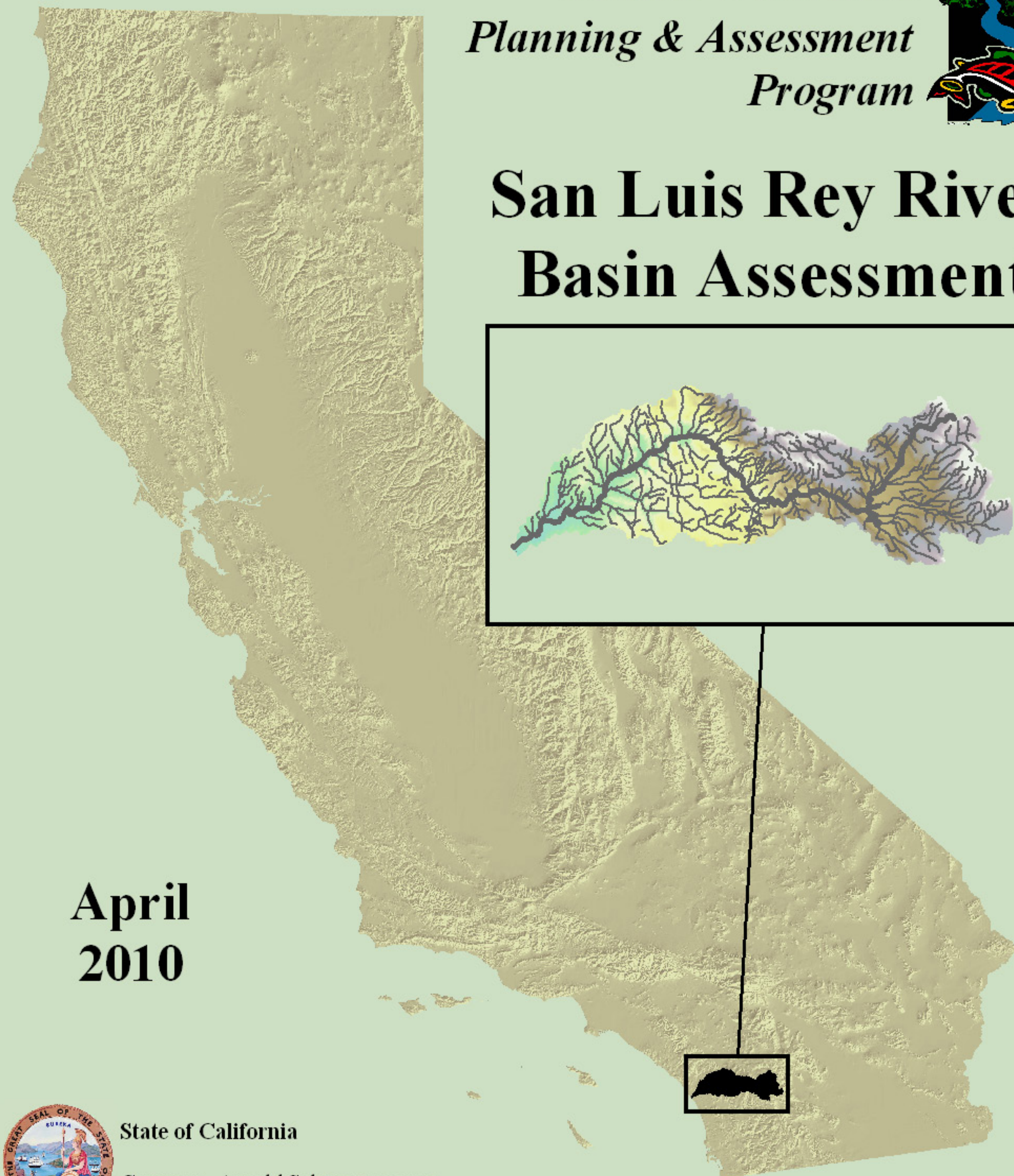
Coastal Watershed Planning & Assessment Program

San Luis Rey River Basin Assessment



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State of California

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California Department of Fish & Game

Director, John McCamman

Pacific States Marine Fisheries Commission

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San Luis Rey River Watershed Assessment

Prepared through a cooperative effort by

California Department of Fish and Game

Pacific States Marine Fisheries Commission

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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;
- o Databases of information used and collected;
- o A data catalog and bibliography;
- o 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).

