Adult steelhead trout prefer gravel ranging in size from 0.5-10 cm for spawning, but will also use mixed sand-gravel or mixed cobble-gravel beds if they are available (Reiser and Bjorn 1979, Bovee 1978). After spawning, the adults may either die, or if conditions permit, return to the ocean to possibly spawn again the following year. Depending on water temperatures in the gravels, hatching typically occurs in thirty days (Lang et al. 1998). Alevins then emerge from the gravels in four to six weeks and move into shallow, protected areas associated with the stream margins. As the fish increase in size, these "fry" soon move to other areas of the stream to establish and defend feeding locations (Shapavlov and Taft 1954).

The offspring (fry) can become resident in freshwater coastal streams or anadromous (migratory) through physiological and morphological changes (smolting), allowing juveniles to migrate from freshwater to the ocean to mature to spawn. A single stream can have both resident and migratory forms and often with some interbreeding between these forms (Swift 2003). In the juvenile stage the two forms are currently considered to be indistinguishable (Boughton et al. 2005). Rainbow trout that do not become steelhead share many of the same ecological requirements with their anadromous relatives and appear to play a critical role in the sustainability of the anadromous steelhead population and evolutionary potential of the species by contributing to the emigration smolt population and recolonizing temporarily extirpated anadromous runs of steelhead (Boughton et al. 2006). The anadromous form can vary in the amount of time spent in freshwater, but usually spend one to two years rearing in a freshwater stream before returning to the ocean. A larger smolt has a higher chance of surviving in the ocean and returning to reproduce (USFWS 1998; Bond 2006). In the ocean, steelhead feed on a variety of organisms, especially juvenile greenling, squids, copepods, and amphipods (Lang et al. 1998). After spending two to four years in the marine environment, adult fish may return to the stream where they originated, or stray to other streams and may re-colonize streams that have been extirpated for some years due to prolonged drought, devastating fires, or other adverse effects (Swift 2003).

During CDFGs 2007 habitat assessment surveys (May 2nd & 8th), one adult steelhead (Figure 25) was observed in the SLR River, between Douglas Avenue and College

Avenue (RM 7). While the winter and spring of 2007 was considered a low water year, this healthy-looking, adult steelhead (estimated at 20-24 inches in length) managed to enter the SLR River from the Pacific Ocean and swam upstream approximately seven miles. At the time of observation, the river's low flow conditions would have prevented it from continuing further upstream over the boulder rip-rap configuration located below the College Avenue Bridge and or moving downstream through the boulder rip-rap configuration at the Douglas Avenue Bridge. A United States Geological Survey (USGS) technician reported to have observed a second adult steelhead (the technician observed two large trout-like fish) within the same time frame and location on the river as the original CDFG sighting. The second steelhead could not be verified by a CDFG biologist through a follow up survey; however, this section of the river as with most of the river in the Coastal Subbasin has multiple channels and contains abundant cover making detection of steelhead difficult.

Annual field surveys have not been conducted in the SLR River or any of its tributaries, so it is not surprising that additional confirmed recent sightings of steelhead in the watershed have been limited. A consultant reported observing an adult steelhead in the lower SLR River in 1997, but could not provide any additional information on this sighting (G. Wilkins personal communication 2008). Consultant biologists observed two large trout (15-16 inches in length) in Gomez Creek during a September 2005 survey (Dudek & Associates 2007) in the lower watershed. No scale samples were taken at the time of observation; therefore, it is impossible to conclude their origin. However, based on reports of an upstream landowner stocking catchable rainbow trout for recreational fishing in Gomez Creek, these were most likely hatchery rainbow trout. Significant rain events that occurred in the winter of 2004-2005 potentially washed these trout downstream, where they were later identified in the fall of 2005.

Figure 25. Adult Southern California Coast Steelhead. Observed in the lower SLR River near Oceanside (RM 7), May 2007.

Arroyo Chub, *Gila orcutti*

Arroyo Chub (*Gila orcutti*) are a small, native minnow that is classified by the CDFG as a Species of Special Concern. Typical lengths of these fish are between 70-80mm, but can reach lengths up to 120mm. Arroyo chub are found in slow-moving or backwater sections of warm to cool (24-10°C) streams with mud or sand substrates (Moyle et al. 1995). Depths are typically greater than 40cm. Laboratory studies indicate that the arroyo chub is physiologically adapted to survive hypoxic conditions and widespread temperature fluctuations common in south coastal streams (Moyle et al. 1995). They are omnivorous, feeding mostly on algae in warm water streams, but will also consume insects and small crustaceans. Chubs normally spawn from late March to June by attaching their eggs to vegetation in slow to moderate stream flows. While spawning is absent in the summer, occasional reproduction may occur again in the fall (Tres 1992).

According to a CDFG report (1972) these fish were "abundant" in the SLR River (The context of the report seemed to indicate the chubs were present in tributaries above Lake Henshaw as well as downstream of the dam.). A September 2007 CDFG electro-fishing survey performed at two locations (RM 45, which is 1/2 mile below Cleveland Forest Service boundary and RM 46) did not yield any arroyo chubs or any other native fish, and it seems unlikely that they occur in this area due to the high density of exotic game fish. They may,

Table 11. Fishery resources of the SLR River Basin.

Common Name	Scientific Name
Anadromous	
Steelhead Trout	Oncorhynchus mykiss
Freshwater	
Black Bullhead*	Ameiurus melas
Brown Bullhead*	Ameiurus nebulosus
Common Carp*	Cyprinus carpio
Western Mosquito Fish*	Gambusia affinis
Resident Threespine Stickleback	Gasterosteus aculeatus microcephalus
Arroyo Chub	Gila orcuttii
Channel Catfish*	Ictalurus punctatus
Bluegill*	Lepomis macrochirus
Green Sunfish*	Lepomis cyanellus
Largemouth Bass*	Micropterus salmoides
Rainbow Trout	Oncorhynchus mykiss
Black Crappie*	Pomoxis nigromaculatus
Brown Trout*	Salmo trutta
Marine or Estuarine Dependent	
Yellowfin Goby*	Acanthagobius flavimanus
Deepbody Anchovy	Anchoa compressa
Topsmelt	Atherinops affinis
Arrow Goby	Clevelandia ios
California Killfish	Fundulus parvipinnis
Longjaw Mudsucker	Gillicthys mirabilus
Pacific Staghorn Sculpin	Leptocottus armatus
Cheekspot Goby	Llypnus gilberti
Striped Mullet	Mugil cephalus
Golden Shiner*	Notemigonus crysoleucas
California Halibut	Paralichthys californicus
Spotted Turbot	Pleuronichthys ritteri
Bay Pipefish	Sygnathus leptorhynchus
Yellowfin Croaker	Umbrina roncador
Amphibians	
Garden Slender Salamander	Batrachoseps major
Western Toad	Bufo boreas
Arroyo Toad	Bufo microscaphus californicus
Large-blotched Salamander	Ensatina eschscholtzii klauberi
California Tree Frog	Hyla cadaverina
Pacific Tree Frog	Pseudacris regilla
Bullfrog*	Rana castesbeiana
Western Spadefoot Toad	Spea hammondi

Data from CDFG 2007 & 1978, MBC Applied Environmental Sciences 2003 & 2000, SLR Watershed Council 2000, Stephenson and Calcarone 1999, and USFWS 1998.
* Denotes non-native species

however, exist in the lower to middle portion of the Middle Subbasin, where the habitat is more suitable and less game fish are present. They persist in the Upper Subbasin in the West Fork and North Fork of the SLR River, and Agua Caliente Creek (M. Bond and Bradley 2006). In addition, there was an anecdotal report of chub being found in Moosa Canyon Creek in the Coastal Subbasin within the recent past.

Resident Threespine Stickleback, G*asterosteus aculeatus microcephalus*

Resident, also known as partially armored threespine stickleback (*Gasterosteus aculeatus microcephalus*), are found in streams from the Oregon border south to Baja California. This species of stickleback are small (usually 3-5cm total length), laterally compressed fish with 3 sharp spines precluding a soft dorsal fin. They prefer quiet-water, living in shallow, weedy pools and backwaters or among emergent plants at stream edges over bottoms of gravel, sand and mud (Moyle 2002). Resident stickleback requires cool, clear water for feeding and growth of aquatic plants, where they build nests. They have broad salinity tolerances as these freshwater populations can be readily reared in saltwater (Moyle 2002). Most sticklebacks can complete their lifecycle in one year.

Even with their bony plates and spines, stickleback are frequently important prey of salmonids and birds (Moyle

2002). Cooper (1874) first noted the presence of this species of stickleback in the Upper Subbasin in the headwaters of the SLR River in 1862. They most likely were present in numerous streams in the basin. It is unknown if they still inhabit this system, for stickleback species have disappeared from many streams or stream reaches in southern California.

Pacific Lamprey, *Lampetra tridentata*

Pacific lamprey (*Lampetra tridentate*) belong to a primitive group of fishes that are eel-like in form but lack the jaws and paired fins associated with true eel species. They have a round sucker-like mouth, no scales, and gill openings. Historically, pacific lamprey were thought to be distributed wherever salmon and steelhead occurred, in Pacific Coast streams from Japan, throughout Alaska, southward to the Rio Santa Domingo in Baja, California (Moyle 2002). However, recent data indicate that this species distribution has been greatly reduced or eliminated from most drainages. Malibu Creek, Los Angeles County, seems to be the southernmost point of regular occurrence in California. In 1998, a single ammocoete (larvae) was taken from the SLR River at Foussat Road (RM 4), but there is no further evidence of occurrence in this area (MBC 2000; Moyle 2002).

Most lamprey species have a similar life cycle: all begin life in freshwater, but some are anadromous (going from ocean to freshwater tributaries to spawn). In the beginning of their life cycle, the lamprey eggs hatch and the young ammocoetes (larvae) drift downstream to areas of low velocity and silt or sand substrate. They remain burrowed in the stream bottom, living as filter feeders for 2 to 7 years, filter-feeding on algae and detritus (Kostow 2002; Moyle 2002). Metamorphosis to macropthalmia (juvenile phase) occurs gradually over several months as developmental changes occur, including the appearance of eyes and teeth, and they leave the substrate to enter the water column. Transformation from ammocoetes to macropthalmia typically begins in the summer and is complete by winter. They move downstream as they migrate to the ocean between late fall and spring where they mature into adults (http://www.fws.gov/oregonfwo/Species/Data/PacificLamprey/Documents/012808PL-FactSheet.pdf).

Stocking and Origins of Trout (O. mykiss)

As discussed in the Historical Accounts of Steelhead Run section (p. 51), historical reports and studies, such as "Animal life of the Cuyamaca Mountains" (Cooper 1874), "A list of fishes of San Diego Ca.," (Smith 1880), and "The fishes of San Diego County" (Eigenmann 1892) reported of native trout (self-reproducing) in the SLR River Basin prior to any introduction of hatchery raised fish. Recent genetic analysis from the rainbow trout of Pauma Creek and West Fork SLR River indicate that the current populations are of native coastal origin. Nielson's (1994) genetic sampling of Pauma Creek rainbow trout stated the fish possessed unique genetic markers common only to southern California trout. Similarly, NOAA (1999) in their genetic variability study from rainbow trout of Pauma Creek affirmed: "the high level of genetic variability among these samples is consistent with the pattern we noted for southern California *O. mykiss* populations in the west coast status review…..it seems more than likely that these fish are part of a native coastal *O. mykiss* lineage". Supporting evidence of a historical trout population in the Upper Subbasin includes a 1979 chromosome analysis and electrophoretic analysis of proteins from trout taken from the West Fork SLR. In this analysis, the U.C. Davis geneticist, concluded, "it seems likely that the West Fork population is composed predominately of fish native to the region" (Thorgaard 1979). More recently, the NMFS final biological opinion (2008) concerning the operation of the Vern Freeman Diversion Dam on the Santa Clara River addressed the role of previous stockings on the current population and range of the southern Steelhead DPS. The report stated:

> *NMFS is not aware of any evidence indicating naturally spawning hatchery steelhead are contributing progeny to the endangered Southern California DPS of steelhead. While extensive and widespread stocking of steelhead has occurred in southern California streams historically (e.g., United Water Conservation District 2007b, c, d), hatchery steelhead are not currently planted in the DPS except upstream of long standing barriers to anadromy (Boughton et al. 2007b). Evidence indicates the historical plants from Fillmore Fish Hatchery and hatcheries from northern California have not contributed to the reproduction and perpetuation of native steelhead ancestry in southern California (Girman and Garza 2006, Boughton et al. 2007a, Boughton and Garza 2008, Garza undated).*

Previous research describes the probable introduction of hatchery rainbow trout (*O. mykiss*) into the SLR River Basin as early as 1893 by local settlers in cooperation with the state fish hatchery at Sisson, Ca. According to Greenwood (1996) who examined early issues of the San Diego Union newspaper, 45,000 rainbow trout fingerlings, varying in size from one half inch to an inch, were planted in the tributaries of the SLR River. In this paper, Greenwood states, "We know from an 1893-94 CA. Fish Commission Biennial report that 10,000 of these rainbow trout fingerlings were planted in Pauma Creek." Botteroff and Deinstadt (1978 Draft) also described trout plants by a local landowner, most likely a result of similar shipments from the same hatchery at Sisson, in Iron Springs Creek (tributary to Pauma Creek) and the West Fork SLR River.

In addition to the native *O. mykiss* that inhabited the SLR River and its tributaries, the introduced stock may have provided more abundant numbers and/or trout for areas of stream that lacked fish. For example, to accommodate a popular demand for recreational sport fishing opportunities within the region, CDFG initiated a yearly rainbow trout stocking program in the mid-1940s in the upper SLR River near the water release of Lake Henshaw and downstream in the La Jolla Indian Reservation. A 1947 Fish and Game Field Correspondence Memo indicated that over three thousand fishermen participated in the opening day of fishing season downstream of Henshaw Dam, including La Jolla Tribal lands (additional site of trout plants).

The trout plants ranged from highs of 46,500 in 1972 and 50,500 in 1970 to a low of 845 trout in 2003, the last year the river was stocked. From the 1950s to the late 1970s, average yearly plant totals were approximately 30,000 fish. From the late 1970s on, yearly stocking totals gradually decreased. The Mojave State Hatchery in Victorville, California (San Bernardino County) supplied the majority of these trout fingerlings. The number of trout planted was dependent upon the amount of water in the river and the overall water quality. Generally, in drought years fewer fish were planted than in years with moderate to high precipitation.

O. mykiss were stocked for a brief period in the 1990s in the SLR River within the Wilderness Gardens County Park boundaries by schools that were provided fish from the Mojave Hatchery. Water quality testing and sampling of aquatic insects indicated at the time of the releases that conditions were favorable for trout survival. Rainbow trout have also been stocked in various private and public ponds within the Basin, such as Doane Pond in Mount Palomar State Park. In recent years, since the fall of 2003, CDFG has not planted the river because of concerns of stocked rainbow trout competing and possibly predating on the federally listed arroyo (southwestern) toad, *Bufo* (*microscaphus) californicus.* Furthermore, CDFG has not stocked any of the tributaries in the basin with trout (Doane Pond continues to be stocked, but a fish screen was installed in January, 2008 to prevent genetic mixing between stocked trout and native trout found in Pauma and French creeks.)

Exotic, warm-water gamefish such as large-mouth bass, bluegill, brown and black bullhead, and channel catfish, were most-likely introduced into the basin in the 1940s and 1950s and continue to be stocked in Lake Henshaw and various public and private ponds as well (See Exotic Fish Species pp. 71-72).

Steelhead as Potential Predators of Endangered Species

Steelhead were listed as a threat to the tidewater goby (*Eucyclobius newberryi*) and southwestern arroyo toad (*Bufo microscaphus californicus*) by the USFWS in the Federal Register (USFWS 1998). Currently, arroyo toad is found in several locations in the watershed. Tidewater goby was not observed in several seining surveys in the early 2000s, but has the potential to reestablish a population in the estuary due to more recent sightings in the Santa Margarita River, immediately to the north of the SLR River. Under natural conditions predation would most likely be insignificant due to the fact that southern steelhead, tidewater goby, and arroyo toad coevolved. This coexistence was recently observed in Malibu Creek Lagoon, Santa Ynez Lagoon, Pescadero Creek, San Gregorio Creek, Piru Creek, and Sespe Creek (USFWS 1998).

Tidewater Goby

Although steelhead are a natural predator of tidewater goby and there have been documented cases of steelhead predation of gobies, other studies have shown, however, that steelhead in lagoons usually prefer a diet of invertebrates such as amphipods and shrimp (Smith 1990). Swift (1995) stated that both tidewater goby and steelhead should benefit from management efforts to recover the lagoon habitat. A far greater threat to these endangered species in the SLR River is the presence of exotic species of largemouth bass, crayfish, and bullfrogs.

Southwestern Arroyo Toad

Arroyo toads in San Diego County are found throughout steelhead habitat. In freshwater streams, steelhead primarily consume the immature aquatic stages of insects and secondarily on mature terrestrial insects (Needham 1938; Barnhart 1986). Based on USFWS (1998) literature review of seven diet studies conducted on rainbow trout, no tadpole or toads were observed within their stomach contents. Moreover, steelhead and/or rainbow trout were not listed as predators of any toad life stage in the CDFG report "Amphibians and reptile species of special concern," (Jennings and Hayes 1994). Similar to tidewater goby, exotic species are a greater threat to arroyo toad. Bass, bullhead species, green sunfish, and fathead minnow, crayfish, and bullfrog are known predators of arroyo toad (USFWS 1998).

Habitat Overview

In order to meet the needs of the life stages of steelhead, the SLR River Basin must provide appropriate diverse stream flow regimes, suitable water quality, sufficient gravel substrate for spawning and incubation of eggs, pools of sufficient depth to avoid lethal temperatures and predation, moderate to dense canopy, and adequate food supplies within the fish bearing reaches throughout the basin. Based on available literature, southern California steelhead seem to be very adaptable and able to survive in relatively modest habitat; nevertheless, quality instream and riparian habitat is important for steelhead as they spend a year or more rearing in streams.

As more settlers populated the SLR watershed, increased demands were placed on the available water resources, particularly the mainstem of the river. This eventually led to the construction of Escondido Canal diversion, Henshaw Dam, other water diversions, and groundwater pumping in the basin. The completion of these projects greatly altered the hydrologic conductivity and fluvial processes of the watershed. These and other human related activities contributed significant changes to the historic stream conditions resulting in reduction of steelhead habitat quantity and quality.

Identifying steelhead life history strategies at the basin and regional scales provides clues to the range of stream conditions and environmental requirements for the fish. Steelhead display a range of behavioral patterns that are a product of their habitat and their abundance trends. Some of the life history strategies may already be lost or rarely observed due to changes from historic stream conditions. By gaining insight into the relationships between the diverse life history strategies, fishery population dynamics and status, and by assessing stream habitat condition, efficient recommendations for recovery of depressed populations can be made.

Historic Conditions

Kondolf and Larson (1995) described the natural conditions of the SLR River prior to the completion of Henshaw Dam, as, "… probably perennial in most years; surface flow may have ceased in dry years, but the alluvial water table probably remained high, supporting riparian vegetation and maintaining deep pools as refugia for aquatic organisms." Accounts from local elder tribesmen support this description. Henry Rodriguez of the La Jolla Band, who was born on Palomar Mountain in 1919, recalls when the basin was lush. "I look back to what it was like when I was young, around eight or nine years old. It was full of vegetation, clean water, and wildlife. Everything looked green. There were dry years, we know that, but there was enough to give us a good life" (http://www.slriwa.org/history). He also stated, "there was running water in the San Luis Rey River, with large pools, even down at Rancho Corrido and the narrows–these pools held fish." Babe Ramos, a Native American of the Acjachemen Tribe (located in the present day city of San Juan Capistrano) stated the following: "We would pick up bunches of acorns to take to Pala for the ceremony–for the shaman or doctor. That was fun to go to Pala. Yes, the river was running there" (referring to the SLR River at Pala, CA.) (http://www.sandiegotrout.org/indians.html). Leo Calac, a Rincon elder whose grandfather grew crops stated: "There was enough water every year for those who wanted to farm, the riverbed was full of sycamores and willows…. The old-timers say in Pauma Valley that steelhead used to come up from Oceanside" (Soto 2008). Local tribal names were based on the presence of the water resources in the area. According to the Pauma Band's website, "Pauma" describes the area's principal feature, the San Luis Rey River, and the name "Pauma" translates as "place where there is water" (http://www.pauma-nsn.gov/index.php). Moreover, as discussed in previous sections, prior stream gauges indicated year-round surface flows in the river, which would have been conducive to upstream and downstream migration of adult and juvenile fish.

An historical channel analysis conducted by Kondolf and Larson (1995) examined the change in vegetation along the SLR River from 1928 to 1978. This study utilized historic stream flow data, maps, and channel cross-sections, aerial photographs, ground photos, narrative accounts, and vegetative evidence to derive its results. In a reach that was located along the Wilderness Gardens proper, upstream of Pala, the total area of woody riparian declined from 340 hectares (ha) to 151ha, and shrub declined from 240ha to 195ha. The cultivated area doubled and the area covered by herbaceous vegetation increased from 45ha to 327ha. Although the loss of riparian vegetation was mostly concentrated in one area as opposed to a wholesale alteration of the river character in this reach. The reach that was a part of the study stretched from near Live Oak Creek (just east of Bonsall) to Rice Canyon (1.6 miles upstream of the 395 Bridge). This reach underwent more striking changes in vegetation type from 1928 to 1960. The area of wooded vegetation was reduced from 145ha to 4 ha, shrub type declined from 82ha to 56ha, and the herbaceous vegetation decreased from 95ha to 67ha. All the while, cultivated land increased seven-fold from 31ha to 210ha. The study concluded that these changes reflected the deliberate transformation of active channel into farmland by channelizing the river. A case study report (Jones and Stokes Associates 1976) concerning Lake Henshaw and the SLR River described the historical conditions in the SLR River, primarily in the Middle Subbasin, prior to the completion of the Henshaw Dam, as having year-round instream flows that maintained a well defined channel.

Completion of the dam eliminated periodic flood flows and lead to the encroachment of vegetation into the stream channel. The report stated, "this encroachment along with the accumulation of sedimentation has resulted in a major reduction of fishery habitat".

There are approximately 42 named streams (including canyons containing streams) in the SLR River Basin. Various field surveys have been conducted by CDFG at irregular points in time from 1946 to 2006 in the SLR River and a few of the tributaries (Table 12). This survey record is probably representative of only a portion of the surveys conducted in the basin as previous survey reports may have been lost or no longer available. The majority of the earlier surveys were performed in the Middle Subbasin to document stream conditions prior to the planting of hatchery trout. The results of past stream surveys were not quantitative and cannot be used in comparative analyses with current habitat inventories; however, they generally provide a basic description of prior habitat conditions. The data from these stream surveys provide a snapshot of the conditions at the time of the survey. Summary tables appear in the subbasin sections of this report.

In general, surveys described a range of habitat conditions. The last CDFG survey which surveyed the SLR River in its entirety was in September, 1946. This survey entailed walking the streambed from near the river's mouth to Henshaw Dam (approximately 50 miles), recording general bed and bank and biological observations. The survey described a few large trout near Pala that were presumed to have "washed down from tributaries." The biologist designated the area around Pala (the town) and the section of stream downstream of Lake Henshaw to the Escondido Canal diversion as suitable for trout. Historic stream survey summaries are located in each of the pertinent subbasin sections.

Table 12. CDFG streams survey in the SLR River Basin, 1946-2006.

Survey Year	Subbasin	Stream Name
1946	CST, SOU, NRN, MID	SLR
1947	MID	SLR
1948	UPP	SLR
1949	UPP	WF SLR
1950	MID	SLR
1951	MID	SLR
1952	MID	SLR
1961	MID	SLR
1965	MID	SLR
1966	CST	SLR
1978	CST, UPP	SLR, WF SLR
1979	UPP	WF SLR
1983	MID	SLR
1997	UPP	WF SLR

Subbasin Abbreviations: CST = Coastal; SOU = Southern; NRN = Northern; MID = Middle; UPP = Upper

Current Conditions

Assessment Methodology and Overview

Throughout 2007, the CDFG and Pacific States Marine Fisheries Commission (PSMFC) fisheries crews inventoried 35 miles of the SLR River and 1.2 miles of Pauma Creek (Figure 26). Most of the inventory occurred during the spring and early summer months. Seven other tributaries, three in the Coastal Subbasin, one each in the Southern and Northern subbasins, and two in the Middle Subbasin, were examined for general habitat suitability. Based on fish passage barriers preventing upstream access and/or unsuitable habitat conditions at the time of the survey, it was agreed that steelhead were unlikely to utilize those streams; therefore, full habitat typing protocols were not performed (these tributaries are discussed individually within the appropriate subbasin Current Conditions sections). Additional areas may not have been surveyed due to drought conditions during the 2006/2007 winter and spring, which resulted in a lack of surface flows, a necessary component to performing full habitat inventories. The Upper Subbasin was not inventoried due to the permanent anadromous barrier, Henshaw Dam, located at the beginning of the subbasin.

CDFG and PSMFC fisheries crews were not able to survey the entire SLR River below Henshaw Dam or additional tributaries that possessed potential steelhead habitat as a result of denied landowner permission for stream access. Denied access narrowed the scope of the field assessment and prevented the surveying of potential significant habitats and/or the documentation of important features. One of these areas was the SLR River canyon, located downstream of the Escondido Canal diversion dam (approximately RM 40-37). Subsequent to

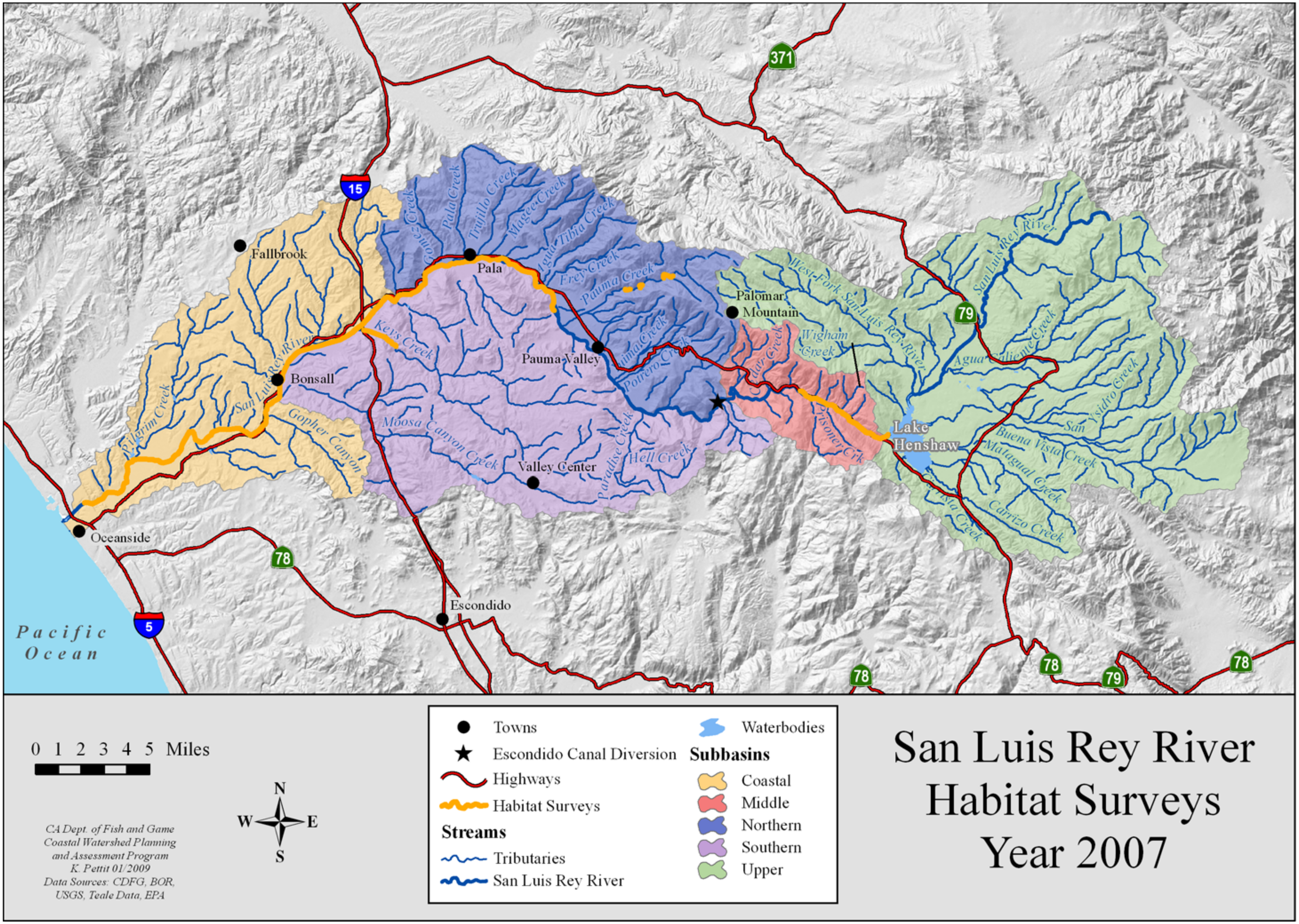


Figure 26. San Luis Rey River 2007 CDFG Stream Habitat Surveys.

the CDFG field surveys, a NMFS biologist accompaniedseveral tribal members of Native American Bands and performed a general reconnaissance level survey of the upper portion of the SLR River canyon (approximately RM 38.5- 40) on August 27, 2009.

The 2007 habitat inventory surveys were the first of their kind within the basin to utilize the stream habitat inventory protocols outlined in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998). The data collected during these inventories are compared to the target values defined in this Manual to determine if habitat conditions within the streams are limiting to salmonid production. This assessment also utilized reference values that were developed in the NMFSs *Guide to the reference values used in south-central/southern California coast steelhead conservation action planning (CAP) workbooks* (NMFS and Keir andAssociates 2008) to help evaluate recommended stream habitat conditions, specifically for Southern California Coast Steelhead. Data gathered through these habitat inventories describe the following habitat characteristics: stream cross sections, pool-riffle-run units, canopy density, length of primary pools, pool depths, mean pool shelter coverage, cobble embeddedness of pool tails, and general biological observations along surveyed reaches within the SLR River Basin. Additionally, CWPAP evaluates these habitat data using the Ecological Management Decision Support (EMDS) system software. The EMDS system can evaluate stream reach conditions for salmonids based on water temperature, riparian vegetation, stream flow, and in channel characteristics.

Target values developed for the Manual and the EMDS were based on northern California streams. Conditions differ in southern California streams and the Southern California Coast Steelhead DPS has adapted to these conditions; therefore, conclusions concerning overall habitat conditions were assessed based on these differences and reference values presented in the NMFS CAP workbooks. More details on the EMDS are located in California Coastal Planning and Assessment Program Introduction and Overview.

Habitat data collected in the SLR River Basin that can be used in the EMDS are canopy, pool quality, pool depth, pool shelter, and embeddedness. Calculations and conclusions made in the EMDS are pertinent to surveyed streams and are based on conditions and habitat available for steelhead at the time these surveys were conducted. The 2007 water year was one of the driest years on record; therefore, it is important to note that habitat survey results, in some instances, reflected low flow conditions.

SLR River and tributary EMDS results and more detailed instream habitat discussions are presented in the subbasin sections. The following paragraphs provide a general overview of the current conditions in the SLR River Basin.

Instream Habitat Conditions

Based on data collected through CDFGs habitat inventory and professional observations, the SLR River in the SLR River canyon (RM 37-39.5) and Northern Subbasin streams provide the largest amount of potential steelhead/trout spawning and rearing habitat within the basin. The SLR River canyon is located in the eastern portion of the Southern Subbasin, just downstream of the Escondido Canal diversion dam (RM 40). A NMFS biologist who surveyed a portion of the canyon observed some deep pools with boulder cover and small surface flows (1.0 +cfs), aided by rising ground water and small side tributaries and springs. Considering the survey was performed during the dry season (late August) and having experienced several below average rainfall years, the presence of surface flows most likely indicates that this area maintains perennial flows. The biologist concluded that this stretch of the river could "…serve as over summering refugia habitat for *O. mykiss"* (M. Capelli, personal communication 2009). A natural waterfall barrier is located at RM 39.5, approximately a half a mile below the diversion dam (the La Jolla Tribe refers to this area by its Luiseño place name "Kye"). While the overall height of the waterfall is about 50 feet, it is broken up into a series of steps, with the largest lowermost step approximately 13 feet, and a narrow steeped crevasse above the first step extending to the top of the waterfall (M. Capelli, personal communication 2010). Under most flow conditions steelhead are very unlikely to navigate through this feature.

In the Northern Subbasin suitable spawning and rearing habitat is present, but not necessarily limited to the following streams: Gomez Creek, Pala Creek, Agua Tibia Creek, Frey Creek, and Pauma Creek. Unfortunately, fish passage barriers prevent ocean run steelhead from accessing potential suitable spawning and rearing habitat, in some if not all, of these streams. Due to the extremely dry conditions and access issues, of these listed streams, only Pauma Creek was surveyed during the 2007 CDFG stream surveys. Potential suitable spawning and rearing habitat for ocean run *O. mykiss* was observed in Pauma Creek. This habitat was limited to an approximately ½ a mile to ¾ of a mile of stream habitat within the vicinity of the Cleveland National Forest Service boundary. Man-made and natural waterfall barriers are present in the canyon that would prevent steelhead from accessing additional upstream habitat. Currently, a native, self-sustaining resident rainbow trout population exists in

Pauma Creek. This population is considered a resident rainbow trout population because ocean run steelhead do not have access into Pauma Creek beyond the Highway 76 Bridge crossing. Rainbow trout are found throughout the Pauma Creek watershed, including these tributaries: Lion Creek, Doane Creek, Iron Springs, and French Valley Creek.

In the spring of 2008, a small section of Gomez Creek was assessed for general habitat conditions, but a full inventory was not performed. A greater amount of Gomez Creek needs to be surveyed to determine overall habitat suitability, but it appears that it could support a small *O. mykiss* population. Further evidence of this includes the two *O. mykiss* (most likely formerly hatchery planted rainbow trout) that were observed in Gomez Creek in September of 2005, which may indicate that conditions are suitable for rearing *O. mykiss*. See Middle Subbasin, Fish Habitat Relationship (pp. 14-16) for further details.

The Coastal Subbasin contains limited spawning habitat: there are only a few riffles that steelhead could potentially utilize for spawning, but elevated rates of sediment transport associated with high flows might fill in these gravels and prevent the incubation/development of steelhead eggs. The subbasin does, however, supports components of suitable rearing habitat conditions, such as areas with sufficient stream flows, pools or slack water for resting, instream cover to avoid predation, and a relatively intact canopy to moderate water temperatures, stabilize stream banks, and provide habitat for macroinvertebrates (a food source for steelhead trout).

Conversely, there are several factors that are unfavorable to rearing juvenile steelhead trout in the Coastal Subbasin. Water quality has received poor ratings, which in turn, may limit macroinvertebrate production. Dense stands of *Arundo* have altered riparian function and habitat. Exotic warm water game fish, bullfrogs, and crawfish are all present and would be formidable predators to juvenile trout. Reaches in the subbasin can go dry, causing juvenile fish mortality. Fish passage barriers are present and need to be modified in order to facilitate downstream juvenile migration. Flood control measures such as the riparian canopy removal in Oceanside could reduce available habitat, elevate stream temperatures, and increase erosion and sediment input.

In the estuary, modifications associated with flood control levees, year-round tidal influence, removal of riparian vegetation, wetland conversion to agriculture and urban development, introduction of warm-water gamefish, and mineral and aggregate extraction in the upstream channel have adversely altered estuarine ecosystem processes and reduced the suitability of the estuary as steelhead habitat. The SLR River estuary, which once sprawled more than 2,200 acres, has been reduced considerably to 164 acres, 7% of its original size. Estuarine areas can be a critical component of juvenile salmonids transition from a freshwater to saltwater environment. Previous estuarine studies have shown that growth rates are greater in juvenile steelhead utilizing the estuarine environment (Shapovalov and Taft 1954; Smith 1994), which, in turn, increases the chance for marine survival and may define adult production from the watershed (Hayes et al. 2008). The NMFS Southern Steelhead Recovery Plan (2009 *Draft*) designated estuarine areas that provide uncontaminated water and substrates; food and nutrient sources to support growth and development; and connected shallow water areas and wetlands to cover and shelter juveniles as critical habitat essential to the recovery of steelhead. The removal of the Pacific Street Bridge in 2008 should help to restore more normal conditions in the estuary and increase the potential for recovery or recolinization of a variety of species of fish, amphibians, and reptiles.

The majority of Southern Subbasin, excluding the SLR River canyon, contains limited surface flows and is dry for much of the year. Riparian and streambed habitat along the SLR River, downstream of the canyon has been significantly altered and degraded. Thus, its potential for spawning and juvenile rearing habitat is very limited. Most of the substrate below Pala is composed of medium sand that is highly transportable and unspawnable. Numerous man-made, partial fish passage barriers are present in the SLR River downstream of the SLR River canyon.

Accessible, potential steelhead bearing tributary habitat is very limited in the Coastal and Southern subbasins. Variable seasonal flows and sandy, alluvial instream habitat conditions restrict access and usage of most tributary streams in the Coastal and Southern subbasins. Within the Coastal Subbasin, limited habitat may exist in Mission/Ostrich Creek and Monserate/Live Oak Creek. Keys Creek, a significant tributary in the Southern Subbasin, was surveyed in 2007 from its confluence with the SLR River to 2.3 miles upstream. No potential steelhead spawning or rearing was observed in this reach. A natural bedrock chute barrier at RM 2.3 would prevent steelhead from accessing any potential habitat upstream.

In addition to variable seasonal flows and multiple downstream barriers, the Middle and Upper subbasins are currently not accessible to ocean run steelhead due to the Escondido Canal diversion dam (RM 40). The Middle Subbasin is basically situated between the Henshaw Dam and the Escondido Canal diversion dam. Its instream habitat is influenced by the flow releases from Henshaw Dam, which do not necessarily mimic the natural flow regime of a typical stream or river in Southern California as seasonal water releases are dependent on water allocation agreements. In addition to variable flows, the SLR River in the Middle Subbasin contains warm water game fish, excessive sedimentation, reduced pool size and frequency, limited suitable spawning gravels, and potentially reduced dissolved oxygen levels caused by a combination of prolonged low flow conditions and moderate to abundant algae growth.

A self-sustaining, resident rainbow trout population exists in the Upper Subbasin in the West Fork of the SLR River. This population is limited to a 3-mile reach approximately 3 mile upstream of its terminus into Lake Henshaw. Natural waterfall barriers generally prevent trout from moving upstream or downstream of this perennial reach. Other creeks in the Upper Subbasin such as Carrizo Creek, Mataqual Creek, San Ysidro Creek, Canada Verde Creek, and Aqua Caliente Creek contain relatively small perennial reaches that have suitable rainbow trout habitat.

The basin lacks stream water temperature data for the summer and fall temperature extreme period. In order to address this data gap and determine if water temperatures could be a limiting factor in steelhead recovery, the CDFG with grantee Trout Unlimited, placed data loggers in 2008 and 2009 to record water temperatures in potentially suitable rearing locations. Trout Unlimited is also performing water quality monitoring and benthic invertebrate studies in key locations to get a better understanding of the overall water quality of the SLR River and some of its tributaries. The findings of these monitoring efforts are discussed more in the Water Temperature section (p. 65) and in Appendix III.

The cumulative effects of water diversions, groundwater pumping, man-made barriers, drought, agricultural activities, exotic flora and fauna, and overall freshwater and estuarine habitat degradation have been identified as leading factors in the decline of SLR River's steelhead runs. The widespread decline of steelhead is likely linked to their sensitivity to degradation of specific habitat components necessary to complete the freshwater and/or estuarine phase of their life cycle. These conditions and factors will be discussed further in the following section.

Adverse Conditions Affecting Steelhead Recovery

Southern California steelhead declined primarily as a result of agriculture, mining, and urbanization activities that have resulted in the loss, degradation, simplification, and fragmentation of habitat (NMFS 2009 *draft*). Anadromous *O. mykiss* in the SLR River Basin face significant challenges from water and land management practices that have degraded or curtailed freshwater and estuarine habitats, reducing their capability to persist within the watershed. While beyond the scope of this assessment, the persistence and recovery of the steelhead is threatened by predicted shifts in climatic and oceanographic conditions that could further hinder recovery given the current condition of the species and the freshwater and estuarine ecosystem (NMFS 2009 *draft*). The following discussion presents the most significant threats currently facing steelhead in the SLR River Basin.

Water Quantity

As discussed in previous sections, stream flow is a primary limiting factor for steelhead, affecting fish passage, and quantity and quality of spawning, rearing, and refugia areas. Habitats with increased current velocity and turbulence usually contain higher dissolved oxygen and food levels; if accessible, steelhead prefer such habitat, particularly under conditions of oxygen stress at higher temperatures (Stoecker and Coastal Project Conception 2002). That is not to discount the importance of intermittent streams or intermittent reaches. Studies have shown *O. mykiss* to use intermittent streams successfully for both spawning and rearing activities, in some instances as frequently as perennial streams (Boughton et al. 2009). While all intermittent streams may not necessarily provide potential *O. mykiss* habitat, they cumulatively contribute essential water flows into the SLR River.

Previous year-round surface flows in the SLR River and some of its tributaries allowed adult steelhead to access potential spawning grounds, provided rearing habitat, and facilitated downstream juvenile emigrations to reach the estuary and hence the ocean. It has been reported that 7 inches is the minimum depth required for successful migration of adult steelhead (Thompson 1972, as cited in Stoecker and Coastal Project 2002), however, the distance fish must swim through shallow water areas is also critical. The hydrologic controls of Henshaw Dam and the Escondido Canal diversion dam, water diversions on tributaries, and overdrafting of underground aquifers along much of the river have resulted in large portions of the river becoming dry most of the year (See Figure 6, p. 12). Consequently, in recent decades there have been an inadequate number of opportunities for steelhead to utilize the SLR River Basin.

The native fishes of the basin are adapted for surviving extended periods of drought through a combination of life history strategies and physiological tolerances (Moyle 1995). Steelhead and their offspring have to contend not only with less water and habitat, but as well as decreased water quality and increased predation from predatory game fish. Considering these factors, steelhead trout and the surrounding riparian habitat and its associated species could be greatly benefited by seasonally appropriate pulse flows that would mimic the natural hydrologic cycle of the river. Allowing water releases from the Escondido Canal diversion dam in normal to high rain years when water is more abundant and steelhead are more likely to utilize the system would not only benefit steelhead recovery, but encourage natural channel forming processes, help restore native riparian, potentially transport more fine material for beach sand replenishment, and restore vertical connectivity of surface flows with groundwater by increasing the exchange between surface water and groundwater flow (Boulton 2007). The timing of water releases would need to coincide with the seasonal timing of the adult steelhead migration into the basin and outmigration of smolts. The timing of steelhead adult migration generally overlaps with smolt outmigration (January through May).

Acquiring water from the middle and upper watershed (above the intake of the Escondido Canal diversion) for these pulse flows are subject to the unique provisions of the San Luis Rey Settlement Act (J. Membrino, personal communication 2009). Between provisions in the Settlement Act and the array of downstream wells and other water users, the possibility of acquiring water for pulse flows to facilitating anadromous runs of steelhead could be limited and costly. Water resources within the basin have been over allocated and considering the scarcity and economic significance of this resource there remains much skepticism/reluctance to provide water for the continuance of essential physical, biological, and ecological processes in river systems.

Water Quality

In 2006, the SLR River was listed as impaired by the San Diego Regional Water Quality Control Board (SDRWQCB), for chloride, total dissolved solids (TDS) and bacteria at the mouth (i.e. the Pacific Ocean shoreline) (Weston Solutions 2007 & PBSJ 2003). The sources of the contaminants are varied and numerous. Some of the major sources are as follows: urban runoff, agriculture/orchards, imported water, livestock, domestic animals, natural sources, sand mining, and septic systems (PBSJ 2003 & San Diego County 2001). As a part of the original requirements of the San Diego Municipal Storm Water Permit developed in 2001 the SLR River Watershed Urban Runoff Management Program (SLR River WURMP) was formed with the intent of collaborating with other Copermittees within the watershed to reduce pollutants from the Municipal Separate Storm Sewer System (MS4) (A. Witheridge, personal communication 2009). It is important to note that the WURMP is not a regulating body, for each municipality listed in the permit is responsible for compliance with the permit.

Due to the impaired listings, the SDRWQCB could consider implementing a Total Maximum Daily Load (TMDL) process in order to determine the watershed's capacity to assimilate pollution, in this case, sediment and chloride sources. This process results in the creation of numerical targets, and provides the state with information on how to reduce pollution within the watershed in order to meet water quality standards. Some entities, like the Mission Resource Conservation District and the City of Oceanside, are collecting and housing data in order to support this effort; those data are presented here. Water districts and Tribes in the Basin also perform their own water quality monitoring programs within their districts and reservations to determine current conditions and evaluate long-term water quality trends.

The SDRWQCB has designated the beneficial uses for all surface and ground waters in the San Diego Region; beneficial uses are defined as the uses of water necessary for the survival and well being of man, plants, and wildlife (L. Thibodaux, personal communication 2009). Beneficial uses related to fisheries are protected by the Clean Water Act, and would most likely be further protected by the TMDL process in the SLR River and its tributaries. The list below is the beneficial uses that can be selected by the SDRWQCB as they relate to a water body; however not all of these uses apply to the entire SLR River. For example, the Lower San Luis Hydrologic Area (essentially all of the Coastal Subbasin and the western portion of the Southern Subbasin) do not have either the COLD or SPWN beneficial use designations (L. Thibodaux personal communication 2009). The beneficial uses are as follows:

- Cold freshwater habitat (i.e., “COLD”, described as uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic saline habitats, vegetation, fish, or wildlife, including invertebrates (http://www.blm.gov/nstc/WaterLaws/california2.html);
- Spawning, reproduction and/or early development potential (i.e., “SPWN”, described as uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish (http://www.blm.gov/nstc/WaterLaws/california2.html);
- Migration of aquatic organisms;
- Preservation of rare, threatened, or endangered species;
- Aquaculture;
- Municipal and Domestic Supply (MUN), which

includes uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply (L. Thibodaux personal communication 2009);

- Commercial and sport fishing.

In the SLR River watershed, surface water and groundwater have become an integrated system. Since groundwater supplies base flow to the river for most of the year, groundwater quality has an important effect on surface water quality (PBSJ 2003). Conversely, because surface waters recharge the shallow alluvial groundwater basins, surface water quality affects groundwater quality. Surface waters are primarily contaminated by the runoff of irrigated agriculture containing sediments, nutrients such as phosphorus and nitrogen, and other pollutants.

As the largest land use in the basin, agriculture practices have been identified as a likely source of sediment and nutrient input into the watershed. Modern agriculture is based on the extensive use of applied chemicals such as fertilizers, pesticides, and herbicides to obtain high crop yields. The improper use of these applied chemicals may lead to serious degradation of surface water quality. Employing BMPs have helped to reduce the amount of sediments and chemicals from entering the streams during storm runoff.

It is important to note, while agricultural practices in the watershed contribute to increased levels of these minerals and nutrients, the water coming into the basin is already high in these minerals and nutrients. Analysis on water in the basin showed the primary source of TDS and chloride coming into San Diego County is from imported water. Greater than 80% of the San Diego Region's water supply comes from a combination of Colorado River water and Northern California water. Most of this imported water, 70%, comes from the Colorado River, which is very high in TDS and chloride. The Basin Plan standard is 500 parts per million, but the water coming in is already at or near the Basin Plan limits (SDRWQCB 2002). In some cases it is actually over it; therefore, when water is simply used for irrigation, it will already exceed the Basin Plan. There is a concern that if agriculture cannot comply with regulations because the available water is derogating without putting fertilizers or other chemicals associated with agricultural practices, then farmers may not be able to stay in business. The loss of agriculture in the region would negatively impact the local economy. Housing developments have and mostly likely will continue to replace agricultural areas, permanently removing a local source of food and the associated workforce (SDRWQCB 2002).

Water bodies in southern California that could support salmonids including steelhead and other native fish species are recognized as cold water habitat (COLD), and their spawning period and habitat (SPWN) are afforded protection under these designations (NMFS & Kier Associates 2008). Much of this region is experiencing high rates of human population growth and development that make water quality preservation challenging.

Water Temperature

Water temperature affects steelhead during all life stages and can be a significant limiting factor for steelhead trout reproduction and survival. Juvenile steelhead over-summering in coastal streams of southern California can experience a continual warm-water environment. Climatic conditions combined with human impacts such as the removal of shade sources and reduced stream flows can elevate temperatures to lethal levels. High water temperatures decrease dissolved oxygen, increase the virulence of many fish diseases and the toxicity of most chemicals (Lantz 1971). While some reports (USFWS 1998) have shown trout to prefer cool water despite low dissolved oxygen concentrations, other studies (Hopper 1973) noted that steelhead have difficulty extracting oxygen from water with temperatures greater than 21°C (69.8°F), regardless of the amount of oxygen present. Daily maximum stream temperatures may begin exceeding 20°C (68°F) in late spring, and eventually reach 21°C (69.8°F) by mid morning, and exceed 28°C (82.4°F) in the afternoon during July and August.

Recent work by Spina (2006) indicates that previously held notions concerning thermal limits and tolerance of Southern California Coast Steelhead may need to be reconsidered. Using data collected primarily within Topanga Creek, which drains the Santa Monica Mountains in Los Angeles County, Spina consistently found that over-summering juvenile steelhead were able to not only tolerate, but remained active and foraged despite temperatures between 17.4°C to 24.8°C (63.3°F to 76.6°F), which have previously been thought to impede physiological processes and ultimately result in either the fish seeking cold water refugia or dying. The report concluded: "The relatively high body temperatures that these steelhead accepted appeared to represent a compromise in exchange for maintaining an expanded geographic (latitudinal) range."

The CWPAP created suitability ranges for maximum weekly average temperatures (MWATs) considering temperature's effect on salmonid viability, growth, and habitat fitness based on studies conducted in northern California and Oregon streams. Because southern California steelhead have adapted to a different range of temperatures, these suitability ranges do not apply for evaluating stream temperatures in the SLR Basin; therefore, this assessment has adopted temperature thresholds (Table 13) that were developed in the *Guide to* *the reference values used in south-central/southern California coast steelhead conservation action planning (CAP) workbooks* (NMFS and Kier and Associates 2008). The tolerance values reflect the findings of Spina's (2006) study. These tolerance values may be redefined as more water temperature data is collected from steelhead streams in the region. Questions remain as to what degree this DPS rely on thermal refugia that result from springs, topographic shading or hyporheic flow (Poole and Berman 2000 as cited in NMFS and Kier and Associates 2008).

Table 13. Proposed CAP interim reference values for MWATs for Southern California Coast Steelhead DPS.

MWAT Range*	Description
< 17°C (62.6°F)	Very Good
17 - 22.5°C (62.6 - 72.5°F)	Good
22.5 - 25°C (72.5 - 77.0°F)	Fair
≥ 25°C (77°F)	Poor

Derived from Kier Associates and NMFS 2008

* Tolerance values are calculated from a seven-day moving average of daily average temperatures. The maximum daily average is also used here to illustrate possible stressful conditions for *O. mykiss*. The instantaneous maximum temperature that may lead to steelhead lethality is >25°C (77°F).

Water temperature data is incomplete for most of the SLR River Basin for any period of time. While water temperatures were continuously measured during CDFG 2007 habitat typing surveys, these measurements provide only a limited subset of data. In general, temperature data recorded during 2007 CDFG habitat typing surveys (both water and air temperatures are measured and recorded at every tenth habitat unit) in the lower Coastal Subbasin ranged from 58°F to 70°F (14.4°C-21.1°C), while temperatures in the Middle ranged from 46°F to 64°F (8°C to 18°C). These data were expected, as the SLR River within the Middle Subbasin is located at higher elevations and data was recorded during a cooler time frame (April); whereas, temperatures recorded in the Coastal Subbasin occurred during the warmer months of May/early June. Pauma Creek, in the Northern Subbasin, was surveyed in mid-July, 2007. In the middle reach, water temperatures ranged very slightly from 66°F to 67°F (18.9°C-19.4°C); in the upper reach (near Mount Palomar State Park) temperatures also varied minimally from 59°F to 61°F (15.0°C-16.1°C).

In order to capture the annual high temperature extreme period (spring through late fall), CDFG in conjunction with grantee, Trout Unlimited, established temperature monitoring stations at locations in the watershed that could potentially be utilized by steelhead/trout. Temperature data loggers were generally deployed in the spring of 2008 and retrieved at the end of November, 2008. These loggers were placed in the SLR River at the following locations: in the estuary (RM 0.3), slightly downstream of Douglas Avenue Bridge (RM 6) and just downstream of the old Highway 395 Bridge and confluence of Keys Creek (RM 18). Data loggers were also stationed in several tributaries: in Gomez Creek (deployed June 4), approximately 2.8 miles upstream of its confluence with the SLR River; and in Moosa Canyon Creek (deployed August 4), approximately 3 miles upstream of its confluence with the SLR River. Data loggers were deployed at these same locations (except in the estuary) in the spring of 2009 and recorded water temperatures through the fall of 2009.

Typically, in order to draw conclusions on stream water temperatures regimes or patterns three to five years of data are needed. Thus, these *preliminary findings* indicate that water temperatures in the lower SLR River at Douglas Avenue (RM 6) and downstream of the old Highway 395 Bridge (RM 18) were generally "good" (according to NMFS reference values, Table 13) with temperatures ranging from 16.5°C to 19°C during the summer months. Water temperatures began decreasing in October. The tributaries of Gomez Creek and Moosa Canyon Creek displayed similar temperature patterns with water temperature in the 16°C to 20°C range in the summer and becoming significantly lower in October. The estuary, on the other hand, exhibited a wide range of temperatures throughout the study period. This was due to the influx of incoming and outgoing tides and the placement of the data logger. The data logger was not positioned in the main channel, so water temperature were generally "poor" during low tides (logger was along the shallow margins and water temperatures rose significantly). Water temperatures were frequently above 25°C and reached 29°C or greater on several occasions. Hence, water temperatures in the estuary were only considered "good" during the early spring or late fall. Future monitoring in the estuary should involve the placement of the logger in the main channel.

Appendix III provides maps of the data logger locations and graphs depicting water temperature data recorded during the spring through fall of 2008 and 2009.

Water Chemistry

Water chemistry interacts with basic trophic levels affecting the production and availability of food for aquatic organisms. Nutrients are often limiting factors in the biological capacity of a stream yet a proper balance is needed to prevent eutrophication. Pollutants are a concern where they interfere with the biological function of aquatic organisms, or can be a threat to those that consume them. Large sources of nutrients and pollutants are commonly associated with urban runoff from the MS4, industrial wastewater facilities, storm runoff, and agricultural operations. Naturally occurring nutrients and heavy metals are often found in much smaller concentrations.

In a recent paper published in the December 2009 issue of the journal *Ecological Applications*, biologists examined the effects of pesticides in rivers and basins on the growth and size of wild salmon populations. The study results indicated that short-term (i.e. four-day) exposures that are representative of seasonal pesticide use, such as diazinon and malathion, may be sufficient to reduce the growth and size at ocean entry of juvenile chinook (Baldwin et al 2009). The paper concluded that exposures to common pesticides may place important constraints on the recovery of ESA-listed salmon species. Considering the widespread use of pesticides including insecticides, herbicides and fungicides that are usually applied to agricultural and urban landscapes throughout the Basin this may be an issue to consider while performing and tracking water quality monitoring results.

The SDRWQCB has set water quality objectives for the following parameters on San Diego streams and rivers:

- Maximum pH standard of 8.5 to maintain beneficial uses, including cold water fish species;
- Total dissolved solids [below 500 mg/L 90% of the time];
- Dissolved Oxygen (above 6.0 mg/L for COLD beneficial use (SDRWQCB 1998);
- Nutrient concentrations: “a desirable goal in order to prevent plant nuisance in streams and other flowing waters appears to be 0.1 mg/L total P.” These values are not to be exceeded more than 10% of the time unless studies of the specific water body in question clearly show water quality objective changes are permissible and approved by the SDRWQCB. Nitrogen to Phosphorus ratio (if data lacking) of N:P = 10:1 on a weight to weight basis.

The County of San Diego in conjunction with the City of Oceanside, private contractors, the water districts, the Indian Tribes, and public community organizations have undertaken water quality studies in the basin to address issues associated with the various agricultural industries, stormwater runoff, nutrient input, bacteria, turbidity, sedimentation, and benthic community quality (see Stream Bioassessment Section pg. 67).

As part of the regional monitoring effort as required by the 2001 Sand Diego Storm Water Permit, a mass loading station was constructed in the fall of 2001, under the Benet Road Bridge (RM 2.5), to assess flow and test for water toxicity and chemistry during three wet weather events each year beginning in 2001 through 2007. In 2007, a new San Diego Storm Water Permit was issued with different monitoring requirements. Beginning with monitoring year 2007-2008, a mass loading station and temporary watershed assessment station, which was placed under Camino del Rey (RM 14.5), assessed flow, chemistry, and toxicity of the SLR during two wet and two dry weather events. This testing will not be continued annually, rather every other year starting with monitoring year 2008-2009, per the new permit requirements (A. Witheridge, personal comm 2009).

Overall results of the mass loading station, survey period of 2001 to 2006, indicated that total dissolved solids continue to be the primary water quality concern in the watershed. The report also notes an increasing trend in indicator bacteria concentration, specifically in fecal coliform at levels above the water quality objective (WQO). While nitrate and dissolved phosphorus were at levels below the WQO both showed significantly increasing trends which may become an issue in the future. Other constituents monitored that were occasionally detected at levels above the WQO include: total suspended solids, turbidity, biochemical oxygen demand, pH, and diazinon (compound in pesticides). These exceedances of WQO were for storm events as the mass loading station was wet weather monitoring. The report concluded that there was no clear link between dry weather results and mass loading station data; however, the cause of occasional, infrequent toxicity during mass loading station monitoring was unknown (Weston Solutions 2007).

The City of Oceanside also began a Dry Weather Analytical Monitoring and Field Screening Program in the spring of 2002 to detect and eliminate illicit connections and illegal discharges to the Municipal Separate Storm Sewer System (MS4) by monitoring selected stations with the MS4 system (A. Witheridge, personal communication 2009). This essentially tests the water quality of urban runoff and the seriousness of certain pollutant problems draining into the City’s rivers and creeks during May through September months when little to no rainfall occurs. The majority of sites surveyed are located in the Coastal Subbasin; however, the total number of sites visited has varied over the years and are currently different with the new 2007 permit.

An Ambient Bay and Lagoon Monitoring (ABLM) Program began in June of 2003 investigating chemistry, toxicity, and benthic community structure in the SLR River estuary. The monitoring program utilizes three sample sites in the estuary: one in the lower portion, south of the railroad crossing; one in the middle portion, south of Interstate 5; and one in the upper portion, approximately 1,300 feet upstream of Interstate 5 (Weston Solutions 2007).

The chemistry (sediment chemistry) monitoring component of the ABLM sampled sediments from 12 coastal embayments, analyzed in four categories of constituents: metals, Polychlorinated Biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and pesticides. Of these, six metals were detected above the detection limit in the SLR River estuary: arsenic, chromium, copper, lead, nickel, and zinc. However, concentrations of metals were low and none exceeded their respective effects range low (ERL) or effects range medium (ERM–upper guideline value) sediment quality value during the 2003-2005 ABLM Program. There were 4.4'-DDE was detected at this site above the ERL value of 2.2 ug/kg (6.91ug/kg, the level detected), but this is below the respective ERM value of 27 ug/kg.

Toxicity results were determined by mean percent survival of the estuarine burrowing amphipod, *Eohaustorius estuaries*, exposed to the SLR River estuary sediments in a 10-day acute toxicity test compared to a control sample. No toxicity was observed during the 2005 testing year in the 10-day solid phase toxicity test using *E. estuaries*. Survival of *E. estuaries* was not significantly different in the SLR sediment (90%) as compared to control sediment (97%), indicating that bioavailable metals found in the SLR River estuary sediment were not toxic to the amphipod *E. estuaries* (Weston Solutions 2007).

The biological component of the ABLM utilized the Benthic Response Index (BRI) and Relative Benthic Index (RBI) as indicators of estuary health. The BRI, as described in the San Diego County Municipal Copermittees 2005-2006 Urban Runoff Monitoring report (2007), is the abundance-weighted average pollution tolerance score of organisms occurring in a sample and is most applicable to marine environments. This report also describes the RBI as the weighted sum of three measures of abundance: 1) total number of species, number of crustacean species, number of crustacean individuals, and number of mollusk species; 2) abundance of three positive and 3) two negative indicator organisms. The two indices combined provided some difference in benthic community health. Overall, for the SLR River estuary during the 2003-2005 monitoring years, the benthic community health was assessed at poor to fair (Weston Solutions 2007). Table 14 summarizes the results of the 2003-2005 ABLM Program in the SLR River estuary.

Table 14. SLR River Estuary 2003-2005 ABLM Monitoring Results.

Index	2003	2004	2005
Chemistry	Good	Fair	Good
Toxicology	Fair	Good	Good
BRI	Poor	Fair	Fair
RBI	Poor	Poor	Fair

BRI = Benthic Response Index RBI = Relative Benthic Index (Weston Solutions 2007)

In addition to water quality studies occurring in the lower watershed, the Vista Irrigation Water District (VID), which manages water supply in the upper portion of the watershed, is required to conduct a Watershed Sanitary Survey every five years. This survey must be consistent with the requirements of the California Drinking Water Source Assessment and Protection Program, and is obligated to include a drainage area assessment and management measures to protect the water quality of drinking water sources (PBSJ 2003). VID sampling sites within the watershed were located at the Escondido Canal inlet at the SLR River and at the Lake Henshaw outlet. Monitoring at these two locations was performed for several parameters including general and physical chemistry, bacteria, inorganics such as minerals and metals, and organics such as pesticides.

According to the PBSJ Urban Runoff Management Program report (2003), most of the parameters measured at the Lake Henshaw outlet and the Escondido Canal diversion occurred within acceptable levels. However, the report noted that manganese and iron concentrations frequently exceeded secondary drinking water standards (0.08 mg/L and 0.03 mg/L, respectively), especially during drought years when Warner Basin well water is supplied to Lake Henshaw. Bacteria monitoring data was available from 1996 to 2000 and included data for total coliform and E. coli. While levels at both sites infrequently surpassed available water quality standards, total coliform concentrations were consistently recorded at elevated levels at both sites with frequent exceedences of 1000 MPN/100mL. E. coli typically occurred in higher concentrations at the diversion site compared to the Lake Henshaw outlet.

Stream Bioassessment

Stream bioassessments generally focus on the overall abundance and diversity of aquatic macroinvertebrates, which are an important food source for steelhead trout fry, juveniles, and smolts. Aquatic macroinvertebrates often reside in interstitial spaces between stream cobble and gravel where steelhead eggs are also deposited. Consequently, sediment pollution can reduce macroinvertebrate abundance and diversity and decrease the success of steelhead egg incubation (NMFS & Kier Associates 2008).

In conjunction with water quality/urban runoff monitoring, Weston Solutions performed a stream bioassessment in the SLR River Basin in October of 2005 and May of 2006 at two urban locations in the Coastal Subbasin as well as in the SLR estuary and at a reference site in Doane Creek in Mt. Palomar State Park. The first urban site was located near the Benet Road Bridge, RM 2.5; the second site was near the Mission Road Bridge, RM 12. Although these bioassessments were not done in concurrence with the CDFG stream habitat surveys, they still provide a useful tool in determining overall stream water quality and habitat, which frequently is a limiting factor in steelhead/trout production due to the extensive land use modifications within many Southern California watersheds (NMFS & Kier Associates 2008).

The monitoring program in the SLR River Basin utilized the Ephemeroptera + Plecoptera + Trichoptera (EPT) taxa richness as a functional measure of stream water quality. This metric is included in the Environmental Protection Agency's (EPA) Rapid Bioassessment protocols. In addition to the EPT, the assessment analysis employed the Index of Biotic Integrity (IBI) and a new analysis tool known as the O/E ratio in summarizing benthic macroinvertebrate communities. The O/E ratio is the ratio of organisms observed at a site (O) to the organisms expected to occur at a site (E). The expected value is based on percent probability of capture of specific taxa under reference conditions and also accounts for factors such as temperature, precipitation, and geology (Weston Solutions 2007).

The assessment determined the two sites were rated below the average of all the County test sites for the IBI. The Mission Road site was just below average and the Benet Road site was about 14% below the average IBI score. They both had an IBI quality rating of Very Poor for each survey in October 2005 and May 2006. The report described in-stream habitat for each monitoring site as sub-optimal due to the unstable sand/gravel substrate, and the Benet Road site had a diminished surface flow due to the low gradient and sandy soils of the river valley. However, each site was composed of a robust willow canopy, dense bank vegetation, and emergent vegetation.

The two sites had differing O/E ratios, but they each still had a negative score. The Benet Road site had a ratio of 0.58, which implies the benthic community had lost an estimated 42% of the biodiversity expected to occur at this site. The Mission Road site contained a lower ration of 0.41, thus an ever greater estimated loss of 59% of biodiversity.

The benthic macroinvertebrate community differed moderately between October and May survey dates. Chironomid midges dominated both surveys in similar percentages; however, in the October survey, Baetid mayflies and the black fly Simulium accounted for a large proportion of the community, and in the May survey, the amphipods *Hyalella* and *Crangonyz,* and earthworms were highly abundant (Weston Solutions 2007). The report stated that amphipods and earthworms were examined because they are generally indicators of higher levels of silty deposits.

Unlike the two urban sites, the Doane Creek reference site, located at an elevation of 4,950 feet on Mt. Palomar, contained favorable scores for the IBI and the O/E ratio. With total IBI scores of 48 and 62 for October and May, respectively, Doane Creek rated Good and Very Good in this category. The preliminary results of the O/E analysis showed that this site had a ratio of 0.71, which implies the benthic community lost an estimated 29% of the biodiversity expected to occur at the site (Weston Solutions 2007). There were 21 and 39 different taxa collected, with 14 and 21 different EPT taxa per survey. There were substantially more EPT and highly sensitive taxa collected here than at any other site.

In summary, the SLR River urban sites had Index of Biotic Integrity Ratings of Very Poor during both surveys. These ratings are typical of a stream that receives a considerable amount of urban runoff and the ratings are comparable to all other urban streams in the county (A. Witheridge, personal communication 2009). The in-stream physical habitat of these sites was qualified as marginal, which could have limited macroinvertebrate colonization. The results indicate that there is evidence of benthic alteration. However, it should be noted that the sites were quite similar to those surveyed at the Santa Margarita site on Camp Pendleton, which had a substantially higher IBI scores. Outside the urban areas in a natural flowing mountain stream, the Doane Creek reference site was the highest rated site in the county program, with the greatest taxonomic diversity and many infrequently encountered organisms (Weston Solutions 2007).

Barriers

While in freshwater steelhead are highly mobile, utilizing optimal aquatic habitats within a stream as conditions change over time. Steelhead occupy a variety of stream habitats from the headwaters to the mouth, as both migratory corridors and habitat for rearing and spawning. Barriers to migration between these habitats have proved disastrous to steelhead populations throughout their range. Types of barriers include: dams, culverts, Arizona road crossings, diversions, flood control channels, flow dynamics, water quality, and natural features such as waterfalls and bedrock chutes. Barriers lead directly to the fragmentation of steelhead habitat and may completely eliminate anadromous steelhead from accessing a stream to spawn.

Twenty six structures considered partial or complete barriers to fish passage were identified below Lake Henshaw within the SLR River Basin that would impede the passage of steelhead. These barriers are reported in the CalFish Passage Assessment Database (CDFG) and displayed in Figure 27. The barriers are split between dams, water diversions, road crossings (culverts), and non-structural (generally consisting of natural waterfalls or bedrock chutes) barriers. From this total, eleven structures were considered partial barriers, meaning they are only barriers to certain life stages of steelhead and only at certain times of the year, usually dependent on flow conditions. Generally, partial barriers are impassible at low flow conditions, which in Southern California extend for the majority of the summer and fall months. Most of the partial barriers are located on the lower to middle SLR River. Fifteen structures were assessed as complete barriers, meaning they are impassible to all anadromous fish species, at all life stages at all times of the year. Examples of these include the natural waterfall in the SLR River canyon, a road crossing on Gomez Creek, a natural bedrock chute on Keys Creek, the Highway 76 Bridge over Pauma Creek, a ten foot concrete wall further upstream in Pauma Creek, etc. An additional eight structures in the basin were described as "unknown," thus their fish passage status is unclear.

During the 2007 CDFG habitat inventory, survey crews identified and evaluated fish passage barriers in the SLR River and its tributaries containing potential steelhead spawning and rearing habitat. Beginning at the ocean and moving upstream to Escondido Canal diversion dam (RM 40), the following road crossings or other man-made structures and natural features were identified as the most significant fish passage barriers, hindering the upstream and downstream movement of adult and juvenile steelhead:

- In Oceanside, the Douglas Avenue Bridge, located six miles upstream of the ocean (RM 6), contains a boulder rip-rap configuration within the SLR Riverbed to protect the bridge abutments. This rip-rap of boulders creates a partial fish barrier, hindering fish passage during low to moderate flows. While the rip-rap configuration below the College Avenue Bridge (RM 7) is not as problematic as the Douglas Avenue Bridge, it still would need to be modified to provide passage during all flow conditions;
- At RM 11 a dirt road crossing utilizes multiple circular plastic and corrugated metal pipes to convey the SLR River. This crossing was constructed on a private landowner's property and is most likely a partial fish barrier depending on stream flows;
- On a private property parcel at RM 17.5 (approximately), an upright, metal sheet spanning the river, functions somewhat similar to a check dam, allowing a portion of the river to flow over and through the metal sheet. This is a low flow barrier to fish;
- In the Southern Subbasin, at approximately RM 20, lies another dirt road crossing (Jamies Lane) with four, poorly positioned, 18-inch circular plastic and corrugated metal pipes used to convey the SLR River flows. This crossing is a partial barrier to fish depending on stream flow conditions;
- At roughly RM 28, a concrete bridge crossing the SLR River on a water district road contains a concrete base with short, high gradient spillway. This would also be a partial barrier during low flows;
- An Arizona road crossing, located on Cole Grade Road (RM 30.6), passes through the SLR River streambed. On the downstream side of the road is a three foot drop without a jumping pool at its base. Moreover, while flowing, the river would spread out evenly across the road with very little depth. This would prevent fish passage during low and even moderate flows;
- Two miles upstream (RM 32.7) of Cole Grade Road, in the Pauma Valley Country Club, the SLR River has been channelized via a concrete-lined channel. While the entire length, approximately two-thirds of a mile, of the lined channel is low gradient, it could pose as a low-flow barrier. The banks of the relatively narrow channel have been gently sloped, allowing golf carts to cross it. Possibly of greater concern are the two road crossings on the course that would create low flow barriers;
- A natural, 50 foot high bedrock waterfall exists in the SLR River canyon (RM 39.5), approximately half a mile downstream of the Escondido Canal diversion dam. The La Jolla Tribe refers to this area by its Luiseño place name "Kye". Members of several local Native American Bands and a NMFS biologist performed a general reconnaissance survey of the area in August of 2009. The NMFS biologist described the waterfall as impediment to fish passage under most flow conditions. While the overall height of the waterfall is about 50 feet, it is broken up into a series of steps with the largest lowermost step approximately 13 feet and a narrow steeped crevasse above the first step extending to the top of the waterfall (M. Capelli, pers comm 2010). Photos of the waterfall, concrete-lined channel (above), and diversion dam are located in the Southern Subbasin, p. 16.

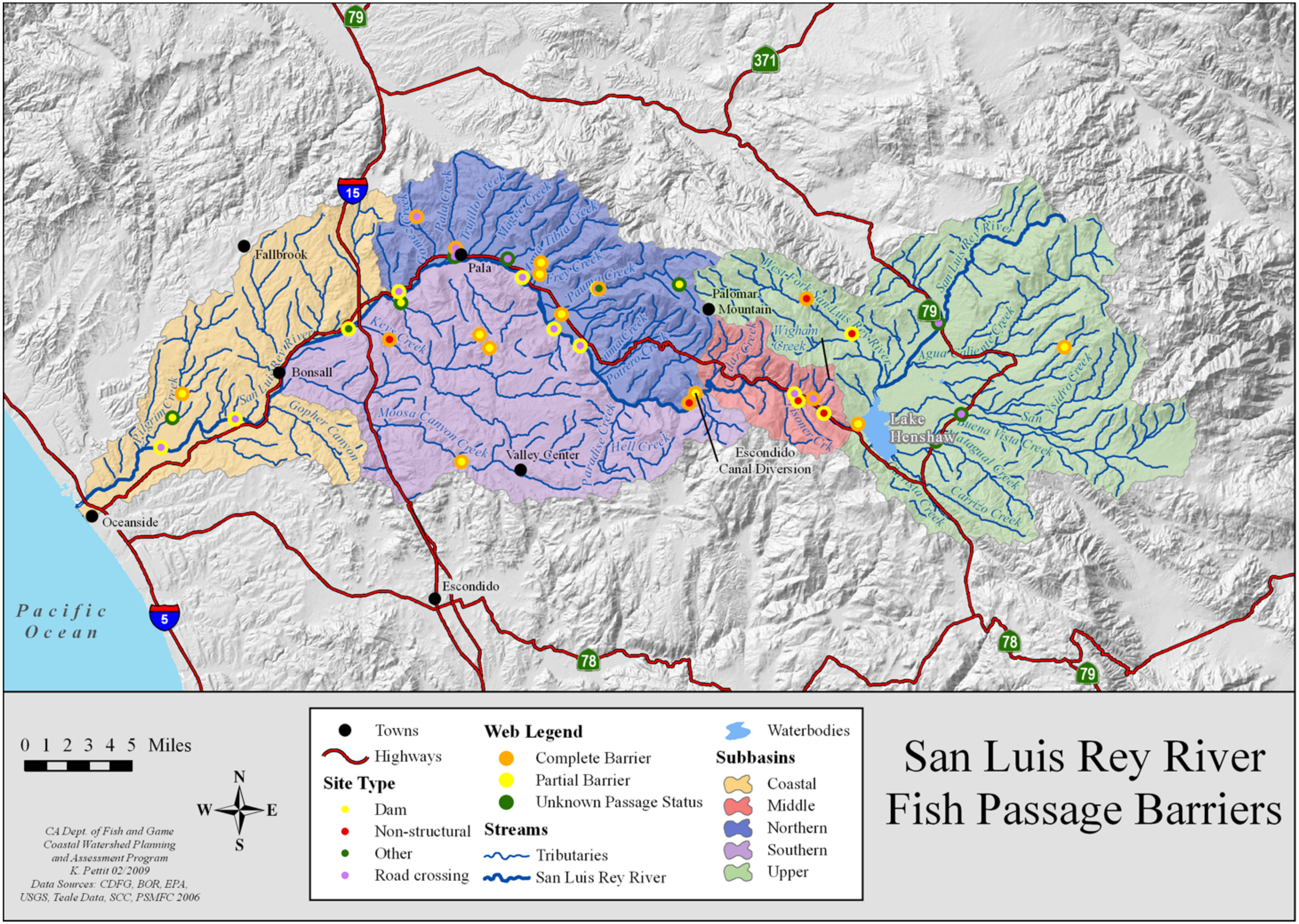


Figure 27. Fish passage barriers of the SLR River Basin.

- The Escondido Canal diversion dam at RM 40 is concrete dam that spans the entire SLR River creating a complete barrier to all fish passage. It is about 12 feet in height and approximately 150 feet in width. It does contain an outlet to allow for the passage of river flows, but this outlet is not passable to fish;
- *In Pauma Creek*: The Highway 76 Bridge crossing Pauma Creek is a complete barrier to all fish passage. This barrier, located approximately ¾ of a mile upstream of Pauma Creek's confluence with the SLR River, consists of three, concrete box culverts with a four to five feet high boulder rip rap configuration on the downstream end. Upstream of the culverts is a gently sloped concrete apron that is also impassible to trout. This apron is approximately 40 feet in length and dissipates the stream flow into a thin sheet of water (30-35 feet wide and 1 to 4 inches deep depending on stream flow).

All of these barriers impair fish passage and may interrupt natural flow and temperature regimes while also modifying aquatic habitat characteristics. Modifying or deconstructing these road crossings, culverts, check dams would assure proper fish passage. Additional passage barriers exist in potential trout spawning and rearing streams in the Northern Subbasin tributaries, such as Gomez Creek, Pala Creek, Frey Creek and Agua Tibia Creek. Considering portions of these streams contain year-round stream flows removal of these barriers could allow steelhead access to suitable habitat and be beneficial to recovery efforts. More details about specific barriers and associated photos are presented in each of the subbasin sections of this report.

Exotic Fish Species

The introduction of exotic fish species in southern California began in the late 1940s, with the growth of dams and water diversions (USFWS 1998). Warm-water game fish were the most prevalent fish observed throughout the habitat typing surveys and during an electrofishing survey in the upper Middle Subbasin. Largemouth bass (*Micropterus salmoides*), green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), brown bullhead (*Ameiurus nebulosus*), and channel catfish (*Ictalurus punctatus*) are present in the mainstem. They all prey on one or more life stages (i.e., eggs, larvae, metamorphs, or adults) of native amphibians and fish. In addition to exotic fish species, bullfrogs (*Rana catesbeiana*) and Louisiana crayfish (*Procambarus clarkii*), which also predate on native amphibian and fish species, were frequently observed in the Coastal and Middle subbasins. The recovery of steelhead in the SLR Basin would be hindered by the presence of these exotics and eradication programs would be necessary to improve instream habitat conditions within the watershed.

The following details the exotic fish, amphibians, and crustaceans that were observed (except black crappie) during the CDFG 2007 surveys and their impact on steelhead. Other exotic fish may exist, but were not observed during surveys.

Largemouth bass: (*Micropterus salmoides*) were commonly seen in the Coastal and Middle subbasins. They mostly likely are transported from Lake Henshaw to the SLR River during water releases. Having observed various size classes in the Middle and Coastal subbasins it is speculated that these fish are not only being transported into the system but are successfully reproducing as well. Largemouth bass take over the role as top predator in the habitat they occupy and can directly predate on juvenile steelhead (USFWS 1998).

Green sunfish: (*Lepomis cyanellus*) were originally native to the Mississippi drainage system, including the Great Lakes, but have since been widely introduced into the West, including Lake Henshaw. They have been observed in the W.F. SLR River and in the SLR River in the Middle Subbasin. In Malibu Creek, green sunfish were found to prey on juvenile trout (Swift 1975), and have been shown to outcompete steelhead for benthic food in other systems (USFWS 1998). They were the dominate fish species in San Mateo Creek Lagoon in the late 1980s and early 1990s (Swift 1994); and may have displaced residual steelhead in upper San Mateo Creek and Devil Canyon during drought periods (Woelfel 1991 as cited in USFWS 1998).

Bluegill: (*Lepomis macrochirus*) are also most likely stocked in Lake Henshaw and have been transported to the SLR River during flow releases. Bluegill are prolific breeders and compete with steelhead by eating similar food sources of insects and crustaceans. A few bluegill were observed in the Middle Subbasin and may be present in portions of the Coastal Subbasin.

Channel catfish: (*Ictalurus punctatus*) appeared to be present in the Coastal, Middle, and Upper subbasins. They are voracious bottom feeders that will consume larval and juvenile fish. According to a 1985 USFWS study on the Columbia River, salmonids composed 25% of channel catfish diet (USFWS 1998).

Bullhead: (*Ameiurus* spp.) were common in both the Coastal and Upper subbasins. Brown bullhead (*Ameiurus nebulosus*) were captured during an electrofishing survey in the Middle Subbasin, but it possible that black bullhead (*Ameiurus melas*) also exist in the system. Bullhead are omnivorous bottom feeders, consuming a wide variety of plant and animal material. Bullheads, particularly brown bullheads, can be voracious predators of newly hatched fish (Moyle 2002 and Orange County Water District 2006).

Mosquito fish: (*Gambusia affinis*) have been introduced throughout much of southern California for mosquito abatement and were found in numerous numbers in the Coastal and Middle subbasin in SLR River. Mosquito fish could possibly serve as a food source for steelhead as they have taken over the niche of native threespine stickleback, which were important prey of salmonids (Moyle 2002). These fish can disrupt food chains and cause large blooms of phytoplankton in small bodies of water by reducing populations of invertebrate predators and grazers (Moyle 2002). Mosquitofish are known to prey on eggs, larvae, and juveniles of many fish. The planting of mosquitofish into the waters of California is favored by the vector control districts because it is an alternative to pesticides and the public reaction is more favorable. However, since they are not restricted to mosquito larvae in their diet, they can have a significant effect on native fish. In addition, many other fish will eat the larvae of mosquitoes and can be just as an effective means of controlling mosquito populations (Orange County Water District 2006).

Common carp: (*Cyprinus carpio*) were observed frequently in large numbers from the Oceanside area downstream to the estuary. Only a few were observed in the Middle Subbasin. Although they prefer different habitat and food items than steelhead, carp can foul the water or alter the aquatic habit in which they live by stirring up and feeding off the bottom of a stream causing poor conditions for steelhead (Moyle 1976).

Brown trout: (*Salmo trutta*) were stocked at one time in the Pauma Creek area. Brown trout are highly adaptable to a wide range of habitat conditions and can withstand summer water temperatures well above the preferred range of native trout (USFWS 1998). Although these fish are more aggressive and territorial than native trout and are known to prey on other juvenile salmonids (Moyle 1976), they do not, however, appear to be problematic to the rainbow trout of Pauma Creek. Allen Greenwood of San Diego Trout (personal communication) described the ratio of rainbow trout to brown trout in Pauma and French Valley Creeks as roughly ten to one. Brown trout were not observed during 2007 CDFG Pauma Creek habitat typing surveys, nor while performing general reconnaissance surveys after the 2007 Poomacha Fire.

Black crappie: (*Pomoxis nigromaculatus*) were introduced from the Midwest into southern California in the early 1900s and have successfully spread to warmwater lakes and reservoirs (Moyle 1976), including Lake Henshaw. Black crappie are prolific breeders and since their preferred diet is minnows, given the opportunity, juvenile steelhead and arroyo chub could be prey items (USFWS 1998).

Bullfrogs: (*Rana catesbeiana*) were commonly observed and heard throughout the Coastal Subbasin and less frequently in the Middle Subbasin. Although they were not observed in Pauma Creek, large numbers of them were present in Doane Pond, which lies near the headwaters of Pauma Creek. Bullfrogs are effective predators of amphibians, aquatic reptiles, and fish. They have a competitive advantage over native frogs and toads because of their large size, generalized food habits, extended breeding season which allows for production of two large clutches a year (females lay from 1,000 to 45,000 eggs, depending on size of female), and larvae that are less palatable to predatory fish (Stephenson and Calcarone 1999).

Crayfish: (*Procambarus clarkii*), native to the South and portions of the Midwest, are commonly sold as live bait and were abundant throughout the mainstem of the SLR River. Crayfish can disperse over land, traveling from pond to pond or stream to stream. They are omnivorous and thus feed on aquatic plants, algae, invertebrates, amphibian eggs and fish eggs (Hobbs et al. 1998).

Invasive Plant Species

As discussed in the "Invasive Plant Species Management" section invasive plants are highly problematic in the SLR River Basin. A paper authored by the Nature Conservancy (Bell 1997) discussing riparian restoration in southern California stated, "by far the greatest threat to the dwindling riparian resources of coastal southern California is the alien grass species known as *Arundo donax*. The removal of *Arundo* from these systems provides numerous downstream benefits in terms of native species habitat, wildfire protection, and water quantity and quality." While eradication efforts have removed hundreds of acres of *Arundo* there are still hundreds of acres remaining along the SLR River and some of its tributaries (Figure 18, pg. 34). Control and management of *Arundo* and other invasive plant species within the SLR River watershed requires a coordinated, watershed-wide approach. Ongoing efforts to remove *Arundo* should focus on upper populations in the watershed to prevent reinfestation of treated downstream sites from upstream sources. Removal of *Arundo* and other invasive plant species coupled with seasonally appropriate flushing flows will help to restore riparian communities and improve overall instream habitat for steelhead.

