WATERWAYS CONSULTING

DRAFT REPORT

ARROYO GRANDE CREEK CHANNEL WATERWAY MANAGEMENT PROGRAM

by John Dvorsky, Principal Scientist

for San Luis Obispo County Flood Control and Water Conservation District
Zones 1 and 1A Flood Control District

February 2010

TABLE OF CONTENTS

1.0 Purpose, Context, and Goals 1

1.1 Purpose of the Arroyo Grande Creek Channel Waterway Management Program 1
1.2 Waterway Management Program Project Elements 1
1.3 Project Background 3
1.4 Project Need 9

2.0 Existing Conditions 10

2.1 Project area 10
2.2 Larger watershed context 10
2.3 Biological conditions 13
2.3.1 Botanical resources 13
2.3.2 Fisheries resources 15
2.3.3 Other Threatened & Endangered species 16
2.4 Hydrologic and hydraulic conditions 19

3.0 Project Elements 21

3.1 Current Efforts 21
3.2 Vegetation Management 26
3.3 Sediment Management 31
3.4 Raise Existing Levees 34
3.5 Union Pacific Railroad Bridge 35

4.0 Monitoring and Adaptive Management Plan 37

4.1 Goals and objectives 37
4.2 Vegetation management 37
4.2.1 Goal 37
4.2.2 Monitoring and Performance Measures 38
4.3 Sediment management 40
4.3.1 Goal 40
4.3.2 Monitoring and Performance measures 41
4.4 Protection measures 44
4.5 Beaver management 48

5.0 References 50

LIST OF FIGURES, TABLES, AND PHOTOS

Figure #	Description	Page #
1	Project area location map	2
2	Historic aerial photos depicting remnant floodplain	4
3	Map of lower Arroyo Grande Creek watershed	11
4	Lagoon and flap gate location map	12
5	Historic and current floodplain extents of Arroyo Grande Creek	14
6	Sample locations for the 2006 relative fish abundance study	17
7	Plan view of extents of levee work that would be conducted under Alternative 3 (3a and 3c phases)	22
8	Conceptual cross-section view of components of Alternative 3	27
9	Typical view of vegetation maintenance activities	28
10	Conceptual typical site plan for Arroyo Grande Creek Channel Sediment and Vegetation Management Plans	33

Table #	Description	Page #
1	Fish abundance, by species, based on electrofishing surveys, October 2006	18
2	Steelhead abundance based on electrofishing and snorkel surveys, October 2006	18
3	Summary of the performance measures and monitoring efforts	39

Photo #	Description	Page #
1	Originally constructed trapezoidal channel	5
2	Oblique aerial view of the levee breach that occurred in 2001	7
3	Ground view of levee breach that occurred in 2001	7
4, 5, 6	Times series of photographs looking upstream of 22nd St.	24
7, 8, 9	Times series of photographs at UPRR bridge.	25
10	Spring/early summer regrowth of vegetation in the flood control channel	30
11	Photo of UPRR Bridge during the 2001 flood	35

Appendices

Appendix A Historical Summary of lower Arroyo Grande Creek

Appendix B Preliminary Engineering Design Plans

1.0 PURPOSE, CONTEXT, AND GOALS

1.1 Purpose of the Arroyo Grande Creek Channel Waterway Management Program

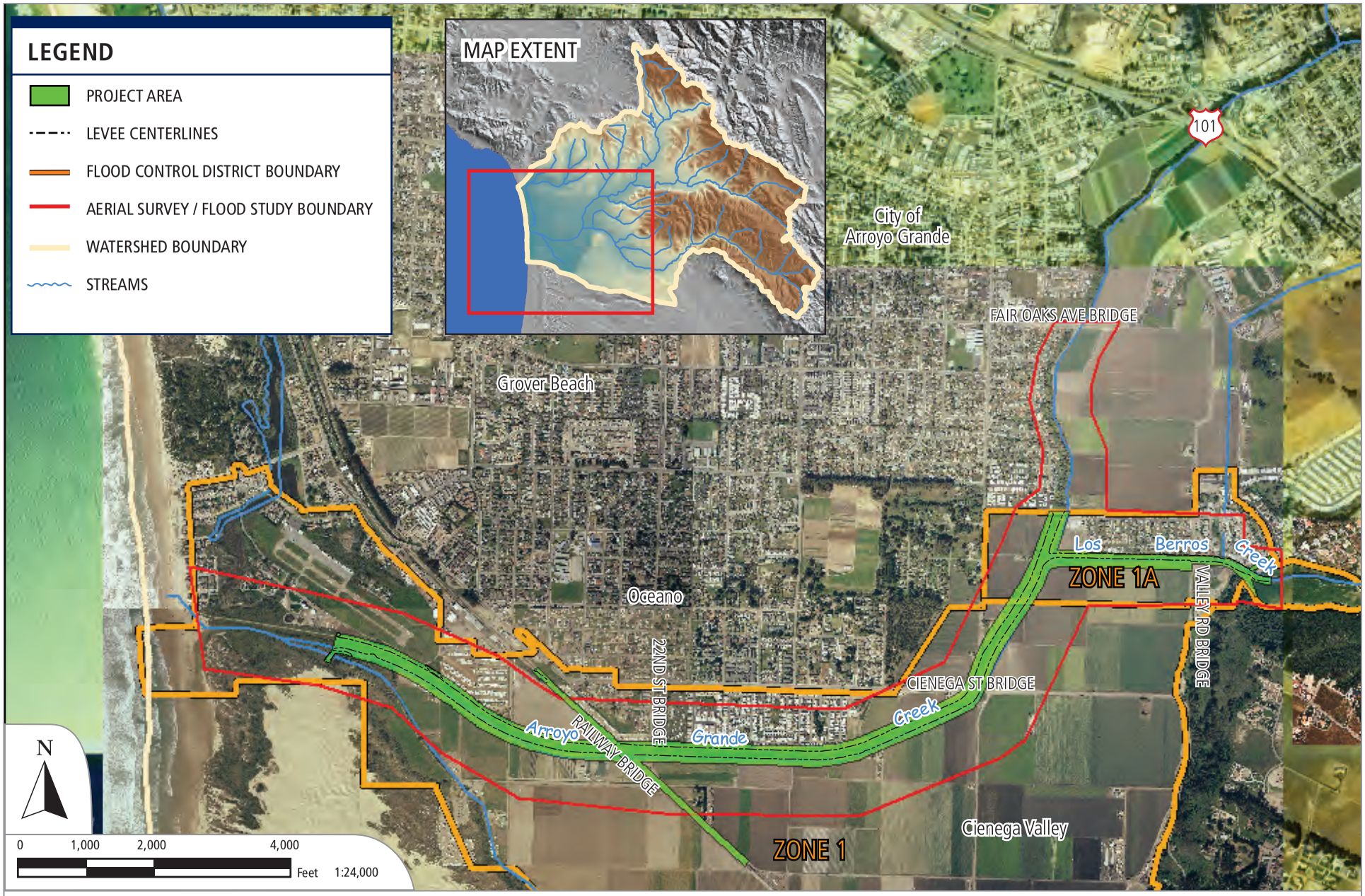
The Arroyo Grande Creek Channel Waterway Management Program (WMP) is a comprehensive set of actions designed to restore the capacity of the levied lower three miles of Arroyo Grande Creek Channel and the Los Berros Creek Diversion Channel (Figure 1) to provide flood protection up to a 20-year storm event while simultaneously enhancing water quality and sensitive species habitat within the managed channel. The WMP establishes a framework for how the lower portion of Arroyo Grande and Los Berros Creeks will be managed, long-term, to meet the goals established by Zones 1 and 1A (Zone 1/1A) of the San Luis Obispo County Flood Control and Water Conservation District (District) (Figure 1).

Management, within the context of the WMP, includes a combination of capital improvement projects, long-term maintenance activities, active restoration and enhancement projects, mitigation measures, performance monitoring, monitoring of implemented projects, programmatic elements, and adaptive management that responds to the performance monitoring activities. A description of each of these management activities are included in the WMP with enough detail so that the WMP will act as a guiding document on how to implement the project or program, how the project or program's success will be monitored, and what mitigation or protection measures will be required as part of project or program implementation.

1.2 Waterway Management Program Project Elements

The WMP was developed subsequent to an alternatives analysis that evaluated options to reduce flooding, manage sediment, and improve habitat conditions in the Arroyo Grande Creek Channel. The program alternatives were developed in cooperation with the community, the Coastal San Luis Resource Conservation District (RCD) and the District and are described in detail in the Arroyo Grande Creek Erosion, Sedimentation, and Flooding Alternatives Study (Alternatives Study) completed in January 2006 by Swanson Hydrology and Geomorphology. Alternatives 3a and 3c are the preferred alternatives and are the basis of the proposed Waterway Management Program. Alternative 3 includes the following key project elements:

- ***Vegetation Management:*** Manage riparian vegetation annually to improve flood capacity. Within the riparian corridor support a continuous canopy cover of mature trees and fill existing gaps while encouraging species diversity.



WATERWAYS CONSULTING
Santa Cruz, CA Portland, OR

FIGURE 1: General location map for the project and study areas on Arroyo Grande Creek. The hydrology and sediment loads are dominated by tributaries such as Los Berros

- ***Sediment Management***: Conduct sediment management in a way that will improve flood capacity and enhance geomorphic function so as to minimize future sediment accumulations that require intensive management;
- ***Levee Raise:*** Raise levees throughout the flood control channel to ultimately achieve a channel capacity that will protect the adjacent community and farmland up to a 20-year flood event; and
- ***Raise UPRR Bridge:*** Raise the Union Pacific Railroad Bridge above the 20-year water surface elevation to increase the flood capacity of the channel.

1.3 Project Background

Arroyo Grande Creek has a long history of flood impacts to agriculture and human habitation that dates back to the time of the early settlements in the mid-19th century. Historical accounts and a geomorphic analysis of the lower watershed and Cienega Valley suggest that much of the valley floor was at grade with the Creek and consisted of a broad thicket of willows and other riparian trees (Dvorsky, 2004). From the time of the earliest settlements, use of the valley for homesteading, agricultural production, dairies, and cattle ranching required clearing of vegetation and active management of the channel and floodplain (Figure 2). Management, in those days, consisting primarily of ditching the channel to provide a predictable flow path, building levees, removing willow thickets, and leveling the land. Much of these activities were carried out by individual landowners with little to no coordinated efforts between adjacent property owners.

