# Table of Contents


Basin Profile and Synthesis ..... 1
- Subbasin Scale ..... 2
- Climate ..... 6
- San Luis Rey River Timeline ..... 9
- Hydrology ..... 11
  - Stream Flow ..... 11
- Geologic Overview ..... 18
  - Rock Types ..... 18
  - Soils ..... 21
  - Erosion ..... 22
  - Tectonics and Faulting ..... 23
- Fluvial Geomorphology ..... 25
  - Stream Gradient and Reach Classification ..... 26
- Vegetation ..... 26
  - Flood Control Project and Channel Maintenance Plan ..... 30
  - Invasive Plant Species Management ..... 31
- Fire History and Management ..... 35
  - 2007 Poomacha Fire ..... 36
  - 2007 Rice Fire ..... 36
- Land and Resource Use ..... 40
  - Pre-European Settlement ..... 40
  - European Settlement ..... 40
  - Present Land Use ..... 41
  - Population ..... 42
  - Ownership ..... 43
  - Agriculture ..... 43
  - Forest Management ..... 45
  - Roads and Railroads ..... 45
  - Mining ..... 47
  - Water Use: Dams, Diversions, and Water Rights ..... 48
  - Waste Water Treatment ..... 50
  - Historic Accounts of Steelhead Runs ..... 51
- Fish Habitat Relationship ..... 51
  - Fishery Resources ..... 51
  - Stocking and Origins of Trout ..... 55
  - Steelhead as Potential Predators of Endangered Species ..... 56
- Habitat Overview ..... 56
  - Historic Conditions ..... 57
  - Current Conditions ..... 58
- Adverse Conditions Affecting Steelhead Recovery ..... 62
  - Water Quantity ..... 62
  - Water Quality ..... 63
  - Barriers ..... 68
  - Exotic Fish Species ..... 72
  - Invasive Plant Species ..... 72
- Conclusions and Limiting Factors Analysis ..... 73
  - Analysis of Instream Habitat Improvement Recommendations ..... 74
- Watershed and Fish Restoration Programs ..... 74
- Biological Resources ..... 75
  - Special Status Species ..... 76
  - Multiple Species Conservation Program ..... 76
- Refugia Areas ..... 76
- Basin Issues ..... 77
- Responses to Assessment Questions ..... 78
- Basin Conclusions ..... 86

# List of Figures

Figure 1. The SLR River Basin. ..... 3
Figure 2. San Luis Rey River Subbasins, delineated using CalWater 2.2.1. ..... 4
Figure 3. Average monthly precipitation within various locations of the SLR Basin. ..... 7
Figure 4. Yearly precipitation statistics over the period of record in downtown San Diego. ..... 7
Figure 5. San Luis River Basin average annual precipitation. ..... 8
Figure 6. Aquifers of the SLR River Basin. ..... 12
Figure 7. SLR River average mean monthly flow recorded at Wilderness Gardens from 1909-1915 (USGS website). ..... 14
Figure 8. Annual peak stream flows for the SLR River at Oceanside (RM 1.25) 1913-2005. ..... 16
Figure 9. SLR River Stream Flow Characteristics. ..... 17
Figure 10. Geology of the San Luis Rey River. ..... 19
Figure 11. Granitic bedrock in the foreground and within the distant hillsides. ..... 20
Figure 12. Alluvium floodplain of the SLR River in the Southern Subbasin. ..... 20
Figure 13. Post-fire erosion potential of the San Luis Rey River Basin, California. ..... 24
Figure 14. Stream gradient of the SLR River Basin. ..... 28
Figure 15. Vegetation of the SLR River Basin, California. ..... 29
Figure 16. Riparian vegetation removal along SLR River in Oceanside. ..... 31
Figure 17. Invasive Plant Species of the SLR River Basin. ..... 33
Figure 18. Focused invasive plants removal in the SLR River Basin. ..... 34
Figure 19. Burned areas of the SLR River Basin 1910 to 1959. ..... 37
Figure 20. Burned areas of the SLR River Basin 1960 to 1999. ..... 38
Figure 21. Burned areas of the SLR River Basin 2000 to 2007. ..... 39
Figure 22. Generalized ownership of the SLR River Basin. ..... 44
Figure 23. Roads and railroads in the SLR River Basin. ..... 46
Figure 24. Photo of Escondido Canal dam diversion in Southern Subbasin. ..... 50
Figure 25. Adult Southern California Coast Steelhead. Observed in the lower SLR River near Oceanside (RM 7), May 2007. ..... 53
Figure 26. San Luis Rey River 2007 CDFG Stream Habitat Surveys. ..... 59
Figure 27. Fish passage barriers of the SLR River Basin. ..... 70

# List of Tables

Table 1. General attributes of the SLR River Basin. ..... 2
Table 2. Median monthly flow (cubic feet per second) for SLR River at Oceanside by decade (USGS website). ..... 14
Table 3. Statistics of mean monthly discharge and maximum and minimum monthly discharges in their respective year(s) for SLR River at Oceanside over the period of record, Water Year (WY) 1967 to 2006. Data from USGS (2006). ..... 15
Table 4. Percentage of rock types in the SLR River Basin. ..... 21
Table 5. Percentage of post-fire erosion potential for the SLR River Basin and individual subbasins. ..... 23
Table 6. USFS classification of vegetation of the SLR River Basin. ..... 27
Table 7. Existing land uses in the SLR Watershed. ..... 41
Table 8. Planned land use of vacant/undeveloped land in the SLR River Watershed. ..... 42
Table 9. 2000 Cities population and 2020 forecast populations; 1995 developable areas and 2020 forecast vacant development areas. ..... 42
Table 10. San Diego County population trends since 1980. ..... 43
Table 11. Fishery resources of the SLR River Basin. ..... 54
Table 12. CDFG streams survey in the SLR River Basin, 1946-2006. ..... 58
Table 13. Proposed CAP interim reference values for MWATs for Southern California Coast Steelhead DPS. ..... 65
Table 14. SLR River Estuary 2003-2005 ABLM Monitoring Results. ..... 67
Table 15. EMDS Anadromous Reach Condition Model results for the SLR River Basin. ..... 73
Table 16. Recommendation categories based on target issues. ..... 74
Table 17. Occurrence of stream habitat inventory recommendations in the first five ranks in the surveyed stream. ..... 74
Table 18. Subbasin salmonid refugia area ratings in the SLR River Basin. ..... 77