Conclusions and Limiting Factors Analysis

Although instream habitat conditions for salmonids varied across the SLR River Basin, several generalities can be made. In general, stream habitat conditions in the SLR River have been adversely altered by anthropogenic activities. The lack of hydrologic connectivity throughout the basin hinders fish passage, increases water temperatures, may decrease overall water quality, and prevents natural stream processes from occurring. These processes play an integral role in helping to develop and maintain complex stream habitat for steelhead and other native aquatic flora and fauna. Poor water quality, numerous instream barriers, limited estuary habitat, and exotic warm water game fish and invasive plant species all limit the potential for steelhead recovery in the basin.

Reviewing EMDS results (Table 15) indicate overall canopy conditions in the basin are evaluated as suitable in surveyed streams across the basin. Moreover, current canopy density measurements do not take into account that the canyon walls in Pauma Creek may provide shade and cover and the differences between smaller, younger riparian vegetation versus the microclimate controls that are provided by older, larger tree canopy conditions. Water temperature measurements, were not currently evaluated by the EMDS, and it is impossible to draw conclusions on limited recorded stream survey temperatures. In 2008 and 2009, stream temperature data loggers will be placed in key locations throughout the basin; this will help determine the temperature regime during the extreme temperatures of the summer and early fall months. Multiple years of data will be needed to draw accurate conclusions on the limitations of water temperatures in the basin.

Instream habitat indicators, pool quality, pool depth, pool shelter, and cobble embeddedness were generally evaluated as unsuitable across surveyed streams in the basin, thus these habitat factors are likely limiting to steelhead populations. Although fish passage barriers are not currently evaluated by the EMDS, barrier type and locations have been recorded throughout the basin. Each subbasin contains a more detailed description of the instream habitat present in the surveyed streams.

Twenty six structures considered partial or complete barriers to fish passage were identified and evaluated below Lake Henshaw within the SLR River Basin (Figure 27, p. 70). These are split primarily between road crossings, natural barriers, or dams. From this total, fifteen structures, such as the Escondido Canal diversion dam, Henshaw Dam, the bedrock chute on Keys Creek, the Highway 76 Bridge over Pauma Creek, were assessed as total barriers. These complete barriers prevent upstream passage of steelhead and are limiting potential steelhead production. Eleven structures were considered partial barriers, meaning they are only barriers to certain species, or life stages, and only at certain times of the year. These partial barriers are mostly located on the lower and middle SLR River but are present in a few tributaries as well. These partial barriers can play a significant role in the movement of fish during low flow conditions.

Macroinvertebrate data indicate that the SLR River is a highly impacted system, as it scored Very Poor in Index of Biotic Integrity Ratings during a 2005 and 2006 survey. The estuary scored only slightly higher during the 2003 to 2005 Ambient Bay and Lagoon Monitoring program, where benthic community health was rated as “poor to moderate.” Conversely, a tributary to Pauma Creek had a very high macroinvertebrate rating. Additional data is needed to determine the status of the mainstem in the Middle Subbasin.

Results of the mass loading station and dry weather analytical monitoring and field screening program in the Coastal Subbasin, survey period of 2001 to 2006, indicated that total dissolved solids continue to be the primary water quality concern in the watershed. The report also notes an increasing trend in indicator bacteria concentration, specifically in fecal coliform at levels above the water quality objective (WQO). While nitrate and dissolved phosphorus were at levels below the WQO both showed significantly increasing trends which may become an issue in the future. Considering the results of the macroinvertebrate monitoring and water quality studies, water quality is likely a limiting factor to steelhead production, specifically nutrient enrichment, excess sediment, and potentially dissolved oxygen.

Table 15. EMDS Reach Condition Model results for the SLR River Basin based on 2007 & 2008 CDFG stream inventory surveys.

Subbasins	EMDS Reach Conditions Categories				
	Canopy	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Coastal	+	-	--	+	---
Southern	--	U	U	U	---
Northern	++	--	--	--	+
Middle	+	--	--	--	--
Upper	U	U	U	U	U

Key: +++ = Highest Suitability U = Insufficient Data or Undetermined --- = Lowest Suitability

Ongoing monitoring programs in the basin, such as the City of Oceanside's Clean Water Program, San Diego Stream Team water quality monitoring and CDFG and Trout Unlimited's partnership with 2008-2009 water quality and benthic macroinvertebrate monitoring will help draw further conclusions on the overall water quality health in relationship with steelhead recovery.

Analysis of Instream Habitat Improvement Recommendations

In addition to presenting habitat condition data, all CDFG stream inventories produce a list of recommendations that address those conditions that did not reach target values presented in CDFG's *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998). A few of these target values have been slightly modified to evaluate conditions occurring in southern California streams and habitat preferences/tolerances of southern California steelhead as outlined in the NMFS and Kier Associates' *Guide to the reference values use in south central/southern California coast steelhead conservation action planning workbooks* (2008). In the SLR River Basin, full habitat inventories were limited to the SLR River and Pauma Creek. Other streams such as Keys Creek and Gomez Creek were adequately assessed in order to make similar recommendations.

In order to compare the SLR River and tributary recommendations within the Basin, the recommendations of each stream were collapsed into five target issue categories: Surface Stream Flow; Fish Passage; Riparian/Water Temperatures; Instream Habitat; and Sediment Delivery (Table 16). These target issues were then paired with the appropriate recommendation category. For example, the target issue "Instream Habitat" was divided into the recommendation categories of: pool, cover, and spawning gravels. CDFG/PSMFC biologists ranked these recommendation categories based on the most important issues needing to be addressed in order to facilitate steelhead recovery (Table 17). The top three recommendations of each stream are considered to be the most important, and are useful as a standard example of existing stream conditions. When examining recommendation categories for the SLR River, Gomez Creek, and Pauma Creek the most important target issues are sufficient stream flows and fish passage. The tributary recommendation process is described in more detail in the Fish Habitat Relationship section of each subbasin.

Table 16. Recommendation categories based on target issues.

Basin Target Issue	Related Table Categories
Surface Stream Flow	Stream Flow
Fish Passage Barriers	Fish Passage
Riparian/Water Temperature	Canopy/Temperature
Instream Habitat	Pool/Cover/Spawning Gravels
Sediment Delivery	Bank/Roads/Livestock

Table 17. Occurrence of stream habitat inventory recommendations in the first five ranks in the surveyed streams.

Stream	Survey Length (mile)	Stream Flows	Fish Passage	Riparian/Water Temps		Instream Habitat			Sediment Delivery		
				Canopy	Temp	Pool	Cover	Spawning Gravel	Bank	Roads	Livestock
San Luis Rey River	32.1	1	2		unk	4	5	3			
Pauma Creek	1.1	2*	1		unk	4	5	3			
Keys Creek	2.5		1		unk	3	4	2	5		
Gomez Creek	0.1	1	2		unk	4	5	3			

Unk = Unknown. The CDFG and Trout Unlimited have deployed temperature data loggers in the SLR River and Gomez Creek to monitor stream temperatures during 2008 and 2009.

* Pauma Creek took in considerations for flows below the Pauma flow diversion, approximately RM 2.4 (Below the diversion, Pauma Creek generally runs dry in the summer and fall. Sufficient flows are located above the diversion).

Watershed and Fish Restoration Programs

In part, due to the lack of awareness and current information concerning steelhead issues in the watershed, fisheries restoration programs have been very limited in the SLR River Basin. With the recent steelhead sighting and certainly the potential for more steelhead to enter the basin, more attention should be given to fish habitat improvement projects as watershed restoration programs are carried out.

A couple of significant projects exist in the basin that have already been completed or are in progress, which were not conceived as fisheries restoration projects, nonetheless, have and/or will improve the overall habitat conditions for steelhead in the SLR River. While primarily intended to prevent road wash-outs and reduce maintenance costs, the North Pacific Street realignment and bridge replacement should provide a more natural tidal flow exchange between the ocean and SLR River and thus improve overall estuary conditions. The project reconfigured the road as the culverts at the mouth have been replaced with a bridge spanning the estuary upstream. These culverts may have posed as a fish passage problem during low and extremely high flows.

Viewed as increasing flood and fire risk, degrading crop and rangelands, consuming large quantities of water, and displacement of native species and habitat, invasive plants have been targeted as a priority for removal and management in the watershed, particularly in the Coastal Subbasin. While improving overall canopy cover, the removal of exotics and revegetation with native stock will also increase flows, help fish to navigate through the mainstem more easily, improve overall instream habitat, and benefit many other native species of flora and fauna.

The San Luis Rey Watershed Council in 2000 also identified twelve priority issues with consideration to long term planning within the watershed. These issues are as follows: water quality and quantity, heavy industrial uses, extractive uses, invasive plant species management, agricultural uses, fire management, flood plain management and flood plain warning, wildlife management, recreational uses, public open space management, wetlands protection and restoration, and preserve historical and cultural legacies (SLR Watershed Council 2000).

Other projects that have occurred or are currently underway that have improved stream habitat conditions or contributed to the monitoring of the stream habitat conditions include the following:

- Land acquisition for the SLR River Park and resource conservation;
- City of Oceanside’s Clean Water Program which is a multi-faceted program that helps enhance water quality through pollution prevention practices, community activities and education;
- Water quality monitoring performed by the City of Oceanside and associated contractors (2001 to present). This monitoring includes the analysis of chemistry, bacteria, and toxicity data collected during storm water events and dry weather data from the dry weather monitoring program;
- Stream bioassessment performed by consultants for the City of Oceanside;
- Spring 2008 to December 2009 water temperature monitoring by the Department of Fish and Game in conjunction with Trout Unlimited;
- Spring 2008 to December 2009 water chemistry analysis and bioassessment by Trout Unlimited in conjunction with the San Diego Coastkeeper;
- Water quality control via animal waste improvement projects;
- Mission RCD working with area farmers on Best Management Practices for pesticide and erosion control and prevention;
- Mission RCD *Arundo* and *Tamarisk* removal along the SLR River and native tree and shrub planting;
- City of Oceanside’s removal of the Pacific Street Bridge at the mouth of the river;
- The Pala, Pauma, and La Jolla Indian Tribes all have on-going water resource monitoring programs that monitor groundwater levels and water quality parameters for wells and streams on reservation lands;
- Collectively, the San Luis Rey Watershed Copermittees hosted and participated in numerous cleanup and outreach events, including creek and coastal cleanups and regional event presentations at which watershed concepts were emphasized (PBSJ 2003);
- The San Luis Rey Watershed Copermittees delivered formal presentations to approximately 1,035 students throughout the watershed. Common learning tools used in these presentations include the Enviroscape watershed model, outdoor field trips puzzles, water quality posters, videos and PowerPoint presentations (PBSJ 2003);

Biological Resources

Stretching from the Pacific Ocean to the montane region surrounding Lake Henshaw, the SLR Basin encompasses an abundance of high quality, biological resources of local as well as regional value. Sensitive communities, such as coastal beach/strand, coastal sage scrub, alluvial fan scrub, marshes, native grasslands, vernal pools, riparian forests, oak woodlands and forests, and conifer forests are all represented within the watershed (Lettieri et al. 1995).

A United States Department of Agriculture report titled, “Southern California Mountains and Foothills

Assessment" (Stephenson and Calcarone 1999) classified the area of the Warner Basin and 4-mile stretch of riparian habitat along the SLR River, below Lake Henshaw, as an 'Area of High Ecological Significance'. This designation intends to increase public and agency awareness of their regional significance. The stretch of riparian supports the largest southwestern willow flycatcher population in southern California. Of equal significance are the populations of the federally listed arroyo toad and arroyo chub in the West Fork SLR River and Agua Caliente Creek. This area (Upper Subbasin) contains some of the most extensive remaining native grasslands (occupied by the federally listed Stephens' kangaroo rat) in southern California and the largest Engelmann oak woodland in the world (National Audubon Society 2008). The Upper Subbasin is also one of the few areas in southern California where the red-sided garter snake has recently been observed, and Lake Henshaw supports a small wintering population of bald eagles (Stephenson and Calcarone 1999). Downstream of the Upper Subbasin, the river and its associated riparian area support numerous other sensitive and listed species, such as the arroyo toad, western pond turtle, least Bell's vireo and light-footed clapper rail (SLR Watershed Council 2000).

The Important Bird Areas Program (IBA), a global initiative to identify and conserve areas that are vital to birds and other biodiversity, has designated the SLR River watershed as an IBA (National Audubon Society 2008). This designation, one of only 145 in California, is based on the fact that the river still contains some of the most extensive riverine habitat in Southern California and is of major importance to riparian bird species in the region.

The San Diego region has been identified as a major "hot spot" for biodiversity and species endangerment, nationally and globally. San Diego County is home to more species of native animals and plants than any other county in the continental United States (The Nature Conservancy 2007). Many unique and endangered species are found in the region, including the SLR River Watershed. The combination of high biodiversity, large numbers or rare and unique species, and increasing urbanization has led to intense conflicts among the issues of economic growth, biological conservation, and quality of life (SANDAG 2004).

Special Status Species

The San Luis Rey River Basin and the northern San Diego County/Southern Riverside County area are rich in numbers and variety of species. Due to the reduction of suitable habitat, many of these species are declining and some of them have been designated as "threatened" or "endangered" by state and federal governments. Numerous other species whose habitat and numbers are declining are listed by the state as "species of special concern." Most of these species and the basin will be regulated and managed through San Diego County's North County Multiple Species Conservation Program described below. For a complete list of designated species see the CDFG Appendix.

Multiple Species Conservation Program

The County of San Diego with local governments initiated a Multiple Species Conservation Program (MSCP) to develop regional plans to protect the long-term survival of sensitive plant and animal species and conserve the native vegetation found throughout San Diego County.

In order to create a regional preserve system and provide Endangered Species Act coverage for all of the unincorporated areas, the County of San Diego divided the unincorporated area into three planning areas. Each area will have its own http://www.mscpsandiego.org/images/mscpsubareas_lg.jpg MSCP plan prepared and approved. The North County MSCP is the second of three parts of the County's MSCP. A Public Review Draft of the North County MSCP text was released on February 19, 2009 (http://www.co.san-diego.ca.us/dplu/mscp/nc.htm.).

Currently, there are 61 species of sensitive plants, mammals, birds, amphibians, reptiles, and invertebrates to pursue for coverage (receive an incidental take permit) in the North County MSCP. Many of these species occur or could potentially occur in the watershed. In order to develop this list the County considered numerous factors such as species distribution, life history, sensitivity and vulnerability to human activities, viability, dependence on conservation, current listing status and its likelihood to be listed as rare, threatened or endangered in the future under the state or federal endangered species acts (http://www.sdcounty.ca.gov/dplu/mscp/index.html).

Refugia Areas

The CWPAP biologists identified and characterized refugia habitat in the SLR River Basin by utilizing field survey data, prior reports, discussions with various stakeholders and agency personnel, expert professional judgment and criteria developed for south coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, agriculture and other land uses, land ownership, potential risk from sediment delivery, water quantity and hydrologic connectivity, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by the

EMDS at the stream reach scale.

Based on available literature, southern steelhead seem very adaptable and able to survive in relatively modest habitat conditions. Basic requirements for the freshwater portion of their life cycle are migration/emigration without the impediment of instream barriers, adequate spawning gravel, areas of perennial flow or intermittent flow associated with pools of sufficient depth to avoid lethal temperatures. Shallow, isolated pools can be kept below lethal levels if intersected by subsurface flow or if they occur in the vicinity of cold water seeps or springs. Fish in shallower pools likely have a higher mortality due to predation by birds and snakes (USFWS 1998). Deep pools able to thermally stratify likely provide the best in-river rearing potential in the absences of predatory fish.

Previous studies suggests that the recovery prospects for steelhead runs would be significantly improved by identifying, restoring, and protecting those freshwater/ estuarine habitats that tend to produce large smolts (NMFS 2009 *Draft*). Large body size of migrants at ocean entry has been shown to substantially improve subsequent survival in the ocean (Ward et al. 1989; Bond 2006). Rapid growth of juveniles may be attained through several mechanisms. One mechanism is through freshwater streams or brackish lagoons that allow cool water temperatures to co-exist with high primary productivity during the summer growing season. High primary productivity of plants may result in increased allochthonous carbon inputs, including invertebrate food items (primary component of juvenile steelhead diet) associated with riparian vegetation (NMFS 2009 *Draft*). A similar means is through cool-water habitats that receive large terrestrial inputs (insects) of food items.

The most complete data available in the basin were for the SLR River mainstem and Pauma Creek, which were surveyed by CDFG. Streams in the Coastal and Southern subbasins were assessed to determine fish habitat suitability but full stream inventories were not performed. CDFG was not able to survey the entire SLR River below Henshaw Dam or additional tributaries in the Northern Subbasin that possessed potential steelhead habitat as a result of denied landowner permission for stream access. Drought conditions during the 2006/2007 winter and spring resulted in a lack of surface flows, a necessary component to performing full habitat inventories.

The best potential habitat conditions for steelhead in the SLR Basin are in mainstem within the SLR River canyon (RM 37-39.5) and in the tributaries of the Northern Subbasin, such as Pauma Creek, Frey Creek, Agua Tibia Creek, Gomez Creek and Pala Creek. While access to the SLR River canyon and most of the Northern Subbasin tributaries contain fish passage barrier problems, they possess potential spawning and rearing habitat. The remaining Southern and Coastal subbasins provide lower quality refugia; however, the Coastal Subbasin could potentially provide for critical estuarine as well as instream rearing habitat if proper restoration projects were in place and fish passage barriers were modified. Habitat in the Middle and Upper subbasins is inaccessible to steelhead due to the Escondido Canal diversion dam at RM 40. A few streams in the Upper Subbasin including the WF SLR River, which contains a native rainbow trout population, maintain sections of perennial flows and have some limited instream trout habitat. Predatory fish are found in the Coastal, Middle and Upper subbasins. All subbasins contained temporary or permanent fish passage barriers (Table 18, Figure 27).

Table 18. Subbasin salmonid refugia area ratings in the SLR River Basin.

Subbasin	Refugia Categories				Other Categories		
	High Quality	High Potential	Medium Potential	Low Quality/ Low Potential	Passage Barrier Limited	Critical Contributing Area/Function	Data Limited
Coastal				x	x		
Middle				x	x		x
Northern			x		x		x
Southern			x*		x		
Upper				x	x		x

* Based on suitable habitat available in the SLR River Canyon, RM 37-39.5.

Key Basin Issues

- Water quantity has been greatly reduced as water resources have been over allocated. The hydrologic connectivity of the SLR River Basin has been significantly altered due to dams, water diversions, and extensive pumping of the underground aquifers throughout the basin;

- Water quality is impaired in some tributaries and in the lower SLR River;
- Accessibility to potential spawning and rearing habitat is blocked at various points in the basin;
- Introduction of exotic flora and fauna have adversely altered riparian communities and habitat conditions along the SLR River and some of its tributaries;
- Urban and agricultural runoff poses a problem to aquatic ecosystems in the mainstem SLR River;
- Historic and current land use has altered watershed processes and conditions;
- Alterations to watershed processes have affected the basin both socially and economically;
- Overall loss of estuarine habitat and estuarine function has been adversely affected;
- Fish and wildlife have been adversely impacted by current watershed conditions in the basin.

Responses to Assessment Questions

What are the history and trends of the size, distribution, and relative health and diversity of fish populations in the SLR River Basin?

Findings and Conclusions:

- The SLR River Basin once supported steelhead runs, but they have nearly been extirpated from the SLR River Basin. One adult steelhead was observed in the SLR River in Oceanside (RM 7) during CDFG 2007 habitat surveys. Other confirmed, recent sightings of steelhead in the watershed have been limited; however, annual field surveys have not been conducted in the SLR River Basin and detection is difficult;
- Documented and anecdotal accounts report of steelhead runs in the SLR River and some of its tributaries. Anecdotal accounts from Pauma Indian Tribal elders spoke of annual runs and ceremonies associated with large fish, presumably steelhead, on SLR River (USFWS 1998);
- With the completion of the Henshaw Dam in the mid-1920s, the size of the runs diminished in the early 1900s and were all but eliminated by the late 1940s;
- Historical accounts indicate a recreational fishery in the lower SLR River was present until the 1940s. The SLR River in the Middle Subbasin formerly supported a significant recreational fishery through the CDFG trout stocking program until the early part of this decade;
- Currently, the recreational fishery has been limited to the Upper Subbasin and Pauma Creek watershed in the Northern Subbasin as fishing in coastal streams has been closed;
- A healthy population of native, self-sustaining rainbow trout persists in the Pauma Creek watershed in the Northern Subbasin. Although, due to the effects (large sediment input into the stream) of the 2007 Poomacha Fire this population suffered some losses. Genetic sampling performed on these fish concluded that “it seems more than likely that these fish are part of a native coastal *O. mykiss* lineage.” Furthermore the report stated, “these populations may be reasonable choices to consider in efforts to re-establish anadromous runs in their respective streams” (NOAA 1999). These trout are currently blocked from accessing the SLR River and thus potentially the Pacific Ocean due to the impassible culvert that runs below Highway 76;
- The Upper Subbasin also holds populations of resident native rainbow trout. Genetic sampling on trout taken from the West Fork SLR River concluded that, “it seems likely that the West Fork population is composed predominantly of native fish to the region” (Thorgaard 1979). This remote population is limited by reaches with perennial flows and low water or drought years;
- The Upper Subbasin also holds populations of native arroyo chub in the West Fork of the SLR River and Aqua Caliente Creek (Greenwood 2007; and Stephenson and Calcarone 1999);
- Warm water game fish such as largemouth bass, bluegill, green sunfish, channel catfish, and bullhead, which were introduced into the basin, and are abundant in the Coastal, Middle, and Upper subbasins;
- Tidewater goby, a species listed as endangered under the federal Endangered Species Act (ESA) has not been

observed or collected in limited estuary surveys.

What are the current steelhead habitat conditions in the SLR River Basin? How do these conditions compare to desired conditions?

Findings and Conclusions:

Flow and Water Quality:

- Intermittent and perennial flows exist in areas with potentially suitable habitat: SLR River within the SLR River canyon (approximately RM 37 to the natural waterfall barrier, RM 39.5) as well as portions of the Northern Subbasin tributaries, such as Pauma Creek, Aqua Tibia Creek, Frey Creek, Gomez Creek, and Pala Creek;
- The Southern and Coastal subbasins are not hydrologically connected to flows in the Middle and Upper subbasins. Flows have been altered throughout the basin as Henshaw Dam impedes flows into the Middle Subbasin and then downstream as Escondido Canal diversion diverts virtually all flows out of the mainstem at the upper end of the Southern Subbasin;
- Dry or intermittent reaches on the SLR mainstem prevent connection with the estuary and thus the ocean and hinders the recovery of steelhead in the basin;
- Stream flows in tributaries have been reduced or in some cases eliminated through extraction for anthropogenic use;
- Perennial stream flows in the SLR River exist in most of the Middle Subbasin from just downstream of Henshaw Dam to the Escondido Canal diversion, in the SLR River canyon (RM 37-39.5), and in several locations in the Coast Subbasin, such as the area around Interstate 15 downstream to the town of Bonsall and near the Ocean. Many tributaries throughout the watershed also possess sections of perennial stream flows;
- The SLR River is listed as impaired by the SDRWQCB for Total Dissolved Solids, chloride and fecal coliform (at the mouth);
- Water quality is most likely being impacted in the Upper Subbasin by cattle defecating near Lake Henshaw or in streams flowing into Lake Henshaw;
- According to the 2003-2005 Ambient Bay and Lagoon Monitoring Program, the benthic community health in the SLR River estuary was assessed as “poor to fair.” The program rated toxicology and chemistry as “good” for two out of the three years of monitoring (Weston Solutions 2007).

Erosion/Sediment:

- Due to the natural occurring geology within the majority of the basin, which consisting of loosely consolidated sediments, bank erosion and land sliding along the streams is present;
- Natural and human related sedimentation within the watershed has resulted in an overall loss of spawning, rearing and feeding habitat for salmonids within the basin;
- The dominant material below Pala (Southern Subbasin) is median sand, which is highly transportable during floods, limiting spawning and rearing habitat in the Coastal and lower portions of the Southern subbasins;
- Henshaw Dam and the Escondido Canal diversion dam reduce the transport of sediments that would normally help to replenish beach sand along the coast and various substrates in the riverbed;
- Although soil erosion from crops have been minimized through Best Management Practices, due to the large scale farming and roads associated with these operations soil erosion is expected to still occur within the basin. This erosion has degraded aquatic habitat;
- The 2007 wildfires, which occurred in large areas of the Northern and Southern subbasins, caused debris flows and increased runoff and erosion, resulting in higher than usual peak flows along stream channels. Ash and other sediment/nutrient loads has washed and blown into ephemeral and perennial streams.

Riparian Condition/Water Temperature:

- U.S. Army Corps of Engineers planned vegetation removal (Operation and Maintenance Plan) for flood control purposes will greatly alter the riparian structure in the Coastal Subbasin resulting in serious impacts to the aquatic habitat. These impacts are as follows: loss of overstory shade, reduction in necessary cover from predation, decreasing components that contribute to pool formation, lessening of macro-invertebrate production, and decline in bank stabilization;
- While the Operation and Maintenance Plan in the Coastal Subbasin will adversely remove a great deal of native riparian willow and cottonwood trees, it will however, help to eradicate areas that have become overgrown with giant reed, *Arundo donax*, which has numerous negative impacts on the riparian and stream habitat;
- The Coastal Subbasin had suitable canopy density measurements, but a good percentage of these canopy measurements were aided by the dense stands of *Arundo* that lined the stream channel or occupied the stream channel itself. The lowest reach in the Coastal Subbasin had a poor canopy rating, but this was attributed to the wide river channel, limiting the extent of the overstory canopy;
- The majority (70%) of the mainstem reaches surveyed in the Middle Subbasin and tributary reaches within the Northern Subbasin met or nearly met the target value of 80% canopy coverage with the exception of the uppermost reach in the SLR River in the Middle Subbasin. Canopy cover in these reaches was composed of mature forest canopy consisting of alders and oaks and to a lesser extent cottonwoods and willow;
- The majority of the surveyed SLR River in the Southern Subbasin, however, is largely devoid of tree bankside vegetation except for areas in the western portion of the subbasin and isolated patches elsewhere. Most of the riparian vegetation was composed of shrubs and grassland species;
- Water temperatures recorded during the 2007 CDFG surveys of streams in the SLR River Basin indicate ‘unsuitable to moderately unsuitable’ temperatures for salmonids in the Coastal Subbasin and ‘suitable’ in the Middle and Northern subbasins; however, these water temperature data are limited, and therefore inconclusive;
- Hobo thermometers were placed in various locations in the SLR River and in a few tributaries, Gomez Creek and Moosa Canyon Creek, during the temperature extreme period (spring through fall for 2008 & 2009). Overall, the 2008 recorded data displayed unsuitable water temperatures in the estuary during the summer months; however, water temperatures in the tributaries and middle SLR River were considered suitable throughout data collection period;
- Stream temperatures could increase in the Coastal Subbasin with the removal of riparian canopy due to the Flood Control Project.

Instream Habitat:

- Quality pool structure is generally lacking in the mainstem throughout the basin. All surveyed reaches had an inadequate number of pools and the overall length of pool habitat was lacking; while a few of the reaches contained adequate shelter, only one reach surveyed met standards for preferred pool depths;
- Pauma Creek contained the most suitable instream habitat conditions of the tributary and SLR River reaches evaluated during the assessment; however, some tributaries and sections of the SLR River could not be surveyed due to denied access. Subsequently, a NMFS biologist performed a general reconnaissance survey of the mainstem within the SLR River canyon in the summer of 2009 and described the area as having suitable over summering refugia habitat based on perennial stream flows with cool water temperatures and a few deep pools with boulder cover;
- Stream bioassessments were performed (independently of CDFG’s habitat surveys) in the lower mainstem SLR River and a reference site on a tributary of Pauma Creek and provide an indication of overall stream health. The SLR River urban sites had Index of Biotic Integrity Ratings of Very Poor during both surveys, while the Doane Creek reference site was the highest rated site in the county program, with the greatest taxonomic diversity (Weston Solutions 2007);
- The SLR estuary’s health assessed during the 2003-2005 period was rated as poor to fair based on analysis of Benthic Response Index and Relative Benthic Index scores.

Gravel/Substrate:

- Due to the geology of basin and increased sedimentation from anthropogenic practices, the SLR River streambed has been described as silted in 2007 CDFG stream habitat inventories;
- Less than 5% of pool tail outs in the SLR River have cobble embeddedness in categories one and two, which meet spawning gravel targets for salmonids. The SLR River and its tributaries in the Coastal and Southern subbasins (downstream of the SLR River canyon) offer very little potential spawning habitat;
- Surveyed reaches in the SLR River upstream of the Escondido Canal diversion dam contain pockets of potential spawning gravels, but overall suitable spawning areas are also limited;
- Henshaw Dam and the Escondido Canal diversion dam severely limits the recruitment of new gravel and cobble from the middle and upper watershed, which is needed downstream for spawning habitat and overall habitat diversity in the SLR River;
- Areas containing suitable spawning gravels exist throughout Pauma Creek and were observed in portions of Gomez Creek. Other tributaries in the Northern Subbasin, such as Agua Tibia Creek, Frey Creek, and Pala Creek most likely contain suitable substrate for spawning as well.

Refugia Areas:

- The Northern Subbasin (Pauma Creek) provides medium potential refugia. Additional refugia areas may be present in several other Northern Subbasin tributaries, including Gomez Creek, Agua Tibia Creek, Frey Creek, and Pala Creek. However, a majority of the refugia in this subbasin is inaccessible to steelhead due to lack of river flows, multiple barriers throughout Coastal and Southern subbasins, and additional barriers in the Northern Subbasin tributaries;
- While most of the Southern Subbasin is devoid of surface flows for the majority of the year and is uninhabitable for fish, the upper portion of the subbasin within the SLR River canyon (RM 37-39.5) contains perennial flowing water with pool habitats, instream cover, and most likely suitable water temperatures due to the rising groundwater and small tributaries and springs. This stretch of river could serve as spawning and over summering refugia habitat;
- The Coastal Subbasin provide lower quality refugia. The subbasin could provide critical instream and estuarine rearing habitat if riparian areas were maintained and habitat restoration projects were implemented in the mainstem and estuary;
- The Middle Subbasin is inaccessible to ocean run fish due to the Escondido Canal diversion dam at RM 40 and further hindered by the altered flow regime and additional fish passage problems downstream. Overall, the Middle Subbasin provides low quality refugia;
- Some suitable trout habitat exists in the streams of the Upper Subbasin as evident by the self-sustaining native rainbow trout populations in the WF SLR River and should be maintained as resident, native fish habitat.

Barriers:

- Numerous partial and complete barriers exist on the mainstem of the SLR River and its tributaries that do not meet CDFG and NOAA Fisheries fish passage guidelines. In the Coastal Subbasin, three partial barriers are located along the SLR River that prevent passage to certain life stages of steelhead at certain times of the year;
- The SLR River in the Southern Subbasin contains a complete barrier in the Escondido Canal diversion dam at RM 40. A natural waterfall barrier at RM 39.5 would prevent fish passage during most flow conditions. Four partial barriers (such as Cole Grade Road crossing on the SLR River and road crossing in the Pauma Valley Country Club) and two additional barriers whose passage status are unknown exists below the natural waterfall barrier;
- Tributaries in the Northern Subbasin that have fish passage barriers include Pauma Creek, Gomez Creek, Frey Creek, Agua Tibia Creek, and Pala Creek, which limit steelhead access to potentially significant refugia areas;
- The Middle Subbasin contains two complete barriers: a natural bedrock chute/waterfall approximately two

miles downstream of Henshaw Dam and Henshaw Dam itself. Several non-structural, partial barriers were also observed within the middle to upper survey area.

What are the impacts of fluvial, geologic, vegetative, and other natural processes on watershed and stream conditions?

Findings and Conclusions:

- SLR River Basin receives varied precipitation and has extremely altered runoff rates, discharge is typified by peaks in the winter, including flood flows, and very low flows in the summer. Periods of intensive or extensive rain occur infrequently, even during winter months;
- Flows in the SLR River and some of its tributary streams are influenced/aided by the surface water and shallow, alluvial aquifer relationship in the basin. These alluvial groundwater aquifers exist adjacent to and along the riverbed and extend from the eastern edge of Oceanside upstream to Pauma Valley as well as in the Lake Henshaw area;
- Most of the tributaries in the basin are intermittent streams, which typically run dry in the summer;
- Large floods periodically occur due to large winter rain events and extremely altered runoff rates. The floods of 1980, 1993, 1995, and 2005 significantly impacted the basin and caused most of the sediment transport and stream channel changes in recent years (SLR Watershed Council 2003);
- The SLR River Basin is located in a tectonically and seismically active area containing a series of faults that run through the area. These faults trend northwest and are associated with the Pacific Plate/North American Plate boundary;
- Decomposed granitic rock and steep upstream terrain present in the basin combined with winter storms can result in sliding, enhanced erosion, and potential debris-flow;
- With climatic models predicting a hotter and drier climate for the region in the future, frequency and intensity of wildfires may increase within the basin. Wildfires alter the functionality of soils and a loss of vegetation, which in turn, allows for increased surface erosion and transport of sediments to the stream channels;
- A hotter and drier climate in the region could also exacerbate decreased stream flow conditions within the watershed and hinder the recovery of steelhead in the basin. Although the Southern California Coast Steelhead DPS has evolved and adapted to drier conditions present in the region, these adaptations occurred without the added stresses of human development and water resources extraction within the available habitat in the basin.

How has land use affected these natural processes and conditions?

Findings and Conclusions:

- Loss of stream flows due to Henshaw Dam and Escondido Canal diversion;
- The natural function of the SLR River estuary, which once sprawled more than 2,200 acres, has been altered considerably by agriculture and urban development within the floodplain and watershed, and upriver mineral and aggregate extraction within the SLR River streambed. Presently, the estuary, composed of 164 acres, is only 7% of its original size;
- The basin's vegetation historically was composed of mixed sagebrush communities in the lowland and coastal areas, chaparral and brush communities in the mid-elevations, oak woodlands in upper elevations, and scattered grasslands dispersed throughout the basin. Presently, large areas of sage and chaparral communities have been converted to agriculture and urban areas;
- Along the SLR River and other tributaries, riparian forests and wetlands that once paralleled the stream courses have been greatly reduced or eliminated all together;
- Primarily due to the human disturbance, exotic vegetation such as giant reed, *Arundo donax*, and salt cedar, *Tamarisk sp.*, have displaced large areas of native riparian vegetation reducing stream flows, degrading aquatic habitat, and reducing overall biological diversity;

- *Arundo,* abundant in the lower parts of the SLR River Basin, along with the hydrologic controls in the middle and upper watershed, has effectively altered some riparian forests from a flood-defined to a fire-defined natural community;
- Wastes from the various agricultural industry, as well as urban storm runoff have affected the water quality in tributaries and in the SLR River;
- Sedimentation and in-filling as a result of urbanization, land subdivision activities, flood control, and gravel mining practices have resulted in an overall reduction in channel area, and consequently in available salmonid habitat;
- Combining previous in-channel sand mining operations and the effects of the hydrologic controls of Henshaw Dam and the Escondido Canal diversion, the overall sediment delivery of sand and gravel at the river's mouth has been greatly reduced. This reduction of sediment for the Oceanside Littoral Cell has resulted in a sediment deficit, loss of beach sand, and accelerated coastal erosion (Inman and Jenkins 1985);
- Because of the geologic characteristics within the SLR River, the basin is affected by highly variable runoff rates. Disturbance of the basin's already unstable soils by land use activities has perturbed runoff rates;
- The introduction of Colorado River water to the basin has altered the water chemistry and has increased TDS and chloride in the basin.

Based upon these conditions, trends, and relationships, are there elements that could be considered to be limiting factors for steelhead production?

Findings and Conclusions:

Based on available information for the SLR River Basin, the CWPAP team believes that salmonid populations are limited by:

- Reduced or non-existent stream flow rates due to water extractions and diversions;
- Variable seasonal precipitation and flows;
- Impaired water quality in the SLR River and its estuary;
- Presence of temporal or complete barriers on the mainstem and important tributaries;
- Displacement of native riparian vegetation with exotic vegetation;
- Loss of estuarine habitat;
- Potentially high summer water temperatures;
- High levels of fine sediments in streams;
- Limited areas with suitable spawning gravels in mainstem and tributaries;
- Competition with warm water gamefish, crayfish, and bullfrogs.

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Recommendations:

<u>Flow and Water Quality Improvement Activities:</u>

- Further analysis is needed to determine if water releases, seasonally appropriate pulse flows, through Henshaw Dam and the Escondido Canal diversion dam could ameliorate the adverse conditions affecting steelhead recovery in the SLR River and how much water would be required to provide minimum stream flows necessary for steelhead adult and juvenile migration in the SLR River;
- These flushing flows would also allow natural hydrologic processes to occur, which are important to creating and developing instream habitat, improve riverine restoration, restoring hydrologic processes and provide

sediment delivery for much needed beach sand replacement; however, longstanding water rights and water settlements, such as the Settlement Act, would limit opportunities to provide water for restoration/recovery activities;

- Enforce maximum irrigation efficiency with both agricultural and urban users. Implement the reuse of treated gray water for irrigation purposes;
- Strongly encourage homeowners to reduce their overall water use by converting lawns and landscaping to drought tolerant, native plants;
- Continue to build upon current region wide water conservation programs that are being enforced in many cities and municipals;
- Work with private property owners to establish conservation easements in the watershed, particularly along or near riverine habitats;
- Maximize fertilizer and pesticide efficiency and utilize integrated pest management to reduce overall use of pesticides.

Barrier Modification Activities:

- Modify existing fish passage barriers at public and private road crossings and other man-made barriers along the SLR River. Modification of partial barriers in the SLR River within the Coastal and lower Southern subbasins, such as the boulder rip-rap configuration under Douglas Avenue bridge and would be relatively low-cost projects that would facilitate the migration of both adult and juvenile fish during all flow conditions;
- Further fish passage barrier modifications in Northern Subbasin streams, such as Pauma, Agua Tibia, Frey, and Gomez creeks are necessary for steelhead to access potential suitable spawning and rearing habitats. While some of these barrier modifications may be more costly, they are essential for the successful completion of their freshwater lifecycle stages.

Erosion and Sediment Delivery Reduction Activities:

- The impact of property subdivision on streams of the SLR Basin should be minimized through the use of better land management practices and stormwater pollution prevention programs;
- Continue to encourage the use of Best Management Practices (BMPs) for nutrient runoff, pesticide management, and erosion control for homeowners and agricultural and industrial uses. The Natural Resource Conservation Services, local Resource Conservation District, and the Farm and Home Advisors' Office have been integral in the information and assistance in these practices;
- Existing sediment production problem sites that have potential to deliver sediments to streams should be evaluated and mitigated.

Riparian and Habitat Improvement Activities:

- Develop and implement a restoration and management plan for the SLR River estuary. This includes identifying and prioritizing locations within the estuary where vegetation can be returned to salt tolerant species, thus improving the habitat recovery of the estuary for all marine dependent species that may use the estuary;
- Control and management of *Arundo* and other invasive plant species within the SLR River watershed requires a coordinated, watershed-wide approach. Ongoing efforts to remove *Arundo* should focus on upper populations in the watershed to prevent reinfestation of treated downstream sites from upstream sources. Continuous monitoring and eradication efforts must be performed in order to prevent the re-colonization of exotics and allow for the establishment of natives;
- Support the Mission RCD in its efforts to eradicate and remove exotic plant species in the Coastal and Southern subbasins;
- Release of water from dams in seasonal appropriate flood pulses may enhance establishment of riparian species such as cottonwood and willow in cohorts that may survive for decades. This would be especially important along the SLR River in the Southern Subbasin;

- Programs to increase riparian vegetation should be implemented in streams where shade canopy is below target values of 80% coverage. This was evident along the SLR River in the Southern Subbasin.
- Although not surveyed, it was also evident that many streams in the Upper Subbasin lacked riparian vegetation and where appropriate could be benefited by revegetation projects. Any riparian planting must take into consideration the presence of invasive plant species and the hydrologic processes of the river in order to make a sustained, beneficial impact;
- Replace annual grasses with native perennial grasses. This would help the regeneration of oak savanna habitat and potentially improve groundwater storage in portions of the basin;
- In creeks where fish spawning and rearing habitat is limited, pool enhancement and instream structures should be added to increase complexity. Due to the lack of potential spawning gravels throughout the watershed, the placement of cobbles and gravels from outside resources in key locations, where stream flows are sufficient and rearing habitat is present, may improve the probability and success of steelhead spawning in the SLR River Basin;
- In order to protect riparian vegetation, and decrease stream bank erosion due to unrestricted access of cattle to streams, use of livestock management fencing should be prescribed where necessary.

Education, Research, and Monitoring Activities:

- Continue to build upon current educational outreach to the community concerning the elimination of exotic flora and fauna plantings and stockings;
- Expand education programs in schools and community outreach to promote water conservation in the watershed;
- Implement or expand on educational programs in schools and communities about the issue of fire, its benefits, drawbacks, and prevention;
- Research private property available for purchase by public agencies and non-profit groups, for various habitat conservation and open space plans;
- Conduct stream habitat and fish inventories in the SLR River canyon and in streams of the Northern Subbasin, including Gomez, Aqua Tibia, Frey, and Pala Creeks;
- Partner with local academic institutions and private agencies as a means to encourage the study of fish and habitat;
- Explore the potential of installing a steelhead counting station downstream of Bonsall as a means of establishing abundance and trends of adult anadromous runs of steelhead and juvenile migration;
- Continue to monitor summer/early fall water temperatures in the estuary, lower SLR River, and important tributaries in the Northern Subbasin for at least a three to five year period;
- Consider an economic study to determine the cost of water needed for steelhead recovery as well as its impact on the local stakeholders;
- Continue to monitor the potential effects of new and existing wells in the Coastal Subbasin concerning reduced surface flows and/or a lowered groundwater table, thus effecting wetlands and riparian areas and enabling saltwater intrusion;
- In the estuary, the completion of the Pacific Street bridge replacement will partially restore the natural flow regime. Water quality and estuary conditions will require monitoring. Salinities should be collected in the estuary and upstream to determine the extent of brackish conditions. Biological surveys should be performed in the estuary for at least a three year period;
- Continue to monitor the potential effects of the 2007 fires on sediment input, habitat and fish populations in the Pauma Creek watershed and the SLR River.

Basin Conclusions

The California Department of Fish and Game's Coastal Watershed Planning and Assessment Program considered a great deal of information regarding basin processes related to stream conditions in the San Luis Rey River Basin. Existing scientific studies and reports that portray physical and biological watershed characteristics were combined with the multidisciplinary investigations and integrated synthesis performed by the CWPAP team. This relatively large data base provided a considerable amount of information for analysis, interpretation and for addressing the CWPAP assessment questions and making recommendations to improve stream habitat conditions.

SLR River Basin historically contained runs of southern California steelhead. As late as the 1890s early 1900s these runs were reportedly sufficient enough to provide a major food supply for the Luiseño Indians (USFWS 1998). However, expanding human settlement and on-going water resources development severely reduced or eliminated surface flows in the SLR River and its tributaries altogether. Subsequently, steelhead populations became severely depleted by the late 1930s. An extended dry cycle from the mid 1940s through the late 1970s further exacerbated instream and flow conditions. Currently, the Southern California Coast Steelhead Distinct Population Segment (DPS) is listed as a federally endangered species. Limited surface flows, poor water quality, numerous fish passage barriers on the SLR River and its tributaries, the introduction of exotic flora and fauna, and loss of estuarine habitat have been identified as leading factors in nearly extirpating steelhead from the basin.

Southern California steelhead's high genetic diversity make-up may help to explain the remarkable capacity of this DPS to persist in seemingly unfavorable environments (Moyle 2003). For the millennia the southern California steelhead have successfully dealt with natural environmental fluctuations such as prolonged droughts, flash-floods, uncontrolled wildfires, sea-level alternations, periodic massive influxes of sedimentation, and climate changes – natural environmental fluctuations which also currently challenge the human population of southern California (NMFS 2009 *Draft*). While instream habitat conditions have been severely altered in the SLR River Basin, areas still persist in the watershed that could sustain steelhead populations: suitable spawning and rearing habitat are present in the SLR River within the SLR River canyon (RM 37-39.5) and in Northern Subbasin tributaries, such as Pauma Creek, Gomez Creek, Aqua Tibia Creek, and Frey Creek. Some limited rearing habitat is present in the lower river within the Coastal Subbasin. The removal of the Pacific Street Crossing could restore more normal conditions in the SLR estuary and increase the potential for recovery or recolinization of a variety of species of fish, amphibians, and reptiles. Although, the presence of exotic fish species and poor habitat conditions of the estuary/lagoon will likely impede juvenile steelhead survival before ocean entry until further actions are taken to restore historic ecosystem processes/habitat in the SLR River estuary/lagoon. While suitable spawning and rearing habitat was observed in the upper SLR River, above the Escondido Canal diversion dam, the dam and a natural waterfall barrier downstream of the dam prevent steelhead from accessing any of this potential habitat.

Steelhead recovery in the SLR River Basin is intimately tied to the condition of its riverine ecosystems. Restoring steelhead runs would coincide with restoring/maintaining riverine areas in the SLR River Basin and have numerous biological and socio-economic benefits. Riverine ecosystems are one of the most degraded ecosystems by humans, yet they hold critical significance to the state's biodiversity and wildlife populations as well as connections between ecological diversity, stream environments, floodplain management, and social issues and needs. Situated in the lowest-lying areas of landscapes, riverine ecosystems act as an important filter for the high levels of pollutants and excessive nutrients from agriculture, industries, and domestic sources that are typically deposited in these areas (Naiman et al. 2002). Biologically, 25% of all land mammals in California depend on riparian habitat and more species of birds nest here than any other California plant community (http://www.coastal.ca.gov/). Perhaps as much as 95% (http://www.coastal.ca.gov/) of the historic riparian habitat in the southern region of California has been lost to agriculture, urban development, flood control, and other human-caused impacts. The hydrology of the SLR River and its adjoining riparian zones have been transformed by wetland reclamation, dredging, aggregate mining, agricultural production, channelization, and clearing of riparian zones. These activities have profoundly changed the processes that drive ecosystem function and structure (Poff et al. 1997; and Jansson et al. 2000). This includes the loss of annual flooding, channel migration, and occasional large flood events, which maintain a cycle of riparian succession and therefore sustain a mosaic of diverse natural communities (Gregory et al. 1991).

Human societies rely on numerous freshwater and riparian ecosystem services, such as provision of clean water for domestic, agricultural and industrial uses, potential aquatic food source, their role as a clean water filter, helping maintain higher water quality, and leisure activities (Jansson et al. 2007). As municipal areas of the watershed look to become less reliant on dwindling and expensive outside water sources, in addition to meeting high standards of water quality, the river, accompanied by a functional riparian is essential to maintaining water quality and local groundwater supplies. Concern should be acknowledged that these services are threatened and might not be sustained in the future if current riverine areas are not protected and if restoration efforts are not initiated in degraded streams and river habitats. Recovery of steelhead in the SLR River Basin will rely on measures that will provide steelhead opportunities to complete all stages of their life cycle, beginning with increasing the water quantity in the river and its tributaries. This implies improving the connectivity of the river by reintroducing aspects of natural flow regimes. Improving water quality, mitigating fish passage barriers, and removing exotic flora and fauna are also key components to steelhead recovery in the SLR River Basin. Dominant land uses such as agricultural production and urban development hold significant socio-economic importance for local residents and the region's economy. These functions may conflict with the importance of increasing habitat diversity and quality by restoring ecological processes. Increasing surface flows and stream habitat improvements largely depends on achieving a balance between established water rights, the socio-economic needs for agriculture and urban development and implementing management needed to improve basin conditions that restore steelhead runs. Implementation of a conservation and restoration strategy in the SLR study area depends on the political will of the people who control and use land in the floodplain. Thus, systematic improvement project development is dependent upon the cooperative attitude of resource agencies, watershed groups and individuals, and landowners and managers. It remains for the people that live in and regulate the watershed to determine the functions to be restored and the desired landscape and community pattern.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Coastal Subbasin

The Coastal Subbasin includes the watershed area along the SLR River from its mouth at the Pacific Ocean to RM 19 at Rice Canyon, approximately one mile east of Interstate 15 (Figure 2). Stream elevations range from sea level at the mouth of the SLR River to approximately 1,600 feet in the headwaters of the tributaries. While it is the third largest subbasin of the SLR Basin at 102 square miles, 18% of the total watershed, it is easily the most populated. This assessment area encompasses the dominant population centers in the basin area with the cities of Oceanside, Vista, Bonsall, and portions of Fallbrook residing within its boundaries. The lower and southern portions of the subbasin are mostly urban/residential, commercial, and light industrial areas. The northern portions of the basin are held in larger private parcels managed for agricultural crop production. California Highway 76 runs parallel to the river throughout the subbasin.

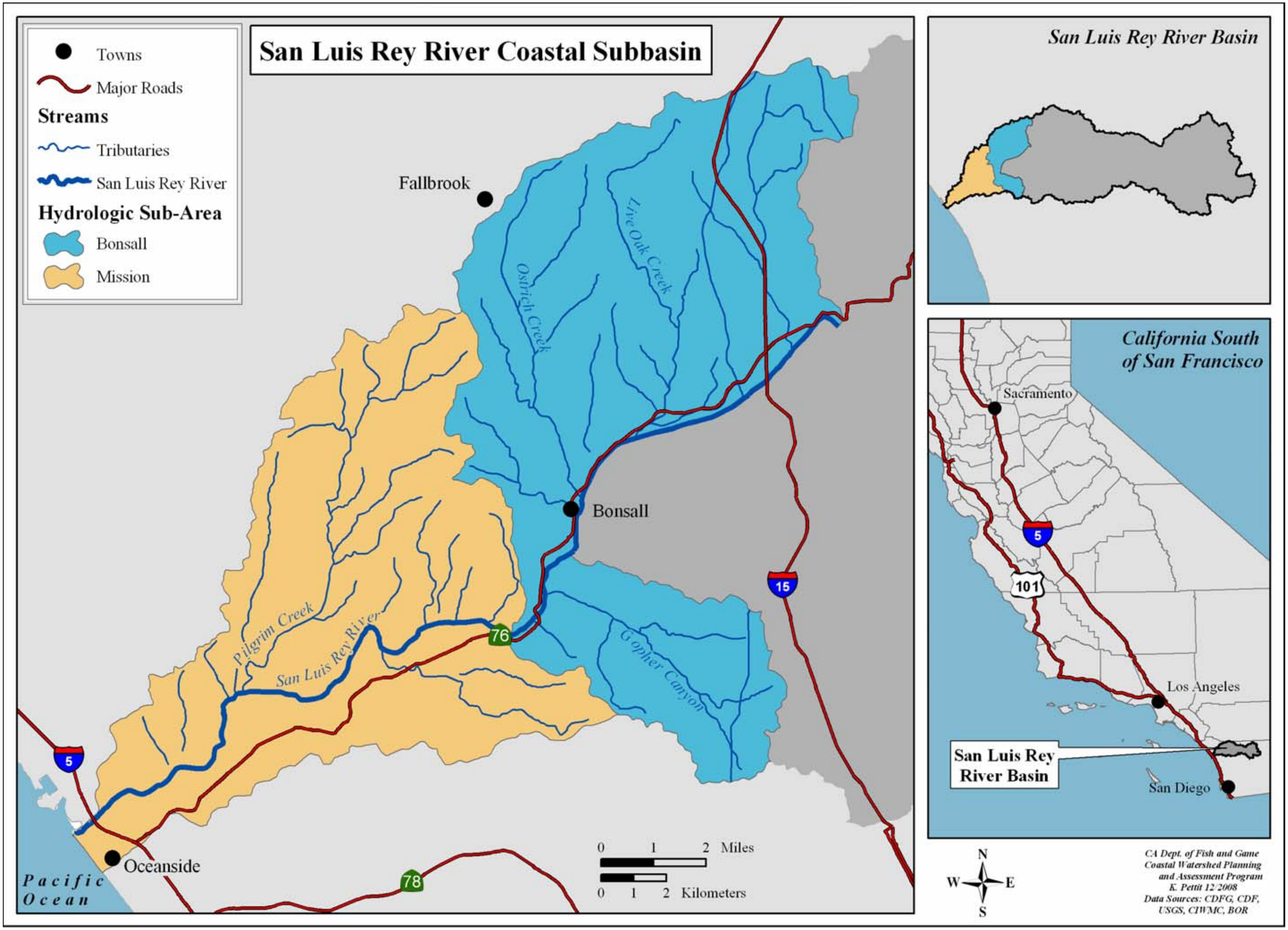
As a result of population growth in the subbasin the river, its stream channel and the surrounding riparian have been the most altered and managed area in the basin. The channelization of the river, manipulation of riparian vegetation, draining and downsizing the estuary, and utilizing numerous wells throughout the subbasin have cumulatively changed the form, function, and habitat of the river and its estuary.

An adult steelhead was observed in the SLR River on two separate occasions during the CDFG 2007 habitat typing surveys. This fish was observed on May 2nd and May 8th, 2007, at RM 7, approximately ½ mile downstream of College Avenue in Oceanside. Due to the lack of coordinated survey efforts and the fact that CDFG has not surveyed the lower SLR River since the 1940s, there is minimal information available on the presence of steelhead in the Coastal Subbasin. Only a few sightings have been reported within the subbasin since the mid-1940s.

Hydrology

The Coastal Subbasin is made up of one complete CalWater Unit, Mission, and the majority of the Bonsall CalWater Unit (Figure 2). There are four named tributaries (Table 1) and 133 permanent and intermittent stream miles in this subbasin. A majority of these stream miles are intermittent. The mainstem SLR River is a second order stream, using the Strahler (1964) classification. During typical rainfall years, the mainstem in the Coastal Subbasin will retain surface flows until the late summer with portions of the river flowing year round (Basin Profile, Figure 6). The tributaries are intermittent or first order streams. Flows in tributaries are affected by agricultural, landscaping, and urban runoff. Drainage areas in smaller, unnamed tributaries range from less than three square miles to the 102.5 square mile SLR River within the Coastal Subbasin.

Figure 1. The SLR River in Oceanside, Interstate 5 is in the background.



CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 12/2008
Data Sources: CDFG, CDF,
USGS, CIWMC, BOR

Figure 2. Coastal Subbasin locator map and CalWater Units.

Table 1. Major streams in the Coastal Subbasin.

Stream	Tributary to	River Mile	Drainage Area (square miles)	Stream Order	Permanent (miles, in Subbasin)	Intermittent (miles)
San Luis Rey River	Pacific Ocean	--	102.5	2	19.0	2.1
Pilgrim Creek	SLR River	4.9	19.5	1	7.1	2.5
Gopher Canyon	SLR River	12.5	11.5	n/a	0.0	5.5
Ostrich Creek	SLR River	14.8	11.6	1	3.2	4.1
Live Oak Creek	SLR River	16.3	12.5	n/a	0.0	7.8

Geology

This basin is predominately underlain by plutonic rock types, “granitic rock” of the Peninsular Range Batholith that intruded into older marine sediments between 90 and 140 million years ago (Figure 3). The plutonic rocks have subsequently been exposed by tectonic uplift and erosion, and only remnants of the older sediments remain atop the granitic rock in the upper portion of this basin. At the lower end of this subbasin sediments from the eroding upper portion of the basin have been deposited in a series of marine and river terraces as well as alluvial fans and valley fill material (Kennedy and Tan 2005).

Table 2. Geologic composition of the Coastal Subbasin.

Lithologic Unit	Percent of Basin
Mesozoic Granitic	63.47
Eocene Sedimentary	17.25
Quaternary Alluvium	10.3
Mesozoic Sedimentary	6.64
Miocene Sedimentary	1.19
Quaternary Terraces	.81
Tertiary Volcanic	.19
Mio-Pliocene Marine	.03

Percent area of basin represents a rough approximation based on GIS mapping.

Compositional Overview

Rock Types

Mesozoic Granitic

Granitic rocks compose the majority of the Coastal Subbasin. They occupy approximately 63.5% of its surface area. They are predominantly Cretaceous (154.5 million through 65.5 million years ago) in age. These rocks are very hard and resistant to erosion, however they do tend to exfoliate to some extent in exposed surfaces and preferentially weather at structural joints. Over long periods of time, granitic rocks tend to decompose, become “soft,” and much less resistant to erosion producing “decomposed granite.” In more advanced forms, the minerals within the granite disaggregate and form “Arkosic Sand” which is made of individual mineral grains disaggregated from the granitic parent rock. These sands are predominantly comprised of quartz and feldspar. This material is highly susceptible to erosion, sliding, and fluvial transport.

Eocene Sedimentary

This rock type makes up about 17.2% of the subbasin. It contains sedimentary rocks ranging in composition from siltstone through conglomerate. The sediments that make up these rock types were deposited on land between 56 and 34 million years ago. The sediments of these rock types range from siltstone through conglomerate and from poorly consolidated to well indurated.

Quaternary Alluvium

Alluvium covers about 10.3% of the subbasin. It consists of unconsolidated sediments that range from clay to boulders and is generally deposited in low lying areas and in floodplains producing a relatively flat landscape. Alluvium is transported and deposited by the streams and makes up most of the bed and banks of the streams. Units of alluvium delineated by the geology map (Figure 3) include sediment currently being acted upon by the streams and bank and flood-plain deposits occasionally acted upon by the streams. If the alluvium within the stream channel is of sufficient depth it can readily transport water via the subsurface pore-spaces allowing stretches of the stream to have subsurface flow.

Mesozoic Sedimentary

Mesozoic sedimentary rocks compose around 6.6% of the subbasin and consist mostly of siltstone, sandstone, and conglomerate and were deposited some 65.5 to 225 million years ago. The original deposition of the sediments that make up these rock types occurred in environments ranging from marine to terrestrial. Some of these rock types have subsequently undergone metamorphism especially in areas in contact with granitic rock types. These sedimentary rock types are generally more susceptible to erosion than granitic rock types.

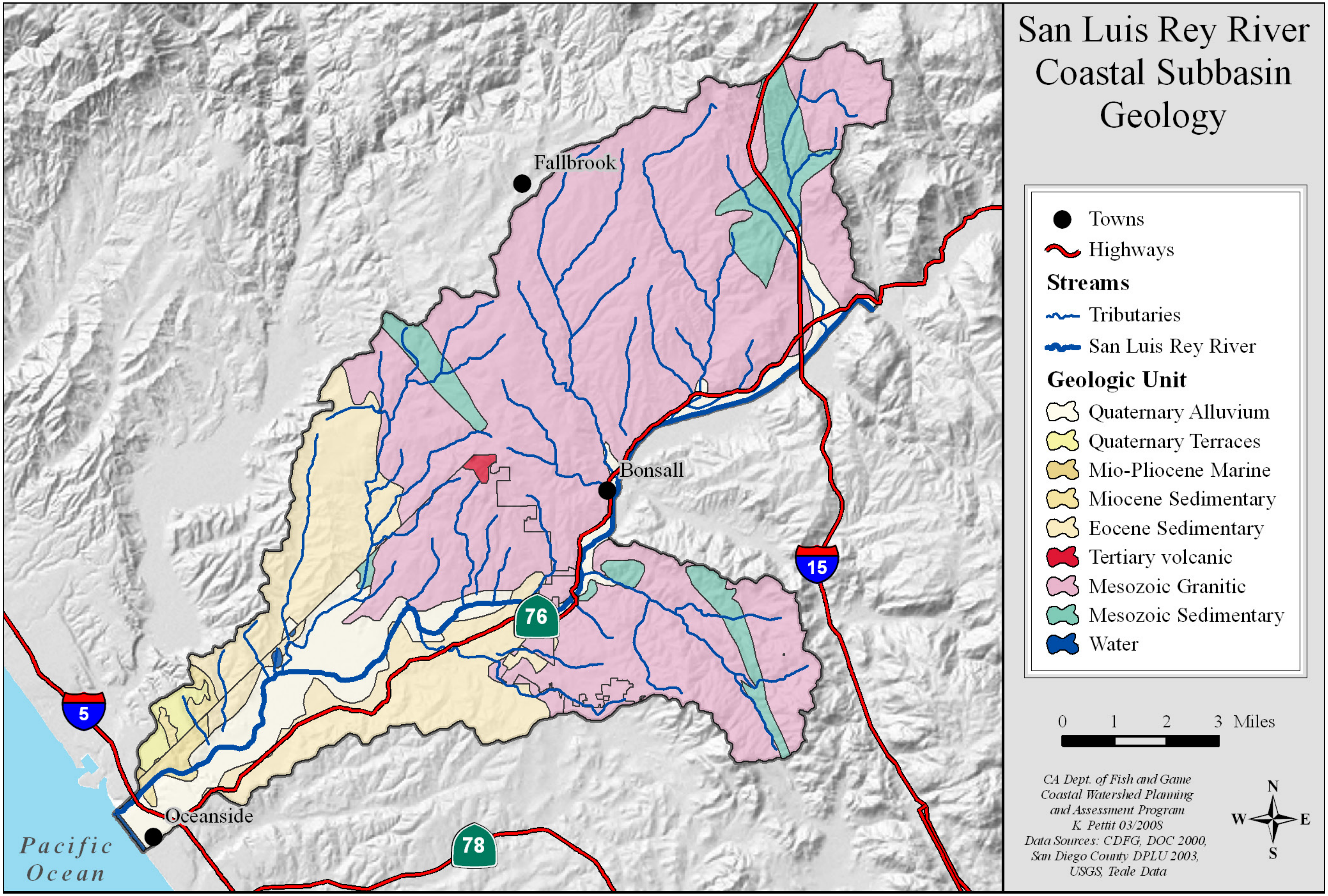


Figure 3. Geology of the Coastal Subbasin.

Miocene Sedimentary

This rock type makes up 1.2% of the subbasin. It consists of sedimentary rocks ranging in composition from siltstone through conglomerate. The sediments that make up these rock types were deposited on land between 23 and 5 million years ago. The sediments of these rock types range from siltstone through conglomerate and from poorly consolidated to well indurated.

Tertiary Volcanic

Tertiary volcanic rocks compose less than 1% of the subbasin. This unit consists of volcanic flows of dacitic composition that were deposited between roughly 65 through 2 million years ago.

Quaternary Terraces

Terrace deposits occupy less than 1% of the subbasin. They consist mainly of marine terraces with minor amounts of river terrace deposits. The marine terraces are made of near-shore and shoreline sediments and wave-cut platforms that have been uplifted above current sea level by tectonic forces associated with the transform plate boundary between the North American and Pacific Plates. The river terraces consist of unconsolidated flood-plain sediments that have been uplifted above the active stream channel. These terrace deposits are prone to dry ravel and slumping when perched steeply above the stream channel.

Mio-Pliocene Marine

This rock type makes up less than 1% of the subbasin. It is made out of sedimentary rocks ranging in composition from siltstone through conglomerate. The sediments that make up these rock types were deposited on land between roughly 23 and 2 million years ago. The sediments of these rock types range from siltstone through conglomerate and from poorly consolidated to well indurated.

Soils

The underlying bedrock is generally responsible for a soil’s texture and erodability characteristics. The sediment contribution from soils found in the Coastal Subbasin is dependent largely on slope, soil sediment size, consolidation, cohesion, compaction, the type and amount of vegetation cover, land use, and amount, intensity, and duration of local rainfall, and finally time.

The majority of bedrock throughout the subbasin is composed of various granitic rock types (Table 3) producing associated soil types that are in general very well drained and is somewhat prone to erosion and transport by fluvial processes as well as wind. Soils with high sand and silt content are typically more susceptible to erosion than soils with high clay content which exhibit a greater degree of cohesion.

Table 3. Soil types in the Coastal Subbasin.

Soil Type	% of Upper Subbasin	Composition Ranges
Vista-Fallbrook-Cieneba (s1011)	49.32	granitic
Las Flores-Antioch (s1019)	16.9	sandstone
Tujunga-Salinas-Elder (s1001)	14.28	granitic/sandstone-shale
Rock outcrop-Las Posas (s1012)	7.02	granitic/igneous
Sesame-Rock outcrop-Cieneba (s1010)	4.03	granitic
Ramona-Placentia-Linne-Greenfield (s999)	3.74	mixed rock/shale-sandstone/granitic
San Miguel-Friant-Exchequer (s1013)	2.86	metavolcanic/schist-gneiss
Urban land-Marina-Chesterson (s1002)	1.35	marine terrace deposits
Rock outcrop-Lithic Torriorthents (s1021)	.49	granitic/mixed rock

% area of Basin represents a rough approximation based on GIS mapping.

Landslides

Like the other SLR River subbasins, the Coastal Subbasin is mantled with unstable soils. The floodplain in the Coastal Subbasin consists of alluvial material, while the hillsides are often composed of sandstones and other sedimentary materials. Both of these rock composition are susceptible to surface erosion, headwater erosion, gullying, stream bank raveling, and landsliding. This area has undergone tectonic uplift leaving poorly consolidated sediments in the form of marine terraces perched above the stream channels, as well as creating steep canyon walls further up the subbasin (Kennedy and Tan 2005). As tectonic forces push the land up, gravity tries to pull it down, and the result is usually landslides and rock falls. Landsliding is further exacerbated by seasonal rain storms. As the hillsides become saturated, pore pressure between grains becomes greater making them unstable and more prone to landsliding.

Earthquakes and Faults

Although no currently established Fault Zone cuts through the Coastal Subbasin, it is still considered tectonically and seismically active. This subbasin is nestled between the Lake Elsinore Fault Zone to the northeast and the Inglewood/Rose Canyon Fault Zone offshore to the southwest. Both of these faults are right-lateral strike-slip faults that are related to the transform plate boundary between the Pacific Plate and the North American Plate (S/an Andreas Fault System). The Lake Elsinore fault zone is capable of generating earthquakes in the range of M = 6.0 – 7.2 and has an average recurrence interval of 250 years. The Inglewood/Rose Canyon Fault Zone is capable of generating earthquakes in the range of M = 6.5 – 7.5 (SCEDC). Ground shaking generated by earthquakes can trigger rock falls and landslides that deliver large amounts of sediment to the streams. The 1994, Northridge Earthquake, whose epicenter was located 20 miles northwest of downtown Los Angeles (M = 6.7), triggered in excess of 11,000 landslides in a 6,200 square mile area (USGS) in similar terrain.

Fluvial Geomorphology

The Coastal Subbasin is considered a depositional reach because the mainstem has less than a 4% slope. Sediment erodes from the steeper hillsides and is brought by tributaries entering the mainstem in this subbasin as well as from the mainstem that transports the sediment from upper subbasins.

The most recent stream surveys of four reaches in the Coastal Subbasin found Rosgen channel types DA and F (Table 4*)*. These reaches were on the mainstem of the SLR River. Type DA reaches have multiple channels that typically are narrow and deep with expansive, well vegetated floodplain and generally have associated wetlands. They have very gentle relief with highly variable sinuosities and stable stream banks. Type F stream reaches are wide, shallow, single thread channels. They are deeply entrenched, low gradient reaches and often have high rates of bank erosion. Type F reaches flow through low-relief valleys and gorges, are typically working to create new floodplains, and have frequent meanders (Rosgen 1994).

Nearly half of the 19 mainstem miles in the subbasin have been artificially confined with the channelization of the lower river. This has effectively converted this reach of the river from a distributary, meandering flow regime into a channelized flow regime to accommodate for agriculture and residential growth. Channelization creates a change in both the sediment budget and hydrologic flow regime since the river is disconnected from its floodplain. Typically, rivers are described by their diversity of meanders, pools, riffles and runs; but when a river or stream is channelized, the diversity of habitats and channel roughness is reduced. Roughness can be described as channel features that slow water velocity, create a diversity of habitat types, and form and maintain a channel that is appropriate for the amount of discharge, suspended sediment, and bedload. The reduction in roughness in the channelized portion of the SLR River explains the lack of pools and relative uniformity in habitat types (see current conditions, p. 18).

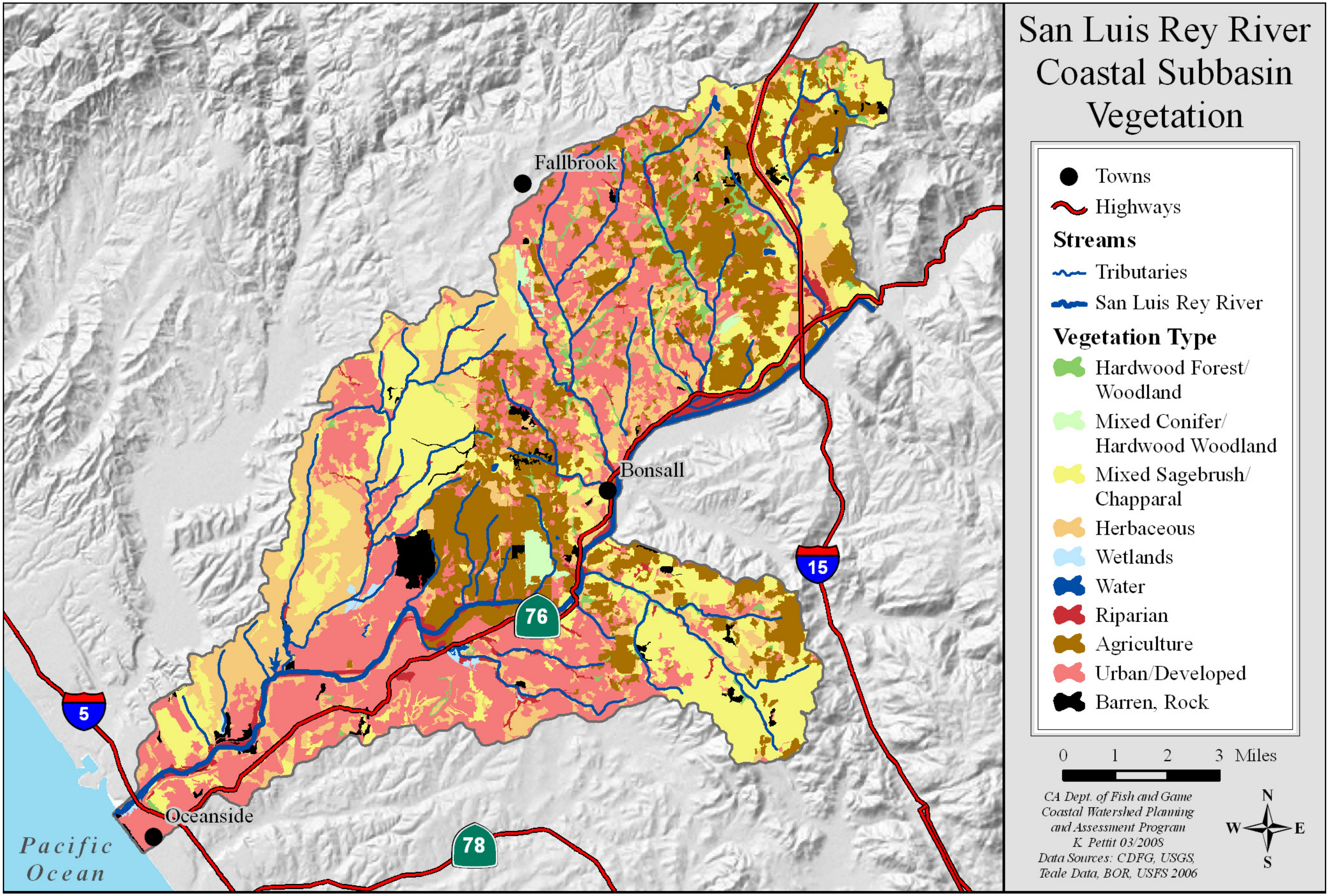
Table 4. Channel types in surveyed streams of the Coastal Subbasin

Stream	Reach	Length (feet)	Channel Type
SLR River	1	31,325	DA5
	2	17,952	F5
	3	19,702	F5

Vegetation

The predominant vegetation cover type as described by the USFS CALVEG data is urban/development, covering approximately 28.5% of the subbasin (Table 5). This is due to the large urban/residential areas occupied by the cities of Oceanside, Vista, Fallbrook, and Bonsall. With the exception of Valley Center in the Southern Subbasin, none of the other subbasins contain any significant urban/residential areas. Mixed sagebrush/chaparral is the second most abundant vegetation cover type at 21.5 %, followed closely by herbaceous with 20.5%.

While agriculture is listed as the fourth most prevalent vegetation cover type at 19%, this figure does not reflect the overall percentage of acres dedicated to the growing of crops for livestock. Within the Coastal Subbasin, pastures used for grazing for livestock may not be included in this vegetation designation since land use is often difficult to remotely ascertain. For this reason, it can be assumed that areas mapped as annual grasslands may also be agricultural in nature; therefore, the agriculture vegetation cover type may compose similar or even a greater number of total acres than the urban/development type. Although, urban and residential areas continue to expand, decreasing the amount of farm land in the subbasin. The impact of agriculture and urban/residential areas in the subbasin are described further in the Land Use Section.



San Luis Rey River Coastal Subbasin Vegetation

CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 03/2008
Data Sources: CDFG, USGS,
Teale Data, BOR, USFS 2006

Figure 4. Vegetation of the Coastal Subbasin.

Table 5. Vegetation of the Coastal Subbasin. These statistics exclude the classification of water.

Vegetative Cover Type	Percent of Basin	Primary Vegetation Type	Percent of Cover Type
Urban/Development	28.5	Urban/Development	100
Chaparral/Scrub	21.5	Basin Sagebrush	0
		Buckwheat	0
		California Sagebrush	72.0
		Ceanothus Mixed Chaparral	0
		Chamise	0
		Lower Montane Mixed Chaparral	27.5
		Manzanita Chaparral	0
		Red Shanks Chaparral	0
		Upper Montane Mixed Chaparral	0
		Other	0.5
Herbaceous	20.5	Annual Grasses/Forb Alliance	90.7
		Non-Native/Ornamental Grass	7.6
		Perennial Grasses and Forbs	1.7
Agriculture	18.9	Agriculture	0
		Orchard Agriculture	77.0
		Pastures and Crop Agriculture	23.0
Riparian	4.3	Baccharis (Riparian)	2.3
		Fremont Cottonwood	0.2
		Riparian Mixed Hardwood	23.3
		Riparian Mixed Shrub	23.8
		Willow (Tree and Shrub)	49.8
Hardwood Forest/Woodland	3.0	Black Oak	0
		California Sycamore	2.8
		Canyon Live Oak	0
		Coast Live Oak	80.0
		Engelmann Oak	0
		Eucalyptus	11.7
		Interior Mixed Hardwood	0
		Non-native/Ornamental Hardwood	5.4
Barren/Rock	1.8	Barren	6.3
		Tilled Earth	22.7
		Urban related bare soil	71.0
Mixed Conifer/Woodland	0.77	Bigcone Douglas - Fir	0
		Coulter Pine	0
		Mixed Conifer – Fir	0
		Mixed Conifir - Pine	0
		White Fir	0
		Nurseries	100
Water	0.34	Water	100
Wetlands	.33	Tule – Cattails	100
		Wet Meadows	0

Data from CALVEG,USFS

Non-Native Plants

Probably because many non-native plants first become established in the coastal areas of California, their numbers tend to decline with increasing elevation and distance from the coast (Stephenson and Calcarone 1999). This is evident in the SLR River Basin as exotic plant species are most dominant in lower elevation areas within the western portion of the watershed (Figure 4). Currently, there are two plant species that represent the greatest threat to the Coastal Subbasin in terms of area occupied, potential to spread, impact to the quality and quantity of native habitat, and problems they pose to land managers: giant reed

(*Arundo donax*) and salt cedar (*Tamarisk spp*.). Among the many detrimental impacts, these invasive plants occupy habitat that normally has little vegetation, such as the SLR River's sandy channel bed in the Coastal Subbasin. Their presence changes the habitat in a manner that is potentially detrimental to the native fauna, such as the endangered Arroyo southwestern toad that utilizes open areas. See Invasive Species Management section in the Basin Profile (p. 33) for a more detail discussion.

The Mission Resource District, working with the SLR Weed Management Area, as of August 1, 2007, had treated approximately 292 of 507 acres of *Arundo* in the watershed, mainly in the mainstem and some tributaries (http://smslrwma.org/). Although, due to the Corps long-term Operation and Maintenance Plan in Oceanside along the concrete-lined channel, a much larger area of exotic and native plant species will be treated and added to these totals. In late February 2008, the Corps began removing the majority of native and non-native vegetation inhabiting the banks of the SLR River just upstream of the Oceanside Harbor. The vegetation removal, as planned, will continue eastward, depending on weather and stream flow conditions. This first phase of a multiple phase plan concluded on March 15th 2008, the commencement of the breeding season for federally endangered birds, such as the least Bell's vireo and the southwestern willow flycatcher. Vegetation removal resumed in the fall (end of the breeding season) of 2008 and continued to remove the majority of the vegetation, native and non-native, located between the leveed river banks.

Land and Resource Use

Historic Land Use

Prior to European settlement, the basin was inhabited by the Shoshonean Indians which comprised the Luiseño people. As described in the Basin Profile, the SLR River was a prominent natural feature of the Luiseño territory providing the residents with subsistent food sources that included ocean and freshwater fish and shellfish, a wide variety of plants and seeds, birds and small to large mammals available in the riparian habitat and from surrounding areas (Lettieri-McIntyre Associates 1995). The Spaniards arrived in the late 1760s and shortly afterwards established missions, including the Mission de San Luis Rey de Francia located just east of Oceanside. History and politics were to see the decline of the mission in the 1840s, but the area's advantages were common knowledge by this date as a greater number of homesteaders continued to populate the area. With the completion of the Southern California Railway in the 1880s and the Highway connecting Los Angeles with San Diego in the 1920s the area continued to expand. World War II saw the transformation of Oceanside from a small town to a modern city with the establishment of Camp Pendleton, the nation's largest Marine Corps Base, on its border (http://www.ci.oceanside.ca.us/).

Agriculture became a prominent feature of much of the area outside the developing cities of Oceanside and to a lesser extent, Vista. Aside from Oceanside, the rest of the basin experienced rather moderate growth from World War II till the 1990s when the region, including San Diego County, experienced a housing boom that continued until the recent economic downturn.

Agriculture

Agriculture was the most significant historic land and resource use in the basin. Beginning with the grazing of cattle, sheep and horses around the San Luis Rey Mission, agriculture grew throughout the basin. As annual grasses became established, replacing perennial native grasses, livestock numbers declined dramatically. Before water was made widely available in the l950s (through imported Colorado River water), most agriculture was limited to dryland crops. Farming of grain and grain hay developed and expanded on homestead lands around Fallbrook, Bonsall, and Oceanside (SLR Watershed Council 2000). Extensive planting of olives in the 1880s around Fallbrook and Bonsall eventually gave way to the establishment of citrus orchards in the 1920s. Imported water supplies provided the needed resources for many intensive agricultural enterprises in the coastal basin and throughout the watershed such as truck crops, flowers, and nurseries.

Gravel Mining

Gravel mining operations have been an important industry in the basin. The SLR River has provided the San Diego region with a major source of sand, gravel, and aggregate. The river contains particularly valuable deposits of quality sand that requires little processing because the river's fluvial process have ground and sorted the material (Micheli 1994). This sand has been used by the construction industry for a variety of concrete and asphalt applications. Sand mining has long caused major disagreements in the watershed and was a dominant factor in the initiation of a general resource plan for this area.

During the past several decades multiple sand mining operations have been active on the river, almost exclusively in the Southern and Northern subbasins.

Beginning with the H.G. Felton Materials Company, which in 1969 was issued the first Major Use Permit for a sand mining operation on the SLR River, multiple sand mining operations have been active on the river, from just east of Bonsall to Pala. As development in San Diego County increased, including the housing construction boom during the 1980s, sand and gravel mining became the most economically important industry in the watershed (SLR Watershed Council 2000). At one time, there were thirteen operations. Of more recent significance was the termination of the Felton Mine site operated by Hansen Aggregates. This was an in-stream mine that encompassed 225 acres and mined an average of 600,000 tons of sand per year during the late 1990s and early 2000s. This sand accounted for about 20% of all the concrete use in San Diego County (Chester 2000). Their Major Use Permit expired in 2005 and the site was dedicated as open space.

The current condition of the SLR River, particularly in the Coastal Subbasin, demonstrates that the previous traditional approaches to regulating in-stream mining have failed to adequately protect river resources over the long term. The extraction of sand and aggregates has contributed to a range of significant environmental impacts. The cumulative effect of the mining operations has been to lower the overall bed elevation of the river (Micheli 1994). The process of channel degradation was accelerated by upstream and downstream erosion due to excavation of deep pits, some 80 feet in depth, in the active river channel. The mining contributed to a shift in channel morphology from a shallow and braided channel, sinuating back and forth across the broader portions of the floodplain as it deposits sand and creates scrub-shrub habitat, to a channel that is now in some places deeply incised with steep erodible walls (Micheli 1994). This channel degradation and streambed erosion has compromised bridge supports and exposed buried water and natural gas lines. Biologically, the degraded streambed causes the following impacts: lowering of groundwater levels, loss of riparian vegetation due to erosion and die-offs from the lack of water, a minimal low-flow channel that implicates a loss of deep holding pools for adult and juvenile steelhead migration, loss of cover and complex habitat for juvenile steelhead.

In addition to effecting riverine ecosystems, sand mining also contributes to a reduced supply of sand transported through the mouth to replenish the beaches of Oceanside (Kondolf 1993). Combining the effects of the Henshaw Dam impounding sediment, the mining produced an even larger sediment deficit. According to Kondolf (1997), the five gravel mines that were in operation in the 1990s, within 8km of the Highway 395 Bridge, they extracted a permitted volume of approximately 300,000 m^3/yr. This was about 50 times greater than the estimated post-dam bedload sediment yield, further exacerbating the coastal sediment deficit.

The SLR River is one of several key locations in the county that can provide the sand and gravel resource. However, sand mining has been shown to have a costly effect through infrastructure degradation, loss of environmental resources in the watershed, and a large reduction in beach sand. If future sand mining operations were to occur in the basin some of these impacts could be minimized by stricter monitoring and compliance of permit requirements by governmental enforcement agencies and the mining operations themselves.

Current Land Use

Agriculture

Agriculture is the fourth largest industry in San Diego County (SLR Watershed Council 2000). The SLR watershed is a major agricultural area in San Diego County. The warm coastal climate of the Coastal Subbasin makes it ideal for the growing of tomatoes, avocados, citrus fruit, herbs, nursery stock, and flowers. Numerous small and large-scale farms populate the subbasin, including land adjacent to the river.

The large agricultural production in the basin may contribute to reduced water quantity and quality. Although many agricultural producers use water from imported sources (the Colorado River and State Water Project) (SLR Watershed Council 2000), water pumps were observed during CDFG 2007 field surveys in or near the flood plain within the Coastal Subbasin. These pumps may divert groundwater, which normally contributes to SLR River flows, to assist crop production.

The use of pesticides in San Diego County is closely scrutinized by the local Agricultural Commissioner’s office, and growers must be concerned with issues involving use of pesticides. Growers are increasingly required to reduce and capture runoff water, re-use tailwater and utilize other best management practice to minimize the effects of agriculture on water quality and water bodies in the areas where they farm. See Agriculture section in the Basin Profile (p.42) for further details of the impacts of agriculture.

Urbanization

The major population centers in the watershed are located in the Coastal Subbasin, where over two-thirds of the watershed population resides. The City of Oceanside, Vista (near the coast), and the community of Fallbrook, located in the north central portion of the Coastal Subbasin contain a majority of the population in this subbasin. By the year 2020, the City of Oceanside is expected to add 41,000 people, Vista 13,000 people, Bonsall 8,000 people, and Fallbrook 10,500 people. These substantial increases in populations will put additional stress on the natural resources and further encroach on native habitats as additional developments will occur to provide the necessary services and infrastructure to accommodate the enlarged population in the subbasin.

The increase in urbanization and impervious surfaces, as well as the removal of riparian vegetation has significantly affected the watershed's ability to respond to precipitation, which can increase urban flooding. Consequently, urbanization alters the rates of infiltration, evaporation (the conversion of water from a liquid into a gas), and transpiration (transfer of water from plants to the atmosphere) that would otherwise occur in a natural setting. The replenishing of groundwater aquifers is also effected and does not occur, or occurs at a slower rate (SANDAG 2004). Together, these various effects determine the amount of water in the system and can result in extremely negative consequences for river watersheds, aquifers, and the environment as a whole.