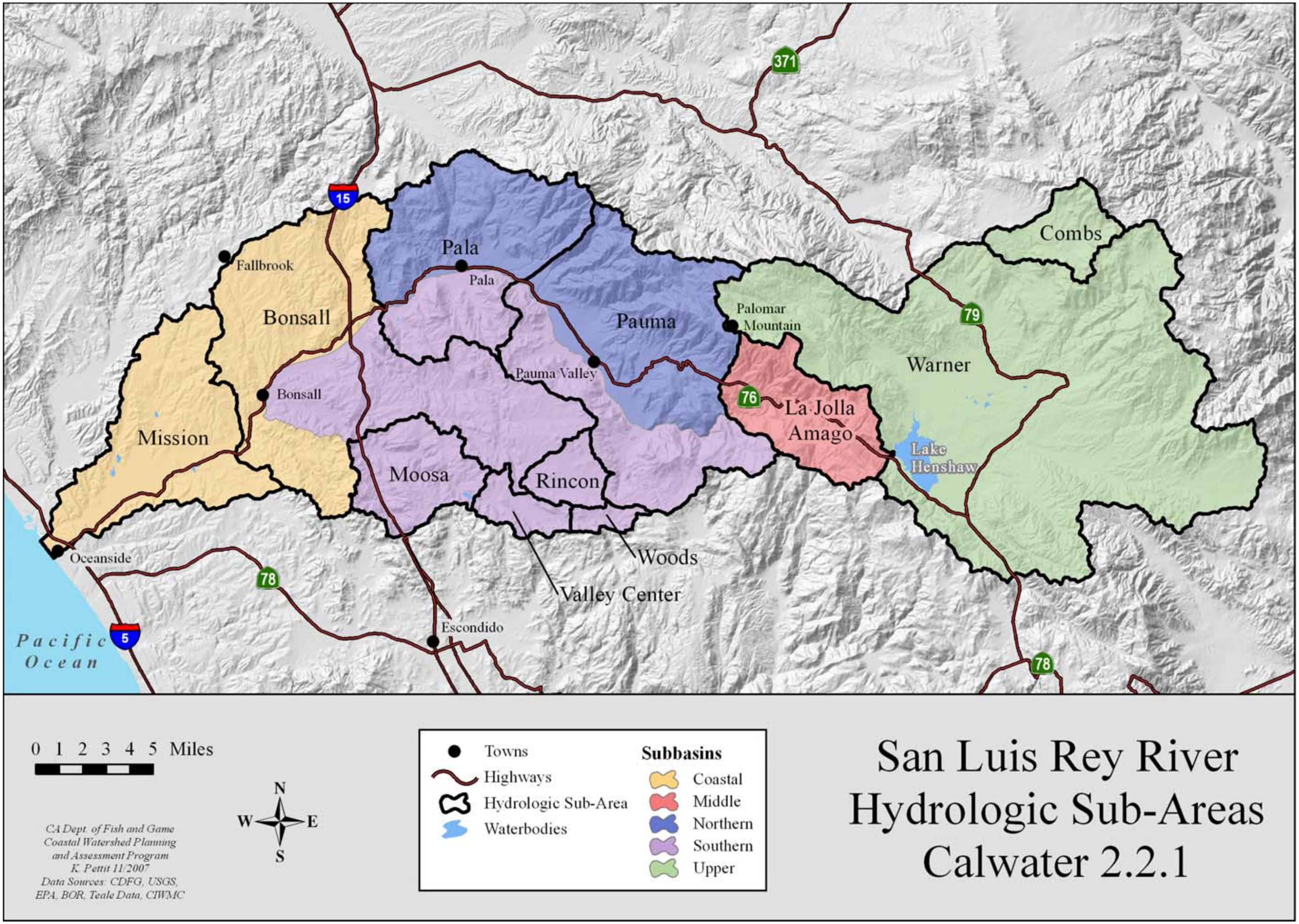

Figure 2. SLR River Hydrologic Sub-Areas CalWater 2.2.1