In the 1950's, severe flooding from Arroyo Grande Creek resulted in inundation of prime farmland in the Cienega Valley and significant impacts to existing infrastructure. At the time, Arroyo Grande and adjacent communities were primarily rural with a combined population of less than 5,000 residents. To reduce future economic impacts to the agricultural economy and the growing urban and rural residential population, the community organized the Arroyo Grande Creek Flood Control Project (Project). The Project, led jointly by the USDA-Soil Conservation Service/Arroyo Grande Resource Conservation District, was completed in 1961 to protect homes and farmland in La Cienega Valley. (These organizations are now known as the USDA-Natural Resources Conservation Service and the Coastal San Luis RCD, respectively.)

The main feature of the Project was a levee system and trapezoidal channel that confined Arroyo Grande Creek from its confluence with Los Berros Creek downstream to the Pacific Ocean (Photo 1). In addition, the lower portion of Los Berros Creek from the Valley Rd Bridge to the confluence with Arroyo

A: Remnant riparian area evident in 1939 aerial photo, (highlighted in red), no longer exists in 2002 aerial photo.

B: Wide floodplain / riparian area evident in 1939 aerial photo, in 2002 aerial photo riparian area is confined by agricultural fields.

WATERWAYS CONSULTING

Santa Cruz, CA Portland, OR

FIGURE 2: A) 1939 and 2003 comparison of aerial photos showing remnant floodplain and channel features. B) 1939 and 2002 comparison of aerial photos showing changes to riparian width.

Grande Creek was diverted from its pre-1960 channel, which ran along the southern edge of La Cienega Valley, to its current confluence upstream of the Highway 1 Bridge. Runoff from the Meadow Creek watershed, which runs though Pismo Lake, was designed to enter Arroyo Grande Creek through a pair of flap gates, known as the Sand Canyon Flap Gates, near the Pismo State Beach. Maintenance of the Project, following construction was the responsibility of the District Zone 1/1A. Landowners within the zone are assessed an annual fee to support management and maintenance of the flood control reach.

Photo 1. Constructed trapezoidal channel at UPRR bridge in 1958.

The original flood control channel was built in 1959 and was designed to carry a discharge of 10,120 cubic feet per second (cfs), which, at the time of the analysis, was determined to have a recurrence of once every 100 years. Maintenance of the flood control channel as required by the 1959 Operation and Maintenance Agreement between the District, NRCS, and the CSLRCD (1959 Agreement), consisted primarily of vegetation and sediment removal to maintain the design geometry and capacity of the channel and routine maintenance of the levee system and associated infrastructure. Maintenance activities in recent years were restricted by a combination of lack of funding (Zone 1/1A maintenance funds had not risen appreciably since the creation of the special district) and environmental concerns about the impacts of vegetation and sediment removal on aquatic and riparian habitat in the flood control reach.

Environmental concerns and restrictions increased following the listing of the California red-legged frog (*Rana aurora draytonii*), in 1996, and steelhead (*Oncorhynchus mykiss*), in 1997. Protection of critical habitat for these two species meant that past maintenance activities, required under the 1959 Agreement with the NRCS and RCD, were no longer feasible. Limited sediment management did occur in November 1999 and October 2001 but pursuit of subsequent sediment management projects ended when the District pursued a permit in 2002 and it was determined that a Coastal Development Permit (CDP) was required. Although the Coastal Commission issued a CDP, they required preparation of a comprehensive analysis of the alternatives available for long-term flood protection, to be completed in three years. The District felt that development of a comprehensive plan would require more time and the 2002 CDP was withdrawn.

The requirements put forth by the Coastal Commission led the U.S. Fish and Wildlife Service, NOAA Fisheries, and the California Department of Fish and Game to also request that a more comprehensive strategy be prepared to manage the flood control reach through a maintenance program that specifically protects aquatic habitat. The 1959 Agreement was terminated by all parties on December 1, 2009. The termination of the agreement recognizes that the original project has reached its design life (50 years) and achieved its intended purpose. Parties to the agreement concur that major changes in watershed regulations, hydrology and objectives for the watershed require a new watershed plan not consistent with the 1959 maintenance agreement.

In 1999, the US Army Corps of Engineers developed a study to assess the existing capacity of the flood control reach. The results suggested that the system currently has a reduced capacity of 1,700 cfs which equates to a recurrence interval of approximately 2-year to 5-years (USACE, 2001). The capacity of the as-built channel (the channel as built in 1961), according to the USACE model, was determined to be 6,500 cfs with an associated level of protection between the 10-year and 20-year runoff event. These results showed that even with 1961 geometry, where sediment has been removed, the capacity of the channel has been reduced by approximately 1,000 cfs, most likely due to changes in the levee geometry from settlement and erosion. The USACE study pointed to the need for a more detailed alternative assessment to define project opportunities and costs associated with improving overall capacity and flood protection.

On March 5, 2001, during a high intensity rain event, the levee was breached on the south side between the mouth and the Union Pacific railroad bridge (Photos 2 and 3). It was estimated by observers in the field at the time of the levee breach that the levee would have overtopped upstream of the 22nd Street bridge had the levee not breached and lowered the overall water surface. Hundreds of acres of

farmland and several residences were flooded in La Cienega Valley. Impacts from the flooding persisted beyond the winter season as many of the lower lying areas with clay soils located in the southern portion of the valley remained saturated. The northern levee remained intact, thereby protecting several residential developments, the Oceano Aiport, and the regional wastewater treatment plant that services the communities of Arroyo Grande, Oceano and Grover Beach.

Photo 2. Oblique photo of flooding in the Cienega Valley following the levee breach of March 2001 (looking south).

Photo 3. Close-up view of the levee breach and flooding of farmland in March 2001 (looking at south levee from north levee).

As a result and subsequent to the 2001 flooding, the RCD, on behalf of the District, contracted with the consulting firm of Swanson Hydrology and Geomorphology (SH+G) to develop a range of flood protection alternatives, known as the Alternatives Study, which was completed in January 2006. The Alternatives Study focused in-depth on erosion sources, sedimentation and hydrology as they relate to recurring flooding in the lower reaches of the creek. The final study described six different

"Alternatives", or sets of feasible projects and management actions, that could be implemented to manage flooding in Zone 1/1A, and provides estimates of the degree of flood protection afforded by each Alternative. The Zone 1/1A Task Force, a technical subcommittee of the Zone 1/1A Advisory Committee, met with SH+G staff twice during 2005 to provide feedback and recommendations regarding which options to consider for analysis in the Alternatives Study, and to review preliminary results. The Zone 1/1A Task Force consisted of representatives from U.S. Fish and Wildlife, California Department of Fish and Game, the Coastal Conservancy, NOAA/NMFS, Regional Water Quality Control Board, San Luis Obispo County Public Works and Environmental Planning Departments, City of Arroyo Grande, Oceano Community Services District, Central Coast Salmon Enhancement, Zone 1/1A Advisory Committee, and U.S. Army Corps of Engineers.

The completion of the Alternatives Study provided Zone 1/1A with a range of viable solutions to improve flood capacity in the channel(s). The Zone 1/1A Advisory Committee endorsed Alternative 3 as the preferred alternative and in 2006 the property owners in Zone 1/1A approved additional property tax assessments to substantially enhance maintenance and operation efforts to the Arroyo Grande and Los Berros Creek Channels. Funding was now available to develop and carry out a long-term management plan for the flood control channel. In fall 2007, SLO County Public Works drafted a Notice of Preparation and a Request for Qualifications for preparation of an environmental impact report/environmental assessment and assistance with regulatory permitting. Representatives of the Zone 1/1A Advisory Committee Task Force joined SLO County Public Works staff in reviewing applications, conducting interviews, and selecting a consulting firm to recommend to the SLO County Board of Supervisors for contract. The firm selected was the Morro Group, now SWCA, Inc., partnering with SH+G (now Waterways Consulting) to prepare a Waterway Management Program (WMP) that includes project actions described under Alternative 3 of the Alternatives Study combined with enhancement actions that improve habitat conditions in the flood control reach for steelhead, California red-legged frog, and other species that rely on the aquatic environment.

In addition to activities specifically addressed in the WMP relating to the Arroyo Grande Creek channel, a Memorandum of Understanding (MOU) is in place that is designed to improve watershed conditions and limit sediment delivery from upslope areas to impacted reaches Arroyo Grande Creek such as the flood control reach. The County of San Luis Obispo and the County Flood Control and Water Conservation District became a signatory to the Arroyo Grande Creek Watershed MOU on April 22, 2008. The purpose of the MOU is to enhance an overall understanding of watershed issues and promote consensus between the parties in order to better protect, manage and enhance the Arroyo Grande Creek watershed.

The MOU recognizes that some of the agencies have existing responsibilities within the watershed and that those autonomous responsibilities will continue. The intent of the MOU involves educating each other on those efforts and identifying how collaborative efforts in the watershed management can be implemented in the future more efficiently and effectively. Future implementation of collaborative efforts will require development of cost sharing agreements and action plans, which will need separate approval by participating agencies.

By signing the MOU, the County showed its support for collaborative watershed management. Other signatories of the MOU include: the City of Arroyo Grande, RCD, and the Central Coast Salmon Enhancement. The RCD and the Central Coast Salmon Enhancement have become key advocates for the MOU and are working with other resource agencies to become signatories, including: US Fish and Wildlife Service, Natural Resource Conservation Service, CA Department of Fish and Game, and CA Department of Parks and Recreation. The CA Regional Water Quality Control Board was solicited for signature, but was unable to sign and instead endorsed the MOU.

1.4 Project Need

The proposed project is needed to provide the residents of Zone 1/1A with improved flood protection. The District, Zone 1/1A, is responsible for operation and maintenance of the leveed lower three miles of Arroyo Grande Creek. As concerns for environmental protection have increased, the District has been limited in its ability to conduct periodic maintenance to reduce flood risks to adjacent landowners and sustain the channel's design capacity. Consequently, the existing channel has a severely reduced capacity and can only provide protection up to the 4.6 year flow recurrence event. This level of flood protection is inadequate and severely limits the ability of Zone 1/1A to meet its obligations to residents in the District. This was evidenced during the 2001 levee system breach on the south side which inundated hundreds of acres of farmland and several residences. It could have been much worse if the system breached on the north side. However, the northern levee remained intact, thereby protecting several residential developments, the Oceano Airport, and the South County Sanitation District Wastewater Treatment Plant that services the communities of Arroyo Grande, Oceano, and Grover Beach.