Streams in urban areas often belong to the category of most degraded. Urban planning must consider where water flows and the impacts of development on the water resources, including drinking water. In a natural setting, runoff water flows through vegetated land areas and other pervious services, which filter water before entering reservoirs. Interruption of this process can affect the quality and quantity of drinking water. Additionally, too much infiltration of urban runoff can cause pollutant build up in underground aquifers, which can negatively impact groundwater supplies (SANDAG 2004). Large sums of money could be spent restoring urban streams. However, the proper management of storm water is a prerequisite for successful restoration of urban streams. Urban stream restoration should not be undertaken unless integrated with broader catchment management strategies, and when design options are so constrained that significantly improving ecological conditions in streams is unrealistic (Bernhardt & Palmer 2007). In the case of the SLR River, the SLR River Watershed Urban Runoff Management Program (SLR River Watershed URMP), contains collaborative plans and efforts to reduce the impacts of urban activities on receiving waters within the SLR River Watershed to the maximum extent practical (PBSJ 2003). Utilizing this plan in conjunction with urban restoration projects could provide the most effective means of restoring and maintaining stream habitat in the lower SLR River.

Currently, there are numerous on-going or proposed projects associated with urbanization and land-use developments that will have potentially significant impacts on the subbasin's natural resources and habitats.

<u>Housing Projects:</u> While there are numerous housing development plans, a proposed 1,244-home development, north of California Highway 76 just east of Interstate 15, is the largest potential development near the river. A housing project of this size in addition to other developments would require additional water supplies that may be taken from wells near the river, potentially lowering the groundwater table. Moreover, increased housing would most likely require a new wastewater facility or an expansion of the current facilities, which would require more water and potentially affect the water quality of the river or tributaries.

<u>Highway Widening:</u> Caltrans has a project to widen, improve, and realign Highway 76 as part of the high-priority, Early Action Program of the TransNet transportation improvements funding program. Highway 76 from west of East Vista Way to I-15 is scheduled for widening to a four-lane roadway by 2012. As proposed, Caltrans' planning and design of Highway 76 improvements would affect riparian areas and potential water quality and sediment delivery along the SLR River.

<u>Gregory Canyon Landfill:</u> The proposed Gregory Canyon Landfill is located primarily in the Southern Subbasin, three miles east of Interstate 15 and south of Highway 76 (a portion of the project site extends into the Rice Canyon and Gomez Creeks watersheds, north of the highway). This 1,770-acre landfill would most likely have significant impacts not only in Southern and Northern subbasins but also downstream in the Coastal Subbasin. Proponents of the landfill, primarily the project proponent and the County, have argued for over a decade that San Diego County could run out of space in the near future to accommodate its solid waste. This proposed landfill has caused a considerable amount of community concern, from a broad range of interest groups. Organizations that have opposed the landfill include but are not limited to: The Pala Band of Mission Indians, the Federal Bureau of Indian Affairs, the City of Carlsbad, The City of Oceanside, the San Diego Water Authority Board of Directors, San Diego Baykeeper, Riverwatch, the Natural Resources Defense Council, and the SLR

Watershed Council. The SLR Watershed Council has voiced its concerns on the landfills impacts to air quality, water quality, transportation, wildlife, cultural and historical resources (SLR Watershed Council 2000). The Council was particularly concerned with the location of the landfill with respect to the aquifer of the San Luis Rey River (SLR Watershed Council 2000). The potential exists for the landfill to leak, causing contamination of one of San Diego County's few reliable sources of groundwater (see Local Water Supply Development below).

A lawsuit was filed in January of 2009 against the County of San Diego and Gregory Canyon Ltd. in which the plaintiffs (Riverwatch and the Pala Band of Mission Indians) asserted that the Solid Waste Facility Permit for the landfill has been rescinded and therefore cannot be modified. The case was consolidated with a CEQA case involving the same facility and litigants. A hearing on a planned demurrer by Gregory Canyon, Ltd. and the County of San Diego Department of Environmental Health has been scheduled for June 26, 2009 (http://www.sdcounty.ca.gov/deh/waste/chdgregory.html.).

Currently, approval of the proposed landfill depends largely on whether the court decides if water supply for the landfill has been properly addressed. In order to operate the landfill, nearly 200 acre-feet of water per year is needed to help control dust and odor (Pfingsten 2008). Any agreement would require the water supplier to continuous deliver large amounts of water over a 60-year period, regardless of drought conditions or increased demand from other users. Most recently (May, 2009), the Olivenhain Municipal Water District board voted to not supply recycled water to Gregory Canyon. The operator will therefore have to identify another source or sources of water in order to obtain a modified solid waste facility permit, and the County will have to complete any necessary CEQA analysis concerning those sources (http://www.sdcounty.ca.gov/deh/waste/chdgregory.html.).

Local Water Supply Development: With the intent on diversifying their water supply, the San Diego County Water Authority and the City of Oceanside agreed to drill two new wells to help supply the City of Oceanside. Currently the city receives about 7% of the city's need from wells in the basin. Once these new wells are up and running as well as other wells that awaiting proper filtration installation, this figure will increase to about 20% of the city's needs (Burge 2007). This increase equates to pumping 2.4 million gallons per day to 8.4 million gallons per day once the proper carbon filters are installed and public health permits are granted (City of Oceanside 2007). The new wells are located a significant distance from the current riverbed and it seems unlikely that these new wells with affect surface flows of the SLR. On-going monitoring of these wells is necessary to minimize any impact to the groundwater table. Any lowering of the groundwater table and diminished surface flows could, in turn, impact wetlands and riparian areas and may lead to a saltwater intrusion in the lower river. The City of Oceanside monitors the production wells weekly and the monitoring wells monthly using a sounding device that measures the distance in feet from the surface to the top of the water in the well. This ongoing monitoring will be essential in determining alterations in water quantity in the lower portion of the SLR River. See Water Use section in the Basin Profile (p. 50) for further discussion.

Mining

Although there are no current mining operations within the subbasin, the Rosemary's Mountain Quarry site is set to begin operations in 2009/2010 and is projected to sell one million tons of sand and gravel a year for 20 years (Pfingsten 2008). This 94-acre mine, of which 38-acres will be mined, is located on the boundary of the Coastal and Northern Subbasins, 1.5 miles east of Interstate 15 and Highway 76. The mine will increase vehicle traffic on Highway 76 with a projected 452 daily truck trips added to the already busy highway (Pfingsten 2008). To compensate for the additional traffic the mining company, Granite Construction, will be widening and straightening 1.3 miles of the highway. While the quarry will provide the area with what some state officials say are needed aggregate supplies within areas of nearby development (Jones 2007), the quarry is located adjacent to the SLR River and there is a concern of its operations affecting the air quality, sediment input and water quality of the river. Strong site specific permit compliance is needed to minimize the impacts of the operations on the environmental quality of the river and local habitat.

Waste Water Facilities

The Rainbow MWD's sewage treatment system has very nearly reached capacity, with less than 50 remaining EDU available for new connections (Rainbow MWD 2006b). The Rainbow MWD has identified three possible solutions to the sewer capacity limits: (1) do not allow future projects/development rights to the sewer system, (2) construct a wastewater treatment plant for treatment of sewage, or (3) upgrade the existing Oceanside Wastewater Treatment Plant to allow for more treatment capacity (Rainbow MWD 2006a).

The San Luis Rey Wastewater Treatment Plant, at

3950 N. River Road, provides wastewater treatment and disposal for 80% of the City of Oceanside's water, essentially covering all areas east of Interstate 5. The La Salina Wastewater Treatment Plant serves all areas west of Interstate 5, downtown, and along the coast.

Recreational

Numerous recreational opportunities exist in the Coastal Subbasin along and near the river. A multi-use path for runners, hikers, bikers, etc. extends 7.2 miles from near the Interstate 5 river crossing to the east end of College Avenue. This path receives moderate to heavy use all year round. Current plans are underway to extend the bike path a couple of miles further east. Horseback riding trails are available east of the Bonsall area to Interstate 15 on both sides of the river. Several parks, Guajome and Live Oak, which provide camping, fishing, and habitat protection are found within the subbasin. There are an increasing number of golf courses being developed as a part of new housing developments. These golf courses can contribute to water quality problems with the large amount of pesticide and fertilizers that go into the management of these large turf areas. Golf courses tend to use large amounts of water and can exacerbate erosion or water quality problems with runoff from these courses.

A San Luis Rey River Park is currently in the planning stages. This proposed regional park would span 8.5 miles along the SLR River corridor between Interstate 15, west to the old Bonsall Bridge. The creation of this park aims to incorporate a balance of recreation preservation/restoration/interpretation of the SLR River's sensitive resources to serve the Fallbrook and Bonsall Community Planning Areas (CPAs) and the larger North County region (Held, 2008 Draft). The County plans to develop the Park with a goal of designating about 40 acres of San Luis Rey River Park as active use areas and with passive use sites, multi-use trails, and about 1,600 acres of natural preserve. Some land acquisitions have occurred, but additional private lands need to be purchased. These private lands for the Park would be acquired from willing sellers only.

Fish Habitat Relationship

Fishery Resources

Prior to the 1940s, steelhead trout were found in the SLR River in sufficient numbers to provide the local region with recreational fishing opportunities. This fishery included areas of the Coastal Subbasin, such as the estuary. In addition to anecdotal accounts, fish presence (steelhead) in the Coastal Subbasin was also documented by field observations (See Basin Profile, Fishing and Historic Accounts of Steelhead Runs p. 51, for more detailed information). It is unknown if steelhead used any of the tributaries in the subbasin; academic research did not reveal any historical observations and historical stream surveys were very limited. Since the mid 1940s there have been very few reports of steelhead sightings in the lower river or any of the tributaries in the Coastal Subbasin; however, no annual, or even periodic, systematic surveys have been conducted within the Coastal Subbasin.

During the 2007 CDFG stream habitat surveys, an adult steelhead was observed in the mainstem, approximately 7 miles upstream from the estuary. While the winter and spring of 2007 was considered a low water year, this adult steelhead (estimated at 20-24 inches in length) managed to enter the SLR River from the Pacific Ocean and swam upstream approximately seven miles. At the time of observation, the river's low flow conditions would have prevented it from continuing upstream over the boulder rip-rap configuration at the College Avenue Bridge and similarly downstream at the Douglas Bridge. Prior to this sighting, the last report of a steelhead (adult) in the Coastal Subbasin was in 1997 by a consultant working in the mainstem. Its location in the river is unknown. Other than limited, one-day seining surveys in the estuary in 2000 and 2003, no other focused surveys for steelhead have occurred in the Coastal Subbasin since the 1940's. In recent years, steelhead have not been detected in any of the Coastal Subbasin tributaries. Even though there has been a lack of focused surveys in these tributaries, it seems unlikely that steelhead/trout would utilize the majority of these streams due to insufficient stream flows, the lack of suitable habitat, fish passage barriers, and water quality issues. However, field surveys utilizing appropriate protocols are necessary to confirm the presence or absence of steelhead/trout.

In addition to steelhead, the Coastal Subbasin, specifically the estuary, is host to numerous other marine or estuarine dependent fish species, such as deepbody anchovy, topsmelt, arrow goby, and cheekspot goby to name a few (see Table 10, in the Basin Profile for a complete list). Many of these fish species depend on the estuarine environment to complete one of more stages of their lifecycles. The federally endangered, tidewater goby (*Eucyclogobius newberryi*), was once present in the SLR estuary and in the Santa Margarita estuary to the north. The last museum collection of the tidewater goby in the San Luis Rey River occurred on 11 January 1958 (MBC Applied Environmental Sciences 2000). Although the river has been surveyed for tidewater goby on several occasions in the 1970s and more recently in 2000 and

2003, no tidewater gobies have been noted. However, tidewater gobies are known to recolonize sites that are in close proximity to other sites, particularly during winter high flows (Lafferty et al. 1999a,b). Thus, the presence of tidewater gobies in the Santa Margarita River (last detected in 2000) and in San Mateo Creek, just north of the Santa Margarita River (identified in 2003), coupled with the Pacific Street bridge replacement at the river's mouth, could allow them to access the SLR River during a wet year (MBC Applied Environmental Sciences 2003).

Estuary

The SLR estuary, which once sprawled more than 2,258 acres, has been significantly altered by agriculture and urban development within the floodplain and watershed and mineral and aggregate extraction in the channel (http://ceres.ca.gov/wetlands/geo_info/so_cal/san_luis.html). According to an 1893 USGS map of the lower portion of the river, 2200 acres were designated as high marsh and the remaining 58 acres were labeled as low marsh. Prior to human intervention, there were seasonal breakthroughs of the sand berm in the winter, followed by closures of the river mouth by accumulating sand in the late spring and throughout the summer. Winter flows would often scour out much of the lagoon and bring in fresh sediments and nutrients. When the sand bar closed in the spring, the lagoon would be relatively low in salinity due to sufficient freshwater inflow to keep the salinity down. In addition to the natural hydrologic regime, intermittent connections during wet winters existed with the lagoon of the Santa Margarita River in the early 1900s (MBC Applied Environmental Sciences 2000).

The estuary and its surrounding floodplains have been utilized by humans for the past hundred years, altering the size and function of its associated ecosystems. Probably the most significant anthropogenic related impact to the estuary was the development of the Oceanside Harbor in early 1960s. In order to create the harbor, the estuary and river was re-contoured, dredged, levies were built, and vegetation was removed. Filling in of the north and south shores and construction of the Pacific Street berm inland of the original barrier sand bar made the lagoon long and narrow rather than wide and parallel to the barrier beach as it was historically (MBC Applied Environmental Sciences 2003). Extensive agricultural activities in the lower watershed, including the former floodplains, coupled with groundwater extraction to supply Carlsbad and Oceanside drinking water, altered the water quality and water chemistry of the lagoon. The overall water chemistry and water quality was further changed when the City of Oceanside discharged treated wastewater directly into the river from 1958 to 1974.

Presently, the estuary has been downsized to an approximately 164 acre floodplain (Figure 5) with very little native habitat. The vast majority of the surrounding floodplain is now privately owned. The Oceanside Harbor and lower eight miles of the river is owned by the City of Oceanside. Most of the native vegetation has either been removed or displaced by exotic, non-native vegetation. Boulders line portions of the southern banks of the lower estuary, leaving that area devoid of vegetation. Interstate 5 and the railroad dissect the estuary. Constriction of the estuary/lagoon increased scouring with flood events and severely decreased the amount of lateral shallow or emergent habitat necessary for some fishes and other lower vertebrates. Due to these changes the vulnerability of some populations of fishes amphibians, and reptiles is increased and can lead to extirpation of local populations (MBC Applied Environmental Sciences 2003).

Prior to its removal in October, 2008, the Pacific Street Crossing located at the river's confluence, contained two, large corrugated metal culverts that allowed the exchange of freshwater with the ocean water. While allowing for a year-round tidal influence, these culverts changed the function and habitat quality of the estuary. This continuous exchange often created a saline lens at the bottom of the lagoon; whereas prior conditions, discussed above, kept the salinity at lower concentrations (MBC Applied Environmental Science 2003).

Despite the modification of the mouth of the lagoon with the former Pacific Street Bridge configuration allowing this continuous exchange between saline water with freshwater and the decrease in the lagoon size and overall quality of habitat, biological sampling conducted in the spring (April 21) of 2000 and summer (July 24) of 2003 demonstrated a typical subset of estuarine fishes that have marine adult or larval stages (MBC Applied Environmental Sciences 2003). These surveys employed various size beach seines at eight locations from west of the Pacific Street bridge, upstream to just east of the Interstate 5 bridge. The surveys were initiated to determine any potential impacts to the area that might be affected by the bridge replacement project, and to determine the presence of any endangered species or species of special concern within the river, with particular emphasis on the presence or absence of tidewater goby (*Eucyclogobius newberryi*) and steelhead. No tidewater gobies or steelhead smolts were observed during these surveys;

the timing of one of the surveys (atypical period for smolt migration) and presence of exotic predatory species may partially explain the lack of young steelhead. The exotic predatory species, such as largemouth bass, black bullhead, and blue gill, likely contribute to a loss of available habitat in the estuary.

Role of estuaries/lagoons for steelhead

The use of estuaries by southern steelhead has been documented for central California coast streams, but not necessarily for streams further south (USFWS 1998). There are several factors that may explain this lack of documentation. Southern California Coast Steelhead populations are a small fraction of Central Coast populations, making it more difficult to potentially study/identify them in southern California estuaries. Overall, greater development and loss of habitat has occurred in southern California estuaries than in estuaries to the north. It is also important to note that a key factor affecting steelhead use of lagoons is the ability of adults and juveniles to migrate between the freshwater spawning habitat and the lagoon. Due to watershed management practices, which affect the migration corridor, this can be a significant constraint of estuary/lagoon use if there is a considerable distance between the estuary/lagoon and upstream habitats. The effects of droughts would only exacerbate these conditions as fewer smolts may emigrate.

In similar streams in central California, Smith (1994) described lagoon/estuary usage by juvenile steelhead as infrequent due to restrictive up and downstream migration opportunities and that the contribution of an estuary to smolt production probably varies from year to year. Most of steelhead smolt production would benefit from estuary rearing during good water years but receive little to no benefit in periods of drought (USFWS 1998). Previous estuarine studies have shown that growth rates are greater in juveniles utilizing the estuarine environment (Shapovalov and Taft 1954, Smith 1994; cited in USFWS 1998; Bond 2006), but if access is not available, then rearing will occur in the river. A recent study of steelhead in a small central California watershed (Hayes et al. 2008) states that southern coastal estuaries that form lagoons provide the opportunity for trout to achieve the necessary size for marine survival, which heavily influences adult escapement and possibly defines adult production from the watershed. Given the historical cyclic wet to dry weather patterns, it is plausible that steelhead reared in the SLR River lagoon in wet years and in the river or other Basin streams in dry years. In addition to steelhead, tidewater gobies, red-legged frogs, arroyo toads, two-striped and southwest garter snakes, and southwestern pond turtles (all federally endangered, threatened or state species of special concern) all depend on lowland river floodplains and lagoons and were historically present in the lower SLR River (MBC Applied Environmental Sciences 2003).

Figure 5. SLR River Estuary following the removal of the Pacific Street Bridge, December, 2008.

The removal of the Pacific Street Crossing could restore more normal conditions in the lagoon and increase the potential for recovery or reintroduction of a variety of species of fish, amphibians, and reptiles. The return of somewhat natural flows may perhaps serve to enhance a potentially significant halibut nursery and make the area more suitable to tidewater gobies (MBC Applied Environmental Sciences 2003). Although, other factors must be addressed to further enhance the potential for the species to recolonize the SLR lagoon and river. These include the restoration of lateral habitat lost by the filling in of the northern and southern margins, the elimination of predatory exotics, and the reduction of the scouring and other habitat alterations as a result of the river's channelization. A hydrologic/biological study should be developed to study the ongoing effects of the bridge replacement on sediment transport, water quality, lagoon habitat, and include monitoring of estuarine dependent fish species.

Habitat Overview

Historic Conditions

As with most of the basin, there has been a limited amount of stream surveys done in the Coastal Subbasin. Stream surveys were conducted by CDFG as early 1946; however, stream survey efforts were neither specific nor standardized until the 1990s when the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998) was published. Most early observations in the historic stream surveys are not quantitative and have limited use in comparative analysis with current habitat inventories. However, data from these stream surveys provide a snapshot of conditions at the time of survey (Table 6).

The earliest stream survey in this subbasin was a 1946 field survey of the SLR River. This survey generally indicated that the river within the Coastal Subbasin was unsuitable for trout. Much of the river in this section was dry, as numerous pumps in or near the riverbed were noted.

The lack of information on the habitat and presence of steelhead within the Coastal Subbasin, particularly before the completion of water diversions, most notably the Escondido Canal diversion in 1895, and the Henshaw Dam in 1922 makes it difficult to speculate on historical use of the subbasin for steelhead spawning and rearing. Considering the river was located in what was once a large, alluvial floodplain, it seems likely that steelhead used this portion of the river as a migration corridor to more suitable spawning habitat upstream. With perennial river flows prior to the completion of the Escondido Canal diversion, the mainstem would have been more conducive to upstream adult migration and smolt emigration to the ocean. Additional water extractions in tributaries, groundwater pumping, and an extended drought (1940s to mid 1970s) compounded the problem of having insufficient river flows to maintain high quality habitat and allow for fish passage. Considering the documented presence of an extensive riparian area, potentially providing diverse, complex habitat and the occurrence of cooler coastal air temperatures, moderating stream temperatures, the lowland reaches of the Coastal Subbasin may have been utilized as juvenile rearing habitat during emigration to the ocean.

It is unknown whether steelhead utilized any of the tributaries for spawning or rearing within the subbasin. While several large tributaries exist, such as Pilgrim Creek and Gopher Canyon, no annual, or even period, systematic surveys were conducted in these tributaries to detect the presence or absence of steelhead/trout. Whether any of these streams retained perennial flows is also unclear.

Estuary conditions, as described in the Estuary section, were far more suitable for steelhead prior to human intervention as the estuary once encompassed over 2,200 acres and had intermittent connectivity with the Santa Margarita River lagoon to the north. There are anecdotal accounts of steelhead/trout being caught in the Santa Margarita lagoon as well as in the SLR lagoon and it seems more than likely that the area provided excellent rearing habitat for juvenile trout. Figure 6, an aerial photo taken in 1932, displays the former estuary conditions. While the estuary had already been altered, it is evident that far more side channel habitat with abundant vegetation was present, providing excellent nursery habitat for a variety of marine and estuary dependent species.

Figure 6. SLR River estuary in 1932 (Photo courtesy of the City of Oceanside Archives).

Table 6. Habitat observations made in the Coastal Subbasin from 1946-2003.

Stream	Date Surveyed	Source	Habitat Comments	Barrier Comments
San Luis Rey River	09/04/1946	CDFG 1946	Surveyed east of Oceanside to Pala Indian Reservation (approximately RM 7 to RM 23). Stream flow was low with an average depth of 8-10 inches and an average width of 4-5 feet. The water temperature was 68°F. The surveyor reported of numerous pumps in the river and much of the river was dry except for the upper 4-6 miles. Rainbow trout, mosquito fish, and small cyprinids were present; however the trout were most likely observed in the vicinity of the Pala Indian Reservation. The 1946 survey indicated the area within the Coastal subbasin was not supportive for trout.	Escondido Canal diversion, RM 40, and Henshaw Dam, RM 50, were described as complete barriers to fish passage.
	6/20/1975	Swift 1975	"The streambed mainly is sand in the lower reaches. The river is intermittent (from the Escondido Canal) to the vicinity of Bonsall where the flow appears to be permanent. Mosquito fish and a few green sunfish were caught near the Oceanside Airport. Water temp at 3:30 pm was 20°C; dissolved oxygen (ppm) was 5; pH was 7.5; and turbidity (J.U.) was 51.	None described in the lower river
	11/8/1978	CDFG 1978	Fisheries personnel netted and seined approx. 1½ miles of SLR river near Oceanside. The following fish were collected: 8 largemouth bass, 228 bluegill, 37 green sunfish, 11 black bullhead, 1 channel catfish, 327 golden shiners, and "numerous" mosquitofish. Bullfrogs and adult pacific pond turtles (*Clemmys marmorata pallida*) were observed as well as an abundant number of snails (*Physa sp.*) in the river and backwater areas.	No impassible barriers
	04/21/2000	MBC Applied Environmental Sciences (2000)	Survey collection of lagoon from mouth to just upstream of I 5 bridge. Collections demonstrated a typical subset of estuarine fishes that have marine adult or larval stages that can easily enter the lagoon despite culverts at mouth. "Presence of exotic predatory species may partially explain the lack of some native species like killifish, tidewater gobies, and young steelhead. Culverts allow frequent exchange with the ocean, and a saline lens is present in the bottom of the lagoon."	No impassible barriers
	06/24/2003	MBC Applied Environmental Sciences (2003)	Method of survey, collections, and report conclusions coincides with those of 2000 report. Report noted timing of survey occurred most likely after the main-movement of steelhead.	No impassible barriers

Current Conditions

In the Coastal Subbasin, CDFG/PSMFC fisheries crews conducted stream habitat inventories on the entire length of the SLR River with the subbasin, 18.3 stream miles in May, June, and July of 2007 (Table 7 and Figure 7). During the mainstem survey, three tributaries, Gopher Canyon, Ostrich Creek, and Horse Ranch Creek, contained flowing water and were examined for general habitat suitability. Based on the stream habitat conditions at the time of the survey, it seemed unlikely that these streams would be utilized by steelhead; therefore, full habitat inventory protocols were not performed. Other tributaries in the subbasin were not surveyed due to the absence of surface flows or denied landowner access permission.

Gopher Canyon had an approximate flow of 0.5cfs in July of 2007. This low gradient (less than 1% slope) stream was surrounded by agricultural fields and low density housing. Stream flows were most likely attributed to agriculture and residential runoff. Canopy was approximately 50% and provided mostly by deciduous trees and to a lesser extent shrubs. Aquatic plants were prevalent in much of the streambed. Stream substrate consisted almost entirely of sand and was devoid of potential spawning gravels. The stream lacked complexity with only a few, short, and shallow pools. Numerous tree frogs were observed in the lower section, near the confluence of the SLR River.

Ostrich Creek was a low gradient stream whose very low flows were also most likely supplied by agricultural and residential runoff. This creek was very difficult to access and evaluate due to the overgrown vegetation in the stream on its banks. Very little water was present in the creek, streambed substrate was predominantly sand, no spawning gravels were observed, and the creek offered little in the way of habitat diversity.

Stream habitat inventory methods were conducted on the SLR River according to methods determined in the *California Salmonid Stream Habitat Restoration Manual* (Flosi, et al. 1998). Analysis of the SLR River water quality and instream habitat conditions includes the following:

- Canopy Density;
- Habitat Type Categories;
- Pool Characteristics:
- Pools by maximum depth;
- Pool shelter;
- Cobble Embeddedness;
- Water Quality;
- Water Chemistry;
- Waste Water Treatment Facilities.

Table 7. Coastal Subbasin streams surveyed by CDFG, spring 2007.

Stream	Year of Survey	Survey Length (miles)	Percent of Permanent Stream Surveyed	Number of Reaches
San Luis Rey River	2007	18.3	100	4
Gopher Canyon*	2007	0.8	>13	1
Ostrich Creek*	2007	0.3	>5	1
Horse Ranch Creek*	2007	0.1	>2	1

* Full habitat inventories were not performed on these tributaries

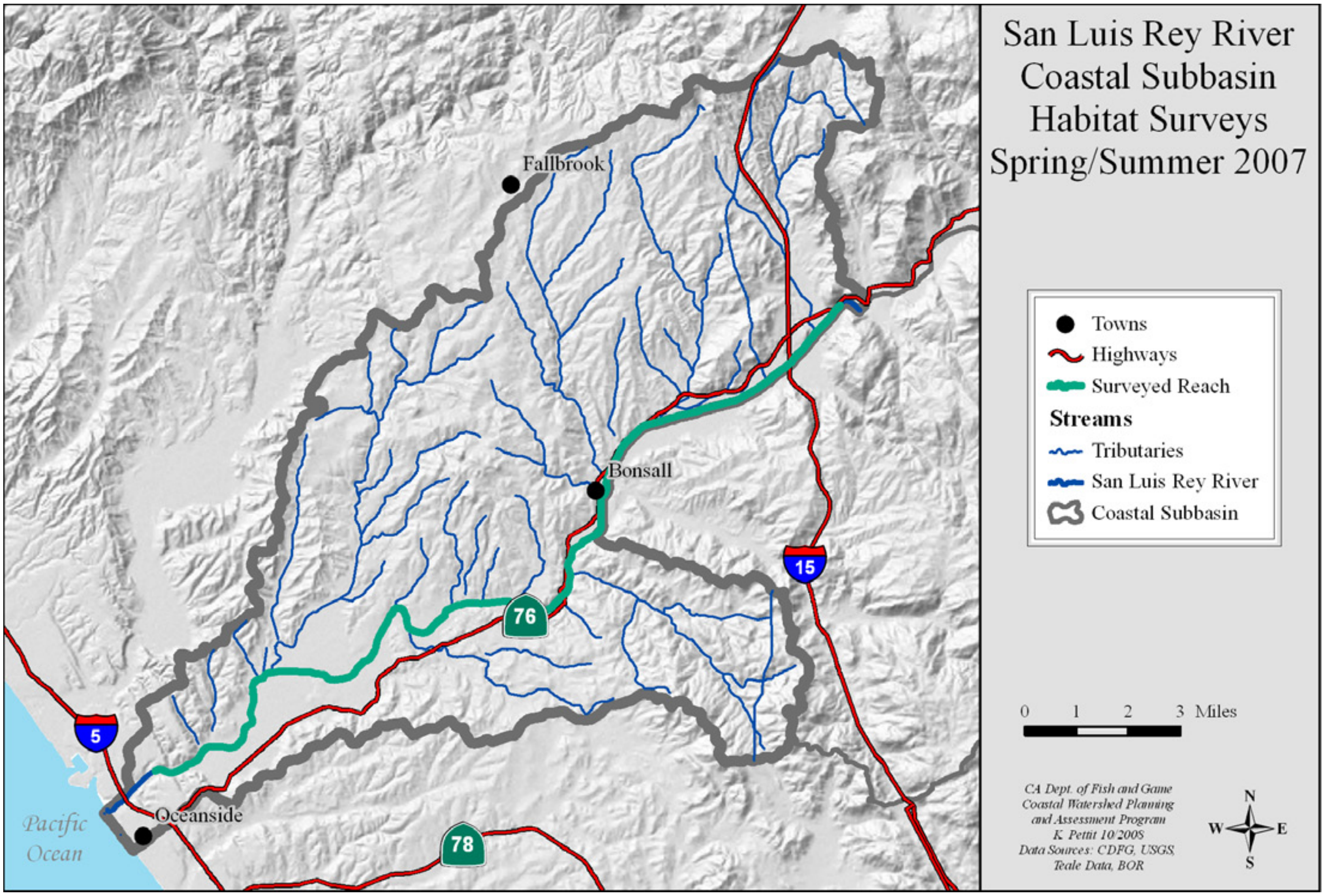


Figure 7. Habitat surveys conducted by CDFG on the SLR River in the Coastal Subbasin.

Canopy Density

Significance: Streamside canopy density is a measure of the percentage of wetted stream that is shaded by riparian tree canopy. Stream water temperature can be an important limiting factor of salmonids, and tree canopy provides shade to reduce direct sun light from increasing water temperatures. Moreover, near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which in turn, influence stream water temperature. Riparian vegetation also bind the stream bank soil and provide resistance to the erosive forces of water, functions as the base of the food chain for biological stream life, helps store water along the stream corridor during the raining season for slow release to the stream in drier seasons, and creates desired complex instream habitat by providing woody debris to streams (Riley 1998). Generally, canopy density less than 50% by survey length is below target values and greater than 80% fully meets target values.

Findings: Canopy density measurements on the SLR obtained suitable values on three of the four reaches (Figure 8 & Figure 10). The overall Coastal Subbasin EMDS canopy density condition truth score is moderately suitable. The canopy coverage was provided by the invasive plant, giant reed (*Arundo donax*), and deciduous trees, mostly in the form of large willows and to a lesser extent, cottonwoods. The uppermost reach had the highest canopy density as river channel width decreased and riparian trees provided cover over the majority of the river. The poor rating in the lower reach can be attributed to the naturally broad stream channel as the actual riparian remained relatively unchanged from other reaches; however, the Corps long-term Operation and Maintenance Plan project in Oceanside has removed and will continue to remove large amounts of vegetation over the next couple of years near the river's wetted channel. This will adversely affect the canopy cover in this area.

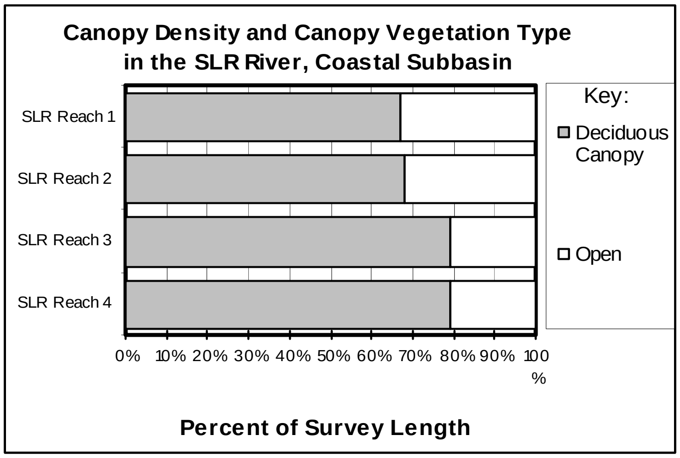


Figure 8. The relative percentage of deciduous canopy vs. open canopy in surveyed reaches of the SLR River, Coastal Subbasin.

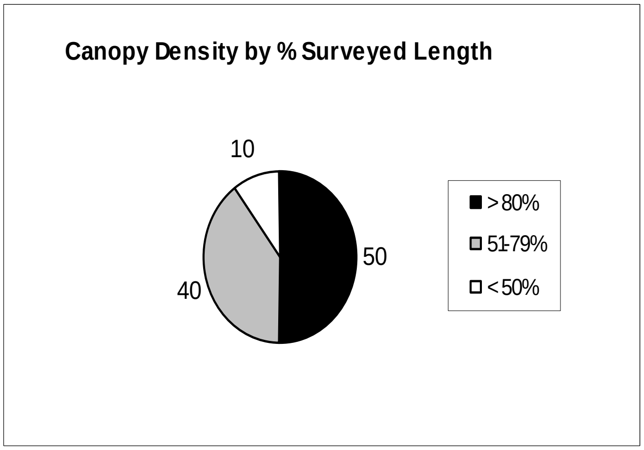


Figure 9. Canopy density of SLR River, Coastal Subbasin.

Averages are weighted by unit length to give the most accurate representation of the percent of a stream under each type of canopy. SLR reaches are listed from west to east within the Subbasin.

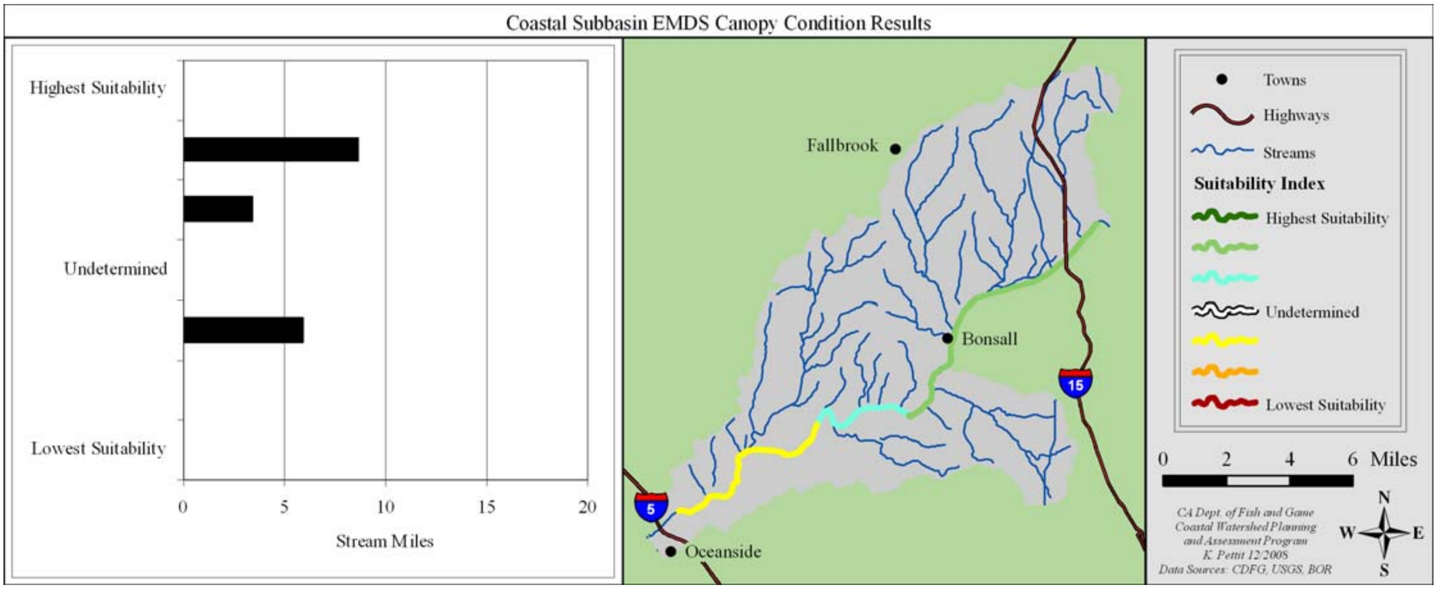


Figure 10. EMDS canopy results for SLR River, Coastal Subbasin, by surveyed stream miles.

Habitat Categories

Significance: Productive anadromous streams are composed of a balance of pool, riffle and run habitat and each plays an important role as salmonid habitat. Pools are the preferred habitat for yearling and older juvenile steelhead, but also provide important resting areas during adult winter/spring migration. Looking cumulatively at pool, riffle, and run relationships helps characterize the status of these habitat types and also provides a measure of stream habitat diversity and suitability for fish. A pool:riffle ratio of approximately 1:1 is suggested as a desirable condition for most wadeable, anadromous, fish bearing streams, but it is not applicable for evaluating salmonid suitability of all stream reaches and channel types (Rosgen 1994). However, pool:riffle:run relationships showing an over abundance of riffles or runs may indicate aggraded channel conditions or lack of scour objects needed for pool formation. Additionally, pool frequency by percent length is preferable to pool frequency by occurrence because the latter may give a false impression of health if there are numerous, shallow, short pools as a result of aggradation (NMFS and Kier 2008).

Findings: While pool habitats in the Coastal Subbasin comprised over 45% of the instream habitat types by occurrence, the overall percentage of pool habitat by survey length was only 16%. All of the reaches in the SLR River comprised less than 25% of their total survey length in pool habitat and two of the reaches contained less than 16% pool habitat (Table 8). In part, the lack of pools can be attributed to the natural hydrology of the lower river, which consists of a low gradient, depositional area. However, the low percentage of pool habitat is also the result of the significantly reduced stream flows, which hinders pool-forming processes from occurring in the lower watershed. The overall low number of riffles and the low percentage of total stream length in riffle habitat may also be attributed to natural hydrology of the lower river; however, anthropogenic activities that have occurred in the subbasin and throughout the entire basin have also played a significant role in altering instream habitat types. These activities have reduced gravel recruitment necessary for riffle formation and increased the fine sediment transport, which would bury existing or potential riffles.

Table 8. Coastal Subbasin percent occurrence and percent by length of pool, run, riffle, and dry habitats.

Stream	Stream Order	Survey Length (miles)	Pool, Riffle, Run Percent Occurrence	Pool:Riffle:Run Percent Total Length	Dry Percent Total Length	No Survey Percent Total Length
SLR River Reach 1	2	5.93	47:2:45	15:1:59	0	25
SLR River Reach 2	2	3.40	48:3:49	23:3:72	0	2
SLR River Reach 3	2	3.73	49:2:49	19:3:72	0	6
SLR River Reach 4	2	4.88	41:2:57	9:4:60	0	27

Pool Depth

Significance: Pool depth and frequency are fundamental attributes of channel morphology and are largely dependent on the presence of large roughness elements such as boulders, bedrock, rootwads, and small and large woody debris in addition to channel type, stream gradient, sinuosity, and channel width. Evaluating the amount of deep pool habitat in a stream reach helps assessment of important channel characteristics for steelhead. Deep pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Greater pool depth provides more cover and rearing space for older age (1+ and 2+) steelhead juveniles and creates better shelter for migrating and spawning adults. Generally, a stream reach should have 35–50% of its length in primary pools to be suitable for salmonids. SLR River, due to the lack of hydrologic connectivity to the middle and upper watershed, was evaluated as a second order stream. The EMDS pool depth model based it suitability ratings on the overall survey reach length containing pools greater than 2.49 feet, with a slight consideration (weight) given to pools greater than 2 feet deep.

Findings: Only 17% of overall survey length in the Coastal Subbasin (SLR River) was comprised of primary pools (Figure 11), which is well below the target values of 35-50%. Subsequently, none of the reaches surveyed in the mainstem met EMDS pool depth target values (Figure 12). While the river was inventoried during one of the driest years on record, the percentage of suitable pool habitat most likely would have only slightly increased during wetter years. It is important to note that the majority of the pools in all of the surveyed reaches were greater than the target depth of 2.49 feet even during this dry survey year. This subbasin is located in a naturally, low-gradient, alluvial streambed; therefore, a high percentage of deep pools would not be typically expected. The lack of hydrologic connectivity from the Middle and Upper subbasins also greatly decreases the amount of stream flow into the Coastal Subbasin, thus hindering the potential for new pool formation and scouring of existing pools. Reach 2 had the most primary pools by survey length, with 22.6% (Table 9).

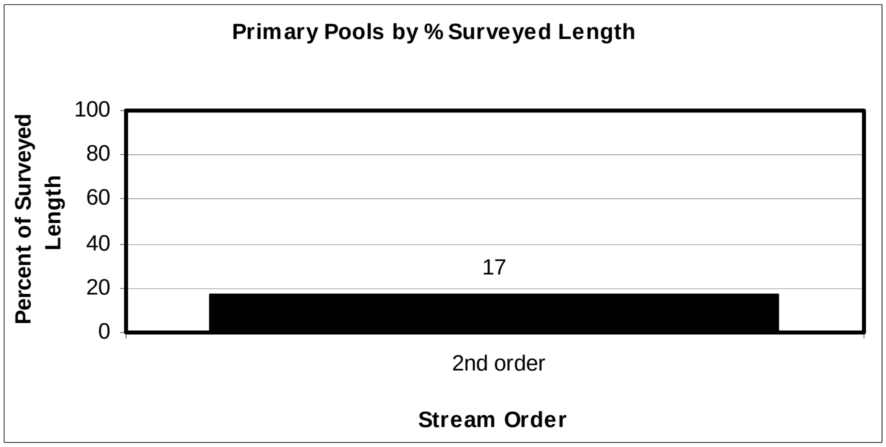


Figure 11. Primary Pools in the SLR River, Coastal Subbasin.
Primary pools are pools greater than 2 feet deep in 1st and 2nd order streams

Table 9. Percent length of the survey area composed of pools and percentage of pool habitat lengths by pool depths in the SLR River,Coastal Subbasin.

Stream	Stream Order	Percent all measured Pools by Survey Length	Percent Pools of Depth 2.0–2.49' by Survey Length	Percent Pools of Depth 2.5'–2.9' by Survey Length	Percent Pools of Depth 3'–4' by Survey Length	Percent Pools of Depth >4' by Survey Length	Percent Pools Within Target Range (>2.49') by Survey Length
SLR River Reach 1	2	19.8	1.7	1.8	4.9	10.4	18.1
SLR River Reach 2	2	22.6	1.5	7.6	7.1	6.4	21.1
SLR River Reach 3	2	18.5	2.5	2.9	7.2	5.9	16.0
SLR River Reach 4	2	7.6	1.2	1.5	1.5	3.4	6.4

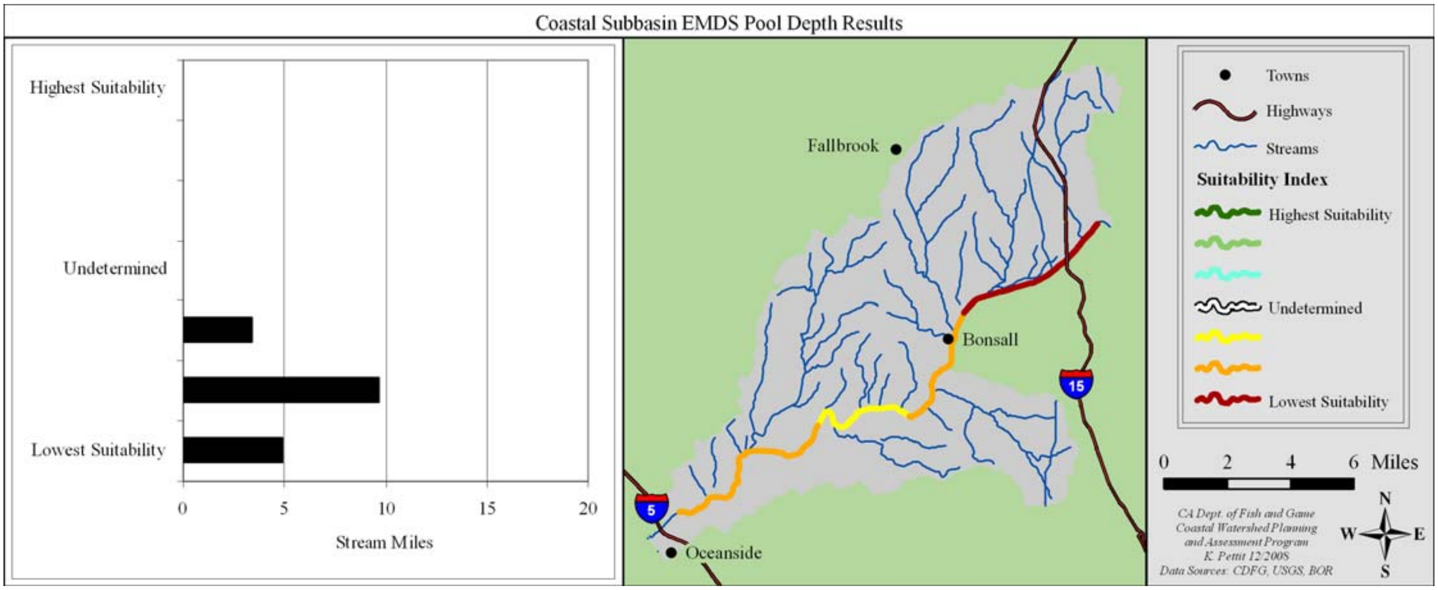


Figure 12. EMDS pool depth results for SLR River, Coastal Subbasin, by surveyed stream miles.

Pool Shelter

Significance: The pool shelter rating is a relative measure of the quantity and percent composition of small woody debris, root wads, boulders, undercut banks, bubble curtains, and submersed or overhanging vegetation in pool habitats. These elements serve as complex instream habitat with protection from predation, rest areas from high velocity flows, and separate territorial units to reduce density related competition. Shelter ratings of 100 or less indicate that shelter/cover enhancement should be considered. Large woody debris generally does not play a significant role in the habitat functions concerning steelhead/trout in southern California rivers and streams; therefore its presence/absence is not relevant in this assessment.

Findings: While pool shelter ratings for surveyed reaches of the SLR River in the Coastal Subbasin were all below the target value of 100% (fully suitable rating) (Figure 13), only reach 3 did not achieve a suitable EMDS rating (Figure 16). Each reach contained pools that met or exceeded the shelter rating of 100 or greater (Figure 14). As described further below, shelter complexity is composed considerably of the invasive species, giant reed (*Arundo donax*), and could be improved throughout much of the subbasin with invasive species eradication efforts and revegetation projects coupled with natural riparian succession.

In addition to shelter complexity rating, instream shelter composition, divided into eight cover types, was also collected during habitat inventories (Figure 15). Due to the widespread presence of *Arundo* within the river channel and along the stream banks, aquatic vegetation (39.7%) followed by terrestrial vegetation (31.7%) were the dominate cover types in the subbasin. *Arundo* has displaced large areas of native riparian vegetation along the SLR River in the Coastal Subbasin. The most significant negative impacts of *Arundo* on the riparian and stream habitat are as follows: *Arundo* increases sediment input by having a weak root system that is susceptible to under-cutting by stream flows; it creates a monoculture that is difficult to penetrate and excludes native plant species; in areas of heavy *Arundo* concentrations, it reduces all forms of wildlife, including the federally endangered species of the least Bell's vireo, southwestern willow flycatcher, and arroyo southwestern toad; and when grown along main stream channels, it provides less shade than native riparian trees because it grows vertically instead of arching over the water channel.

Small woody debris composed the third most common cover type, representing over 21% of the cover in pools. Root mass and undercut banks played a less significant role in providing potential shelter cover in pools. Bedrock ledges, boulders, and bubble curtains were absent or nearly absent from the surveyed reaches and are not included in Figure 15.

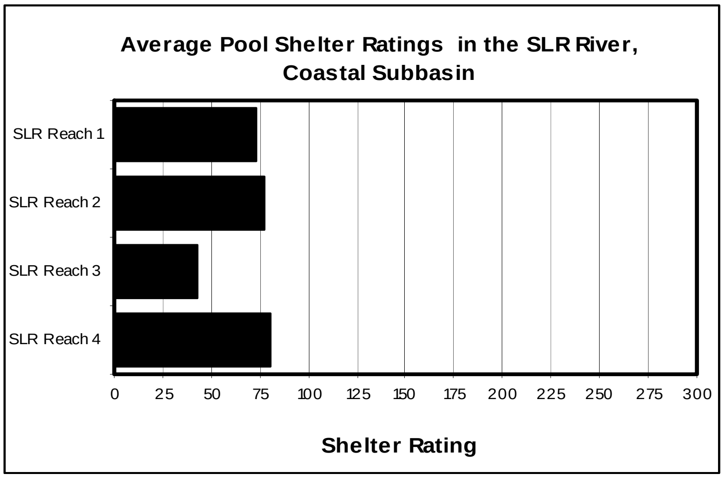


Figure 13. Average pool shelter ratings in the SLR River, Coastal Subbasin.

Stream reaches are listed from west to east.

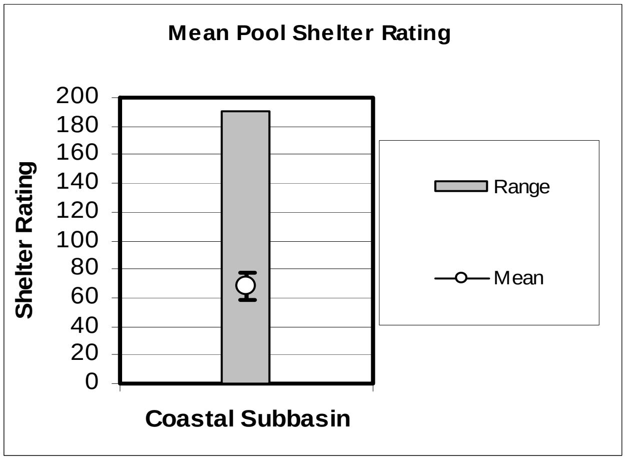


Figure 14. Pool shelter in the SLR River, Coastal Subbasin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, terrestrial vegetation, aquatic vegetation, bubble curtains, boulders, or bedrock ledges) is described and rated in CDFG surveys.

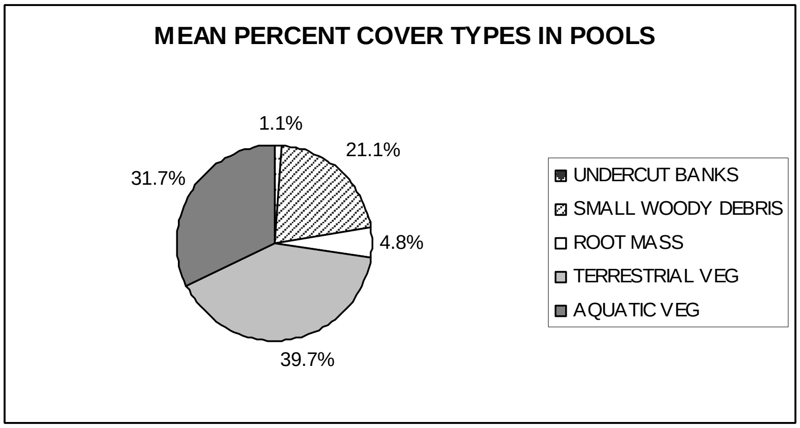


Figure 15. Mean percent of shelter cover types in pools for surveyed reaches of the SLR River in the Coastal Subbasin.

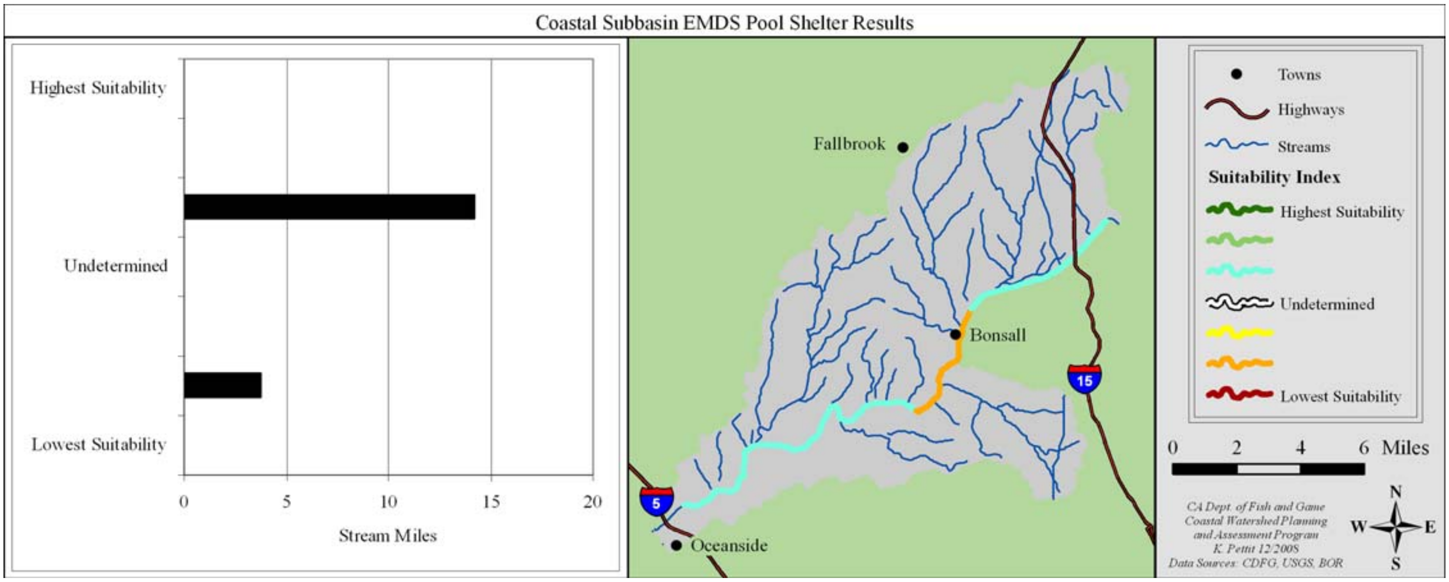


Figure 16. EMDS pool shelter results for the SLR River, Coastal Subbasin, by surveyed stream miles.

Cobble Embeddedness

Significance: Salmonid spawning depends heavily on the suitability of spawning gravel; fine sediments decrease successful spawning and incubation. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category one is 0-25% embedded, category two is 26-50% embedded, category three is 51-75% embedded, and category four is 76-100% embedded. Generally, cobble embeddedness of 0-25% is considered good quality for spawning (Flosi et al. 1998). Excessive accumulations of fine sediment (>50%) reduce water flow (permeability) through gravels in redds which may suffocate eggs or developing embryos. Excessive levels of fine sediment accumulations over gravel and cobble substrate also may alter insect species composition and food availability for growing fish. Consequently, cobble embeddedness categories three and four are not within the fully supported range for successful use by salmonids. Category five was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate like sand, bedrock, log sills, boulders or other considerations.

Findings: The entire stretch of the Coastal Subbasin received the lowest EMDS suitability rating for cobble embeddedness (Figure 19). Approximately 99% of the pool tail-out cobble embeddedness measurements were classified as categories four and five (Figure 18). This poor suitability rating can be primarily attributed to two factors. One, the natural stream morphology of the basin, which consists of a low gradient, alluvial streambed, combined with reduced stream flows into the subbasin hinder natural watershed processes of transporting new gravels. Moreover, severely reduced flows limit the river's scouring potential, leaving an abundance of fine sediments on the riverbed's surface. Two, medium sand is the naturally occurring, dominant substrate throughout the subbasin. The other determining factor involves the sampling method, which only measures potential spawning areas in the pool-tails. Southern California steelhead also utilize riffles as potential spawning grounds. This survey methodology did not take this into account and thus did not record/evaluate these areas. Bear in mind, riffle habitat only occupied approximately 2.5% of the subbasin's stream length. Although few in overall numbers, potential spawning areas were observed in pool tail-outs and at the top of riffles in the Coastal Subbasin. However, the on-going, abundant fine sediment transportation, especially in the lower reaches of the subbasin, may hinder the success of fry emergence from the gravels.

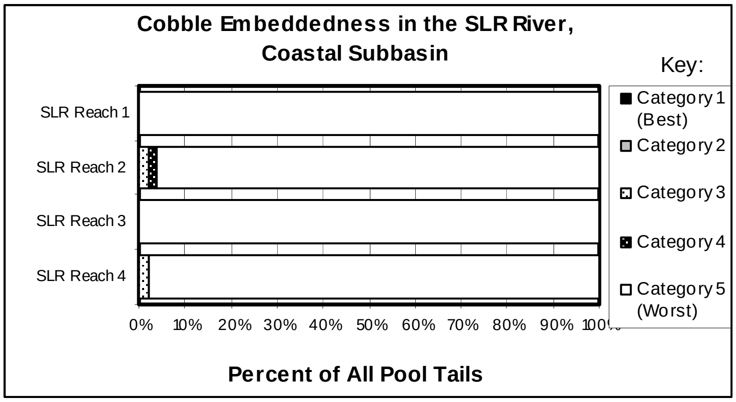


Figure 17. Cobble embeddedness categories as measured at every pool tail crest in SLR River, Coastal Subbasin.

SLR River stream reaches are listed in from west to east in the subbasin.

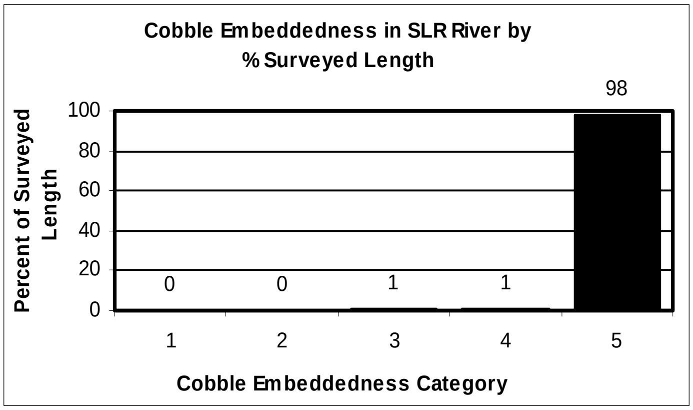


Figure 18. Cobble embeddedness in the SLR River, Coastal Subbasin.

Cobble embeddedness was measured only in pool tail-outs and did not take into account the steelhead may spawn in riffle habitat.

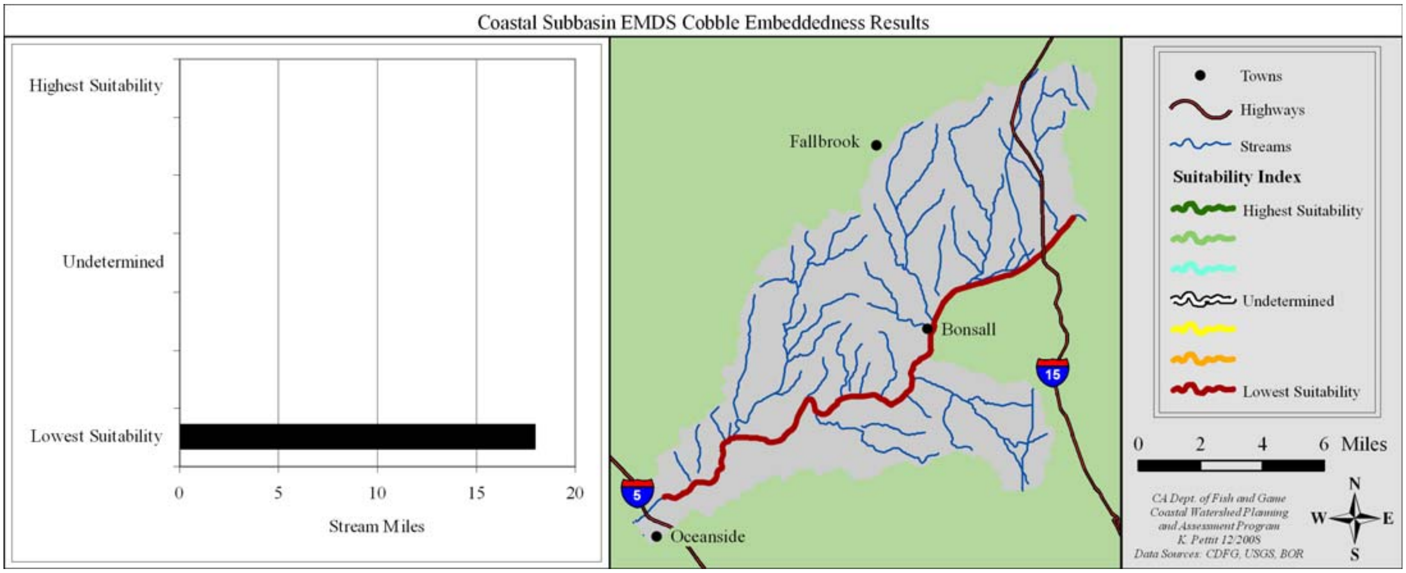


Figure 19. EMDS cobble embeddedness results for the SLR River, Coastal Subbasin, by surveyed stream miles.

Water Quality

The San Diego Regional Water Quality Control Board (SDRWQCB) has set water quality objectives for the following parameters on the San Diego streams and rivers:

- Maximum pH standard of 8.5 to maintain beneficial uses, including cold water fish species;
- Total Dissolved Solids [below 500 mg/L 90% of the time];
- Dissolved Oxygen (above 6.0 mg/L for COLD beneficial use (SDRWQCB 1998).

Nutrient concentrations: “a desire goal in order to prevent plant nuisance in streams and other flowing waters appears to be 0.1 mg/l total P. These values are not to be exceeded more that 10% of the time unless studies of the specific water body in question clearly show water quality objective changes are permissible and approved by the Regional Board. Nitrogen to Phosphorus ratio (if data lacking) of N:P = 10:1 on a weight to weight basis.

Water Chemistry

Significance: Water chemistry interacts with basic trophic levels affecting the production and availability of food for aquatic organisms. Nutrients are often limiting factors in the biological capacity of a stream yet a proper balance is needed to prevent eutrophication. Pollutants are a concern where they interfere with the biological function of aquatic organisms, or can be a threat to those that consume them. Large sources of nutrients and pollutants are commonly municipal and industrial wastewater facilities, storm runoff, and agricultural operations. Naturally occurring nutrients and heavy metals are often found in much smaller concentrations. The SLR River is currently listed impaired by the SDRWQCB for Total Dissolved Solids (TDS), chloride, and bacteria at the mouth, i.e. Pacific shoreline).

Steelhead are an important indicator of the health of the aquatic environment because they require clear, clean water, and they utilize all portions of a river system (McEwan and Jackson 1996).

Findings: Water Chemistry Studies:

The County of San Diego in conjunction with the City of Oceanside, private contractors, and public community organizations have studied water quality conditions in the lower SLR River from 2001 to the present, including water chemistry and macro-invertebrate surveys.

As a part of the regional monitoring effort as required by the 2001 San Diego Storm Water Permit, a mass loading station testing site was constructed in the fall of 2001, under the Benet Road Bridge (RM 2.7), North of Highway 76 to assess flow and to test for water toxicity and chemistry during three wet weather events each year beginning in 2001 through 2007 (A. Witheridge, personal communication 2009). The City of Oceanside also began a Dry Weather Analytical Monitoring and Field Screening Program in the spring of 2002 designed to test the water quality of urban runoff going into the City of Oceanside’s rivers and creeks during the “dry season” (May through September), months when little to no rainfall occurs. By understanding how urban runoff discharges affect the local waterbodies, it provides more information about the quantity and seriousness of certain pollutant problems and where they might originate.

Overall results of the mass loading station and dry weather analytical monitoring and field screening program, survey period of 2001 to 2006, indicated that Total Dissolved Solids (TDS) continue to be the primary water quality concern in the watershed. The report also notes an increasing trend in indicator bacteria concentration, specifically in fecal coliform at levels above the water quality objective (WQO). While nitrate and dissolved phosphorus were at levels below the WQO both showed significantly increasing trends which may become an issue in the future. Other constituents monitored that were occasionally detected at levels above the WQO include: total suspended solids, turbidity, biochemical oxygen demand, pH, and diazinon (compound in pesticides). The report concluded that there was no clear link between dry weather results and mass loading station data; however, the cause of occasional, infrequent toxicity during mass loading station monitoring was unknown (Weston Solutions 2007). It is important to note, in 2007, a new San Diego Storm Water Permit was

<u>Findings:</u> Water Chemistry Studies Continued:

issued with different monitoring requirements. Beginning with monitoring year 2007-2008, an MLS and temporary watershed assessment station, placed under Camino del Rey near the intersection with Hwy 76, assessed flow, chemistry, and toxicity of the SLR River during two wet and two dry weather events. This testing will not be continued annually, but will instead be completed every other year starting with monitoring year 2008-2009, per the new permit requirements (A. Witheridge, personal communication 2009).

An Ambient Bay and Lagoon monitoring program (ABLM) began in June of 2003, investigating chemistry, toxicity, and benthic community structure in the SLR River estuary. Chemistry (sediment chemistry) used sediments from 12 coastal embayments, analyzed in four categories of constituents: metals, Polychlorinated Biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and pesticides. Of these, six metals were detected above the detection limit in the SLR River estuary: arsenic, chromium, copper, lead, nickel, and zinc. However, concentrations of metals were low and none exceeded their respective effects range low (ERL) or effects range medium (ERM – upper guideline value) sediment quality value during the 2003-2005 ABLM program. There were no PAHs found above the detection limit. The pesticide, 4,4'-DDE were detected at this site above the ERL value of 2.2 ug/kg (6.91ug/kg, the level detected), but this is below the respective ERM value of 27 ug/kg.

Toxicity results were determined by mean percent survival of the estuarine burrowing amphipod, *Eohaustorius estuaries*, exposed to the SLR River estuary sediments in a 10-day acute toxicity test compared to a control sample. No toxicity was observed during the 2005 testing year in the 10-day solid phase toxicity test using *E. estuaries*. Survival of *E. estuaries* was not significantly different in the SLR sediment (90%) as compared to in control sediment (97%), indicating that bioavailable metals found in the SLR River estuary sediment were not toxic to the amphipod *E. estuaries* (Weston Solutions, 2007). Overall, for the 2003 to 2005 monitoring years the estuary scored "good" for toxicology and chemistry. The benthic community health in the SLR River estuary was assessed as "poor to fair" (Weston Solutions 2007).

Lastly, in conjunction with the water quality/urban runoff monitoring, Weston Solutions performed a stream bioassessment in the SLR River Basin in October of 2005 and May of 2006 at two urban locations in the Coastal Subbasin as well as in the SLR River estuary and a reference site in Doane Creek in Mt. Palomar State Park. Although these bioassessments were not done in concurrence with the stream habitat surveys, they still provide a useful tool in determining overall stream water quality and habitat, which frequently is a limiting factor in steelhead/trout production due to the extensive land use modifications within many Southern California watersheds (NMFS & Kier Associates 2008). In summary, the SLR River urban sites had Index of Biotic Ratings of very poor during both surveys. The in-stream physical habitat of these sites was qualified as marginal, which could have limited macroinvertebrate colonization. These ratings are typical of a stream that receives a considerable amount of urban runoff and the ratings are comparable to all other urban streams in the County (A. Witheridge, personal communication 2009). Nonetheless, it should be noted that the sites were quite similar to those surveyed at the Santa Margarita site on Camp Pendleton, which had a substantially higher IBI scores. The results indicate that there is evidence of benthic alteration (Weston Solutions 2007).

Habitat Discussion and Conclusions

The SLR River has undergone dramatic changes since European settlers first moved into the basin. Prior to the 2007 CDFG habitat inventory, very few surveys had been completed on the river, detailing the habitat conditions. Data from older stream surveys provide only a snapshot of the conditions at the time of the survey. Terms such as excellent, good, fair, and poor were based on the judgment of the biologist who conducted the survey. The results of historic stream surveys are qualitative and cannot be used in comparative analyses with quantitative data provided by habitat inventory surveys with any degree of accuracy. However, the two data sets can be compared and may indicate general trends.

Very little habitat data is available to compare historic stream conditions to present conditions (Table 11). The spread of invasive, exotic plant species has certainly changed the composition of the riparian and canopy cover, shifting from native trees and shrubs to the invasive *Arundo donax* and *Tamarisk sp*. species. Moreover, the channelization of the lower river altered natural hydrologic processes and most likely changed the river's course from a meandering stream channel to a confined transport reach. This channelization has influenced the ratio of pool to riffle to run instream habitat types as runs dominate the lower reaches and riffles are almost completely absent.

Instream habitat conditions were generally poor in this subbasin at the time of the 2007 CDFG surveys. Surveyed reaches fell below target values and were evaluated as unsuitable for steelhead by EMDS for habitat characteristics except canopy density and pool shelter in portions of river (Table 10). However, the survey was performed during one of the driest years on record and some habitat factors such as pool depth and pool shelter may receive higher scores under normal flow conditions in the river.

The U.S. Army Corps of Engineers (Corps) Long-term Operation and Maintenance Plan along the lower seven miles of the river (between the levees) in Oceanside will most likely impact canopy density, pool shelter, pool depth and overall habitat complexity as native riparian trees as well as the large areas overgrown with *Arundo* are scheduled to be removed. While the removal of *Arundo* will help improve habitat conditions for numerous flora and fauna species, near-stream native tree removal will most likely have an adverse effect on steelhead habitat. During periods of high flows, steelhead survival may depend on access to areas of lower velocity on terraces adjacent to the stream. Riparian forests, large downed trees or other structural elements on the flood plain historically formed areas with slow backwaters where steelhead juveniles and adults could find refuge until flows receded. Levee construction and diking have been used for more than a century to confine stream courses and protect agricultural and housing developments on historic floodplains. Velocities inside dikes and levees increase during high flow events and juvenile steelhead may be flushed into the ocean prematurely, minimizing their chance of survival (NMFS and Kier Associates 2008).

The reduction in riparian along the river may also affect water temperatures, which would be a limiting factor for steelhead in the subbasin. Limited data were available on water temperatures, but CDFG in cooperation with Trout Unlimited and Golden State Flycasters have deployed data loggers to record river temperatures during the temperature extreme period from April to the end of October. This collection will take place over the next several years (2008-2009) in at least three locations in the subbasin where year-round flow is present: estuary, downstream of Douglas Avenue (RM 6), and downstream of Keys Creek confluence with the SLR River (RM 18).

Cobble embeddedness and pool depth were unsuitable on all surveyed reaches–thus these habitat factors are likely limiting to potential steelhead recovery. Cobble embeddedness and pool depth are affected by the natural geology of the area as well as the subbasin's lack of hydraulic connectivity to the Middle and Upper subbasins.

Macroinvertebrate data indicate that the SLR River is a highly impacted system, as it scored very poor in Index of Biotic Ratings during a 2005 and 2006 survey. The estuary scored only slightly higher during the 2003 to 2005 Ambient Bay and Lagoon Monitoring Program, were benthic community health was rated as "poor to moderate." Results of the mass loading station and dry weather analytical monitoring and field screening program, survey period of 2001 to 2006, indicated that total dissolved solids continue to be the primary water quality concern in the watershed. The report also notes an increasing trend in indicator bacteria concentration, specifically in fecal coliform at levels above the water quality objective (WQO). While nitrate and dissolved phosphorus were at levels below the WQO both showed significantly increasing trends which may become an issue in the future.

Table 10. EMDS reach condition results for the SLR River, Coastal Subbasin

Stream	Year	Canopy	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
SLR River Reach 1	2007	-	-	--	+	---
SLR River Reach 2	2007	+	+	-	+	---
SLR River Reach 3	2007	++	--	---	--	---
SLR River Reach 4	2007	++	-	---	+	---
Coastal Subbasin		+	-	--	+	---

Table 11. Comparison between historic habitat conditions with current habitat inventory surveys in the SLR River, Coastal Subbasin

Stream	Canopy Cover		Spawning Conditions		Pool Depth/Frequency		Shelter/Cover		Summary of Changes from Historic to Current
	Historic	Current	Historic	Current	Historic	Current	Historic	Current	
SLR River	ND	Fully suitable	Poor	Fully unsuitable	ND	Fully unsuitable	ND	Fully unsuitable	Lower river channelized; Pool habitat most likely decreased; large areas of the riparian and canopy cover now consists of *Arundo donax*

*ND is no data available
Where multiple years of historic streams surveys were available, the oldest surveys were used.

Stream Habitat Improvement Recommendations

In addition to presenting habitat condition data, all CDFG stream inventories provide a list of recommendations that address those conditions that did not reach target values presented in CDFG's *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998) and in *NMFS's Guide to reference values used in south-central/southern California coast steelhead conservation action planning workbooks* (2008) (see the Current Conditions pp. 20-27). Stream habitat improvement recommendations were developed based on results from stream surveys conducted along potential salmonid bearing stream reaches in 2007. Full habitat inventories were performed only in the SLR River. Other tributaries in the subbasin were either not accessible to steelhead/trout, did not appear suitable for these fish, or could not be surveyed due to landowner access issues; therefore, full habitat inventories were not conducted and are not included in stream habitat improvement recommendations.

In order to compare SLR River reach recommendations within the subbasin, the recommendations of each reach were collapsed into five target issue categories: Surface Stream Flow; Fish Passage; Riparian/Water Temperatures; Instream Habitat; and Sediment Delivery (Table 12). These target issues were then paired with the appropriate recommendation category. For example, the target issue "Instream Habitat" was divided into the recommendation categories of: pool, cover, and spawning gravels. CDFG/PSMFC biologists selected and ranked habitat improvement recommendations based on survey inventory results collected in SLR River within the Coastal Subbasin (Table 13). The top three recommendations of each reach are considered to be the most important, and are useful as a standard example of the stream. When examining recommendation categories by number of stream reaches in the SLR River, the most important target issue in the Coastal Subbasin is maintaining sufficient stream flows.

In general, there was little difference in ranking of inventory recommendations throughout the four reaches in the SLR River (Table 13). Reach one and Reach two differed slightly from the other reaches because the instream habitat in Reach one is going to be altered by the Army Corps vegetation removal project and Reach two did not contain any passage barriers. Overall, following stream flow, the next most common rankings were fish passage and instream habitat – spawning gravel, pool habitat, and cover were all lacking in these reaches. Because of the high number of recommendations dealing with these target issues, high priority should be given to restoration projects that emphasize improved seasonally appropriate flows, removal of passage barriers, riparian vegetation planting, and water temperature monitoring, improving spawning gravels, pools formation, and cover.

Table 12. Recommendation categories based on basin target issues.

Basin Target Issue	Related Table Categories
Surface Stream Flow	Stream Flow
Fish Passage Barriers	Fish Passage
Riparian / Water Temp	Canopy / Temp
Instream Habitat	Pool / Cover / Spawning Gravels
Sediment Delivery	Bank / Roads / Livestock

Table 13. Occurrence of stream habitat inventory recommendations for different reaches of the SLR River of the Coastal Subbasin.

Stream	**Survey Length (mile)**	**Stream Flows**	**Fish Passage**	**Riparian/Water Temps**		**Instream Habitat**			**Sediment Delivery**		
				Temp	**Canopy**	**Pool**	**Cover**	**Spawning Gravel**	**Bank**	**Livestock**	**Roads**
SLR Reach 1	5.93	1	2	unk	3		5	4			
SLR Reach 2	3.40	1	5	unk		4	3	2			
SLR Reach 3	3.73	1	2	unk		4	5	3			
SLR Reach 4	4.88	1	2	unk		4	5	3			

Restoration Projects

With the few number of steelhead observed in the basin in the recent past, few projects have been initiated to improve or restore steelhead habitat in the SLR River or its tributaries. The CalFish website (http://www.calfish.org/) did not list any agency or organization funded stream restoration projects in the subbasin (CalFish is a multi-agency program for collecting, standardizing, maintaining, and providing access to quality fisheries data and information for California.).

A couple of significant projects currently underway in the basin that were not conceived as fisheries restoration projects, nonetheless, have and/or will improve the overall habitat conditions for steelhead in the SLR River. While intending to prevent wash-outs of the road and reduce maintenance costs, the Pacific Street realignment and bridge replacement should provide a more natural tidal flow exchange between the ocean and SLR River and thus improve overall estuary conditions. The project replaces two large culverts that drained the river at its mouth with the ocean with a bridge that will span the estuary. These culverts may have posed as a fish passage problem during low and extremely high flows and have altered the natural tidal exchange.

Viewed as increasing flood and fire risk, degrading crop and rangelands, consuming large quantities of water, and displacement of native species and habitat, invasive plants have been targeted as a priority for removal and management in the watershed, particularly in the Coastal Subbasin. While improving overall canopy cover, the removal of exotics and revegetation with native stock will also improve flows and help fish to navigate through the mainstem more easily. The Mission Resource Conservation District (Mission RCD) in conjunction with the Weed Management Area, has treated approximately 292 acres of 507 acres of *Arundo* had been in the watershed, mainly in the Coastal Subbasin along the mainstem and some tributaries. Another 100 acres is slated for treatment during the 2007/2008 season, mostly along lower Keys Creek (http://smslrwma.org/). These treatment efforts will be an on-going project in the subbasin.

Information on other watershed stream restoration projects can be found on CalFish (www.calfish.org) or on the Natural Resources Project Inventory online database (www.ice.ucdavis.edu/nrpi/). Other projects that have occurred or are currently underway that have improved stream habitat conditions or contributed to the monitoring of the stream habitat conditions include the following:

- Land acquisition for the SLR River Park and resource conservation;
- Corps and Mission RCD's *Arundo* and Salt Cedar removal projects along the SLR. Mission RCD projects replanted areas with native plant species;
- Water quality monitoring performed by the City of Oceanside and associated contractors (2001 to present). This monitoring includes the analysis of chemistry, bacteria, and toxicity data collected during storm water events and dry weather data from the dry weather monitoring program;
- Stream bioassessment performed by consultants for the City of Oceanside;
- Spring 2008 to December 2009 water temperature monitoring by the Department of Fish and Game in conjunction with Trout Unlimited;
- Spring 2008 to December 2009 water chemistry analysis and bioassessment by Trout Unlimited in conjunction with the San Diego Coastkeeper;
- Water quality control via animal waste improvement projects;
- Mission RCD working with area farmers on Best Management Practices for pesticide and erosion control

and prevention;

- Collectively, the San Luis Rey Watershed Copermittees, such as the City of Oceanside, hosted and participated in numerous cleanup and outreach events, including creek and coastal cleanups and regional event presentations at which watershed concepts were emphasized;
- The San Luis Rey Watershed Copermittees delivered formal presentations to approximately 1,035 students throughout the watershed. Common learning tools used in these presentations include the Enviroscape watershed model, outdoor field trips puzzles, water quality posters, videos, and PowerPoint presentations (PBSJ 2003).

Refugia Areas

CDFG/PSMFC biologists identified and characterized refugia habitat in the Coastal Subbasin by using professional judgment and criteria developed for coastal watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, stream flows, agriculture and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by the EMDS at the stream reach scale (Table 10).

The most complete data available in the Coastal Subbasin was the mainstem surveyed by CDFG. However, the mainstem was still lacking data for some factors considered. Salmonid habitat conditions in the Coastal Subbasin on surveyed streams are generally rated as low potential refugia (Table 14). Portions of the mainstem provide potential rearing habitat for juvenile trout. With habitat improvement projects the SLR River estuary could potentially provide critical rearing habitat as well. In the absence of performing full habitat inventories in Coastal Subbasin tributaries, sections of a few tributary streams (Table 14) containing flowing water were surveyed on foot in order to make general observations of the habitat conditions. Based on these limited surveys, Ostrich Creek, Gopher Canyon, and Live Oak Creek most likely provide low quality refugia. Pilgrim Creek, located near the western end of the subbasin was not surveyed; therefore it is difficult to speculate the type and quality of habitat present in this creek. There is a barrier approximately 1 mile upstream its confluence with the SLR River and flows appear to be diverted for irrigation. The following refugia area rating table (Table 14) summarizes subbasin salmonid refugia conditions.

Table 14. Tributary salmonid refugia ratings in the Coastal Subbasin

Stream	**Refugia Categories**				**Other Categories**		
	High Quality	**High Potential**	**Medium Potential**	**Low Quality/Low Potential**	**Passage Barrier Limited**	**Critical Contributing Area**	**Data Limited**
SLR River				x			
Pilgrim Creek					x		x Needs survey
Gopher Canyon				x			x
Ostrich Creek				x			x
Live Oak Creek				x			x

Key Subbasin Issues

- The Coastal Subbasin is not hydrologically connected to flows in the Middle and Upper subbasins, which adversely impacts water quality and quantity, complex instream habitat, native flora and fauna, recruitment of new streambed substrates and providing beach sand replacement along the coast;
- Invasive plant species, *Arundo and Tamarisk,* have altered the riparian landscape and degraded instream habitat conditions of the SLR River;
- The natural function of the SLR River estuary, which once sprawled more than 2,200 acres, has been altered considerably by the marina, urban development, and on-going flood protection activities within the estuary and floodplain area. Presently, the estuary has been downsized to an approximately 164 acre

floodplain with degraded habitat conditions;

- Urban and agricultural runoff poses a problem to aquatic ecosystems in the mainstem SLR River;
- Partial fish passage barriers exist throughout the SLR River within the subbasin;
- Sediment level in streams is high and creates a multitude of problems for fish habitat;
- The river's streambed is most likely still negatively impacted by previous upstream gravel mining practices.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations in the Subbasin?

Findings and Conclusions:

- Southern California Coast Steelhead (DPS) are federally listed as endangered;
- The Coastal Subbasin once supported steelhead runs, but they have been nearly extirpated from the SLR River. Steelhead most likely used the subbasin, particularly the estuary/lagoon as important rearing habitat during juvenile outmigration;
- Very few steelhead have been observed in the subbasin since the late 1940s;
- Contributing to the lack of observations have been the absence of general and focused surveys for these fish. Aside from a few seining efforts performed in the estuary in 2000 and 2003, no focused or general surveys have occurred in the mainstem for steelhead since the 1940s;
- One adult steelhead was observed during CDFG 2007 habitat surveys in Oceanside, approximately seven miles upstream its mouth with the ocean. A second adult was reported but not confirmed by CDFG personnel;
- There is also a lack of historical information on steelhead using any of the tributaries in the Coastal Subbasin. A literature review provided no records of steelhead sightings in any of these tributaries; however, general or focused surveys have not been performed on any of these tributaries;
- Unarmored threespine stickleback and tidewater goby are federally listed species that once inhabited the SLR River in the Coastal Subbasin but may have been extirpated.

What are the current salmonid habitat conditions in the Coastal Subbasin? How do these conditions compare to desired conditions?

Findings and Conclusions:

Flow and Water Quality:

- The Coastal Subbasin is not hydrologically connected to flows in the Middle and Upper subbasins as practically all river flows are diverted to the Escondido Canal. Stream flows are also seriously impacted by numerous extraction pumps and other anthropogenic uses located throughout the subbasin;
- Low summer flows may be stressful to salmonids, and dry or intermittent reaches on the SLR River seasonally prevent connection to the estuary;
- Water quality is being impacted by agricultural and urban runoff that have direct access to streams;
- The SLR River urban sites had an Index of Biotic Ratings of Very Poor during both surveys. The in-stream physical habitat of these sites was qualified as marginal, which could have limited macroinvertebrate colonization.

Erosion/Sediment:

- Excessive sediment in stream channels has resulted in an overall loss of spawning, rearing and feeding habitat for salmonids. The majority of the SLR River channel is composed of Quaternary Alluvium consisting of sand and silt. High sediment levels are confirmed by embeddedness measurements in surveyed reaches;
- Livestock have unrestricted access to some tributaries, resulting in stream bank erosion;
- Soils (and bedrock) in streams of the Coastal Subbasin are prone to erosion, and slides and streambank failures have been observed to contribute fines to the streams.