## Basin Profile and Synthesis

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

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

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

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

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

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

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

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

## Subbasin Scale

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

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

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

*Table 1. General attributes of the SLR River Basin.*

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

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

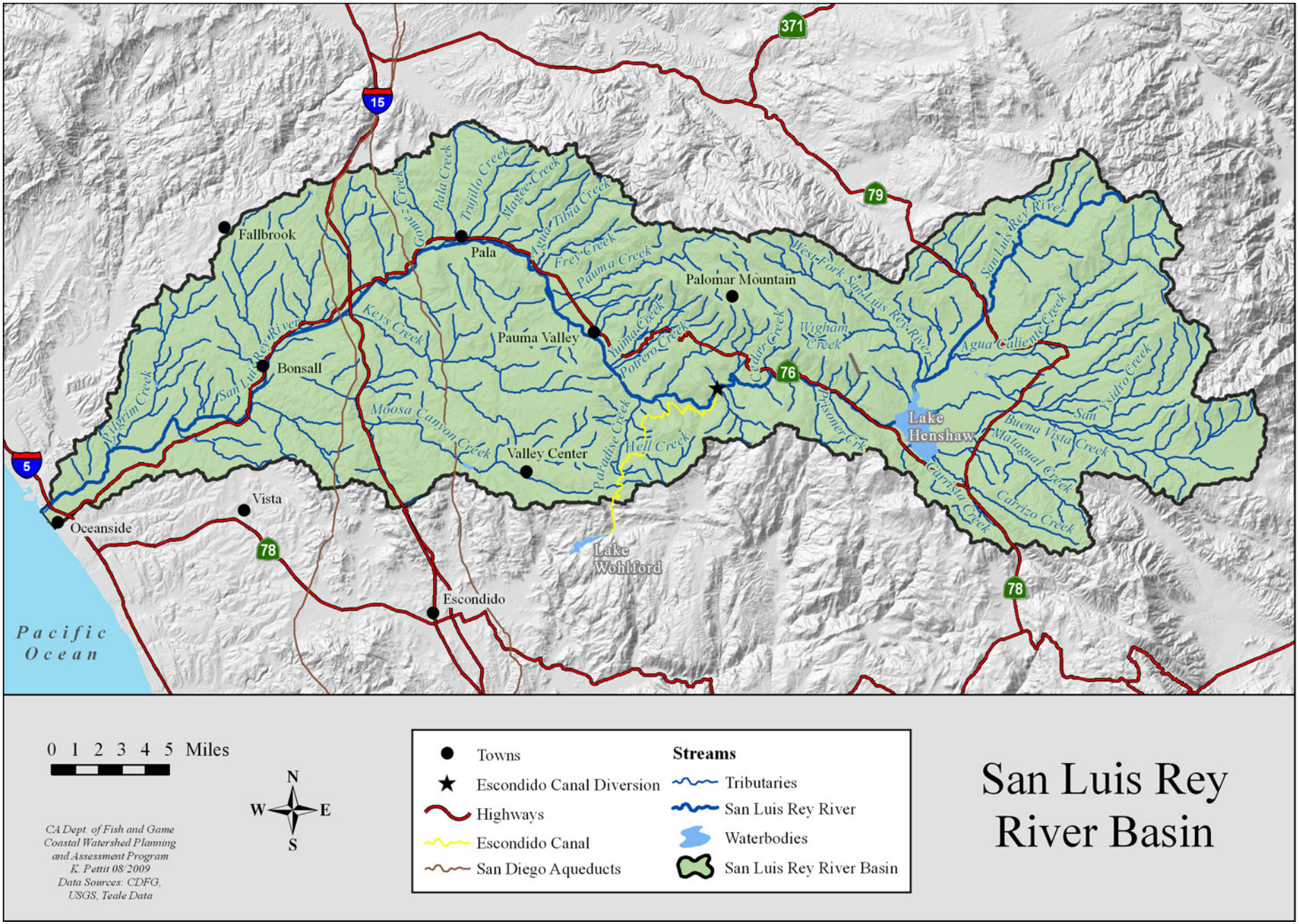


*Figure 1. The SLR River Basin.*

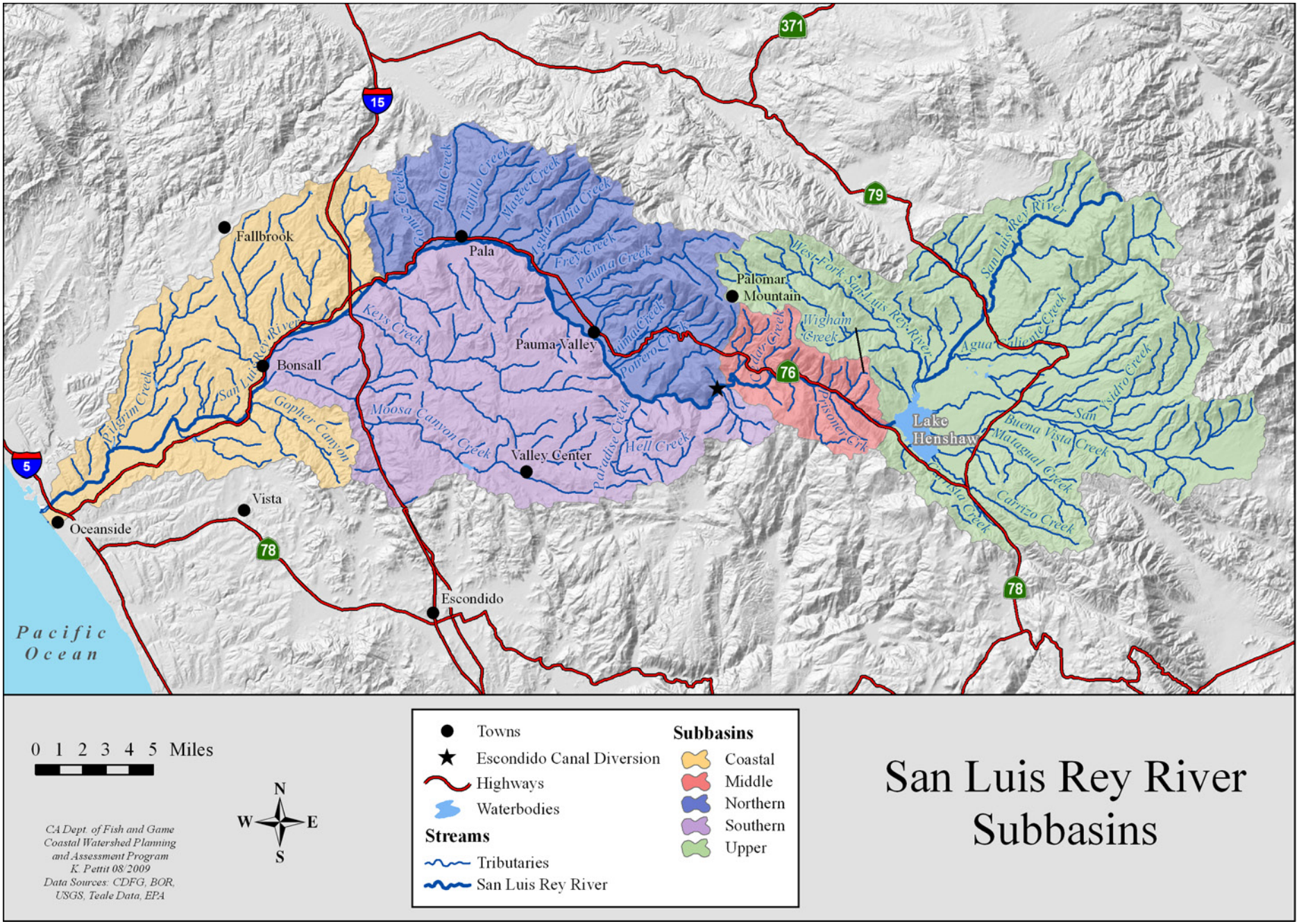


*Figure 2. San Luis Rey River Subbasins, delineated using CalWater 2.2.1.*

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

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

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

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

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

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

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

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

## Climate

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

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

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

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

perhaps drier rainy seasons, reduced snowfall in mountainous regions, and perhaps more intense precipitation events in some areas (NMFS 2009 *Draft*).

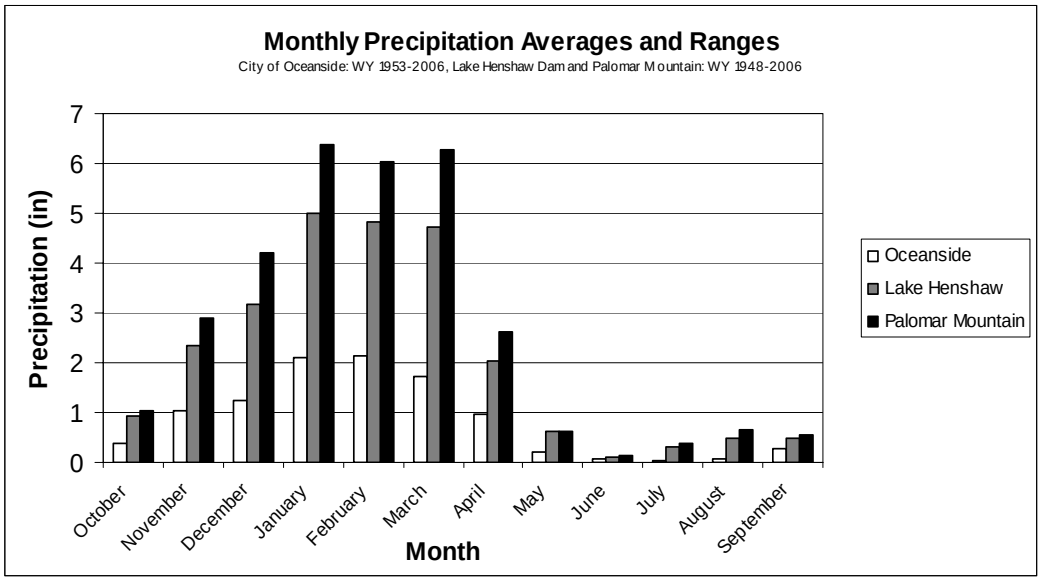


*Figure 3. Average monthly precipitation within various locations of the SLR Basin.*
(Western Regional Climate Center website, http://www.wrcc.dri.edu/).