2.0 EXISTING CONDITIONS

2.1 Project area

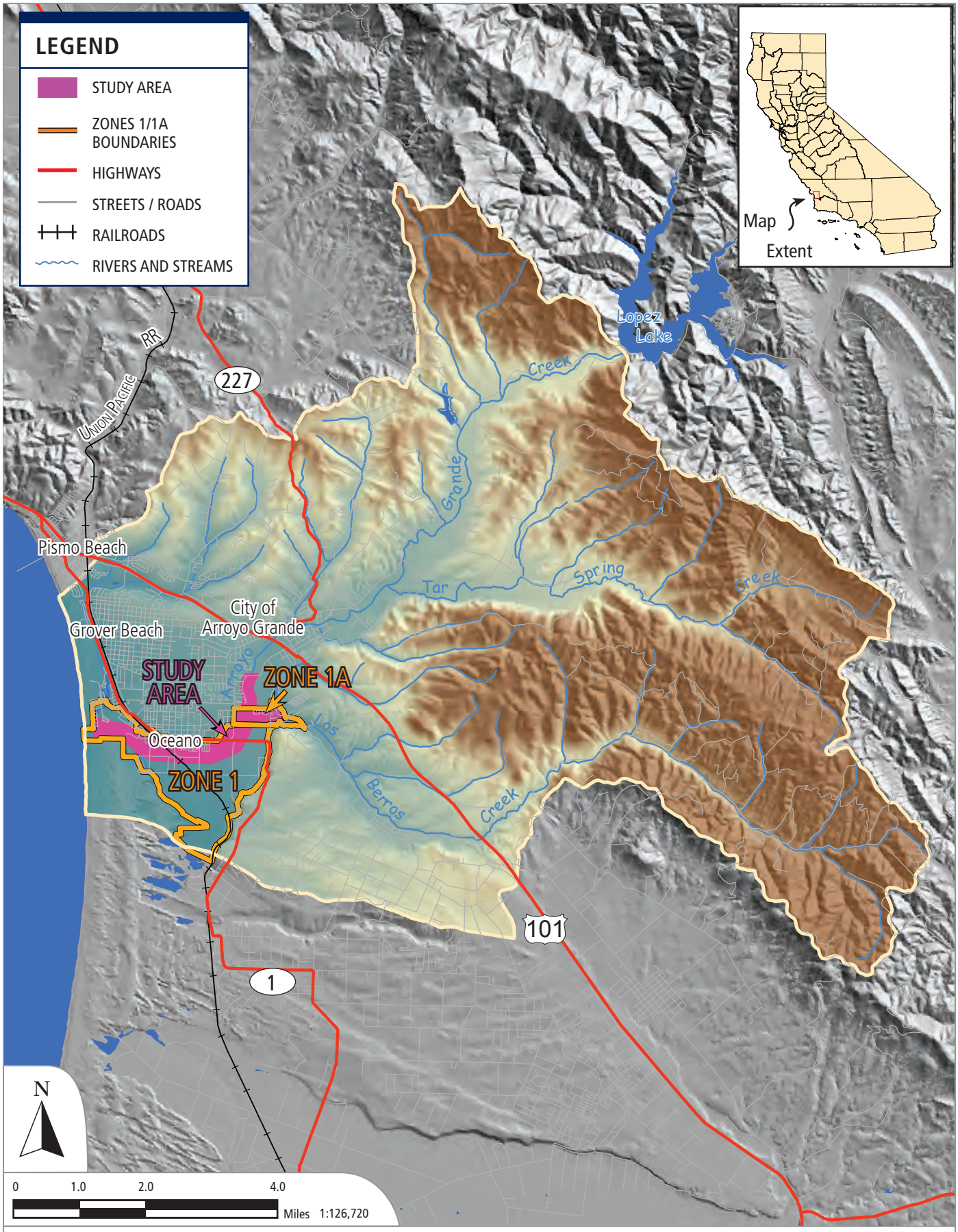
Arroyo Grande Creek is a 157 square mile coastal watershed located in west-central San Luis Obispo County (Figure 3). The mainstem of Arroyo Grande Creek flows through the cities of Arroyo Grande and Oceano and is an important regional waterway, providing agricultural and municipal water to the communities of Arroyo Grande, Grover Beach, Oceano, Pismo Beach, and Avila Beach by way of Lopez Reservoir located in the upper portion of the watershed. An expanding urban population and a desire to maintain the region's agricultural roots has resulted in an increasing demand on the natural and biological resources of the Arroyo Grande Creek watershed.

The Waterway Management Program project area is located along the lower portion of mainstem Arroyo Grande and Los Berros Creeks within San Luis Obispo County, California. The project area is a linear corridor with two segments: (1) beginning on Arroyo Grande Creek 0.14 mile upstream of the confluence of Los Berros Creek and continuing downstream to the upper edge of the Arroyo Grande Creek lagoon at the Pacific Ocean, and (2) beginning at the Century Lane Bridge on Los Berros Creek and continuing downstream to the confluence with Arroyo Grande Creek (Figure 1). The total project length is approximately 3.5 miles.

The project area ends just upstream of a euryhaline coastal lagoon that occurs at the mouth of Arroyo Grande Creek (Figure 4). Portions of the lagoon lie within the Pismo Dunes State Reserve and the lagoon bisects Pismo State Beach. Similar to other coastal lagoons in central California, the mouth of the creek is seasonally obstructed by a sand bar that forms in spring and persists until winter rains are sufficient to hydraulically force the sand bar to open. During drought or periods of prolonged dry weather the sand bar may not open at all. When the sand bar is in place depths in the lagoon can increase causing the lagoon to backwater a significant distance up into the flood control channel.

2.2 Larger watershed context

Though it is difficult to definitively describe what Arroyo Grande Creek may have historically looked like, historical accounts from early settlers and an understanding of the physical setting provides a glimpse into the past and a picture of how the channel functioned. A key feature in the existing landscape of Arroyo Grande is Lopez Dam. Lopez Dam is located at a point in the watershed where there is a



WATERWAYS CONSULTING
Santa Cruz, CA
Portland, OR

FIGURE 3: Study area for the WMP. The WMP includes the levees, channel and riparian areas on lower Arroyo Grande Creek and lower Los Berros Creek within the Zone 1/1A Flood Control District.

WATERWAYS CONSULTING
Santa Cruz, CA
Portland, OR

FIGURE 4: Lagoon and flapgate locations.

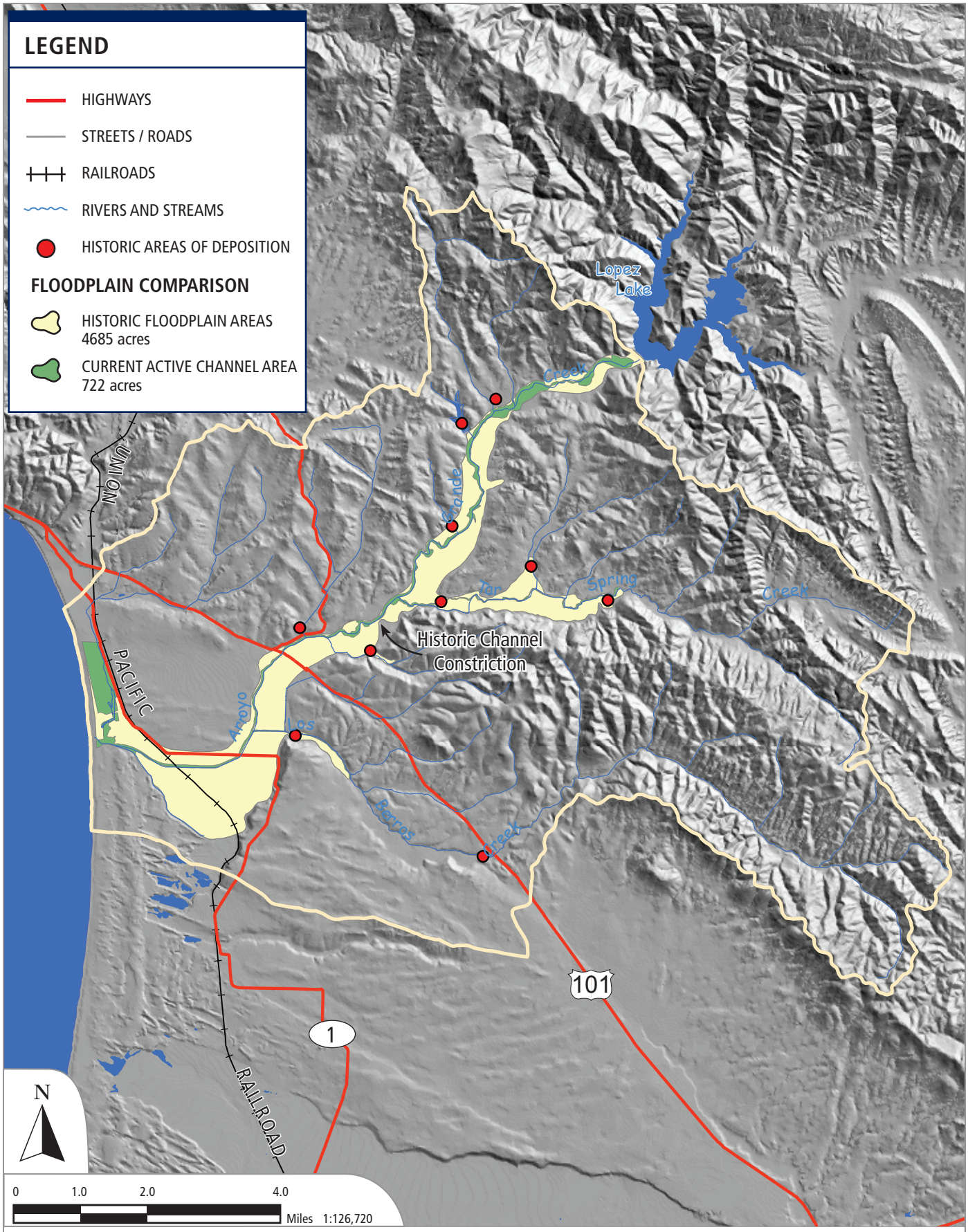
transition from confined mountain valley to an unconfined coastal plain. Dams are often sited in such a location because they provide a convenient constriction point for a dam, thereby minimizing the amount of earthen material required to impound a relatively large area upstream. Downstream of Lopez Dam the channel is much flatter, the valley much wider and historic floodplain deposits occur across the entire valley bottom (Figure 5). This area represents a depositional zone within the watershed where large quantities of water and sediment transported from the upper watershed historically spread across the valley floor, creating the large alluvial valley that exists today. Channels in steep, higher gradient valleys can transport more sediment than channels in lower gradient, wide valleys because the energy required to move sediment is a function of an energy gradient that is related to surface water slope and depth. This is often referred to as the sediment transport competence of the flow. In the lower portions of the mainstem, near the Community of Oceano, the floodplain deposits are extensive. Combined with the potential for a sand berm to form at the mouth, high tides and storm surges during peak flow events, and the constricting presence of the sand dunes, this portion of the system can be classified as deltaic in nature. The lower portion of the channel historically supported a large lagoon that extended into the Meadow Creek wetlands to the north of the existing levee.