Riparian Condition/Water Temperature:

- Canopy density measurements on the SLR obtained suitable values on three of the four reaches. The lower reach, where canopy target values were not met are partially related to the naturally, broad river channel. Riparian trees are present, but are not tall enough to sufficiently cover the entire river;
- Invasive plant species such as *Arundo donax* and *Tamarisk sp*. are widespread and have displaced large amount of native riparian vegetation;
- The Corps Operation and Maintenance Plan in the lower seven miles of the river channel has removed and will continue to remove large amounts of vegetation over the next couple of years. This will adversely affect the canopy cover in this area;
- Water temperature data collected by CDFG during summer habitat inventories indicate acceptable levels, with some streams nearing stressful conditions. However, these data are limited, and therefore inconclusive.

Instream Habitat:

- Based on observations and data recorded during instream habitat inventories, high quality salmonid habitat is lacking in all surveyed reaches of the SLR River within the Coastal Subbasin. Conditions present at the time of the survey indicated a low number of pools as well as a poor percentage of pool habitat by surveyed stream length. Furthermore, the majority of the pools present were shallow and pool shelter cover is generally lacking;
- Stream bioassessments performed in the lower mainstem SLR River had Index of Biotic Integrity Ratings of Very Poor during 2005 and 2006 surveys (Weston Solutions 2007);
- The SLR estuary's health assessed during the 2003-2005 period was rated as poor to fair based on analysis of Benthic Response Index (BRI) and Relative Benthic Index (RBI) scores;
- Tributaries appear to offer very limited additional spawning and rearing habitat due to low flows and unsuitable instream conditions.

Gravel/Substrate:

- Suitable salmonid spawning areas were limited in surveyed reaches of the SLR River. Overall numbers of potential spawning gravels were low and embeddedness measurements did not meet target values, confirming that sediment levels in the subbasin are high;
- The unsuitable embeddedness ratings are the result of the following factors: the natural channel morphology of the alluvial streambed, past (mining) and present human-related activities and the lack of hydrologic connectivity from the middle and upper watershed.

Refugia Areas:

- Salmonid habitat conditions on the mainstem are generally rated as low quality refugia;
- A few tributaries that were surveyed, but not inventoried, such as Gopher Canyon, Ostrich Creek, and Live Oak Creek, also appeared to provide low quality refugia;
- The once expansive SLR River estuary/lagoon could have once provided excellent habitat for rearing juvenile steelhead before their entrance into the ocean. In its current state, the estuary provides low

potential refugia as rearing habitat for juvenile fish is limited.

Barriers:

- Several partial fish passage barriers exist in the SLR River, such as the rip-rap below the Douglas Avenue and College Avenue bridges, road crossing at RM 11 and a metal sheet spanning the river at RM 17.5 that would seasonally obstruct the upstream movement of adult steelhead and hinder juvenile emigration to the estuary and thus the ocean;
- Pilgrim Creek contains possible fish passage barriers in its lower reaches.

What are the impacts of geologic, vegetative, fluvial, and other natural processes on watershed and stream conditions?

Findings and Conclusions:

- The dominant material in the Coastal Subbasin is median sand, which is highly transportable during floods;
- Severely erodible soils comprise 95% of the watershed, including the Coastal Subbasin; slides from the stream banks and roads have been observed to contribute fines to the stream;
- Weathering of the granitic rocks has created younger unconsolidated sediments that are very susceptible to enhanced erosion and mass movement such as landslides and debris-flows;
- The Coastal Subbasin is in a potentially seismically active area. Large seismic events especially when coupled with large storm events can trigger large landslides and mudflows increasing sediment delivery to the streams and altering their hydrologic condition;
- Seismic events off the coast may produce Tsunamis capable of redepositing sediments, filling channels, and initiating even more landsliding;
- Uplift has increased the erosion potential of the area;
- Wildfires that occurred within the watershed during the fall of 2007 most likely resulted in an increase in sediment input into the SLR River.

How has land use affected these natural processes?

Findings and Conclusions:

- The channelization of the lower river for flood protection purposes has altered the natural hydrologic processes of the river and has caused uniformity throughout much of the river's channel;
- Agricultural and urban runoff have affected the water quality of many of the subbasin's streams;
- Disturbance of the basin's already unstable soils by land use activities has altered runoff rates;
- Riparian vegetation has been cleared through agricultural activities and is currently being removed for flood control and maintenance projects in the lower river;
- Large areas of native vegetation along the mainstem and in tributaries have been displaced by non-native plants. These non-natives have altered the channel morphology of the river;
- Invasive plants occupy habitat that normally has little vegetation, for example, the SLR River's sandy channel bed in the Coastal Subbasin;
- The SLR River estuary's natural function has been greatly altered due to the development that has occurred in what was once an expansive network of wetlands, marsh, and stream channels but is now a marina. In addition to steelhead, other fish species are dependent on an estuarine environment for completion of their life histories.

Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?

Findings and Conclusions:

Based on available information for this subbasin, it appears that salmonid populations are limited by:

- Low summer flows and areas in the SLR River that go completely dry during the late spring to early fall months;
- Poor water quality;
- Fish passage barriers;
- Spread of exotic flora such as *Arundo* and *Tamarisk*;
- High levels of fine sediments in streams;
- Loss of habitat area and complexity;
- A shortage of areas with suitable spawning gravel in tributaries;
- Lack of suitable habitat in the estuary;
- Potentially high summer water temperatures;
- Competition with warm water game fish, bullfrogs, and crayfish.

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Habitat improvement activity recommendations are limited to the SLR River since it was the only stream extensively surveyed during the assessment. Other streams, Pilgrim Creek, Live Oak Creek, and Ostrich Creek in the subbasin, may have the potential to support steelhead/trout, but further studies are needed in order to make suitable habitat improvement recommendations for those individual watersheds.

Barriers to Fish Passage

Stream	Recommended Actions XXX: Highest Priority		
SLR River:	Continue efforts to identify and alleviate fish passage impediments at culverts or other public or private road crossings.	Improve fish passage by modifying concrete rip-rap areas below bridges at Douglas Avenue and College Avenue.	Improve fish passage by removing structures on private lands that are currently partial barriers.
	XXX	XXX	XX

Flow and Water Quality

Streams	Recommended Actions XXX: Highest Priority			
SLR River:	Insure that water diversions used for domestic or irrigation purposes bypass sufficient flows to maintain all needs of fishery resources.	Provide seasonally appropriate, pulse flow releases in the upper watershed during adequate water years.	Plant willows, cottonwoods, or alder trees to help reduce water temperature in areas with insufficient shade.	Remove and prevent excessive agricultural or urban runoff contributions to aquatic ecosystems.
	XXX	XXX*	X	XX

*See Basin Profile for limitations concerning this recommendation.

Erosion and Sediment Reduction

Streams	Recommended Actions XXX: Highest Priority			
SLR River:	Continue to identify and reduce sources of sediment delivery to stream channels from road systems.	Re-vegetate exposed stream banks and/or install structures to increase bank stability.	Build livestock exclusionary fencing along creeks and create offsite watering areas.	Install instream structures that enhance natural sorting of spawning gravels.
	XX	X	X	X

Riparian and Instream Habitat

Streams	Recommended Actions XXX: Highest Priority		
SLR River:	Increase depth, area or shelter complexity in pools, by adding boulders. To increase the number of pools install pool forming structures.	Identify and prioritize locations within the estuary where vegetation can be returned to salt tolerant species, thus improving the habitat recovery of the estuary for all marine dependent species that may use the estuary.	Continue to remove *Arundo* and *Tamarisk* plant species in conjunction with upstream eradication efforts. Where appropriate restore these areas with native vegetation such as willow, cottonwood and sycamore to increase streamside shade canopy and allow for woody recruitment.
	X	XX	XXX

Education, Research, and Monitoring

Streams	Recommended Actions XXX: Highest Priority		
SLR River:	Continue, expand, or develop education programs concerning water conservation, water quality, and importance of watershed/riverine ecosystems.	With the removal of the Pacific Street bridge in the estuary, water quality and estuary conditions will require monitoring. Salinities should be collected in the estuary and upstream to determine the extent of brackish conditions. Biological surveys should be performed in the estuary for at least a three year period.	Water quality monitoring should continue on a yearly basis to characterize conditions in the SLR River and its tributaries. Water temperature monitoring should be conducted for a couple of years to assess SLR River temperatures throughout the subbasin.
	XX	XX	XXX

Subbasin Conclusions

There have been more biological and habitat surveys conducted on the SLR River in the Coastal Subbasin than in any of the other subbasins. These studies describe deterioration in steelhead habitat due to an assortment of historical and current anthropogenic activities in the subbasin and throughout the basin. Lack of hydrologic connectivity with the middle and upper watershed, channelization of the river, riparian vegetation removal, invasion of exotic plant species, significant alteration of the estuary, upstream sand and gravel mining, agricultural practices, and urban development have all played a role in changing the natural function of the river, water quality and quantity and thus instream habitat for fish. The infusion of Colorado River water into the basin (beginning in the late 1940s but increasing throughout 1960s) for irrigational and household uses has decreased the water quality of the river, particularly in the Coastal Subbasin. This imported water source contains high levels of TDS and chloride.

The geology of the area also contributes to fluctuating riverine conditions. Soils in this subbasin and upstream are susceptible to erosion and enter the streams through the many road related and stream bank slides. High amounts of sediment are present in the river and its tributaries. Potential steelhead spawning areas have become heavily silted and are therefore unproductive in much of the subbasin. While not conclusive, measured water temperatures in the river neared stressful conditions when compared to suitable steelhead habitat criteria. Additionally, there are several partial, fish passage barriers in the river that fragment steelhead habitat and would hinder/prevent the movement of steelhead trout throughout the subbasin. These barriers are as follows: road crossings containing culverts not designed for fish passage, concrete and boulder rip-rap under bridges that prevent low flow fish passage, an upright metal sheet that spans the river effectively creating a low flow barrier, and dry reaches that would limit the upstream and downstream movement of steelhead/trout.

The lack of historical information regarding previous habitat conditions and presence of steelhead within the Coastal Subbasin makes it difficult for one to speculate on historical use of the subbasin for spawning and rearing habitat. Considering the river is located in what was once a large floodplain, it seems likely that steelhead used this portion of the river as a migration corridor to more suitable spawning areas upstream of the Coastal Subbasin; however, with cooler coastal temperatures, adequate stream flows, and diverse, abundant riparian, steelhead may have utilized this section of the SLR River and almost certainly the estuary as important rearing habitat (Boughton 2006). Having perennial river flows prior to the completion of the Escondido Canal diversion and the Henshaw Dam, the SLR River instream habitat conditions would have been significantly different than their current state. In addition to being more conducive to upstream adult migration and downstream smolt migration to the ocean, the river would have contained more complex habitat.

Estuary conditions were far more suitable for steelhead prior to human's intervention, as the estuary once encompassed over 2,200 acres and included intermittent connectivity with the Santa Margarita River lagoon to the north (MBC Applied Environmental Sciences 2003). This expansive area would have provided excellent rearing habitat for juvenile steelhead before entering the ocean. Previous studies (Smith 1994, Bond 2006, and Hayes et al. 2008) have shown that estuaries in many systems have provided important growth opportunities for out-migrating smolts and brackish areas for fish to adjust to salt water (Healey 1982); these important growth opportunities would improve the chance for smolt survival in the ocean. The removal of the Pacific Street crossing could restore more normal conditions in the lagoon and increase the potential for recovery or recolinization of a variety of species of fish, amphibians, and reptiles. An ongoing hydrologic/ biological study should be implemented to study the ongoing effects of the bridge replacement on sediment transport, water quality, lagoon habitat, and estuarine-dependent fish species.

It is unknown whether steelhead used any of the tributaries within the subbasin. While several large tributaries exist, such as Pilgrim Creek, Ostrich Creek, and Live Oak Creek, there is a lack of recorded or anecdotal information regarding the presence of steelhead in these streams. Whether any of these streams historically retained perennial flows to provide rearing habitat is also unknown.

The current stream habitat condition ratings for steelhead in the Coastal Subbasin were split depending on the category: low suitability for embeddedness and pool depth and moderate to high suitability for pool shelter and canopy density. The U.S. Army Corps of Engineers (Corps) Operation and Maintenance Plan along the lower seven miles of the river in Oceanside will most likely impact canopy density, pool shelter, and pool depth as riparian trees and *Arundo* near the river are scheduled to be removed. While the removal of *Arundo* will help improve habitat conditions for numerous flora and fauna species, near-stream native tree removal will most likely have an adverse effect on instream steelhead habitat. Furthermore, the numerous land and resource use projects currently in the planning stages, such as the Gregory Canyon Landfill, Rosemary's Mountain Quarry, large housing developments at the Interstate 15/Highway 76 interchange, City of Oceanside water wells near the SLR River, etc., will most likely have a significant effect on the riparian, instream habitat, and water quality and quantity of the lower SLR River.

While this area remains a potentially important migration corridor for adult fish, as evident by the adult steelhead observed in the spring of 2007 at RM 7, near College Ave, it could also serve as an important migration/rearing area for juvenile trout on their out migration to the ocean, especially during normal to high flow water years conducive to the movement of steelhead. In addition to the challenges of having on-going water quality issues, little to no surface flows in the lower to mid SLR River, reducing the presence of invasive, non-native flora and fauna, there is the need to maintain hydrologic connectivity of the Northern Subbasin streams with the estuary. Implementing seasonally appropriate, pulse release flows during adequate water years, would greatly facilitate the migration of adult fish and out migration of juvenile fish. These increased flows could also help to restore complex instream habitat conditions. Pulse release flows, in conjunction with fish passage improvements, ongoing exotic plant removal, restoring estuary habitat and other habitat restoration projects are needed to further enhance the overall conditions for steelhead in the subbasin.

Table of Contents

List of Figures

List of Tables

Southern Subbasin

The Southern Subbasin includes the watershed area along the SLR River from Rice Canyon, approximately one mile east of Interstate 15 (RM 19) to just upstream of the Escondido Canal diversion dam (RM 40) (Figure 1). Stream elevations range from near sea level in the lower mainstem to approximately 3,400 feet in the headwaters of the tributaries. The Southern Subbasin occupies approximately a quarter of the total basin at 134 square miles. This assessment area is mostly rural with the exception of the expanding city of Valley Center. Pauma Valley and portions of the communities of Bonsall and Pala are also located within its boundaries. The Rincon Indian Reservation and to a lesser extent, the Pala Band of Luiseño Indians and San Pasqual Indian Reservations, reside within the subbasin. The majority of the subbasin is held in larger private parcels managed for agricultural crop production.

With the exception of the SLR River canyon (RM 37-39.5), the majority of the Southern Subbasin provides little suitable habitat for steelhead as the mainstem and many of the tributaries are dry for the majority of the year with seasonal flows limited to the precipitous periods of the winter and early spring. The SLR River canyon, located in the eastern portion of the subbasin, provides perennial flows with potentially cool water temperatures and deep pools. The mainstem SLR River was most likely used mainly as a migration corridor for adult steelhead to more extensive spawning and rearing habitat located in the Northern Subbasin tributaries and possibly in the mainstem within the SLR River canyon. Juvenile steelhead may have used the mainstem for rearing habitat during their downstream migration to the estuary and thus the ocean. Located in the SLR River canyon at RM 39.5 (approximately ½ mile downstream of the Escondido Canal diversion dam; Luiseño place name "Kye"), is a 50 foot high natural waterfall (Figure 10). This waterfall is broken up into a series of steps; with the largest lowermost step approximately 13 feet, and a narrow steeped crevasse above the first step extending to the top of the waterfall (M. Capelli, personal communication 2010). Considering the altered flow regime with the majority of the stream water being diverted approximately ½ mile upstream at the Escondido Canal diversion, steelhead are very unlikely to navigate through this feature.

Historical evidence of the presence of steelhead in this subbasin is mainly attributed to anecdotal accounts from local tribal elders who spoke of annual runs (USFWS 1998) and the presence of steelhead "…coming up from Oceanside" (Soto 2008). There is limited direct documentation of steelhead in the mainstem or in its tributaries. This is due, in part, to the lack of coordinated survey efforts by CDFG or any other organization. Prior to the 2007-2008 CDFG watershed assessment surveys, CDFG had not surveyed the SLR River in the Southern Subbasin since the 1940s. The CDFG performed this reconnaissance level survey effort in 1946. This survey contained the last documented report of non-hatchery rainbow/steelhead trout in the river (near Pala) within the Southern Subbasin. It is unknown whether these fish had become resident rainbow trout or if they could potentially migrate downstream to the ocean. Another reconnaissance level survey was performed by a fisheries biologist in 1975, but it provided little quantitative or qualitative information about the SLR River within the Southern Subbasin.

For a brief period in the 1990s rainbow trout were stocked in the SLR River within the Wilderness Gardens Preserve boundaries by schools that were provided fish from the CDFG's Mojave Hatchery. Water quality monitoring and sampling of aquatic insects indicated at the time of the releases that conditions were favorable for trout survival. Since the termination of the trout release program information collected in the river within the subbasin has been mostly limited to water quality monitoring performed by the Pala Band of Mission Indians.

Hydrology

The Southern Subbasin is made up of four complete CalWater Units: Moosa, Valley Center, Rincon, Woods, and portions of the Bonsall, and Pauma CalWater Units (Figure 2). There are four named tributaries (Table 1) and 167.4 permanent and intermittent (limited seasonal flows) stream miles in this subbasin. The vast majority of these stream miles are intermittent (See Figure 9 in the Basin Profile). During typical rainfall years, the SLR River in the Southern Subbasin will retain surface flows in the winter and spring after significant rainfall events. Large tributaries in the Northern Subbasin such as Pauma Creek, Agua Tibia Creek, and Frey Creek play an important role in maintaining surface flows in the mid to lower river during this time of the year, but usually become intermittent and contribute little to no water during the summer. Important tributaries in the Southern Subbasin include Keys Creek, Moosa Canyon, Paradise Creek, and Hell Creek. For the most part, flows in these tributaries are influenced by agricultural, landscaping, and urban runoff. Keys Creek, for example, has become a perennial stream in its lower and middle sections due to the large amount of agricultural runoff. While Moosa Canyon and Hells Creek contain small sections of year round flow, these and other unnamed tributaries in the subbasin are mostly intermittent streams. Drainage areas range from less than 3 miles to the 133.8 square mile drainage area of the SLR River within the subbasin.

Currently, there is one operating river gauge (USGS ID 11036700) in the Southern Subbasin. This gauge, located 0.07 miles south of Cole Grade Road, near Pauma Valley, has been in operation since March of 2008 and is recording river gauge height and discharge. Two other gauges operated from March 2008 to October 2008 in the Pauma Valley recording discharge but have since discontinued data collection.

Figure 1. SLR River in the Southern Subbasin near the Wilderness Gardens County Park (approximately RM 27).

Table 1. Major streams in the Southern Subbasin.

Stream	Tributary to	River Mile	Drainage Area (square miles)	Stream Order	Permanent (miles) (in Subbasin)	Intermittent (miles)
San Luis Rey River	Pacific Ocean	--	133.8	1[1]	3.9	18.5
Moosa Canyon	SLR River	13.7	40.8	1[1]	4.5	4.7
Keys Creek	SLR River	18.7	38.2	1[2]	7.8	5.4
Paradise Creek	SLR River	36.9	13.9	n/a	0.0	6.2
Hell Creek	Paradise Creek	2.3	5.4	1[1]	1.1	3.4

[1] Only portions of the SLR River, Moosa Canyon, and Hell Creek retain perennial flows

[2] As mentioned above, the majority of Keys Creek now runs year round due to large amounts of agricultural runoff, but historically was labeled as an intermittent stream for the lower 2.2 miles on USGS 7.5 Bonsall quadrangle maps.

n/a Not applicable due to intermittent flows.

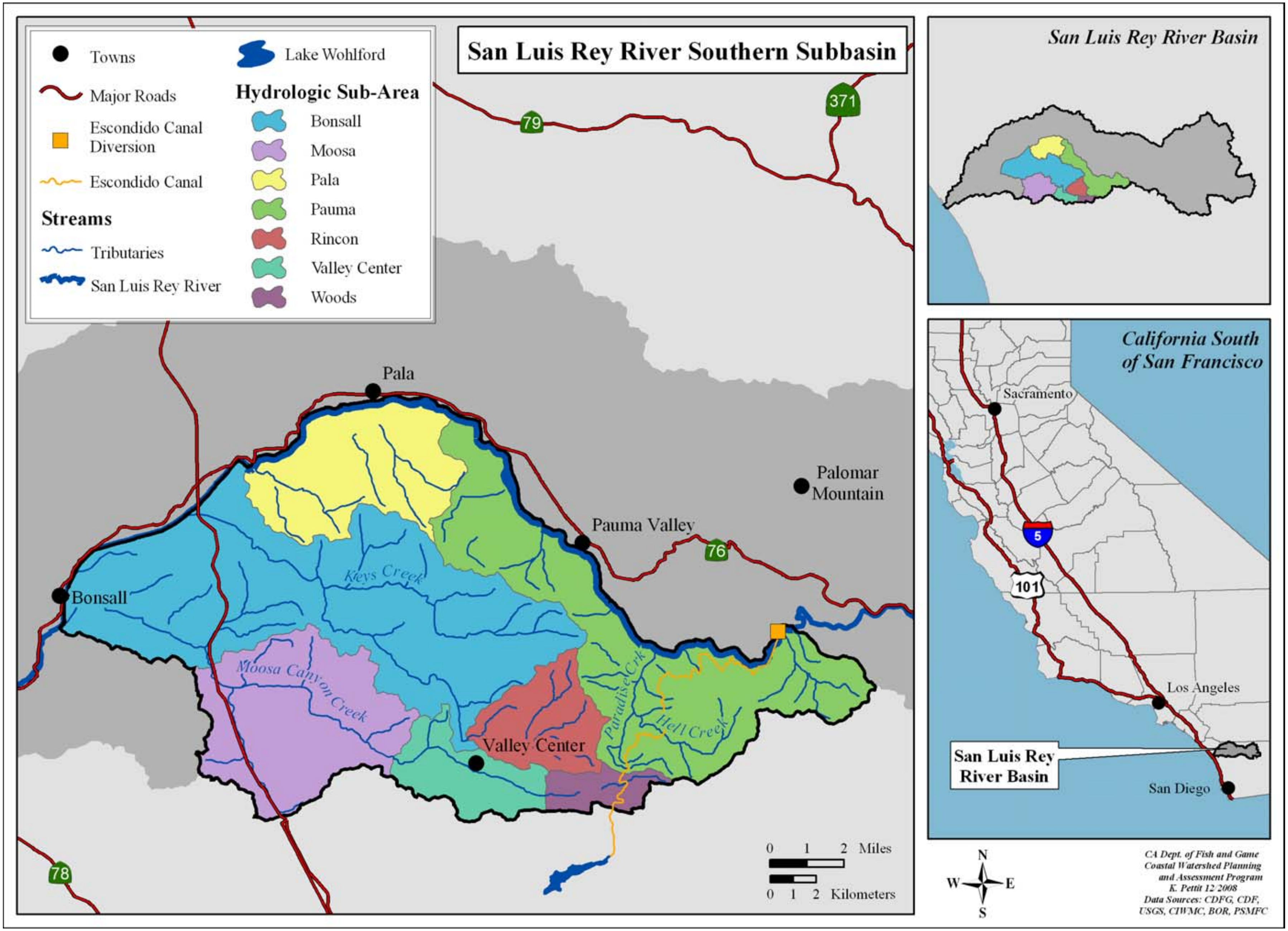


Figure 2. Southern Subbasin locator map and CalWater Units.

Geology

The Southern Subbasin is predominately underlain by granitic rock types of the Peninsular Range Batholith that intruded into older sedimentary, marine, rock types between 90 and 140 million years ago and has subsequently been exposed by tectonic uplift and erosion. Intrusion of the Peninsular Range Batholith as well as regional tectonics has caused some of the marine, sedimentary rocks to undergo metamorphosis.

Erosion has exposed the batholith leaving behind mountains of granitic rock with remnants of the sedimentary rocks it intruded into. Weathering of the granitic rocks has created younger, unconsolidated sediments that are very susceptible to erosion and mass movement such as landslides and debris-flows. These sediments have been deposited in a series of alluvial fans, marine and river terraces, as well as active channel deposits. These sedimentary deposits range from partially consolidated sandstone, siltstone, mudstone, and shale to unconsolidated sand and gravel.

Compositional Overview

Rock Types

The rock types depicted in the geologic map (Figure 3) presented in this report have been combined from various other published source maps. Like rock types based on similar age, composition, genesis, orgin, and geologic history have been combined to help simplify the information presented herein. General descriptions of the geolgic units displayed in the map and in Table 2 are as follows:

Mesozoic Granitic

Granitic rocks make up the majority of this subbasin. They occupy approximately 83% of its surface area. They are predominantly Cretaceous (154.5 million through 65.5 million years ago) in age. These rocks are very hard and resistant to erosion; however, they do tend to exfoliate to some extent in exposed surfaces and preferentially weather at structural joints. Over long periods of time granitic rocks tend to decompose, become “soft,” and much less resistant to erosion producing “decomposed granite.” In more advanced forms, the minerals within the granite disaggregate and form “Arkosic Sand” which is made of individual mineral grains disaggregated from the granitic parent rock. These sands are predominantly comprised of quartz and feldspar and are highly susceptible to erosion, sliding, and fluvial transport.

Quaternary Alluvium

Alluvium covers about 14.3% of the basin. It consists of unconsolidated sediments that range from clay to boulders. Alluvium is transported and deposited by the streams and makes up most of the bed and banks of the streams. Units of alluvium delineated by the geology map (Figure 3) include sediment currently being acted upon by the streams and bank and flood-plain deposits occasionally acted upon by the streams. If the alluvium within the stream channel is of sufficient depth it can readily transport water via the subsurface pore-spaces allowing stretches of the stream to “run dry.”

Alluvium is generally deposited in low lying areas and in flood plains producing a relatively flat landscape.

Mesozoic Sedimentary

Mesozoic sedimentary rocks make up around 3% of the subbasin and consist mostly of siltstone, sandstone, and conglomerate and were deposited some 65.5 to 225 million years ago. The original deposition of the sediments that make up these rock types occurred in environments ranging from marine to terrestrial. Some of these rock types have subsequently undergone metamorphism especially in areas in contact with granitic rock types. These sedimentary rock types are generally more susceptible to erosion than granitic rock types.

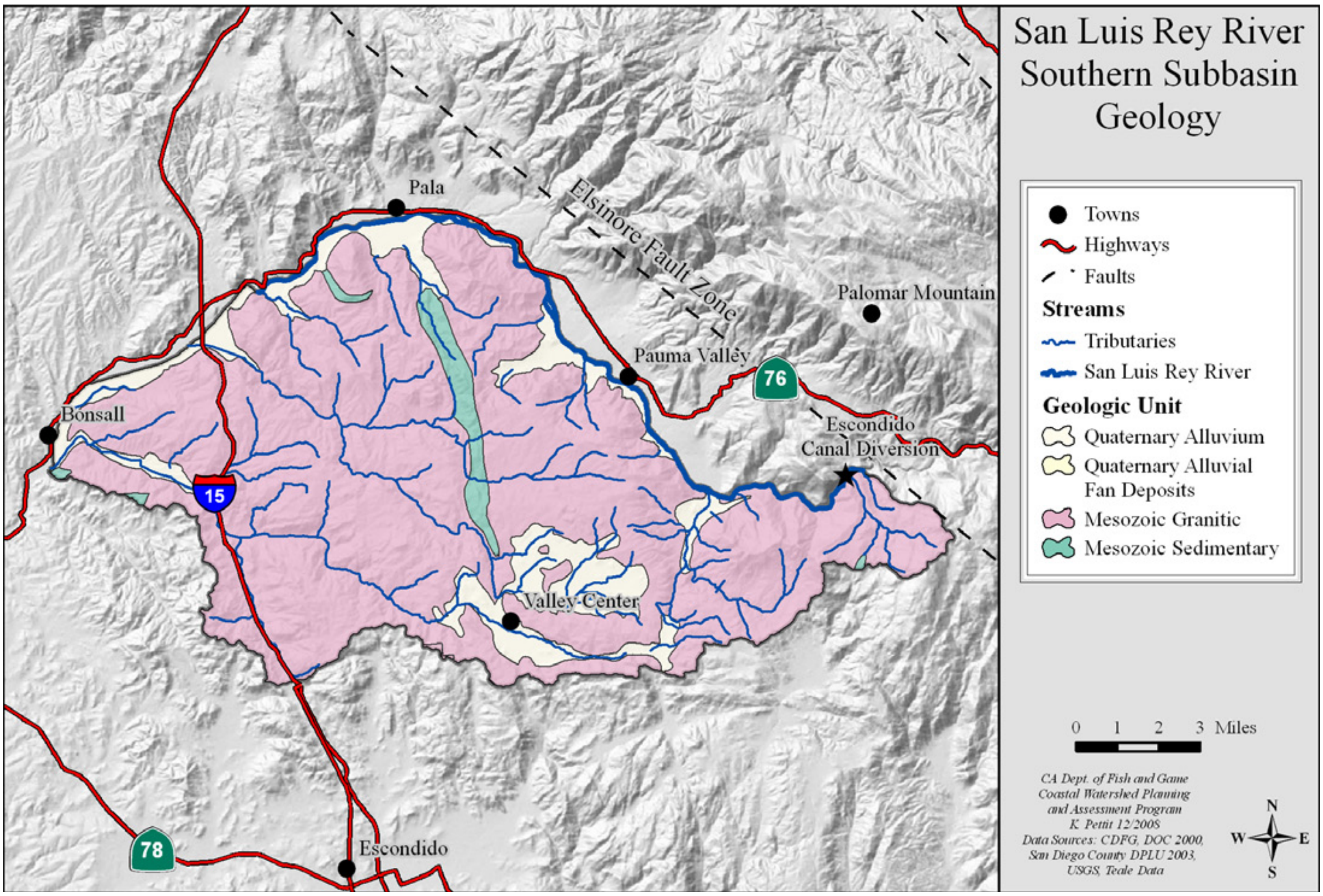
Quaternary Alluvial Fan Deposits

Fan deposits make up less than 1% of the subbasin and consist of unconsolidated sediments ranging from clay to boulders. They wash out of canyons on high slopes and are usually deposited where there is a significant change of slope. They are not usually transported far from there source and therefore consist of sediments made from the bedrock of the mountains from which they come.

Table 2. Rock types in the Southern Subbasin.

Lithologic Unit	Percent of Basin
Mesozoic Granitic	83.02
Quaternary Alluvium	14.30
Mesozoic Sedimentary	2.68
Quaternary Alluvial Fan Deposits	.01

% area of basin represents a rough approximation based on GIS mapping.


San Luis Rey River Southern Subbasin Geology

CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 12/2008
Data Sources: CDFG, DOC 2000,
San Diego County DPLU 2003,
USGS, Teale Data

Figure 3. Geology of the Southern Subbasin.

Soils

The underlying bedrock is generally responsible for a soil's texture and erodability characteristics. The sediment contribution from soils found in the Southern Subbasin is dependant largely on slope, soil sediment size, consolidation, cohesion, compaction, the type and amount of vegetation cover, land use, and amount, intensity, and duration of local rainfall (Table 3).

The majority of bedrock throughout the subbasin is composed of various granitic rock types producing associated soil types that are in general very well drained and is somewhat prone to erosion and transport by fluvial processes as well as wind. Soils with high sand and silt content are typically more susceptible to erosion than soils with high clay content which exhibit a greater degree of cohesion.

Table 3. Soil types in the Southern Subbasin.

Soil Type	Percent of Southern Subbasin	Parent Material
Sesame-Rock Outcrop-Cieneba (s1010)	60.12	Weathered granite
Vista-Fallbrook-Cieneba (s1011)	20.7	Weathered granite
Tujunga-Salina-Elder (s1001)	10.6	Weathered granite, sandstone-shale, alluvium
Rock Outcrop-Las Posas (s1012)	4.98	Basic igneous
Hotaw_Crouch_Boomer (s1015)	2.53	Weathered granite, metavolcanic
San Miguel-Friant-Exchequer (s1013)	1.07	Schist-gneiss, metavolcanic

Percent of basin represents a rough approximation based on GIS mapping

Earthquakes and Faults

The San Luis Rey River Basin is tectonically and seismically active and the possibility of seismic activity occurring in the subbasin should be considered similar to the southern California region as a whole. Due to nearby active faults, such as the Elsinore Fault, the subbasin has the potential for strong seismic movement. The Elsinore Fault Zone (currently established Alquist-Priolo Earthquake Fault Zone) runs northwest along the easternmost extent of this subbasin. The Elsinore Fault is a right-lateral, strike-slip fault system that is related to translational plate boundary tectonics between the Pacific and North American plates. The Elsinore Fault is capable of producing earthquakes in the range of M6.5 – 7.5 and has an average recurrence interval of approximately 250 years (SCEDC). The most recent major earthquake was a M6.0 in 1910. Ground shaking generated by earthquakes can trigger rock falls and landslides that deliver large amounts of sediment to the streams. The 1994, Northridge earthquake (M6.7), triggered in excess of 11,000 landslides in a 6,200 square mile area (USGS) in similar terrain.

Landslides

Like the other SLR River subbasins, the Southern Subbasin is partially mantled with unstable soils. The mainstem and its floodplain in the Southern Subbasin consist predominately of alluvial material, while the hillsides are often composed of granite, weathered granite, as well as some sedimentary rock. Except for fresh granite these rock types are susceptible to surface erosion, headword erosion, gullying, stream bank raveling, and landsliding. This area has undergone tectonic uplift leaving steep canyon walls above the streams. As tectonic forces push the land up gravity tries to pull it down and the result is usually landslides and rock falls. Landsliding is further exacerbated by seasonal rain storms. As the hillsides become saturated pore pressure between grains becomes greater making them unstable and more prone to landsliding.

Fluvial Geomorphology

On average the Southern Subbasin should act as both a sediment transport reach, delivering sediments to the coastal basin, and a depositional reach, storing sediments in its flood plain. The slope of the mainstem was calculated to be 5% or less based on GIS mapping. Sediment erodes from the steeper hillsides and is brought by tributaries to the mainstem as well as being transported by the mainstem from the upper reaches.

The most recent stream surveys of the two reaches in the Southern Subbasin found DA5 Rosgen channel types (Table 4). These reaches were on the mainstem of the SLR River and in Keys Creek. Type DA reaches have multiple channels that typically are narrow and deep with expansive well vegetated floodplain and generally have associated wetlands. They have very gentle relief with highly variable sinuosities and stable stream banks (Flosi, et al., 1998).

Alluvium, which consists of unconsolidated sediment within the active influence of the stream channel, is relatively deep in places within the mainstem valley. The course, unconsolidated nature of these sedimentary deposits makes them excellent mediums in which to accommodate the subsurface flow of water. This can cause surface reaches of the mainstem as well as tributaries to go dry during times of low flow.

Table 4. Channel types in surveyed streams, Southern Subbasin.

Stream	Reach	Length (feet)	Channel Type
San Luis Rey River	1	51,142	DA5
Keys Creek	1	11,690	DA5

Vegetation

The predominant vegetation cover type as described by the U.S.F.S. CALVEG data is chaparral/scrub, covering 43.2% of the Southern Subbasin (Figure 4, Table 5). This cover type is split primarily between lower montane/mixed chaparral and California sagebrush vegetation types. Agriculture, consisting of orchards, pastures, crops, and nurseries is the second most abundant cover type at 28.6 %. Agriculture is the dominant land use throughout the subbasin as a great deal of native habitat has been converted to agricultural practices. Moreover, similar to the Coastal Subbasin, this figure does not reflect the overall percentage of acres dedicated to the growing of crops or livestock. Within the Southern Subbasin, pastures used for grazing of livestock may not be included in this vegetation designation since land use is often difficult to remotely ascertain. For this reason, it can be assumed that areas mapped as annual grasslands may also be agricultural in nature. The herbaceous cover type, composing 9% of the subbasin, most likely contains acres of agricultural related land as almost 90% of this herbaceous cover type consists of the annual grasses/forb alliance.

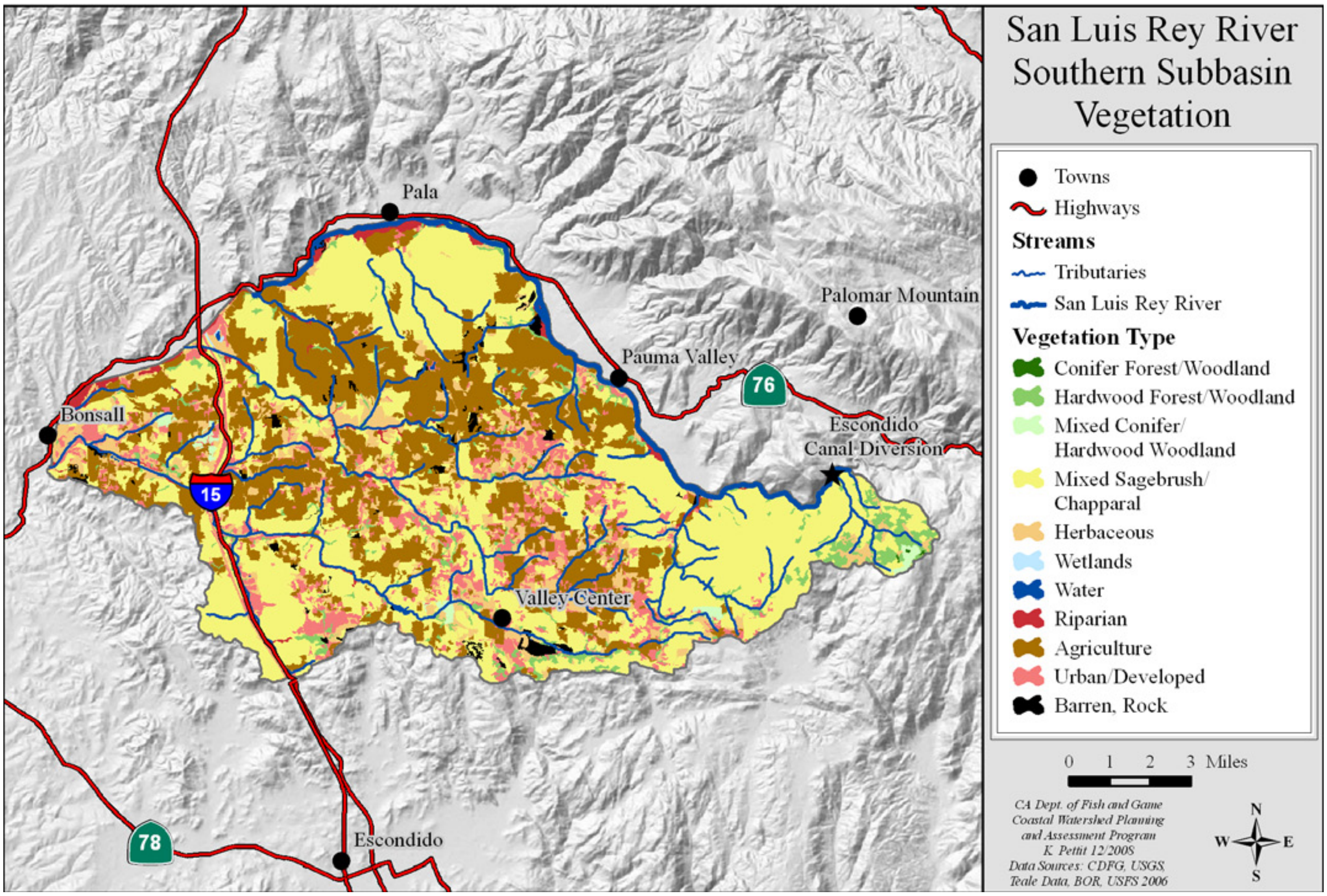
The only significant urban/residential area in the subbasin consists of Valley Center, located in the southern portion of the subbasin. Although, urban and residential areas continue to expand, especially around Valley Center, which has led to a reduction in the amount of farm land and native areas in the subbasin.

The impact of agriculture and urban/residential areas in the subbasin are described further in the Land Use Section below.

Non-Native Plants

Many non-native plants first became established in the coastal areas of California. They tend to decline with increasing distance from the coast (Stephenson and Calcarone 1999); however, anthropogenic activities have allowed non-natives to extend eastward in the SLR River Basin. Exotic plant species are most dominant to the lower elevations of the Coastal Subbasin, but have easily spread into the western portion of the Southern Subbasin, RM 19 to RM 24 (Basin Profile, Figure 17 & 18). Hydrologic changes to the SLR brought on by the dams and diversions appear to reduce the ability of native riparian plants to survive, creating conditions that promote the establishment of exotic species. High levels of disturbance and habitat modification tend to favor a non-native flora (Stephenson and Calcarone 1999). Currently, giant reed (*Arundo donax*) represents the greatest threat to the Southern Subbasin in terms of area occupied, potential to spread, impact to the quality and quantity of native habitat, and problems they pose to land managers. *Arundo* is widespread in the SLR River and some of its tributaries within the western portion of the Southern Subbasin. See Invasive Species Management section in Basin Profile (p.32) for a more detailed discussion of *Arundo*.

The Mission Resource Conservation District, working with the Santa Margarita–San Luis Rey Weed Management Area, as of August 1, 2007, had treated approximately 292 acres of 607 acres of *Arundo* in the watershed, mainly in the mainstem and some tributaries (http://smslrwma.org/). Although, due to the Corps long-term Operation and Maintenance Plan in Oceanside, within the concrete-lined channel (RM 1 to RM 7), a much larger area of exotic and native plant species have been and will continue to be treated, adding to these totals. The Weed Management Team has plans to remove/treat 100 acres of *Arundo* along Keys Creek. *Arundo* is widespread along its stream banks from half a mile upstream of its confluence with the SLR River to approximately 2.2 miles (RM 2.2) upstream. At RM 2.2 the creek increases in gradient and moves out of the alluvial floodplain with native species becoming the dominant vegetation. Additional treatments of *Arundo* are needed in Moosa Canyon and along the lower mainstem in the subbasin.



CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 12/2008
Data Sources: CDFG, USGS, Teale Data, BOR, USFS 2006

Figure 4. Vegetation of the Southern Subbasin.

Table 5. Vegetation of the Southern Subbasin.

Vegetative Cover Type	Percent of Basin	Primary Vegetation Type	Percent of Cover Type
Chaparral/Scrub	43.2	Basin Sagebrush	0
		Buckwheat	0
		California Sagebrush	41.8
		Ceanothus Mixed Chaparral	2.8
		Chamise	0.5
		Lower Montane Mixed Chaparral	54.8
		Manzanita Chaparral	0
		Red Shanks Chaparral	0
		Upper Montane Mixed Chaparral	0
		Other	0.1
Agriculture	28.6	Agriculture	0
		Orchard Agriculture	85.1
		Pastures and Crop Agriculture	14.9
Herbaceous	9.2	Annual Grasses/Forb Alliance	89.3
		Non-Native/Ornamental Grass	10.3
		Perennial Grasses and Forbs	0.4
Urban/Development	8.6	Urban/Development	100
Hardwood Forest/Woodland	5.1	Black Oak	0
		California Sycamore	1.7
		Canyon Live Oak	0
		Coast Live Oak	80.3
		Engelmann Oak	28.2
		Eucalyptus	2.3
		Interior Mixed Hardwood	0
		Non-native/Ornamental Hardwood	0.8
Riparian	2.5	Baccharis (Riparian)	31.9
		Fremont Cottonwood	0.2
		Riparian Mixed Hardwood	33.7
		Riparian Mixed Shrub	16.0
		Willow (Shrub)	16.0
Barren/Rock	1.2	Barren	7.7
		Tilled Earth	47.0
		Urban related bare soil	45.3
Mixed Conifer/Woodland	0.65	Bigcone Douglas - Fir	0
		Coulter Pine	23.9
		Mixed Conifer – Fir	0
		Mixed Conifer - Pine	0
		White Fir	0
		Nurseries	76.1
Water	0.20	Water	100
Wetlands	0.03	Tule – Cattails	50.0
		Wet Meadows	50.0
Conifer Forest/Woodland	0.02	Coulter Pine	100

These statistics exclude the classification of water.

Data from CALVEG, USFS

Land and Resource Use

Historic Land Use

Prior to the settlement of Europeans, the Southern Subbasin was inhabited by the local Indian tribe comprised of the Luiseño people. While acorns from the numerous oaks in the area provided a staple for their diet, there was a variety of other food sources. As described in the Basin Profile, the San Luis Rey River was a prominent natural feature of the Luiseño territory providing the residents with subsistent food sources that included ocean and freshwater fish, a wide variety of plants and seeds, birds, and small and large mammals. The Spaniards were the first Europeans to arrive in the basin, in late 1760s. They entered in the Coastal Subbasin and began moving and settling throughout the basin. One of the earliest settlements near the Southern Subbasin coincided with the establishment of the Mission San Antonio De Pala, located in what is now the town of Pala. This mission was founded by Father Antonio Peyri on June 13th, 1816. Prior to California becoming a state, a few early settlers were given grazing rights on large lots of land through enormous land grants, called ranchos, whose property rights were retained by the Mexican government. These ranchos were phased out by the late 1830s.

The area's attractions were common knowledge by the 1850s as a greater number of homesteaders continued to populate the area and eventually forced Indian tribes off of their lands and onto reservations. The first lands set aside were for the Pala Reservation in 1875 (SLR Watershed Council 2000). The Luiseño people were placed on this 10,000-acre reservation in what is now the town of Pala. Shortly afterwards, in the early 1900s, the Cupeños Indian tribe were removed from their residence in Warner Valley in the Upper Subbasin, and relocated to the Pala Indian reservation. This act herded two distinct Indian tribes together onto one reservation (http://www.palatribe.com/). In 1881, the smaller Rincon Indian Reservation was established. Both the Pala and the Rincon Reservations were formed alongside the SLR River with the Pala reservation situated downstream of the Rincon reservation.

With the completion of the Southern California Railway in the 1880s and the highway connecting Los Angeles with San Diego in the 1920s the Coastal Subbasin continued to expand; however, the Southern Subbasin experienced minimum growth. Aside from the agriculture that was occurring in the subbasin throughout the 20th century, it wasn't until the housing boom of the whole county in the 1990s to the present that the Southern Subbasin gained a moderate population growth. This growth occurred mainly around the city of Valley Center.

Agriculture

Agriculture was the most significant historic land and resource use in the Southern Subbasin. Beginning with the grazing of cattle, sheep and horses, agriculture grew throughout the basin. As annual grasses became established, replacing perennial native grasses, livestock numbers declined dramatically. Farming of grain and hay developed and expanded on homestead lands in the subbasin. The first commercial mill in Northern San Diego County was a grist mill located in the area of the Wilderness Gardens. Powered by the SLR River, this successful mill operated from 1881 till the early 1890s, grinding corn and wheat into flour provided by farmers throughout the region. As agricultural operations expanded in the watershed, numerous citrus orchards became established by the 1930s. While citrus is still an important crop, many areas have more recently been planted with avocado groves. Imported water supplies provided the needed resources for many intensive agricultural enterprises in the Southern Subbasin and throughout the watershed such as truck crops, flowers, and nurseries.

Gravel Mining

Gravel mining operations have established an important industry in the basin. Most sand mining operations occurred in the Southern and Northern subbasins. While the effects of these operations were evident in the SLR River in the Southern Subbasin, they also contributed to a range of significant environmental impacts downstream in the Coastal Subbasin. Therefore, this report has discussed mining operations at greater lengths in the Basin Profile and Coastal Subbasin sections of the report.

At one time there were thirteen active mining operations, and gravel mining was the most economically important industry in the watershed in the 1980's. The last operating mine in the subbasin and the overall basin was the Felton Mine site operated by Hansen Aggregates. This was an in-stream mine that encompassed 225 acres and mined an average of 600,000 tons of sand per year during the late 1990s and early 2000s. Their major use permit expired in 2005 and the site was dedicated to open space. The reclamation and mitigation that occurred is mostly in the form of several large ponds just east of Pala on the south side of Highway 76. These ponds currently contribute seasonal runoff into to the river.

The current condition of the SLR River, particularly in the Coastal and Southern subbasins, demonstrates that the previous traditional approaches to regulating in-stream mining have failed to adequately protect river resources over the long term. For a more detailed discussion of mining operations and their impacts on the watershed, please refer in the Coastal Subbasin and Basin Profile mining sections.

Escondido Canal

The Escondido Canal is located approximately ten miles below Henshaw Dam, just downstream of the divide between the Middle Subbasin and the Southern Subbasin (RM 40). The canal was constructed in 1895 for the purposes of supplying water for expanding agricultural needs and urban development to what is known today as the City of Escondido. This water diversion is made possible by a concrete dam approximately 150 feet long and 12 feet high across the main channel, creating a complete barrier to fish passage (Figure 5). Shortly after its completion the canal diverted approximately 45 cfs of SLR River water into the man-made canal that transferred it out-of-basin into Lake Wolford near the City of Escondido. Historically, the canal has diverted approximately 90% of the SLR River water away from the five Indian Tribes (Pala, Pauma, Rincon, La Jolla, and San Pasqual) to the Local Entities (City of Escondido and the Vista Irrigation District) (R. Smith, Chairman of Pala Band of Mission Indians, personal communication 2009). This drastic reduction of river flows below the diversion to the rest of the basin consequently altered the landscape and habitat of the riverine area.

Current Land Use

Many of the land use issues impacting the natural resources and riverine habitat in the Coastal Subbasin are also present in the Southern Subbasin. Some of these impacts are due to the same types of anthropogenic activities or proposed projects that will have a detrimental effect on the natural resources of the subbasin.

Agriculture

Agriculture plays a significant role in the San Diego County economy and the SLR Basin is a major area of agricultural production. Numerous small and large-scale farms populate the subbasin including land adjacent to the river and its tributaries. The warm climate of the Southern Subbasin makes it ideal for the growing of avocados, citrus fruit, nursery stock, and ornamental varieties of plants and flowers. The majority of these nursery operations ship their plants to overseas markets. Cattle and other livestock operations persist in the subbasin as well.

The large agricultural production in the basin contributes to reduced water quantity and most likely quality as well. Although many agricultural producers rely on water from imported sources (the Colorado River and State Water Project) (SLR Watershed Council 2000), water pumps were observed during CDFG 2007 field surveys in or near the flood plain within the Southern Subbasin. These pumps likely divert groundwater, which normally contributes to SLR River flows, to assist crop production. With uncertainties surrounding the delivery of imported water as well as rising costs, a greater importance will be placed on local sources such as groundwater. Increased groundwater pumping would have numerous detrimental impacts to the river and riverine habitat such as lowering the groundwater table, which would reduce potential surface flows and place additional stress on the water demands of riparian plant species.

The use of pesticides in San Diego County is closely scrutinized by the local Agricultural Commissioner’s office, and growers must be concerned with issues involving use of pesticides. Growers are increasingly required to reduce and capture runoff water, re-use tailwater and utilize other best management practice to minimize the effects of agriculture on water quality and water bodies in the areas where they farm. See Agriculture section in the Basin Profile for further details of the impacts of agriculture to water quality and quantity (p.43).

The recent impact of rising water prices has caused a number of farmers to remove some crops such as citrus and avocados. About 10 to 15% of the 24,000 acres of tree crops in Valley Center have been taken out of production since 2005 (Fikes, 2008). Due to competition from Mexico, rising water, fuel and other operational costs, agriculture is becoming increasingly marginal in Southern California. There is a concern that more agricultural lands will be taken out of production because of these rising costs, and agriculture and its benefits to the local and regional economy will lost.

Mining

Currently there are no mining operations occurring in the subbasin. The Rosemary’s Mountain Quarry site, which is set to begin operations sometime between 2009 and 2010 is located primarily in the Coastal Subbasin, but portions of the mine extend into the western end of the Southern Subbasin. This mining operation is discussed in further detail in the Coastal Subbasin Current Land Use section.

Urbanization

The only major population center in the Southern Subbasin is located in the southern portion of the subbasin in Valley Center. The 2000 population census indicated that 15,639 people lived within the Community Planning Areas (CPAs) of Valley Center. This figure is expected to more than double to 33,006 by the year 2020 (SANDAG 2002). This substantial increase in populations will put additional stress on the natural resources and further encroach on native habitats as additional developments will occur to provide the necessary services and infrastructure to accommodate the increased population in the subbasin. There are also projects currently in the planning stages that will have considerable impacts on the subbasin's natural habitats.

Gregory Canyon Landfill

The proposed Gregory Canyon Landfill, which was also discussed in the Coastal and Northern subbasin's Urbanization section, is located in the Southern and Northern subbasins, a couple of miles east of Interstate 15 (approximately RM 21). Most of the landfill project site would be just south of California Highway 76, with a slight portion extending north of Highway 76 into the Rice Canyon watershed). This 1,770 acre landfill, which is currently in the permitting stages, is due to the increased need for waste storage as primarily a result of the growth that has and will be occurring in San Diego County including the urban areas of the Coastal and Southern Subbasins.

Currently, approval of the proposed landfill depends largely on whether the court decides if water supply for the landfill has been properly addressed. In order to operate the landfill, nearly 200 acre-feet of water per year is needed to help control dust and odor. Gregory Canyon Ltd. has contracted with Olivenhain Water District in Encinitas to provide those millions of gallons in the form of recycled water delivered via trucks on a daily basis (Pfingsten 2008). This agreement would require the water district to continue delivering large amounts of water over a 60-year period, regardless of drought conditions or increased demand from other customers in Encinitas.

Escondido Canal

The Escondido Canal continues to provide an important source of water for the City of Escondido as well as Vista. Upgrades to the canal and expansion of Lake Wohlford have increased the diversion potential of the canal as it is capable of diverting up to 70cfs of river water, an annual average of 14,000 acre-feet of water. Thus, under normal conditions, little to no flow passes the diversion point; therefore, the SLR River is generally dry (except following periods of sufficient precipitation) from the diversion dam (RM 40) to 19 miles downstream where a higher water table creates minimal year round surface flows.

Figure 5. Escondido Canal diversion dam (RM 40).

Tribal Indian Reservations

In conjunction with altering the ecosystems below the Escondido Canal diversion dam, the diversion of the river water was devastating to the way of life of the La Jolla, Rincon, Pala, Pauma, and San Pasqual Band of Mission Indians (http://www.slriwa.org/history). These tribes relied on the flowing river for farming, subsistence, ceremonies, and other culturally significant activities (see Basin Profile, Water Use: Diversions, Dams, and Water (pp. 48-50) for a further discussion of the appropriation of the SLR River water.

The Rincon Luiseño Band of Mission Indians consists of approximately 1,500 tribal members on nearly 4,000 acres of land (http://www.sandiego.edu/nativeamerican/reservations.html). This reservation is located predominately within the Southern Subbasin, along the SLR River and in the lower Paradise Creek watershed. A portion of the reservation extends into the Northern Subbasin on the north side of the river, approximately 4 miles downstream of the Escondido Canal diversion dam. The Rincon Indians operate a large, 55,000 square feet gaming casino (Harrah's), including a 21-story hotel, along the SLR River (RM 35), just downstream the Paradise Creek/SLR River confluence.

The San Pasqual Band of Indians is a smaller tribe whose reservation area consists of five non-contiguous tracts of land. Some of these tracts extend into the southernmost area of the subbasin.

The Pala Band of Mission Indians tribal lands extend almost equally between the Northern and Southern subbasins, with slightly more of their lands occupying the Southern Subbasin. However, due to the town of Pala, situated in the Northern Subbasin, the assessment chose to discuss the Pala Indians in the Northern Subbasin profile. The Pauma Band of Mission Indians (reservation almost entirely within the Northern Subbasin) is also discussed in the Northern Subbasin; whereas, the La Jolla Band of Luiseño Indians overview is located in the Middle Subbasin profile.

Recreational

Due to the majority of land being held in private or Indian Reservation lands, few recreational opportunities exist in the Southern Subbasin. One historically and ecologically significant public park is the Wilderness Gardens Preserve (RM 27), located along the SLR River, east of Pala. This is a 584-acre county park consisting of oak woodlands, chaparral, and riparian habitats. The park was the site of a former ranch and a commercial grist mill as described in the Historic Land Use (Agriculture, pg. 8) section. Aside from this park, the Hellhole Canyon Open Space Preserve, located east of Valley Center in the southern portion of the subbasin, provides hiking and horseback riding trails on 1,900-acres in mixed chaparral vegetation communities. There are also a few golf courses in the Southern Subbasin. These golf courses can contribute to water quality problems with the large amount of pesticide and fertilizers that go into the management of these large turf areas. Golf courses also tend to use large amounts of water, depleting groundwater levels and can exacerbate erosion or water quality problems with runoff from these courses.

Fish Habitat Relationship

Fishery Resources

Steelhead trout were historically found in the SLR River, including the Southern Subbasin, in sufficient numbers to provide the Indian Tribes with a subsistence food source and subsequently the local region with recreational fishing opportunities (USFWS 1998). Adult steelhead most likely used the SLR River in Southern Subbasin as a migration corridor for accessing more extensive habitat in tributaries of the Northern Subbasin and possibly mainstem habitat in the SLR River canyon (Figure 6 & 7) below natural barriers. Juvenile steelhead could have utilized the mainstem in the SLR River canyon as over-summering habitat and the rest of the river to migrate to the ocean and possibly for rearing habitat.

For a brief period in the 1990s, rainbow trout were successfully reared in the SLR River near the Wilderness Gardens Preserve boundaries. Local schools were provided fish from the CDFG Mojave Hatchery for release into the SLR River. At the time of their release water quality testing and sampling of aquatic insects indicated that conditions were favorable for trout survival.

In recent years, steelhead/trout have not been detected in the Southern Subbasin. It seems unlikely that steelhead/trout could utilize the majority of mainstem (below the canyon) or tributaries in the Southern Subbasin due to insufficient stream flows, passage barriers, the lack of suitable habitat, potentially high water temperatures, and water quality issues. Nonetheless, field surveys utilizing appropriate protocols are necessary to confirm the presence or absence of steelhead/trout.

Habitat Overview

Historic Conditions

As with most of the basin, there has been a limited amount of stream surveys conducted in the Southern Subbasin. Early stream survey efforts performed by CDFG were neither specific nor standardized until 1990 when the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998) was published. Most observations in the historic stream surveys are not quantitative and have limited use in comparative analysis with current habitat inventories. However, data from these stream surveys provide a snapshot of conditions at the time of survey (Table 6).

The earliest stream survey in this subbasin was conducted by CDFG in 1946 in the SLR River. Most of the river flows had been continuously diverted for the prior 50 years and habitat conditions observed most likely reflected the effects of drastically reduced surface flows. This survey generally indicated that the river within the Southern Subbasin was unsuitable for trout, except for a small stretch of river around Pala where rainbow trout were observed. The report described a predominantly dry riverbed, with numerous extraction pumps in or near the river.

Prior to the completion of Escondido Canal diversion, Henshaw Dam and other major water diversions projects in conjunction with conversion of the riparian and surrounding areas to agricultural production, the SLR River possessed considerably different instream and riparian conditions. Leo Calac, a Rincon elder stated: “The riverbed was full of sycamores and willows… the old-timers say in Pauma Valley that steelhead used to come up from Oceanside” (Soto 2008). See Stream Flow (pp. 11-15) and Historic Conditions (pp. 57-58) in the Basin Profile for further historical stream flow data and anecdotal information. During normal to wet rain years, perennial surface flows would have facilitated upstream adult migration and smolt migration to the ocean. The SLR River with year-round flows and an extensive riparian habitat may have also provided some rearing habitat for emigrating juvenile steelhead. A recent report by Boughton et al. (2006) compiled historical evidence on central and southern California streams to suggest that the low gradient areas, such as the SLR River in the Southern Subbasin, “may once have been suitable for steelhead before alteration in the form of 1) widespread clearing of riparian cottonwoods and willows, 2) down-cutting of channels, and 3) loss of perennial flow.”

It is unknown whether steelhead utilized any of the tributaries within the subbasin. While several large tributaries exist, such as Keys Creek and Moosa Canyon, there is a lack of recorded or anecdotal information regarding the presence of steelhead in these streams. According to the USGS 7.5 Bonsall quadrangle, Keys Creek was an intermittent stream for the lower 2.2 stream miles. Because of extensive agriculture production within the watershed, resulting in large amounts of runoff, the majority of Keys Creek now appears to flow year round. This was witnessed during several site visits in the late summer of 2007 as the creek maintained moderate summer flows (approximately 1 cfs). Other streams within the subbasin that may have contained sufficient flows to support the freshwater lifecycle stages of steelhead were probably very limited. Moosa Canyon is one of the few creeks in the subbasin which contained stream reaches with perennial flows, according to the USGS 7.5 Bonsall, San Marcos, and Valley Center quadrangles. The middle and upper reaches were denoted as having perennial flows, as the lower eight miles is labeled as an intermittent stream. With that many miles of intermittent flows, combined with a low gradient, alluvial streambed, it seems unlikely that Moosa Canyon was utilized by steelhead in most years.

Table 6. Habitat observations made in the Southern Subbasin from 1946-2007.

Stream	Date Surveyed	Source	Habitat Comments	Barrier Comments
San Luis Rey River	09/04/1946	CDFG 1946	Surveyed east of Oceanside to just upstream of Pala Creek (RM 25). Stream flow was low with an average depth of 8-10 inches and an average width of 4-5 feet. The water temperature was 68F. The surveyor reported of numerous pumps in the river and much of the river was dry except for the upper 4-6 miles. Rainbow trout, mosquito fish, and small cyprinids were present; however the trout were most likely observed in the vicinity of the Pala Indian Reservation. The survey indicated the area with the exception of a small stretch of river around Pala that the subbasin was unsuitable for trout.	Escondido Canal diversion dam (RM 40) was described as a complete barrier to fish passage.
	6/20/1975	Swift 1975	“The streambed mainly is sand in the lower reaches. The river is intermittent (from the Escondido Canal, RM 40) to the vicinity of Bonsall (RM 14) where the flow appears to be permanent. Mosquitofish and a few green sunfish were caught near the Oceanside Airport. Water temp at 3:30 pm was 20C; dissolved oxygen (ppm) was 5; pH was 7.5; and turbidity (J.U.) was 51.	Escondido Canal diversion dam

Current Conditions

In the Southern Subbasin, full instream habitat inventories were limited to the SLR River (Table 7 and Figure 8). A CDFG/PSMFC fishery crew conducted this inventory in August of 2007; the crew surveyed nearly 10 miles of the SLR River from the Coastal Subbasin border upstream to Cole Grade Road. The entire river in the subbasin was not surveyed due to denied landowner access. Keys Creek was surveyed in the winter of 2007, but full habitat inventory protocols were not performed because of human alterations to the stream channel and the stream channel/habitat uniformity. Other than Keys Creek, all other tributaries in the subbasin contained little to no surface flows during the majority of the field survey period and appeared to have very little potential suitable habitat for steelhead/trout.

The majority of the habitat characteristics assessed in CDFG's standardized stream inventory protocol are based on the presence of water; therefore, instream habitat conditions in the mainstem SLR River within the Southern Subbasin were difficult to quantify due to the lack of surface flows at the time of the survey. Only the western portion of the river, downstream of Gomez Creek, contained reaches with low flows and/or stagnant water. These surface flows appeared to be aided by runoff from the adjacent detention ponds located between the river and Highway 76. An elevated water table/alluvial aquifer may have also contributed to presence of surface water. Within this area, there is a shift in stream bank vegetation going from grasses and drought tolerant shrubs to moisture-depended flora, such as willows, sedges, bulrush, and *Arundo donax*. The volume of flow seems to increase further downstream, on the western edge of the subbasin and continuing into the Coastal Subbasin. The remaining approximately 9 miles of surveyed riverbed was dry (Figure 8).

Even if surface flows were present, habitat conditions would have been unsuitable for steelhead/trout. Much of the area surveyed exhibited limited instream habitat diversity, sparse riparian vegetation, and potential spawning gravels were absent as the streambed was predominantly composed of sand. Few existing or potential pools were observed, and the broad, alluvial riverbed was also lacking potential instream cover. The combination of the high sediment transport and low stream gradient of the area would prevent deep pool formation. As described in the Geology Section (p. 4), the alluvium nature of the mainstem stream channel creates excellent mediums in which to accommodate the subsurface flow of water. This causes surface reaches of the mainstem as well as tributaries in the subbasin to usually remain dry from the late spring to late fall (May through November).

The majority of the unsurveyed portion of the SLR River, prior to entering the mountainous, canyon area (RM 36) and with the exception of its traverse through the Pauma Valley Country Club (RM 33), appeared to be characterized by similar habitat conditions: dry, sandy river channel with chaparral and non-native and native grasses along the streambanks. Within the Pauma Valley Country Club the river has been channelized by means of a concrete-lined channel for the entire length of the golf course, approximately two-thirds of a mile. This concrete-lined channel has completely altered the streambed and habitat of the riverine area to the point where the channel now merely acts as a means to convey water flows (Figure 9). The golf course and lined channel also contains two road crossings, which are, at minimum, low flow barriers.

In June of 2009, tribal members and a consultant performed a reconnaissance level survey downstream of the Escondido Canal diversion dam into the SLR River canyon. The La Jolla Tribe refers to this area by its Luiseño place name – "Kye". Approximately ½ mile downstream of the diversion dam, RM 39.5, the crew observed a natural bedrock waterfall (Figure 10). While the overall height of the waterfall is about 50 feet, it is broken up into a series of steps, with the largest lowermost step approximately 13 feet, and a narrow steeped crevasse above the first step extending to the top of the waterfall (M. Capelli, personal communication 2010). Under most flow conditions steelhead are very unlikely to navigate through this feature. The survey report described the river flowing through several narrow chutes before reaching the falls (L. Musick, La Jolla Band of Luiseño Indians, personal communication 2009). At the time of the survey, flows were aided by water releases at the Escondido Canal diversion.

Following the June survey to the waterfall a separate reconnaissance level survey was performed in August of 2009 with tribal members and a NMFS fisheries biologist with the intent of examining the waterfall and the habitat conditions below the waterfall. While there was no surface flows directly below the diversion dam, the NMFS fisheries biologist noted flow (1.0+cfs) commencing in the inner gorge about 0.25 miles below the diversion and extending downstream for the duration of the survey (less than one mile below the waterfall). The low flow was attributed to rising ground water, as well as small side tributaries and springs below the Escondido Canal diversion (M. Capelli, personal communication 2009).

Recorded air temperatures were in the mid to high 90's during the day, while water temperature below the waterfall was 66°F. The biologist described the stream morphology consisting of large granite boulders with some deep pools and a number of step pools (Figure 6). The stream bottom was dominated by decomposed granite with little fine/silty material. While the riparian was limited by the steep, narrow nature of the canyon, there were some riparian trees consisting of mostly cottonwood and to a lesser extent sycamores. The biologist concluded, "there appears to be a considerable amount of suitable *O. mykiss* habitat below the waterfall within the inner gorge" (M. Capelli, personal communication 2009).

Keys Creek was surveyed in December of 2007 by PSMFC/CDFG fisheries crews from its confluence with the SLR River to 2.3 miles upstream. At the time of the survey stream flows were approximately 2 cfs. Beginning with its confluence with the SLR River and moving upstream, the first ¼ mile of Keys Creek consisted of a u-shaped, concrete lined channel. The bottom of the concrete channel had been filled in with a thin layer of sand as a result of upstream sediment transport. At approximately 2.2 miles the creek goes from an alluvial, low gradient stream channel to a boulder/bedrock canyon for approximately 400 feet. This short canyon reach contains multiple drops of 5 feet or greater without any potential jump pools for fish. Moreover, the creek appears to go subsurface, flowing through the bedrock layer. This area was classified as a complete barrier to steelhead migration. Below this barrier, Keys Creek has very little suitable habitat for steelhead/trout. While Keys Creek appears to retain year-round flows (surface flows were observed throughout the summer of 2007 and 2008) aided by agricultural irrigation runoff, the creek is almost completely devoid of pools and riffles. Flatwater (runs) are the dominate stream habitat type, occupying over 95% of the stream habitat downstream of the bedrock chute barrier. *Arundo* has overtaken the native riparian and has nearly formed a vegetation monoculture along the stream banks. Sand is the dominant substrate, as few, if any, potential spawning gravels were noted. Above the barrier, the habitat improved moderately as native vegetation was present along the stream banks and more pools and riffles were noted. However, the survey above the canyon was too limited to verify its potential to support trout.

Stream habitat characterization charts and EMDS maps were not produced for the Southern Subbasin due to the lack of surface flows, which are required in order to complete CDFG's standardized stream inventory protocols.

Table 7. Southern Subbasin streams surveyed in 2007 by CDFG.

Stream	Year of Survey	Survey Length (miles)	Percent of Permanent Stream Surveyed	Number of Reaches
San Luis Rey River	2007	9.74	43	1
Keys Creek*	2007	2.3	Unknown	1

* A full habitat inventory was not performed on Keys Creek. A natural bedrock chute passage barrier was encountered at 2.2 miles upstream of its confluence with the SLR River.

Figure 6. SLR River canyon below the waterfall, approximately RM 39, August 2009 (NMFS 2009).

Figure 7. SLR River canyon, below the waterfall, August 2009 (NMFS 2009).

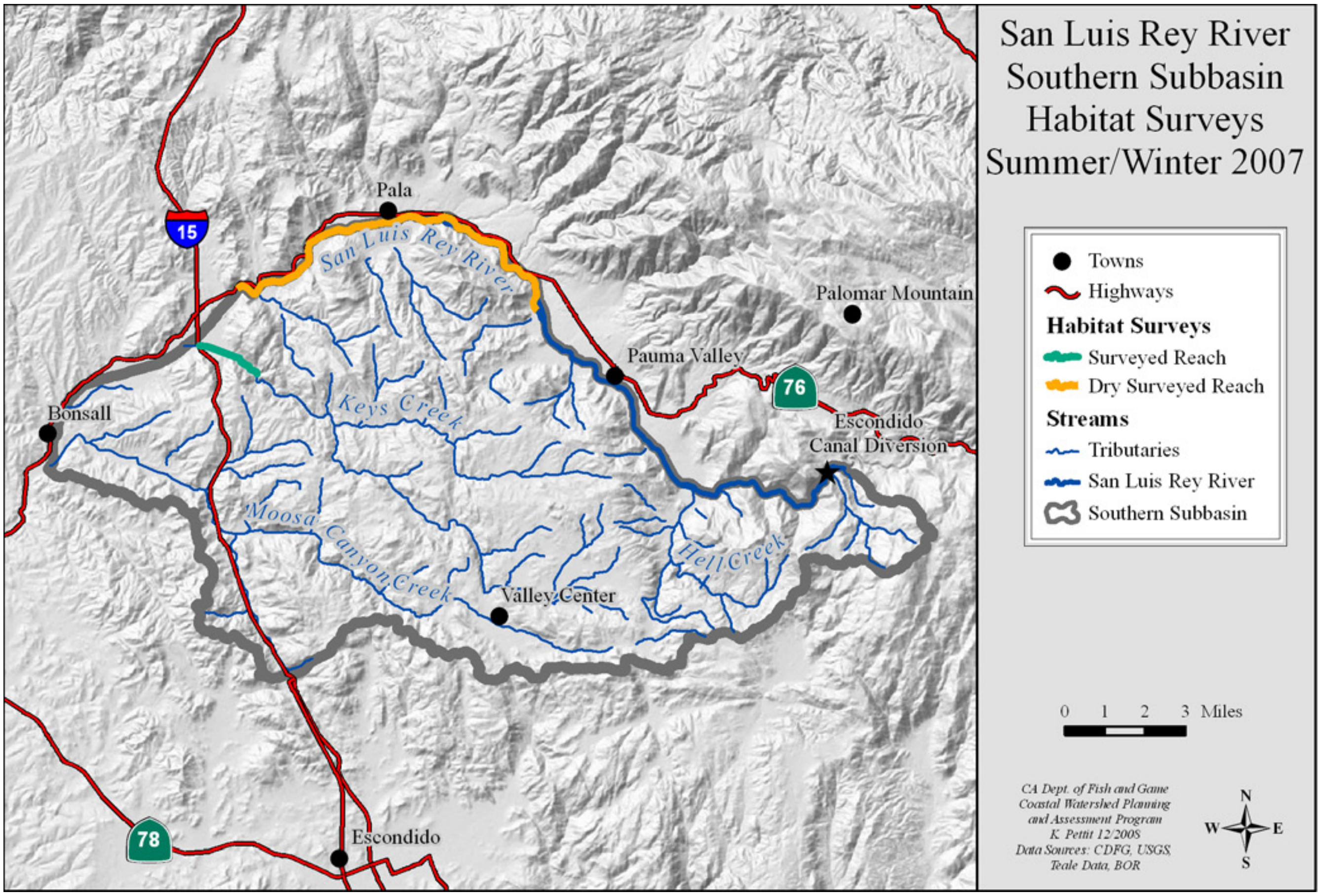


Figure 8. CDFG 2007 summer and winter stream habitat surveys in the Southern Subbasin.

Figure 9. SLR River flowing through the Pauma Valley Country Club (RM 32.7).

Figure 10. SLR River waterfall at "Kye" (RM 39.5), June 2009. (photo courtesy of La Jolla Indian Tribe).

Habitat Conclusions

The SLR River has undergone dramatic changes since European settlers first moved into the basin. Historically, the SLR River in the Southern Subbasin was most likely a perennial river, except during drought years. Water from the upper watershed and large tributaries such as Pala Creek, Agua Tibia Creek, and Pauma Creek (among others) would have most likely retained flows in the SLR River through hot, dry periods in the summer and fall (discussed further in Basin Profile, Hydrology, pp. 11-14). With the completion of dams, water diversion projects and other anthropogenic activities the river's surface flows have nearly disappeared and the riverine habitat has deteriorated.

Prior to the 2007 CDFG habitat inventory, very few surveys had been completed on the river, detailing the habitat conditions (Table 8). Previous CDFG surveys performed in 1946 and subsequently in 1975, noted that the river was dry, except around the Pala area (CDFG 1946 & 1975). The 1946 report indicated only the Pala area had suitable trout habitat. Considering the river has lacked hydrologic connectivity to the middle and upper watershed since the 1920s, it is not surprising that suitable steelhead/trout habitat conditions are currently limited to the SLR River canyon within the subbasin.

Presently, most of the riverbed channel in the subbasin is dry or is composed of "losing reaches" from the spring till the late fall; therefore, instream habitat conditions are difficult to quantify and qualify with instream habitat inventory protocols that require surface flows for evaluation. Even in the absence of quantifiable data, it is reasonable to conclude that stream habitat conditions appear unsuitable for *O. mykiss* spawning or rearing activities in the areas surveyed by CDFG during the assessment. Even if a survey was conducted during a period of surface flows, the river most likely would have still displayed unsuitable habitat conditions. Much of the area surveyed had minimal riparian vegetation, potential spawning gravels were absent, and the high sediment input and transport of the area would hinder deep pool formation and instream habitat diversity. The broad, alluvial riverbed was also lacking potential instream cover. Even though the survey was performed during one of the driest years on record, it is unlikely that stream habitat conditions would have varied much under normal flow conditions in the river. Cobble embeddedness, pool depth, and pool shelter were unsuitable on all surveyed reaches (Table 9), thus these habitat factors are likely limiting to potential steelhead recovery. Cobble embeddedness and pool depth are affected by the natural geology of the area as well as the subbasin's lack of hydraulic connectivity to the Middle and Upper subbasins. The only instream habitat component that appeared meet the preferred suitable values within the subbasin was the extensive canopy cover on Keys Creek. Unfortunately, this canopy cover was composed almost entirely of the exotic *Arundo donax* as very little native riparian tree species remained along its stream banks.

Contrasting the CDFG surveyed areas within the subbasin, the SLR River in the SLR canyon appeared to maintain perennial flows with suitable water temperatures and deep pool habitat. This section of river could serve as over summering refugia habitat for *O. mykiss* (M. Capelli, personal communication 2009).

CDFG, with grantee Trout Unlimited, conducted water quality studies in the SLR River near Couser Canyon (RM 21) in the summer and fall of 2008 and 2009. This small section (approximately 500 feet) of perennially flowing river seems to benefit from a high water table and potential runoff from the reclamation ponds (mitigation for prior mining activities) adjacent to the river. The data from 2008 indicated low enough dissolved oxygen levels during August through December to consider this a threat to long-term survival of *O. mykiss* (S. Jacobson, Trout Unlimited, personal communication 2009). Other water quality parameters, such as specific conductivity, pH, phosphates and nitrate levels were within acceptable ranges for steelhead survival.

Table 8. Comparison between historic habitat conditions with current habitat inventory surveys in the Southern Subbasin.

Stream	Canopy Cover		Spawning Conditions		Pool Depth/Frequency		Shelter/Cover		Summary of Changes from Historic to Current
	Historic	Current	Historic	Current	Historic	Current	Historic	Current	
SLR River	ND*	Fully unsuitable	Poor	Fully unsuitable	ND	Fully unsuitable	ND	Fully unsuitable	Pool habitat decreased

Where multiple years of historic streams surveys were available, the oldest surveys were used.

Table 9. EMDS reach condition results for the Southern Subbasin.

Stream	Year	Canopy	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
SLR River - Reach 1	2007	---	---	---	---	---
Southern Subbasin		---	---	---	---	---

Key: +++ = Highest Suitability U Insufficient Data or Undetermined - - - = Lowest Suitability

Stream Habitat Improvement Recommendations

In addition to presenting habitat condition data, all CDFG stream inventories provide a list of recommendations that address those conditions that did not reach target values presented in CDFG's *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998) and in *NMFS's Guide to reference values used in south-central/southern California coast steelhead conservation action planning workbooks* (2008). Stream habitat improvement recommendations were developed based on results from stream surveys conducted along potential salmonid bearing stream reaches in 2007. Full habitat inventories were limited to reaches in the SLR River that contained surface flows; otherwise, detailed habitat conditions were recorded in the SLR River and in Keys Creek.

In order to compare SLR River reach recommendations within the subbasin, the recommendations of each reach were collapsed into five target issue categories: Surface Stream Flow; Fish Passage; Riparian/Water Temperatures; Instream Habitat; and Sediment Delivery (Table 10). These target issues were then paired with the appropriate recommendation category. For example, the target issue "Instream Habitat" was divided into the recommendation categories of: pool, cover, and spawning gravels. A CDFG biologist selected and ranked habitat improvement recommendations for the SLR River and in Keys Creek, in the Southern Subbasin (Table 11). The top three recommendations of each reach are considered to be the most important, and are useful in guiding restoration priorities.

Table 10. Recommendation categories based on subbasin target issues.

Basin Target Issue	Related Table Categories
Surface Stream Flow	Stream Flow
Fish Passage Barriers	Fish Passage
Riparian/Water Temperature	Canopy/Temperature
Instream Habitat	Pool/Cover/Spawning gravels
Sediment Delivery	Bank/Roads/Livestock

Other tributaries in the subbasin were not included in stream habitat improvement recommendations because: a) they were not accessible to steelhead/ trout; b) they did not appear suitable for steelhead/ trout, including lacking stream flows; or c) they could not be surveyed due to landowner access issues.

When examining recommendation categories by stream reach in the SLR River, the most important target issue is stream flow (Table 11). The SLR River streambed in this subbasin remains dry for much of the year. Fish passage ranked second, as four partial barriers and two complete barriers (the natural waterfall in the SLR River canyon, "Kye", and the Escondido Canal diversion dam) were observed during the 2007 CDFG habitat inventory or documented after the field surveys. The reduced stream flows have in turn adversely affected the riparian/water temperatures and instream habitat; therefore, the other top recommendations reflect these altered conditions.

Differing from the mainstem SLR River, Keys Creek maintains sufficient water flows, aided by agricultural runoff; however, a complete barrier (bedrock chute) is located 2.2 miles upstream of its confluence with the SLR River. This barrier prevents steelhead from accessing more suitable habitat upstream. Below the barrier, the instream habitat is devoid of spawning gravels and offers little to no rearing habitat as it lacks any instream habitat diversity. These poor conditions are reflected in the recommendations of Table 11.

Based on these subbasin target issue recommendations, high priority should be given to restoration projects that emphasize increasing seasonally appropriate flows, removal of passage barriers, riparian vegetation plantings, water temperature monitoring, improving spawning gravels, and pool formation projects.

Table 11. Occurrence of stream habitat inventory recommendations for different reaches of the SLR River of the Southern Subbasin.

Stream	Survey Length (mile)	Stream Flows	Fish Passage	Riparian/Water Temps		Instream Habitat			Sediment Delivery		
				Temp	**Canopy**	**Pool**	**Cover**	**Spawning Gravel**	**Bank**	**Livestock**	**Roads**
SLR River	9.7	1	2	N/A	3	4		5			
Keys Creek	2.2		1	N/A		3	5	2	4		

N/A: Long term stream temperature data was not available.

Restoration Projects

Few projects have been initiated to improve or restore steelhead habitat in the SLR River or its tributaries. The CalFish website, http://www.calfish.org/, (CalFish is a multi-agency program for collecting, standardizing, maintaining, and providing access to quality fisheries data and information for California.), does not list any agency or organization funded stream restoration projects in the subbasin. However, several projects, while not conceived as fisheries restoration projects have either been completed or are in progress, and they will benefit and/or improve the overall habitat conditions for steelhead in the SLR River or potential tributaries.

One of these projects is the on-going exotic vegetation removal in the basin. Viewed as increasing flood and fire risk, degrading crop and rangelands, consuming large quantities of water, and displacement of native species and habitat, invasive plants have been targeted as a priority for removal and management in the watershed, with some removal occurring within the Southern Subbasin. Eradication of *Arundo* in the lower river (Coastal Subbasin) will only be successful if its seed source is completely removed from the upper portions of the watershed (i.e. Southern Subbasin). While improving overall canopy cover, the removal of exotics and revegetation with native stock could also improve flows and help fish to navigate through the mainstem more easily. The Mission Resource Conservation District (Mission RCD) in conjunction with the Santa Margarita and San Luis Rey Watersheds Weed Management Area is slated to treat 100 acres during the 2007/2008 season, mostly along lower Keys Creek (http://smslrwma.org/). These treatment efforts will be an on-going project in the subbasin.

Information on other watershed stream restoration projects can be found on CalFish (www.calfish.org) or on the Natural Resources Project Inventory online database (www.ice.ucdavis.edu/nrpi/). Projects that have occurred or are currently underway that have contributed to the monitoring of water quality and stream habitat conditions and improved water quality conditions include the following:

- Spring 2008 to December 2009 water temperature monitoring by the CDFG in conjunction with Trout Unlimited;

- Spring 2008 to December 2009 water chemistry analysis and bioassessment by Trout Unlimited in conjunction with the San Diego Coastkeeper;
- Water quality monitoring conducted by the Pala Indian Tribe;
- Mission RCD working with area farmers on Best Management Practices for pesticide and erosion control and prevention;
- Collectively, the San Luis Rey Watershed Copermittees hosted and participated in numerous cleanup and outreach events, including creek and coastal cleanups and regional event presentations at which watershed concepts were emphasized (PBSJ 2003);
- The San Luis Rey Watershed Copermittees delivered formal presentations to approximately 1,035 students throughout the watershed. Learning tools used in these presentations include the Enviroscape watershed model, outdoor field trips puzzles, water quality posters, videos, and PowerPoint presentations (PBSJ 2003).

Refugia Areas

The interdisciplinary team identified and characterized refugia habitat in the Southern Subbasin by using professional judgment and criteria developed for southern coastal watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, stream flows, agriculture and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by the EMDS at the stream reach scale.

The most complete dataset available for streams in the Southern Subbasin was for the SLR River, which was surveyed by CDFG/PSMFC fishery crews in the summer of 2007. The lack of surface flows in the river resulted in low EMDS stream reach scores. However, the entire river within the subbasin was not surveyed: the entire portion of the river upstream of Cole Grade Road could not be surveyed due to denied landowner access. Moreover, the dry conditions at the time of the survey limited the type of data that could be collected. Stream temperatures and water quality, important components in determining refugia categories, were not evaluated due to the absence of stream flows.

When considering the suitable stream habitat conditions encountered by a NMFS biologist during a summer of 2009 reconnaissance survey in the SLR River canyon, the refugia potential of the SLR River within the Southern Subbasin can be labeled as Medium Potential rating (Table 12). The biologist described the area river below the natural waterfall as having, “a considerable amount of suitable *O. mykiss* habitat” and “would serve as over summering refugia habitat…” (M. Capelli, personal communication 2009). Historically, the SLR River in the Southern Subbasin was most likely used as a migration corridor for steelhead to more extensive habitat in Northern Subbasin tributaries and/or the habitat upstream within the SLR River canyon. With year round surface flows and an extensive riparian area, portions of the subbasin may have also offered suitable rearing habitat for juvenile steelhead trout.