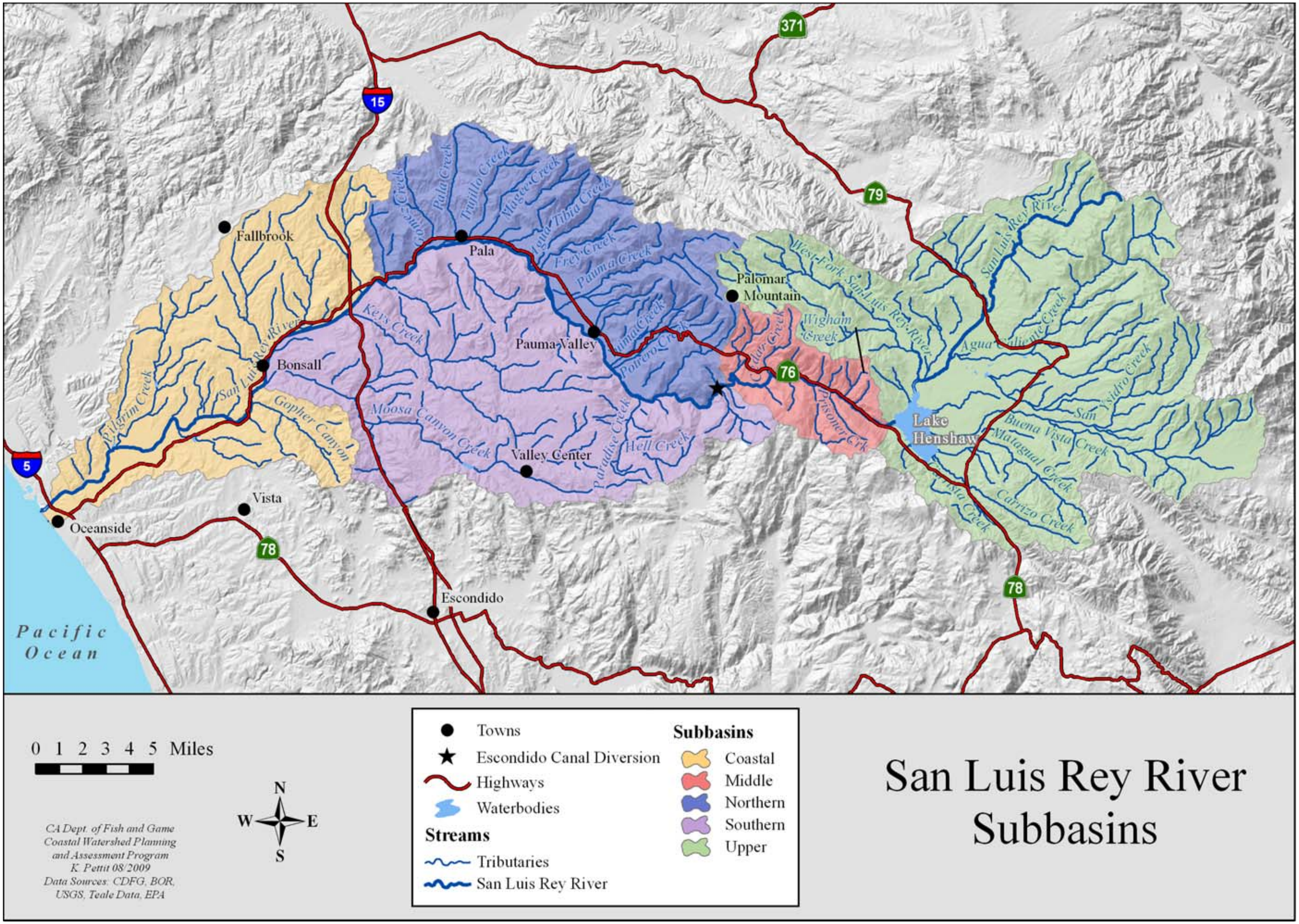

Figure 3. San Luis Rey River Basin with subbasin boundaries.