2.3 Biological conditions

2.3.1 Botanical resources

Six plant community types occur within the Project Area including willow riparian woodland, riparian scrub, coyote brush scrub, ruderal (weedy) grassland, in-stream wetlands, and landscape tree groves. The willow riparian woodland habitat type comprises the majority of the proposed flood control area. In addition to the main plant community types, four special status species have been identified as having the potential to occur in the project area including sand marshwort, La Graciosa thistle, Gambels watercress, and San Bernardino aster. The potential for these species to occur is based on a records search of the California Native Plant Society (CNPS) and California Natural Diversity Database (CNDDB) inventories and the presence of suitable habitat on site.

When the flood control channel was constructed in 1959 all riparian vegetation was removed from the channel, resulting in a flat-bottom trapezoidal channel devoid of all vegetation. This condition was maintained for many decades with periodic dredging of the channel to maintain overall capacity. Due to concerns associated with the presence of threatened species, past management activities that maintained flood conveyance were restricted. Since 2006 vegetation is annually managed as part of a program conducted by the District with assistance from the RCD. The current program acquires annual permits from California Department of Fish and Game and the California Coastal Commission.



WATERWAYS CONSULTING

Santa Cruz, CA Portland, OR

FIGURE 5: Historic versus existing active channel areas on Arroyo Grande Creek and tributary channels downstream of Lopez Reservoir. Mapped surfaces represent areas of active deposition and storage of sediment delivered from the upper watershed. Loss of potential sediment storage in the lower valley results in transport and delivery of supplied sediment to the flood control reach.

2.3.2 Fisheries resources

Historically, Arroyo Grande Creek supported a large native population of steelhead (*Oncorhynchus mykiss*). Land use impacts in the watershed and construction of Lopez Dam and Reservoir has greatly reduced their numbers to a point where only a small run of adult steelhead occur today. Access to historic spawning habitat upstream of Lopez Reservoir was completely cut off due to construction of the dam in the late 1960's. The remaining habitat consists of the mainstem of Arroyo Grande Creek downstream of the dam and short reaches of year-round flow on tributaries such as Los Berros and Tar Springs. Unfortunately, the mainstem of Arroyo Grande Creek downstream of Lopez Reservoir, Los Berros Creek, and Tar Spring Creek do not provide the prime spawning and rearing habitat that historically occurred upstream of Lopez Reservoir. The accessible reaches of the mainstem of Arroyo Grande Creek consist of approximately 14 miles of channel along the mainstem, 14 miles of channel along Los Berros and an equal amount along Tar Springs.

In 1997, steelhead (*Oncorhynchus mykiss*) runs along the Central Coast of California were listed as threatened under the Endangered Species Act. Due to their declining numbers and federal protection, awareness has been raised about the fate of the steelhead run in Arroyo Grande Creek and a strategy is being pursued to restore this population through habitat enhancement measures downstream of Lopez Reservoir.

The most recent habitat assessment and steelhead abundance surveys were conducted in 2004 and 2006, respectively. Habitat assessments of the entire mainstem of Arroyo Grande Creek below Lopez Reservoir were conducted in the summer of 2004 by the California Conservation Corps (Close and Smith, 2004). Those data were then used to develop a random sample of discreet habitat units for a fish abundance survey conducted in the fall of 2006 (Dvorsky and Hagar, 2008). Within the Project Area a total of five discreet habitat units were sampled representing approximately 840 feet of channel. All of the habitat units were sampled via snorkeling and one of the habitat units was sampled via both snorkeling and electrofishing. The number of steelhead observed via snorkeling in all five habitat units sampled as part of the study was five. No steelhead were captured via electrofishing in the single habitat unit.

In the 2006 study, steelhead were markedly more abundant upstream of the flood control channel than within the flood control reach and then declined within the vicinity of Lopez Dam. In general low numbers of steelhead visually observed and sampled during the 2006 survey are consistent with previous studies on Arroyo Grande Creek which have suggested low steelhead adult returns, poor

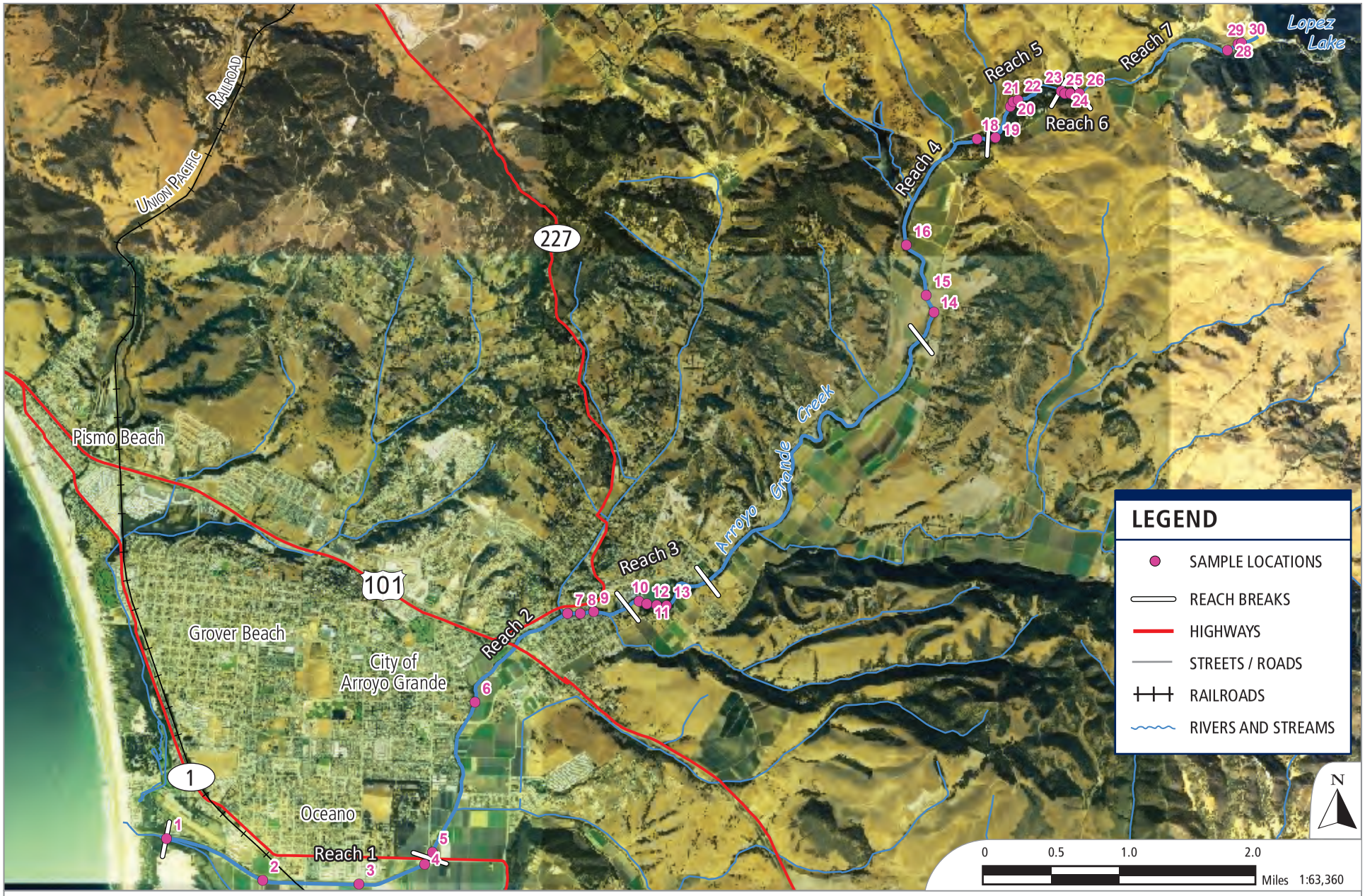
quality habitat, and impacts from loss of historic, high quality habitat present above Lopez Reservoir. The observations summarized in the 2008 report suggest that the best habitat present in the system occurs in the upper portions of Reach 2, Reach 3, and the lower portion of Reach 4 (Figure 6; Tables 1 and 2). Habitat conditions in the upper portions of Reaches 4, 5, 6, and 7 appear to be significantly influenced by a lack of high flows due to regulation by Lopez Reservoir. The lack of channel flushing flows has resulted in a narrow low-flow channel that lacks complexity (Close and Smith, 2004). In addition, much of the bed of the channel consists primarily of silt that likely limits spawning. The presence of excessive fine sediment loads in streams has been shown to limit macroinvertebrate production, reduce the amount of cover habitat available to juvenile salmonids, and limit successful spawning (Terhune, 1958; McNeil and Ahnell, 1964; Vaux, 1962; Cooper, 1965; Daykin, 1965). Portions of Reaches 2, 3, and 4 probably exhibit higher steelhead abundance because unregulated flows from Los Berros, Tar Springs, and Corbett/Carpenter Creeks allow for introduction of coarse material for spawning and flushing of fine sediment from pools and riffles.

In addition to steelhead a number of other species of fish occur in the system including Sacramento sucker, California roach, and threespine stickleback. Non-native fish species include bullhead, centrarchids, and mosquitofish.

Fisheries resources were evaluated in the lagoon from 2003 through 2006 (Rischbieter 2004; Rischbieter 2006; Rischbieter 2007). The purpose of the lagoon study was to understand fish use of the lagoon and evaluate the impacts that off-highway vehicles have on habitat quality and use. Off-highway vehicles are currently permitted to cross the mouth of Arroyo Grande Creek to gain access to the State Vehicular Recreation Area. In the 2006 study a total of 13 species of fish were collected from the lagoon including steelhead and tidewater goby. The highest densities of steelhead occurred in February 2006 with a decline in relative abundance through the summer and into fall of 2006.