Other streams in the subbasin appeared to contain minimum suitable habitat for *O. mykiss* and thus were rated as Low Quality/Low Potential. Keys Creek was the only tributary surveyed extensively in the subbasin. A limited, general reconnaissance of Moosa Canyon showed little habitat available for steelhead as well as a potential barrier near the confluence with the SLR River. A habitat inventory on Keys Creek was initiated but not fully completed based on the following reasons: just upstream of its confluence with the SLR River, the streambed has been concrete-lined for approximately ½ mile; after this concrete channel ends, *Arundo donax* lines the stream banks, preventing continuous upstream access to portions of the stream; and little variance in habitat types (stream channel primarily consisted of long runs) to the fish passage barrier located 2.2 miles from the confluence with the SLR River. The creek provided very little if any suitable habitat that could be utilized by steelhead/trout. No potential spawning areas were observed and complex instream habitat was absent. Other tributaries in the subbasin such as Paradise Creek and Hell Creek were not surveyed and habitat conditions are relatively unknown. A thorough literature review contained no references to steelhead/trout in any of the tributaries in the Southern Subbasin. With the exception of small perennial sections of Hell Creek and Moosa Canyon, all tributaries in the subbasin are labeled on USGS 7.5 quadrangle maps as being intermittent streams. Table 12 summarizes current subbasin salmonid refugia conditions/ratings.

Table 12. Salmonid refugia ratings in the Southern Subbasin.

Stream	Refugia Categories				Other Categories		
	High Quality	High Potential	Medium Potential	Low Quality/Low Potential	Passage Barrier Limited	Critical Contributing Area	Data Limited
SLR River			X		X		X Needs survey
Moosa Canyon				X	X		X Needs survey
Keys Creek				X	X		
Paradise Creek	NOT ENOUGH INFORMATION TO CLASSIFY						X Needs Survey
Hell Creek	NOT ENOUGH INFORMATION TO CLASSIFY						X Needs Survey

Key Subbasin Issues

- The SLR River in the Southern Subbasin is not hydrologically connected to flows in the Middle and Upper subbasins. With the exception of the SLR River canyon, the majority of the river is dry from late spring until the occurrence of significant rains in the fall or winter;
- Numerous unregulated wells throughout the subbasin most likely have a negative impact on stream flows in the SLR River and some of its tributaries;
- Sediment level in streams is high and creates a multitude of problems for fish habitat;
- The river's streambed is most likely still negatively impacted by previous upstream gravel mining practices;
- Multiple partial barriers are located in the SLR River within the subbasin, hindering the potential upstream movement of steelhead and any potential emigration of juvenile trout down into the estuary and eventually into the ocean;
- Non-native plants, such as *Arundo donax* occupy large areas along the SLR River and in a couple of its tributaries, particularly in the western portion of the subbasin;
- Agricultural wastewater runoff poses a potential problem to aquatic ecosystems in the SLR River and its tributaries.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations in the Southern Subbasin?

Findings and Conclusions:

- Southern California Coast Steelhead (DPS) are federally listed as endangered;
- Historically, adult steelhead most likely used the lower to mid SLR River in the Southern Subbasin as a migration corridor to more extensive spawning habitat in the tributaries located in the Northern Subbasin and possibly in the SLR River canyon within the upper end of the subbasin;
- Juvenile trout could have utilized the mainstem in the Southern Subbasin as over summering habitat within the SLR River canyon and downstream as an outmigration route to the estuary and eventually the ocean. Very few steelhead/trout have been observed in the subbasin since the 1940s;
- There is also a lack of historical information on steelhead using any of the tributaries in the Southern Subbasin;
- Contributing to this lack of information has been the inadequate number of general and focused surveys necessary to detect the presence or absence of steelhead/trout in the subbasin and overall basin.

What are the current salmonid habitat conditions in the Southern Subbasin? How do these conditions compare to desired conditions?

Findings and Conclusions:

Flow and Water Quality:

- The SLR River in the Southern Subbasin is not hydrologically connected to flows in the Middle and Upper subbasins as the river water is diverted to the Escondido Canal. Water flows are also seriously impacted by numerous extraction pumps and other anthropogenic uses located throughout the subbasin;
- The lack of flows or sufficient flows in the SLR River most likely would impede the passage of steelhead to more suitable tributaries located in the Northern Subbasin and potential habitat in the SLR River canyon;
- Water quality is being impacted by agricultural runoff that have direct access to streams.

Erosion/Sediment:

- Without significant, channel altering flows, the movement of bedload materials in the SLR River is severely limited;
- The river's lack of hydrologic connectivity with the Middle and Upper subbasins also most likely hinders potential gravel recruitment;
- Removal of native vegetation for crop production has increased the amount of fine sediments entering tributaries and the SLR River during or after rain events;
- Livestock have unrestricted access to some tributaries, resulting in stream bank erosion;
- Soils (and bedrock) in streams of the Southern Subbasin are prone to erosion, and slides and streambank failures have been observed to contribute fines to the streams.

Riparian Condition/Water Temperature:

- Canopy cover is not suitable for salmonids. The SLR River has wide stream banks with generally sparse canopy. What canopy is available over streams is composed mostly of shrubs and grassland vegetation;
- The vegetation communities along the river have been significantly altered due to the severely diminished surface flows and conversion to agriculture. Riparian vegetation once consisting of willows, cottonwoods, oaks and other typical southern California riparian tree and shrub species have largely been replaced with agricultural crops, mixed sagebrush/chaparral and herbaceous vegetation communities;
- Invasive, exotic plant species, specifically *Arundo*, is widespread in the western portion of the subbasin in the mainstem and along some of the tributaries;
- Water temperature data collected by CDFG during summer habitat inventories are limited, and therefore inconclusive.

Instream Habitat:

- Due to the lack of sufficient surface flows, moderate to high quality salmonid habitat is lacking in the majority of the SLR River within the subbasin. The river is mostly devoid of riparian vegetation, contains high sediment levels, lacks potential spawning gravels, and displays minimum instream habitat diversity;
- The exception being is in the SLR River canyon where perennial flows coupled with cool water temperatures and deep pools provide a considerable amount of suitable *O. mykiss* habitat;
- The one tributary that was surveyed, Keys Creek, did not contain suitable steelhead/trout habitat below a natural bedrock chute barrier at RM 2.2. The first half mile of the creek contained a concrete-lined channel, which gave way to dense stands of giant reed that dominated the left and right banks.

Gravel/Substrate:

- Suitable salmonid spawning areas were very limited in surveyed reaches of the SLR River and Keys Creek. Overall numbers of potential spawning gravels were low and embeddedness measurements did not meet target values, confirming that sediment levels in the subbasin are high;
- The few potential spawning gravels are a result of the natural channel morphology, lack of hydrologic connectivity from the middle and upper watershed, which prevents gravel recruitment, and past and present human related activities.

Refugia Areas:

- A NMFS biologist who surveyed a portion of the mainstem within the SLR River canyon in the summer of 2009 concluded that the habitat below the waterfall (RM 39.5) within the inner gorge could serve as over summering refugia habitat for O. mykiss (M. Capelli, personal communication 2009);
- Salmonid habitat conditions in the CDFG surveyed portions of Keys Creek are generally rated as low potential refugia;
- Current habitat status is relatively unknown for a few other tributaries, such as Hells Creek and Paradise Creek, but no historical records exist of steelhead/trout utilization of these streams. Considering the majority of these streams' reaches are labeled as intermittent streams on USGS 7.5 quadrangles, it seems unlikely that they would contain even moderate quality habitat.

Barriers:

- The Escondido Canal diversion dam (RM 40) is a complete barrier and the natural waterfall in the SLR River canyon at "Kye" (RM 39.5) is most likely impassible due to the altered flow regime. Both of these barriers are located along the SLR River in the eastern portion of the subbasin;
- Partial barriers that would significantly hinder the passage of steelhead/trout in the SLR River include Arizona Road crossing at Cole Grade Road and two road crossings in the Pauma Valley Country Club Golf Course;
- Several other roads crossing exist on the SLR River containing either culverts or concrete-lined channel bottoms with significant gradient changes, which create seasonal/temporary fish passage problems;
- Keys Creek contains a natural boulder chute approximately 2.2 miles upstream its confluence with the SLR River and appeared to be impassible to steelhead/trout;
- Moosa Canyon also has a small, man-made dam approximately 1 mile upstream from its confluence with the SLR River that trout are unlikely to successfully pass.

What are the impacts of geologic, vegetative, fluvial, and other natural processes on watershed and stream conditions?

Findings and Conclusions:

- The dominant material in the Southern Subbasin from Pala downstream is medium sand, which is highly transportable during floods and lacks gravel and cobble sized substrate need for spawning;
- The alluvium nature of the mainstem stream channel creates excellent mediums in which to accommodate the subsurface flow of water. This causes surface reaches of the mainstem as well as tributaries in the subbasin to go dry during the mid-spring to mid-fall months (May through October);
- Severely erodible soils comprise 95% of the watershed, including the Southern Subbasin, slides from the stream banks and roads have been observed to contribute fines to the stream;
- Weathering of the granitic rocks has created younger unconsolidated sediments that are very susceptible to enhanced erosion and mass movement such as landslides and debris-flows;
- The Southern Subbasin is in a potentially seismically active area as several faults cut through this basin,

including the Elsinore Fault Zone located on the eastern edge of the subbasin;

- Large seismic events, especially when coupled with large storm events, can trigger large landslides and mudflows increasing sediment delivery to the streams and altering their hydrologic condition;
- Uplift has increased the erosion potential of the area;
- The Rice and Poomacha wildfires that occurred within the watershed during the fall of 2007 most likely resulted in an increase in sediment input into the SLR River and in tributaries such as Hell Creek, Paradise Creek and the upper watershed of Keys Creek.

How has land use affected these natural processes?

Findings and Conclusions:

- The lack of hydrologic connectivity from the Middle and Upper subbasins as well as numerous other water withdrawals has reduced or eliminated surface flows and lowered the groundwater table in the SLR River. As less water was available for shrubs and trees, the formerly lush riparian was replaced by drought tolerant chaparral species and other non-native grasses;
- Reduced water flows also hinders the recruitment of cobbles and gravel from the upper portion of the subbasin as well as diminishing flushing flows needed to scour and transport fine sediments downstream;
- Large areas of native vegetation along the mainstem and in tributaries have been displaced by non-native plants such as *Arundo* and *Tamarisk sp*. These non-natives have altered the channel morphology of the river and tributary streams. Efforts have been undertaken to remove these exotics and replace them with native vegetation;
- Invasive plants occupy habitat that normally has little vegetation, for example, the SLR River's sandy channel bed. Their presence changes the habitat in a manner that is potentially detrimental to the native fauna, such as the endangered arroyo toad that utilizes open areas;
- Agricultural runoff has affected the water quality and quantity of some of the subbasin's streams;
- Disturbance of the basin's already unstable soils by land use activities has altered runoff rates.

Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for steelhead production?

Findings and Conclusions:

- Based on available information for this subbasin, it appears that salmonid populations are limited by:
    - Lack of hydrologic connectivity, which hinders surface stream flows and inhibits adult upstream migration and downstream juvenile movement to the lagoon and thus the ocean;
    - Fish passage barriers;
    - High levels of fine sediments in streams;
    - Loss of habitat area and complexity;
    - The presence of invasive plants, such as *Arundo donax* in the SLR River and tributaries, which degrades habitat quality and reduces surface flows;
    - A shortage of areas with suitable spawning gravel in tributaries;
    - Competition with bullfrogs and crayfish in some of the tributaries.

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Habitat improvement activity recommendations are limited to the SLR River and Keys Creek since they were the only streams extensively surveyed during the assessment. Other streams, Hell Creek and Paradise Creek, may have the potential to support steelhead/trout, but further studies are needed in order to make suitable habitat improvement recommendations for those individual watersheds. Moosa Canyon has a fish passage barrier only a mile from its confluence with the SLR River and seems unlikely to be utilized as steelhead/trout habitat.

Barriers to Fish Passage

Streams	**Recommended Actions** **XXX: Highest Priority**		
	Continue efforts to identify and alleviate fish passage impediments at culverts or other public or private road crossings.	Improve fish passage by modifying Arizona road crossings.	Improve fish passage by removing structures on private lands that are currently partial barriers.
SLR River	XX	XXX	XX
Keys Creek	X		X

Flow and Water quality

Streams	**Recommended Actions** **XXX: Highest Priority**				
	Insure that water diversions used for domestic or irrigation purposes bypass sufficient flows to maintain all needs of fishery resources.	Provide seasonally appropriate, pulse flow releases from the middle and upper watershed during adequate water years.	Reduce water temperatures	Plant willows, cottonwoods, and/or sycamore trees to restore riparian habitats and help reduce water temperature in areas with insufficient shade.	Remove and prevent excessive agricultural or urban runoff contributions to aquatic ecosystems
SLR River	XXX	XXX	XX	XX	XX
Keys Creek	X			XXX	XX

Erosion and Sediment Reduction

Streams	**Recommended Actions** **XXX: Highest Priority**			
	Continue to identify and reduce sources of sediment delivery to stream channels from road systems.	Re-vegetate exposed stream banks and/or install structures to increase bank stability.	Build livestock exclusionary fencing along creeks and create offsite watering areas.	Install instream structures that enhance natural sorting of spawning gravels.
SLR River	XX	X	X	X
Keys Creek	X			X

Riparian and Instream Habitat

Streams	**Recommended Actions** **XXX: Highest Priority**			
	Increase depth, area or shelter complexity in pools, by adding boulders.	Increase the number of pools, design and install pool forming structures.	Continue to remove non-native exotic plant species such as *Arundo donax* and replant with native trees and shrubs.	Consider planting barren nearstream areas with willow, cottonwood, or sycamore trees to increase streamside shade canopy and allow for woody recruitment.
SLR River	X	X	XXX	XXX
Keys Creek		X	XXX	XX

Education, Research, and Monitoring

Streams	**Recommended Actions** **XXX: Highest Priority**		
	Continue, expand, or develop education programs concerning water conservation, water quality, and importance of watershed/riverine ecosystems.	Conduct further habitat surveys and/or presence absence surveys.	Water quality and temperature monitoring should be conducted over several years to characterize conditions in streams.
SLR River	X	XX	XXX
Keys Creek	X		X

Subbasin Conclusions

Although there has been limited biological and habitat surveys conducted on the SLR River and its tributaries in the Southern Subbasin evidence suggests that steelhead once utilized this section of the river. Anecdotal accounts from a Pauma Indian Tribal elder spoke of annual runs and ceremonies associated with large fish, presumably steelhead, on SLR River (USFWS 1998). A 1946 reconnaissance level survey noted the presence of trout in the river around the Pala area. Further evidence is discussed in the Basin Profile, Historical Accounts of Steelhead Runs, p. 51.

When comparing anecdotal accounts as well as the few historical stream surveys and scientific studies on the riparian and river channel to the present conditions observed during the 2007 CDFG habitat inventory, it is easy to conclude that there has been a deterioration of instream habitat due to an assortment of historical and on-going anthropogenic activities within the subbasin and throughout the basin. Lack of hydrologic connectivity, water extractions, riparian vegetation removal, invasion of exotic plant species, previous sand and gravel mining operations, agricultural practices, and urban development have all played a role in changing the natural function of the river, water quality and quantity and thus instream habitat for fish. The geology of the area also contributes to fluctuating riverine conditions. Soils in this subbasin and upstream are susceptible to erosion and enter the streams through the road related and stream bank slides. High amounts of sediment are present in the river and its tributaries. Steelhead spawning areas are nearly absent as sand is the predominant substrate in the riverbed. Currently, suitable *O. mykiss* habitat is available within the SLR River canyon. This section of river, below the natural waterfall (RM 39.5), provides perennial flows with rising ground water to moderate water temperatures and pool habitat with boulder cover.

Fish passage in the Southern Subbasin is very limited due to the dry or “losing” reaches present in the SLR River and its tributaries for most of the year. Additionally, there are several partial barriers that hinder fish passage/movement in the river. These barriers are the result of humans and vary in their degree of difficulty for steelhead/trout to pass. Specifically, the following barriers are present along the SLR River in the Southern Subbasin (described from east to west): a private road near Couser Canyon constructed with fill and utilizes small circular culverts that inadequately facilitate mainstem flows (RM 20); a concrete bridge situation within the channel of the SLR River (RM 28 on a water district road); the Arizona road crossing at Cole Grade Road (RM 30); and several road crossings in the Pauma Valley Country Golf Course (RM 32.7). Upstream of all these partial barriers in the SLR River canyon (RM 39.5) is a 50 foot high natural bedrock waterfall that is broken up into a series of steps. Taking into account the altered flow regime with the majority of the stream water being diverted approximately ½ mile upstream at the Escondido Canal diversion, steelhead are very unlikely to navigate through this feature. The Escondido Canal diversion dam (RM 40) is a complete barrier to fish passage.

Considering the river is located in a dry, alluvial area, it seems likely that steelhead used this portion of the river as a migration corridor to more suitable spawning and rearing areas either in the SLR River canyon or in the streams of the Northern Subbasin. However, having perennial river flows prior to the completion of the Escondido Canal diversion and the Henshaw Dam, the SLR River instream habitat conditions would have been quite different than their current state. While being more conducive to upstream adult migration and downstream smolt migration to the ocean, the river would have also contained a diverse, lush riparian and potentially more complex instream habitat.

It is unknown whether steelhead used any of the tributaries within the subbasin. While several large tributaries exist, such as Keys Creek, Paradise Creek, and Moosa Canyon, there is a lack of recorded or anecdotal information regarding the presence of steelhead in these streams. Whether any of these streams retained perennial flows to provide potential rearing habitat is also unknown.

Implementing seasonally appropriate, pulse release flows are necessary during adequate water years and would greatly facilitate the migration of adult fish and out migration of juvenile fish. These increased flows could also help to restore riparian and complex instream habitat conditions. Without adequate pulse release flows, in conjunction with fish passage and other habitat improvement projects there is little hope of improvement of overall conditions to support the survival of southern steelhead in the Southern Subbasin.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Northern Subbasin

The Northern Subbasin includes the watershed area immediately north of the SLR River from Rice Canyon, approximately one mile east of Interstate 15 (RM 20), to just upstream of the Escondido Canal Diversion (RM 40) (Figure 2). This subbasin does not include the SLR River, rather all the tributaries north of the river within this geographical area. Differing from the lower elevations and alluvial streams in the Southern Subbasin, most of the Northern Subbasin tributaries flow out of the steeper, higher Agua Tibia Range and Palomar Mountain as a part of the southern Peninsular Ranges of southern California. These mountain ranges, particularly the area around Mount Palomar, typically receive over 30 inches of annual precipitation, considerably more moisture than the rest of the basin. Stream elevations range from 300 feet in the southwestern portion of the subbasin to approximately 5,200 feet in the headwaters of Doane and French creeks, near Palomar Mountain State Park. The Northern Subbasin occupies less than one fifth of the total basin at 92 square miles and is the second smallest assessment subbasin.

This assessment area is predominantly rural, containing only portions of the small communities of Pala and Pauma Valley. Almost a third of the basin is held in Indian tribal lands, primarily between three tribes: Pala Band of Luiseño Indians, La Jolla Band of Luiseño Indians, and the Pauma Band of Mission Indians. A portion of the Rincon Band of Mission Indians Reservation is also located within the Northern Subbasin. The remaining land area is held in larger private parcels managed for agricultural crop production, and there are also large amounts of federal and state lands.

The Northern Subbasin provides suitable habitat for steelhead trout in several tributaries to the SLR River, but most of these streams have fish passage barriers, hindering steelhead's access to potential spawning and rearing habitat. Historical evidence documents steelhead in Gomez Creek, Pala Creek, Agua Tibia Creek, Frey Creek, and Pauma Creek. Pauma Creek and a few of its tributaries currently support a healthy population of native rainbow trout. Genetic sampling performed on these fish concluded that "it seems more than likely that these fish are part of a native coastal *O. mykiss* lineage" (NOAA 1999). This report went on to state, "these populations may be reasonable choices to consider in efforts to re-establish anadromous runs in their respective streams." Pauma Creek's resident trout population is currently blocked from accessing the SLR River due to an impassible culvert that runs below Highway 76. This culvert also prevents passage upstream into the Pauma Creek watershed. Prior to the 2007/2008 CDFG stream surveys, very few surveys have been conducted in any of the tributaries in the Northern Subbasin.

Figure 1. Northern Subbasin. Photo taken just east of the Pauma Creek drainage facing southwest.

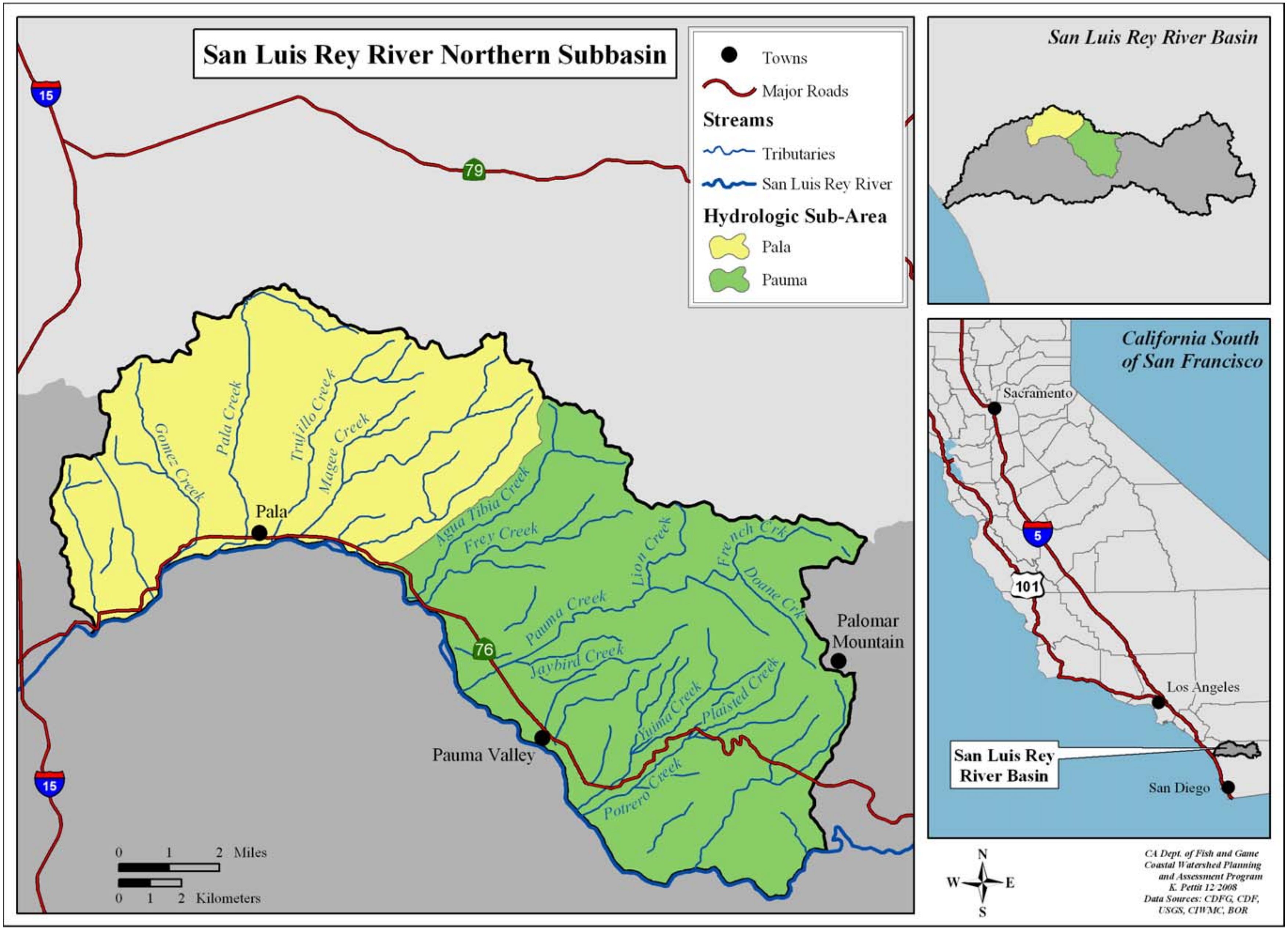


Figure 2. SLR Northern Subbasin and CalWater Units.

Hydrology

The Northern Subbasin is made up of portions of two CalWater Units, the Pala and Pauma CalWater Units (Figure 2). There are twelve named streams (Table 1) and 127.9 permanent and intermittent stream miles in this subbasin. Other than the Pauma Creek watershed, the majority of these stream miles are intermittent. Pauma Creek is easily the largest creek by drainage area and is considered a second order stream, using the Strahler (1964) classification. There are also numerous named and unnamed canyons containing intermittent streams.

The Northern Subbasin receives significantly more moisture than the other subbasins; therefore, many of the streams sustain surface flows for a longer duration throughout the year during typical rainfall years. The larger streams in the Northern Subbasin, such as Pauma Creek, Pala Creek, Agua Tibia Creek, and Frey Creek once played an important role in helping maintain surface flows in the mid to lower SLR River. Many of these tributaries are labeled as perennial streams on USGS 7.5 quadrangles, but have been reduced to intermittent streams whose surface flows seldom reach the SLR River during late spring/summer until the first significant rains of fall because of water diversions. Gomez Creek, Pala Creek, Agua Tibia Creek, Pauma Creek, and other streams within the subbasin are utilized for human consumption via agricultural practices or household uses. Northern Subbasin stream drainage areas range from a 3 square mile watershed (unnamed stream in the western portion of the subbasin) to as large as the 15.2 square mile Pauma Creek watershed.

Table 1. Major streams in the Northern Subbasin.

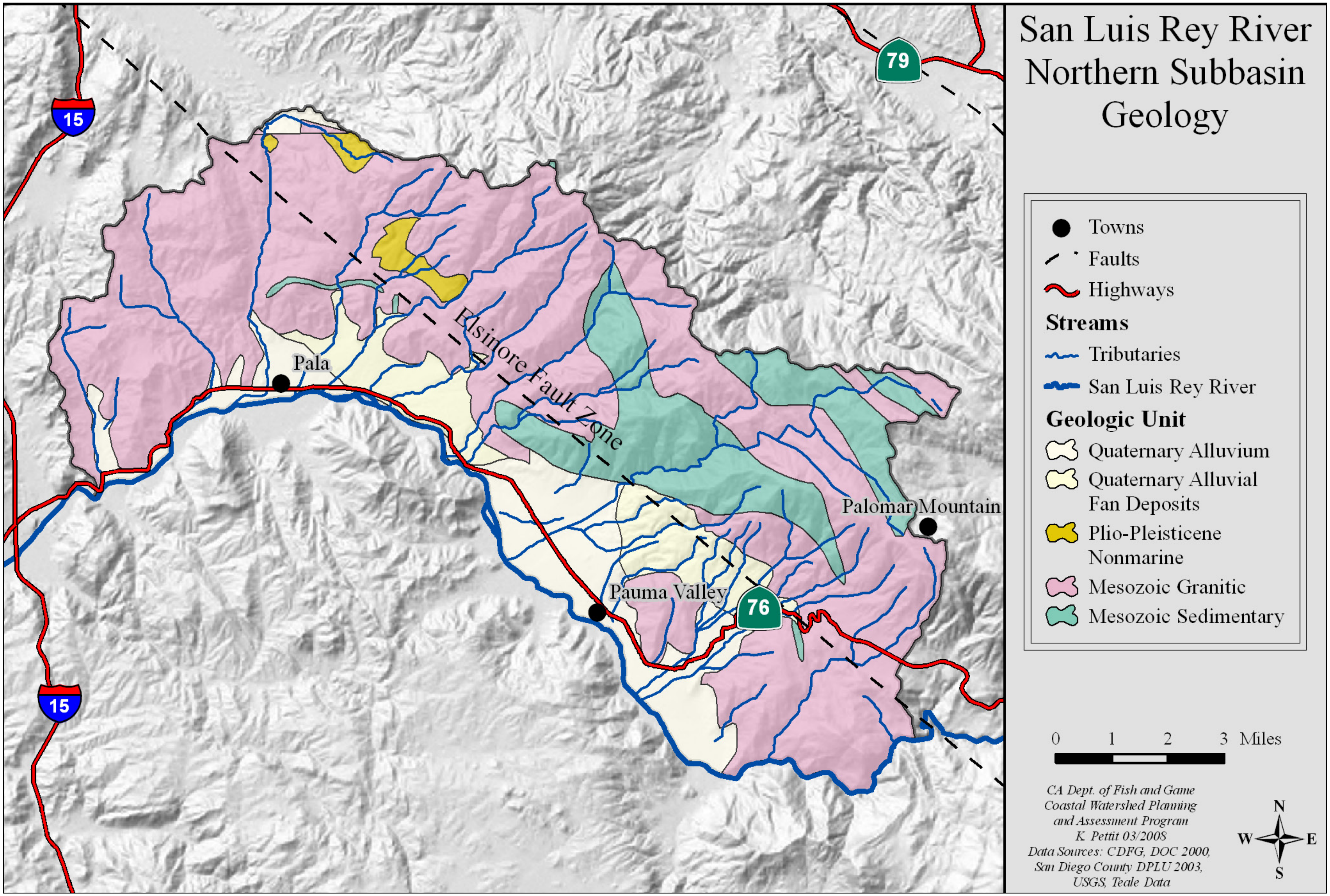
Stream	Tributary to	River Mile	Drainage Area (square miles)	Stream Order	Permanent (miles) (in Subbasin)	Intermittent (miles)
Gomez Creek	SLR River	22	7.10	1	1.9	3.2
Pala Creek*	SLR River	24	9.48	Intermittent	1.0	7.6
Truijillo Creek	SLR River	24.7	5.68	Intermittent	0.0	5.8
Magee Creek	SLR River	25.7	6.78	Intermittent	0.0	3.4 (0.7)
Agua Tibia Creek	SLR River	28.1	5.62	1	0.8	4.8
Frey Creek	SLR River	28.5	4.01	1	2.0	2.7
Pauma Creek	SLR River	30.8	15.21	2	5.3	1.9
Jaybird Creek	Pauma Creek	1.3	0.83	Intermittent	0.0	2.1
Lion Creek	Pauma Creek	5.3	1.70	1	0.7	1.8
Doane Creek	Pauma Creek	7.8	2.27	1	0.7	2.0
French Creek	Pauma Creek	7.8	2.56	1	1.5	1.3 (0.2)
Yuima Creek	SLR River	34.7	4.78	Intermittent	0.0	5.3
Potrero Creek	SLR River	34.9	5.17	Intermittent	0.0	4.2
Plaisted Creek	Potrero Creek	38.0	3.04	Intermittent	0.0	2.7

*A portion of Pala Creek retains perennial flows.

Geology

The Northern Subbasin is predominately underlain by granitic rock types of the Peninsular Range Batholith that intruded into older (Mesozoic) sedimentary, marine rock types between 90 and 140 million years ago (Figure 3) and has subsequently been exposed by tectonic uplift and erosion. Intrusion of the Peninsular Range Batholith as well as regional tectonics has caused some of the marine, sedimentary rocks to undergo metamorphosis.

Erosion has exposed the batholith leaving behind mountains of granitic rock with remnants of the sedimentary rocks it intruded into. Weathering of the granitic rocks has created younger unconsolidated sediments that are very susceptible to erosion and mass movement such as landslides and debris-flows. These sediments have been deposited in a series of alluvial fans, marine and river terraces, as well as active channel deposits. These sedimentary deposits range from partially consolidated sandstone, siltstone, mudstone, and shale to unconsolidated sand and gravel.



CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 03/2008
Data Sources: CDFG, DOC 2000,
San Diego County DPLU 2003,
USGS, Teale Data

Figure 3. Geology of the Northern Subbasin.

Compositional Overview

Rock Types

The rock types depicted in the geologic map (Figure 3) presented in this report have been combined from various other published source maps. Like rock types based on similar age, composition, genesis, orgin, and geologic history have been combined to help simplify the information presented herein. General descriptions of the geolgic units displayed in the map and in Table 2 are as follows.

Mesozoic Granitic

Granitic rocks make up the majority of this subbasin as they occupy approximately 64% of its surface area. The mountains of the subbasin are composed almost entirely of these granitic rocks (Figure 3). They are predominantly Cretaceous (65.5 through 154.5 million years ago) in age. These rocks are very hard and resistant to erosion, however, they do tend to exfoliate to some extent in exposed surfaces and preferentially weather at structural joints. Over long periods of time granitic rocks tend to decompose, become “soft,” and much less resistant to erosion producing “decomposed granite.” In more advanced forms, the minerals within the granite disaggregate and form “Arkosic Sand” which is highly susceptible to erosion, sliding, and fluvial transport.

Mesozoic Sedimentary

Mesozoic sedimentary rocks make up around 14% of the subbasin and consist mostly of siltstone, sandstone, and conglomerate and were deposited some 65.5 to 225 million years ago. The original deposition of the sediments that make up these rock types occurred in environments ranging from marine to terrestrial. Some of these rock types have subsequently undergone metamorphism especially in areas in contact with granitic rock types. These sedimentary rock types are generally more susceptible to erosion than granitic rock types.

Quaternary Alluvium

Alluvium covers about 13% of the basin. It consists of unconsolidated sediments that range from clay to boulders. Alluvium is transported and deposited by streams and makes up most of the bed and banks of the streams. Units of alluvium delineated by the geology map (Figure 3) include sediment currently being acted upon by the streams and bank and flood-plain deposits occasionally acted upon by the streams. If the alluvium within the stream channel is of sufficient depth it can readily transport water via the subsurface pore-spaces allowing stretches of the stream to “run dry.”

Quaternary Alluvial Fan Deposits

Fan deposits make up less than 8% of the subbasin and consist of unconsolidated sediments ranging from clay to boulders. They wash out of canyons on high slopes and are usually deposited where there is a significant change of slope. They are not usually transported far from their source and therefore consist of sediments made from the bedrock of the mountains from which they originate.

Plio-Pleisticene Nonmarine

This unit occupies about 1.5% of the subbasin. It is composed of sedimentary rocks ranging in composition from siltstone through conglomerate and from poorly consolidated to well indurated. The sediments that make up these rock types were deposited on land between 11,000 and 5 million years ago as river flood-plain, colluvium, as well as alluvial fan deposits (Kennedy 2000).

Table 2. Rock types in the Northern Subbasin.

Lithologic Unit	% Basin
Mesozoic Granitic	63.78
Mesozoic Sedimentary	13.58
Quaternary Alluvium	13.10
Quaternary Alluvial Fan Deposits	8.07
Plio-Pleisticene Nonmarine	1.46

% area of basin represents a rough approximation based on GIS mapping.

Soils

The underlying bedrock is generally responsible for a soil’s texture and erodability characteristics. The sediment contribution from soils found in the Northern Subbasin is dependent largely on slope, soil sediment size, consolidation, cohesion, compaction, the type and amount of vegetation cover, land use, and amount, intensity, and duration of local rainfall (Table 3).

The majority of bedrock throughout the subbasin is composed of various granitic rock types producing associated soil types that are in general very well drained and is somewhat prone to erosion and transport by fluvial processes as well as wind. Soils with high sand and silt content are typically more susceptible to erosion than soils with high clay content which exhibit a greater degree of cohesion.

Table 3. Soil types in the Northern Subbasin.

Soil Type	Percent of Upper Subbasin	Parent material
Hotaw-Crouch-Boomer (s1015)	22.5	weathered metavolcanic/granite
Sesame-Rock outcrop-Cieneba (s1010)	20.01	weathered granite
Tujunga-Salinas-Elder (s1001)	19.8	Weathered granite, sandstone-shale, alluvium
Rock outcrop-Las Posas (s1012)	18.85	Basic igneous
Sheephead-Rock outcrop-Bancas	9.69	weathered granite/gneiss
Tollhouse-Rock outcrop-La Posta	4.28	weathered granite/igneous
Rock outcrop-Lithic Torriorthents (s1021)	3.63	weathered granite
Ramona-Placentia-Linne-Greenfield (s999)	1.25	shale/sandstone/alluvium

% area of basin represents a rough approximation based on GIS mapping.

Landslides

Like the other SLR River subbasins, the Northern Subbasin is partially mantled with unstable soils. The mainstem and its floodplain in the Northern Subbasin consist predominately of alluvial material, while the hillsides are often composed of granite, weathered granite, and sedimentary rock. Except for fresh granite, these rock types are susceptible to surface erosion, headword erosion, gullying, stream bank raveling, and landsliding. This area has undergone tectonic uplift leaving steep canyon walls above the streams. As tectonic forces push the land up gravity tries to pull it down, typically resulting in landslides and rock falls. Landsliding is further exacerbated by seasonal rain storms. As the hillsides become saturated, pore pressure between grains becomes greater making them unstable and more prone to landsliding.

Earthquakes and Faults

The whole of the San Luis Rey River Basin is tectonically and seismically active, and the possibility of seismic activity occurring in this subbasin is similar to the entire southern California region. Due to active faults within this subbasin, such as the Elsinore Fault, as well as those in close proximity, the subbasin has the potential for strong seismic movement. The Elsinore Fault Zone (currently established Alquist-Priolo Earthquake Fault Zone) runs northwest through the middle of this subbasin. The Elsinore Fault is a right-lateral, strike-slip fault system that is related to translational plate boundary tectonics between the Pacific and North American plates. The Elsinore Fault is capable of producing earthquakes in the range of M 6.5–7.5. It has an average recurrence interval of approximately 250 years (http://www.data.scec.org/faultindex/elsfault.html). The most recent major earthquake was a M 6.0 in 1910. Ground shaking generated by earthquakes can trigger rock falls and landslides that deliver large amounts of sediment to the streams. The 1994 Northridge earthquake (M 6.7) triggered in excess of 11,000 landslides in a 6,200 square mile area (USGS) in similar terrain. Other than being able to trigger landslides strike-slip faults can weaken bedrock, offset streams, truncate and oversteepen certain topographic landforms thus enhancing erosion and transport of sediment to the streams.

Wildfires

Wildfire can and frequently will increase the erodability of a region. As a fire moves through an area it is capable of burning off the duff layer that effectively armors the soil. It can also intensively dry the soil as well as destroying organic matter that helps to bind the soil together, leaving behind a loose, “hydrophobic” soil in its wake (Figure 4). During subsequent rain storms the soil’s capacity to absorb water is greatly reduced and surface flows are proportionally increased. Wildfires can destroy woody debris strewn on hill slopes allowing for less resistance to the erosive power of surface runoff transporting increased amounts of sediment downstream. The propensity for debris flows is also increased following a wildfire on steep slopes which can block drainage ways, destroy structures, strip vegetation, and deliver great amounts of sediment to the streams (Cannon et al. 2004). Relatively hot fires may cause thermal expansion of individual minerals within the rock causing fracturing of its surface layers leading to enhanced erosion.

The 2007 Poomacha Fire, which began in late October and continued until early November burned a large portion of the Northern Subbasin, including the majority of the middle and upper Pauma Creek watershed (Figure 21, Basin Profile). Due to the underlying geology and steep nature of the surrounding hillsides, most streams east of Agua Tibia Creek within the subbasin were prone to sediment deposition as a result of the fire. Compounding the effects of the fire were several large storm events that hit the region in November and December of 2007 releasing significant amounts of rainfall. For example, during the last weekend/first weekend in November/December, Palomar Mountain recorded 6.85 inches of rain (Soto 2007). This large amount of precipitation over a relatively short period of time triggered debris flows and a large influx of ash and sediments into the subbasin streams.

CDFG/PSMFC fisheries crews conducted reconnaissance-level surveys in Pauma Creek in December and early January to evaluate the combined effects of the fire and ensuing large rain events on stream habitat conditions and native fish populations within the Pauma Creek watershed. The surveys indicated areas with significant debris and sediment input into Pauma and French Creek, which reduced pool depths, buried potential spawning gravels, and created debris jams. However, considering the high gradient character of Pauma Creek and potential for significant rainfall, which would help to flush out sediments more quickly than in a lower gradient stream the long-term impacts of the increased sediment load may be minimal. Furthermore, the severity of the fire within the watershed appeared to range from low to moderate. Based on CDFG and PSMFC biologists' observations in the upper watershed of Pauma Creek and lower French Creek, the Poomacha Fire appeared to be a low intensity fire, burning mainly the ground cover and understory and leaving mature trees mostly intact. Most conifers and the vast majority of oaks appeared to be in good health. Fire scars on large trees was generally limited to their lower trunks. Only a small percentage of conifers were completely burned. The riparian area remained almost untouched by the fire (Figure 7). Firefighters who were on-site helping to contain the fire in Palomar Mountain State Park, also described the fire as a low intensity ground fire that moved through the area rather quickly without getting into the crown of the trees.

As explained in the Basin Profile (Wildfires section pp. 22-23), post-fire erosion potential has been estimated as moderate to high (Table 5, Basin Profile) for most of this subbasin. This estimate was derived from data prior to 2005; therefore, it does not take into account the results of the more recent fires and other potential land use activities which may or may not have affected the erosion potential. Wildfires, including the 2007 Poomacha Fire are discussed in greater detail in the Fire History and Management section located in the Basin Profile (pp.35-39).

Figure 4. Post-Poomacha Fire (fall of 2007) photo of exposed hydrophobic soil on a steep slope within the Northern Subbasin.

Fluvial Geomorphology

The Northern Subbasin consists of the streams flowing mostly out of the Agua Tibia and Palomar Mountain ranges. These streams contain eroded sediment from the steeper slopes and deliver them to the SLR River which, in turn, redistributes sediments with its floodplain and also transports sediments further downstream. Most of these streams contain extensive areas where the stream gradient is greater than 4%

(Basin Profile, Figure 14).

The most recent full habitat inventory stream surveys in the subbasin were limited to Pauma and French creeks. French Creek is located in the headwaters of the Pauma Creek watershed; the survey provided baseline data for mountainous stream habitat containing native, rainbow trout. Pauma Creek was surveyed in three separate reaches to obtain reach conditions in the: 1) lower canyon, 2) middle canyon, 3) upper canyon (near confluence with French and Doane creeks. The lower and upper reaches were B Rosgen channel types, while the middle reach was an A channel type (Table 4). These reaches and channel types may be representative of other streams in the subbasin. Type A reaches are steep, narrow channels with cascading, step-pool habitat types that contain high energy/debris transport associated with depositional soils. Type B channels are moderately entrenched, moderate gradient, riffle dominated channels with infrequently spaced pools. The banks are usually stable (canyon walls) as well as the plan and profile. They have a moderate relief with moderate sinuosities and stable stream banks (Flosi, et al. 1998).

Table 4. Channel types in surveyed streams of the Northern Subbasin.

Stream	Reach	Length (feet)	Channel Type
Pauma Creek	1	1,373	B2
Pauma Creek	2	1,396	A2
Pauma Creek	3	3,330	B2
French Creek	1	1,374	B2

Vegetation

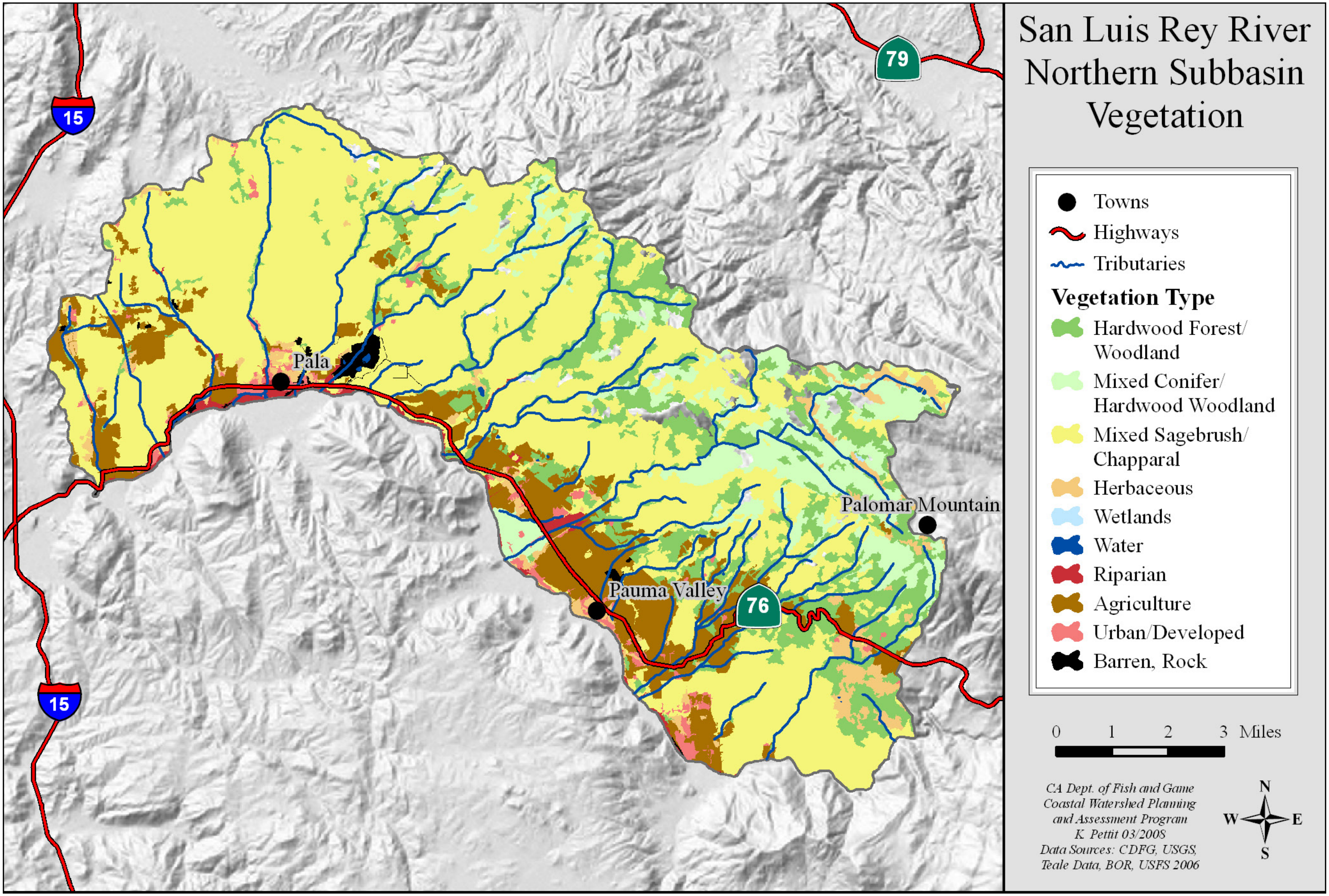
The predominant vegetation cover type as described by the USFS CALVEG data is mixed sagebrush/chaparral, covering 55.27% of the Northern Subbasin (Figure 5 and Table 5). This cover type is split primarily between lower montane/mixed chaparral and California sagebrush vegetation types. Hardwood forest/woodland was the second most abundant cover type at 15.93%. Canyon live oaks, coast live oaks, black oaks, and Engelmann oaks compose the majority of this cover type. Agriculture, consisting of orchards, pastures, crops, and nurseries is the third most abundant cover type at 11.6 %. Agriculture is the dominant land use in the lower elevations of the subbasin as large areas of native habitat have been converted to agricultural practices. Moreover, similar to the Coastal and Southern subbasins, this figure does not reflect the overall percentage of acres dedicated to the growing of crops or livestock. Within the Northern Subbasin, pastures used for livestock grazing may not be included in this vegetation designation since land use is often difficult to remotely ascertain. For this reason, it can be assumed that areas mapped as annual grasslands may also be agricultural in nature.

The Northern Subbasin contains the greatest percentage of mixed conifer/hardwood woodland (based on each subbasin's acre totals) out of the five subbasins. This cover type is located in the upper elevations of the Peninsular Range. This mountain range also contains the only quantifiable percent of coniferous trees within the basin. As the range extends into the Upper Subbasin, a small percentage of coniferous trees are also present in those localities.

The only significant urban/residential area in the subbasin consists of the communities of Pala and Pauma Valley, which are both located just north of the river, in close proximity to Highway 76. Residential areas continue to expand, but at slower rates than in the Coastal and Southern subbasins. The impact of agriculture and urban/residential areas in the subbasin are described further in the Land Use Section.

Non-Native Plants

Unlike the Coastal and Southern subbasins, non-native, invasive plants are not as problematic in the Northern Subbasin. Invasive plants, aside from non-native grasses which are widespread and common, have generally been found in smaller numbers in a few locations and do not pose the threat of overtaking large areas of habitat as is the case in the Coastal and Southern subbasins. See the Upper Subbasin's Non-Native Plants section for a more detailed discussion of the effects of non-native grasses.



CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 03/2008
Data Sources: CDFG, USGS,
Teale Data, BOR, USFS 2006

Figure 5. Vegetation of the Northern Subbasin.

Table 5. Vegetation of the Northern Subbasin.

Vegetative Cover Type	Percent of Basin	Primary Vegetation Type	Percent of Cover Type
Mixed Sagebrush/Chaparral	55.27	Basin Sagebrush	0
		Buckwheat	3.2
		California Sagebrush	29.9
		Ceanothus/Mixed Chaparral	0
		Chamise	5.5
		Lower Montane Mixed Chaparral	59.7
		Manzanita Chaparral	0
		Upper Montane Mixed Chaparral	1.3
		Southern Mixed Chaparral	0.28
		Other	0.1
Hardwood Forest/Woodland	15.93	Black Oak	9.3
		California Sycamore	0
		Canyon Live Oak	34.6
		Coast Live Oak	34.2
		Engelmann Oak	8.4
		Eucalyptus	0
		Interior Mixed Hardwood	0
		Non-native/Ornamental Hardwood	13.4
Agriculture	11.62	Agriculture	9.5
		Orchard Agriculture	72.4
		Pastures and Crop Agriculture	19.1
Mixed Conifer/Woodland	9.02	Bigcone Douglas - Fir	54.7
		Coulter Pine	12.7
		Mixed Conifer - Pine	8.8
		White Fir	17.6
		Nurseries	6.2
Herbaceous	3.56	Annual Grasses/Forb Alliance	77.3
		Non-Native/Ornamental Grass	0.10
		Perennial Grasses and Forbs	23.6
Urban/Development	1.64	Urban/Development	100
Scrub Oak	1.32	Scrub Oak	100
Riparian	0.84	Baccharis (Riparian)	55.2
		Fremont Cottonwood	0
		Riparian Mixed Hardwood	33.3
		Riparian Mixed Shrub	9.6
		Willow (Shrub)	1.9
Barren/Rock	0.66	Barren	5.2
		Tilled Earth	15.1
		Urban related bare soil	79.7
Water	0.20	Water	100

These statistics exclude the classification of water. Data from CALVEG, USFS

Land and Resource Use

Historic Land Use

Prior to the settlement of Europeans, the Northern Subbasin was inhabited by the local Indian tribe comprised of the Luiseño people. While acorns from the numerous oaks in the area provided a staple for their diet, there was a variety of other food sources. The SLR River was a prominent natural feature of the Luiseño territory providing the residents with subsistent food sources that included freshwater fish, a wide variety of plants and seeds, birds, and small and large mammals. In the 1760s the Spaniards were the first Europeans to arrive in the basin. They entered in the Coastal Subbasin and began moving and settling throughout the basin. One of the earliest settlements in the Northern Subbasin coincided with the establishment of the Mission San Antonio De Pala, located in what is now the town of Pala. This mission was founded by Father Antonio Peyri OFM on June 13th, 1816. The location of the mission was based upon the perennial water supplies of Pala Creek and the nearby SLR River. Aside from the mission, prior to California becoming a state, a few early settlers were given grazing rights on large lots of land through enormous land grants, called ranchos, whose property rights were retained by the Mexican government. The ranchos were phased out by the late 1830s.

Similar to the Southern Subbasin, by the 1850s, the Northern Subbasin had slowly become a popular area for a greater number of homesteaders. These homesteaders utilized the area for cattle grazing and growing a variety of crops. Eventually, Mexican and subsequently, American settlers forced Indian tribes off their lands and onto reservations. The Luiseño people were placed on the 10,000-acre reservation (Pala Indian Reservation) in what is now the town of Pala. Shortly afterwards, in the early 1900s, the Cupeños Indian Tribe was removed from their residence in Warner Valley in the Upper Subbasin, and relocated to the Pala Indian Reservation. The Pauma Indian Reservation was created in 1891, at the foothills of the Palomar Mountains, adjacent to Pauma Creek.

With the completion of the Southern California Railway in the 1880s and the highway connecting Los Angeles with San Diego in the 1920s, the Coastal Subbasin continued to expand its populations, but the Northern Subbasin experienced minimum growth. Over time, more of the Northern Subbasin was converted to small and large-scale farming operations. By the early 2000s the Indian tribes had built casinos and later expanded the size and capacity of these casinos; thus more people were drawn into the area, and Highway 76 now experiences heavy vehicular traffic.

Agriculture

Aside from land that was set aside for Indian reservations, agriculture was the most significant historic land and resource use in the Northern Subbasin. Agriculture grew throughout the basin as settlers utilized the foothills of the Peninsular Range for growing a variety of crops such as wheat, corn, beans and other leguminous plants as well as the area along the SLR River for the grazing of cattle, sheep, and horses. As annual grasses became established, replacing perennial native grasses, livestock numbers declined dramatically. With the drop in livestock production, farming of grain and grain hay expanded on homestead lands in the subbasin. Settlers relied on the water sources of streams flowing out of the Peninsular Range and the SLR River. The first commercial mill in the region was a grist mill located in the area of the Wilderness Gardens County Park. Powered by the SLR River, the mill served farmers throughout the region grinding corn and wheat into flour. As agricultural operations expanded, numerous citrus orchards became established by the 1930s. While citrus is still an important crop, many areas have more recently been planted with avocado groves. Imported water supplies and groundwater sources provided the needed resources for many intensive agricultural enterprises in the Northern Subbasin and throughout the watershed such as truck crops, flowers, and nurseries.

Gravel Mining

Gravel mining operations have been an important industry in the SLR River Basin, which has provided the San Diego region with a major source of sand and gravel aggregate. Sand mining operations have extended from the river into the Northern Subbasin.

The last major mining operation was the Felton Mine site operated by Hansen Aggregates. This was an in-stream mine that encompassed 225 acres and mined an average of 600,000 tons of sand per year during the late 1990s and early 2000s. This sand accounted for about 20% of all the concrete used in San Diego County (Chester 2000). Their Major Use Permit expired in 2005 and the site was dedicated as open space. Reclamation and mitigation occurred on this land, which included several large ponds, located in the southwestern portion of the Northern Subbasin.

The cumulative effects of the mining operations have been discussed extensively in the Basin Profile, Coastal, and Southern subbasin sections, but it is important to note that biologically, the degraded streambeds from previous mining operations causes lowering of groundwater levels and loss of riparian vegetation due to erosion and die-offs from the lack of water. Moreover, degraded streambeds generally create a minimal low flow channel that implicates a decrease of cover, loss of deep holding pools for adult migration and juvenile rearing, and overall reduction in complex, instream habitat needed for the successful completion of the lifecycle stages of steelhead.

Current Land Use

A number of the land use issues impacting the natural resources and riverine habitat in the Southern Subbasin are also present in the Northern Subbasin. Some of these impacts result from the same types of anthropogenic activities and currently proposed projects that will have a detrimental effect on the natural resources of the subbasin.

Agriculture

Agriculture is the fourth largest industry in San Diego County (SLR Watershed Council 2000), generating approximately five billion dollars a year in economic output. The SLR basin is a major agricultural area in San Diego County. The warm climate of the Northern Subbasin makes it ideal for growing avocados, citrus fruit, nursery stock, and flowers. Cattle and other livestock operations still persist as well. Numerous small and large-scale farms populate the subbasin including land adjacent to the river and its tributaries.

The large agricultural production in the basin contributes to reduced water quantity and most likely quality as well. Although many agricultural producers rely on water from imported sources (the Colorado River and State Water Project) (SLR Watershed Council 2000), water extraction pumps were observed during CDFG 2007 field surveys in or near streams and flood plains within the Northern Subbasin. These pumps may divert surface flows or groundwater, which normally contributes to tributary and SLR River flows, to assist crop production. Pauma Creek, for example, is used primarily as a source of irrigation water for agricultural operations within the subbasin. Although not used as a drinking water source, it is hydraulically linked to the aquifer that supplies drinking water. These ground and surface water diversions on Pauma Creek hinder the movement of trout from just downstream of the canyon's mouth to its confluence with the SLR River.

With uncertainties surrounding the delivery of imported water as well as rising costs, a greater importance will be placed on local sources such as groundwater. Increased groundwater pumping would have numerous detrimental impacts to the river and riverine habitat such as lowering the groundwater table, reducing potential surface flows, and placing additional stress on the water demands of riparian plant species. In Gomez Creek, PSMFC biologists witnessed near streamside groundwater pumping, which resulted in a dry streambed; whereas, areas with little to no groundwater pumping retained surface flow. The drawing down of surface flows within the subbasin would minimize the overall potential habitat available to juvenile trout and degrade conditions in areas maintaining flowing water by reducing surface flows, thus potentially raising water temperatures and lowering dissolved oxygen levels.

Much of the farmland in the Northern Subbasin is located on the hillsides and foothills of the Peninsular ranges; therefore, there is the potential for runoff of groundwater and pesticide water into the local streams impacting water quality. Due to the large-scale farming operations and concerns over water quality, the use of pesticides, sediment control, and runoff water, San Diego County is closely scrutinized by the local Agricultural Commissioner's Office. Growers must be concerned with issues involving use of pesticides. Growers are increasingly required to reduce and capture runoff water, re-use tailwater and utilize other best management practices to minimize the effects of agriculture on water quality and water bodies in the areas where they farm. See Agriculture section in the Basin Profile of the assessment for further detail of the impacts of agriculture (pp.43-45).

The recent impact of rising water prices has caused a number of farmers to remove some crops such as citrus and avocados. Due to competition from Mexico, rising cost of water, fuel and other operational costs, agriculture is becoming increasingly marginal in Southern California. There is a concern that more agricultural lands will be taken out of production because these rising costs, and housing developments will occupy current agriculture lands; agriculture and its benefits to the local and regional economy will be permanently lost.

Tribal Indian Lands

Almost a third of the Northern Subbasin is held in Indian tribal lands, primarily between the Pala and the Pauma Band of Mission Indians and to a lesser extent, the Rincon Band of Mission Indians and La Jolla Bands of Luiseño Indians. A portion of the communities of Pala and Pauma Valley is made up of these respective tribal members. The Pala Band of Mission Indians consists of 918 members, the majority of which live on the 12,273-acre reservation (http://www.palatribe.com/). These reservation lands also extend into the Southern Subbasin. The Pauma Tribe consists of approximately 176 tribal members, many living on the 5,877-acre reservation, entirely within the Northern Subbasin. Overall, most of the tribal lands are sparsely populated with single family dwellings. The tribes' reservations support agricultural that primarily grows citrus and avocados.

Gaming casinos are a primary source of income for the Pala, Pauma, and Rincon Indians. The Pala and Pauma Band of Mission Indians currently operate casinos located in the subbasin. The Pala Casino Resort Spa is a multi-functional, Vegas-style casino occupying approximately 650,000-square feet with a 507-room hotel; whereas, the Casino Pauma is considerably smaller with approximately 35,000 square feet of gaming, dining, and entertainment activities. The Pauma tribe is looking to expand their current casino operations in the near future (Tierra Environmental Services 2008). Pauma has proposed to build a large, 19-story, 400-room hotel in addition to expanding the casino to 102,372 square feet. This development is estimated to add approximately 4,000 vehicles per day on Highway 76 (Soto 2008). While the proposed Pauma casino expansion is projected to use less water through conservation methods than the current casino and adjacent fruit orchards, it will nonetheless place demands on limited local water resources.

Urbanization

Most of the Northern Subbasin remains rural in nature with low-density housing and numerous small and large-scale agricultural operations. The only major population center in the Northern Subbasin is located in the small communities of Pala and Pauma Valley. The 2000 population census indicated that 6,156 people lived within the Community Planning Areas (CPAs) of Pala–Pauma. This figure is expected to only slightly increase to 6,908 by the year 2020. This is a small, sustainable increase compared to many other areas located in the basin. This insignificant amount of growth should only have a slight impact to the natural resources including water quality and quantity of the area. However, there are projects, described in more detail below, which are currently in the planning stages that will have considerable impacts on the subbasin's natural resources and native habitats.

Gregory Canyon Landfill—The proposed Gregory Canyon Landfill, which is discussed more extensively in the Coastal and Southern subbasin Current Land Use sections, is located in the Southern and Northern subbasins, a couple of miles east of Interstate 5 and primarily just south of California Highway 76 (partially extending north of Highway 76 into the Rice Canyon watershed). This 1,770 acre landfill, which is currently in the permitting stages, is a response to the increased need for waste storage as a result of the growth that has and will continue to occur in Northern San Diego County. This proposed landfill has caused a broad and considerable amount of community concern, from a diverse base of interest groups. Organizations that have opposed the landfill include but are not limited to: The Pala Band of Mission Indians, the Federal Bureau of Indian Affairs, the City of Carlsbad, The City of Oceanside, the Natural Resources Defense Council, and the SLR Watershed Council. The SLR Watershed Council has voiced its concerns on the landfill's impacts to air quality, water quality, transportation, wildlife, cultural and historical resources, and general water quality. The Council was particularly concerned with the location of the landfill with respect to the aquifer of the San Luis Rey River (SLR Water Council 2000). The potential exists for the landfill to leak, causing contamination of the groundwater below.

Warner Ranch housing development—As planned, this would be an approximate 900-home development on the 500-acre Warner Ranch located on the north side of Highway 76 just west of the Pala Casino. Considering the average four-person household in San Diego County uses ½ an acre foot of water each year (http://www.sdcwa.org/ about/), a development of this size would require vast amounts of water in an area that is already struggling to maintain its water resources. Currently, this proposed housing development is considered somewhat speculative.

Resort Casinos—The proposed expansion of the Indian gaming casino was discussed in the Indian Tribal Lands section above.

Recreational

Although the majority of land in the Northern Subbasin is held in private or Indian Reservation lands, there are recreational opportunities on state and federal lands. Palomar State Park, located in the northeast corner of the subbasin, is a 1,882 acre park that provides camping, hiking, picnicking, and trout/catfish fishing in Doane Pond and trout fishing in Pauma Creek, Doane Creek, and French Valley Creek. The 2007 Poomacha Fire burned through portions of the park, but the fire appeared to be a low intensity fire. While most of the ground cover and areas of forest understory were burned, larger trees displayed only lower fire scars. Firefighters on scene described the fire as a low intensity ground fire that moved through the area rather quickly without getting into the crown of the trees.

Recreational opportunities also exist in the Cleveland National Forest, which occupies portions of the mountain ranges in the Northern Subbasin. Due to the steep nature of this range, there is relatively little access to these areas of the forest. Mount Olympus Regional Park lies between the Gomez Creek and Pala Creek. This park, consisting of 661 acres, provides protection for native chaparral communities and has limited hiking opportunities.

Mining

Currently there are no mining operations in the Northern Subbasin. The nearest proposed mine is the

Rosemary's Mountain Quarry site, located 1.5 miles east of Interstate 15 and Highway 76. This mine is set to begin operations in 2009/2010 (Jones 2008) and has been discussed in further detail in the Basin Profile and Coastal Subbasin Current Land Use sections.

Fish Habitat Relationship

Fishery Resources

Steelhead trout were historically found in the SLR River and in some of the tributaries of the Northern Subbasin. The steelhead were found in sufficient numbers to provide the Indian tribes with a subsistence food source and, subsequently, the local region with recreational fishing opportunities. Anecdotal accounts from Pauma Indian Tribal elders spoke of annual runs and ceremonies associated with large fish, presumably steelhead, on the SLR River (USFWS 1998). As steelhead migrated through the SLR River, some of them most likely utilized extensive habitat located in Northern Subbasin tributaries for spawning and rearing before returning to the SLR River and eventually the ocean as adults or out-migrants (juvenile fish). One of the Pauma Indian Tribal member elders described catching trout by hand in pools in Pauma Creek (USFWS 1998). See Basin Profile, Fishing and Historical Accounts of Steelhead Runs for additional information.

Currently, resident populations of native rainbow trout exist within the Pauma Creek watershed (Lion Creek, Doane Creek, and French Creek). Although Pauma Creek and Lion Creek were originally stocked by a local landowner with rainbow trout from the state hatchery at Sisson, CA in the late 1800s (Greenwood 1995), recent genetic sampling performed on these fish (NOAA 1999) concluded that "it seems more than likely that these fish are part of a native coastal *O. mykiss* lineage." Furthermore, the report stated, "these populations may be reasonable choices to consider in efforts to re-establish anadromous runs in their respective streams." The NMFS Southern California Steelhead Recovery Plan (2009 *Draft*) recognizes the importance of these resident trout populations above barriers because they may produce progeny, with smolt-like characteristics, that emigrate downstream to the ocean. The potential for the resident trout in Pauma Creek to emigrate successfully downstream of the Highway 76 bridge to the SLR River is extremely unlikely if not impossible. Rescue operations have occurred in recent years to capture and relocate trout that have been washed down from the stream habitat in the canyon to unsuitable habitat upstream of Highway 76. This section of creek tends to go dry in the summer and contains little to no cover from possible bird or mammal predation on the trout.

Recent sightings of steelhead in the subbasin have been limited. However, no annual, or even periodic, systematic surveys have been conducted within the Northern Subbasin tributaries. Consultant biologists observed two large rainbow trout (15-16 inches in length) in lower Gomez Creek during a September 2005 survey (Dudek 2007). However, these were most likely hatchery, resident rainbow trout, as an upstream landowner previously stocked rainbow trout in Gomez Creek for recreational fishing. See Current Conditions for further details.

Access into and out of streams in the Northern Subbasin is severely limited due to insufficient stream flows and fish passage barriers as a result of anthropogenic activities. Steelhead and resident trout would have a difficult time entering and exiting most of the critically important streams. Pauma Creek, Pala Creek, Frey Creek, and Gomez Creek all have man-made barriers in their lower watersheds that would prevent steelhead from accessing potentially suitable spawning and rearing habitat. It is unknown if Agua Tibia Creek contains any fish passage barriers.

Habitat Overview

Historic Conditions

Similar to the other subbasins, there has been a limited amount of coordinated stream surveys performed in the Northern Subbasin. Prior studies pertaining to streams in the Northern Subbasin focused on the genetic makeup of the native trout found in Pauma Creek and its tributaries. While a few infrequent surveys were performed on the SLR River and a couple of its tributaries in the Upper Subbasin, CDFG surveys of the Northern Subbasin streams were not detected during a literature review; therefore, historic stream habitat conditions in this subbasin are relatively unknown.

Adjacent to the Northern Subbasin, the SLR River was once a perennially flowing river with a robust, functioning riparian habitat. According to the Pauma Band's website, "Pauma" describes the area's principal feature, the San Luis Rey River, and the name "Pauma" translates as "place where there is water" (http://www.pauma-nsn.gov/index.php). These year-round flows allowed adult steelhead to migrate up the SLR River and enter the subbasin's tributaries where potential spawning and rearing habitat was located. Deriving water supplies from higher elevations and supplemented by natural springs, some of these tributaries also maintained perennial flows, providing year-round habitat for trout. Historically, several creeks were noted as steelhead/rainbow trout breeding streams. Allen Greenwood and Mike Pottorff of San Diego Trout, who have compiled anecdotal information from local Indian tribe members and longtime residents of the area, surmised that Pala Creek, Agua Tibia Creek, Frey Creek, and Pauma Creek all contained steelhead/trout at one time. It is unknown whether steelhead used other tributaries within the subbasin.

Table 6. Habitat observations made in the Northern Subbasin.

Stream	Date Surveyed	Source	Habitat Comments	Barrier Comments
Pauma Creek	01/18/2008	CDFG 2008	Reconnaissance level survey to: 1) document the post-burn impacts to the stream from the October 2007 fire, 2) identify and map the barriers to fish migration. Evidence of high flow events from recent storms was apparent in many areas. The storms have washed down a large amount of sediment into the stream from the steep, and now mostly denuded, hillsides that comprise the Pauma Creek Watershed. However, most of the sediment is moving through this area, which is not surprising given the high gradient nature of the stream. The accumulation of sediment in the survey area was relatively minor and most of the gravels should provide high quality spawning habitat. In addition, although there is a layer of fine sediment in many pools, it has not reduced pool volume appreciably, and good rearing/feeding/holding habitat exists throughout the survey area. Very little riparian vegetation was burned and area supports a good canopy.	Seventeen natural barriers (7 partial/10 total) and one-man-made barrier located between RM 3.4 and 4.2

Current Conditions

Stream habitat inventories in the Northern Subbasin conducted by CDFG were limited to Pauma and French creeks. Pauma Creek was surveyed in three separate sections from the Cleveland National Forest property boundary upstream to near its origination at the confluence of Doane and French creeks in Mount Palomar State Park. All of the surveys began above the current accessible habitat for steelhead, but provide a snapshot of the habitat conditions, particularly in the lower two reaches in Pauma Creek, that could be available for steelhead if the Highway 76 Bridge (RM 0.8) over Pauma Creek was modified to allow for fish passage (Figure 8). Upper Pauma and French Creek were surveyed, in part, to acquire baseline data of habitat conditions in stream reaches that supported known populations of rainbow trout. It is important to note that the lowest reach, which began at the Forest Service property boundary, was conducted in January, 2008, a couple of months after the Poomacha Fire. This fire contributed a large amount of debris and sediment to the creek (see Wildfire pp. 8-9). Flows were also substantially higher in the winter as surveyors estimated surface flows at 4.5 cfs compared to summer flows of 1cfs.

A general, reconnaissance level habitat survey was performed on approximately 400 feet of Gomez Creek, about 2.8 miles upstream of its confluence with the SLR River. This survey in June, 2008, was performed by a PSMFC fisheries biologist; at the time of the survey the biologist also deployed a stream temperature data logger. Stream habitat conditions were described as: low flow conditions (<1cfs); cool water temperatures; canopy density was estimated between 85 and 95%, composed primarily of large oaks; spawning gravels were present but not in great numbers; streambed substrate varied, ranging from sand to large boulders; sand/gravel/small cobble were the dominant substrate types; pools were relatively shallow (the deepest pool was 18 inches) and few in number; and pool shelter appeared relatively poor with little cover besides boulders and some undercut banks. A greater amount of Gomez Creek needs to be surveyed to determine overall habitat suitability, but it appears that it could support a small trout population. While this stretch of Gomez Creek retained perennial flows, the landowner noted that upstream sections of the creek were dry due to water extraction for crop production and overall drought-like spring conditions.

In September of 2005, during a follow up survey in Gomez Creek, consulting biologists observed two trout (one was caught via rod and reel, (Figure 6). No scale samples were taken at the time of observation; therefore, it is impossible to determine their origin. However, based on conversations with other landowners and physical appearance of the fish, it is believed that these trout were hatchery derived rainbow trout, planted by a landowner upstream of where they were observed/caught for recreational fishing purposes. They were most likely washed downstream during the significant rain events in the 2004/2005 winter/spring. It is important to note that these trout were able to survive in the creek throughout the spring and summer months, which may indicate that conditions are suitable for trout rearing in Gomez Creek.

Figure 6. Photo of trout caught in Gomez Creek in September 2005 (Dudek 2007).

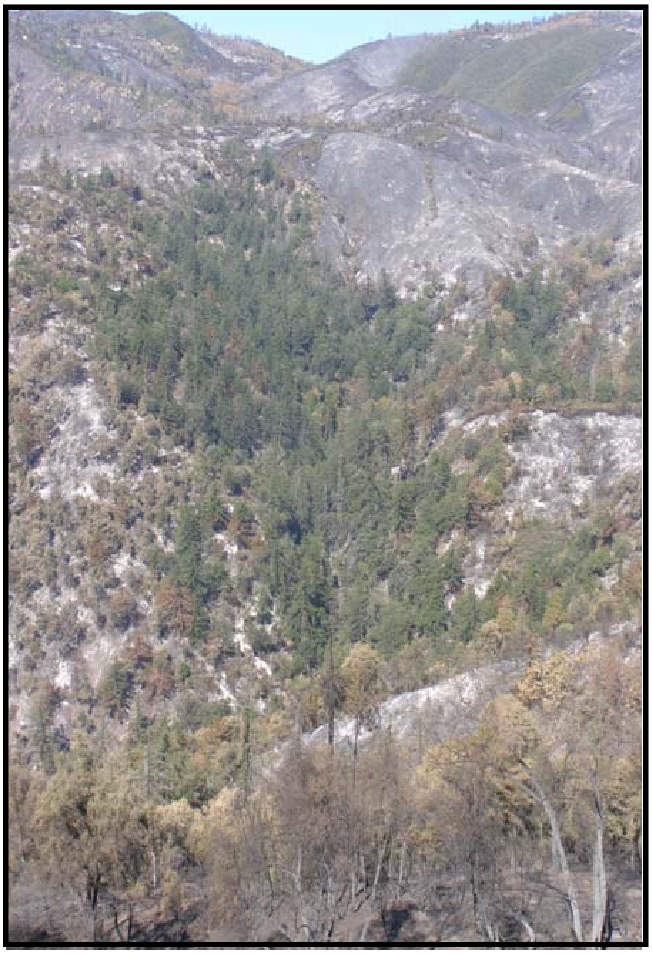


Figure 7. Mid to upper Pauma Creek after the 2007 Poomacha Fire. Note riparian area remained intact.

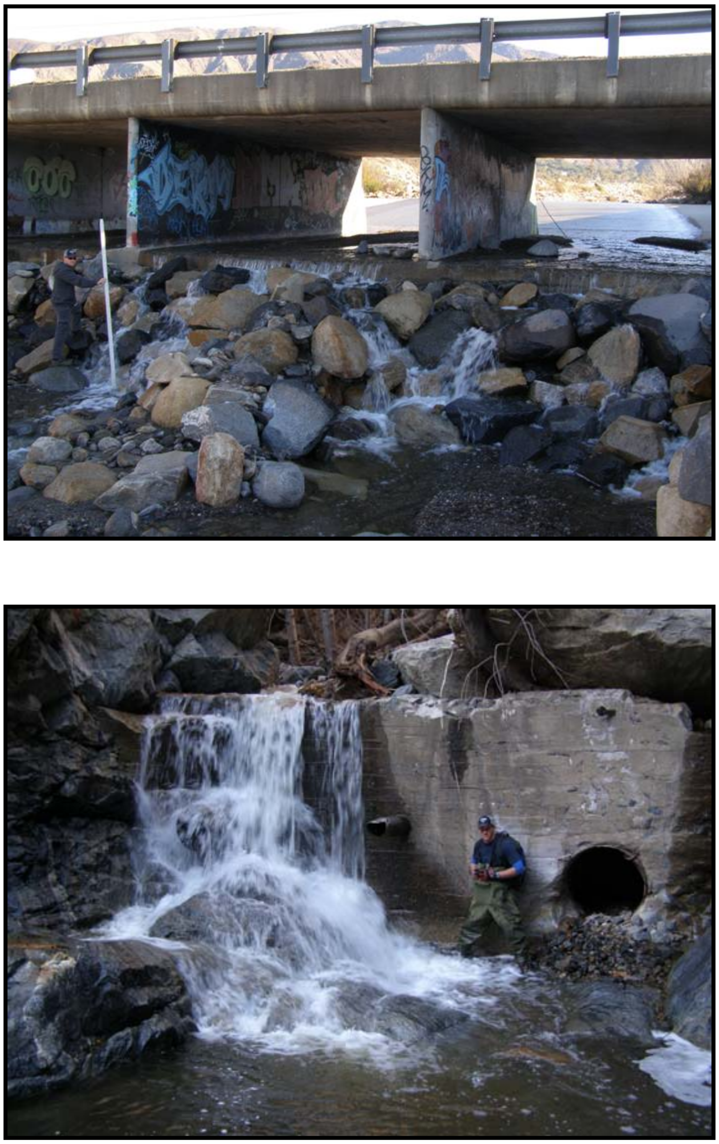


Figure 8. Steelhead/trout barriers on lower Pauma Creek.

Top photo: Pauma Creek below Highway 76 (RM 0.8);
Bottom Photo: Pauma Creek, concrete wall barrier located approximately 2.4 miles upstream of Highway 76.

Currently, the CDFG and Trout Unlimited are monitoring stream water temperatures and conducting monthly water quality sampling in Gomez Creek. The 2008-2009 sampling will provide valuable information on the range of water temperatures experienced during the hot summer and early fall months and water chemistry data throughout the year. Considering juvenile steelhead trout spend at least one year rearing in freshwater before migrating to the ocean, these data will help determine habitat suitability, identify potential limiting factors, and if necessary, make habitat improvement recommendations.

Stream habitat inventory methods were conducted on Pauma and French Creek according to methods outlined in the *California Salmonid Stream Habitat Restoration Manual* (Flosi, et al. 1998). Appendix II consists of the full Pauma Creek Stream Inventory Report.

Analysis of Pauma Creek includes the following:

- Canopy Density;
- Habitat Type Categories;
- Pool Characteristics:
- Pools by maximum depth;
- Pool shelter;
- Cobble Embeddedness.

Table 7. Northern Subbasin streams surveyed by CDFG.

Stream	Year of Survey	Survey Length (miles)	Percent of Permanent Stream Surveyed	Number of Reaches
Pauma Creek	2007 & 2008	1.17	19	3
French Creek	2007	0.26	15	1
Doane Creek*	2008	0.7	35	1
Gomez Creek*	2008	0.1	5	1

* Full habitat inventories were not performed on these tributaries

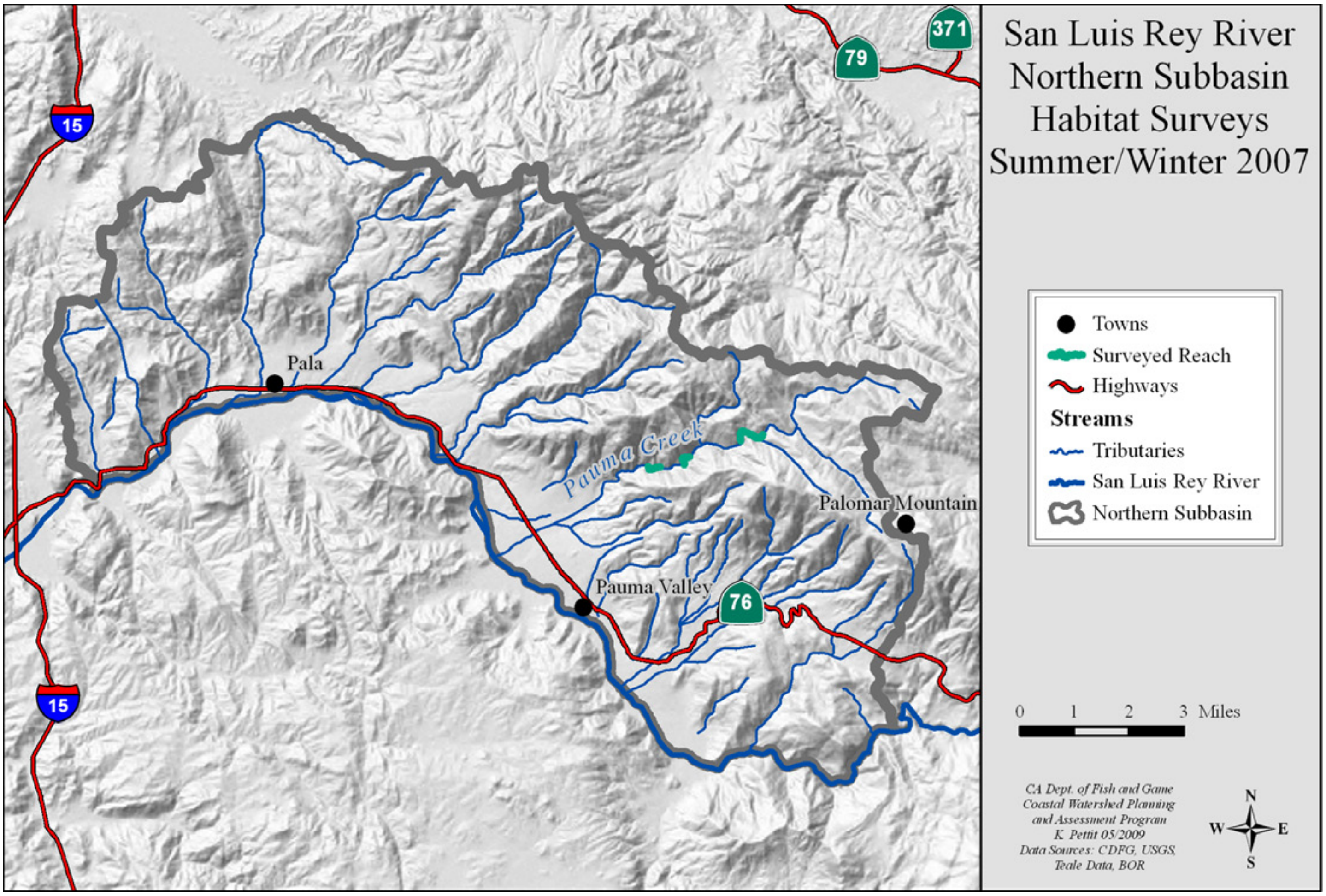


Figure 9. CDFG 2007 summer and winter habitat surveys in the Northern Subbasin.

Canopy Density

Significance: Streamside canopy density is a measure of the percentage of wetted stream that is shaded by riparian tree canopy. Stream water temperature can be an important limiting factor of salmonids, and tree canopy provides shade to reduce direct sun light from increasing water temperatures. Moreover, near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which in turn, influence stream water temperature. Riparian vegetation also bind the stream bank soil and provide resistance to the erosive forces of water, functions as the base of the food chain for biological stream life, helps store water along the stream corridor during the raining season for slow release to the stream in drier seasons, and creates desired complex instream habitat by providing woody debris to streams (Riley 1998). Generally, canopy density less than 50% by survey length is below target values and greater than 80% fully meets target values.

Findings: Canopy density measurements in Pauma Creek obtained suitable values on all three reaches (Figure 10 & Figure 12). The overall Northern Subbasin EMDS canopy density condition truth score is fully suitable. In Reaches 1 and 2, the entire canopy coverage was provided by deciduous trees, mostly in the form of mature alders and to a lesser extent, oaks, and willow. Conifers, primarily white fir, sugar pine, and incense cedar, supplied almost 25% of the canopy in Reach 3. Reach 2 had the highest canopy density as numerous riparian trees provided cover over the majority of the creek.

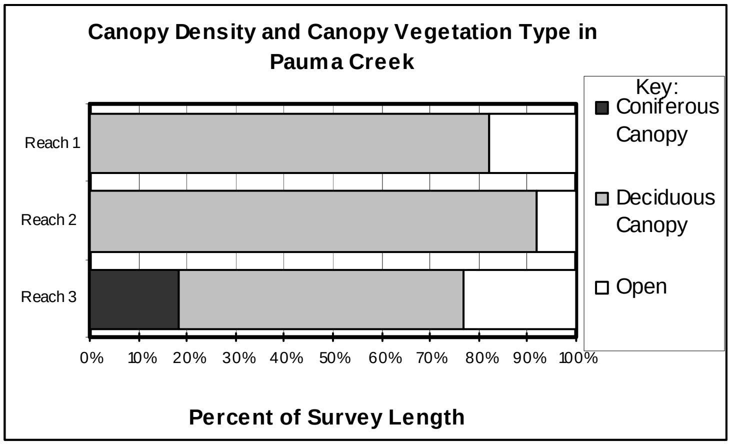


Figure 10. The relative percentage of deciduous and open canopy covering the surveyed reaches of Pauma Creek.

Averages are weighted by unit length to give the most accurate representation of the percent of a stream under each type of canopy. Pauma Creek reaches are listed from south to north within the watershed.