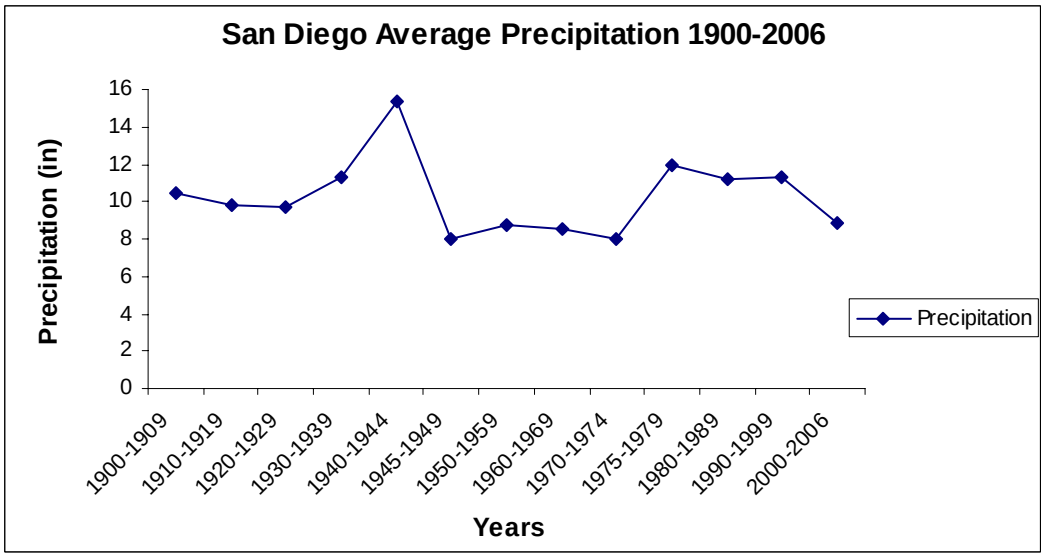


*Figure 4. Yearly precipitation statistics over the period of record in downtown San Diego.*
(Western Regional Climate Center website, http://www.wrcc.dri.edu/).

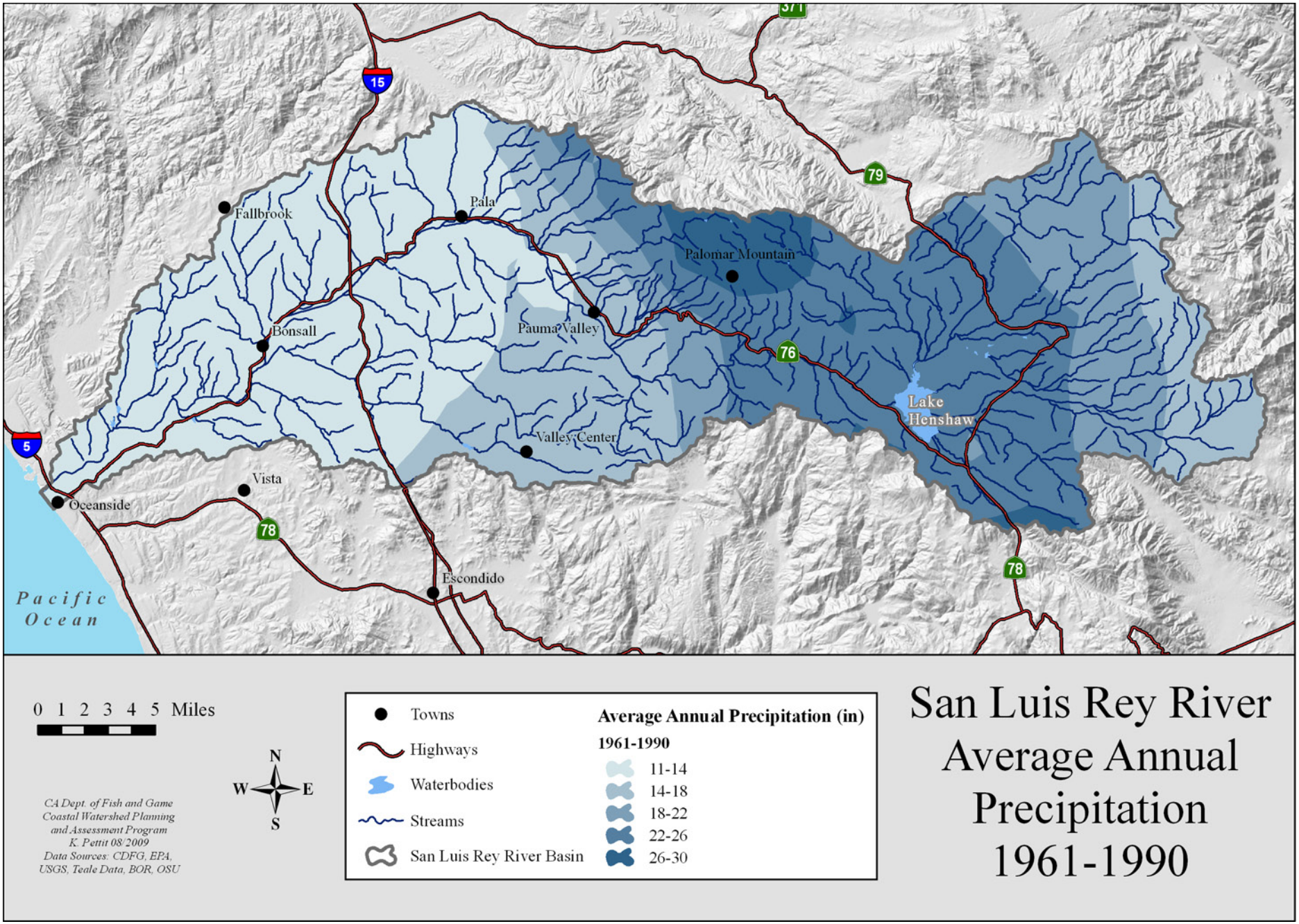


*Figure 5. San Luis River Basin average annual precipitation.*

## San Luis Rey River Timeline

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

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

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

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

1829: Mission San Luis Rey is expanded;

1846-1848: Mexican-American War;

1850: California becomes 31st state;

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

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

1888: Cities of Oceanside and Escondido are incorporated;

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

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

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

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

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

1923: Vista Irrigation District (VID) is formed;

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

1928: Metropolitan Water District of Southern California is incorporated;

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

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

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

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

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

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

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

1962: Pauma Valley Water District is formed;

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

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

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

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

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

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

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

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

1997: San Luis Rey Watershed Council is organized;