2.3.3 Other Threatened & Endangered species

The California red-legged frog is a State Species of Special Concern and is Federally listed as threatened. This species is found in quiet pools along streams, in marshes, and ponds. Red-legged frogs are closely tied to aquatic environments, and favor intermittent streams which include some areas with water at least 0.7 meters deep, a largely intact emergent or shoreline vegetation, and a lack of introduced bullfrogs and non-native fishes. This species' breeding season spans January to April (Stebbins 1985). Females deposit large egg masses on submerged vegetation at or near the surface. Embryonic stages require a salinity of $\leq$4.5 parts per thousand (Jennings and Hayes 1994). They are generally found on



WATERWAYS CONSULTING
Santa Cruz, CA Portland, OR

FIGURE 6: Map indicating sample locations for the 2006 relative fish abundance study and geomorphic reaches along Arroyo Grande Creek.

Table 1

Reach	Sample Unit #	Steelhead	Sacramento Sucker	California Roach	Threespine Stickleback	Speckled Dace	Sculpin	Bullhead Catfish
1	3		19	15	12	1		
2	8	6	58	22		1	7	1
3	13	8	31	25	2	10		
4	14	3	10		1			
5	22	6	5		1			
6	23	4	12					1
7	28		13					

Table 2

Reach	Unit #	Electrofishing Total Catch	Snorkel Total Count
1	1		1
	2		1
	3	0	1
	4		2
2	5		0
	6		0
	7		21
	8	6	14
	9		15
3	10		28
	11		7
	12		12
	13	8	22
4	14	3	20
	15		6
	16		16
	18		3
5	19		1
	20		10
	21		2
	22	6	3
6	23	4	3
	24		1
	25		5
	26		0
7	28	0	4
	29		0
	30		9
	Grand Total	**27**	**207**

Note: Gray highlights denote habitat units that were electrofished and visually sampled.

TABLES 1 & 2: Table 1 - Fish species abundance as determined from electrofishing surveys in Arroyo Grande Creek, October 2006; Table 2 - Steelhead abundance in Arroyo Grande Creek based on electrofishing and visual surveys, October 2006.

streams having a small drainage area and low gradient (Hayes and Jennings 1988). Recent studies have shown that although only a small percentage of red-legged frogs from a pond population disperse, they are capable of moving distances of up to 2 miles (Bulger 1999). The red-legged frog occurs west of the Sierra Nevada-Cascade crest and in the Coast Ranges along the entire length of the state. Much of its habitat has undergone significant alterations in recent years, leading to extirpation of many populations. Other factors contributing to its decline include its former exploitation as food, water pollution, and predation and competition by the introduced bullfrog and green sunfish (Moyle 1973, Hayes and Jennings 1988).

California red-legged frogs have been observed within the flood control reach of Arroyo Grande Creek (Essex Environmental 2002; CSLRCD 2005). The flood control reach is expected to provide summer foraging habitat for the frog; however, due to swift winter flows through the study area, it is not likely to provide suitable frog breeding habitat. The lack of vegetation and dry summer conditions in the Los Berros Creek portion of the study area make it unsuitable for California red-legged frogs. The study area is not within the currently designated critical habitat for California red-legged frog (USFWS 2005).

2.4 Hydrologic and hydraulic conditions

Winter peak flow events on Arroyo Grande Creek can be characterized as flashy and are tied closely to the duration and magnitude of winter rainfall and antecedent soil moisture conditions. In most years, the rainy season begins in October, but the soil moisture demand of the surrounding areas is not met until a significant amount of precipitation has occurred. Once the ground is saturated, a greater percentage of the precipitation is converted to stream flow during storm runoff and the continual contribution of groundwater and subsurface flow to stream channels increases the winter baseflows. Precipitation is typically much lower during April, but the stream flows remain elevated as groundwater and subsurface flow continues to contribute water to the streams. By May, the water levels in the streams are typically low and relatively unresponsive to small spring thundershowers.

Historically, in lower Arroyo Grande Creek, summer baseflow was primarily maintained by releases from Lopez Reservoir. Summer releases from Lopez Reservoir were conducted to recharge the aquifer and meet the municipal water needs and those of the farming community. Currently, downstream releases are conducted on a daily basis throughout the year to ensure that environmental and agricultural needs are being met. This downstream release flow regimen is expected to change once the flood control district completes an on-going Habitat Conservation Plan (HCP). It is anticipated that the HCP will be completed within the next 2-3 years. Although it is rare due to the moderate coastal climate in the area

and the presence of a summer marine layer, off-shore winds can result in unusually warm temperatures on the coastal plain. When these conditions occur, heavy pumping of the local aquifer for agricultural uses can result in temporary dewatering of portions of lower Arroyo Grande Creek.

In the 1950's, the AG Creek flood control channel was designed to handle a 100-year storm, then calculated to be 10,120 cubic feet per second (cfs). However, since construction of the flood control channel, additional data has been collected that better describes less frequent peak discharge events such as the 50-year and 100-year recurrence events. In addition, urbanization of the watershed has likely altered the timing, magnitude, and frequency of high flow events. Both the 1999 Army Corps of Engineers report and 2006 Alternatives Study now calculate the 100-year flood at more than 19,200 cfs, almost twice the 1950's estimate of 10,120 cfs (USACE 1999; SH+G 2006). More frequent events also have a higher discharge than what was calculated when the flood control channel was constructed. The modeling has also been improved allowing for more precise estimates of channel roughness and the influence of debris and sediment on the ability of a channel to convey water. Consequently, even if regulatory constraints were not present and the original cross-sectional area of the flood control channel was restored, the Project could not protect adjacent property owners during a 100-year event.

Most recent estimates of peak flow hydrology for the Arroyo Grande Creek channel were conducted in 1998-99 by the U.S. Army Corps of Engineers, Los Angeles District. These data show the effect of the dam on peak flow in lower Arroyo Grande Creek. Downstream of Lopez Dam, a 2-year event is only 25% of what it would be if the dam were not present. During a 100 year event it is approximately half. The opposite is true for summer baseflow conditions. Winter peak flows are stored in Lopez Reservoir for release in the dry summer months for groundwater recharge for municipal and agricultural uses. Historically, those releases have been managed to maximize recharge and minimize the amount of water that reaches the Pacific Ocean. Currently, additional releases are being made for environmental considerations as well. Therefore, higher base flows occur along lower Arroyo Grande Creek than under pre-dam conditions. The hydrologic record suggests that median summer baseflow conditions prior to construction of Lopez ranged between 1.5 to 2.5 cubic feet per second (cfs), as opposed to 3 to 4 cfs post-dam. During dry and drought years, the data suggest that the Creek would periodically dry up between July and October pre-dam but maintain flows between 0.5 and 2 cfs post-dam (Stetson, 2004).

3.0 PROJECT ELEMENTS

Following completion of the Alternatives Study, the Task Force that was directed to oversee completion of the study met to discuss the proposed project alternatives and to make a decision on how to move forward. The approach selected by the Task Force was to pursue a phased implementation of Alternative 3 as funding within the local flood control district became available and/or opportunities arose to pursue grant funding or long-term loans. Alternative 3, once completely implemented, would provide flood protection up to the modeled 20-year return period. Given limited funding on an annual basis, the need to fund the environmental review and regulatory permitting, and the ongoing vegetation management program, Alternative 3 would most likely be implemented in several phases to eventually provide the expected level of flood protection (Figure 7).

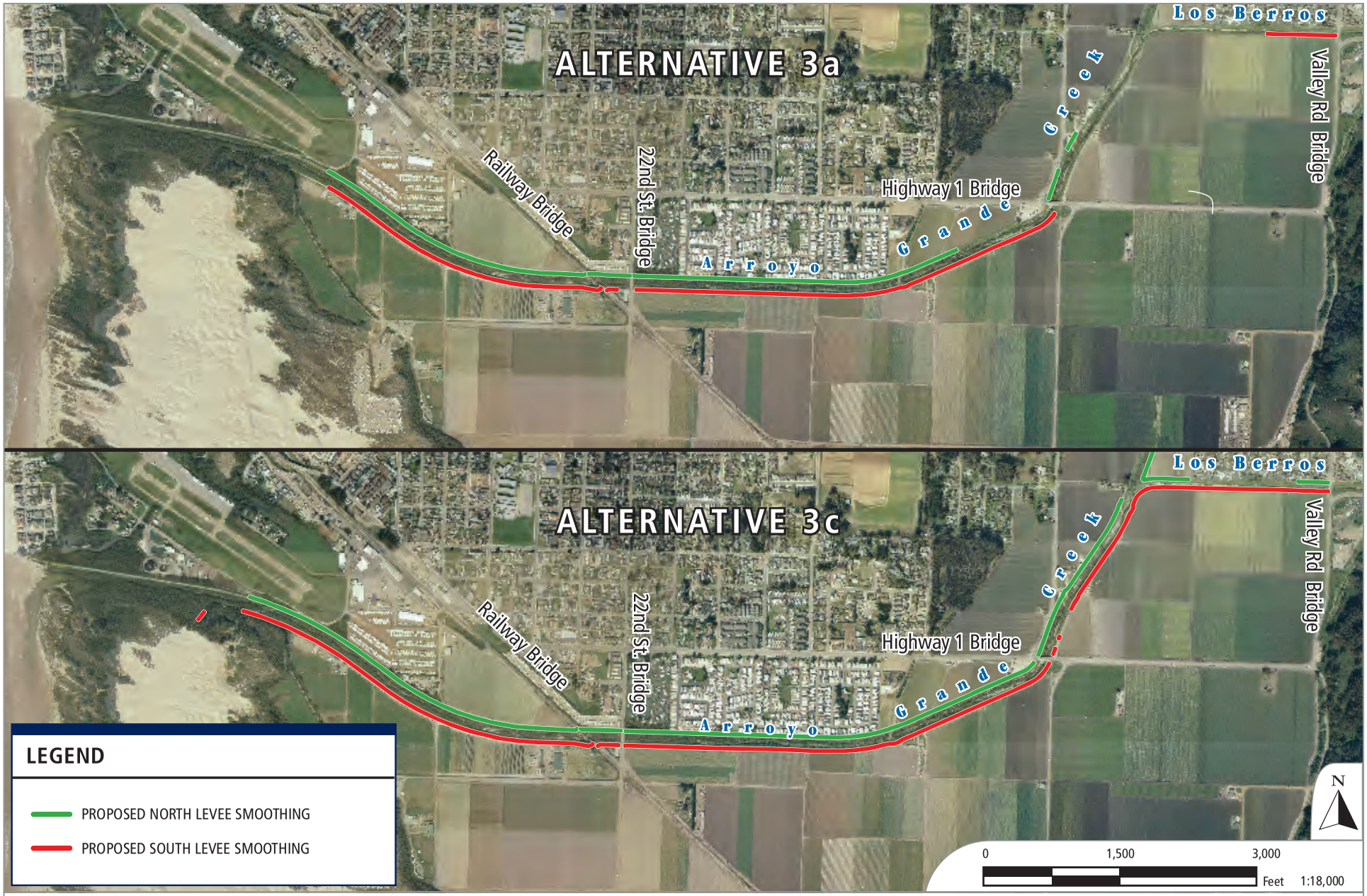
Alternative 3 includes the following components:

- Annual vegetation management;
- An initial phase of sediment removal with maintenance in subsequent years;
- Raising existing levees in two stages representing protection from 10-year and 20-year floods; and,
- Raising and/or retrofitting the Union Pacific Railroad Bridge that crosses Arroyo Grande Creek to improve conveyance and reduce flood risk.