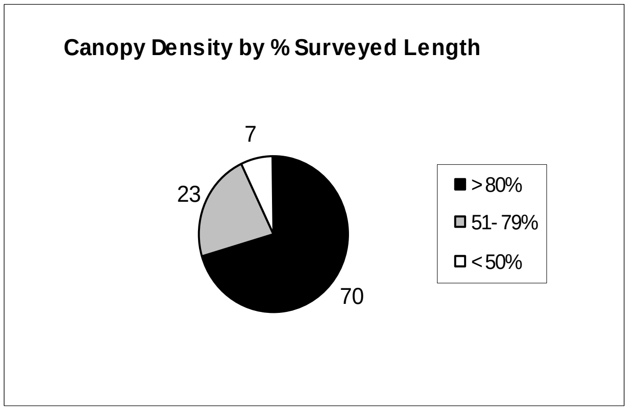


Figure 11. Canopy Density in Pauma Creek.

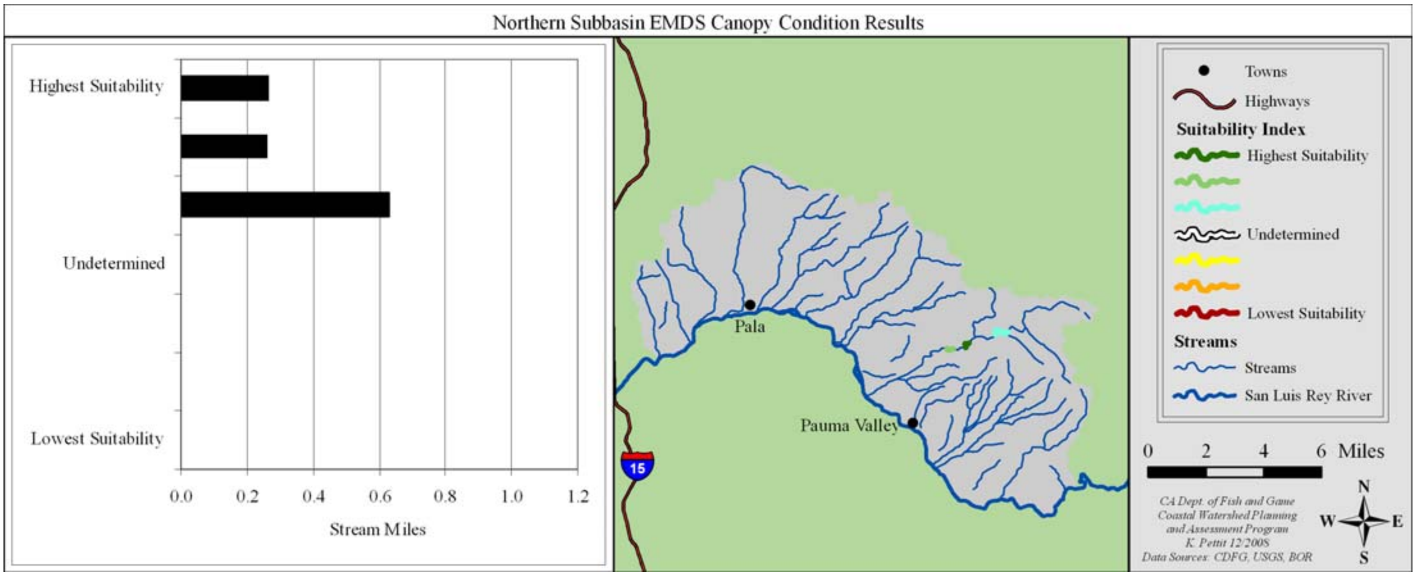


Figure 12. EMDS canopy results for Pauma Creek, Northern Subbasin by surveyed stream miles.

Habitat Categories

Significance: Productive anadromous streams are composed of a balance of pool, riffle and run habitat and each plays an important role as salmonid habitat. Pools are not only the preferred habitat for yearling and older juvenile steelhead, but also provide important resting areas during adult winter/spring migration. Looking cumulatively at pool, riffle, and run relationships helps characterize the status of these habitat types and also provides a measure of stream habitat diversity and suitability for fish. A pool: riffle ratio of approximately 1:1 is suggested as a desirable condition for most wadeable, anadromous, fish bearing streams, but it is not applicable for evaluating salmonid suitability of all stream reaches and channel types (Rosgen 1996). However, pool:riffle:run relationships showing an over abundance of riffles or runs may indicate aggraded channel conditions or lack of scour objects needed for pool formation. Additionally, pool frequency by percent length is preferable to pool frequency by occurrence because the latter may give a false impression of health if there are numerous, shallow, short pools as a result of aggradation (NMFS and Kier 2008).

Findings: Reaches 1 and 2 had a similar percent of total pools and percent of pools for the total survey length (Table 8), indicating that pool size was appropriate for the channel width of each reach, respectively. However, these reaches had a low percent of pool habitats based both on pool occurrence and overall pool habitat length. Reach 3 had a disproportional percent of pool occurrence when compared to the total percent of pool length for the reach. This would tend to indicate that pools in this reach are short and most likely shallow; therefore, these pools may lack complex instream habitat and not provide adequate protection from predators. Overall, pools occupied only 21% of the total length and 25% of the occurrence of the habitat inventory, which is much lower than the preferred amount. This would indicate poor stream habitat diversity.

Table 8. Pauma Creek percent occurrence and percent by length of pool, run, riffle, and dry habitats.

Stream	Stream Order	Survey Length (miles)	Pool, Riffle, Run Percent Occurrence	Pool:Riffle:Run Percent Total Length	Dry Percent Total
Pauma Creek Reach 1	2	0.26	30:23:40	27:23:50	0
Pauma Creek Reach 2	2	0.27	27:41:32	28:37:35	0
Pauma Creek Reach 3	2	0.63	23:48:28	15:53:32	2

Pool Depth

Significance: Pool depth and frequency are fundamental attributes of channel morphology and are largely dependent on the presence of large, roughness elements such as boulders, bedrock, root wads, and small and large woody debris in addition to channel type, stream gradient, sinuosity, and channel width. Evaluating the amount of deep pool habitat in a stream reach helps assessment of important channel characteristics for steelhead. Deep pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Greater pool depth provides more cover and rearing space for older age (1+ and 2+) steelhead juveniles and creates better shelter for migrating and spawning adults. Generally, a stream reach should have 35–50% of its length in primary pools to be suitable for salmonids. Pauma Creek was evaluated as a second order stream. First and second order streams are comprised of primary pools that are greater than 2.0 feet deep.

Findings: Only 15% of overall survey length in the Northern Subbasin (Pauma Creek) was comprised of primary pools (Figure 13), which is well below the target values of 35-50%. Subsequently, none of the reaches surveyed in the Pauma Creek met EMDS pool depth target values (Table 9). Reach 2 had the most primary pools by survey length, with 25.5% (Table 9).

Reach 1 was surveyed in the winter of 2008, after the 2007 Poomacha Fire. While the number of pools and percent of pool length habitat were similar to Reach 2, located just upstream, pool depths were shallower and thus received a lower EMDS rating. As a result of the 2007 fire, Pauma Creek received large amounts of sediment input, which was readily observed throughout the stream, including the pools. In some pools, a foot or more of sediment was present, greatly reducing the overall pool depth. Barnhart (1986) states that “excessive sediment inputs that fill pools can greatly reduce a stream’s capacity to rear steelhead to smolt size.” It may take a couple of years, depending on rainfall, to push the sediment downstream, reestablishing deeper pools.

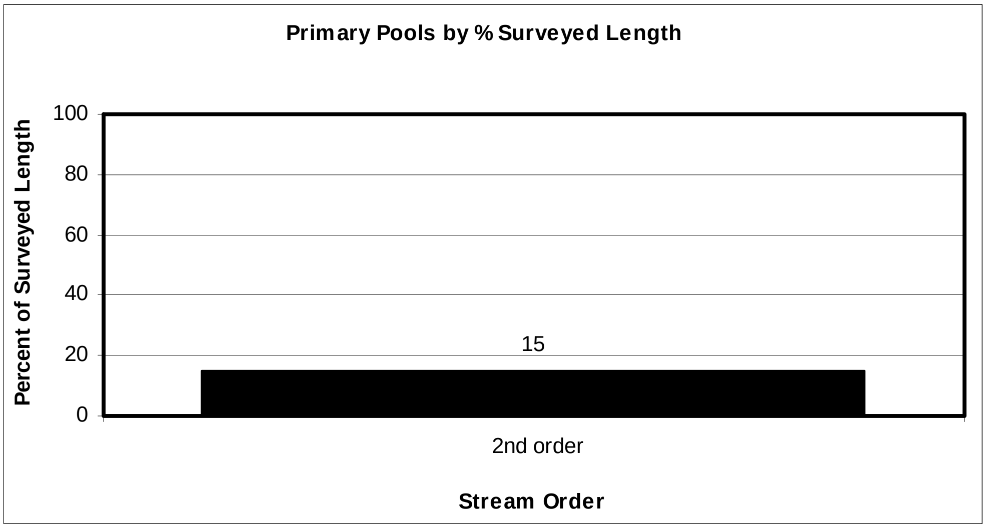


Figure 13. Primary Pools in Pauma Creek, Northern Subbasin.

Primary pools are pools greater than 2 feet deep in 1st and 2nd order streams

Table 9. Percent length of a survey composed of pools in Pauma Creek, Northern Subbasin.

Stream	Stream Order	Percent all measured pools by survey length	Percent pools of depth 2.0-2.49' by survey length	Percent pools of depth 2.5' - 2.9 by survey length	Percent pools of depth >3' by survey length	Percent pools within target range (>2.0') by survey length
Pauma Creek Reach 1	2	27.2	13.6	2.7	0	16.3
Pauma Creek Reach 2	2	28.2	7.2	18.3	7.1	25.5
Pauma Creek Reach 3	2	15.5	6.4	1.2	1.7	9.3

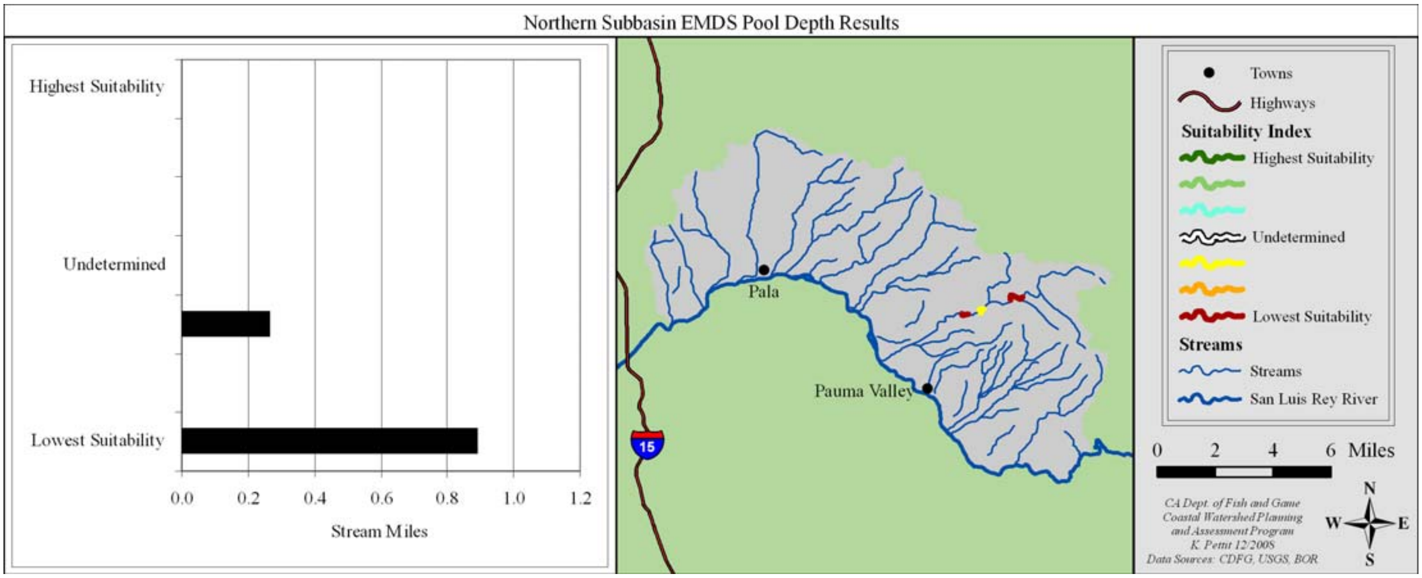


Figure 14. EMDS pool depth results for Pauma Creek, Northern Subbasin by surveyed stream miles.

Pool Shelter

Significance: The pool shelter rating is a relative measure of the quantity and percent composition of small woody debris, root wads, boulders, undercut banks, bubble curtains, and submersed or overhanging vegetation in pool habitats. These elements serve as complex instream habitat with protection from predation, rest areas from high velocity flows, and separate territorial units to reduce density related competition. Shelter ratings of 100 or less indicate that shelter/cover enhancement should be considered. Large woody debris generally does not play a significant role in the habitat functions concerning steelhead/trout in southern California Rivers and streams; therefore its presence/absence is not relevant in this assessment.

Findings: Pool shelter ratings for surveyed reaches of Pauma Creek in the Northern Subbasin were all well below the target value of 100%, thus they received low EMDS suitability ratings (Figure 15 & Figure 18). There were only a few pools located throughout the survey that had a shelter rating greater than 100.

In addition to shelter complexity rating, instream shelter composition, divided into eight cover types, was also collected during habitat inventories (Figure 17). Boulders were the dominant shelter cover type comprising 67% of the shelter in pools. Whitewater and small woody debris were the only other significant cover types having provided 21% and 8% respectively of the pool shelter. The remaining pool shelter was divided equally between bedrock ledges, terrestrial vegetation, root mass, and undercut banks. Aquatic vegetation was rarely observed in the surveyed reaches and did not play a role in providing cover in pools.

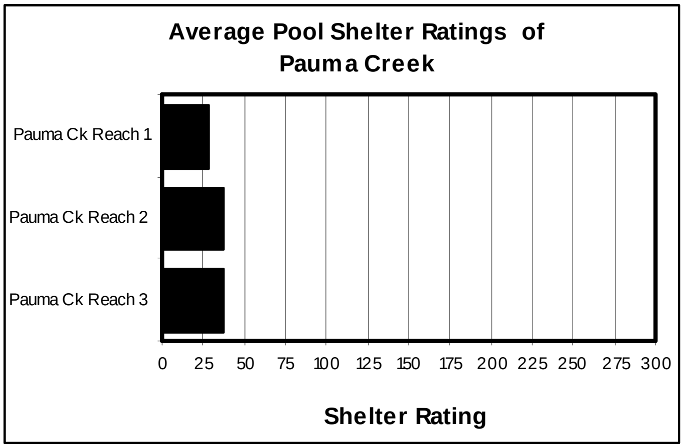


Figure 15. Average pool shelter ratings from CDFG stream surveys in Pauma Creek, Northern Subbasin.

Stream reaches are listed from lower Pauma to upper Pauma.

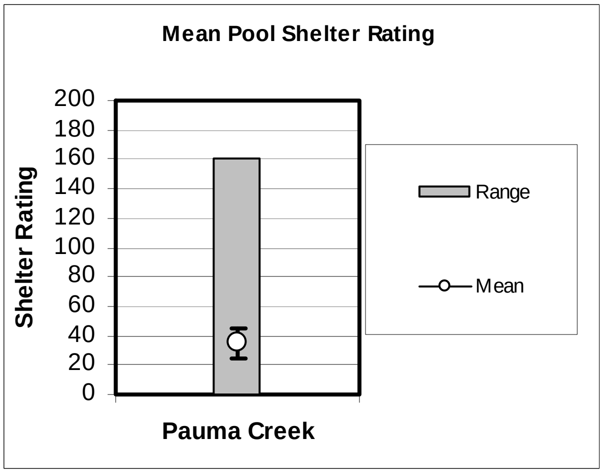


Figure 16. Pool shelter in the Pauma Creek, Northern Subbasin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, terrestrial and aquatic vegetation, bubble curtains, boulders, or bedrock ledges) is described and rated in CDFG surveys.

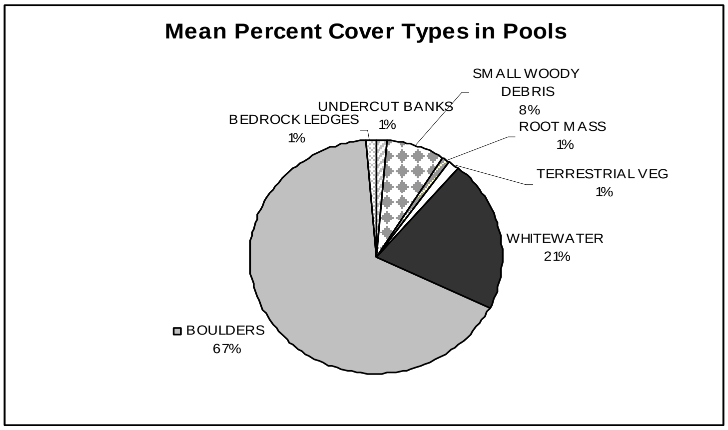


Figure 17. Mean percent of shelter cover types in pools for surveyed reaches of Pauma Creek, Northern Subbasin.

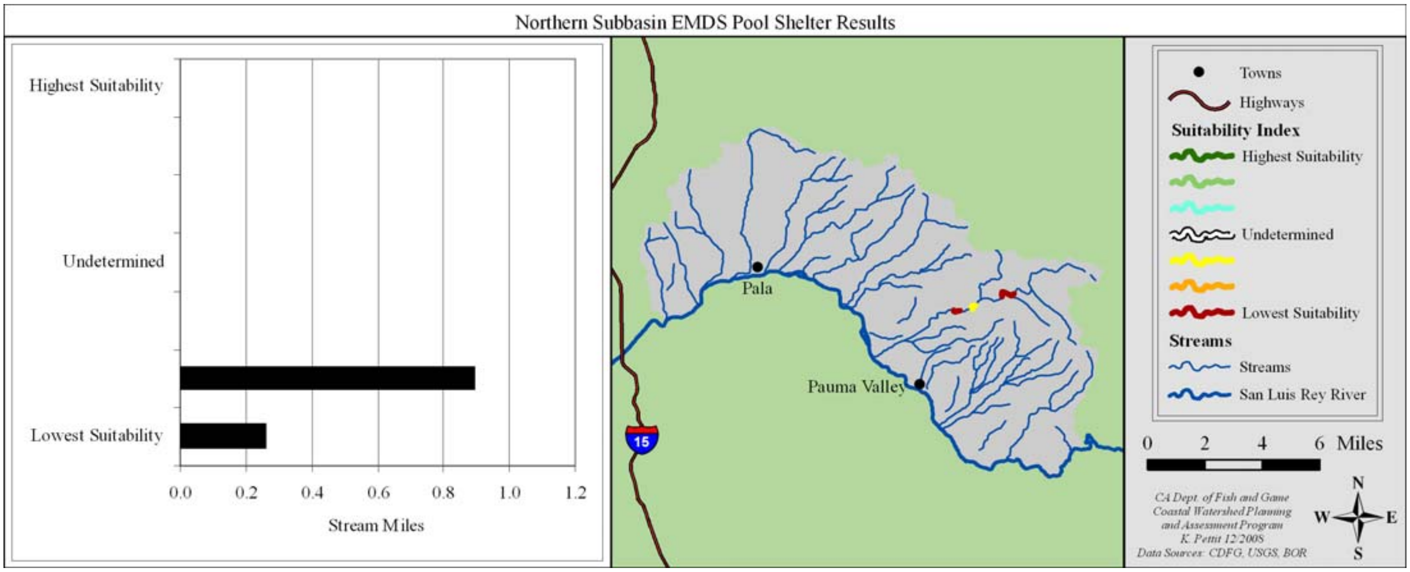


Figure 18. EMDS pool shelter results for Pauma Creek, Northern Subbasin by surveyed stream miles.

Cobble Embeddedness

<u>Significance:</u> Salmonid spawning depends heavily on the suitability of spawning gravel; fine sediments decrease successful spawning and incubation. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, category 3 is 51-75% embedded, and category 4 is 76-100% embedded. Generally, cobble embeddedness of 0-25% is considered good quality for spawning (Flosi et al. 1998). Excessive accumulations of fine sediment (>50%) reduce water flow (permeability) through gravels in redds which may suffocate eggs or developing embryos. Excessive levels of fine sediment accumulations over gravel and cobble substrate also may alter insect species composition and food availability for growing fish. Consequently, cobble embeddedness categories 3 and 4 are not within the fully supported range for successful use by salmonids. Category 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate like bedrock, log sills, boulders or other considerations. Southern California steelhead also utilize riffles as potential spawning grounds. This survey methodology, which measures only pool tail-outs, did not take this into account and thus did not record/evaluate these areas.

<u>Findings:</u> Pauma Creek possessed suitable spawning gravels for the majority of reach 1 and reach 3 surveyed areas (Figure 19 & Figure 21). Reach 2 received an unsuitable rating due to the amount of pool tail outs that had a greater than 50% embeddedness rating (Figure 20). It is important to note that reach 1 was surveyed in the winter of 2008 after some of the impacts of the 2007 Poomacha Fire had occurred. Even though the 2007 Poomacha Fire deposited large amounts of fine sediments, Pauma Creek still had suitable spawning gravels as evident by the survey results of reach 1. Given the high gradient nature of the stream, sediments appear to be moving through the system. Additional suitable spawning gravels were observed in numerous riffles throughout the surveyed area.

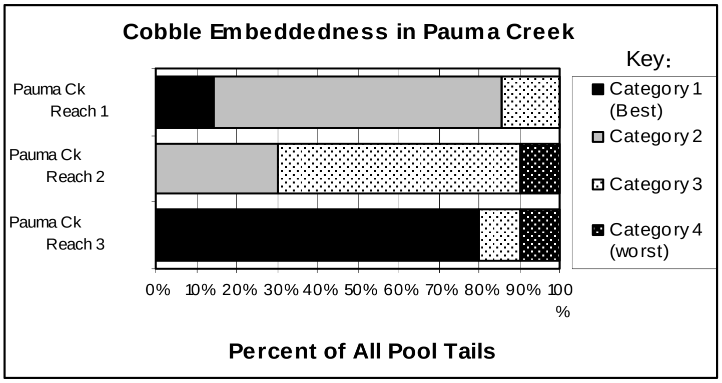


Figure 19. Cobble embeddedness categories as measured at every pool tail crest in Pauma Creek.

Stream reaches are listed in from lower Pauma to upper Pauma Creek.

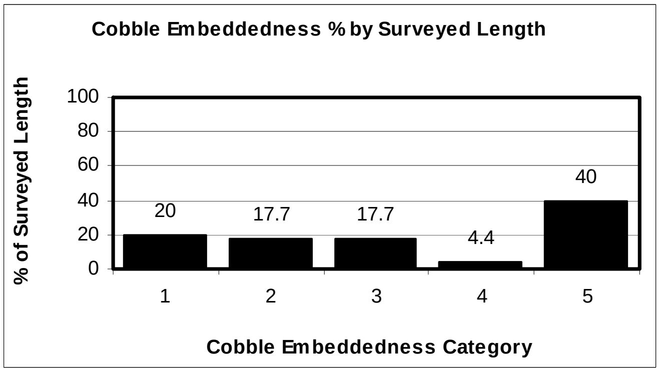


Figure 20. Cobble Embeddedness in Pauma Creek.

Cobble Embeddedness was measured only in pool tail-outs and did not take into account the steelhead may spawn in riffle habitat.

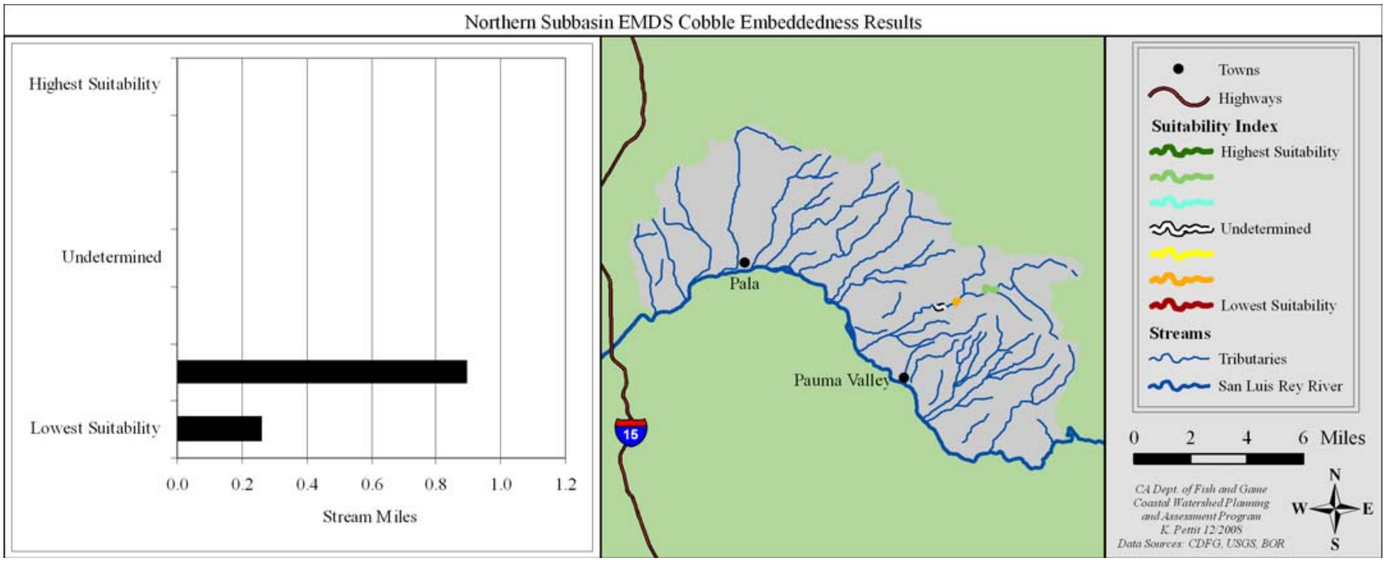


Figure 21. EMDS cobble embeddedness results for Pauma Creek, Northern Subbasin by surveyed stream miles.

Habitat Discussion and Conclusions

Due to time constraints and access issues, CDFG stream inventories in the Northern Subbasin were limited to Pauma Creek. Unfortunately, prior to the CDFG 2007-2008 Pauma Creek stream inventories and post-fire, general habitat assessments, little information is available on historic conditions of the creek and its watershed. Generally, data from older stream surveys provide a snapshot of the conditions at the time of the survey, but these are unavailable. Historic information is limited to genetic sampling of trout from the creek and brief, anecdotal accounts of fishing on Pauma Creek.

At the time of the 2007 and 2008 CDFG Pauma Creek habitat inventory surveys instream habitat conditions were considered poor to good depending on the habitat category. In the three surveyed reaches pool quality, pool depth, and pool shelter habitat characteristics fell below EMDS target values and were evaluated as unsuitable for steelhead trout. Conversely, canopy density and cobble embeddedness met EMDS target values and were evaluated as suitable conditions for steelhead (Table 10).

Canopy density was suitable on all surveyed reaches of Pauma Creek (Table 10). Current canopy density measurements do not take into account differences between smaller, younger riparian vegetation versus the larger microclimate controls that are provided by deep, narrow canyon canopy conditions. Water temperature measurements, recorded every hour on the hour during the surveys, were considered suitable for steelhead, but more long-term data is needed to determine water temperature suitability throughout the high temperature extremes of the summer months.

Cobble embeddedness was suitable on reaches 1 and 3 in Pauma Creek (Table 10). Even though large amounts of fine sediment were deposited as a result of the 2007 Poomacha Fire, reach 1 (surveyed in January 2008) displayed suitable cobble embeddedness conditions. Pool quality, depth, and pool shelter were unsuitable on all surveyed reaches, thus these habitat factors are likely limiting to steelhead trout populations. Pool depths were adversely impacted (decreased) by the sediment input from the 2007 Poomacha Fire. Due to the steep gradient and potentially significant winter precipitation, the sediment will most likely be flushed downstream over the course of several years and deeper pool depths will be restored.

Although macroinvertebrate data indicate that Doane Creek, tributary to Pauma Creek, is a healthy system, with the greatest taxonomic diversity of the sites tested in San Diego County, there is not enough data to determine whether water chemistry is a limiting factor in other tributaries in this subbasin. Doane Creek may be representative of the Pauma Creek watershed where limited human activities occur; it may not, however, be indicative of conditions in other streams in the subbasin where agricultural activities could have more of an impact on water quality. Current water quality monitoring being conducted on Gomez Creek should provide insight to water quality conditions that are more typical of streams in the subbasin where residential housing and farming operations dominate the lower to middle elevations of streams.

Prior to the 2007 Poomacha Fire, numerous trout of all age classes (young of the year to 3+ fish) were observed in reaches 2 and 3 of Pauma Creek. No fish were observed in reach 1 during the January 2008 habitat inventory, though trout are generally inactive and difficult to identify during the winter months with colder stream temperatures. In May of 2008, a CDFG fisheries biologist and PSMFC fisheries technician surveyed Pauma Creek from reach 2, (approximately 4.3 miles upstream its confluence with the SLR River) upstream 3.2 miles to its origination at the confluence of French Creek and Doane creeks. No trout were observed until near the confluence of French and Doane Creek; however, deep pools were not snorkeled and runs and riffles were not electro-fished to ascertain the presence/absence of trout. The biologist noted large amounts of sediment input as a result of the 2007 Poomacha Fire. Moderate quality spawning and rearing habitat were still present even with this sediment input and lack of fish observations.

If fish passage modifications occurred at the Highway 76 Bridge, approximately ¾ to a mile of suitable spawning and rearing habitat would become available to steelhead trout. This potentially suitable habitat is located downstream of the Forest Service property boundary (approximately 1.5 miles upstream of Highway 76) and extends into the canyon within FS proper. This reach retains perennial flows, deeper pools, potential cover, suitable spawning gravels and potentially suitable water temperatures (based on water temperatures recorded a short distance upstream, during the July 2007 habitat inventory). The potential habitat terminates at a ten-foot high, concrete wall located 2.4 miles above Highway 76; this concrete wall is a complete barrier to fish passage (Figure 8). Additional suitable habitat is located above this wall; however multiple partial to most likely complete barriers are located within a ¼ mile upstream of this wall. Depending on flow conditions, several potential partial, natural barriers (bedrock chutes) exist just downstream of this man-made structure.

A small section of Gomez Creek, approximately 2.8 miles upstream of its confluence with the SLR River, was examined in June of 2008 for general habitat conditions. Low flow conditions (less than 1cfs) were present at the time of the survey. Canopy cover appeared to be excellent and stream water temperatures were cool. The stream had very little pool formations and the pools that were present were relatively shallow (maximum pool depth was 1.3 feet). Spawning gravels were sparse and appeared to be 50% embedded. A landowner downstream may currently be stocking Gomez Creek with rainbow trout. In the recent past (2005) these trout were washed downstream during significant winter rain events, but appeared to survive throughout the spring and summer as they were caught the following September. This may indicate instream habitat conditions are suitable for supporting trout populations.

Table 10. EMDS reach condition results for the Northern Subbasin.

Stream	Year	Canopy	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Pauma Creek - Reach 1	2007	++	---	---	---	+
Pauma Creek - Reach 2	2007	+++	-	-	--	--
Pauma Creek - Reach 3	2007	+	--	---	--	++
Northern Subbasin		++	--	--	--	+

Key: +++ = Highest Suitability U Insufficient Data or Undetermined - - - = Lowest Suitability

Stream Habitat Improvement Recommendations

In addition to presenting habitat condition data, all CDFG stream inventories provide a list of recommendations that address those conditions that did not reach target values presented in CDFG's *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998) and in *NMFS's Guide to reference values used in south-central/southern California coast steelhead conservation action planning workbooks* (2008) (see the Current Conditions pp. 20-25). Stream habitat improvement recommendations were developed based on results from stream surveys conducted along potential salmonid bearing stream reaches in 2007. Full habitat inventories were conducted on Pauma Creek and general stream observations were recorded on sections of Gomez Creek. Even though the majority of Pauma Creek is currently inaccessible to steelhead due to the Highway 76 Bridge crossing on Pauma Creek, CDFG wished to qualify/identify the potential habitat available to steelhead if fish passage improvement projects were implemented at this crossing and other locations in the lower SLR River. In addition to presenting habitat condition data, all CDFG stream inventories provide a list of recommendations that address those conditions that did not reach target values (see the Fish Habitat section of this subbasin). A CDFG biologist selected and ranked habitat improvement recommendations for the survey conducted in Pauma Creek, in the Northern Subbasin (Table 11). Because other tributaries in the subbasin were not accessible to fish or could not be surveyed due to landowner access issues, these creeks were not included in stream habitat improvement recommendations. The SLR River was evaluated in the Southern Subbasin, so it was not incorporated in these recommendations.

In order to compare recommendations within Pauma Creek, the recommendations of each reach were collapsed into five target issue categories: Surface Stream Flow; Fish Passage; Riparian/Water Temperatures; Instream Habitat; and Sediment Delivery (Table 11). These target issues were then paired with the appropriate recommendation category. For example, the target issue "Instream Habitat" was divided into the recommendation categories of: Pool, Cover, and Spawning Gravels. CDFG/PSMFC biologists selected and ranked habitat improvement recommendations based on survey inventory results collected in Pauma Creek. The top three recommendations of each reach are considered to be the most important, and are useful as a standard example of the stream. When examining recommendation categories by number of reaches, the most important target issue in Pauma Creek is fish passage. High priority should be given to restoration projects that emphasize fish passage modification, sediment reduction, and pool enhancement and formation. This could apply to other potential fish bearing streams in the subbasin such as Gomez Creek, Agua Tibia Creek, Frey Creek, and Pala Creek.

Table 11. Recommendation categories based on basin target issues.

Basin Target Issue	Related Table Categories
Surface Stream Flow	Stream Flow
Fish Passage Barriers	Fish Passage
Riparian / Water Temp	Canopy / Temp
Instream Habitat	Pool / Cover / Spawning Gravels
Sediment Delivery	Bank / Roads / Livestock

Table 12. Occurrence of stream habitat inventory recommendations for different reaches of the SLR River of the Northern Subbasin.

Stream	Survey Length (mile)	Stream Flows	Fish Passage	Riparian/Water Temps		Instream Habitat			Sediment Delivery		
				Temp	Canopy	Pool	Cover	Spawning Gravel	Bank	Livestock	Roads
Pauma Creek Reach 1	0.27		1			2	3	4			
Pauma Creek Reach 2	0.27		1			2	3	4			
Pauma Creek Reach 3	0.63		1			2	3	4			
Gomez Creek	0.1	1	2	unk		3	5	4			

Restoration Projects

Restoration projects within the subbasin have been limited to those done by local landowners, the Mission RCD, San Diego Trout, and Golden State Flycasters/Trout Unlimited. Considering that few trout have been observed within the subbasin, there has been little emphasis on implementing fisheries based restoration projects, with the exception of a few projects in the Pauma Creek watershed. The CalFish website, http://www.calfish.org/, (CalFish is a multi-agency program for collecting, standardizing, maintaining, and providing access to quality fisheries data and information for California), it did not list any agency or organization funded stream restoration projects in the subbasin.

Most recently, San Diego Trout, in conjunction with San Diego Fly Fisherman's Club and CDFG, installed a downstream catchment weir at the outlet of Doane Pond in Mount Palomar State Park. Historically, Doane Pond, located upstream of Pauma Creek on a portion of Doane Creek, has been stocked with rainbow trout and catfish to provide recreational fishing opportunities. The purpose of the weir is to protect the genetic gene pool of the downstream wild, native trout populations in Doane and Pauma Creek, and prevent the downstream movement of exotic game fish (bluegill and catfish), crayfish, and bullfrogs from potentially populating Doane Creek and Pauma Creek.

Past or current projects that have improved stream habitat conditions or contributed to the monitoring of the stream habitat conditions include the following:

- Spring 2008 to December 2009 water temperature monitoring by the Department of Fish and Game in conjunction with Trout Unlimited;

- Spring 2008 to December 2009 water chemistry analysis and bioassessment by Trout Unlimited in conjunction with the San Diego Coastkeeper;
- Water quality control via animal waste improvement projects;
- Mission RCD working with area farmers on Best Management Practices for pesticide and erosion control and prevention.

Information on other watershed stream restoration projects can be found on CalFish (www.calfish.org) or on the Natural Resources Project Inventory online database (www.ice.ucdavis.edu/nrpi/).

Refugia Areas

The interdisciplinary team identified and characterized refugia habitat in the Northern Subbasin by using professional judgment and criteria developed for southern coastal watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, stream flows, agriculture and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by the EMDS at the stream reach scale.

The most complete data available in the Northern Subbasin was for Pauma Creek, which was surveyed by CDFG during the summer of 2007 and in the winter (January) of 2008 during higher water flows. The SLR River was designated completely within the Southern Subbasin; therefore, it is not discussed in this subbasin. Salmonid habitat conditions in the Northern Subbasin on surveyed streams are generally rated as medium potential refugia.

Full instream habitat inventories were performed on French and Pauma creeks, while Doane and Gomez creeks had general reconnaissance level surveys to determine habitat suitability for steelhead. Resident, rainbow trout were found in Pauma, French and Doane creeks. Gomez Creek may currently be stocked with rainbow trout on a private landowner's property, immediately downstream of the surveyed section. Pauma Creek most likely contains the best habitat within the SLR River Basin that could be made available to steelhead with a barrier modification of the culvert below Highway 76.

In Gomez Creek, full habitat inventory was not performed due to limited landowner access; therefore only a relatively short section of the creek was access for habitat suitability. This section of Gomez Creek provided marginal habitat that could be utilized by steelhead/trout. Spawning habitat was limited and complex instream habitat was generally lacking. However, more of the creek would need to be surveyed to draw further conclusions on its overall habitat suitability. Other tributaries in the subbasin such as Agua Tibia Creek, Frey Creek, and Pala Creek were not surveyed and habitat conditions are relatively unknown. A literature review contained references to steelhead/trout in Agua Tibia Creek, Frey Creek, and Pala Creek. These tributaries are labeled on USGS 7.5 quadrangle maps as containing small to moderate reaches of perennial flows. Further field studies are needed to determine the habitat suitability and limiting factors for steelhead/trout production in these streams. The following refugia area rating table summarizes subbasin salmonid refugia conditions.

Table 13. Refugia rating table for the Northern Subbasin.

Stream	**Refugia Categories**				**Other Categories**		
	High Quality	**High Potential**	**Medium Potential**	**Low Quality/Low Potential**	**Passage Barrier Limited**	**Critical Contributing Area**	**Data Limited**
Gomez Creek			X		X		X
Pala Creek				X	X		X Needs survey
Magee Creek	Not enough information to classify						X Needs Survey
Agua Tibia Creek	Not enough information to classify						X needs Survey
Frey Creek	Not enough information to classify				X		X Needs Survey
Pauma Creek			X		X		

Key Subbasin Issues

- The lack of hydrologic connectivity in the SLR River hinders the potential for steelhead/trout to access streams in the Northern Subbasin;
- Numerous unregulated wells throughout the subbasin have a negative impact on stream flows in the tributaries;
- Access to extensive habitat located in several of subbasin's streams is currently blocked by man-made barriers;
- Agricultural wastewater runoff poses a potential problem to aquatic ecosystems in the tributaries;
- Increased sediment levels in streams degrade instream habitat and creates a multitude of problems for fish.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations in the Subbasin?

Findings and Conclusions:

- Southern California Coast Steelhead (DPS) are federally listed as endangered;
- The Northern Subbasin once supported steelhead runs in its streams but have since been extirpated. Historically, steelhead utilized some of the tributaries in the subbasin for spawning and rearing habitat before returning to the SLR River and eventually the ocean as adults or out-migrants (juvenile fish);
- The following tributaries were reported to have steelhead at one time: Pauma Creek, Pala Creek, Agua Tibia Creek, and possibly Frey Creek. There is a lack of historical information available for size of runs in these tributaries;
- Within the past several decades, steelhead have not been observed in these tributaries listed above, but focused surveys have not occurred to document the presence/absence of steelhead potentially utilizing these streams;
- The Pauma Creek watershed retains a population of native, self-reproducing rainbow trout. During the July 2007 CDFG habitat inventory, trout were observed in abundant numbers in the middle and upper reaches of Pauma Creek, French Creek, and Doane Creek. However, a CDFG May 2008 post-fire general reconnaissance-level survey, reported observing trout only in the upper portions of Pauma Creek (trout were still observed in French Valley Creek and Doane Creek);
- Introduced brown trout (*Salmo trutta*) are also found in the upper portions of Pauma Creek as well as in French Creek and Doane Creek.

What are the current salmonid habitat conditions in the Northern Subbasin? How do these conditions compare to desired conditions?

Findings and Conclusions:

Flow and Water Quality:

- Nearly all of the streams containing suitable habitat for steelhead/trout have to some extent, on-going water extraction activities for anthropogenic uses. This reduction of surface flows minimizes the available habitat for rearing fish, hinders upstream and downstream fish movement, and affects water temperature and water quality;
- Pauma Creek contains perennial flows from its headwaters downstream to the Pauma Indian Tribe's water diversion, which is located approximately 1/3 of a mile downstream of the Cleveland National Forest Service boundary. Thereafter, the stream loses surface flows during the mid to late summer months;
- Gomez Creek, Pala Creek, Agua Tibia Creek, and Frey Creek contain only sections of perennial surface

flows during the summer and early fall months. These sections may be sufficient to support small trout populations;

- The lack of flows altogether or insufficient flows in the SLR River most likely would impede the passage of steelhead to these more suitable streams in the Northern Subbasin;
- Water quality is being impacted by agricultural runoff that have direct access to streams;
- There is a lack of water quality data on the streams in the Northern Subbasin. Results of a fall 2005 and spring 2006 bioassessment in Doane Creek indicated an Index of Biotic Integrity quality rating of “good” and “very good,” respectively.

Erosion/Sediment:

- The 2007 Poomacha Fire resulted in a large amount of sediment input to Pauma Creek that filled in deep pools as well as covered potential spawning gravels. In addition to fine sediment, log jams had formed from woody debris being carried downstream during significant rain events;
- Other streams such as Agua Tibia Creek and Frey Creek, which were also within the burned area of the Poomacha Fire, may have experienced similar sediment inputs;
- Large agricultural production has resulted in numerous terraced, steep hillsides. Although best management practices are in place, erosion from these hillsides most likely contributes fine sediments to the streams in the Northern Subbasin;
- Livestock have unrestricted access to some tributaries, resulting in stream bank erosion;
- Soils (and bedrock) in streams of the Northern Subbasin are prone to erosion, and slides and streambank failures have been observed to contribute fines to the streams.

Riparian Condition/Water Temperature:

- Canopy cover on Pauma Creek and its tributaries (French Valley Creek and Doane Creek) was suitable for salmonids. In general, the Poomacha Fire did not adversely affect the canopy, as the fire, for the most part, did not burn in the riparian areas and remained a ground fire;
- Canopy cover in Pauma Creek is also aided by the steep, canyon walls along much of the middle and upper portions of the creek and similar conditions may exist in other subbasin streams;
- Water temperature data collected by CDFG during summer habitat inventories indicate suitable stream temperatures. However, these data are limited, and therefore inconclusive.

Instream Habitat:

- At the time of the 2007 and 2008 CDFG Pauma Creek habitat inventory surveys instream habitat conditions were considered poor to good depending on the habitat category. In the three surveyed reaches pool quality, pool depth, and pool shelter habitat characteristics fell below EMDS target values and were evaluated as unsuitable for steelhead trout. Conversely, canopy density and cobble embeddedness met EMDS target values and were evaluated as suitable conditions for steelhead;
- Lower Pauma Creek has been modified as the creek has been straightened, lined with boulders, and all vegetation has been removed;
- Marginal trout habitat was present in a small, surveyed portion of Gomez Creek, approximately 2 miles upstream of its confluence with SLR River. This area retained perennial flows with a robust canopy and a few potential spawning areas. It lacked deep pools and sufficient instream cover;
- Similar habitat may be available in Agua Tibia, Frey Creek, and Pala Creek. Agua Tibia Creek appeared to retain surface flows for a longer duration, as witnessed during the summer of 2007 and late spring of 2008.

Gravel/Substrate:

- Suitable salmonid spawning areas were available in the surveyed reaches of the Pauma Creek and to a lesser extent Gomez Creek. In Pauma Creek, overall numbers of potential spawning gravels were moderate and embeddedness measurements met suitable EMDS target values;
- The effects of the 2007 Poomacha Fire increased sediment input into the creek and most likely resulted in the burying of potential spawning gravels; nevertheless, numerous additional spawning areas were readily observed in a stream survey following the fire;
- The accumulation of sediments as a result of the fire may require a series of winter storms in order to flush out these fine sediments and restore suitable spawning grounds throughout Pauma Creek.

Refugia Areas:

- Salmonid habitat conditions in Pauma Creek are rated as moderate potential refugia. In general, if fish passage modifications occurred at the Highway 76 Bridge, approximately ¾ of a mile to one mile of suitable spawning and rearing habitat would become available to steelhead trout. The potential habitat terminates at a ten-foot high, concrete wall located 2.4 miles above Highway 76;
- Gomez Creek appeared to have a small stream reach of potential steelhead habitat, but without surveying downstream of this habitat it is not known if steelhead could access this area;
- There are a few other tributaries, Agua Tibia Creek, Pala Creek, and Frey Creek, whose current habitat status is relatively unknown, but anecdotal records describe them as containing steelhead/rainbow trout habitat that was formerly utilized by these fish. Due to issues with accessibility and water extractions, available habitat may be more limited in these streams.

Barriers:

- Several partial fish barriers exist along the lower SLR River that hinders/limits the potential for steelhead to utilize streams in the Northern Subbasin;
- Fish passage barriers are present in Pauma Creek at the Highway 76 Bridge (RM 0.8) and 2.4 miles upstream of the Highway 76 bridge in the form of a 10-foot high concrete wall.
- Other known barriers include the Pala Mission Road crossing in Pala Creek and in Gomez Creek at a road crossing 3.7 miles upstream its confluence with the SLR River. Additional barriers are most likely present in lower Gomez Creek, Frey Creek, and Agua Tibia Creek north of Highway 76.

What are the impacts of geologic, vegetative, fluvial, and other natural processes on watershed and stream conditions?

Findings and Conclusions:

- Severely erodible soils comprise 95% of the watershed, including the Northern Subbasin. Slides from the stream banks and roads have been observed to contribute fines to the stream;
- Weathering of the granitic rocks has created younger unconsolidated sediments that are very susceptible to enhanced erosion and mass movement such as landslides and debris-flows;
- The Northern Subbasin is a potentially seismically active area as several faults cut through this basin, including the Elsinore Fault Zone. Large seismic events, especially when coupled with significant storm events, can trigger large landslides and mudflows increasing sediment delivery to the streams and altering their hydrologic condition;
- Uplift has increased the erosion potential of the area;
- Large areas of native vegetation along the tributaries have been displaced by agricultural crop production, which require irrigation. This watering lowers the ground-water table and reduces, or in some cases, eliminates surface flows altogether in the tributaries;
- The 2007 Poomacha Fire that burned within the Northern Subbasin resulted in an increase in sediment input as witnessed in Pauma Creek during CDFG reconnaissance level surveys. The increased sediment

input filled in pools, reduced potential spawning areas, and led to trout mortality;

- Other streams such as Frey Creek and Agua Tibia Creek were also located in the burned area and may have experienced similar effects of the fire.

How has land use affected these natural processes?

Findings and Conclusions:

- Agricultural runoff has affected the water quality and quantity of some of the subbasin's streams;
- Disturbance of the basin's already unstable soils by land use activities has altered runoff rates;
- Water extraction to supply large and small scale agricultural operations has reduced or eliminated surface flows, lowered the groundwater table, and thus reduced the habitat available to trout in many of the streams in the Northern Subbasin;
- As less water is available for shrubs and trees, the vegetation along these streams may be altered from riparian trees to more drought tolerant chaparral species. The potential shift in vegetation could affect instream habitat conditions and increase water temperatures;
- The possible expansion of large gaming casinos could further impact the subbasin's water resources.

Based upon these conditions, trends, and relationships, are there elements that could be considered to be limiting factors for steelhead production?

Findings and Conclusions:

Based on available information for the Northern Subbasin, it appears that salmonid populations are limited by:

- Lack of hydrologic connectivity in the SLR River, which would inhibit passage of seasonally appropriate migrations of adult and juvenile fish to suitable habitat in the Northern Subbasin streams;
- Fish passage barriers;
- High levels of fine sediments in streams due to the 2007 Poomacha Fire;
- Loss of habitat area and complexity due to anthropogenic water extraction;
- A shortage of areas with suitable spawning gravel in tributaries.

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Habitat improvement activity recommendations are limited to the Pauma and Gomez creeks since they were the only streams surveyed during the assessment. Other streams, Agua Tibia, Frey, and Pala creeks, may have the potential to support steelhead/trout, but further studies are needed in order to make suitable habitat improvement recommendations for those individual watersheds. All of these creeks have fish passage barriers that would need to be addressed for steelhead to access potentially suitable habitat.

Barriers to Fish Passage

Streams	Recommended Actions XXX: Highest Priority		
	Improve fish passage to streams in Northern Subbasin by modifying partial passage barriers in the SLR River.	Continue efforts to identify and alleviate fish passage impediments at culverts or other public or private road crossings.	Improve fish passage by removing structures on private lands that are currently partial barriers.
Pauma Creek	XXX		XXX
Gomez Creek	XXX	XXX	XXX

Flow and Water Quality

Streams	Recommended Actions XXX: Highest Priority			
	Insure that water diversions used for domestic or irrigation purposes bypass sufficient flows to maintain all needs of fishery resources. Considering purchasing water rights if necessary to accomplish this.	Reduce water temperatures	Plant willows, cottonwoods, or alder trees in lower reaches to help reduce water temperature and improve overall habitat.	Remove and prevent excessive agricultural or urban runoff contributions to aquatic ecosystems
Pauma Creek	XXX		X	
Gomez Creek	XXX		X	XX

Erosion and Sediment Reduction

Streams	Recommended Actions XXX: Highest Priority			
	Continue to identify and reduce sources of sediment delivery to stream channels from road systems.	Re-vegetate exposed stream banks and/or install structures to increase bank stability.	Build livestock exclusionary fencing along creeks and create offsite watering areas.	Install instream structures that enhance natural sorting of spawning gravels.
Pauma Creek		X		X
Gomez Creek	X	X		X

Riparian and Instream Habitat

Streams	Recommended Actions XXX: Highest Priority			
	Increase depth, area or shelter complexity in pools, by adding boulders, or if possible, woody debris.	Develop and implement a plan to restore natural channel features where feasible.	Continue to remove non-native exotic plant species such as *Arundo donax* and replant with native trees and shrubs.	Consider planting barren nearstream areas in lower reaches with willow, cottonwood or sycamore trees to increase streamside shade canopy and allow for woody recruitment.
Pauma Creek	X	XX		X
Gomez Creek	X	XX		X

Education, Research, and Monitoring

Streams	Recommended Actions XXX: Highest Priority		
	Continue, expand, or develop education programs concerning water conservation, water quality, and importance of watershed/riverine ecosystems.	Conduct further habitat surveys and/or presence/absence surveys.	Water quality and temperature monitoring should be conducted over several years to characterize conditions in streams.
Pauma Creek	X	X	XX
Gomez Creek	XXX	XX	XX

Subbasin Summary and Conclusions

The Northern Subbasin contains potentially suitable habitat for steelhead in several streams, but fish passage issues must be resolved both in the lower SLR River and in these tributaries in order to provide access to this habitat. Currently, a population of native rainbow trout persists in the Pauma Creek watershed. Genetic sampling performed on these fish concluded that "it seems more than likely that these fish are part of a native coastal *O. mykiss* lineage." Furthermore the report stated, "these populations may be reasonable choices to consider in efforts to re-establish anadromous runs in their respective streams" (NOAA 1999). However, these trout are currently blocked from accessing the SLR River due to the impassible crossing located under the Highway 76 Bridge on Pauma Creek. The NMFS Southern California Steelhead Recovery Plan (2009 *Draft*) recognizes the importance of these resident trout populations above barriers because they may produce progeny, with smolt-like characteristics, that emigrate downstream to the ocean.

Others streams in the subbasin were historically utilized by steelhead, but also have fish passage problems that may prevent steelhead from accessing suitable spawning and rearing habitat. Gomez Creek could support a population of steelhead, but most likely contains a couple of man-made, temporary fish passage barriers, limiting steelhead access to upstream habitat. A local landowner approximately 2.7 miles upstream of the confluence with the SLR River most likely stocked rainbow trout on his property. It is assumed that these fish are able to survive year-round in Gomez Creek. In order to retain these planted fish on the property, the stream channel was probably modified and these modifications may pose as fish barriers problems to ocean run fish. The potential mixing of hatchery strain with wild fish would also be detrimental to the gene pool of ocean run fish.

Pala Creek was a former steelhead breeding stream, but due to multiple water extractions, only a small perennial reach remains. This reach, located upstream of the Pala Indian Reservation, is comprised of minimal pool and riffle habitat. Fish passage is hindered, possibly blocked altogether, at the Pala Mission Road stream crossing.

Agua Tibia Creek was also historically a steelhead rearing stream and may contain suitable spawning and rearing habitat in the Cleveland National Forest, approximately one and half miles upstream its confluence with the SLR River. Frey Creek may fit this description as well. Further habitat surveys are needed to determine access and habitat suitability on these streams.

The 2007 Poomacha Fire burned a large portion of the Northern Subbasin, including areas of the Pauma Creek, Frey Creek, and Agua Tibia Creek watersheds. Reconnaissance-level surveys in Pauma Creek indicated significant sediment input into the creek, which reduced pool depths, buried potential spawning gravels, created debris jams, and led to trout mortality. Trout survived in the upper portion of the watershed and eventually could reseed lower portions of the creek. Agua Tibia Creek and Frey Creek were not surveyed after the fire, but may have experienced similar results from the fire.

Large and small scale farming operations located in the southern portions of the Northern Subbasin rely on local water sources to help supplement these operations. Reductions in water deliveries, and increased water prices have forced many farmers to scale back their operations, and possibly become more dependent on local water sources for crop production. Even prior to these cuts in water deliveries, surface flows in Northern Subbasin streams were already reduced or completely eliminated during the summer and early fall due to water extractions. The potential expansion of large gaming casinos would likely put further stress on the available water resources. Reduced surface flows in Northern Subbasin streams would minimize the movement of steelhead and available habitat. If fish passage modification projects in the SLR River and in these streams are undertaken, one must also consider the supply of water and habitat available in order to sustain the freshwater stages of the steelhead life history.

While the prospects for steelhead to succeed in the Northern Subbasin are moderate to difficult, opportunity exists for successful steelhead production in these streams. Restoration measures are needed to provide access into and out of the available spawning and rearing habitats. Maintaining adequate stream flows in these streams would be essential in facilitating fish movement and improving their overall success rate.

Table of Contents

List of Figures

List of Tables

Middle Subbasin

The Middle Subbasin is the smallest of the subbasins, occupying twenty-six square miles. The watershed area is bracketed by the Escondido Canal diversion dam on the western side (the diversion is just downstream of the downstream subbasin boundary) and the Henshaw Dam on the eastern end (Figure 2). This subbasin includes the SLR River from RM 41, just upstream of the diversion, and all of its tributaries upstream to RM 50, Henshaw Dam. Stream elevations range from 1,700 feet in the western portion of the SLR River to approximately 5,000 feet in the headwaters of tributaries draining the eastern portion of Palomar Mountain. The elevation of the river at the base of the dam is approximately 2,700 feet. In general, precipitation increases in the higher elevations of the subbasin. Average yearly rainfall at Henshaw Dam is approximately 26 inches (based on data collected from 1948 to 2006) (http://www.wrcc.dri.edu/).

The Middle Subbasin assessment area is rural with no concentrated housing communities. It is predominantly composed of native habitats consisting of mixed sagebrush/chaparral in the lower elevations and hardwood forest/woodlands in the higher elevations. Ownership is split almost evenly between private ownership, La Jolla Band of Luiseño Indians Reservation, and US Forest Service (Cleveland National Forest). The western portion of the subbasin was greatly impacted by the 2007 Poomacha Fire as over 9,000 acres (90%) of the La Jolla Indian Reservation was burned, including the loss of 55 homes and displacement of 180 tribal members (http://www.lajollaindians.com/).

Prior to the completion of Henshaw Dam, the SLR River at the dam site was a perennially flowing river. According to historic USGS stream gauge data recorded from 1912 to 1922 at the present dam site, the river maintained minimum monthly summer flows of 1.4 cfs, while minimum monthly winter and spring flows averaged above 8 cfs (see Figure 5, p.11). Former California CDFG biologist, Gary Shaw, speculated that the river below the dam site “supported a minimum trout fishery” (Jones and Stokes Associates, Inc. 1976). Moreover, trout were first documented in the Upper Subbasin, headwaters of the SLR River as early as 1862 (Cooper 1874). This written documentation was well before the introduction of hatchery raised fish, indicating the movement of steelhead trout through the Middle Subbasin. Currently, the Escondido Canal diversion dam (RM 40) prevents passage into the Middle Subbasin. Additionally, a waterfall in the SLR River canyon (RM 39.5) and multiple partial fish passage barriers would also restrict steelhead from accessing the potentially suitable spawning and rearing habitat found in the Middle Subbasin.

Fish passage into the subbasin is only one of several problematic issues concerning the possibility of steelhead/trout successfully utilizing the Middle Subbasin. Water releases from the Henshaw Dam may not coincide with the freshwater life cycle stages of steelhead trout. The amount and timing of water releases by Henshaw Dam are based on water right agreements with the La Jolla Indians and the Rincon Band of Mission Indians, precipitation totals, as well as water supply needs of the City of Escondido. Altered hydraulic processes, poor to moderate instream habitat conditions, and numerous, exotic, predatory game fish all contribute to less than ideal conditions for steelhead trout production.

Rainbow trout were once stocked in the SLR River just downstream of Lake Henshaw and within the La Jolla Indian Reservation to accommodate a popular demand for recreational sport fishing opportunities in the region. The stocking of trout has ceased in recent years due to drought-like conditions and because of concerns of stocked rainbow trout competition and possible predation of the federally listed arroyo toad, *Bufo californicus.* No progeny from these trout were observed during CDFG 2007 electro-fishing sampling or while performing the habitat inventory in the upper five miles of the SLR River.

Hydrology

The Middle Subbasin comprises the La Jolla Amago CalWater Unit (Table 1). There are four named tributaries and a few named canyons (Figure 2) containing 41.0 permanent and intermittent stream miles in this subbasin. The vast majority of these tributaries are intermittent streams. The largest of the tributaries is Lusardi Canyon. Although this is a blue-line stream on USGS 7.5 Palomar Observatory and Mesa Grande quadrangles, in actuality, it is an intermittent stream with a small section of perennial flow. This discrepancy between what is delineated on quadrangle maps to current, typical stream flow conditions also applies to the other named tributaries in the subbasin. Wigham Creek and Cedar Creek are labeled as blue-line streams, but only contain year-round surface flows in portions of the creek. Nonetheless, these streams play an important role in maintaining or increasing surface flows in the mainstem.

While the Middle Subbasin does receive more precipitation than the Coastal and Southern subbasins, portions of the SLR River mainstem go dry in the summer unless flows are supplemented by water releases from the Henshaw Dam. Water releases, controlled by Vista Irrigation District (VID), can vary year to year, but typically occur in the spring and continue through mid to late summer. The amount of the release is usually dependent on the rainfall totals and amount of water stored in Lake Henshaw. In 2007, 24 cfs was released on April 27 and continued through late July (personal communication, Don Smith). Numerous wells, located throughout the subbasin as well as surface diversions provide water for anthropogenic uses. These wells and surface diversions reduce surface flow in the tributaries as well as in the mainstem and could lower the groundwater table. Tributary drainage areas within the subbasin range from less than one square mile (unnamed stream) to as large as the 26.5 square mile drainage area of the SLR River.

Table 1. Major streams in the Middle Subbasin.

Stream	Tributary to	River Mile	Drainage Area (square miles)	Stream Order	Permanent (miles) (in Subbasin)	Intermittent (miles)
SLR River	Pacific Ocean	40	26.45	2	10.0	0.0
Cedar Creek*	SLR River	42.5	2.96	Intermittent (1)	1.5	2.4
Lusardi Canyon*	SLR River	45	4.02	Intermittent (1)	0.9	3.5
Prisoner Creek*	SLR River	46	1.51	Intermittent	0.0	2.8
Wigham Creek*	SLR River	46.8	1.50	Intermittent (1)	1.2	0.4

* A portion of these creeks retains perennial flows during normal rain years with Cedar Creek generally containing the longest stream area with perennial flows.

Figure 1. Middle Subbasin from Henshaw Dam looking west.

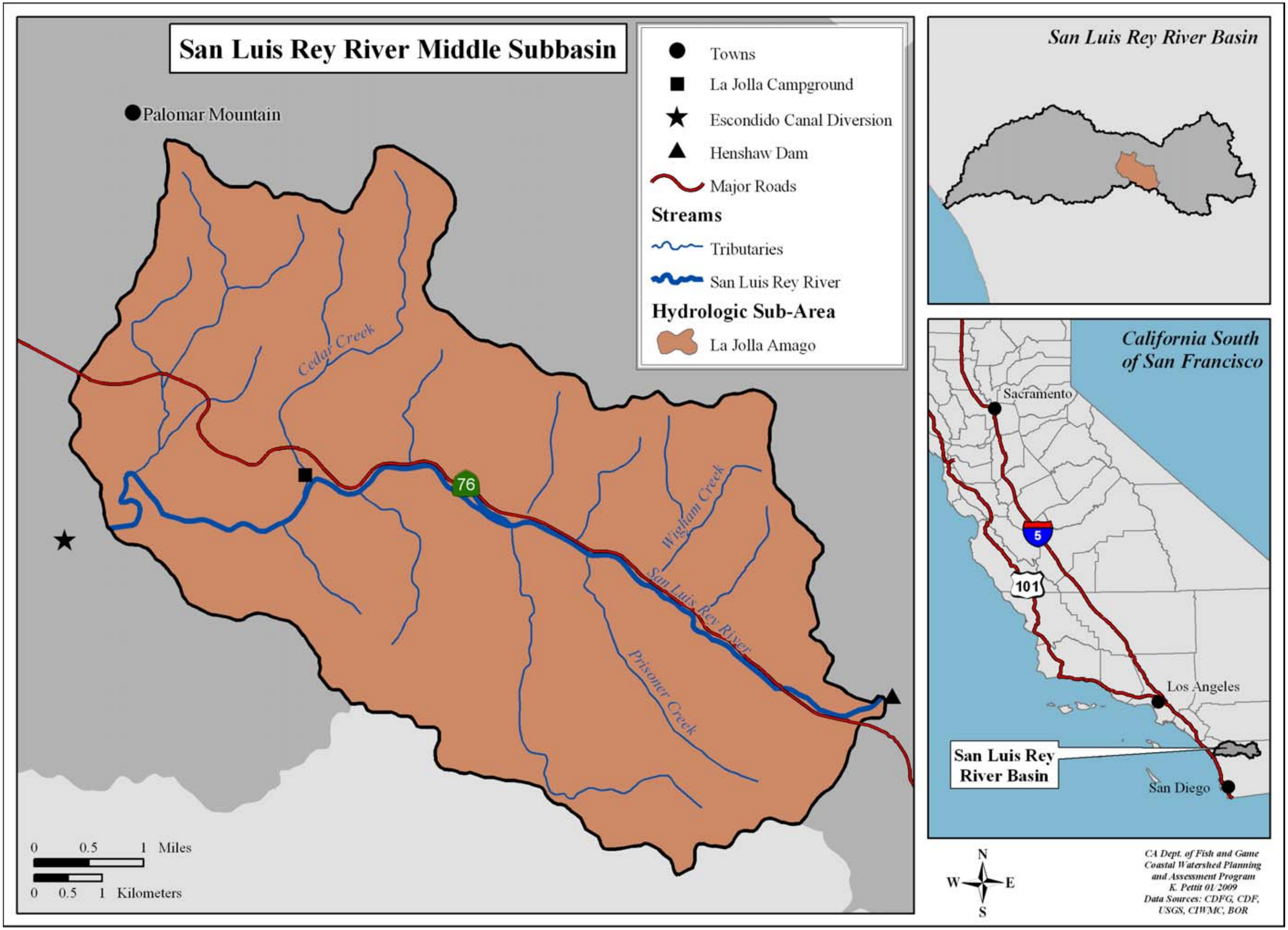


Figure 2. Middle Subbasin locator map and CalWater Unit.

Geology

During the Mesozoic Era the Farallon (oceanic) plate was subducting under the North American (continental) Plate. As the Farallon plate was plunged into the upper mantle it heated to the point where it began to melt. Some of this melt was lighter than the surrounding material and began to migrate upwards through the upper mantle and into the continental crust above it. As this magma reached the upper portion of the crust it intruded into sediments that had washed off of North America and it began to cool and crystallize. The heat of the magma, the thickness and pressure of the sediments, and compression generated by plate tectonics caused metamorphism forming metasedimentary rocks surrounding the magma that was slowly crystallizing into granite. The crystallizing mass of proto-granite was so vast that it underlaid most of what is now southern California. Massive intrusive igneous bodies of this size are classified as batholiths (bathos = depth, lithos = rock). This particular batholith is known as the Peninsular Range Batholith. Uplift of this region then brought the sedimentary rocks and portions of the buried batholith above sea level. Erosion occurring over millions of years gradually stripped most of the sedimentary rocks off of the batholith exposing the granitic mountains that we see today in this region. The Middle Subbasin is almost completely composed by these granitic rock types and in places has preserved remnants of the sedimentary rocks into which they intrude.

Weathering and erosion of these rock types has and is producing alluvium which is transported downstream or temporally stored in river terrace deposits and floodplains within this subbasin.

Compositional Overview

Rock Types

Mesozoic Granitic

Granitic rocks make up the majority of this subbasin. They occupy approximately 90% of its surface area. They are predominantly Cretaceous (154.5 million through 65.5 million years ago) in age. These rocks are very hard and resistant to erosion, however, they do tend to exfoliate to some extent in exposed surfaces and preferentially weather at structural joints. Over long periods of time granitic rocks tend to weather and become "soft" reducing their density, increasing their porosity, and making them much less resistant to erosion producing "decomposed granite." In more advanced forms, the minerals within the granite disaggregate and form "Arkosic Sand," which is highly susceptible to erosion, sliding, and fluvial transport.

Mesozoic Sedimentary

Mesozoic sedimentary rocks make up around 10% of the subbasin and consist mostly of siltstone, sandstone, and conglomerate and were deposited some 65.5 to 225 million years ago. The original deposition of the sediments that make up these rock types occurred in environments ranging from marine to terrestrial. Some of these rock types have subsequently undergone metamorphism especially in areas in contact with granitic rock types. These sedimentary rock types are generally more susceptible to erosion than granitic rock types.

Quaternary Alluvium

Alluvium covers less than 1% of the basin. It consists of unconsolidated sediments that range from clay to boulders. Alluvium is transported and deposited by the streams and makes up most of the bed and banks of the streams. Units of alluvium delineated by the geology map (Table 2) include sediment currently being acted upon by the streams and bank and flood-plain deposits occasionally acted upon by the streams. If the alluvium within the stream channel is of sufficient depth it can readily transport water via the subsurface pore-spaces allowing stretches of the stream to "run dry."

Table 2. Rock types in the Middle Subbasin.

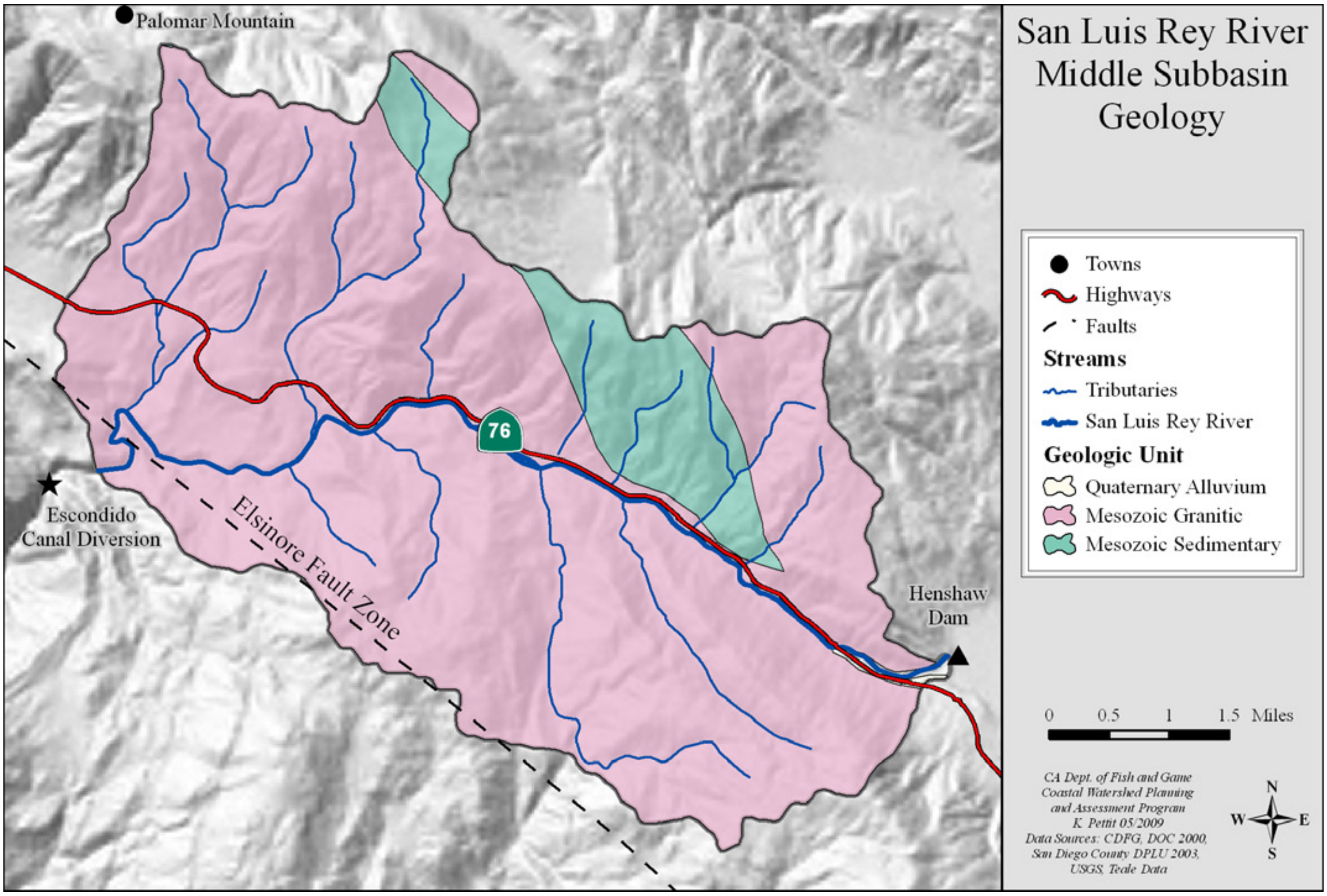
Lithologic Unit	% Basin
Mesozoic Granitic	89.94
Mesozoic Sedimentary	9.61
Quaternary Alluvium	.07

Percent area of basin represents a rough approximation based on GIS mapping.

Soils

The underlying bedrock is generally responsible for a soil's texture and erodability characteristics. The sediment contribution from soils found in the Middle Subbasin are dependent largely on slope, soil sediment size, consolidation, cohesion, compaction, the type and amount of vegetation cover, land use, and amount, intensity, and duration of local rainfall.

The majority of bedrock throughout the subbasin is composed of various granitic rock types producing associated soil types that are generally very well drained and is somewhat prone to erosion and transport by fluvial processes as well as wind. Soils with high sand and silt content are typically more susceptible to erosion than soils with high clay content which exhibit a greater degree of cohesion.



CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 05/2009
Data Sources: CDFG, DOC 2000,
San Diego County DPLU 2003,
USGS, Teale Data

Figure 3. Geology of the Middle Subbasin.

Table 3. Soil types in the Middle Subbasin.

Soil Type	% of Upper Subbasin	Parent material
Hotaw-Crouch-Boomer (s1015)	63.23	weathered granite/metavolcanic
Tollhouse-Rock outcrop-La Posta	36.36	weathered granite/igneous
Tujunga-Salinas-Elder (s1001)	.41	weathered granite/sandstone-shale

Percent area of basin represents a rough approximation based on GIS mapping

Landslides

Like the other SLR River subbasins, the Middle Subbasin is partially mantled with unstable soils. Alluvial material is generally confined to the mainstem while the hillsides are often composed of granite, weathered granite, and sedimentary rock. Except for fresh granite, these rock types are susceptible to surface erosion, headward erosion, gullying, stream bank raveling, and landsliding. This area has undergone tectonic uplift leaving steep canyon walls above the streams. As tectonic forces push the land up gravity tries to pull it down and the result is usually landslides and rock falls. Landsliding is further exacerbated by seasonal rain storms. As the hillsides become saturated, pore pressure between grains becomes greater making them unstable and more prone to landsliding. These conditions can be exacerbated by moderate to extreme wildfires.

Earthquakes and Faults

The whole of the San Luis Rey River Basin is tectonically and seismically active, and the possibility of seismic activity occurring in this subbasin is similar to the entire southern California region. Due to active faults within this subbasin, such as the Elsinore Fault, as well as ones in close proximity, the subbasin has the potential for strong seismic movement. The Elsinore Fault Zone (currently established Alquist-Priolo Earthquake Fault Zone) runs northwest and cuts through the southwestern portion of this subbasin. The Elsinore Fault is one of the largest right-lateral strike-slip faults in southern California. It is related to translational plate boundary tectonics between the Pacific and North American plates. Although this fault has been one of the quietest in historic times, it is capable of producing earthquakes in the range of magnitude (M) 6.5 – 7.5. It has an average recurrence interval of approximately 250 years (http://www.data.scec.org/fault_index/elsfault.html). The southeastern extension of the Elsinore Fault Zone, the Laguna Salada Fault, located south of Interstate 8, ruptured in 1892 in a M 7 quake, but the main trace of the Elsinore Fault Zone has only seen one historical event greater than M 5.2. This was the area's earthquake of 1910, a M 6 shock near Temescal Valley, which produced no known surface rupture and did little damage (http://www.data.scec.org/fault_index/elsfault.html). Strong ground shaking generated by earthquakes can trigger rock falls and landslides that deliver large amounts of sediment to the streams. The 1994, Northridge earthquake (M 6.7) triggered an excess of 11,000 landslides in a 6,200 square mile area (USGS) in similar terrain.

Other than being able to trigger landslides, strike-slip faults can weaken bedrock, offset streams, and truncate and oversteepen certain topographic landforms thus enhancing erosion and transport of sediment to the streams. Due to the presence of these faults and potential for seismic activity, the California Division of Dam Safety in 1971 declared the Henshaw facility (dam) prone to failure and VID was required to permanently reduce the lake's capacity from 200,000 acre-feet to 50,000 acre-feet (Babbitt 1993).

The occurrence and movement of groundwater in the subbasin is also significantly tied to the occurrence of the Elsinore Fault Zone and adjacent joint systems. Groundwater aquifers on the La Jolla Indian Reservation are primarily found in fractured bedrock (Tierra Environmental Services 2006).

Wildfires

Wildfire can and frequently will increase the erodability of a region. As a fire moves through an area it is capable of burning off the duff layer that effectively armors the soil. It can also intensively dry the soil as well as destroy organic matter that helps to bind the soil together, leaving behind a loose, "hydrophobic" soil in its wake. During subsequent rain storms the soil's capacity to absorb water is greatly reduced and surface flows are proportionally increased. Wildfires can destroy woody debris strewn on hill slopes allowing for less resistance to the erosive power of surface runoff transporting increased amounts of sediment downstream. The propensity for debris flows is also increased following a wildfire on steep slopes which can block drainageways, destroy structures, strip vegetation, and deliver great amounts of sediment to the streams (Cannon et. al. 2004). Relatively hot fires may cause thermal expansion of individual minerals within the rock causing fracturing of its surface layers leading to enhanced erosion. Post-fire erosion potential has been estimated as moderate to high (Basin Profile, Table 5) for most of this subbasin (USGS). See Basin Profile, Fire History and Management (pp. 35-39) for a more detailed discussion.

The 2007 Poomacha Fire, which began in late October and continued until early November burned a large portion of the western Middle Subbasin, including 92% of the La Jolla Indian Reservation (http://www.wildfirelessons.net/Additional.aspx?Page=135) (Basin Profile, Figure 13). Within this subbasin the fire burned at a moderate to high level on the soil burn severity scale (State of California 2007); thus, when a major storm event hit the area in late November/early December of 2007, releasing large amounts of precipitation, many of these erosion potentials became a reality. Debris flows occurred in some of the tributaries to the SLR River, particularly those that flowed out of the Palomar Mountain region, which received the greatest rainfall totals and contain the watershed's highest post-fire erosion potential. See Basin Profile, Fire History and Management (pp.35-39) for further information concerning the Poomacha Fire.

Fluvial Geomorphology

The Middle Subbasin consists of a portion of the SLR River and its contributing tributaries between Henshaw Dam and the Escondido Canal diversion dam. On average this subbasin should act as both a sediment transport reach, delivering sediments to the lower basins, and a depositional reach, storing sediments in its floodplain. Because of the timing and amount of water released through the Henshaw Dam, this is not always the case. The slope of the mainstem was calculated to be 5% or less based on GIS mapping (Basin Profile, Figure 14). Sediment erodes from the steeper hillsides and is brought by tributaries to the mainstem.

The 2007 CDFG stream habitat inventories in the Middle Subbasin were limited to the upper half of the SLR River (above the La Jolla Indian Reservation). This survey area included approximately five miles of the river, which were divided into five reaches consisting of four 'B' and one 'C' Rosgen channel types (Table 4). Type B channel types are defined as moderately entrenched, moderate gradient, riffle dominated channels with infrequently spaced pools. The banks are usually stable (canyon walls) as well as the plan and profile. They have a moderate relief with moderate sinuosities and stable stream banks (Flosi, et al. 1998). Type C channels are characterized as being low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains. This reach was the final reach leading up to Henshaw Dam and consisted of a predominantly dry channel.

Based on observed fish passage barriers and/or stream habitat conditions at the time of the survey, it seemed unlikely that other streams within the subbasin would be utilized by steelhead/trout; therefore, full habitat inventory protocols were not performed.

Table 4. Channel types in surveyed stream, Middle Subbasin.

Stream	Reach	Length (feet)	Channel Type
SLR River	1	14,429	B3
SLR River	2	764	B4
SLR River	3	1,370	B2
SLR River	4	6,079	B4
SLR River	5	3,202	C5

Reaches listed from west to east

Vegetation

Overall, the Middle Subbasin has remained relatively undisturbed as a majority of the land is still considered native habitat. The predominant vegetation cover type as described by the USFS CALVEG data is mixed sagebrush/chaparral, covering 53.97% of the Middle Subbasin (Figure 4 & Table 5). This cover type is primarily composed of the lower montane mixed chaparral vegetation type. Hardwood forest/woodland was the second most abundant cover type at 27.42%. These forest/woodlands consisted primarily of a variety of oak species, such as coast live oaks, canyon live oak, black oaks, and Engelmann oaks and were generally located in the mid to upper elevations or along drainages within the subbasin. Although, numerous oaks are also found on lower elevations within the La Jolla Indian Reservation. The Middle Subbasin contains the greatest percentage of hardwood forest/woodland (based on each subbasin's acre totals) out of the five subbasins. The remaining cover types composed a significantly smaller portion of the subbasin. Mixed conifer/woodland and herbaceous cover types each compose approximately 6% of the land in the subbasin. The herbaceous cover type is almost entirely made up of annual grass/forb alliance vegetation type. A portion of these acres are utilized for livestock grazing.

There is no significant urban/residential area in the Middle Subbasin. The majority of the residents are either La Jolla Indian tribal members or private residents on larger plots of land. With almost two-thirds of the Middle Subbasin being under ownership of Native Americans or the USFS, there is minimum potential of rapid expansion of residential or commercial development. There is also little agriculture, less than 1% of the total land in the subbasin, compared to the other subbasins. When considering land that has been designated as "herbaceous," this figure may rise slightly to account for acres developed for livestock grazing.

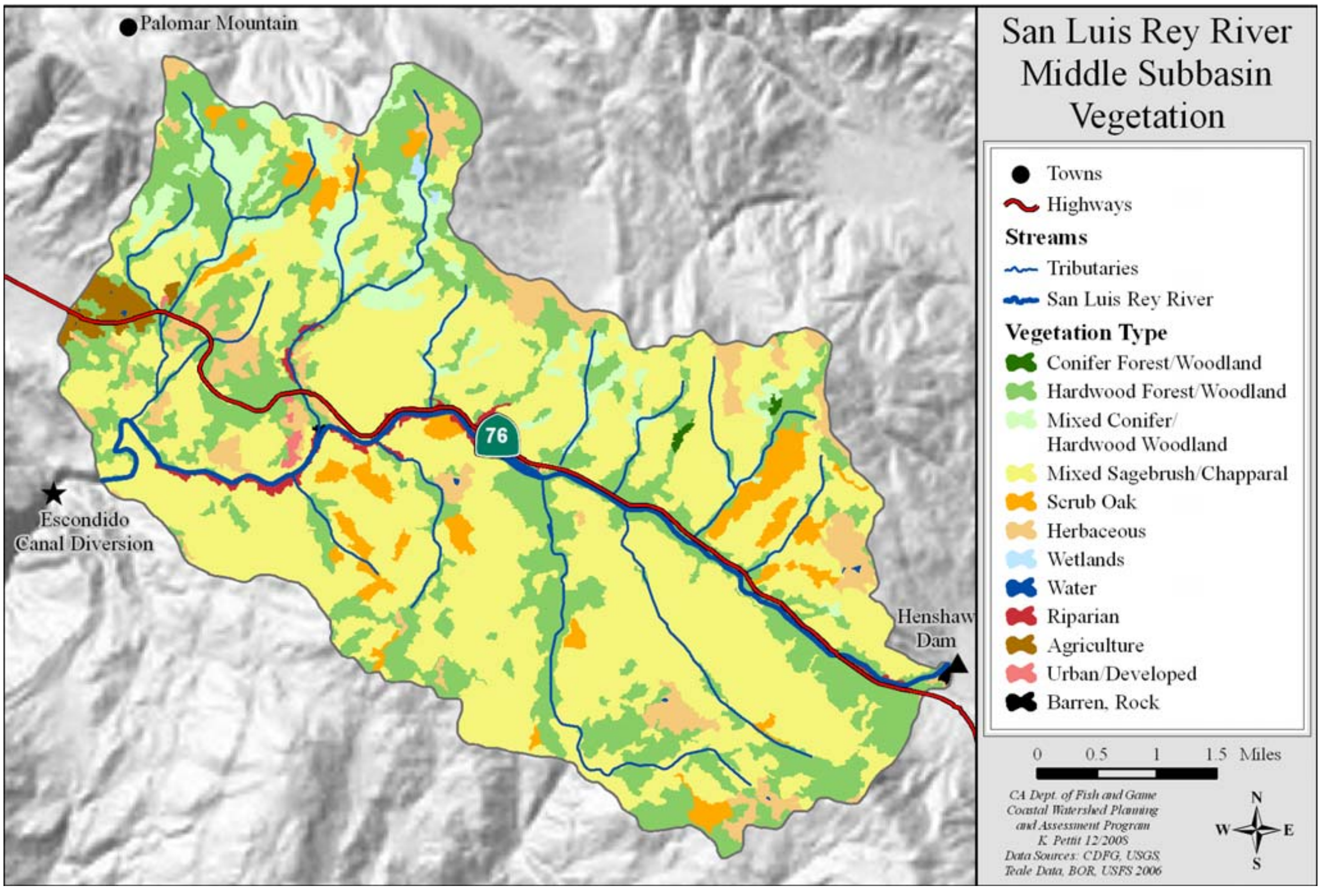


Figure 4. Vegetation of the Middle Subbasin.

Table 5. Vegetation of the Middle Subbasin.