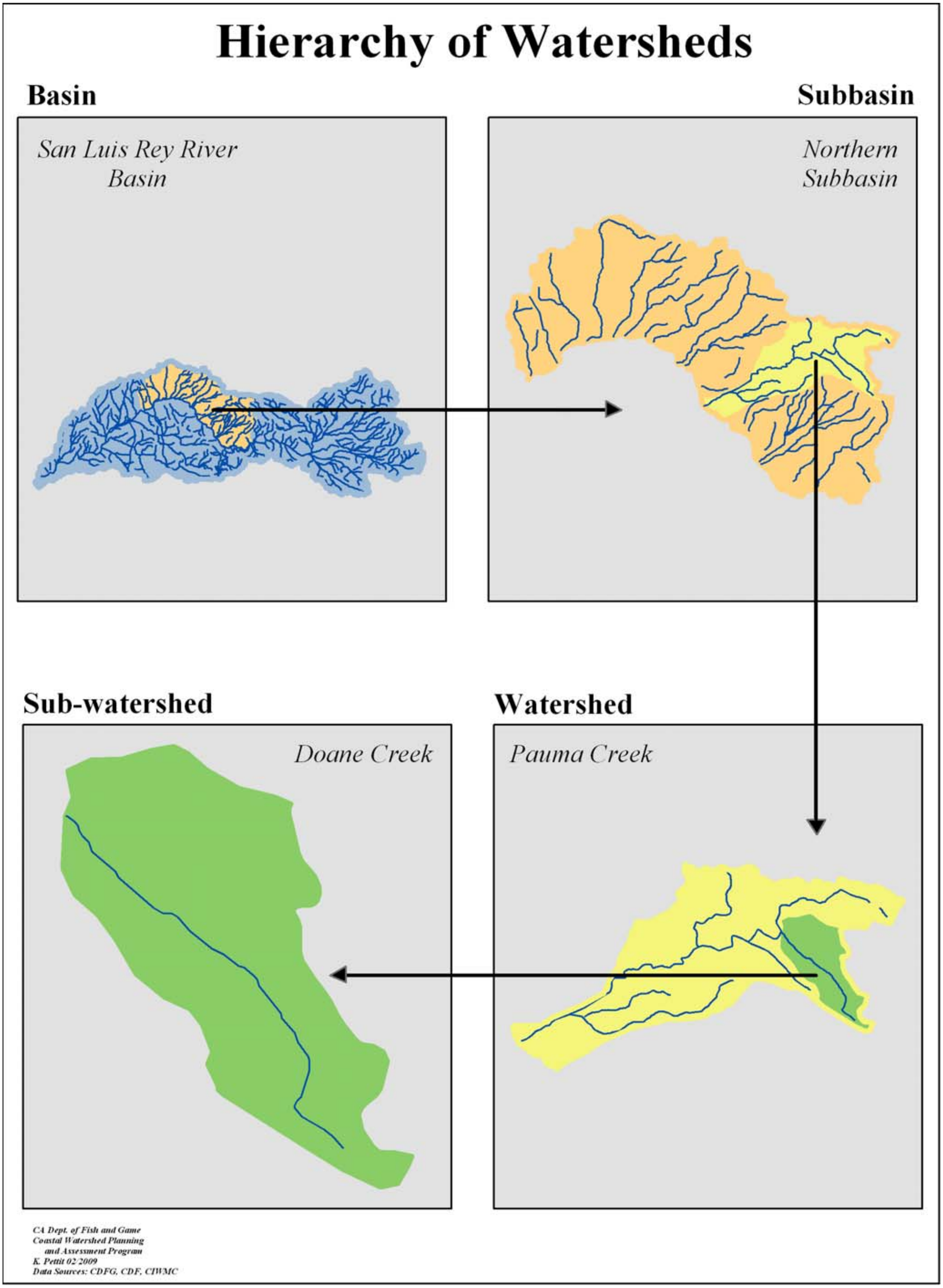

Figure 4. Hydrography hierarchy.

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).

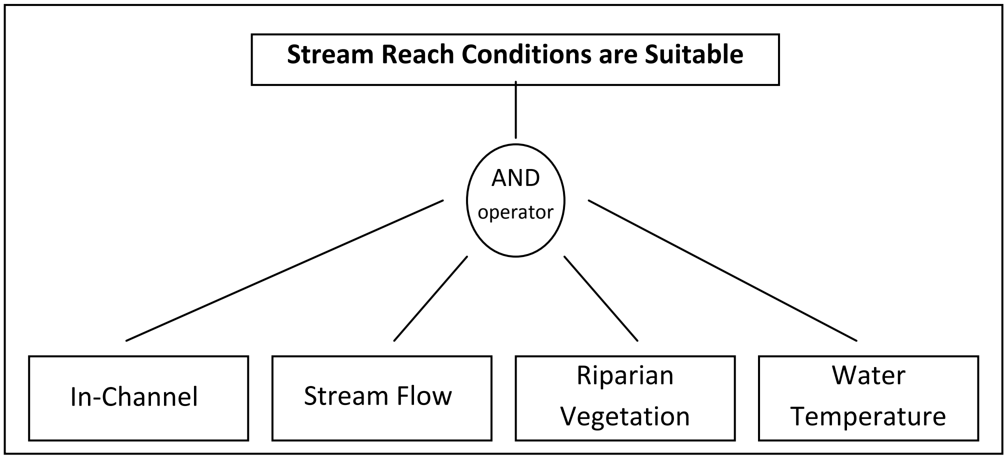

Figure 5. Tier one of the EMDS stream reach knowledge base network.

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).