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

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

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

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

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

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

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

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

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

## Hydrology

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

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

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

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

### *Stream Flow*

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

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

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

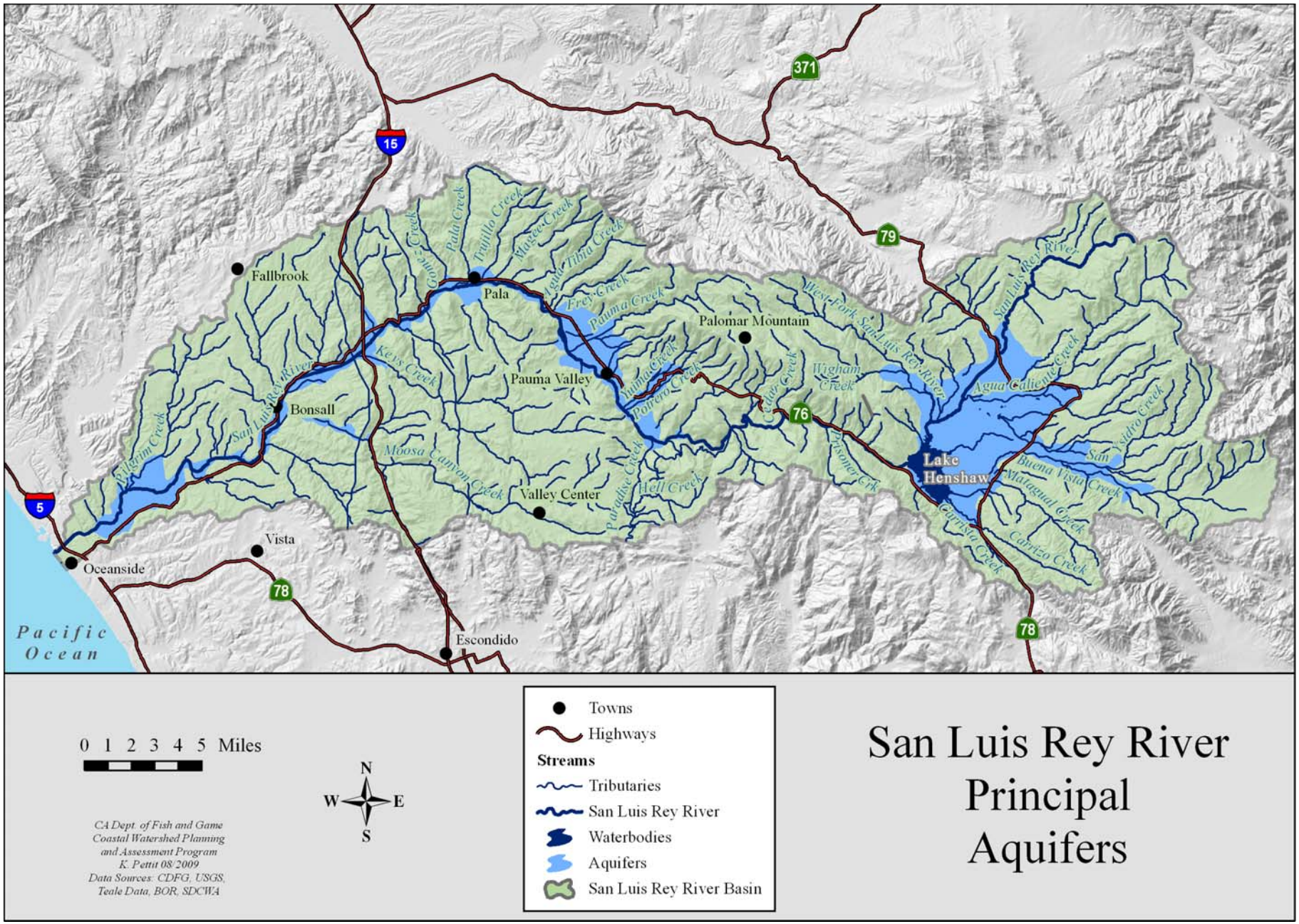


*Figure 6. Aquifers of the SLR River Basin.*

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

### *Historical Stream Flows*

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

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

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

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

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

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

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

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

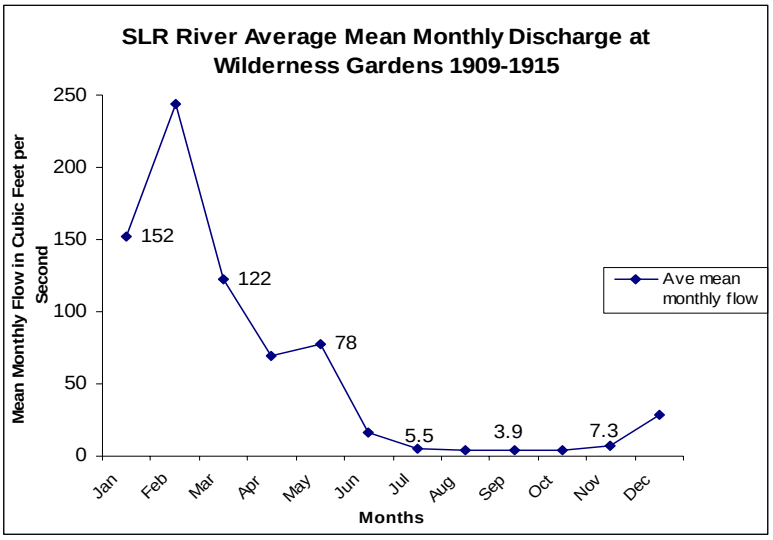


*Figure 7. SLR River average mean monthly flow recorded at Wilderness Gardens from 1909-1915 (USGS website).*

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

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

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

### *Influence of Imported Water Supplies on Stream Flows*

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

distribute water across the region, including the SLR River Basin, through a network of pipelines (http://www.yuimamwd.com/).

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

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

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

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

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

### *Current Stream Flow Conditions*

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

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

The SLR River contains perennial stream flows through the majority of the Middle Subbasin between Henshaw Dam and the Escondido Canal diversion, RM 40. Immediately downstream of the Escondido Canal diversion dam, stream flow is usually absent unless

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

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

### *Floods*

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

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

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

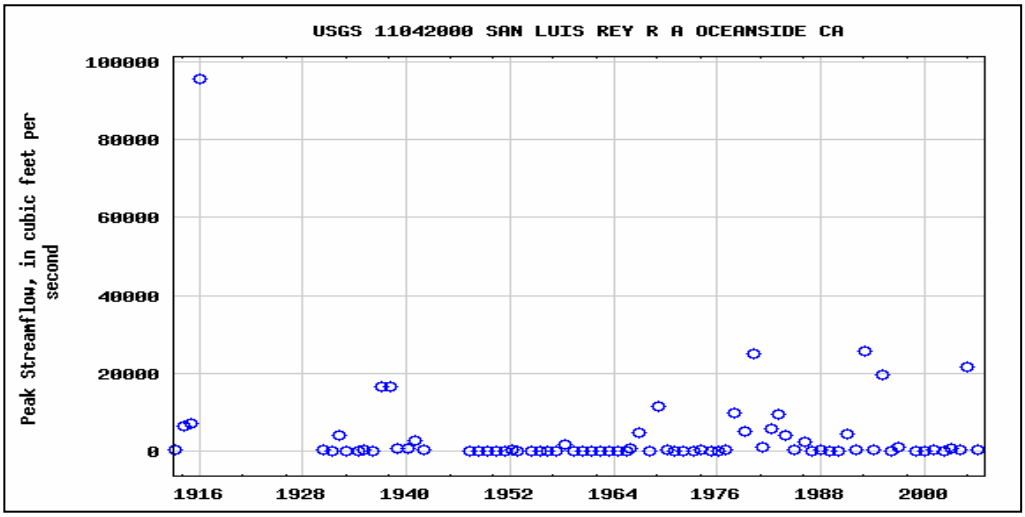


*Figure 8. Annual peak stream flows for the SLR River at Oceanside (RM 1.25) 1913-2005. Gaps in data collection occurred from 1917 to 1929 and from 1943 to 1946 (http://www.usgs.gov/).*