3.1 Current Efforts

Currently, the District conducts annual vegetation management, but has not conducted any sediment removal since 2001. No sediment removal has been authorized due to environmental restrictions and requirements put forth by regulatory agencies that a more comprehensive strategy be prepared to manage the flood control reach (see section 1.3).

In 2006 the RCD received a permit on behalf of the District, from California Department of Fish and Game to begin a vegetation management program through the flood control reach from approximately the Union Pacific Bridge upstream to Los Berros Creek. The vegetation maintenance program generally followed the approach laid out in the Alternative Study, limbing up existing vegetation to encourage formation of a riparian canopy, removal of smaller stems and trunks to reduce cross-sectional



WATERWAYS CONSULTING

Santa Cruz, CA Portland, OR

FIGURE 7: Plan views of levee raise locations for Alternative 3a - Levee Smoothing (10-year protection), and Alternative 3c - Levee Raise (20-year protection). Under Alternative 3a, the north levee is raised approximately 4-inches above the south levee to provide additional protection to residential areas as compared to the south levee which is dominated by agricultural land uses. Under Alternative 3c, levee raising would occur along most of the flood control reach including the Los Berros channel.

roughness, and invasive removal. In 2007 the RCD received a permit, on behalf of the District, from the Coastal Commission to extend the vegetation management program within the Coastal Zone from the Union Pacific Railroad Bridge to just downstream of Guitton's Crossing. Vegetation management activities utilizing these principles has greatly improved the riparian canopy and complexity throughout the Arroyo Grande Creek Channel while at the same time providing increased flood protection. Improvements in the riparian canopy conditions are illustrated in Photos 4-9.

The long-term effectiveness of the existing vegetation management program, conducted by the District with assistance from the RCD, to reduce the potential for flooding on lower Arroyo Grande Creek is limited by the following factors:

1. The current vegetation management program is only permitted by short-term agreements with the California Department of Fish and Game and the California Coastal Commission. The program does not require a U.S. Army Corps of Engineers permit and therefore does not have incidental take statements issued by U.S. Fish and Wildlife and National Marine Fisheries Service that would protect the District from an enforcement action if ESA listed species were "taken" during annual maintenance activities. The current permits only allow for biological monitors to be present during maintenance activities and avoid areas where species, mainly California red-legged frog, are found. This has resulted in a lack of vegetation management along portions of the channel, creating segments where channel roughness is high relative to upstream and downstream segments and flood conveyance is low. Because overall flood conveyance is generally limited by the segment with the least conveyance, discontinuities in the vegetation management program have reduced flood conveyance along the entire flood control reach.
2. The current permit does not allow for complete removal of all woody vegetation outside the 10 foot buffer or any long-term program to manage sediment. The program proposed in the Alternatives Study was developed to protect the primary low flow channel and maintain a functional riparian corridor while providing improved flood protection by increasing conveyance. Outside the designated riparian corridor, secondary channels would be created and maintained for flood conveyance. Meeting the competing objectives of improving flood capacity and protecting aquatic and riparian resources required this compromise.

The need to address the reduced flood protection of the levee system due to sediment accumulation, the obstruction at the UPRR Bridge, and the limitations in the annual vegetation management program prompted the preparation of the WMP. The intent of the WMP is to define how lower Arroyo Grande and Los Berros Creek Channels will be managed to provide long-term reductions in flood risk and improved aquatic habitat conditions for key species of interest. The key components of the WMP

WATERWAYS CONSULTING

Santa Cruz, CA Portland, OR

PHOTOS 4,5,6: Times series of photographs looking upstream of 22nd St. Photos show recovery and improvement of the riparian corridor along the Arroyo Grande Creek Channel following sediment removal in 1999 and annual vegetation management activities after 2006.

WATERWAYS CONSULTING

Santa Cruz, CA Portland, OR

PHOTOS 7,8,9: Times series of photographs at UPRR bridge. Photos show recovery and improvement of the riparian corridor along the Arroyo Grande Creek Channel following sediment removal in 1999 and annual vegetation management activities after 2006.

include vegetation management, sediment management, two phases of levee raise, and replacement or modification of the Union Pacific Railroad Bridge.

3.2 Vegetation Management

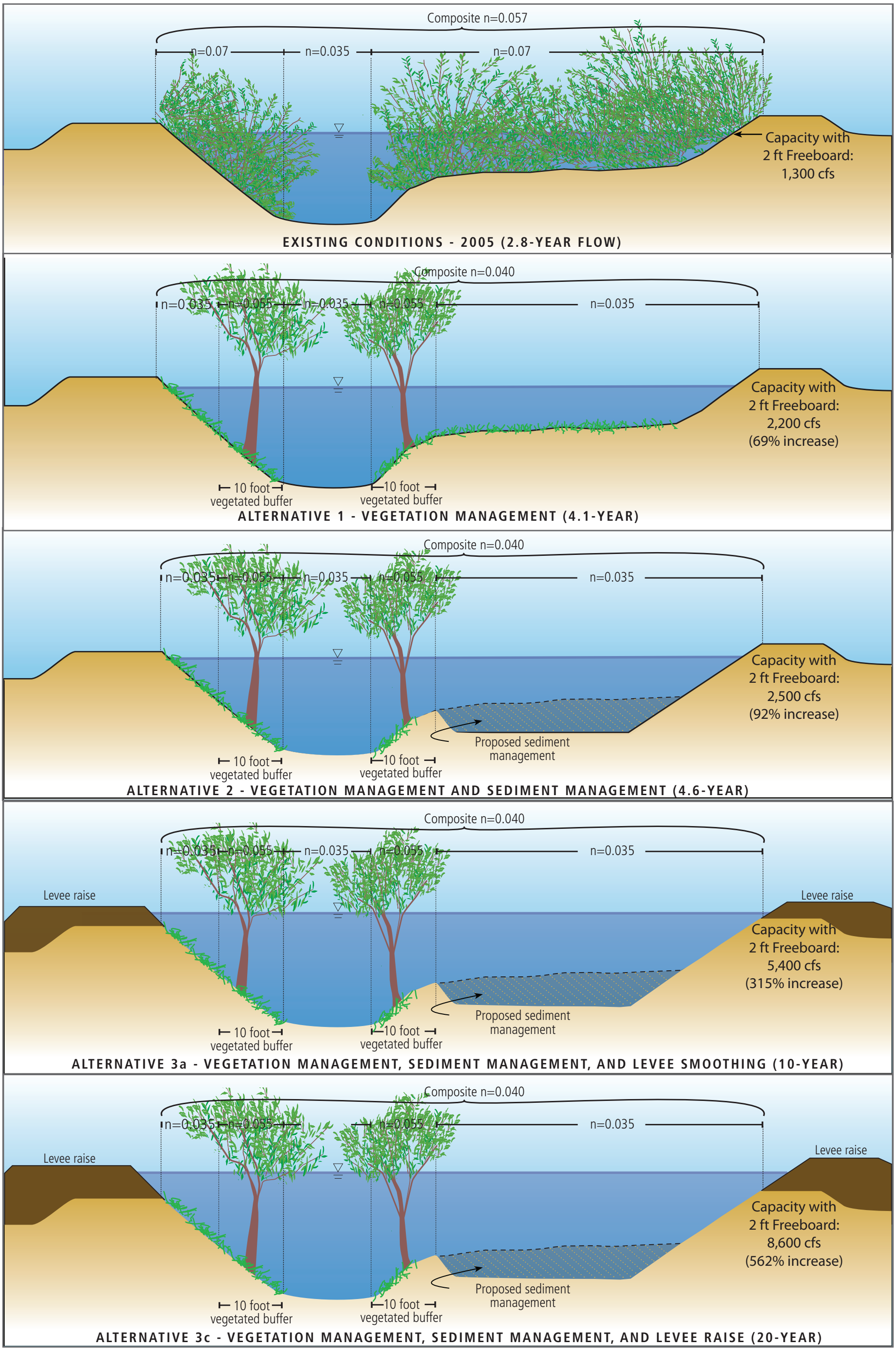
For vegetation management activities, a differentiation is made between the Arroyo Grande Creek Channel and Los Berros Creek Channel. Because the relative size of these channels are completely different and the flood control channel reach of Los Berros lacks any appreciable flow in the summertime, vegetation management activities need to be different to reflect site conditions, opportunities, and constraints.

The vegetation management program for the Arroyo Grande Creek Channel will consist of maintaining a 10-foot buffer on both sides of the low-flow channel to provide riparian habitat and streamside cover to protect aquatic habitat (Figure 8). Where riparian vegetation exists on the Los Berros Creek Channel, a 5-foot buffer on each side of the active low flow channel will be maintained. Each buffer would be measured at breast height (i.e. - similar to the technique of measuring tree trunk diameters at breast height) and does not necessarily represent the width of the riparian canopy. Depending upon the maturity of the trees, the upper portion of the tree canopy would likely extend well beyond the buffer width although the exact future width of the canopy would be unknown and would vary (Figure 9).

The buffer would also act to maintain a primary low-flow channel that has developed over the last several years by providing root strength along the low flow channel margins. Woody vegetation outside of the buffer would be removed completely to allow for high flows to access secondary channels (see sediment management program) and provide for increased conveyance and flood capacity. Non-woody herbaceous vegetation would not be removed as they are expected to lay down during a large flow event. Willows present within the buffer would be limbed up to reduce cross-sectional roughness but still provide adequate stream shading and riparian habitat.