Vegetative Cover Type	Percent of Basin	Primary Vegetation Type	Percent of Cover Type
Mixed Sagebrush/Chaparral	53.97	Basin Sagebrush	0.2
		Buckwheat	0
		California Sagebrush	4.1
		Ceanothus/Mixed Chaparral	0
		Chamise	11.8
		Lower Montane Mixed Chaparral	81.3
		Manzanita Chaparral	0
		Upper Montane Mixed Chaparral	2.4
		Southern Mixed Chaparral	0
		Other	0.1
Hardwood Forest/Woodland	27.42	Black Oak	15.5
		California Sycamore	0
		Canyon Live Oak	14.8
		Coast Live Oak	58.2
		Engelmann Oak	11.5
		Eucalyptus	0
		Interior Mixed Hardwood	0
		Non-native/Ornamental Hardwood	0
Mixed Conifer/Woodland	5.86	Bigcone Douglas - Fir	54.4
		Coulter Pine	25.4
		Mixed Conifer - Pine	0
		White Fir	20.2
		Nurseries	0
Herbaceous	5.82	Annual Grasses/Forb Alliance	97.3
		Non-Native/Ornamental Grass	0
		Perennial Grassses and Forbs	2.7
Scrub Oak	4.22	Scrub Oak	100
Riparian	1.27	Baccharis (Riparian)	0
		Fremont Cottonwood	0
		Riparian Mixed Hardwood	100
		Riparian Mixed Shrub	0
		Willow (Shrub)	0
Agriculture	0.91	Agriculture	100
		Orchard Agriculture	0
		Pastures and Crop Agriculture	0
Urban/Developed	0.16	Urban/Developed	100
Conifer Forest/Woodland	0.12	Bigcone Douglas-Fir	60.5
		Coulter Pine	39.5
		Mix Conifer – Fir	0
Wetlands	0.10	Wet Meadows	100

These statistics exclude the classification of water. Data from CALVEG & USFS.

Non-Native Plants

Unlike the Coastal and Southern subbasins, non-native, invasive plants are not problematic in the Middle Subbasin. Invasive plants have been found in relatively small numbers in a few locations and do not pose the threat of overtaking large areas of land/native habitats as is the case of the Coastal and Southern subbasins. Periwinkle (*Vinca major*), was the only invasive plant observed in significant numbers during the 2007 CDFG stream habitat survey along the SLR River in the Middle Subbasin.

Land and Resource Use

Historic Land Use

Prior to the settlement of Europeans, the Middle Subbasin was inhabited by the local Indian people, the Shoshoneans. These inhabitants of northern San Diego County were called Luiseños by Franciscan friars who named the San Luis Rey River.

The Luiseño people lived in small villages, mostly consisting of family members and relatives, near fresh water sources. While acorns from the numerous oaks in the area provided a staple for their diet, there was a variety of other food sources as well. Nearly all natural resources of the region were exploited by the Luiseño in a highly developed seasonal mobility system (Tierra Environmental Services 2006). Ample water supplies and favorable thermal zones found in the subbasin, coupled with a heavy growth of forest cover along the streams, provided both vegetal and animal food supplies. The Luiseño gathered seeds, roots, wild berries, wild grapes, and hunted deer, rabbits, wood rats, and game birds. At least two village sites were located within the subbasin; however, much of the eastern portion of the subbasin was unpopulated as village sites were more common along the western edge and more so in the Pauma Valley and Rincon area (True 1954).

The Spaniards were the first Europeans to arrive in the Basin in late 1760s. They entered in the Coastal Subbasin and began moving and settling throughout the basin. Most of these Spaniards survived through farming and hunting a variety of game. Prior to California becoming a state, a few early settlers were given grazing rights on large lots of land through enormous land grants, called ranchos, whose property rights were retained by the Mexican government. A few of these ranchos were located in the Middle Subbasin. Eventually, the ranchos were phased out by the late 1830s.

Homesteaders continued to slowly settle into the area and eventually the Luiseños Indians were forced off of their land, or portions of their land, and onto reservations. The La Jolla Indian Reservation was established in 1875, by executive order from President Ulysses S. Grant. This reservation, mostly in the western half of the subbasin, consists of 9,998 acres of federal land, with the SLR River cutting through its middle.

With the creation of the La Jolla Indian Reservation and land being designated as Cleveland National Forest, approximately two-thirds of the subbasin was set aside. Unlike other subbasins where mining, agriculture, and urbanization played a role in land use and development, the Middle Subbasin remained relatively undisturbed, containing large areas of native habitats.

Current Land Use

Current land use in the Middle Subbasin is limited by ownership designation and the relatively steep terrain. While land use by humans has less of an impact on the function of the natural systems when compared to other subbasins, nonetheless, it still plays a role in shaping the landscape and the natural resources contained in the subbasin.

Agriculture

Differing from the rest of the basin, agriculture plays a small role in shaping the landscape of the Middle Subbasin. With much of the subbasin designated as Cleveland National Forest or Indian Tribal Lands there is less area available for farming operations. The steep, rugged, relatively dry terrain also limits the potential for crop production. Agriculture, including herbaceous grasslands used in livestock production, accounts for only 5% of the land use in the Middle Subbasin.

Agriculture still plays a role by utilizing surface flows in tributaries to the SLR River and groundwater supplies. These agricultural water extractions place stress on the water demands of riparian plant species and could lessen the surface flows of streams in the subbasin, impacting the aquatic community.

Tribal Indian Lands

Almost a third of the Middle Subbasin is held in Indian Tribal Lands, primarily in the La Jolla Band of Luiseño Indians Reservation. This reservation includes 9,998 acres of federal land and around 702 enrolled tribal members (http://www.lajollaindians.com/). Most of the tribal lands are sparsely populated with single family dwellings. The forced compliance with the reservation system disrupted Luiseño social organization and settlement patterns, yet many aspects of the original Luiseño culture still persist today. While maintaining certain rituals and religious practices, traditional games, songs, and dances continue as well as the use of foods such as acorns, yucca, and wild game (Tierra Environmental Services 2006).

The La Jolla Indians had plans to develop a casino on their reservation, just off Highway 76, but have recently broken ties with the Nevada Gold & Casinos Inc. of Houston to develop and manage a $25 to $30 million gaming resort. The development of this casino will most likely have an impact on local water resources as demand for water consumption will only increase. In addition to a casino, future development plans include a golf course. While there is uncertainty when and if this golf course will be developed, it is important to note the course would remove native habitats, displace wildlife, require large amounts of water, and contribute to water quality problems with the large amount of pesticide and fertilizers that go into the management of these large turf areas.

Urbanization

Most of the Middle Subbasin remains rural in nature with low-density housing and a few small-scale agricultural operations. No incorporated communities exist within the subbasin. The subbasin is a mix of La Jolla tribal members and private landowners, many of which have been long-time residents to the area.

Recreational

Almost one-third of the Middle Subbasin is held in US Forest Service lands that have recreational opportunities. Hunting, hiking, fishing, picnicking and other activities are available on these lands. The 2007 Poomacha Fire mostly avoided the Cleveland National Forest, and recreational areas in the forest were left relatively undisturbed.

Recreational opportunities also exist in the La Jolla Indian Reservation along the SLR River. The tribe has a campground adjacent to the river. This campground promotes fishing in the SLR River for warm-water game fish, such as bass and bluegill, and summer float tube trips are available during sufficient flow releases. Without a gaming casino, the campground and river setting provide important sources of income for the La Jolla Indian Tribe.

Fish Habitat Relationship

Fishery Resources

Historically, steelhead have not been documented in the SLR River within the Middle Subbasin. However, trout were documented in the Upper Subbasin, headwaters of the SLR River as early as 1862 (Cooper 1874). This observation of trout upstream, prior to any introduction of hatchery raised fish, would seem to signify that steelhead could have accessed the Middle Subbasin and utilized its habitat for spawning and rearing activities. Anecdotal and documented accounts of steelhead in the SLR River indicate a productive fishery in the lower to middle mainstem (below the Middle Subbasin) and in tributaries such as Pala and Pauma creeks.

Even though there has been a lack of focused surveys in the Middle Subbasin tributaries to record the potential presence of steelhead/trout, it seems unlikely that ocean run fish would have utilized far reaching habitats in these streams. These fish would have a difficult time entering and exiting some of these tributaries due to insufficient stream flows and natural and anthropogenic related fish passage barriers.

The Department initiated a yearly rainbow trout stocking program in the mid-1940s in the upper SLR River near the water release of Henshaw Dam and, periodically, downstream in the La Jolla Indian Reservation. This stocking program was intended to accommodate the strong demand for a recreational sport fishery for local San Diego County fishermen. The trout plants ranged from a high of 36,080 in 1955 and 39,040 in 1970 to a low of 845 trout in 2003 (See Basin Profile, "Stocking"); the last year the river was stocked. Although the river was somewhat recently stocked, there are no known populations of resident rainbow trout in the SLR River or its tributaries within the Middle Subbasin. CDFG and PSMFC fisheries biologists conducted electro-fishing surveys in the SLR River in the Cleveland National Forest during the early fall of 2007. This survey did not yield any trout or any other native fish species. Additionally, no trout were observed during the spring 2007 CDFG habitat inventory surveys.

Warm-water game fish, which are most likely carried downstream from Lake Henshaw, now populate the river. Largemouth bass, bluegill, green sunfish, brown and black bullhead, channel catfish, common carp, and western mosquito fish were either captured or observed during electro-fishing and habitat inventory surveys. Some pools contained large numbers (>40) of these fish. The frequency and occurrence of the fish was generally greater near the dam, on US Forest Service and VID property. Largemouth bass and bluegill were observed in the La Jolla Campground, and there was evidence of recent fishing activities.

Habitat Overview

Historic Conditions

A report by Jones and Stokes (1976) for the U.S. Fish and Wildlife determined that prior to the completion of Henshaw Dam the upper SLR River maintained perennial flows. This report, which assessed the effects of altered streamflows on fish and wildlife in California, based its findings on data recorded at a formerly operating USGS stream gauge located at the present dam site. This gauge recorded stream flow data from October 1912 to September 1922. During this period, minimum monthly summer flows averaged above 1.4 cfs, while minimum monthly winter and spring flows averaged above 8 cfs (Figure 5). Mean monthly flows were much greater and reached as high as 254 cfs during the winter months. The report briefly describes the instream channel conditions prior to the completion of the Henshaw Dam and the effects the dam had on the channel morphology and the associated riparian vegetation in the Middle Subbasin:

> *Historically the fluctuation of instream flows maintained a well defined stream channel . . . . After the dam was completed and impoundment of all flood flows the riparian vegetation began encroaching into the stream channel. This encroachment along with the accumulation of sedimentation has resulted in a major reduction of fishery habitat. At the present time the river below Henshaw Dam supports very few fish and may not support any at all.*

Similar to the other subbasins, there has been a limited amount of coordinated stream surveys performed in the Middle Subbasin. The majority of the stream surveys performed in the Middle Subbasin only described general weather and habitat conditions at the time of trout releases into the SLR River; therefore, aside from the Jones and Stokes report, historic stream habitat conditions are relatively unknown.

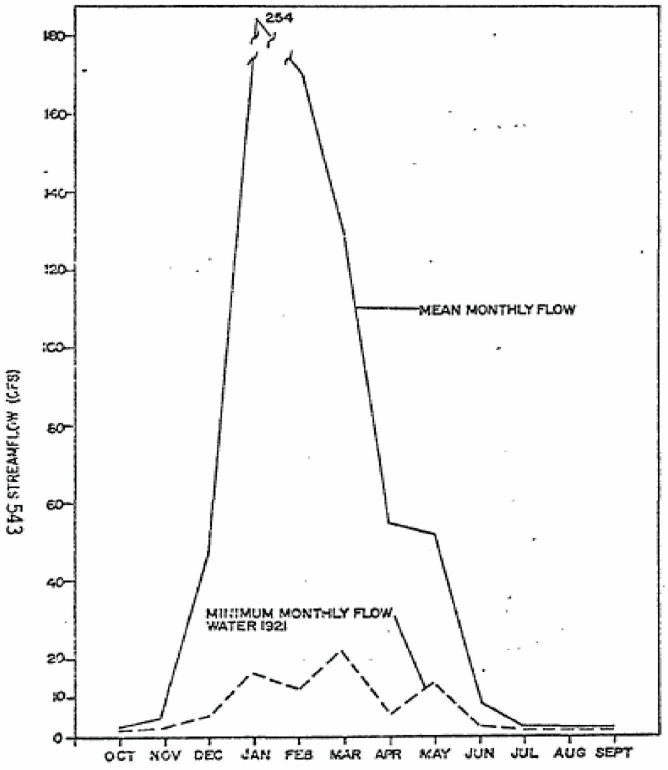


Figure 5. SLR River streamflow conditions from October 1912 to September 1922 at present site of Henshaw Dam (Jones and Stokes 1976).

Current Conditions

Stream habitat inventories conducted by CDFG/PSMFC fishery crews in the Middle Subbasin were limited to the SLR River from Henshaw Dam downstream to the La Jolla Indian Reservation (Figure 6). This approximately 5-mile stretch of river consisted of property within the Cleveland National Forest, VID, and several large private landowners. The survey was divided into 5 reaches of various lengths (Table 4). At the time of the survey, mid to late April 2007, flows were approximately 1cfs, except for reach 5 (uppermost reach) which contained sections of dry stream channel. All of the surveyed area began above the current accessible habitat for steelhead, but the survey provided an important snapshot of the current habitat conditions. Aside from its potential to support fisheries resources, the four-mile stretch of riparian habitat along the SLR River below Henshaw Dam supports the largest southwestern willow flycatcher (federally listed) population in southern California (Stephenson and Calcarone 1999). In general, the surveyed area was not affected by the 2007 Poomacha Fire; however, downstream in the La Jolla Indian Reservation, large portions of the reservation and surrounding land were consumed by the fire. Within the burned area, the riparian along the SLR River burned at a moderate intensity with patches of high severity (State of California 2007). The effects of the fire contributed a significant amount of debris and sediment into some of the streams in the western portion of the subbasin.

During the mainstem survey three tributaries, Wigham Creek, Prisoner Creek, and an unnamed left bank tributary just downstream of Prisoner Creek contained flowing water and were examined for general habitat suitability. Based on observed fish passage barriers and/or stream habitat conditions at the time of the survey, it seemed unlikely that these streams would be utilized by steelhead; therefore, full habitat inventory protocols were not performed. Wigham Creek was inaccessible beyond 0.1 stream miles due to a raised culvert below Highway 76; Prisoner Creek contained a large natural bedrock chute that appeared impassible, also 0.1 miles upstream of its confluence with the SLR River. Other tributaries in the subbasin were not surveyed due to the absence of surface flows or denied landowner access permission.

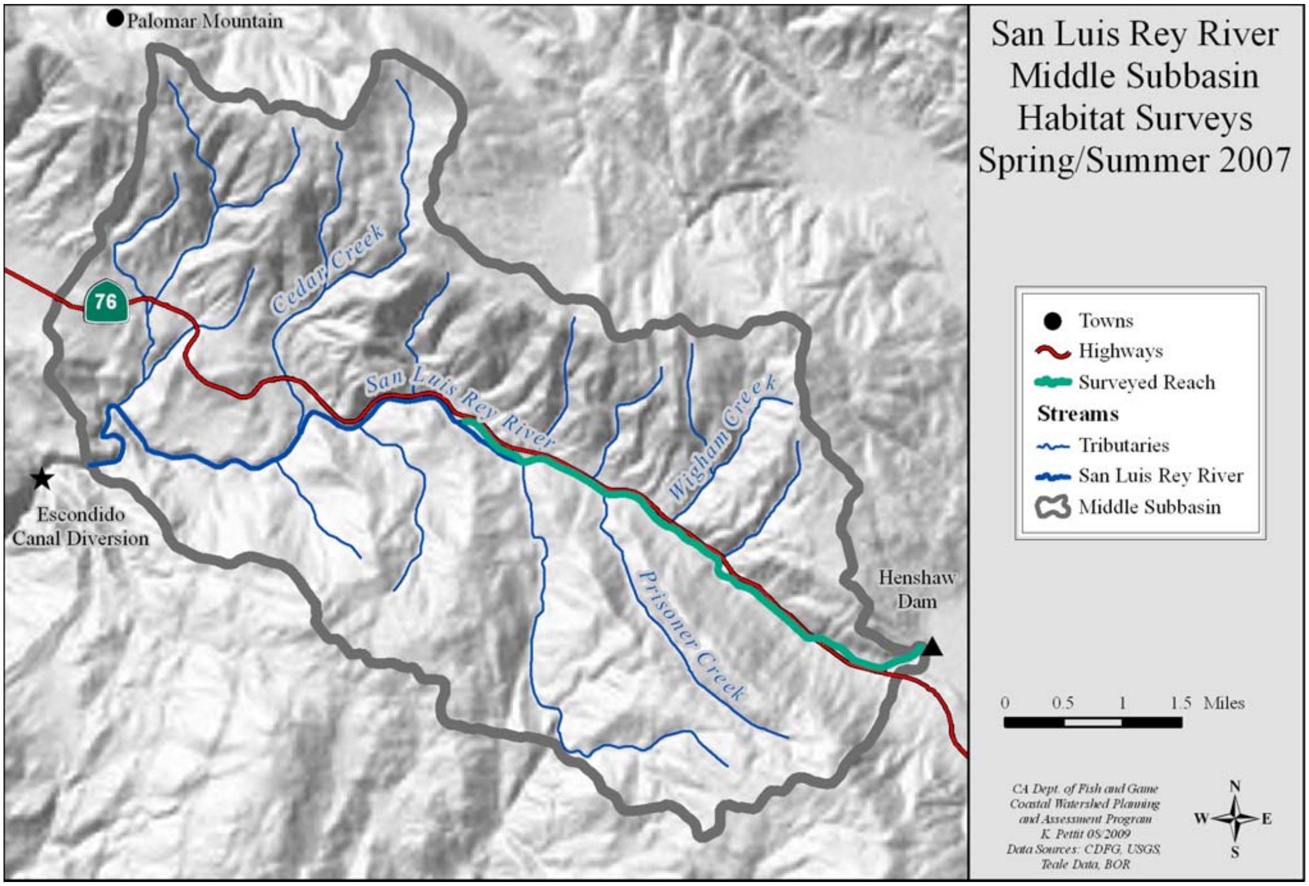
Stream habitat inventory methods were conducted on the SLR River according to methods determined in the *California Salmonid Stream Habitat Restoration Manual* (Flosi, et al. 1998). Analysis of the SLR River includes the following:

- Canopy Density;
- Habitat Type Categories;
- Pool Characteristics;
- Pools by maximum depth;
- Pool shelter;
- Cobble Embeddedness.

Table 6. Middle Subbasin streams surveyed by CDFG in 2007.

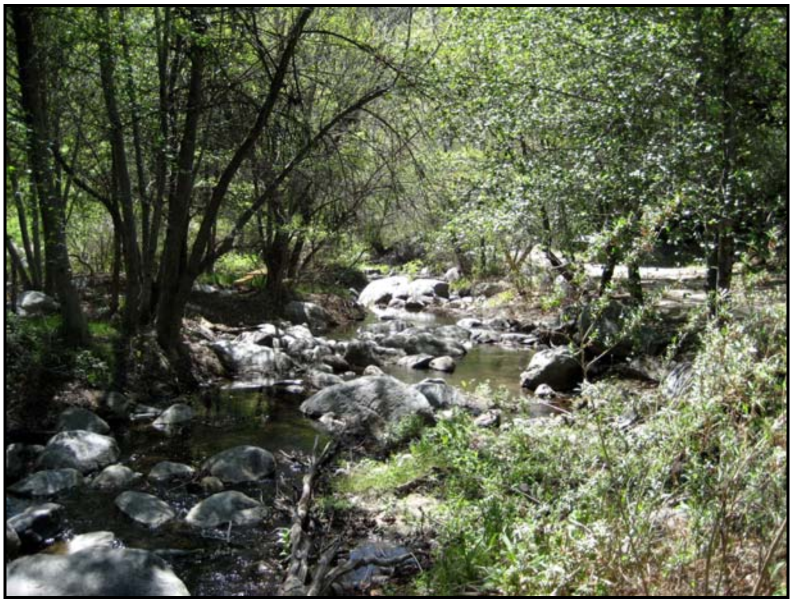
Stream	Year o f Survey	Survey Length (Miles)	Percent of Permanent Stream Surveyed within Subbasin	Number of Reaches
San Luis Rey River	2007	4.89	50	5
Wigham Creek*	2007	0.2	0	1
Prisoner Creek*	2007	0.2	0	1
Unnamed left bank tributary*	2007	0.2	0	1

* Full habitat inventories were not performed on these tributaries



CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 05/2009
Data Sources: CDFG, USGS,
Teale Data, BOR

Figure 6. SLR River Middle Subbasin Habitat Surveys Spring/Summer 2007.



View of typical habitat in the SLR River within the Middle Subbasin. Photo taken spring of 2007.

Canopy Density

Significance: Streamside canopy density is a measure of the percentage of wetted stream that is shaded by riparian tree canopy. Stream water temperature can be an important limiting factor of salmonids, and tree canopy provides shade to reduce direct sun light from increasing water temperatures. Moreover, near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which in turn, influence stream water temperature. Riparian vegetation also bind the stream bank soil and provide resistance to the erosive forces of water, functions as the base of the food chain for biological stream life, helps store water along the stream corridor during the raining season for slow release to the stream in drier seasons, and creates desired complex instream habitat by providing woody debris to streams (Riley 1998). Generally, canopy density less than 50% by survey length is below target values and greater than 80% fully meets target values.

Findings: Canopy density measurements in the SLR River obtained suitable values, greater than 70% canopy, on all but the final reach, reach 5 (Figure 7 & Figure 8). The overall Middle Subbasin EMDS canopy density condition truth score is suitable. There is a downward trend in canopy density going from high canopy density in the western reaches to a low canopy density on the eastern most reach, reach 5. The entire canopy cover was composed of deciduous trees, mostly of alders, willows, and oaks.

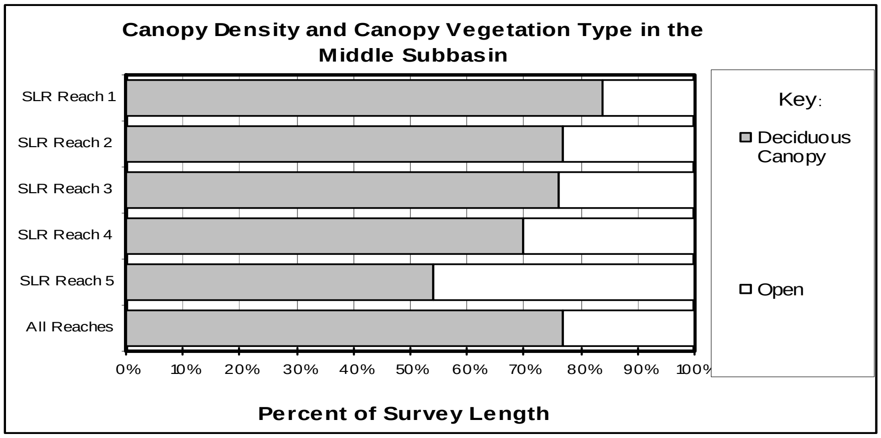


Figure 7. The relative percentage of deciduous canopy vs. open canopy on the surveyed reaches of the SLR River.

Averages are weighted by unit length to give the most accurate representation of the percent of a stream under each type of canopy. SLR River reaches are listed from west to east within the watershed.

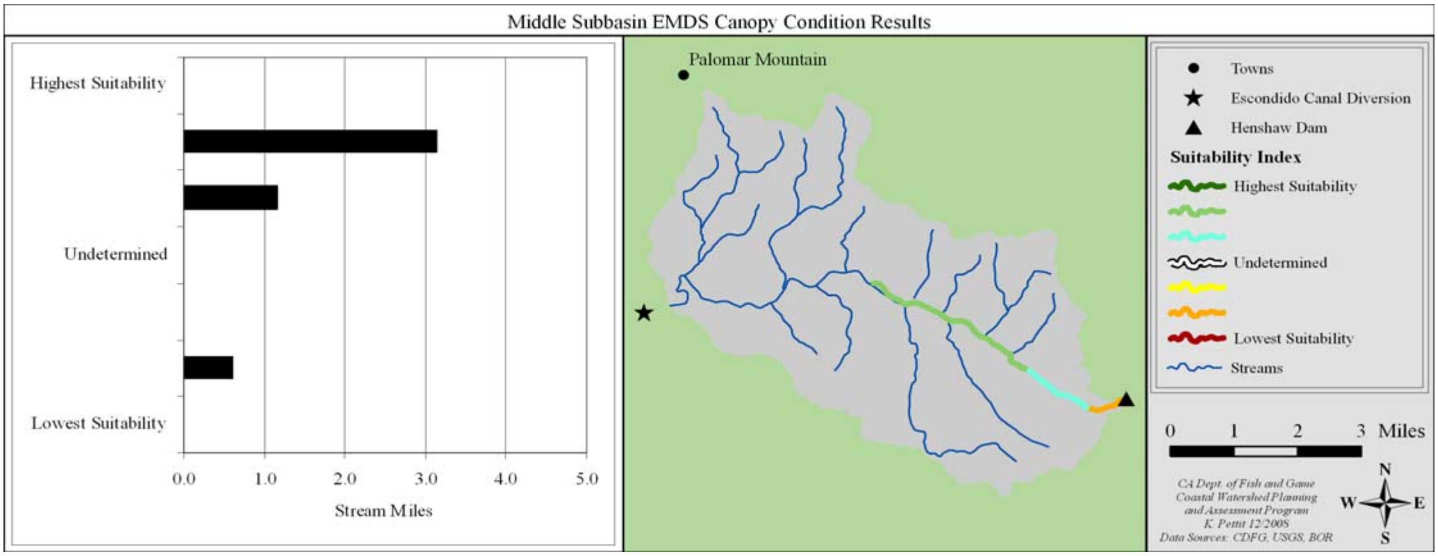


Figure 8. EMDS canopy results for the SLR River, Middle Subbasin by surveyed stream miles.

Habitat Categories

Significance: Productive anadromous streams are composed of a balance of pool, riffle, and run habitats and each plays an important role in salmonid habitat. Pools are not only the preferred habitat for yearling and older juvenile steelhead, but also provide important resting areas during adult winter/spring migration. Looking cumulatively at pool, riffle, and run relationships helps to characterize the status of these habitat types and also provides a measure of stream habitat diversity and suitability for fish. A pool: riffle ratio of approximately 1:1 is suggested as a desirable condition for most wadeable, anadromous, fish bearing streams, but it is not applicable for evaluating salmonid suitability of all stream reaches and channel types (Rosgen 1996). However, pool:riffle:run relationships showing an over abundance of riffles or runs may indicate aggraded channel conditions or lack of scour objects needed for pool formation. Additionally, pool frequency by percent length is preferable to pool frequency by occurrence because the latter may give a false impression of health if there are numerous, shallow, short pools as a result of aggradation (NMFS and Kier 2008).

Findings: Overall, pools occupied only 23% of the total habitat inventory (Table 7), which is much lower than the targeted value and is an indication of poor stream habitat diversity. Reach 3 was the only reach that had a similar percent of total pools and percent of pools for the total survey length, indicating that pool size was appropriate for the channel width. The remaining reaches had a disproportional percent of pool occurrence when compared to the total percent of pool length for the reach. This would tend to indicate that pools in this reach are short and most likely shallow, lack complex instream habitat and may not provide adequate protection from predators, such as the warm-water gamefish present throughout the surveyed area. Only the relatively short reaches 2 and 3 contained the desired amount of pool habitat (approximately 42%) based on stream length.

Table 7. SLR River–percent occurrence and percent by length of pool, run, riffle, and dry habitats.

Stream	Stream Order	Survey Length (Miles)	Pool, Riffle, Run Percent Occurrence	Pool:Riffle:Run Percent Total Length	Dry Percent Total Length
SLR River Reach 1	2	2.73	31:26:43	20:22:58	0
SLR River Reach 2	2	0.14	50:7:43	38:3:59	0
SLR River Reach 3	2	0.26	49:7:44	44:10:46	0
SLR River Reach 4	2	1.15	36:34:30	26:24:50	0
SLR River Reach 5	2	0.61	34:10:46	20:4:61	15
Total	**2**	**4.89**	**32:22:42**	**23:19:54**	**4**

Pool Depth

Significance: Pool depth and frequency are fundamental attributes of channel morphology and are largely dependent on the presence of large roughness elements such as boulders, bedrock, rootwads, and small and large woody debris in addition to channel type, stream gradient, sinuosity, and channel width. Evaluating the amount of deep pool habitat in a stream reach helps assessment of important channel characteristics for steelhead. Deep pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Greater pool depth provides more cover and rearing space for older age (1+ and 2+) steelhead juveniles and creates better shelter for migrating and spawning adults. Generally, a stream reach should have 35 – 50% of its length in primary pools to be suitable for salmonids. SLR River was evaluated as a second order stream. First and second order streams are comprised of primary pools that are greater than 2.0 feet deep. The EMDS model based it suitability ratings on pools greater than 2.49 feet, with a slight consideration (weight) given to pools greater than 2-feet deep.

Pool Depth Cont.

Findings: None of the reaches surveyed in the mainstem met target values for pool habitat and depth with only 10% of surveyed reaches being composed of primary pools (Figure 9). Reach 3 had the most primary pools by survey length, with 40.2%; reach 4 was a distant second with 22.7% (Table 8). The remaining reaches contained less than 8% primary pools by survey length. Reach 3 was the only reach that met EMDS suitability ratings (Figure 10). The lower number of pools indicates a disruption to channel forming processes such as insufficient stream flows to assist in the pool forming and pool scouring processes and elevated levels of stored sediments.

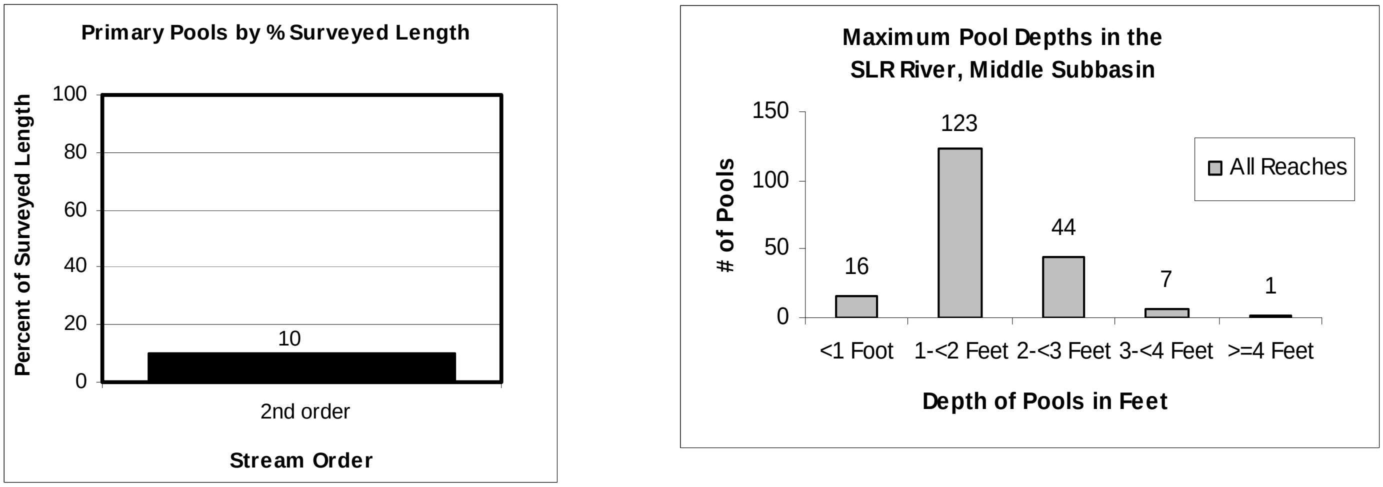


Figure 9. Percent of primary pools and number of pools by maximum depth in the SLR River, Middle Subbasin.

Primary pools are pools greater than 2 feet deep in 1st and 2nd order streams

Table 8. Percent length of a survey composed of pools in the SLR River, Middle Subbasin.

Stream	Stream Order	Percent all Measured Pools by Survey Length	Percent Pool of Depth 2.0-2.49 feet by survey length	Percent Pools of Depth 2.5–2.9 feet by Survey Length	Percent Pools of Depth >3 feet by Survey Length	Percent Pools Within Target Range (>2.0 feet) by Survey Length
SLR River Reach 1	2	20.1	4.4	3.0	0	7.4
SLR River Reach 2	2	37.6	0	6.1	0	6.1
SLR River Reach 3	2	43.6	0	24.7	15.5	40.2
SLR River Reach 4	2	26.7	6.3	14.8	1.6	22.7
SLR River Reach 5	2	20.2	5.5	1.1	0	6.6

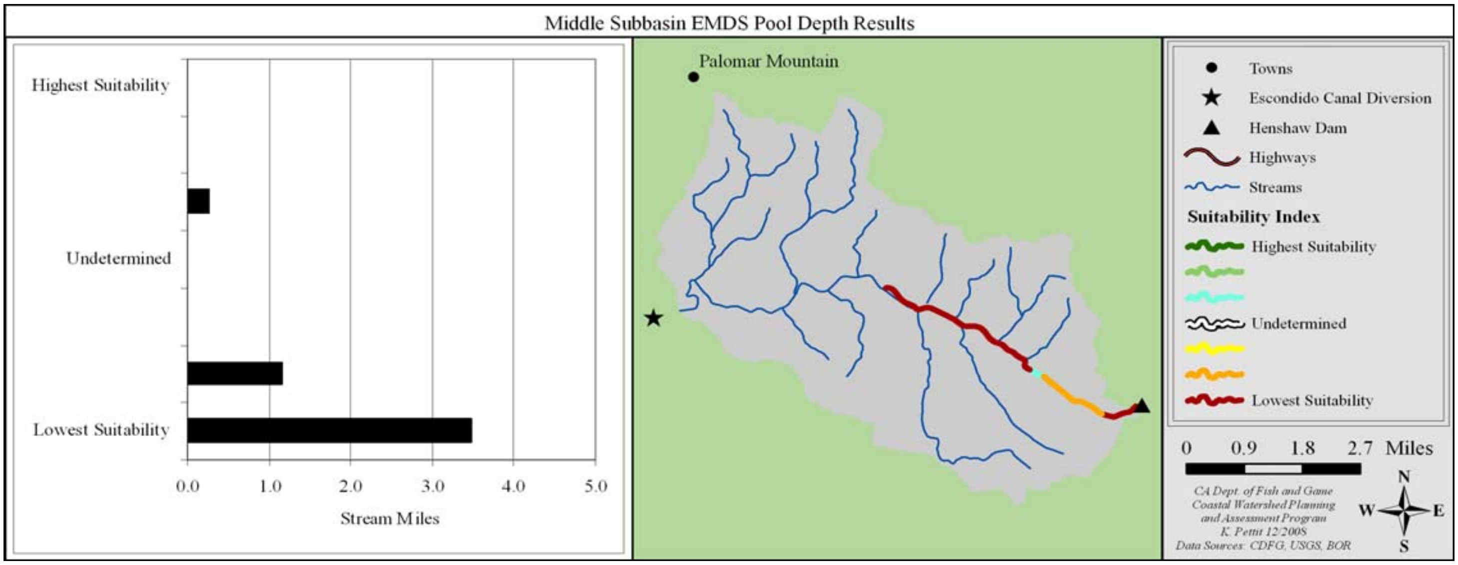


Figure 10. EMDS pool depth results for the SLR River, Middle Subbasin by surveyed stream miles.

Pool Shelter

Significance: The pool shelter rating is a relative measure of the quantity and percent composition of small woody debris, root wads, boulders, undercut banks, bubble curtains, and submersed or overhanging vegetation in pool habitats. These elements serve as complex instream habitat with protection from predation, rest areas from high velocity flows, and separate territorial units to reduce density related competition. Shelter ratings of 100 or less indicate that shelter/cover enhancement should be considered. Large woody debris generally does not play a significant role in the habitat functions concerning steelhead/trout in southern California rivers and streams; therefore, its presence/absence is not relevant in this assessment.

Findings: Pool shelter ratings for surveyed reaches of the SLR River in the Middle Subbasin were all well below the target value of 100 (Figure 11) and every reach except reach 5 had poor EMDS suitability ratings (Figure 14). There were only a few pools located throughout the survey that had a shelter rating greater than 100. The overall pool shelter rating for the entire survey area was only 29 (Figure 12).

In addition to shelter complexity rating, instream shelter composition, divided into eight cover types, was also collected during habitat inventories (Figure 13). Boulders (19.8%) followed by small woody debris (18.0%) are the dominate cover types in the subbasin. Undercut banks and terrestrial vegetation were also a significant cover type representing over 17.6 and 16.1% of the cover in pools respectively. Aquatic vegetation and root mass played a lesser role in providing potential shelter cover in pools. Large wood debris and whitewater were almost completely absent from pools in the subbasin.

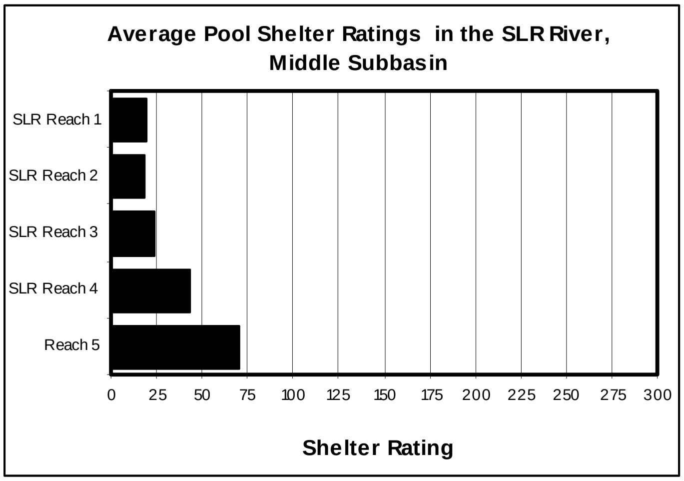


Figure 11. Average pool shelter ratings from CDFG stream surveys in SLR River in the Middle Subbasin.

Stream reaches are listed from west to east.

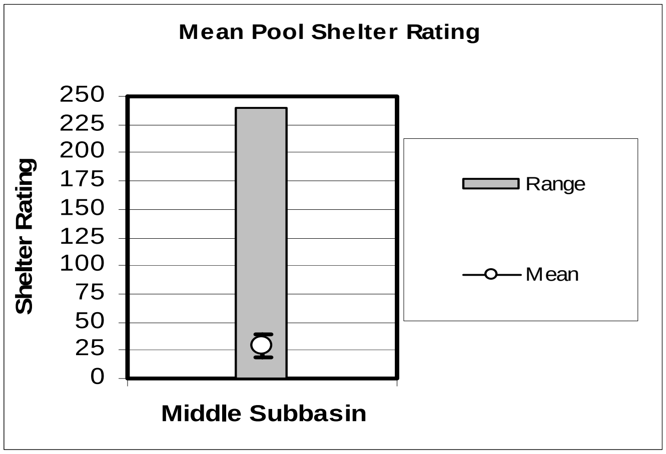


Figure 12. Pool shelter in the SLR River, Middle Subbasin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, etc.) is described and rated in CDFG surveys.

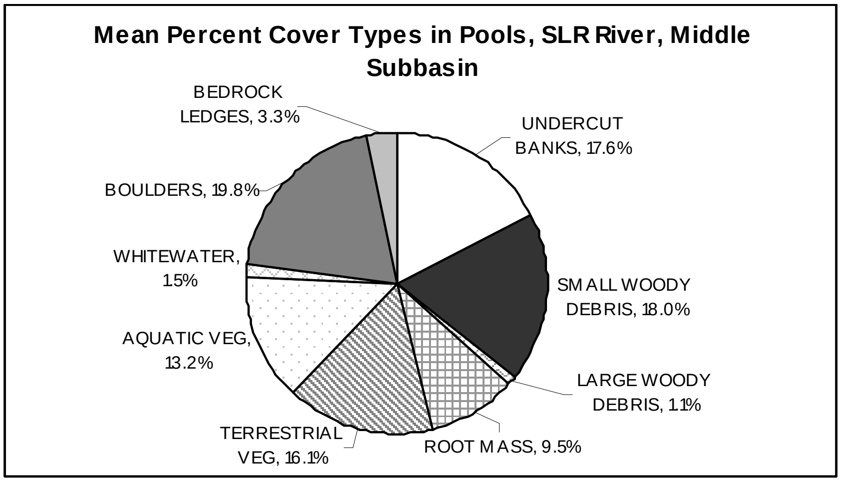


Figure 13. Mean percent of shelter cover types in pools for surveyed reaches of the SLR River in the Middle Subbasin.

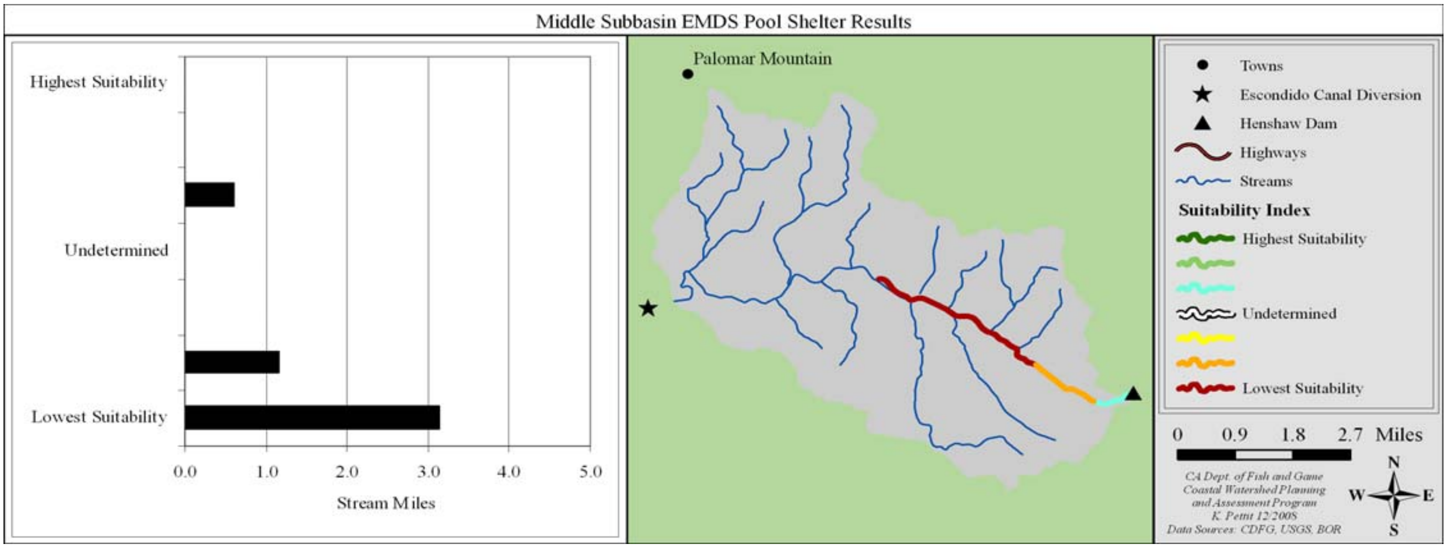


Figure 14. EMDS pool shelter results for the SLR River, Middle Subbasin by surveyed stream miles.

Cobble Embeddedness

<u>Significance:</u> Salmonid spawning depends heavily on the suitability of spawning gravel; fine sediments decrease successful spawning and incubation. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail-out that is embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, category 3 is 51-75% embedded, and category 4 is 76-100% embedded. Generally, cobble embeddedness of 0-25% is considered good quality for spawning (Flosi et al. 1998). Excessive accumulations of fine sediment (>50%) reduce water flow (permeability) through gravels in redds which may suffocate eggs or developing embryos. Excessive levels of fine sediment accumulations over gravel and cobble substrate also may alter insect species composition and food availability for growing fish. Consequently, cobble embeddedness categories 3 and 4 are not within the fully supported range for successful use by salmonids. Category 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate like bedrock, log sills, boulders or other considerations. Southern California steelhead also utilize riffles as potential spawning grounds. This survey methodology, which measure only pool tail-outs, did not take this into account and thus did not record/evaluate these areas.

<u>Findings:</u> The SLR River possessed suitable spawning gravels for less than 13% of the surveyed area and exhibited ideal spawning conditions, 0-25% embedded, in only 1% of the total surveyed area (Figure 16). A little over half of the pool tail-outs were considered unspawnable due to the presence of inappropriate substrate (s) at the pool tail-out. These figures led to poor EMDS scores for the entire reach (Figure 14). Reach 3 contained the only significant percentage of category 1 spawning gravels as well as a small percent of category 2. Additional suitable spawning gravels were observed in numerous riffles throughout the surveyed area but were not measured or accounted for the purpose of this survey.

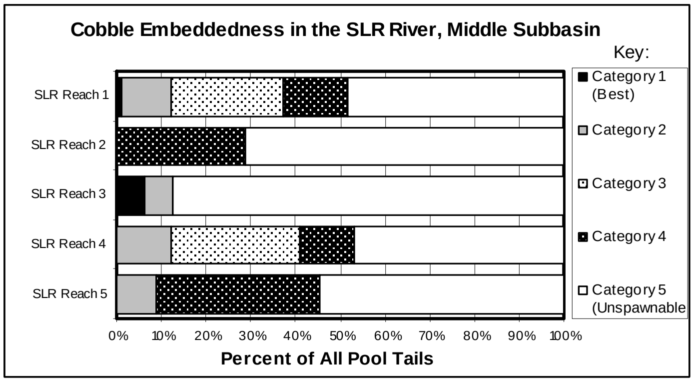


Figure 15. Cobble embeddedness categories as measured at every pool tail crest in the SLR River, Middle Subbasin.

SLR River stream reaches are listed in from west to east in the Subbasin.

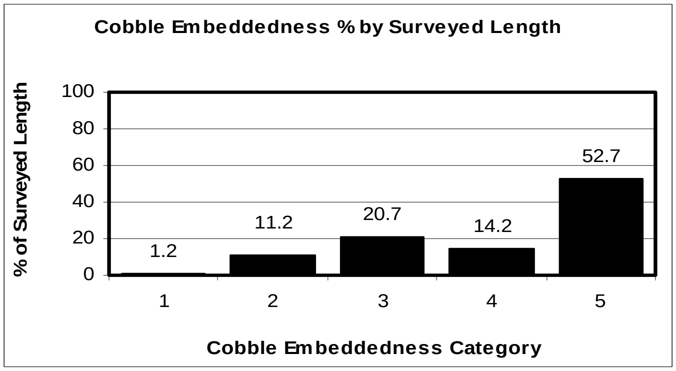


Figure 16. Cobble Embeddedness in the SLR River, Middle Subbasin.

Cobble Embeddedness was measured only in pool tail-outs and did not take into account that steelhead may spawn in riffle habitat.

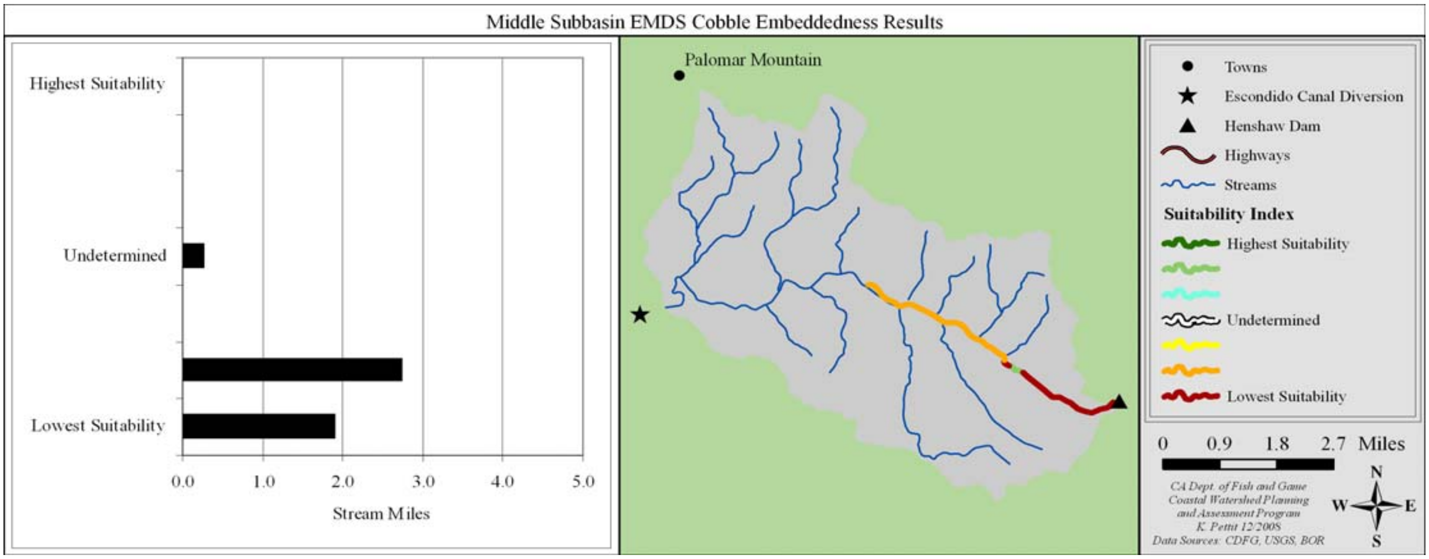


Figure 17. EMDS cobble embeddedness results for the SLR River, Middle Subbasin by surveyed stream miles.

Habitat Discussion and Conclusions

In the spring of 2007, CDFG/PSMFC fisheries crews performed stream habitat inventories in the mid to upper portion of the SLR River within the Middle Subbasin. This habitat inventory cover almost 5 stream miles, represented about half of the SLR River in the subbasin. A presence/absence electrofishing survey was also conducted in late September of 2007. Other streams were examined to determine general habitat suitability conditions, but these streams contained fish passage barriers near their confluence with the mainstem; therefore, full stream inventories were not performed. Prior to these stream inventories, historic stream habitat conditions were limited to stocking and angling reports that contained very general information on overall conditions. These descriptions do not offer enough information to qualify previous stream conditions. Generally, older stream surveys, at the minimum, can provide a snapshot of the conditions at the time of the survey, but a literature review could not find any such historic surveys.

Steelhead trout access to the subbasin is currently blocked at the Escondido Canal diversion dam (RM 40). Access is also restricted downstream due to the altered flow regime and its impact on downstream fish passage barriers, including a natural waterfall at RM 39.5; this waterfall has an overall height of 50 feet, but is broken up into a series of steps, with the largest lowermost step approximately 13 feet, and a narrow steeped crevasse above the first step extending to the top of the waterfall (M. Capelli, personal communication 2010). (See Figure 9, p.16 in the Southern Subbasin section for a photo of this description.) The river could potentially provide important spawning and rearing habitat for steelhead/trout, but would require extensive mitigation of the natural and man-made barriers. Additional habitat in tributaries appears to be limited. Currently, natural and man-made barriers inhibit fish passage into some of these streams.

Since the completion of the Henshaw Dam in the early 1920s, the river has experienced a reduction in peak flows associated with runoff. Reduction of the large flushing flows has resulted in the encroachment of vegetation into the stream and a buildup of fine sediments. While these changes may have benefited the canopy cover of the river, which met canopy target values with the exception of the upper reach, the remaining instream habitat conditions were adversely impacted. Surveyed reaches fell below EMDS target values and were evaluated as unsuitable for salmonids for pool quality, pool depth, pool shelter, and cobble embeddedness habitat characteristics. These poor conditions would likely be limiting factors to salmonid production. The 2007 Poomacha Fire contributed fine sediment into tributaries and the SLR River in the western half of the Middle Subbasin's, which most likely exacerbated the high levels of sediment and fines already present in the river.

Water temperature measurements were suitable at the time of the surveys, but more long term data is needed to determine water temperature suitability. High water temperatures and low dissolved oxygen levels could be limiting factors to salmonid production in the SLR River. Stream temperature data loggers, deployed in the spring of 2008 in the SLR River, will provide some insight to stream temperatures during the temperature extreme period.

During the one day, presence/absence survey, which was conducted in two separate reaches (one reach on U.S. Forest Service proper and the other one approximately one mile downstream), only non-native species were observed. Warm water game fish, such as largemouth bass, bluegill, green sunfish, brown and black bullhead were captured in the upper reach and are most likely abundant in the river. These fish are washed down from Lake Henshaw during flow releases. Western Mosquitofish was the only fish species caught in the lower reach. Although trout were released as recent as 2003, none were observed. Downstream of the surveyed areas, largemouth bass were also observed in the SLR River within the La Jolla Indian campground and evidence of recreational fishing was present. If trout were ever provided access to this subbasin, these warm water game fish would most likely predate on all early life cycle stages of trout.

Table 9. EMDS reach condition results for the Middle Subbasin.

Stream	Year	Canopy	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
SLR River Reach 1	2007	+++	---	---	---	--
SLR River Reach 2	2007	++	--	---	---	--
SLR River Reach 3	2007	++	-	+	---	++
SLR River Reach 4	2007	+	--	--	--	---
SLR River Reach 5	2007	--	-	---	+	---
Middle Subbasin		++	--	--	--	--

Key: +++ = Highest Suitability U= Insufficient Data or Undetermined - - - = Lowest Suitability

Stream Habitat Improvement Recommendations

In addition to presenting habitat condition data, all CDFG stream inventories provide a list of recommendations that address those conditions that did not reach target values presented in CDFG's *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998) and in *NMFS's Guide to reference values used in south-central/southern California coast steelhead conservation action planning workbooks* (2008) (see the Current Conditions pp. 14-18). Stream habitat improvement recommendations were developed based on results from stream surveys conducted along potential salmonid bearing stream reaches in 2007. Although the SLR River in the Middle Subbasin is above limits of anadromy due to the Escondido Canal diversion dam (RM 40), the CDFG surveyed and analyzed the data in order to assess the quality and quantity of the stream habitat available in the subbasin. Because the tributaries in the subbasin were not accessible to fish or could not be surveyed due to landowner access issues (Cedar Creek), these creeks were not included in stream habitat improvement recommendations.

In order to compare mainstem recommendations within the subbasin, the recommendations of each reach were collapsed into five target issue categories: surface stream flow, fish passage, riparian/water temperatures, instream habitat, and sediment delivery (Table 10). These target issues were then paired with the appropriate recommendation category. For example, the target issue "Instream Habitat" was divided into the recommendation categories of: Pool, Cover, and Spawning Gravels. CDFG/PSMFC biologists selected and ranked habitat improvement recommendations based on survey inventory results collected in the SLR River. The top three recommendations of each reach are considered to be the most important, and are useful as a standard example of the stream. When examining recommendation categories by number of reaches, the most important target issue in the Middle Subbasin is stream flows, as they have been greatly reduced, altering important stream channel forming processes. The diminished surface flows have degraded the following instream habitat factors: pool frequency, pool depth, and spawning gravels. Initiating pulse flows strong enough to move fine sediments through the river and recruit larger substrate for spawning would also benefit pool enhancement and formation. High priority should be given to restoration projects that emphasize sediment reduction and pool formation. Most fish passage problems were seasonal migration barriers due to natural causes such as a bedrock chute or a waterfall. Water temperatures were not monitored during the high temperature extreme period of the summer months and thus data is limited for evaluation considerations.

Table 10. Recommendation categories based on Basin target issues.

Basin Target Issue	Related Table Categories
Surface Stream Flow	Stream Flow
Fish Passage Barriers	Fish Passage
Riparian/Water Temperature	Canopy/Temperature
Instream Habitat	Pool/Cover/Spawning Gravels
Sediment Delivery	Bank/Roads/Livestock

Table 11. Occurrence of stream habitat inventory recommendations for surveyed reaches of the SLR River, Middle Subbasin.

Stream	Survey Length (feet)	Stream Flows	Fish Passage	Riparian/Water Temps		Instream Habitat			Sediment Delivery		
				Temp	Canopy	Pool	Cover	Spawning Gravel	Bank	Livestock	Roads
SLR Reach 1	14,429	1	5	unk		2	4	3			
SLR Reach 2	764	1	5	unk		2	4	3			
SLR Reach 3	1,370	1	5	unk		2	1	4			
SLR Reach 4	6,079	1	3	unk		2	5	4			
SLR Reach 5	3,202	1	3	unk	4	2		5			

Unk = Conditions Unknown

Restoration Projects

Restoration projects within the subbasin have been limited to those performed by local landowners, the Cleveland National Forest Service, and the La Jolla Indian Tribe. Even though trout were recently stocked in the subbasin there is little evidence that habitat improvement projects occurred in the river. Reviewing the CalFish website (CalFish is a multi-agency program for collecting, standardizing, maintaining, and providing access to quality fisheries data and information for California), it did not list any agency or organization funded stream restoration projects in the subbasin.

Projects that have occurred or are currently underway that have improved stream habitat conditions or contributed to the monitoring of the stream habitat conditions include the following:

- Spring to December 2008 water temperature monitoring by NMFS in the SLR River within the Cleveland National Forest proper;
- Spring 2008 to December 2009 water chemistry analysis and bioassessment by Trout Unlimited in conjunction with the San Diego Coastkeeper in SLR River in Cleveland National Forest proper;
- The La Jolla Indian Tribe has an on-going water resource monitoring program that monitors and records rainfall, stream flow, groundwater levels, and water quality parameters for all Reservation streams and wells (L. Musick, , personal communication 2009);
- Water quality control via animal waste improvement projects;
- Watershed education in classrooms, including SLR River site visits, trout rearing and release in the SLR River.

Information on other watershed stream restoration projects can be found on CalFish (www.calfish.org) or on the Natural Resources Project Inventory online database (www.ice.ucdavis.edu/nrpi/).

Refugia Areas

The interdisciplinary team identified and characterized refugia habitat in the Middle Subbasin by using professional judgment and criteria developed for southern coastal watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, stream flows, agriculture and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by the EMDS at the stream reach scale.

The most complete data available in the Middle Subbasin was for the SLR River, which was surveyed by CDFG/PSMFC during the spring of 2007. Steelhead habitat conditions in the Middle Subbasin on surveyed streams are generally rated as low potential/low quality refugia. Wigham Creek and Prisoner Creek were the only other tributaries examined in the subbasin. Habitat inventories were not performed on these creeks because they both contained fish passage barriers within 400 feet of their confluence with the SLR River. Wigham Creek had a bedrock chute that appeared to be impassible, unless extremely high flows allowed fish to swim up the chute, but this seemed unlikely. Prisoner Creek was impassible at the Highway 76 road crossing as a large culvert was situated four and half feet above the wetted channel with no significant jumping pool. Moreover, fish would most likely not be able to swim through the culvert based on its angle and the flow velocities it creates. Other tributaries such as Cedar Creek were not surveyed and habitat conditions are relatively unknown. A literature review did not contain any references to steelhead/trout in any tributaries within the subbasin. Further field studies are needed to determine the habitat suitability and limiting factors for steelhead/trout production in these streams if fish passage improvement projects were to occur. The following refugia area rating table summarizes subbasin salmonid refugia conditions.

Table 12. SLR River and tributary salmonid refugia ratings in the Middle Subbasin..

Stream	Refugia Categories				Other Categories		
	High Quality	High Potential	Medium Potential	Low Quality/Low Potential	Passage Barrier Limited	Critical Contributing Area	Data Limited
SLR River				X	X		X Needs survey
Cedar Creek							X Needs survey
Wigham Creek				X	X		
Prisoner Creek				X	X		

Key Subbasin Issues

- Southern California steelhead are currently blocked from accessing potentially suitable habitat in the Middle Subbasin due to the Escondido Canal diversion dam (RM 40) and by the altered flow regime coupled with the natural barriers in the SLR River canyon;
- The regulated timing, duration, and amount of flow releases from Henshaw Dam are likely not conducive to the lifecycle requirements of salmonids;
- Warm water game fish present in the river would pose a major threat to the successful completion of the early lifecycle stages of steelhead/trout;
- The decreased magnitude and frequency of flood flows has resulted in the buildup of fine sediments and decreased size and number of pools.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations in the subbasin?

Findings and Conclusions

- Southern California Coast Steelhead (DPS) are federally listed as endangered;
- Historically, it is unknown if steelhead inhabited the SLR River in the Middle Subbasin. Trout were first observed in the Upper Subbasin, headwaters of the SLR River, in 1862 (Cooper 1874); therefore, considering the sustained surface flows prior to the completion of the Henshaw Dam and Escondido Canal diversion, it seems possible that steelhead could have migrated upstream of the natural waterfall barriers present with the SLR River canyon and inhabited the Middle Subbasin;
- Currently, steelhead trout are absent from the subbasin. Steelhead trout access to the subbasin is currently restricted due to the altered flow regime and downstream fish passage barriers, including the Escondido Diversion dam and a natural waterfall at RM 39.5;
- In order to accommodate a strong demand for a recreational fishery, rainbow trout were stocked in the SLR River from the mid-1940s until 2003. Generally, these trout were stocked in the SLR River within the Cleveland National Forest proper and in the vicinity of the La Jolla campground. There was no record of these planted trout spawning in the river and producing a progeny.

What are the current salmonid habitat conditions in the Middle Subbasin? How do these conditions compare to desired conditions?

Findings and Conclusions:

Flow and Water Quality:

- The regulated timing, duration, and amount of flow releases from Henshaw Dam is not necessarily conducive to the lifecycle requirements of salmonids;

- When water is not released from Henshaw Dam during periods of low flow, water temperatures and water quality are adversely affected. In addition to areas of the river going dry, stream water temperature increases could spur algal growth, which in turn, depletes the dissolved oxygen content, and the overall water quality may deteriorate;
- The decreased magnitude and frequency of flood flows has resulted in the encroachment of vegetation into the stream, a buildup of fine sediments, and limited pool habitat;
- Commercial groundwater harvesting near the headwaters of Cedar Creek removes tens of thousand of gallons of groundwater daily, reducing the amount of water flowing into Cedar Creek and thus into the SLR River.

Erosion/Sediment:

- High amounts of fine sediment were observed throughout the surveyed area in shallow pools, pool tail-outs, and riffle habitats;
- Soils (and bedrock) in streams of the Middle Subbasin are prone to erosion, and slides and streambank failures have been observed to contribute fines to the streams.

Riparian Condition/Water Temperature:

- Streamside tree canopy providing shade over the water was generally suitable for the surveyed area. In addition to shrub and trees, some additional stream shade may be provided by areas where canyon walls are in close proximity to the river;
- The 2007 Poomacha Fire burned the riparian habitat along the SLR River (western portion of subbasin) at a moderate severity with patches of high burn severity. During a post-fire visit to the Escondido Canal diversion dam, the riparian along the river appeared to be intact, but most of the surrounding hillsides were burned and moderately to highly denuded of vegetation;
- Water temperature data collected by CDFG during spring habitat inventories indicate suitable stream temperatures. However, these data are limited, and therefore inconclusive;
- NMFS employed a data temperature logger in the SLR River in the Cleveland National Forest proper during the spring of 2008 and will monitor the temperature extreme period during the summer and early fall months.

Instream Habitat:

- Limited suitable spawning and rearing habitat were present in the SLR River within the surveyed area. Deep complex pools are lacking in the river as all of the reaches received poor EMDS ratings in pool quality, pool depth (except reach 3), and pool shelter;
- The relatively high embedded substrate observed from pool tails and the relative shallow pools are indicative of the lack of significant stream flows to scour deeper pools and remove excessive fine sediments;
- Warm water game fish were present throughout much of the surveyed area. If trout were provided access these fish would likely predate on the various lifecycle stages of trout;
- Tributary habitat was inaccessible due to fish passage barriers, but appeared to be limited even above these barriers.

Gravel/Substrate:

- Suitable salmonid spawning areas were available but limited in the subbasin. High embeddedness levels in pool tail-outs potentially limit successful egg incubation and the development and emergence of salmonid fry;

- The post-fire effects of increased sediment input in the western half of the subbasin most likely resulted in buried spawning gravels that will require another series of storms in order to flush out these fine sediments and restore suitable spawning grounds.

Refugia Areas:

- Salmonid habitat conditions in the Middle Subbasin are generally rated as low quality/low potential refugia. The subbasin is currently inaccessible to steelhead. Numerous downstream fish passage barriers would need to be modified in order to allow trout to have access to the area;
- The habitat that is currently present is generally of poor quality; however, with seasonally appropriate flow releases from Henshaw Dam that would allow proper hydrologic processes to occur, the subbasin's habitat suitability for trout could greatly increase;
- Limited suitable habitat exists in the tributaries that were examined and are currently contain fish passage barriers near their confluences with the SLR River (see below).

Barriers:

- In addition to the natural waterfalls in the SLR River canyon and the Escondido Canal diversion dam located in the Southern Subbasin, several natural waterfall and bedrock chute barriers also occur in the SLR River in the Cleveland National Forest proper. These are partial, low flow barriers and under the right flow conditions, may be passable;
- Wigham Creek is impassible at Highway 76, approximately 300 feet upstream of its confluence with the SLR River, as a culvert is perched four and half feet above a shallow pool;
- Prisoner Creek contains a long, steep bedrock chute near its confluence with the SLR River that would seem impassible to fish.

What are the impacts of geologic, vegetative, fluvial, and other natural processes on watershed and stream conditions?

Findings and Conclusions:

- Severely erodible soils comprise 95% of the watershed and slides from the stream banks and roads have been observed to contribute fines to the stream;
- Weathering of the granitic rocks has created younger unconsolidated sediments that are very susceptible to enhanced erosion and mass movement such as landslides and debris flows;
- The Middle Subbasin is in a potentially seismically active area as several faults cut through this basin, including the Elsinore Fault Zone. Powerful seismic events, especially when coupled with significant storm events, can trigger large landslides and mudflows increasing sediment delivery to the streams and altering their hydrologic condition;
- Uplift has increased the erosion potential of the area;
- Reduction of peak flows associated with runoff has resulted in the encroachment of vegetation into the streambed and a buildup of fine sediments;
- The combination of the high burn severity of the 2007 Poomacha Fire followed by significant rainfall events caused large debris flows in portions of the western Middle Subbasin. These debris flows were composed of highly mobilized ash, sediment, and woody debris. Water quality and aquatic biota downstream of the burn areas were adversely affected by the fire and subsequent rainfall events.

How has land use affected these natural processes?

Findings and Conclusions:

- Henshaw Dam has altered the natural hydrologic processes of the SLR River. A reduction of peak flows has resulted in the encroachment of vegetation into the streambed, buildup of fine sediments, limited cobble and gravel recruitment, and reduced the river’s scouring capabilities (i.e. pool formation);

- The timing of flow releases does not necessarily mimic natural flow conditions and would not coincide with a steelhead lifecycle;
- Water extraction by commercial groundwater harvesting and numerous wells in the subbasin may reduce water available to riparian species and overall surface flows in tributaries and in the SLR River.

Based upon these conditions, trends, and relationships, are there elements that could be considered to be limiting factors for steelhead production?

Findings and Conclusions:

- Based on available information for the Middle Subbasin, it appears that salmonid populations are limited by:
    - Steelhead trout currently do not have access into the subbasin due to the Escondido Diversion dam. Additional partial fish passage barriers exists in the Southern Subbasin that would hinder the potential for steelhead to access the Middle Subbasin;
    - The disruption of hydrologic connectivity and the natural hydrologic processes that are altered by the Henshaw Dam and the Escondido Canal diversion. The altered flow regime has a direct impact on fish passage within the subbasin as well as downstream;
    - Limited stream flows;
    - High levels of fine sediments in streams due to the 2007 Poomacha Fire;
    - The limited amount of areas in the river providing suitable spawning gravel;
    - The lack of deep, complex pools;
    - Presence of predatory warm water gamefish;
    - Potentially high water temperatures and poor water quality issues;
    - Limited access and available habitat in the subbasin’s tributaries.

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Barriers to Fish Passage

Streams:	**Recommended Actions** **XXX: Highest Priority**		
	Continue efforts to identify and alleviate fish passage impediments at culverts or other public or private road crossings.	Research the feasibility of creating fish passage around the Escondido Canal diversion dam.	Improve fish passage by removing structures on private lands that are currently partial barriers.
SLR River	X	XX	X

Flow and Water Quality

Streams:	**Recommended Actions** **XXX: Highest Priority**		
	Insure that water diversions used for domestic or irrigation purposes bypass sufficient flows to maintain all needs of fishery resources. Considering purchasing water rights if necessary to accomplish this.	When appropriate, allow flushing flow releases to mimic natural hydrologic processes that occurred before the completion of the dam.	Remove and prevent excessive agricultural runoff contributions to Lake Henshaw, which in turn affects water quality in the SLR River.
SLR River	X	XXX	XX

Erosion and Sediment Reduction

Streams:	**Recommended Actions** **XXX: Highest Priority**			
	Continue to identify and reduce sources of sediment delivery to stream channels	Re-vegetate exposed stream banks and/or install structures to	Build livestock exclusionary fencing along creeks and create offsite	Install instream structures that enhance natural sorting of spawning gravels.

	from road systems.	increase bank stability.	watering areas.	
SLR River	X	X	-	-

Riparian and Instream Habitat

Streams:	Recommended Actions XXX: Highest Priority			
	Increase depth, area or shelter complexity in pools, by adding boulders or if possible woody debris.	To increase the number of pools, design and install pool forming structures.	Efforts to eradicate warm-water gamefish should be undertaken if fish passage is provided into the subbasin.	Consider planting barren nearstream areas with willow, cottonwood, or sycamore trees to increase streamside shade canopy and allow for woody recruitment.
SLR River	-	-	XX	-

Education, Research, and Monitoring

Streams:	Recommended Actions XXX: Highest Priority			
	Continue, expand, or develop education programs concerning water conservation, water quality, and importance of watershed/riverine ecosystems.	Research methods to prevent or inhibit warm water game fish from entering the SLR River from Henshaw Dam.	Conduct further habitat surveys and/or presence/absence surveys in the lower to middle sections of the SLR River.	Water quality and temperature monitoring should be conducted over several years to characterize conditions in streams.
SLR River	XX	XX	XX	XX

Subbasin Conclusions

The Middle Subbasin has remained mostly undisturbed and retains large areas of native habitat; however, Henshaw Dam has altered the natural flow regime of the SLR River has adversely affected the stream habitat conditions. The timing, duration, and magnitude of flow releases are controlled by water rights and the amount of water stored in Lake Henshaw. The existing seasonal flow releases are not necessarily conducive to the steelhead/trout freshwater lifecycle.

The Middle Subbasin is not accessible to steelhead/trout. Numerous downstream fish passage barriers, including the Escondido Canal diversion dam would require mitigation for steelhead to access the Middle Subbasin. The altered flow regime has impacted fish passage downstream of the Middle Subbasin. Natural waterfalls in the SLR River canyon would restrict steelhead trout upstream movement during most flow conditions.

Current instream habitat conditions in the SLR River are limited. The reduction of large flushing flows due to Henshaw Dam has led to an excess in fine sediments, filled in pool habitat, limited new cobble recruitment, and allowed for the encroachment of streamside vegetation. The 2007 Poomacha Fire most likely only exasperated these conditions in the western half of the subbasin by contributing large amounts of fine sediments. Warm water game fish are most likely established throughout the subbasin in the SLR River and continue to enter the system during flow releases from the dam. These fish would present a predatory problem for the early to mid-lifecycle stages of juvenile trout. In the surveyed area, tributary habitat was very limited as a result of fish passage barriers. It is unknown if suitable habitat exists in any of the lower tributaries within the subbasin.

While some suitable habitat could be available for steelhead/trout in the Middle Subbasin within the SLR River, utilizing restoration opportunities in the lower watershed and in the Northern Subbasin streams would be a more effective means in the immediate future in helping re-establishing steelhead populations in the SLR Basin. Nonetheless, allowing large flushing flows from Henshaw Dam would benefit the instream habitat and riparian conditions in the Middle Subbasin. Allowing these flows to pass through the Escondido Canal diversion dam would further improve trout migration, instream habitat and riparian areas downstream. If restoring steelhead populations is a goal, then sufficient river flows are required to allow steelhead opportunities to successfully complete all phases of its lifecycle.

Table of Contents

List of Figures

List of Tables

Upper Subbasin

The Upper Subbasin is the largest of the subbasins, occupying two-hundred and six square miles or a little over one-third of the watershed. The watershed area comprises Lake Henshaw on its western boundary and all of the surrounding streams and their drainage areas that flow into the lake (Figure 1). Lake and stream elevations range from 2,727 feet at the spillway on Henshaw Dam (RM 50) to nearly 6,000 feet in the headwaters of a few tributaries on the southwestern portion of the subbasin. The SLR River flows into the lake at approximately 2,730 feet; however, the river's headwaters approach 5,000 feet in Anza Borrego State Park and exceed 5,000 feet in the headwaters of West Fork SLR River (W.F. SLR River). In general, precipitation increases in the higher elevations of the subbasin. Average yearly rainfall at Henshaw Dam is approximately 26 inches (based on data collected from 1948 to 2006) with higher rainfall totals in the surrounding Palomar, Aguanga, and Hot Springs Mountains.

This assessment area is mostly rural, containing only the small community of Warner Springs in the north-central part of the subbasin and Los Coyotes and Santa Isabel tribal members. It is predominantly composed of grasslands and native habitats consisting of mixed sagebrush/chaparral and hardwood forest/woodlands. The four mile stretch of riparian habitat along the SLR River below Lake Henshaw and the Warner Basin, which composes most of the Upper Subbasin, has been identified by The Southern Mountains and Foothills Assessment (Stephenson and Calcarone 1999) as an area of particularly high ecological significance. This designation describes areas that include critical habitats for rare and vulnerable species, those of high ecological integrity, and locations with unique ecological associations. The assessment describes how there are significant populations of arroyo toad and arroyo chub in the West Fork and North Fork of the SLR River and Agua Caliente Creek located within the subbasin. A self-sustaining native rainbow trout population is present in the West Fork SLR River. Extensive grasslands in the Warner Basin are occupied by federally listed Stephens' kangaroo rat (*Dipodomys stephensi*), and the subbasin is also one of the few areas in southern California where the red-sided garter snake (*Thamnophis sirtalis infernalis*) has recently been observed (Stephenson and Calcarone 1999). Moreover, the Upper Subbasin contains some of the most extensive remaining native grasslands in southern California, and the largest Engelmann oak woodland in the world (http://www.audubon.org /bird/iba05/2009).

The Vista Irrigation District (VID) is the largest landowner in the subbasin as well as in the SLR Basin. VID's property consists of Lake Henshaw and much of the surrounding grazing land around the lake and extending west of Highway 79. Indian reservations occupy the next largest segment of land with the Los Coyotes Indians and the Santa Ysabel Indians owning large tracts of land within their reservations. Cleveland National Forest and private landowners also occupy large portions of the subbasins.

Prior to the completion of the Henshaw Dam in 1922, the SLR River at the Henshaw Dam site was a perennially flowing river with minimum monthly summer flows of 1.4 cfs (see Middle Subbasin, Habitat Overview, pp. 11-12). The majority of these flows were most likely the result of the numerous tributaries flowing into the river in the western portion of the subbasin. Historically, the mainstem and most likely the West Fork SLR River, contained large areas of year round flows and supported trout populations of original ocean decent. Currently, native rainbow trout are only found in the W.F. SLR River.

To accommodate a popular demand for recreational sport fishing opportunities in inland lakes, warm water game fish, such as largemouth bass, bluegill, green sunfish, black crappie, and catfish were introduced into many lakes and reservoirs in southern California in the late 1940's. These fish may have been stocked into Lake Henshaw around this time as well. They are now common in the SLR River below the dam and are likely present in other streams within the basin.

Hydrology

The Upper Subbasin is composed of the Combs and Warner CalWater Units (Figure 2). There are eight named tributaries (Table 1) and 41.0 permanent and intermittent stream miles in this subbasin. The vast majority of these stream miles are intermittent. There are also a few named canyons containing intermittent and sections of permanent streams miles. The largest of the tributaries is W.F. SLR River. Although it is a blue-lined stream on USGS 7.5 quadrangles Palomar Observatory and Warner Springs, it is actually an intermittent stream with sections of perennial flow. This also applies to the SLR River and other named tributaries in the subbasin. Agua Caliente Creek and San Ysidro Creek are labeled as blue-lined streams, but only contain surface flows in portions of their channels. These streams and other tributaries play an important role in contributing to the overall volume of water in Lake Henshaw. Tributary drainage areas range from less than 3.5 square miles to the 91.0 square mile SLR River in the Upper Subbasin. The subbasin also contains a large aquifer, which is located in the area surrounding Lake Henshaw. The aquifer's production is utilized by the settlement parties in the San Luis Rey Settlement Agreement (J. Membrino, personal communication 2009).

With the exception of the Northern Subbasin, the Upper Subbasin receives more precipitation than all the other subbasins. Lake Henshaw's mean annual precipitation total is 26 inches, based on the water years 1948-2005 (http://www.wrcc.dri.edu/). Water releases, controlled by VID, can vary year to year, but typically occur in the spring and continue through mid to late summer. The amount of the release usually depends on the rainfall totals and amount of water stored in Lake Henshaw. In 2007, 24 cfs was released on April 27 and water releases continued till late July.

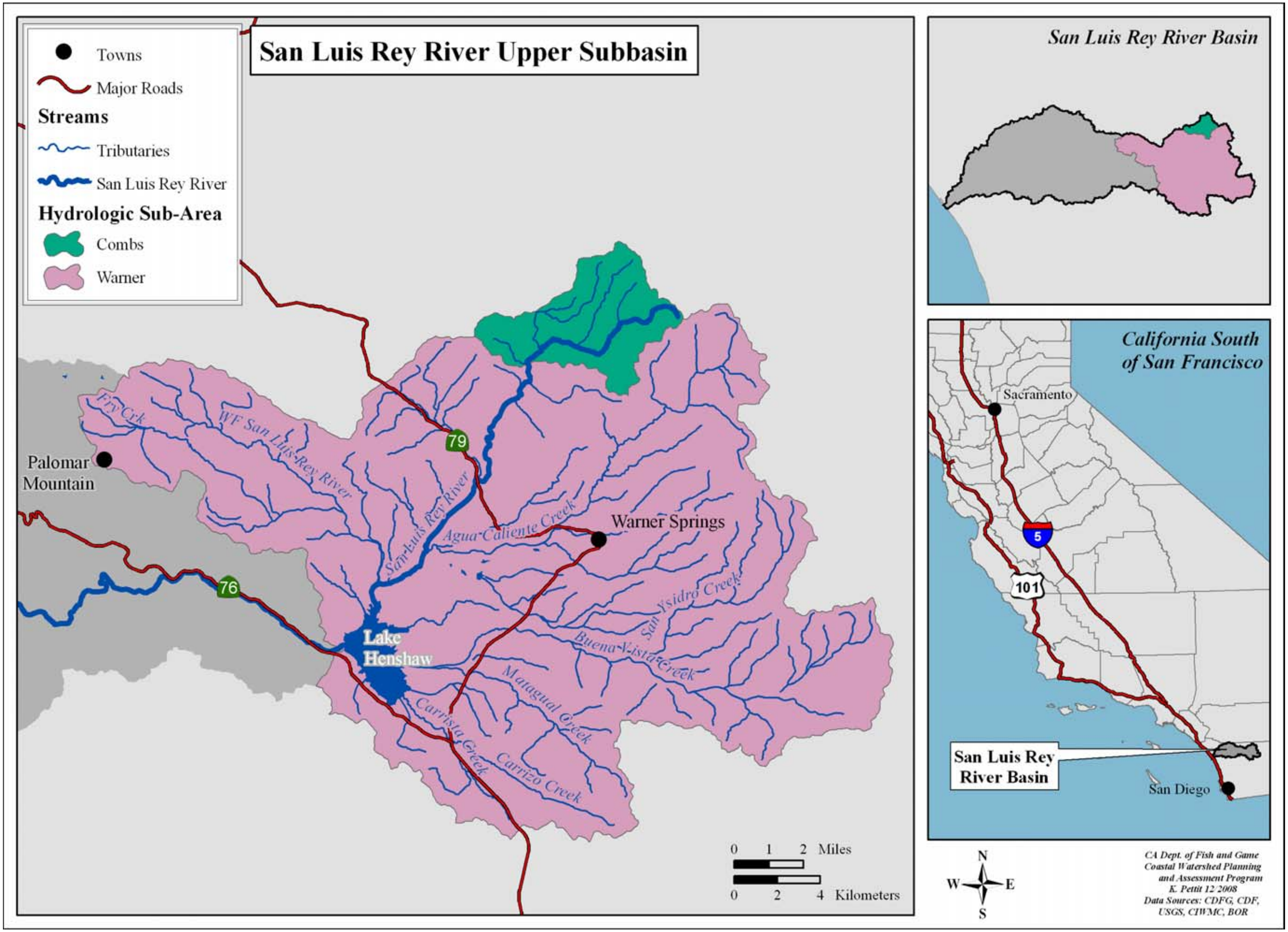
Numerous wells, located throughout the subbasin, provide water for anthropogenic uses. These wells most likely reduce surface flow in the tributaries as well as in the mainstem and could lower the groundwater table.

Table 1. Major streams in the Upper Subbasin.

Stream	Tributary to	River Mile	Drainage Area (square miles) (in Subbasin)	Stream Order	Permanent (miles) (in Subbasin)	Intermittent (miles) (in Subbasin)
Mainstem SLR River*	Lake Henshaw	-	91.0	1	1.1	12.3 (10.6)
West Fork SLR River*	Lake Henshaw	50.0	30.6	1	2.1	9.3
Agua Caliente Creek*	SLR River	55.8	39.4	1	1.6	12.0 (1.6)
Cañada Verde	Agua Caliente Ck	3.9	6.4	INT	0.0	5.1
Ward Canyon	Agua Caliente Creek	0.5	4.8	INT	0.0	6.0
Buena Vista Creek*	Lake Henshaw	50.0	55.3	INT	0.3	11.3 (1.2)
San Ysidro Creek*	Buena Vista Creek	5.8	15.4	INT	0.8	7.3
Matagual Creek*	Buena Vista Creek	1.0	10.6	1	2.1	5.5
Carrista Creek	Lake Henshaw	50.0	10.4	INT	0.0	1.7
Carrizo Creek*	Carrista Creek	2.3	4.8	1	2.1	3.5

*A portion of these creeks retain perennial flows during normal rain years with WF SLR River generally containing the longest stream area with perennial flows.
INT = Intermittent stream

Figure 1. Lake Henshaw and surrounding area in the Upper Subbasin.



CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 12/2008
Data Sources: CDFG, CDF, USGS, CIWMC, BOR

Figure 2. Upper Subbasin locator map and CalWater Units.

Geology

Like all of the subbasins within the San Luis Rey watershed, the Upper Subbasin is predominately underlain by granitic rock types of the Peninsular Range Batholith that intruded into older (Mesozoic) sedimentary, marine rock types between 90 and 140 million years ago and has subsequently been exposed by tectonic uplift and erosion (Figure 3). Intrusion of the Peninsular Range Batholith as well as regional tectonics has caused some of the marine, sedimentary rocks to undergo metamorphosis.

Erosion has exposed the batholith leaving behind mountains of granitic rock with remnants of the sedimentary rocks into which they intrude. Weathering of these rocks has created younger unconsolidated sediments that are very susceptible to erosion and mass movement such as landslides and debris-flows. These sediments have been deposited in a series of alluvial fans, marine and river terraces, as well as active channel deposits. These sedimentary deposits range from partially consolidated sandstone, siltstone, mudstone, and shale to unconsolidated sand and gravel (Table 2).

Compositional Overview

Rock Types

Mesozoic Granitic

Granitic rocks make up the majority of this subbasin. They occupy approximately 67% of its surface area. They are predominantly Cretaceous (65.5 million through 154.5 million years ago) in age. These rocks are very hard and resistant to erosion, however they do tend to exfoliate to some extent in exposed surfaces and preferentially weather at structural joints. Over long periods of time granitic rocks tend to weather and become "soft" reducing their density, increasing their porosity, and making them much less resistant to erosion, producing "decomposed granite." In more advanced forms, the minerals within the granite disaggregate and form "Arkosic Sand" which is highly susceptible to erosion, sliding, and fluvial transport.

Quaternary Alluvium

Alluvium covers less than 15% of the basin. It consists of unconsolidated sediments that range from clay to streams and makes up most of the bed and banks of the streams. Units of alluvium delineated by the geology map include sediment currently being acted upon by boulders. Alluvium is transported and deposited by the streams, bank and flood-plain deposits occasionally acted upon by the streams, and sediment that has accumulated within Lake Henshaw. If the alluvium within the stream channel is of sufficient depth it can readily transport water via the subsurface pore-spaces allowing stretches of the stream to "run dry."