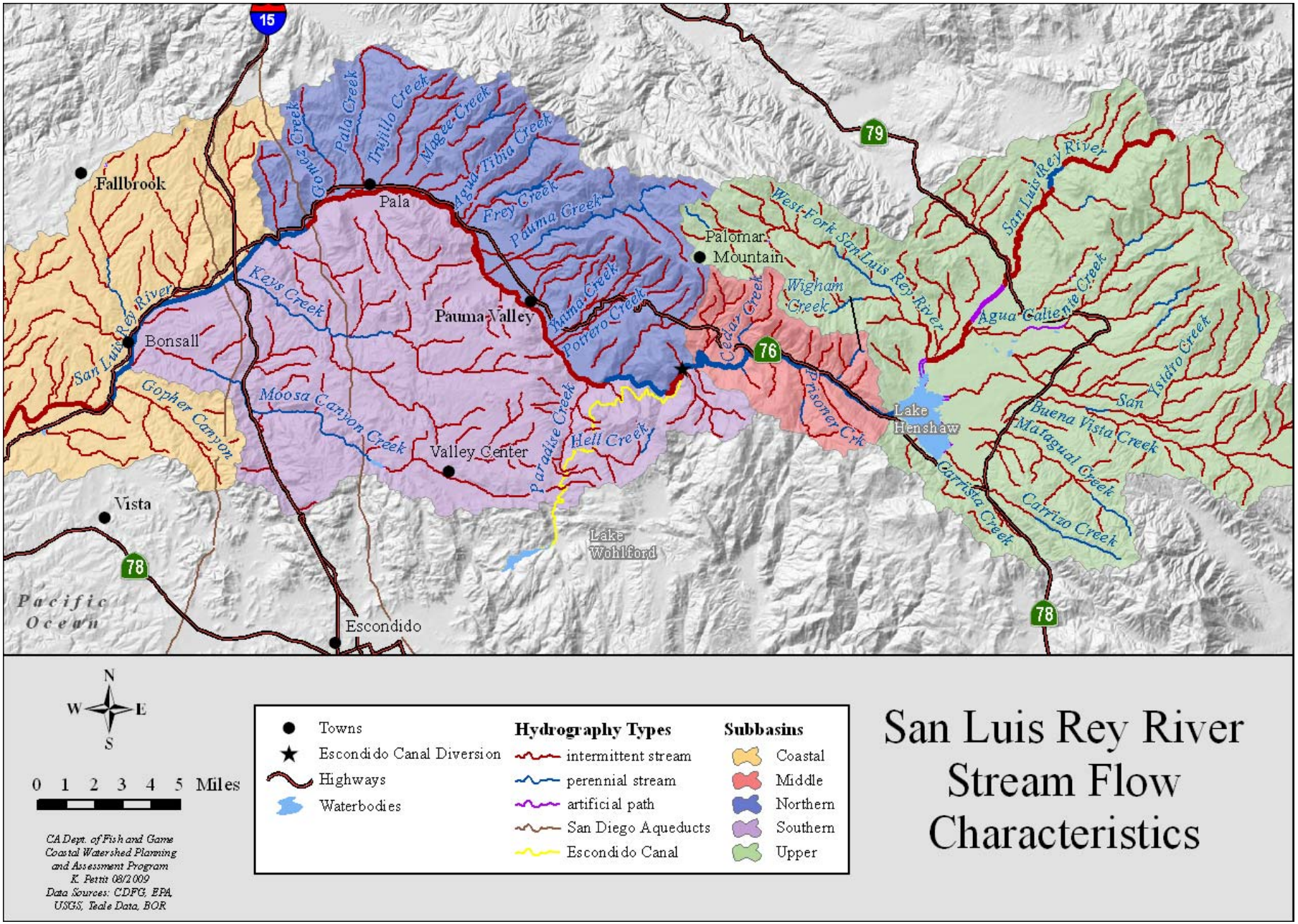


*Figure 9. SLR River Basin Stream Flow Characteristics*.*

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

## Geologic Overview

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

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

### *Rock Types*

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

#### *Mesozoic Granitic*

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

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

#### *Quaternary Alluvium*

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

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

#### *Quaternary Alluvial Fan Deposits*

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

#### *Sedimentary Rock Types*

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

#### *Mesozoic Sedimentary*

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

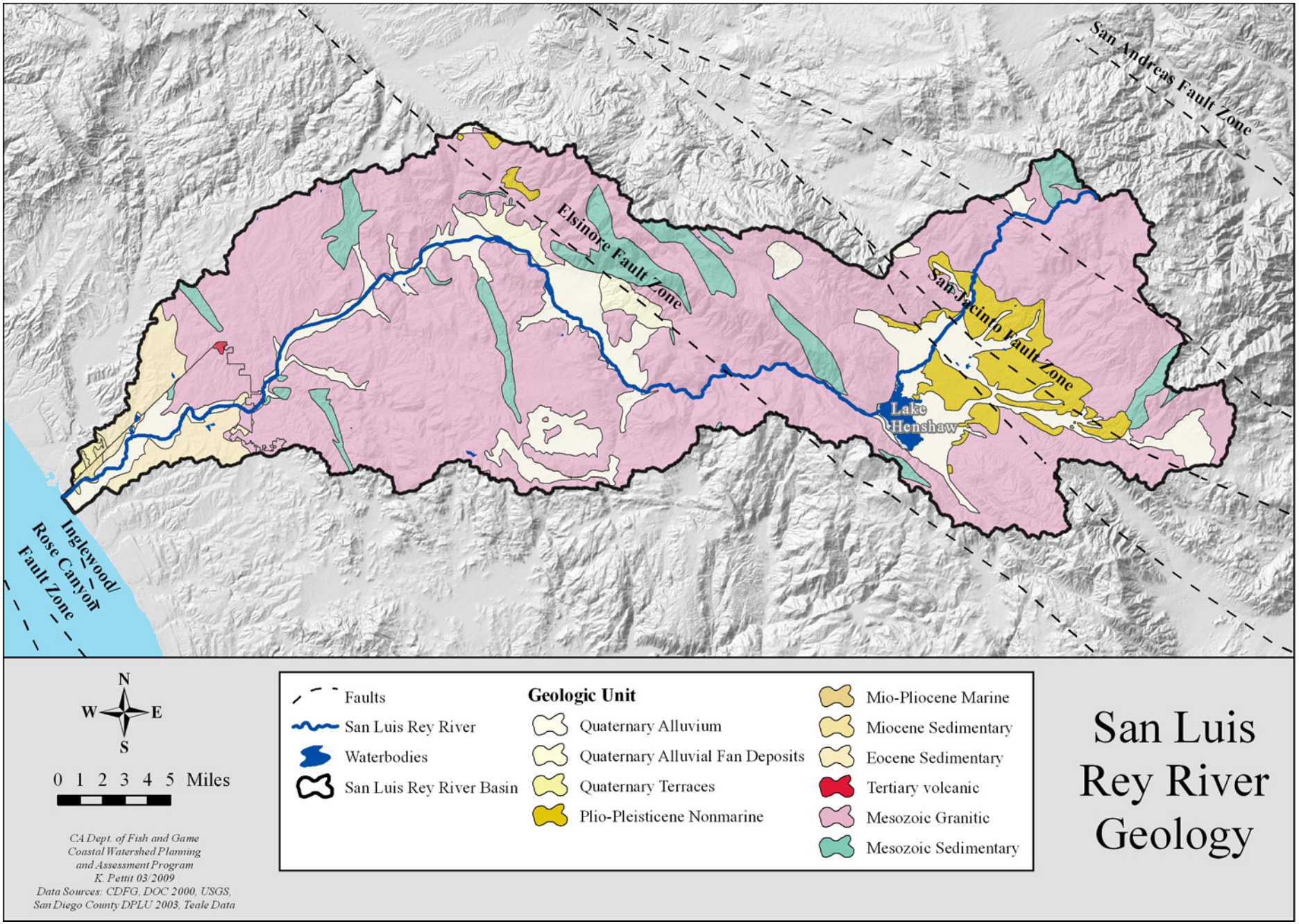


*Figure 10. Geology of the San Luis Rey River.*

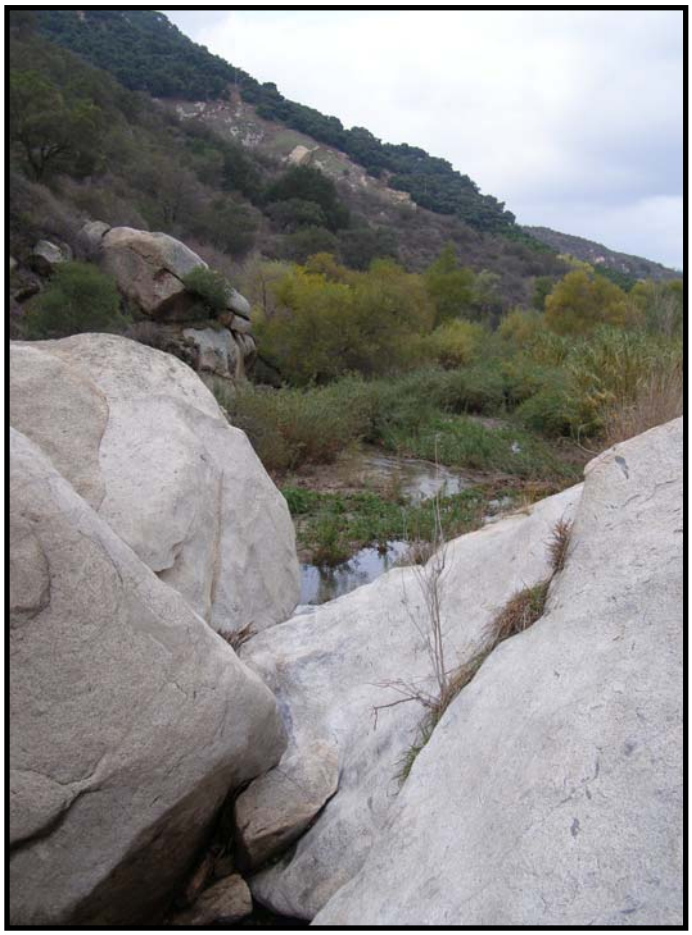

*Figure 11. Granitic bedrock in the foreground and within the distant hillsides.*

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

***Plio-Pleisticene Nonmarine***

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

***Eocene Sedimentary***

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

conglomerate and from poorly consolidated to well indurated.

***Miocene Sedimentary***

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

***Tertiary Volcanic***

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

***Mio-Pliocene marine***

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

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

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

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

## Soils

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

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

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

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

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

can have a significant alter soil structure and stability.

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