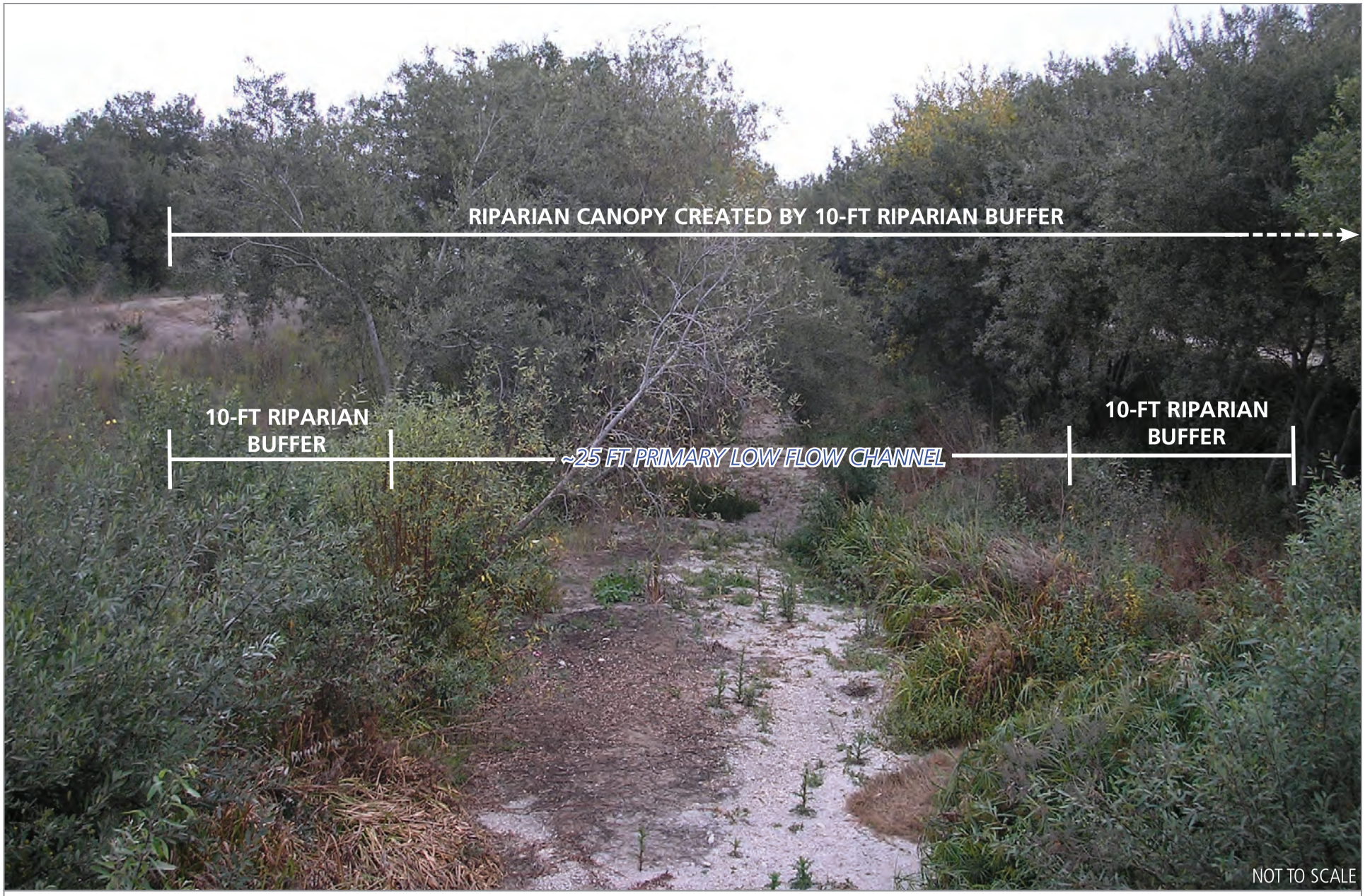
Management activities within the buffer will consist of the following:

- Trees greater than 4” in diameter on the banks of the active channel, from the toe of the active stream channel uphill to a distance of 10 feet from the channel (5 feet for Los Berros), will have horizontal branches trimmed to a height of not more than six feet from ground level. If creek shade is provided by adjacent larger trees, willow sprouts less than 4” in diameter will be cut to within 6” of the ground. Trimming the trees on the banks in this manner will encourage growth



WATERWAYS CONSULTING
Santa Cruz, CA Portland, OR

FIGURE 8: Conceptual cross-section view.



WATERWAYS CONSULTING
Santa Cruz, CA Portland, OR

FIGURE 9: Typical view of vegetation maintenance activities.

in the upper canopy of the trees, improving their ability over time to shade the creek, while also improving channel capacity to handle high flows by lowering the roughness coefficient.

- No trees will be removed within the buffer area with the exception of trees that have fallen over and are a risk to the integrity of the levee (e.g. – lodged against levee or bridge) or have the potential to increase the risk of flooding (e.g. – have fallen across the channel and are obstructing flow). All root balls will be left intact to enable resprouting and to help stabilize soils.

All woody vegetation within the buffer occurring 50 feet upstream and 30 feet downstream of existing bridges will be removed completely.

- Vegetation management activities will be conducted by hand crews and will include the use of mechanized and non-mechanized hand equipment such as chainsaws, loppers, etc. No debris will be allowed to enter the stream channel and debris from invasive species will be separated, bagged and disposed of at a designated landfill. Native vegetation cut from the channel will be mulched on site and either used as mulch on the back side of the levees or removed to a designated off-site area.

To improve riparian habitat through the project area, existing gaps in the riparian buffer would be revegetated with native riparian species including cottonwood, sycamore, and willow, with the exception of the Los Berros portion of the project area. Los Berros Creek differs from Arroyo Grande Creek in that it is not a perennial channel therefore vegetation characteristics are different and it lacks a mature riparian corridor. Cottonwood, sycamore, and alder will be planted at random along the length of the Arroyo Grande Creek Channel to encourage long-term diversity in the riparian corridor. Vegetation management activities will be combined with an active program to remove non-native vegetation from the flood control channel. Non-native species to be actively removed include Himalayan blackberry, English ivy, fennel, weeping willow, giant reed, castor bean, poison hemlock, and geranium. Non-native species management activities could include use of goats, application of herbicides, or removal by hand of plant and rootball. Non-native vegetation removed from the channel will be bagged and disposed of accordingly to limit their spread.

Vegetation management would be conducted as often as necessary to maintain a composite roughness of 0.04 through an adaptive management approach that would include reconnaissance surveys and site visits with regulatory agency staff. Vegetation management activities would likely occur annually depending on the amount of re-growth and funding. Based on vegetation management activities that

have occurred over the last four years, regrowth of managed vegetation during the spring and summer is heavy, requiring annual maintenance.

Vegetation management involving tree trimming would occur as late as possible in the summer and fall of each year to maximize stream shading during the warmer summer months and would only occur between July 1 and October 15 of any given year. If tree trimming activities occur prior to August 15 protocols to avoid impacts to nesting birds will be followed. Vigorous regrowth of willow is expected in late winter and spring providing low, overhanging vegetation during critical months for steelhead and red-legged frog rearing (Photo 10). In the Los Berros Creek Channel, since there are few trees but an overgrowth of non-native species, vegetation management to remove the invasive species would occur in early spring to prevent the vegetation from going to seed. If activities occur prior to July 1, protocols to avoid impacts to the low flow channel will be followed. These will include a start date no earlier than April 15 in the Los Berros Channel and activities will occur when the channel is dry and with agency authorization. Removing the invasive species prior to them going to seed will reduce vigorous regrowth during the following winter/spring and promote the growth of native species.

Photo 10. Spring/early summer regrowth of vegetation in the flood control channel just upstream of the 22nd St Bridge.

3.3 Sediment Management

The need for constant dredging of the flood control channel to maintain design capacity is primarily rooted in two geomorphic principles that dictate sediment delivery and transport in the flood control reach. They include:

1. Much of lower Arroyo Grande Creek downstream of Lopez Dam historically consisted of a broad floodplain characterized by an ephemeral active channel that migrated across the floodplain in response to sediment deposition and debris jams. The loss of that function has resulted in delivery of high sediment loads to the lower reaches of the watershed resulting in excessive sediment deposition in the flood control reach.
2. The original flood control channel design did not consider the concept of a “bankfull” channel when sizing bed dimensions. Bankfull can be defined as the stage that corresponds to the discharge at which channel maintenance is the most effective. It is at the bankfull discharge where, over time, the largest volume of sediment is moved and in-stream morphologic features, such as pools and riffles, are created.

Field observations in the flood control reach, following an extended period with no appreciable dredging, suggests that a bankfull or primary low-flow channel width of approximately 20-25 feet has developed along the Arroyo Grande Creek channel (bankfull was difficult to evaluate in areas backwatered by beaver dams). The flood control channel design created a bottom width of 60-70 feet, resulting in excessive sediment deposition because flow was spread out, resulting in shallower water depths and less energy to move sediment (shear stress, a measure of the water’s ability to do work, is a function of flow depth). Consequently, the geomorphic setting and design geometry are an important reason why there is a need to constantly remove sediment from the channel. Maintenance of a primary low-flow channel, enforced by the presence of a stable riparian corridor, will improve sediment transport conditions through the flood control reach.

To enhance geomorphic function, improve flood conveyance, and "set" the flood control channel to an initial condition that will enhance sediment transport, a two step process has been proposed for sediment management within the project area. The two step process consists of an initial phase of sediment removal that will be completed the first year, followed by a long-term sediment management program that will rely on periodic monitoring of sediment conditions in the channel and consultation with permitting agencies to "reset" conditions back to the first year condition.

The first year sediment removal program will include removal of sediment on the levee side of the riparian buffers (Figure 9). Where excessive sediment has built up in the designated off-channel areas, sediment would be removed to a depth of 1.5-foot above the thalweg elevation of the Arroyo Grande Creek Channel and 1-foot above the Los Berros Creek Channel, as measured at a riffle. These depths were estimated as the appropriate bankfull depth for these channels based on field indicators. Sediment that has accumulated as a bar feature along the buffers will not be removed, thereby encouraging higher velocity flows along the primary and secondary channels and enhancing sediment transport conditions.