Plio-Pleisticene Nonmarine

This unit occupies about 13% of the basin. It is composed of sedimentary rocks ranging in composition from siltstone through conglomerate. The sediments that make up these rock types were deposited on land between eleven thousand and five million years ago. The sediments of these rock types range from siltstone through conglomerate and from poorly consolidated to well indurated.

Mesozoic Sedimentary

Mesozoic sedimentary rocks make up around 5% of the subbasin and consist mostly of siltstone, sandstone, and conglomerate and were deposited some 65.5 to 225 million years ago. The original deposition of the sediments that make up these rock types occurred in environments ranging from marine to terrestrial. Some of these rock types have subsequently undergone metamorphism especially in areas in contact with granitic rock types. These sedimentary rock types are generally more susceptible to erosion than granitic rock types.

Quaternary Alluvial Fan Deposits

Fan deposits make up about 1% of the basin and consist of unconsolidated sediments ranging from clay to boulders. They wash out of canyons with steep slopes and are usually deposited where there is a significant change of slope. They are not usually transported far from their source and therefore consist of sediments made from the bedrock of the mountains from which they come.

Table 2. Rock types in the Upper Subbasin.

Lithologic Unit	Percent of Basin
Mesozoic Granitic	66.74
Quaternary Alluvium	14.73
Plio-Pleisticene Nonmarine	12.52
Mesozoic Sedimentary	4.56
Quaternary Alluvial Fan Deposits	1.32

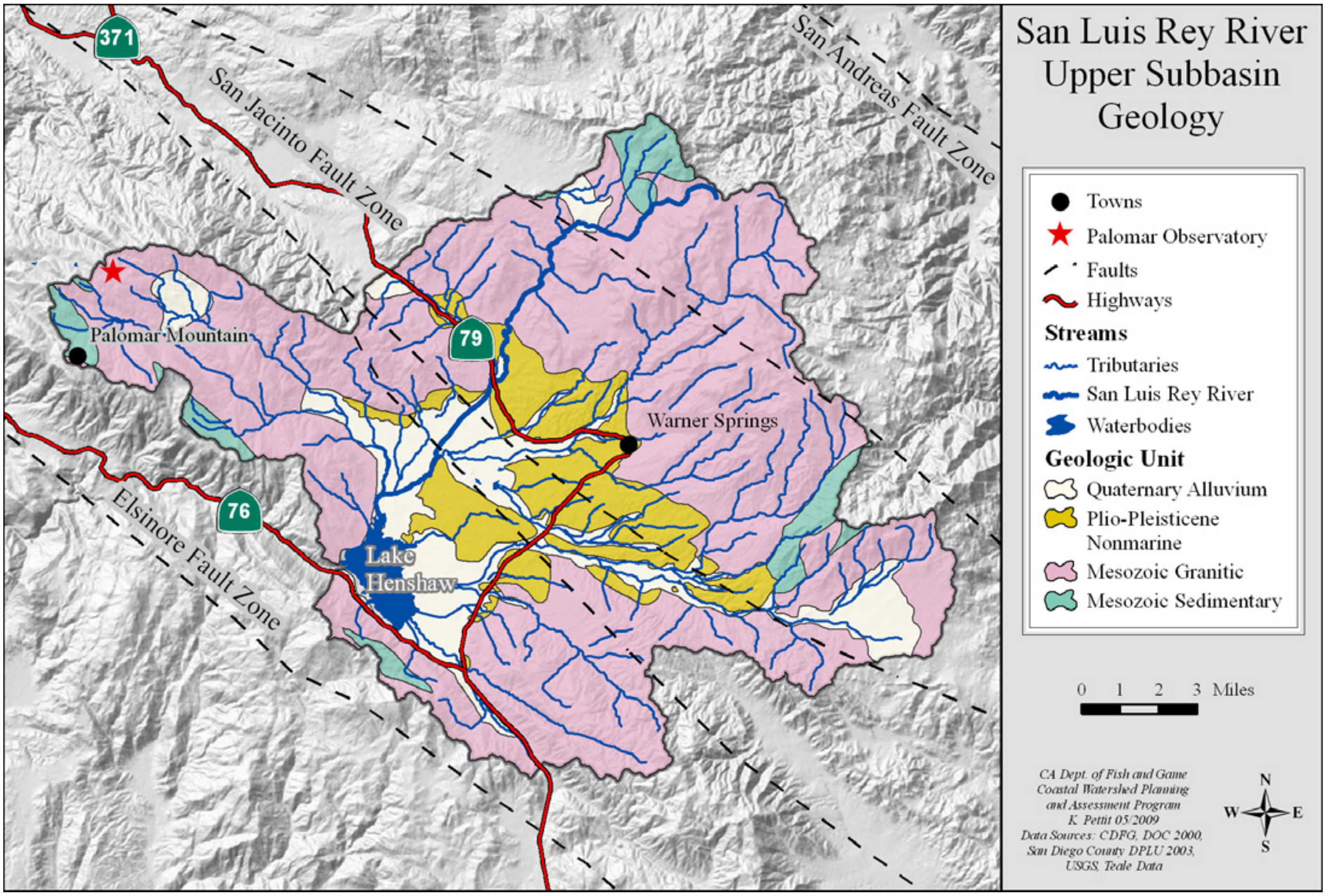


Figure 3. Geology of the Upper Subbasin.

Soils

The underlying bedrock is generally responsible for a soil's texture and erodability characteristics. The sediment contribution from soils found in the Upper Subbasin is dependent largely on slope, soil sediment size, consolidation, cohesion, compaction, the type and amount of vegetation cover, land use, and amount, intensity, and duration of local rainfall.

The majority of bedrock throughout the subbasin is composed of various granitic rock types (Table 3) producing associated soil types that are, in general, very well drained and are somewhat prone to erosion and transport by fluvial processes as well as wind. Soils with high sand and silt content are typically more susceptible to erosion than soils with high clay content which exhibit a greater degree of cohesion.

Table 3. Soil types in the Upper Subbasin.

Soil Type	Percent of Upper Subbasin	Composition
Tollhouse-Rock outcrop-La Posta	44.06	igneous/granitic
Oak Glen-Mottsville variant-Calpine	23.12	granitic
Sheephead-Rock outcrop-Bancas	15.76	gneissic/granitic
Hotaw-Crouch-Boomer (s1015)	12.68	granitic/metavolcanic

Percent area of basin represents a rough approximation based on GIS mapping.

Landslides

Like the other SLR River Subbasins, the Upper Subbasin is partially mantled with unstable soils. Alluvial material is generally confined to the mainstem while the hillsides are often composed of granite, weathered granite, and sedimentary rock. Except for fresh granite, these rock types are susceptible to surface erosion, headword erosion, gullying, stream bank raveling, and landsliding. This area has undergone tectonic uplift leaving steep canyon walls above the streams. As tectonic forces push the land up, gravity tries to pull it down, and the result is usually landslides and rock falls. Landsliding is further exacerbated by seasonal rain storms. As the hillsides become saturated, pore pressure between grains becomes greater making them unstable and more prone to landsliding. These conditions can be exacerbated by moderate to extreme wildfires.

Earthquakes and Faults

The whole of the San Luis Rey River Basin is tectonically and seismically active, and the possibility of seismic activity occurring in this subbasin is similar to the entire southern California region. The Upper Subbasin lies between the active fault zones of the Elsinore Fault Zone on its southwest border and San Jacinto Fault Zone, which cuts through the northern portion of the subbasin (Figure 3). Many faults are found between these two major zones; moreover, the San Andreas Fault Zone lies just to the north of the subbasin. All of these faults are right-lateral, strike-slips faults that are related to translational plate boundary tectonics between the Pacific and North American plates. These faults all maintain the potential for strong seismic movement. The San Jacinto Fault Zone (currently established Alquist-Priolo Earthquake Fault Zone), for example, is capable of producing earthquakes in the range of magnitude (M) 6.5–7.5 and has an average recurrence interval of approximately 100–300 years. The most recent quake that occurred in the region was due to the San Jacinto Fault Zone, which produced a M 6.5 quake in 1968 (http://www.data.scec.org/index.html).

Strong ground shaking generated by earthquakes can trigger rock falls and landslides that deliver large amounts of sediment to the streams. For instance, the 1994, Northridge earthquake, whose epicenter was located 20 miles northwest of downtown Los Angeles, was a M 6.7 earthquake that triggered in excess of 11,000 landslides in a 6,200 square mile area (USGS) in similar terrain. In addition to potentially triggering landslides, strike-slip faults can weaken bedrock, offset streams, and truncate and oversteepen certain topographic landforms thus enhancing erosion and transport of sediment to the streams. If situated near or above artesian wells, these faults may also cause the natural upward migration of water, creating seeps, springs, and potentially surface flows. For example, water moving up the Agua Caliente Fault forms Warner Springs, demonstrating that the fault affects subsurface flow at this location. The Aguanga Fault, along with other unnamed faults that cut through this basin possess the potential to cause earthquakes, but have an unknown effect on groundwater (California Groundwater Bulletin 2004: 118).

In 1971, the California Division of Dam Safety declared the Henshaw facility prone to failure in the event of seismic activity VID was required to permanently reduce the lake's capacity from 200,000 acre-feet to 50,000 acre-feet (Babbitt 1993). Today, the dam functions at less than 10% of its original storage capacity because of the Division of Dam Safety's reduction requirement, the collection of sediment over the years, and the drought-like conditions that have been experienced this past decade. More recently, in the Carlsbad Watershed to the south of the SLR River Basin, a federal analysis in 2007 determined that a large earthquake could liquefy the earthen portions of the Lake Wohlford Dam and cause potential flooding in the central part of Escondido. Most of the water used to fill Lake Wohlford comes via the Escondido Canal from Lake Henshaw.

Wildfires

Wildfire can, and usually will enhance the erodability of a region by burning off the duff layer and organic matter that helps to bind the soil together, as well as intensively drying it leaving behind a loose, "hydrophobic" soil in its wake. During subsequent rain storms the soil's capacity to absorb water is greatly reduced and surface flows are proportionally increased. Sometimes this hydrophobic layer can persist for years, especially if it is relatively thick. Wildfires can destroy woody debris strewn on hill slopes allowing for less resistance to the erosive power of surface runoff transporting increased amounts of sediment downstream. The propensity for debris flows on steep slopes is also increased following a wildfire (Cannon et al. 2004). Relatively hot fires may cause thermal expansion of individual minerals within the rock resulting in fracturing of its surface layers and thus, enhanced erosion.

The 2007 wildfires did not occur within the Upper Subbasin; however, wildfires have occurred frequently in the subbasin within the past decade (2006, 2004, 2003, and 2002; Figure 21, Basin Profile). Considering the arid climate and the dominant vegetation types, mixed sagebrush/chaparral and grasslands, the area is certainly prone to future fires. Post-fire erosion potential has been estimated as moderate to low (Table 5, Basin Profile) for most of this subbasin (USGS).

Fluvial Geomorphology

On average, the Upper Subbasin should act as a sediment source, transport, and deposition reach. Tributaries erode sediment from the steeper slopes and deliver them to the mainstem which in turn redistributes sediments within its floodplain and also transports sediments further downstream. When the mainstem enters Lake Henshaw, its flow regime drastically changes allowing sediment carried in bedload and by suspension to drop out and accumulate as lacustrine (lake) deposits. The slope of the mainstem was calculated to be 5% or less based on GIS mapping. However, many other streams in the Upper Subbasin, such as WF SLR River, Agua Caliente Creek, and Carrista Creek contain significant stream reaches where the slope is greater than 5%. Sediment erodes from the steeper hillsides and is brought by tributaries and deposited into Lake Henshaw.

The Upper Subbasin is underlain by a basement of granitic rock. Roughly 30% of this granitic rock is covered by sedimentary deposits along major drainages. These sediments consist of unconsolidated, alluvial fill and to locally cemented sediments deposited sometime within the last 5 million years. The coarse unconsolidated nature of these sedimentary deposits allows them to hold and transport water. The underlying (sometimes more than 100 feet in depth) granitic rock acts as an aquitard making the overlying sediments essentially aquifers. The large Lake Henshaw area aquifer extends outward from the lake to Highway 79 with further upstream extensions along the W.F. SLR River and Buena Vista Creek (See Figure 6, p.12 of the Basin Profile).

Numerous wells populate the Upper Subbasin, which are used for irrigation, human consumption, and water storage. The VID, for example, utilizes 24 wells within its holdings surrounding Lake Henshaw to supplement water supplies to the lake (VID 2008). Cumulatively, these wells have various effects on the groundwater levels in the subbasin. In the southeast part of the subbasin, the water level in one well declined only about three feet from 1912 through 1967; however, in the central part of the subbasin, groundwater levels in wells declined 30 to 138 feet during the 1950s and 1960s (DWR 1971).

Sediment budget studies have estimated that coastal rivers and streams supply, on average, 70 to 90% of beach sand in California (Bowen and Inman, 1966; Best and Griggs, 1991). In southern California rivers, most sediment transport occurs during infrequent floods (Brownlie and Taylor 1981), but it is these energetic events that flood control dams are constructed to prevent. In the San Luis Rey River, which is one of the principal sources of sediment for the Oceanside littoral cell, Henshaw Dam reduced suspended sediment yield by 6 million tons, total sand and gravel yield by 2 million tons (Brownlie and Taylor 1981).

Although Henshaw Dam is utilized for water storage, it also functions as a sediment trap. According to a 1951 survey of Lake Henshaw, the capacity of the reservoir was found to be 194,300 acre-feet as compared to 200,000 acre-feet when it was first completed in 1922 (Lettieri-McIntyre and Associates 1995). This 3% decrease in the lake's capacity occurred over a relatively short period, 29 years. In addition to trapping sediment, the dam reduces peak flows. While the hydrologic controls in the basin, Henshaw Dam and the Escondido Canal diversion dam diminish the potential for property damage along the river downstream, they in turn, contribute to property damage along the coast by eliminating sediment supply to the protective beaches (California Department of Boating and Waterways and State Coastal Conservancy 2002). For the rivers contributing sediment to the Oceanside littoral cell, sediment from about 40% of the catchment area is now cut off by dams. Because the rate of longshore transport (a function of wave energy striking the coast) is unchanged, the result has been a sediment deficit, loss of beach sand, and accelerated coastal erosion (Inman 1989).

Vegetation

The Upper Subbasin, while containing large areas utilized as cattle and livestock grazing, retains native habitats over the majority of the subbasin. The predominant vegetation cover type as described by the USFS CALVEG data is mixed sagebrush/chaparral, covering 54.59% of the Upper Subbasin (Figure 4 and Table 4). This cover type is divided between lower montane/mixed chaparral, red shanks chaparral, and chamise vegetation types. Herbaceous was the second most abundant cover type at 16.38%. While there is a separate agriculture cover type, a large portion of the herbaceous cover type is most likely used for the grazing of cattle and other livestock, but is not accounted for since land use is often difficult to remotely ascertain. For this reason, it can be assumed that areas mapped as annual grasslands may also be agricultural in nature.

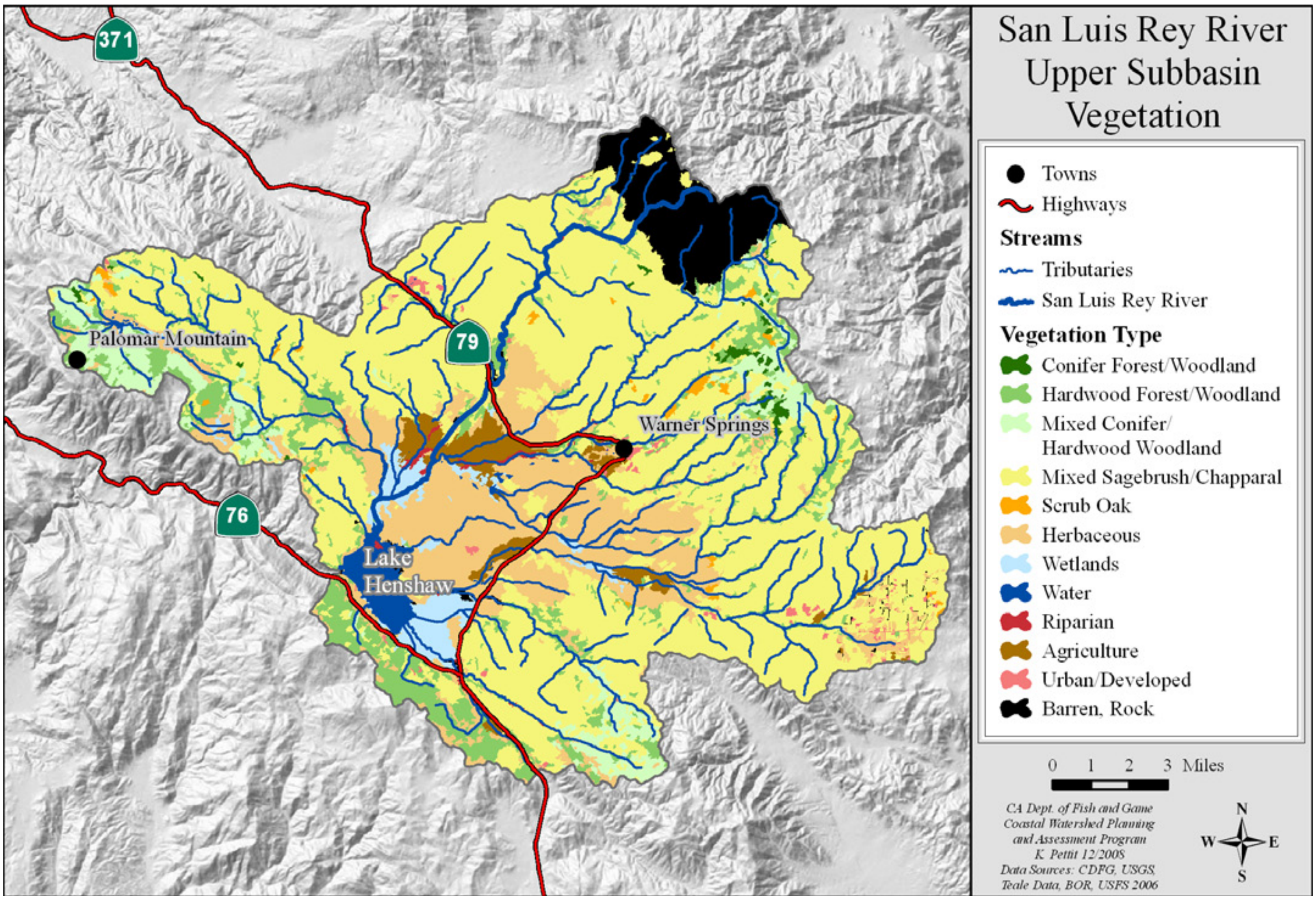
The third most abundant vegetation cover type is hardwood forest/woodland (10% of the subbasin). Coast live oaks make up a little over half of this cover type. Canyon live oak, black oaks, and Engelmann oaks compose the remaining vegetation types in this category. The rest of the cover types compose a significantly less amount of land. Mixed conifer/woodland and barren/rock cover types each compose approximately 5% of the subbasin. Although wetlands, mostly in the vicinity of Lake Henshaw, make up only 2.5% of the subbasin, they are an important ecological component of the subbasin as well as the basin as a whole. It is important to note the grasslands within the subbasin are some of the most extensive in southern California and the surrounding Engelmann oak woodland is the largest in the world (http://www.audubon.org/bird/iba 05/2009).

There is no significant urban/residential area in the Upper Subbasin. The majority of the residents are single family dwellings. About one third of the Upper Subbasin is under ownership of Native Americans, USFS, and other federal and state lands. Another quarter of the subbasin is owned by water districts, mostly the VID. In all likelihood, there seems little potential of rapid expansion of residential or commercial development in the near future.

Non-Native Plants

Non-native, invasive plants in the Upper Subbasin consist primarily of exotic grasses. The invasive species that are problematic in the Coastal and Southern subbasins are almost non-existent in the Upper Subbasin. Similar to many other areas of California, non-native annual grasses and forbs have displaced perennial native grasses within this subbasin. The deep roots of native grasses stabilize the soil, increase water filtration, and recycle nutrients (http://www.cnga.org/). Native grasslands also provide important habitat to numerous sensitive species, including, but not limited to: the northern harrier (*Circus cyaneus*), mountain plover (*Charadrius montanus*), burrowing owl (*Speotyto cunicularia hypugaea*), and the Stephens' kangaroo rat (*Dipodomys stephensi*) (Lettieri-McIntyre & Associates 1995).

Conversely, non-native grasses reduce the quality of forage and cover for wildlife. Once alien grasses become established it is difficult for native vegetation to recover. Non-native grasses germinate quickly, grow aggressive, and establish extensive fibrous root systems (Beyers et al. 1998). The faster aboveground growth rate of annuals (non-natives) results from their rapid uptake of available resources and results in a reduction in light for native seedlings. With their earlier development, exotic annuals may also effectively deplete soil resources before seedlings of native species have a chance to do so (D'Antonio et al. 2003). Oak regeneration is hampered by non-native grasses as they diminish the upper soil moisture


San Luis Rey River Upper Subbasin Vegetation

CA Dept. of Fish and Game
Coastal Watershed Planning
and Assessment Program
K. Pettit 12/2008
Data Sources: CDFG, USGS,
Teale Data, BOR, USFS 2006

Figure 4. Vegetation of the Upper Subbasin.

Table 4. Vegetation of the Upper Subbasin.

Vegetative Cover Type	Percent of Basin	Primary Vegetation Type	Percent of Cover Type
Mixed Sagebrush/Chaparral	54.59	Basin Sagebrush	0.8
		Buckwheat	4.3
		California Sagebrush	0.6
		Ceanothus/Mixed Chaparral	0
		Chamise	25.2
		Lower Montane Mixed Chaparral	34.7
		Manzanita Chaparral	1.4
		Upper Montane Mixed Chaparral	1.9
		Red Shanks Chaparral	30.2
		Other	0.9
Herbaceous	16.38	Annual Grasses/Forb Alliance	22.8
		Non-Native/Ornamental Grass	0.7
		Perennial Grasses and Forbs	76.5
Hardwood Forest/Woodland	10.14	Black Oak	23.4
		California Sycamore	0
		Canyon Live Oak	10.2
		Coast Live Oak	52.0
		Interior Live Oak	0.5
		Engelmann Oak	1.5
		Eucalyptus	0
		Interior Mixed Hardwood	12.1
		Non-native/Ornamental Hardwood	0
Mixed Conifer/Woodland	5.37	Bigcone Douglas - Fir	9.5
		Coulter Pine	52.1
		Mixed Conifer - Fir	11.8
		White Fir	24.1
		Mixed Conifer - Pine	2.5
Barren, Rock	5.18	Barren	98.9
		Urban-related Soil	1.1
Wetlands	2.47	Wet Meadows	100
Agriculture	2.39	Agriculture	100
		Orchard Agriculture	0
		Pastures and Crop Agriculture	0
Water	1.44	Water	100
Urban/Developed	0.58	Urban/Developed	100
Scrub Oak	0.55	Scrub Oak	100
Conifer Forest Woodland	0.48	Bigcone Douglas-Fir	2.1
		Coulter Pine	43.3
		Mixed Conifer - Fir	53.3
		White Fir	1.3
		Fremont Cottonwood	0
		Riparian Mixed Hardwood	60.6
		Riparian Mixed Shrub	0
		Willow (Shrub)	39.4

These statistics exclude the classification of water. Data from CALVEG & USFS.

content, which decreases the likelihood of acorns successfully sprouting. Gophers, whose population numbers generally increase in non-native grasslands, can devastate oak seedling establishment (Apostol et al. 2006). Moreover, other studies have shown that the presence of exotic annual grasses negatively influences reproduction of native perennials in California grasslands by reducing inflorescence number and seed output (D’ Antonio et al. 2003).

Land and Resource Use

Historic Land Use

Prior to the settlement of Europeans, the Upper Subbasin was inhabited by the local Native Americans comprised of the Cahuilla Indians and the Kuupangaxwichem Indians. The Spanish called the Kuupangaxwichem Indians the Cupeños, which has been adopted as the more commonly used name. The Cupeño and Cahuilla Indians of San Diego County belong to the Cupan subgroup of the Takic language family of Uto-Aztecan. This language is sometimes called Southern California Shoshonean (http://infodome.sdsu.edu/research/guides/calindians/insdcnty.shtml). The Cahuilla lived throughout Riverside County and in Northern San Diego County where they numbered from 6,000 to 10,000 people (http://www.kumeyaay.info/). Conversely, the Cupeños were one of the smallest tribes in California and lived primarily around what is now the Warner Springs area.

These Indian tribes had very little contact with the Spanish or any other outsiders until the early 1800s. The Cupeños lived in the Warner Springs area in two villages (Cupa was one of these villages), with each maintaining a clan leader, and were politically independent (Tetra Tech 2000). The Cupeño diet consisted of acorns, berries, seeds, cactus fruit, deer, quail, rabbits, and other small game. These villages were relatively undisturbed until the arrival of Spanish settlers in 1810, which soon established an inland outpost of coastal missions and began raising cattle on Cupeños land. As settler numbers increased in this region, the Indians began to work in serf-like relations to the newcomers. One of these newcomers was Juan Jose Warner, a naturalized Mexican citizen. Warner received a land grant from the Mexican Government on November 28, 1844, which encompassed much of the Cupeños land. A failed revolt attempt in 1948 against all foreign invaders to the region led to the burning of the village of Cupa (http://www.palatribe. com/). As the hot springs and other resources located on Cupa territories became more popular, the desire to expel the native people increased. Eventually, through a 1903 court case involving the former governor of California claiming rights to the Warner Springs area on Cupeños land, the Cupeños were forced to relocate to the Pala Indian Reservation. This reservation was a Luiseño Indian Reservation; thereby, forcing two distinct Indian tribes to gather on one reservation. The 40-mile journey from Cupa to Pala took three days (September 4-6, 1903), which the Cupeños refer to as their “Trail of Tears” (http://www.palatribe.com/).

The Cahuilla Indians were divided into roughly a dozen independent clans that contained 500 to 1200 people. Similar to the Cupeños, the Cahuilla became a part of the labor force for the Spanish and Mexican settlers. Europeans had damaging effects on the Cahuilla people; most noteworthy was the death of perhaps 80% of their population from European diseases. The Europeans also took over most of the Cahuilla land, which combined with the population decrease lead to the gradual loss of Cahuilla political autonomy (http://www.manataka.org/). Eventually, the Cahuilla in the Upper Subbasin formed the Los Coyotes Band of Mission Indians and currently maintain some of their culture and traditions on the reservation.

Agriculture

The grazing of cattle, sheep, and horses was the principle form of agriculture developed in the Upper Subbasin. Livestock was grazed in the valley bottoms before Lake Henshaw was created and, subsequently, around the lake. A few crops, such as grapes and various tree fruits, were grown near water sources.

Water Storage

From 1893 to 1895, the Escondido Irrigation District constructed the thirteen mile long Escondido Canal that brought SLR River water by gravity flow from the canal’s intake (RM 40) on the La Jolla Indian Reservation into the adjacent Carlsbad Watershed to what is now Lake Wohlford. When built, the canal’s carrying capacity was approximately 40cfs. If there were additional flows, such as following significant rain events, these flows were passed on downstream in the riverbed. The canal’s carrying capacity has since been increased to its current carrying potential of 70cfs (http://www.vid-h2o.org/home/index.asp). Shortly after the canal was completed, Vista Irrigation District’s predecessors, William Henshaw and San Diego County Water Company, obtained water rights along the SLR River and completed the construction of Henshaw Dam (1922), located approximately ten miles upstream from the intake of the Escondido Canal. The dam’s primary purpose at the time of construction was to provide water for downstream agricultural needs (Hazel et. al 1975). The dam began the delivery of water to the City of Escondido in 1925 and the VID in 1926 (SLR Watershed Council 2000).

Current Land Use

Current land use in the Upper Subbasin is limited by ownership designation and general terrain. Cumulatively, the Los Coyotes Indian Reservation, state park lands, the Cleveland National Forest and Bureau of Land Management compose over one-third of the subbasin. The VID is the largest landowner in the subbasin as well as in the entire SLR River basin.

Scattered dwellings occur within the subbasin; however, open space and rangeland are the predominant land uses. Human activities, such as water extraction and storage, agriculture, and to a lesser extent tourism/recreational opportunities associated with Warner Springs and Lake Henshaw, play a large role in shaping the landscape and the natural resources within the subbasin.

Agriculture

Agriculture in the Upper Subbasin is dominated by cattle grazing around Lake Henshaw and nearby surrounding areas. Fruit trees, grapes and other crops occupy a less significant amount of land in the subbasin. The steep, rugged, relatively dry terrain also limits the potential for crop production.

In a three-year study (1999-2002) on the Warner Ranch surrounding Lake Henshaw, Atwill and Tate (2003) examined the cattle ranching and its effects on the water resources of the area. Specifically, this study: 1) evaluated the risk that livestock poses to drinking water resources on the Warner Ranch (The Ranch); 2) evaluated current grazing management and stocking levels on The Ranch comparative to sustainable forage production and conservation of natural resources; and 3) developed recommendations for livestock and grazing management options to achieve a balance between viable livestock production and water quality and natural resources protection. Scientists determined a risk to source water due to the presence of *Cryptosporidium parvum*, a pathogen species found in livestock feces that causes parasitic diseases. The risk was greatest in the form of direct deposition of the cattle, particularly from calves, into Lake Henshaw and waterways leading to the lake. While the risk is off-set by significant thermal inactivation and the high infiltration capacity of The Ranch's soil, the risk is greatest during high rainfall years, under saturated soil conditions, with the potential for overland transport of the pathogen to waterways and the lake. Their study goes on to state the following:

> Forage resources are in a degraded condition. Of specific concern is inadequate residual forage cover contributing to a lack of plant diversity in the forage base, a diminished seed base, poor seedling establishment conditions, significant bare soil, and degraded riparian plant communities. This results from periods of grazing beyond the Ranch's carrying capacity, as well as a recent period of severe drought. Annual rangeland and riparian areas on The Ranch are resilient, and will recover with moderation of grazing pressure given average or above average rainfall conditions.

The report outlined management options to reduce or minimize the potential for source water contamination as well as improve natural resource protection/ restoration. Utilizing some of these management recommendations, the Ranch has implemented rotational grazing and constructed cattle fencing around Lake Henshaw to minimize source water contamination and protect biological resources. More management options could be applied, such as erecting cattle exclusionary fencing around more inlet streams and restoring riparian habitat.

In addition to these concerns associated with grazing around the lake, agriculture plays a role in diverting surface flows in streams in the subbasin and overall groundwater supplies. These water extractions place stress on the water demands of riparian plant species and most likely reduce stream surface flows in the subbasin.

Water Storage and Extraction

Henshaw Dam, which controls 206 square miles of the drainage basin, is the principle hydraulic control of the basin. The original storage capacity of the lake was 200,000 acre-feet, but due to dam safety concerns because of potential seismic activity, sediment accumulation, and recent drought conditions the lake's capacity has been greatly reduced and generally does not even approach it current storage capacity of 52,000 acre-feet. After a dry spring, the lake's capacity in July, 2008, had receded to 10,251 acre-feet, only 20% percent of its potential capacity (http://www.vid-h2o.org/home/index.asp). Presently, Lake Henshaw functions as an important source of water for human use. The VID owns Lake Henshaw and controls flow releases into the SLR River downstream, where most, if not all of the flows, are diverted into the Escondido Canal. The canal's current carrying capacity is approximately 70cfs. Only during periods of canal maintenance or extreme winter flows is some water allowed to continue down the SLR River below the Escondido Canal diversion dam.

Numerous wells, located primarily around the lake, continue to supplement the overall water supply in the lake. The VID is the primary water supplier to the Rincon Indian Reservation, the City of Escondido, and Vista. Approximately two-thirds of the water is used for residential use, with the remaining contributing to irrigation, agriculture, and commercial/industrial uses (http://www.vid-h2o.org/home/index.asp).

Tribal Indian Lands

Approximately 12% of the Upper Subbasin is in tribal reservation land. This area is made up of the Los Coyotes Band of Mission Indians and the Santa Ysabel Band of Mission (Diegueño) Indians reservations. The Los Coyotes Reservation is located between Anza Borrego State Park and the Cleveland National Forest in the headwaters of the Agua Caliente Creek, Cañada Verde Creek, and San Ysidro Creek. Situated in this remote region of southern California mountains, the nearly 25,000 acre reservation is the largest Native American reservation in San Diego County. The tribe has about 288 enrolled tribal members, of which only 74 live on the reservation (http://www.kumeyaay.info/); the tribal lands are sparsely populated with mostly single family dwellings.

The Santa Ysabel Reservation has approximately 700 members and is composed of three tracts of land that total 15,000 acres. These tracts are located east of Lake Henshaw, on the north and south sides of Highway 79 between the towns of Santa Ysabel and Warner Springs. The largest tract, which includes the tribal offices, most of the tribe's residents, and the tribe's new casino is situated on the slopes of the Volcan Mountains. The tribe's newly constructed casino opened in April, 2007 with the hope of providing much needed income for the poverty-stricken tribe (Sifuentes 2007).

Urbanization

Most of the Upper Subbasin remains rural in nature with low-density housing and small to large scale agricultural operations. The only incorporated community in the subbasin is the small, resort town of Warner Springs, located in the north-central part of the subbasin. Warner Springs got its namesake from the naturally occurring springs that are located within the vicinity of the resort. As described above, the subbasin is home to the small populations of the Los Coyotes Band of Mission Indians and the Santa Ysabel Band of Mission (Diegueño) Indians.

Recreational

Lake Henshaw remains a popular recreational spot for local and regional residents. The lake provides angling opportunities for a variety of warm water game fish, such as largemouth bass, bluegill, green sunfish, crappie, channel catfish, bullhead, and common carp. Hunting of waterfowl is very popular on the lake and its surrounding area. A campground and cabin rentals are located on the south side of the lake as well.

The Cleveland National Forest occupies a large portion of the northwestern corner of the subbasin. Most of this land is within the West Fork SLR River drainage. Hunting, hiking, fishing, picnicking, and other activities are available on these lands. The Pacific Crest Trail generally meanders from north to south through the Upper Subbasin, crossing near the town of Warner Springs and heading southeast around Lake Henshaw and continues southward out of the basin.

The Los Coyotes Indian Reservation has a campground and offers camping, hiking, horseback riding, and off-road activities on the reservation lands.

Fish Habitat Relationship

Fishery Resources

Currently, there is a self-sustaining, native rainbow trout population in the West Fork SLR River, which indicates suitable trout/steelhead habitat is present in the subbasin. While anecdotal and documented accounts of steelhead in the SLR River indicate a productive fishery in the lower to middle mainstem below the Middle Subbasin and in tributaries such as Pauma Creek, historical documentation of steelhead in the Upper Subbasin is somewhat limited. Nonetheless, the first written evidence of native trout in San Diego County comes from a note in an article by Dr. J.G. Cooper from a scientific collection expedition he conducted in 1862 in the Cuyamaca Mountains. He reported that: "trout and stickleback are found no nearer than Warner's Pass fifteen miles north of San Felipe at the head of the San Luis Rey river" (Cooper 1874). This indicates the mainstem and most likely the West Fork SLR River, at minimum, would be included in observed trout presence in the Upper Subbasin prior to any introduction of fish from outside the basin. Supporting evidence of a historical trout population in the Upper Subbasin includes a 1979 chromosome analysis and electrophoretic analysis of proteins from trout taken from the West Fork SLR. In this analysis, the U.C. Davis geneticist, concluded, "it seems likely that the West Fork population is composed predominately of fish native to the region" (Thorgaard 1979). Considering the SLR River had prior year-round connectivity (except low water years) to the Pacific Ocean and stream conditions would have been dramatically different prior to dam construction, it is certainly possible that ocean-run *O. mykiss* (steelhead) could have utilized the streams in the Upper Subbasin during normal to above average rainfall years.

Hatchery raised rainbow trout were once stocked in the West Fork SLR River and may have been stocked in other streams in the Upper Subbasin. The earliest records of stocking in the West Fork occurred in the

1893. These trout were the progeny of wild trout collected from the Pit River, raised in the Sisson hatchery, and then shipped by railroad car to many areas in Southern California for stocking purposes. These fish represented the original Shasta strain of rainbow trout (Bottroff and Deinstadt 1978, *draft*).

Arroyo chub, *Gila orcutti*, is the only other native fish that still inhabits the subbasin. Known populations are located in the West Fork SLR River and Agua Caliente Creek (Stephenson and Calcarone 1999). These are small populations in limited, perennial flowing reaches of these creeks.

Warm water game fish, were introduced into Southern California lakes in the 1940s and were most likely stocked in Lake Henshaw during this period or shortlythereafter. These non-native fish, described in the "Exotic Fish Species" section of the Basin Profile (pp.68-69), were intended to provide an additional recreational fishery to this inland reservoir. These fish continue to thrive in the lake and even in the SLR River downstream of the dam.

Figure 5. Rainbow trout caught in W.F. SLR River (photo taken in April, 2008).

Habitat Overview

Historic Conditions

Before the completion of the Henshaw Dam, the SLR River was a perennial flowing river. Based on historic SLR River stream flow data recorded during a ten-year period from 1912 to 1922, near the current dam location, the SLR River maintained minimum monthly flows above 1.4 cfs during the summer months and greater than 8 cfs during the winter and early spring (Jones and Stokes Associates, Inc. 1976). Mean monthly flows were much higher, especially during the precipitous portion of the year, December through mid-March were mean monthly flows ranged from 50 cfs up to 254 cfs (see Middle Subbasin, Figure 5, p. 12). These flows were aided by the numerous tributaries that flowed from the surrounding mountains into the SLR River in the present-day Lake Henshaw area.

Historic and more recent surveys in the Upper Subbasin have mostly occurred in the West Fork SLR River and in Agua Caliente Creek (Table 5). In the West Fork SLR River surveys, rainbow trout were identified through electro-fishing, rod and reel, and stream bank observations. Generally, the reports stated suitable spawning and rearing conditions were present for trout. However, the presence of exotic game fish (green sunfish and bullheads) was also noted. The two Agua Caliente Creek surveys performed in the early 1950s had somewhat conflicting accounts of habitat available for trout. One survey dismissed the stream as a potential trout stream, describing the stream as having poor substrate and most likely high summer water temperatures; the other report, while acknowledging the lack of ideal habitat, still concluded that the creek may be a viable option for developing a modest fishery. Conditions in Agua Caliente Creek may have been representational of other streams in the Upper Subbasin, such as San Ysidro Creek and Mataqual Creek, which contained sections of perennial stream flow, potentially providing areas of rainbow trout habitat.

Table 5. Habitat observations made in the Upper Subbasin from 1862-2008.

Stream	Date Surveyed	Source	Habitat Comments	Barrier Comments
W.F. San Luis Rey River	06/09/1978	CDFG 1978	Surveyed between upper and lower falls, approximately 3 miles upstream its confluence w/ Lake Henshaw. Stream flow was high, with an above average cfs of 6-7. The water temperatures ranged from 52°F to 68°F. The surveyor reported a high canopy density and heavily oxygenated water with numerous falls. Substrate consists of numerous large boulders with sufficient spawning gravels. Stream supports "a large population of trout mostly in the 7-8" range with a fair number of 10-11" size group. The quantity of trout is surprising considering that the streams has undergone a three year drought period." Green sunfish were abundant the prior year, but only one was caught on this survey.	Rainbow trout are limited to the surveyed area. The upper falls is a barrier to upstream migration and the lower falls is a barrier to downstream out-migration and would prevent in-migration from downstream.
	7/21/1997	CDFG 1997	Surveyed area was 3 miles upstream of the "penal colony," which is just upstream the confluence with Lake Henshaw. Water temperature was 68°C at 13:30, pH was 8.3, and total alkalinity was 135 milligrams per liter. Riparian vegetation consisted of mature alder and canopy closure near 100%. Stream gradient was 4.8%. River flow was "limited to standing pools, sometimes connected by overland flow." Three pass sampling yielded 57 rainbow trout and one brown bullhead. Spot shocking confirmed the presence of young of the year (YOY) rainbow trout and green sunfish.	None described within sampled area.
Agua Caliente Creek	12/20/1951	CDFG 1951	Surveyed lower and middle sections of stream. Lower creek: Est. flow was 2-3 cfs, average width 8 ft, average depth 3-4 feet with a predominantly sandy bottom. Sparse canopy, poor habitat for fish, and this section of the creek likely dries up in spring. Upper creek (3 miles upstream): live alder and willow trees, steeper gradient, a few areas that had the "appearance of a permanent water area," but pools were only fair and stream substrate mostly sand. Overall, "no area observed could be considered good trout water and it is doubtful whether any section examined is worthy of any development primarily due to the unstable bottom and probably high summer water temperatures."	Approximately 3 1/2 miles upstream is an 8-10 foot waterfall that acts as an impassible barrier to fish life.
	10/31/1952	CDFG 1952	Survey began in Lost Meadows and went upstream. Stream flow was "10 miner's inches" (0.20cfs). Stream was well shaded with cedars and alders throughout its length. Streambed altered between sandy bottom, bedrock, and boulder dominated areas. The biologist concluded, "the valley and canyon, marginal as they may seem, could be developed and a modest fishery developed. It is a wilderness, never apt to attract many, but an effort should be made to improve it, for such primitive areas are not abundant."	No impassible barriers noted.
Upper Subbasin streams	1862	Dr. J.C. Cooper	Noted trout and stickleback in the stream(s) north of Warner Pass.	No impassible barriers noted.

Current Conditions

Due to the location of the Henshaw Dam blocking all fish passage into the Upper Subbasin, tributaries in the Upper Subbasin were not surveyed by the CDFG for the sake of this assessment. Located almost entirely within the Cleveland National Forest, the West Fork SLR River contains a self-sustaining, native residential rainbow trout population. In the West Fork SLR, rainbow trout are limited to a three-mile reach approximately three miles upstream its confluence with Lake Henshaw. This reach is defined by an upper and lower falls, maintaining perennial flows between these falls. A mature riparian with an extensive canopy, suitable spawning gravels, deep pools and other elements of complex habitat are found in this section.

In the recent past (1997), bluegill and brown trout were present in this area. These exotic fish may predate on the early lifecycle stages of trout. Access is limited into the trout inhabited areas; hence, angler use is considered light.

In addition to the West Fork SLR River, other streams in the Upper Subbasin contain suitable trout habitat. The following brief descriptions of these tributaries are based almost entirely on information provided by members of the local San Diego Trout organization who have spent time surveying these creeks and/or know their historical fisheries background.

- Carrizo Creek: rainbow trout habitat located in upper mountainous areas, as lower creek goes dry;
- Mataqual Creek: always runs dry in its lower section as the flow goes subsurface, but abundant rainbow trout habitat is located upstream of the scout camp;
- San Ysidro Creek: small section of stream, in the valley contains perennial flows. Rainbow trout were first recorded near this section in 1863;
- Cañada Verde Creek: has rainbow trout habitat within the perennial section of Eagles Nest, as a spring is dammed with a small, but constant rainbow trout pond;
- Aqua Caliente Creek: contains small, perennial sections of creek utilized by arroyo chubs that overlaps potential rainbow trout habitat;
- Lost Valley Creek (an upper tributary of Agua Caliente Creek): also has a short, perennial section, which has rainbow trout habitat;
- Will Valley Creek (tributary to the W.F.): maintains a small, perennial section of creek providing rainbow trout habitat consisting of deep, rock-pools;
- Iron Springs Creek: also contains a perennial section of creek with rainbow trout habitat.

All of these tributaries are ephemeral streams that retain smaller sections with perennial flows and rainbow trout habitat. Aqua Caliente Creek also holds arroyo chub in its perennial areas.

While these tributaries are suitable for rainbow trout, significant basin challenges such as, downstream barriers and sufficient water flows would prevent steelhead from utilizing these streams anytime in the near future.

Habitat Conclusions

The SLR River and its tributaries in the Upper Subbasin are currently inaccessible to anadromous steelhead trout due to the presence of Henshaw Dam, Escondido Canal diversion dam, and multiple other fish passage barriers located downstream of the subbasin. Considering the Upper Subbasin is completely inaccessible to steelhead, streams were not surveyed in this subbasin. Relatively little historic and current information is available on many of the streams in the Upper Subbasin.

The occurrence of a self-sustaining, native rainbow trout population in the West Fork SLR River indicates suitable trout/steelhead habitat is present in the subbasin. Other streams such as Mataqual Creek, San Ysidro Creek, and Aqua Caliente Creek also have the potential to support small trout populations in perennial sections of their respective creeks. All of the streams in the Upper Subbasin, including the West Fork SLR River, are generally limited by low flow or complete absence of surface flows. High water temperatures and low dissolved oxygen levels could be a limiting factor in some of these streams as well. Barriers in the form of natural waterfalls limit fish passage on the West Fork SLR River to a roughly three mile stretch of creek, approximately three miles upstream of its confluence with Lake Henshaw. There is relatively little information available as to whether natural or man-made barriers exist on the other streams that may impede the movement of fish.

Warm water game fish are present in Lake Henshaw and have been found in the West Fork SLR River. Green sunfish and largemouth bass were observed in CDFG surveys in 1966 and 1997, and most recently bullhead were observed in an upper section of the West Fork SLR River. These warm water game fish will predate on all early life cycle stages of trout; however, removal of non-native species from a stream is very difficult and these fish may provide a threat to the trout for foreseeable future.

Restoration Projects

Restoration projects within the subbasin have been limited to those performed by local landowners, the Cleveland National Forest Service, and the Los Coyotes Indian Tribe. Even though trout exist in the subbasin, there is little evidence of any habitat improvement projects within the subbasin. The CalFish website did not list any agency or organization funded stream restoration projects in the subbasin (CalFish is a multi-agency program for collecting, standardizing, maintaining, and providing access to quality fisheries data and information for California.).

Projects that have occurred, or are currently underway, which have improved stream habitat conditions or contributed to the monitoring of stream habitat conditions include water quality control through monitoring and altering grazing practices around Lake Henshaw and streams to minimize animal waste transport into waterbodies.

Information on other watershed stream restoration projects can be found on CalFish (www.calfish.org) or on the Natural Resources Project Inventory online database (www.ice.ucdavis.edu/nrpi/).

Stream Habitat Improvement Recommendations

Stream habitat improvement recommendations are generally developed based on results from stream surveys conducted along potential salmonid bearing stream reaches. The Upper Subbasin streams are, however, inaccessible to steelhead and would require numerous fish passage/instream habitat improvement projects downstream to provide access into the Upper Subbasin. The mission of the CDFG's Coastal Watershed Assessment Program's is primarily to assess and develop recommendations for stream habitat that is available or could potentially be available for anadromous fish; therefore, because of the numerous obstacles for successful fish migration into the subbasin, CDFG chose not to survey the streams in the Upper Subbasin. Thus, stream habitat improvement recommendations are limited to general guidelines for improving riparian areas, water quality and quantity, and instream habitat for native trout populations in the subbasin. These are discussed in the Issues and Responses to Assessment Questions section below.

Refugia Areas

The interdisciplinary team identified and characterized refugia habitat in the Upper Subbasin by using professional judgment and criteria developed for southern coastal watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, stream flows, agriculture and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity.

The most complete data available in the Upper Subbasin were for the West Fork SLR River, which was last surveyed by CDFG during the summer of 1997. Trout habitat conditions in the Upper Subbasin on surveyed streams are generally rated as medium potential/low quality refugia.

A literature review did not contain any current references to trout in any of the other tributaries with the subbasin. While trout were historically noted in at least one other stream, San Ysidro Creek, further field studies are needed to determine the habitat suitability and limiting factors for trout production in these streams if fish passage/instream habitat improvement projects were to occur. The CDFG Wild Trout Program has plans to survey portions of the West Fork SLR River in 2008 to evaluate current habitat, general status of the trout population, and presence/absence of exotic game fish. The following refugia area rating table summarizes subbasin salmonid refugia conditions.

Table 6. SLR River and tributary salmonid refugia ratings in the Upper Subbasin.

Stream	**Refugia Categories**				**Other Categories**		
	High Quality	**High Potential**	**Medium Potential**	**Low Quality/Low Potential**	**Passage Barrier Limited**	**Critical Contributing Area**	**Data Limited**
SLR River							x Needs survey
W.F. SLR River			X		X		
Mataqual Creek							x Needs survey
San Ysidro Creek							x Needs survey
Cañada Verde Creek							x Needs survey
Aqua Caliente Creek							x Needs survey
Lost Valley Creek							x Needs survey

Key Subbasin Issues

- Southern California Coast Steelhead are currently blocked from accessing potentially suitable habitat in the Upper Subbasin due to the presence of Henshaw Dam, Escondido diversion dam and multiple other fish passage barriers located downstream of the subbasin;
- The West Fork SLR River is currently the only stream in the subbasin to maintain resident, native trout populations;

- Warm water game fish, present in the Lake Henshaw, West Fork SLR River, and potentially other streams in the subbasin pose a threat to trout successfully completing their early lifecycle stages;
- Without sufficient precipitation to sustain surface flows, many streams in the Upper Subbasin contain only small sections of perennial flows.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations in the Subbasin?

Findings and Conclusions

- Prior to any introduction of hatchery raised fish, trout were observed in the Upper Subbasin streams north of Warner's Pass (Cooper 1874). At minimum, this includes the mainstem and the West Fork SLR River;
- A native, self-sustaining rainbow trout population is present in the West Fork SLR River;
- Due to downstream barriers, ocean-run steelhead do not have access into the subbasin;
- In order to accommodate a strong demand for a recreational fishery, exotic game fish were most likely stocked in Lake Henshaw, beginning in the late 1940s, and are abundant today in the lake and have been observed in the West Fork SLR River.

What are the current salmonid habitat conditions in the Upper Subbasin? How do these conditions compare to desired conditions?

Findings and Conclusions:

Flow and Water Quality:

- Stream flows are seasonal in all streams in the Upper Subbasin with some streams maintaining areas with year round water. Low water flow most likely influences water quality and instream water temperatures;
- During these low-flow conditions, water quality and instream water temperatures may be unfavorable to trout;
- Periods of grazing cattle beyond the Warner Ranch's carrying capacity and severe drought have degraded water quality and riparian plant communities in streams and in Lake Henshaw (water quality);
- The numerous wells located on the Warner Ranch may reduce the amount of water available for riparian species and reduce overall surface flows in the SLR River or its tributaries;
- In general, there is a lack of water quality data on the streams in the Upper Subbasin.

Erosion/Sediment:

- There is a lack of data concerning erosion/sediment in the streams of the Upper Subbasin.

Riparian Condition/Water Temperature:

- Generally, streamside canopy appeared to be lacking in many of the subbasin's streams lower reaches near their terminus into Lake Henshaw. These streams' canopy cover may increase further upstream;
- According to a 1978 West Fork SLR River survey report, the three mile section that maintains a trout population contained a mature riparian with nearly 100% canopy closure. More recent surveys on the West Fork have noted the existence a suitable riparian canopy;
- Water temperature data is lacking in the streams in the subbasin. Without an extensive canopy and coldwater seeps, it seems likely that instream water temperatures during the summer and early fall extreme period would be unfavorable for trout.

Instream Habitat:

- None of the streams in the Upper Subbasin were surveyed as a part of the watershed assessment; therefore, the condition of instream habitat in the subbasin's streams is relatively unknown;
- Previous surveys on the West Fork SLR River have noted suitable habitat conditions for trout such as, suitable spawning gravels, presence of moderate to deep pools, and mature canopy cover;
- Warm water game fish are present in the West Fork SLR River and could inhabit other streams in the subbasin. These fish would predate on the various lifecycle stages of trout.

Gravel/Substrate:

- Based on the self-sustaining, resident trout population in the West Fork SLR River, suitable salmonid spawning areas are available in this stream. Other streams with similar geology may possess spawning gravels as well.

Refugia Areas:

- Salmonid habitat conditions in the Upper Subbasin are generally considered unknown as far as potential refugia due to the lack of recent surveys. The West Fork SLR River was considered medium potential because of its current trout population and its watershed boundaries located almost entirely within the Cleveland National Forest;
- The subbasin is currently inaccessible to steelhead. Numerous downstream fish passage barriers would need to be modified in order to allow trout to have access to the area. The limited sections of permanent stream flow would be a limiting factor for potential refugia areas for trout.

Barriers:

- In the West Fork SLR, rainbow trout are limited to a three mile reach at approximately three miles upstream of the confluence with Lake Henshaw, where they are confined by an upper and lower falls;
- Fish passage barriers may be present on some of the streams that drain into Lake Henshaw. Stream surveys are needed to determine the presence/absence of any potential barriers.

What are the impacts of geologic, vegetative, fluvial, and other natural processes on watershed and stream conditions?

Findings and Conclusions:

- Weathering of the granitic rocks has created younger unconsolidated sediments that are very susceptible to enhanced erosion and mass movement such as landslides and debris-flows;
- The Upper Subbasin is in a potentially seismically active area as the basin is bordered by the San Andreas Fault Zone to the north and the Elsinore Fault Zone to the south. While the San Jacinto Fault Zone cuts through the middle of the subbasin;
- Large seismic events, especially when coupled with large storm events, can trigger large landslides and mudflows increasing sediment delivery to the streams and altering their hydrologic condition;
- If situated near or above artesian wells, these faults may also cause the natural upward migration of water, creating seeps, springs, and potentially surface flows. For example, water moving up the Agua Caliente Fault forms Warner Springs, demonstrating that the fault affects subsurface flow at this location.
- Due to sediment accumulations and recent drought conditions Henshaw Dam functions well below its current potential capacity. It the summer of 2008, the dam's water storage was less than 20% of its potential capacity;
- The 2007 Poomacha Fire did not burn within the Upper Subbasin, but several wildfires have occurred within the subbasin since 2002 and future wildfires are likely to occur. Post-fire erosion potential has been estimated as moderate to low for most of this subbasin (USGS).

How has land use affected these natural processes?

Findings and Conclusions:

- Cattle's grazing on the Warner Ranch has previously degraded water quality in subbasin streams and in Lake Henshaw; however, recent implementation of seasonally appropriate grazing rotation on Warner Ranch has minimized the potential for water quality contamination:
- Prior over-grazing has negatively affected riparian communities on many inlet streams to Lake Henshaw;
- Water extraction by numerous wells in the subbasin may reduce water available to riparian species and overall surface flows in streams;
- Various land uses have caused the spread of non-native plant species, particularly non-native grass species, throughout the subbasin altering the landscape and vegetation communities.

Based upon these conditions, trends, and relationships, are there elements that could be considered to be limiting factors for steelhead/trout production?

Findings and Conclusions:

Based on available information for this subbasin, it appears that salmonid populations are limited by:

- Steelhead trout currently do not have access into the subbasin due to Henshaw Dam, the Escondido Canal diversion dam, and numerous downstream fish passage barriers;
- Available instream habitat is limited to isolated sections of streams containing perennial flows;
- Water quality and water temperatures may be unfavorable for trout in many streams in the subbasin;
- Reduced riparian habitat on many subbasin streams' lower reaches;
- Presence of predatory warm water gamefish.

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

<u>Barriers to Fish Passage:</u>

- Information on potential fish passage barriers is mostly limited to the West Fork SLR River. CDFG is not aware of barriers on the other streams in the subbasin, but this is mostly due to the lack of surveys performed on these creeks. General surveys of these streams would be necessary to identify and determine if efforts are needed to alleviate fish passage impediments at culverts or other public or private road crossings.

<u>Flow and Water Quality:</u>

- Insure that water diversions used for domestic or irrigation purposes bypass sufficient flows to maintain all needs of fishery resources;
- Recommendations to improve water quality and riparian areas on the Warner Ranch are derived from Atwill and Tate (2003), whose three-year study outlined management options to reduce the risk to source water and establish sustainable forage production to grazing pressure ratios:

- Minimize grazing of dairy heifers in pastures with direct access to Lake Henshaw to reduce direct fecal deposition to the lake;
- Minimize contact between calf manure and inlet streams from March through July, the period of high calf infection rates;
- Minimize contact between dairy heifer manure and inlet stream channels from October through April (rainfall-runoff season) and during months when surface flows are present.

<u>Erosion and Sediment Reduction:</u>

- Continue to identify and reduce sources of sediment delivery to stream channels from road systems;

- Re-vegetate exposed stream banks and/or install structures to increase bank stability.

Riparian and Instream Habitat:

- Perennial wetlands and riparian areas should maintain livestock exclusionary fencing so that prescribed grazing management can be applied to these sensitive areas. Create offsite watering areas;
- Consider planting barren nearstream areas with willow, cottonwood, or sycamore trees to increase streamside shade canopy and allow for woody recruitment.

Education, Research, and Monitoring:

- Continue, expand, or develop education programs concerning water conservation, water quality, and the importance of watershed/riverine ecosystems;
- Conduct habitat surveys to determine habitat suitability and the presence/absence of fish species on: Carrizo Creek, Mataqual Creek, San Ysidro Creek, Cañada Verde Creek, and Aqua Caliente Creek;
- Perform habitat survey and trout population estimate on the West Fork SLR River;
- Research the possibilities of removing exotic, warm water game fish from the West Fork SLR River;
- Conduct water quality and temperature monitoring on the West Fork SLR River over several years to characterize instream conditions and potentially provide reference values for basin and the regional wild trout fishery.

Subbasin Conclusions

While the Upper Subbasin still retains large areas of native habitats, various land uses has altered the overall function of the upper watershed. Similar to the Middle Subbasin, steelhead once utilized the mainstem and its tributaries within the subbasin; however, it is currently not accessible to steelhead trout. Numerous fish passage barriers downstream prevent steelhead from accessing the Middle and Upper Subbasins and would require mitigation in order for steelhead to access these subbasins.

The West Fork SLR River is inhabited by native rainbow trout and arroyo chub; chub are also found in Aqua Caliente Creek. While instream habitat conditions are suitable for trout in these streams, there is little information available concerning the overall amount of suitable habitat in the streams of the subbasin. Further surveys are needed to determine general habitat suitability and the presence/absence of potential fish passage barriers. Much of the land surrounding Lake Henshaw is utilized for livestock grazing and there appears to be very little habitat associated with this area as riparian areas along the inlet streams have been severely reduced or in many cases, completely eliminated. Generally, these streams retain perennial surface flows only in smaller reaches that are limited to the mid to upper portions of their drainages. Numerous wells that are used to help supplement overall water supplies in Lake Henshaw may reduce water availability in lower stream reaches.

Warm water game fish provide an important recreational opportunity in Lake Henshaw. A few of these game fish may be present in some of the streams in the subbasin, such as West Fork SLR River. These fish would present a predatory problem for the early to mid-lifecycle stages of juvenile trout.

While some suitable habitat is available for steelhead/trout in the Upper Subbasin within the West Fork SLR and potentially other streams (e.g., Agua Caliente Creek, Mataqual Creek and San Ysidro Creek), utilizing restoration opportunities in the lower watershed and the Northern Subbasin tributaries would be more beneficial to re-establishing steelhead populations in the watershed. Overall length of migration, numerous fish passage barriers, varying, unreliable flow rates, and Lake Henshaw containing large populations of exotic predatory fish are all detrimental to the likelihood/feasibility of sustaining steelhead runs in the Upper Subbasin. Nonetheless, efforts should be made to preserve water quantities and water quality in streams and waterbodies as well as restoring/improving riparian areas in the subbasin.

APPENDIX I

References Cited

References Cited

Anton, M. (2008, March 2). The hills are green, but all's not well. The Los Angeles Times website.

Apostol, D. and M. Sinclair. 2006. Restoring the Pacific Northwest: The art and science of ecological restoration in cascadia. Society for Ecological Restoration International. Island Press, Washington D.C.

Atwill, E. R., K. W. Tate, and P. Dorey. 2003. Integrated *Cryptosporidium parvum* assessment and grazing management plan. University of California, Davis, CA and Vista Irrigation District, Vista, CA.

Barnhart, R. A. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) – steelhead. USFWS Biol. Rpt. 1. 121pp.

Bell, G. P. 1997. Ecology and Management of *Arundo donax* and approaches to riparian habitat restoration in southern California. In Plant Invasions: Studies from North America and Europe, eds. J. H. Brock, M. Wade, P. Pysêk, and D. Green. Pp. 103-113. Backhuys, Leiden, the Netherlands. NM.

Beyers, J. L., C. D. Wakeman, P. M. Wohlgemuth, and S. G. Conard. 1998. Effects of postfire grass seeding on native vegetation in southern California chaparral. In: Proceedings of the 19th forest vegetation management conference; 1998 January 20-22; Redding, CA. Sacramento, CA.

Bobbitt, D. H. 1993. Improving seismic safety of dams in California. Department of Water Resources, Sacramento, CA.

Bond, M. and C. Bradley. 2006. Recommend critical biological zones in southern California's four national forests: Los Padres, Angeles, San Bernardino, and Cleveland. Center for Biological Diversity.

Bottroff, L. J. and J. M. Deinstadt. 1978. California wild trout management program, West Fork San Luis Rey River Management Plan *DRAFT*. California Department of Fish and Game, Inland Fisheries Branch, Sacramento, CA.

Boughton, D.A., H. Fish, K. Pipal, J. Goin, F. Watson, J. Hager, J. Casagrande, and M. Stoecker. 2005. Contraction of the southern range limit for anadromous *Oncorhynchus mykiss*. NOAA Technical Memorandum SWFSC -380.

Boughton, D.A., P. Adams, E. Anderson, C. Fusaro, E. Kelley, L. Lentsch, J. Nielsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, and F. Watson. 2006. Steelhead of the south-central/southern California coast: Population characterization for recovery planning. NOAA Technical Memorandum NMFS-SWFSC-394.

Boughton, D.A. Fish H, Pope J, Holt G. Spatial patterning of habitat for Oncorhynchus mykiss in a system of intermittent and perennial streams. Ecology of Freshwater Fish 2009: 18: 92–105.

Bovee, K. D. 1978. Probability of use criteria for the family Salmonidae. Instream Flow Information Paper 4. US Fish and Wildlife Service. FWS/OBS-78/07, Washington, DC.

Bowman, R. H. 1973. Soil survey of San Diego area, California. USDA. Soil Conservation Service, Washington, DC.

Brownlie, W. R. and B. D. Taylor. 1981. Sediment management for southern California mountains, coastal plains and shoreline. Pt. C. Coastal sediment delivery by major rivers in southern California: Cal. Institute of Technology Env. Quality Laboratory Report No. 17-C, 314p.

Burge, M. (2007, August 30). City goes with the flow of new groundwater wells. The San Diego Union Tribune website.

Calfish website. http://www.calfish.org/

California State Coastal Conservancy website. http://www.scc.ca.gov/

California State Coastal Conservancy. The Santa Clara River Parkway website: http://www.santaclarariverparkway.org/theriver/fireflood

California Department of Boating and Waterways and State Coastal Conservancy. 2002. California beach restoration study. Sacramento, California.

CDFG. 1946. CDFG – Field notes.

CDFG. 1972. CDFG – Field notes.

CDFG. 1978. CDFG – Stream Survey. Larry Bottroff. Surveyed performed on November 8, 1978.

CDFG 1996a. McEwan, D and T. Jackson. Steelhead restoration and management plan for California. Inland Fisheries Division, Sacramento, CA.

California Native Grasslands Association website. http://www.cnga.org/

California State Library website. http://www.library.ca.gov/

Cannon, S. H., J. E. Gartner, M. G. Rupert, and J. A. Michael. 2004. Emergency assessment of debris-flow hazards from basins burned by the Cedar and Paradise Fires of 2003, Southern California: Geological Survey Open-File Report OF-04-1011.

Cannon, S. H. and J. DeGraff. 2009. The increasing wildfire and post-fire debris-flow threat in Western USA, and implications for consequences of climate change. USGS, Denver, CO and U.S.D.A. Forest Service, Sierra National Forest, Clovis, CA.

Chester, T. 1997-2000. *http://la.znet.com/~schester/fallbrook/tidbits/fenton_pala_sandmine. html*

City of Oceanside Archives (Photos).

City of Oceanside website. http://www.ci.oceanside.ca.us/

City of Oceanside, City of Vista and County of San Diego. 2008. San Luis Rey River Watershed Urban Runoff Management Program. Prepared for: California Regional Water Quality Control Board – San Diego Region 9.

Cone, M. (2007, December 5). Wildfires left caustic ash, study finds. The Los Angeles Times website.

Cooper J.G. 1874. Animal life of the Cuyamaca Mountains. The American Naturalist 8 (1):14-18.

County of San Diego. 2005. Notes from historic site board meeting. Department of Planning and Land Use, County of San Diego, San Diego, CA.

Dagit, R., K. Reagan, V. Tobias. 2007. Topanga Creek southern steelhead monitoring: habitat suitability and monitoring summary June 2001-December 2006. Prepared for the CDFG.

Dagit, R. and K. Reagan. 2006. Southern steelhead trout Topanga Creek monitoring summary June 2001 – September 2005. Prepared for the CDFG.

D'Antonio, C. M., S. Brainbridge, C. Kennedy, J. Bartolome, S. Reynolds. 2000. Ecology and restoration of California grasslands with special emphasis on the influence of fire and grazing on native grassland species. Departments of Integrated Biology and Environmental Science, Policy and Management, University of California, Berkeley, CA.

Department of Public Works. 1956.

Dudek and Associates Inc. 2007. Memorandum: Warner Ranch stream survey of Gomez Creek. Encinitas, CA.

Escondido Mutual Water Company, et al., Petitioners V. La Jolla, Rincon, San Pasqual, Pauma, and Pala Bands of Mission Indians. 1984. No. 82-2056.

Fikes, B. J. (2008, May 3). Agriculture: Farmers struggle with water price, cuts. The North County Times website.

Finney, K. and J. Edmondson. 2000. Swimming upstream: restoring the rivers and streams of coastal southern California for southern steelhead and other fishes.

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins. 1998. California salmonid stream habitat restoration manual, 3rd edition. California Department of Fish and Game, Sacramento, CA.

Greenwood, A. 1996. The trout of San Diego County and Baja California, the original trout or not? San Diego Trout, San Diego, CA.

Grossi, P. 2008. The 2007 U.S. wildfire season: lessons learned from southern California. Risk Management Solutions, Newark, CA.

Hargreaves Associates. 2007. San Luis Rey River Park Master Plan. San Francisco, CA. Prepared for: County of San Diego, Department of Parks and Recreation, San Diego, CA.

Hawkins, C. P., K. L. Bartz, and C. Neale. 1997. Vulnerability of riparian vegetation to catastrophic flooding: implications for riparian restoration. Restoration Ecology Vol. 5 No. 4S: 75-84.

Hayes, S. A., M. H. Bond, C. V. Hanson, E. V. Freund, J. J. Smith, E.C. Anderson, A. J. Ammann, and R. B. MacFarlane. 2008. Steelhead growth in a small central California watershed: upstream and estuarine rearing patterns. Transactions of the American Fisheries Society

137:114-128.

Hazel, C. R., S. R. Herrera, H. Rectenwald, and J. H. Ives. 1976. Assessment of effects of altered stream flow characteristics on fish and wildlife. Part B: California case studies. Report prepared by Jones and Stokes, Inc. to US Department of Interior, Fish and Wildlife Service.

Held, T. 2008. Draft programmatic environmental impact report: San Luis Rey River Park Master Plan. EDAW Inc., San Diego, CA. Prepared for: County of San Diego, Department of Parks and Recreation, San Diego, CA.

Higgins, P. T. 1991. Southern California steelhead recovery assessment: San Mateo Creek and the Santa Margarita River. Study performed under contract with the South Coast Chapter of Trout Unlimited, Mission Viejo, CA.

Hobbs, H. H., J. P. Jass, and I.V. Huner. 1989. A review of global crayfish introductions with particular emphasis on two North American species (*Decapoda*, *Cambaridae*). Crustaceana 56:299-316.

Hubbs, C. L. 1946. Wandering of pink salmon and other salmonid fishes into southern California. California Department of Fish and Game. Fish Bulletin 32 (2): 81-86.

Hudson, T. 1964. Three Paths Along a River: The heritage of the land of the San Luis Rey. Desert Southwest Publishers, Palm Desert, CA.

Inman, D. L. and S. A. Jenkins. 1985. Erosion and accretion waves from Oceanside Harbor. In Oceans 85: Ocean Engineering and the Environment. Marine Technological Society & IEEE, 1, pp. 591-593.

Iverson, M. E. 1998. Effects of *Arundo donax* on water resources. CalEPPC News 6 (N3): 10.

Jansson, R., C. Nilsson, and B. Malmqvist. 2007. Restoring freshwater ecosystems in riverine landscapes: the roles of connectivity and recovery processes. Freshwater Biology 52:589-596.

Jones and Stokes Associates, Inc. 1976. Assessment of effects of altered streamflows on fish and wildlife in California. Sacramento, CA. Prepared for the USFWS Western Energy and Land Use Team, Fort Collins, CO.

Jones, H. J. (2006, April 9). Gardens a hidden treasure, local history beckons from a little know park. The San Diego Union Tribune website.

Jones, H. J. (2007, July 25). Mining of quarry begins after long wait. The San Diego Tribune website.

Kennedy, M. P. and S. S. Tan. 2005. Geologic map of the OCEANSIDE 30' X 60' QUADRANGLE, California. California Department of Conservation. Digital preparation by K. R. Bovard, R. M. Alvarez and M. J. Watson, U.S. Geological Survey, Department of Earth Sciences, University of California, Riverside.

Kennedy, M. P., B. L. Nelson, and R. M. Hauser. 2000. Geologic map of the PALA 7.5' QUADRANGLE, San Diego County, California: A digital database version 1.0. California Department of Conservation.

Knighton, A. D. 1987. 'River channel adjustment – the downstream dimension', in Richards, K. (Ed.), *River Channels: Environment and Process*, Basil Blackwell, London, 95-128.

Kondolf, G. M. and M. Larson. 1995. Historical channel analysis and its application to riparian and aquatic habitat restoration. Aquatic Conservation: Marine and Freshwater Ecosystems, Vol, pp. 109-126. John Wiley & Sons.

Kondolf, G. M. 1997. Hungry water: effects of dams and gravel mining on river channels. Environmental Management Vol. 21, No. 4: pp. 533-551.

Kondolf, G. M. 1998. Lessons learned from river restoration projects in California. Aquatic Conservation: Marine and Freshwater Ecosystems. 8: 39–52.

Kostow, K. 2002. Oregon lampreys: Natural history, status, and analysis of management issues. Oregon Department of Fish and Wildlife, Portland, OR.

Kumeyaay Information Village website. http://www.kumeyaay.info/

Lafferty, K. D., C. C. Swift, and R. F. Ambrose. 1999a. Postflood persistence and recolinization of endangered tidewater goby populations. North American Journal of Fisheries Management, 19(4):618-622.

Lafferty, K. D., C. C. Swift, and R. F. Ambrose. 1999b. Extirpation and recolonization in a metapopulation of an endangered fish, the tidewater goby. Conservation Biology, 13(6):1147-1453.

La Jolla Band of Luiseño Indians website: http://www.lajollaindians.com/

Lettieri-McIntyre and Associates. 1995. San Luis Rey River resource report. Including land use, biology, cultural resources and hydrology. San Diego, CA.

Manataka American Indian Council website. http://www.manataka.org/

MBC Applied Environmental Sciences. 2000. Biological assessment of the San Luis Rey River for populations of tidewater goby and steelhead. Costa Mesa, CA.

MBC Applied Environmental Sciences. 2003. Biological assessment of the San Luis Rey River for populations of tidewater goby and steelhead. Costa Mesa, CA.

McDonald, A., S. N. Lane, E. Chalk, and N. Haycock. 2004. Rivers of dreams: on the gulf between theoretical and practical aspects of river restoration. Transactions, Institute of British Geographers, 29, 257-81.

Micheli, L. 1994. River and watershed planning: The San Luis Rey River case study. U.C. Berkeley, CA.

Montgomery, D. R. and J. M Buffington. (1993). Channel-reach morphology in mountain drainage basins. Department of Geological Sciences, University of Washington, Seattle,WA.

Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. Fish species of concern in California, Second edition. University of California, Davis, CA. 80-81 pp.

Moyle, P. B. 2002. Inland fishes of California. Revised and expanded. University of California Press, Berkeley.

Naiman, R. J., S. E. Bunn, C. Nilsson, G. E. Petts, G. Pinay, and L. C. Thompson. 2002. Legitimizing fluvial ecosystems as users of water: An Overview. Environmental Management 30 (4): 455-467. 467.

National Audubon Society. 2008. Important bird areas in the U.S. Audubon website: http://www.audubon.org/bird/iba.

National Marine Fisheries Service (NMFS). 1999. Memorandum: Genetic analysis of several samples of California *Oncorhynchus mykiss.* National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, WA.

NMFS. 2007. 2007 Federal recovery outline for the distinct population segment of southern California coast steelhead. NMFS Southwest Regional Office, Long Beach, CA.

NMFS and Kier Associates. 2008. Guide to the reference values used in south-central/southern California coast steelhead conservation action planning (CAP) workbooks. NMFS Southwest Regional Office, Long Beach, CA. Kier and Associates, Arcata, CA.

NMFS. 2008. Final biological opinion for the Bureau of Reclamation’s proposed approval of United Water Conservation District’s plan to operate the Vern Freeman Diversion Dam on the Santa Clara River. Prepared by the Southwest Region, Long Beach, California, for the Federal Energy Regulatory Commission, Washington, DC, July 23, 2008.

NMFS. 2009. Southern California steelhead recovery plan, pubic review draft. NMFS Southwest Regional Office, Long Beach, CA.

National Park Service website. http://www.nps.gov/history/history/online_books/5views/5views1h67.htm

Nielsen, J. L. 1994. Molecular genetics and stock identification in Pacific salmon (*Oncorhynchus spp.*). Dissertation. University of California Berkely, CA.

Nielsen, J. L., C. A. Gan, J. M. Wright, D. B. Morris, and W. K. Thomas. 1994. Biogeographic distributions of mitochondrial and nuclear markers for southern steelhead. Molecular Marine Biology and Biotechnology, 3: 281-293.

NOAA. 1999. Memorandum: Preliminary genetic analysis of several samples of California *Oncorhynchus mykiss*. Northwest Fisheries Science Center, Seattle, WA.

Olson, C. and R. Harris. 1997. Applying a two-stage system to prioritize riparian restoration at the San Luis Rey River, San Diego County, California. Restoration Ecology *Vol.* 5 No. 4S: 43-55.

Orange County Water District. 2006. Aquatic predator and competitor minimization plan for the Prado wetlands. Orange County Water District, Fountain Valley, CA.

Pala Band of Mission Indians website. http://www.palatribe.com/

PBS&J. 2003. San Luis Rey River watershed urban runoff management program. Prepared for the

California Regional Water Quality Control Board – San Diego Region. San Diego, CA.

Pfingsten, T. (2008, February 16). Fallbrook quarry project spurs road work on 76. North Country Times website.

Priest, J., S. Boczkiewicz, and V. Joshi. 2007. Warner Ranch stream survey of Gomez Creek. Dudek – Environmental and Engineering, Encinitas, CA.

Reiser, D. W. and T. C. Bjorn. 1979. Habitat requirements of anadromous salmonids. USDA, Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR General Technical Report PNW-96.

Riley, A. L. 1998. Restoring Streams in Cities: A guide for planners, policymakers, and citizens. Island Press, Washington D.C.

Rogers, T. and M. Lee. (2007, October 28). Biodiversity takes a hit; non-native grasses can take over after wildfires. The San Diego Union Tribune website.

Rosgen, D. L. 1994. A classification of natural rivers. Catena, Vol 22: 169-199, Elsevier Science, B. V. Amsterdam.

Roosevelt, M. (2008, June 25). Climate change threatens two-thirds of California’s unique plants, study says. Los Angeles Times website.

Russell, G. D., C. P. Hawkins, and M. P. O’Neill. 1997. The role of GIS in selecting sites for riparian restoration based on hydrology and land use. Restoration Ecology Vol. 5, No. 4S: 56-68.

Ryan, S., M. K. Dixon, K. A. Dwire, and W. W. Emmett. 2002. Geomorphic Impacts of Wildfire II. Presented at the Geological Society of America Annual Meeting. October, 29, 2002. Session No. 179, Colorado Convention Center, Denver, CO.

San Diego Association of Governments (SANDAG). 1990. San Luis Rey River Habitat Conservation Plan. Prepared as part of the Comprehensive Species Management Plan (CSMP) for the endangered least Bell’s vireo. San Diego, CA.

SANDAG. 1998. SANDAG INFO Watersheds of the San Diego Region. March-April 1998. San Diego, CA.

SANDAG. 2004. Regional comprehensive plan for the San Diego Region. San Diego, CA.

San Diego County website. http://www.sdcounty.ca.gov/cnty/cntydepts/landuse/planning/GP2020/index.html

San Diego County Water Authority website. http://www.sdcwa.org/about/

San Diego Indian reservations website. http://www.sandiego.edu/nativeamerican/reservations.html

San Diego Regional Water Quality Control Board (SDRWQCB). 1998. Water quality control plan for the San Diego Basin. SDRWQCB, San Diego, CA.

SDRWQCB. 2002. Final draft Clean Water Act Section 303(d) list of impaired waters, 2002 update.

SDRWQCB, San Diego, CA.

SDRWQCB. 2007. Water quality control plan for the San Diego Basin September 8, 1994 w/amendments effective prior to April 25, 2007. SDRWQCB, San Diego, CA.

San Diego State University (SDSU). SDSU Information and Library Access website. http://infodome.sdsu.edu/research/guides/calindians/insdcnty.shtml

San Diego Trout website. http://www.sandiegotrout.org/indians.html

San Luis Rey Indian Water Authority website. http://www.slriwa.org/

San Luis Rey Watershed Council. 2000. San Luis Rey River watershed guidelines. Fallbrook, CA.

Santa Margarita and San Luis Rey watersheds weed management area website. http://smslrwma.org/

Schmidt, N. 1990. Plate tectonics and the gulf of California Region, California Geology, v. 43, no.11, p. 252-257.

Seager, R. et al., 2007. “Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America.” Science 316(5828): 1181-1184.

Shapavalov, L. and A. C. Taft. 1954. Life histories of the steelhead rainbow trout, *Salmo gairdneri*, and silver salmon, *Oncorhynchus kisutch.* California Department of Fish and Game, Fish Bulletin 98:1-275.

Sifuentes, E. (2007, April 11). Santa Ysabel casino opens. The North County Times website.

Sifuentes, E. (2008, December 26). Century old water dispute may finally end. The North County Times website.

Smith, J. J. 1994. Status of steelhead in Central California. Department of Biological Sciences San Jose State University. 14 pp.

Soto, O.R. (2007, December 4). Invasion of mud wrecks home on reservation. La Jolla tribe's fire-ravaged land thrashed by floodwater. The San Diego Tribune website.

Soto, O. R. (2008, May 8). Pauma band scales back resort hotel plans. The San Diego Tribune website.

Soto, O. R. (2008, December 1). Water settlement knots finally untangling. The San Diego Tribune website.

Southern California Earthquake Data Center Website 2008. http://www.data.scec.org/index.html.

Spence, B.C., G.A. Lomincky, R.M. Hughes, and R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. National Marine Fisheries Service, U.S. Fish and Wildlife Service, Environmental Protection Agency. TR-4501-96-6057.

Spina, A. P., M. A. McGoogan, and T. S. Gaffney. 2006. Influence of surface-water withdrawal on juvenile steelhead and their habitat in a south-central California stream. California Department of Fish and Game Bulletin 92 (2): 81-90.

Spina, A. P. 2007. Thermal ecology of juvenile steelhead in a warm-water environment. Environmental Biology of Fishes 80 (1): 23-34.

State of California. 2007. Interagency State Burned Area Emergency Response (BEAR) report. The Rice Fire. Sacramento, CA.

State of California. 2007. Interagency State Burned Area Emergency Response (BEAR) report. The Poomacha Fire. Sacramento, CA.

State Waters Resource Control Board. 2002. Hearing: proposed update of the Federal Clean Water Act, Section 303. May 30, 2002 Ontario, California. Linda L. Jackson, CSR NO. 2985.

Stephenson, J. R. and G. M. Calcarone. 1999. Southern California mountains and foothills assessment: habitat and species conservation issues. General Technical Report GTR-PSW-175. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 402p.

Stoecker, M. W. and Conception Coast Project. 2002. Steelhead assessment and recover opportunities in southern Santa Barbara County, CA. Conception Coast Project, Santa Barbara, CA.

Strahler, A. N. 1964. Quantitative geomorphology of drainage basins and channel networks Handbook of Applied Hydrology. Chow, V.T. Editor, McGraw-Hill Book Company, Inc.

Swift, C.C. 1975. Survey of the freshwater fishes and their habitats in the coastal drainages of Southern California. Natural History Museum of Los Angeles County.

Swift, C. C., T. R. Haglund, M. Ruiz, and R. N. Fisher. 1993. The status and distribution of the freshwater fishes of southern California. Southern California Academy of Sciences 92 (3), pp. 101-167.

Swift, C.C. 2003. Survey for native fishes in the Santa Clara River, vicinity of Fillmore, Ventura County, with special reference to the federally endangered south coast steelhead. Prepared for Envicom Corporation.

The Nature Conservancy website. http://www.nature.org/

Thorgaard, G. H. 1979. Genetic status of the West Fork San Luis Rey River rainbow trout. University of California, Davis, CA.

Tierra Environmental Services. 2006. Environmental assessment for the La Jolla septage treatment improvements project. San Diego, CA.

Tierra Environmental Services. 2007. Environmental assessment for the Pala Tribal Wastewater System Rehabilitation Project. San Diego, CA.

Tierra Environmental Services. 2008. Pauma casino and hotel environmental assessment and tribal environmental impact report. San Diego, CA.

Titus R. G., D. C. Erman, and W. M. Snider. 2000. History and status of steelhead in California coastal drainages south of San Francisco Bay. Draft. California Dept. of Fish and Game, Sacramento.

Tres, J. 1992. Breeding biology of the arroyo chub (*Gila orcutti*) (Pisces:Cyprinidae). MS Thesis, Calif. State Polytech. Univ. Pomona.

True, L. D. 1954. Pictographs of the San Luis Rey Basin. American Antiquity Vol 1., No. 20, pp. 68-72. Society for American Archaeology.

United States Census Bureau website: http://www.census.gov/

United States Department of Interior, Bureau of Reclamation website: http://www.usbr.gov/dataweb/html/sandiego.html

United States Forest Service (Cleveland) website. http://www.fs.fed.us/r5/cleveland/

USFWS 1998. Southern steelhead, *Oncorhynchus mykiss*, habitat suitability survey of the Santa Margarita River, San Mateo and San Onofre Creeks on Marine Corps Base Camp Pendleton, California. Department of the Interior, U.S. Fish and Wildlife Service, Arcata, CA.

Vista Irrigation District website. http://www.vid-h2o.org/home/index.asp

Wagner, D. L. 1991. Decomposed granite, California Geology, v.44, no 11, p. 243-249.

Warburton, M. L., C. C. Swift, and R. N. Fisher. 2000. Status and distribution of fishes in the Santa Margarita River Drainage. United States Geological Survey, San Diego, CA.

Wells, W. G. 1985. The influence of fire on erosion rates in California chaparral. In: Proceedings of the Chaparral Ecosystems Management Conference. California Water Resources center, Univ. of California, Davis, CA.

Weston Solutions Inc. 2007. San Diego County municipal copermittees 2005-2006 urban runoff monitoring. Volume I – final report. Prepared for County of San Diego. Carlsbad, CA.

Wildland Fire Lessons Learned Center website: http://www.wildfirelessons.net/Home.aspx

Winter, K. 2000. Cleveland National Forest: Expected vegetation recovery of the Cedar Fire. Unpubished file report, Cleveland NF, San Diego, CA. http://www.cnpssd.org/fire/cedarfirerecovery-winter.pdf.

Witheridge, A. 2009. Comment letter to the San Luis Rey Watershed Assessment Draft report. The City of Oceanside, Oceanside, CA.

Zedler, P. H., C. R. Gautier, and G. S. McMaster. 1983. Vegetation change in response to extreme events: The effect of a short interval between fires in California chaparral and coastal scrub. Ecology: Vol. 64, No. 4, pp. 809-818.