## Erosion

### *Decomposed Granite*

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

### *Steep Slopes*

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

### *Wildfires*

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

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

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

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

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

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

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

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

## *Tectonics and Faulting*

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

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

The fault zones depicted on the map include:

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

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

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

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

### *Uplift*

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

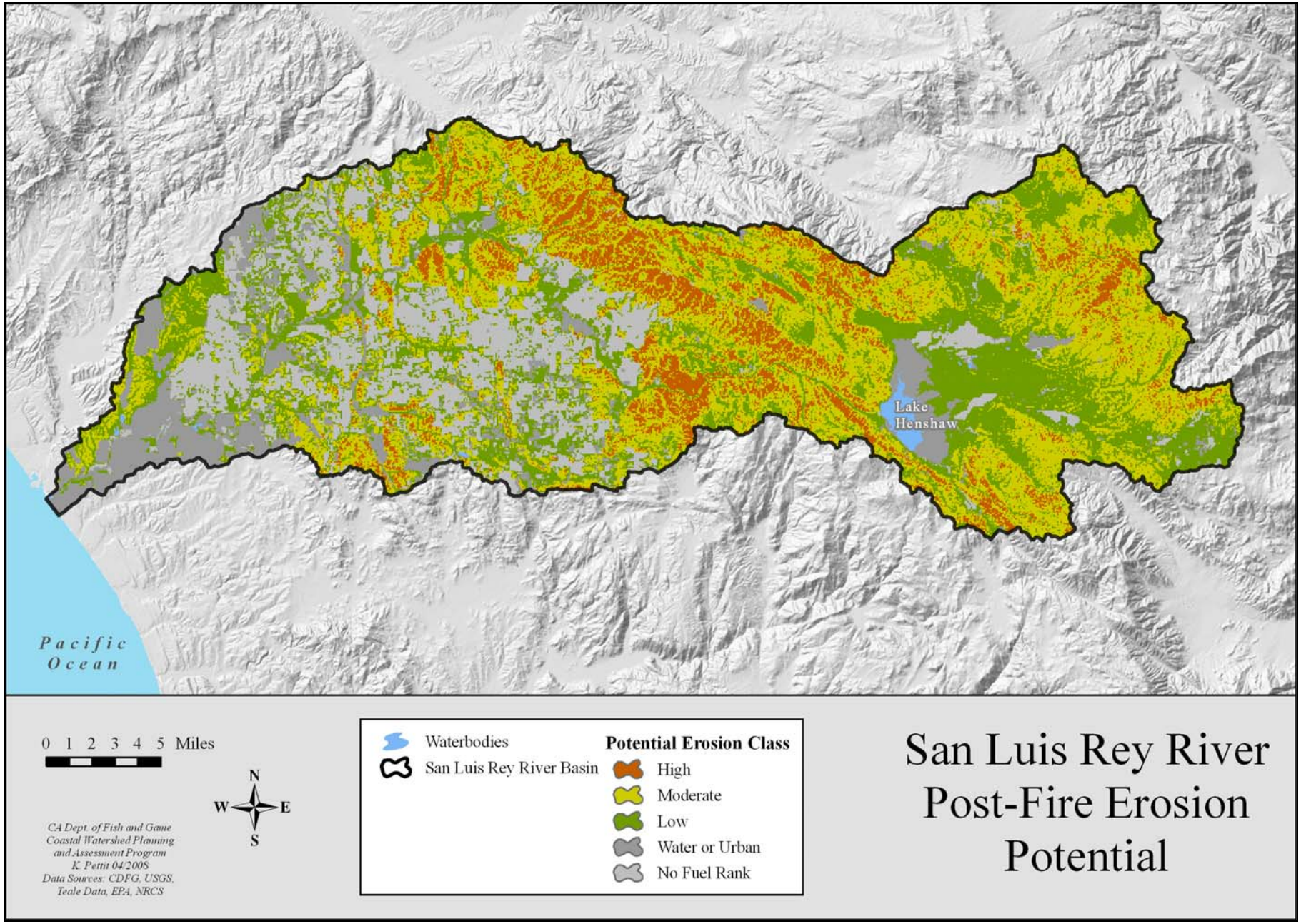


*Figure 13. Post-fire erosion potential of the San Luis Rey River Basin, California.*

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

## Fluvial Geomorphology

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

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

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

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

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

### *Stream Gradient and Reach Classification*

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

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

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

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

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

## Vegetation

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

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

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

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

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

riparian woodlands and forests, and conifer forests are all represented within the watershed (Figure 15).

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

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

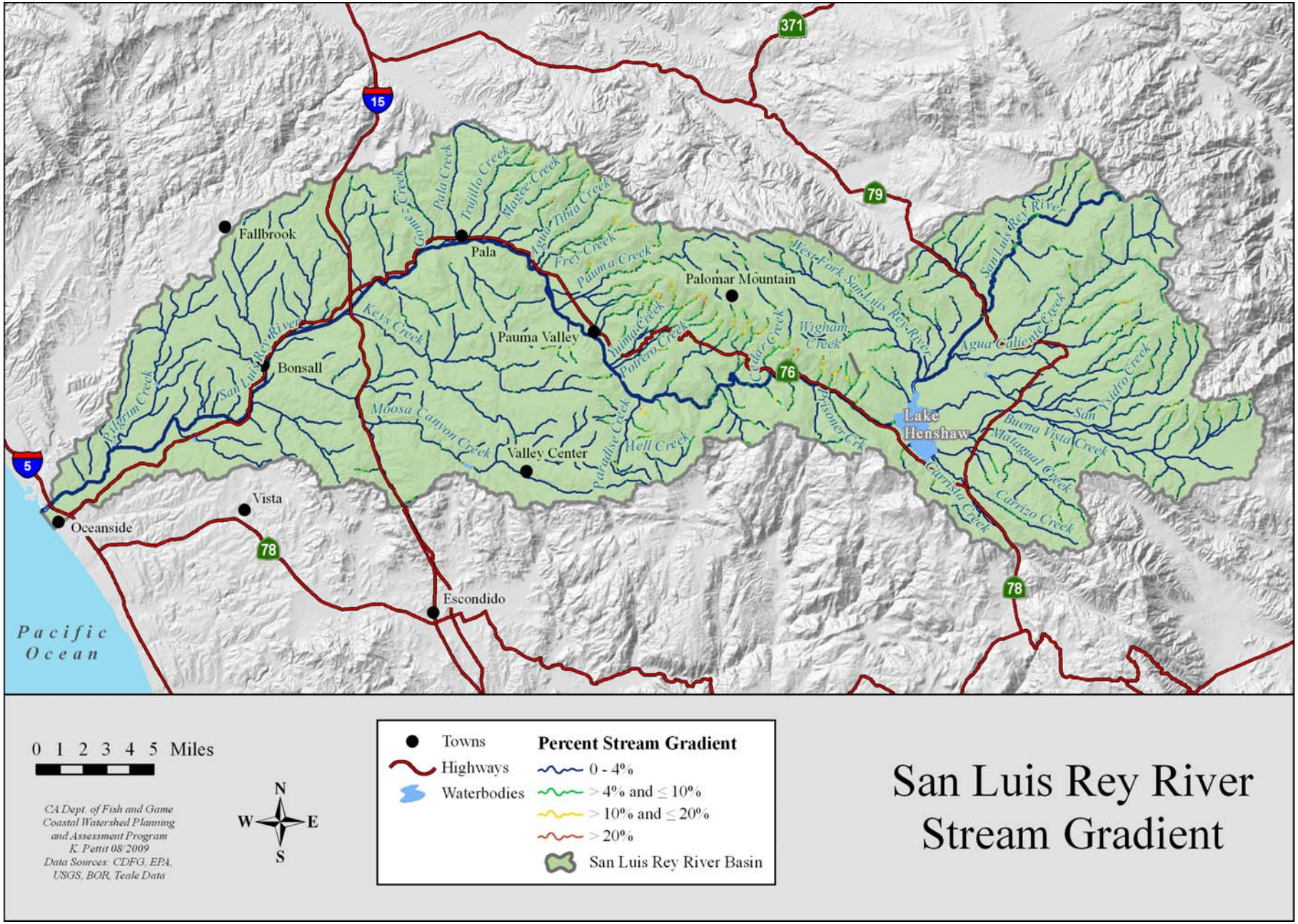


*Figure 14. Stream gradient of the SLR River Basin.*

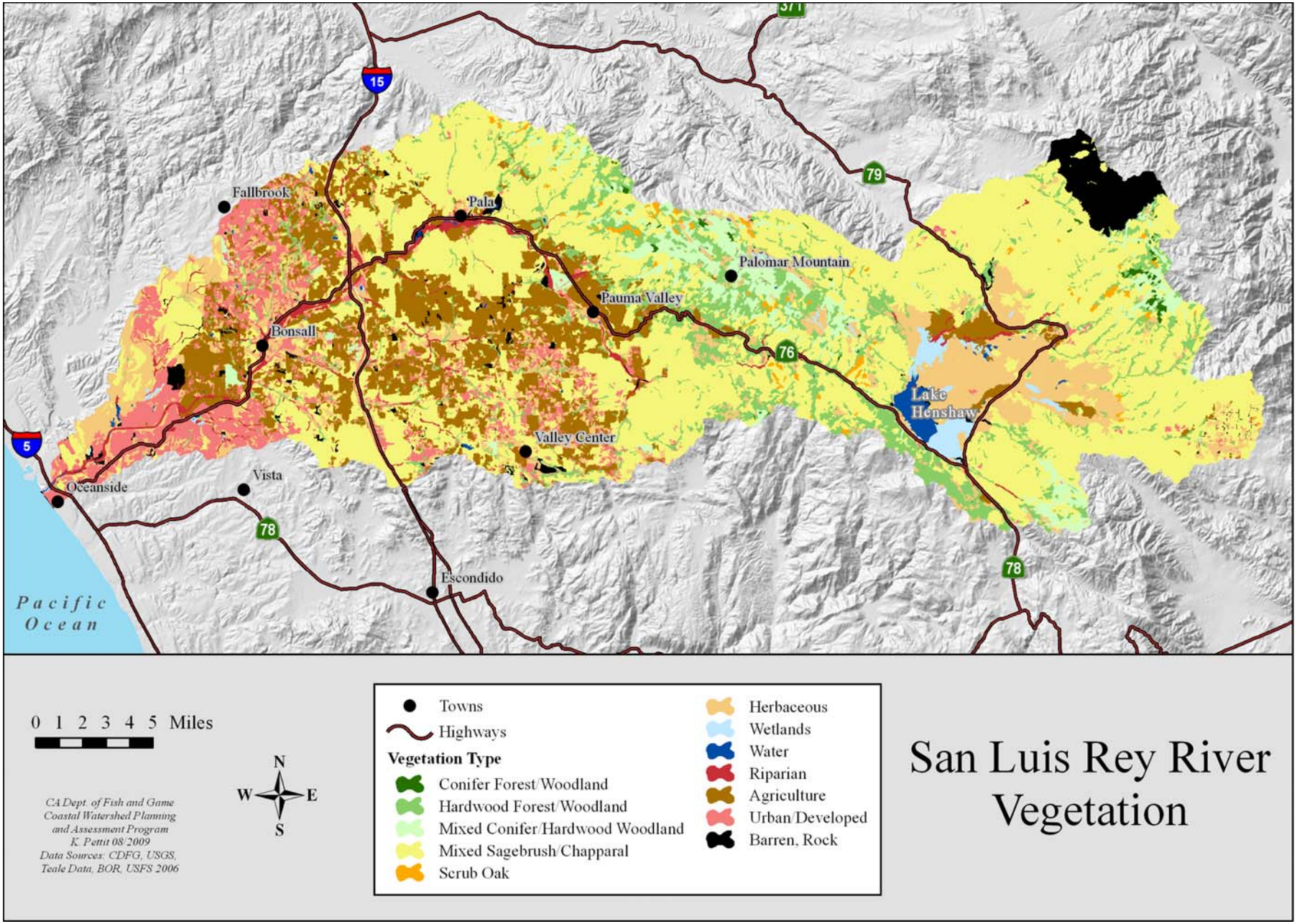


*Figure 15. Vegetation of the SLR River Basin, California.*

### *Flood Control Project and Channel Maintenance Plan*

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

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

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

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

water quality, the river, accompanied by a functional riparian is essential to maintaining water quality and local groundwater supplies.

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

*Figure 16. Riparian vegetation removal along SLR River in Oceanside.*
SLR River is forked but the main channel is to the right of remaining trees. Photo taken March, 2008.

### *Invasive Plant Species Management*

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

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

Any activity that disturbs or spreads soil generally distributes invasive plant seed or plant parts that can grow new individuals. Numerous activities along the SLR River such as channel clearing, the building of flood control structures, gravel mining, and agricultural practices could have easily contributed to the

proliferation of exotics. In addition, as a result of the Escondido Canal diversion, the flood regime has been altered which may have exacerbated the situation by reducing native plant post-flood establishment. The high levels of disturbance and habitat modification tend to favor a non-native flora (Stephenson and Calcarone 1999). Eradication is rarely achieved with one treatment, thus requiring a multi-year effort which is costly and requires accuracy and thoroughness in completing follow-up treatments and monitoring.

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

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

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

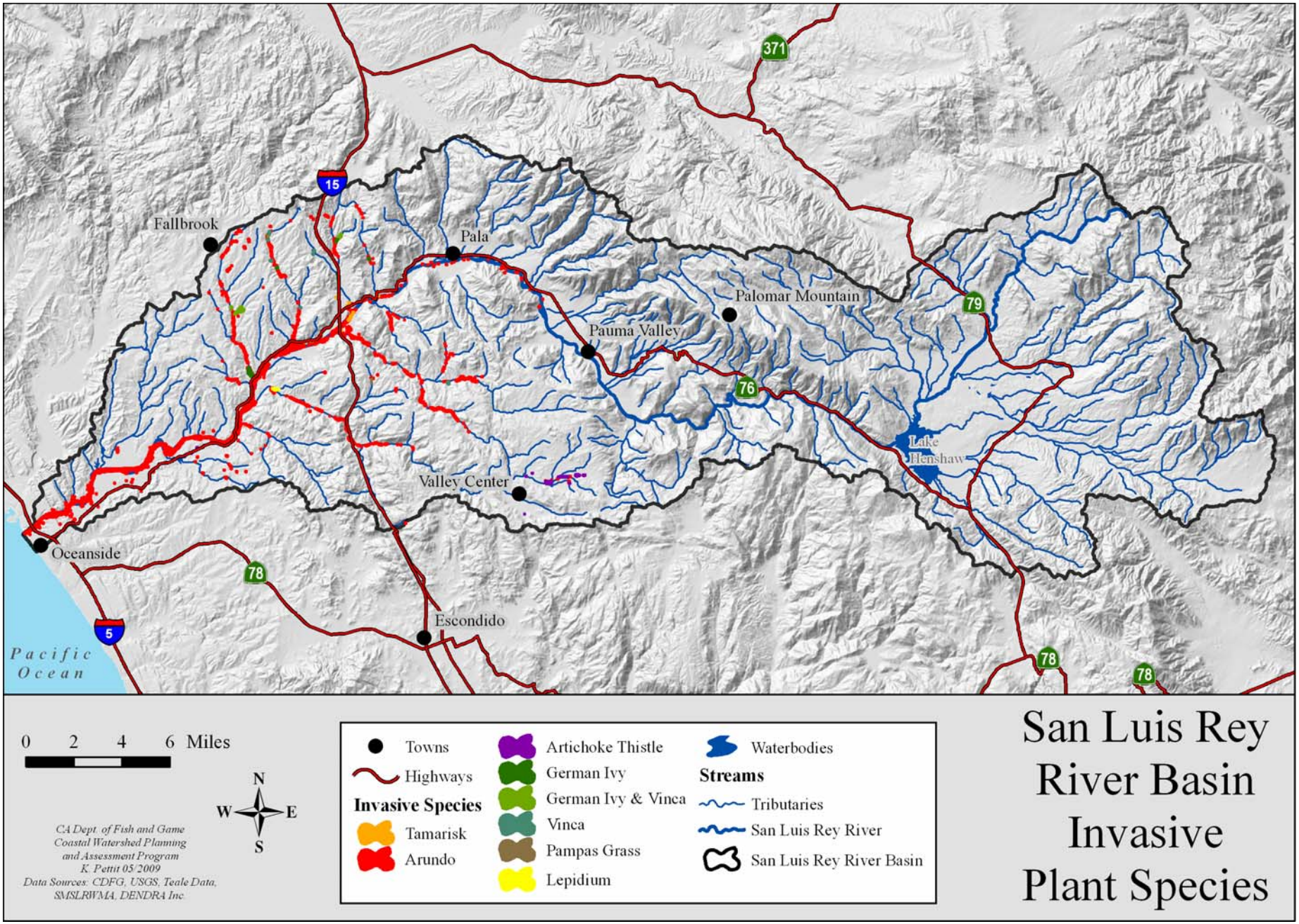


*Figure 17. Invasive Plant Species of the SLR River Basin.*

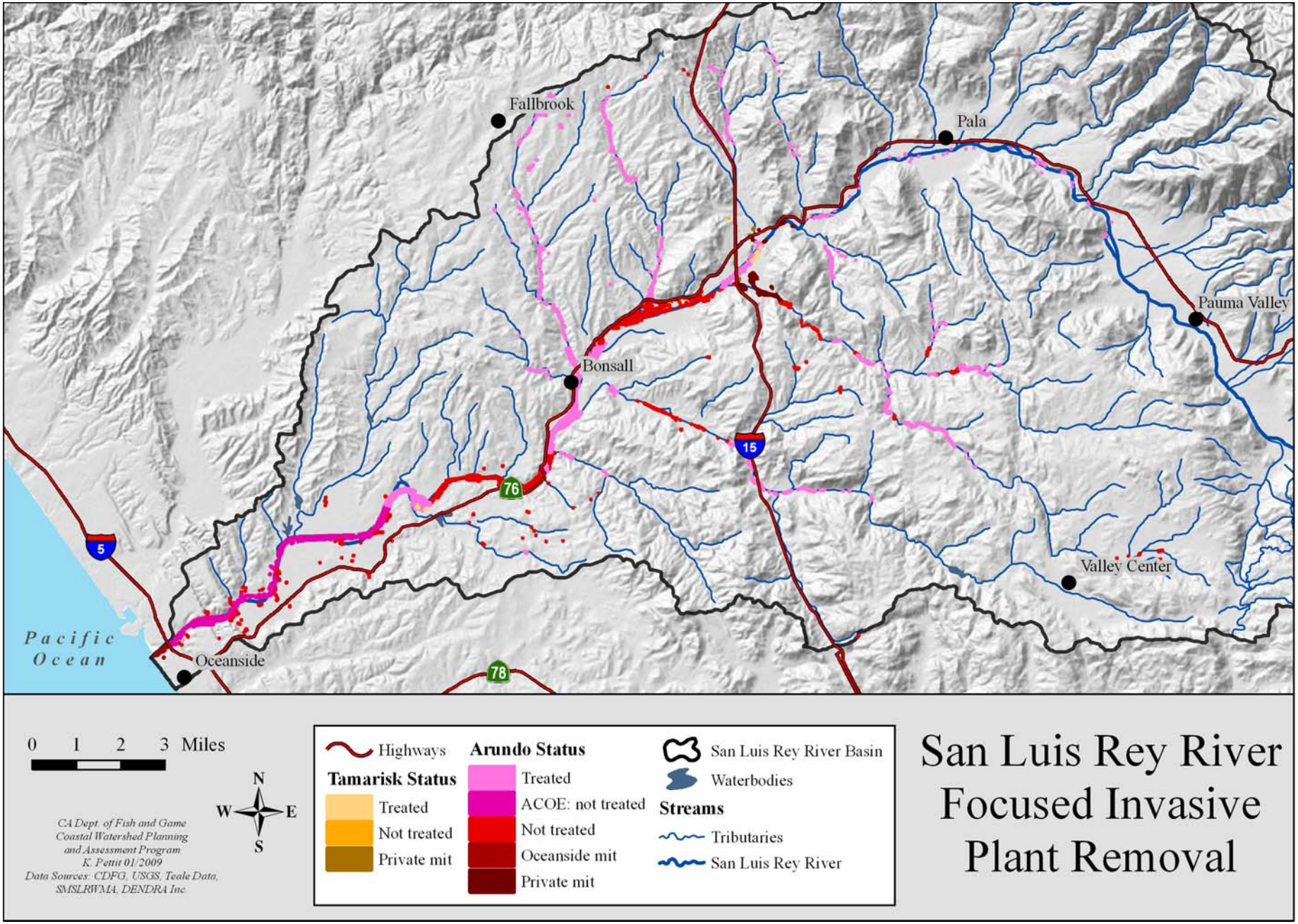


*Figure 18. Focused invasive plants removal in the SLR River Basin.*