Overflow or secondary channels will be excavated in designated off-channel areas to create overflow paths during high flow events. In natural systems, the primary channel contains low flows, whereas secondary channels become activated during higher flows that, on average, occur once a year (Figure 10). The Arroyo Grande Creek flood control channel currently lacks the secondary channels that are found in more natural, low gradient stream environments. Based on the current configuration of the primary (low flow) channel, secondary channels will crisscross the primary channel as the primary channel meanders between the levee side slopes (see Appendix B - Preliminary Engineering Design Plans).

During high flow events, the intersection of the primary and secondary channels are expected to be areas of complex flow conditions that will create localized eddies, backwaters, and scour. To take advantage of these high energy areas and encourage development of complex cover habitat for steelhead and red-legged frog, two types of large woody structures will be constructed at these locations (see Appendix B for details on the proposed log structures). One type of large wood structure will be placed at the downstream end of each secondary channel as it conflues with the primary channel. The structure will provide protection from any headcutting into the secondary channel and therefore enforce the location of the primary channel. The structure has also been designed to encourage pool scour at the confluence and mimic an undercut bank (similar to lunker structures traditionally used to enhance fish habitat). Because pool habitat and escape cover is lacking through the flood control reach, improvements to these physical habitat characteristics are expected to greatly improve aquatic habitat. In addition, these structures will provide escape cover for adults migrating through the reach to preferred spawning and rearing habitat areas that occur upstream of the flood control reach.

The second type of large wood structure would protect the head of bar that would exist at the downstream side of the confluence. This structure would also enforce maintenance of the primary and

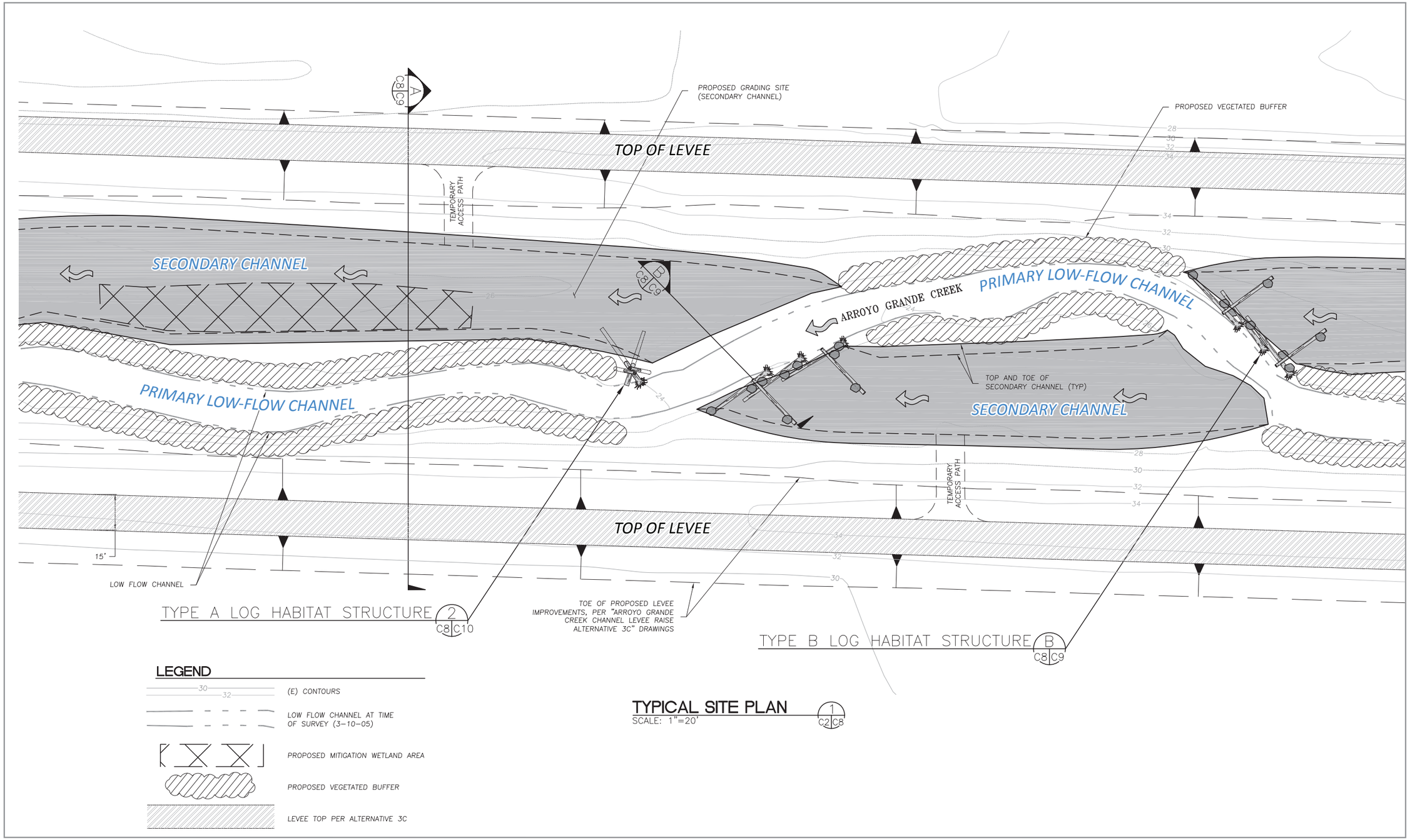


FIGURE 10

Conceptual sediment and vegetation management plans for the Arroyo Grande Creek Channel.

WATERWAYS CONSULTING

Santa Cruz, CA | watways.com | Portland, OR

secondary channel locations and create a hard point that would encourage turbulence and creation of a pool at the confluence of the channels. Although both types of structures are designed to meet different habitat and channel stability objectives, they will promote pool scour, encourage variability in substrate and flow field conditions, and provide deep pools and cover habitat for steelhead and red-legged frog.

Some maintenance of the secondary channels is expected over the long-term. Post first-year sediment management activities will likely consists of an excavator, located on the top of the levee, scooping and removing built up sediment. Removed sediment will be placed in a dump truck, also located at the top of the levee, to take the sediment off-site to a County approved area. Long-term sediment management activities are not expected to involve removal of vegetation or use of equipment within areas with flowing water.

Cross-sections will be monitored periodically to assess the performance of the channel in moving supplied sediment. Modeling presented in Chapter 4 of the Alternatives Study (SH+G, 2006) suggests that increased sediment transport conditions through the flood control reach will not negatively impact the Arroyo Grande Creek lagoon. To ensure that the depth of the lagoon is not impacted, additional cross-sections will be established at the lagoon and monitored following significant runoff events. Cross-sections will also be established along the flood control reach to provide information on the need to do spot removal of accumulated sediment to ensure that the project passes target flood flows. Annual maintenance will also be a component of the overall vegetation and sediment management program. A similar program has been successful on the San Lorenzo River in Santa Cruz County despite concerns about steelhead and Coho salmon (SH+G et al, 2002). In the case of the San Lorenzo River, secondary channels have developed a gravel/cobble surface due to scouring action and lack of fine sediment deposition. The objective of the annual maintenance program is to keep the secondary channels open for flood flows.

3.4 Raise Existing Levees

A key component of the Waterway Management Program involves raising the existing levees to improve flood protection along lower Arroyo Grande Creek. The levees would likely be raised in two phases to ultimately achieve flood protection up to a 20-year flood event. The first phase would raise the levees to an elevation that would provide 10-year flood protection. The second phase would achieve the desired 20-year flood protection. Both phases would incorporate sediment and vegetation management activities to achieve the desired level of flood protection. The levees would be raised along most of

lower Los Berros Creek Channel and along Arroyo Grande Creek Channel from the Los Berros confluence to the upstream end of the lagoon (Figure 8). The existing levees will be raised with the inside slope of the levee at 2:1, the outside levee at a slope of 1.5:1 and top of levee width not less than 15 feet (see Appendix B - Engineering Design Plans for details on the proposed levee raise). All levee raising work would take place on the outside of the existing levee, where feasible, and not impinge upon the existing Ordinary High Water (OHW).

3.5 Union Pacific Railroad Bridge

The Union Pacific Railroad (UPRR) Bridge, located near the downstream end of the flood control reach, presents an obstruction to flow under current conditions (Photo 11). In addition, the bridge does not cross at a 90 degree angle to the flood control channel and the abutments do not run parallel to the flow path of Arroyo Grande Creek. Under the proposal to raise the adjacent levees to provide 20-year flood protection, the UPRR Bridge would need to be modified, raised, or replaced to enable the levee raise. The UPRR Bridge does not need to be modified for the smaller (10-year protection) levee raise project. Given funding issues, it is unclear when the bridge would be modified, raised, or replaced in relation to the proposed levee raise.

Photo 11. Union Pacific Railroad (UPRR) bridge during the 2001 flood.

Any plan to modify, raise, or replace the UPRR Bridge would require work within OHW and within the low flow active channel. A temporary shoo fly track would be constructed adjacent to the existing bridge to provide uninterrupted service along the UPRR line during construction activities. The project

may require temporary dewatering activities during certain phases of the construction which would be accompanied by standard water quality and aquatic habitat protection measures. It is also likely that a small amount of riparian vegetation would need to be removed in the riparian buffer area (beyond the already proposed vegetation removal 50 feet upstream and 30 feet downstream of the bridge), necessitating revegetation efforts following construction.

4.0 MONITORING AND ADAPTIVE MANAGEMENT PLAN

4.1 Goals and objectives

Two key elements of the WMP, namely the vegetation and sediment management programs, will require activity within Arroyo Grande Creek over the long-term and in some cases on an annual basis. To maximize the benefit of these activities, reduce the costs to Zone 1/1A, and protect vital biological resources, long-term management will need to be adaptive to the conditions on site in any given year and will require a regulatory approach that is flexible within the objectives defined by the management program. An integral element of the management program is a well-defined monitoring program that provides the data necessary, in a timely manner, to effectively manage the system. This section outlines the proposed Mitigation and Monitoring Plan that will guide long-term vegetation and sediment management within the flood control reach.

4.2 Vegetation management

4.2.1 Goal

The goal of the vegetation management program is to maintain a balance between flood protection along lower Arroyo Grande Creek and protection of natural resources that rely on a healthy riparian corridor to protect important aquatic habitat. The vegetation management program, as outlined in Section 3.1 accomplishes these objectives in two ways:

1. Management of riparian vegetation to maintain a cross-sectional roughness of 0.04, and
2. Maintenance of a continuous corridor of riparian vegetation along the established primary (low flow) channel.

It is expected that vegetation management activities will occur on an annual basis, requiring a large crew working in the channel between April 15 and October 15. To ensure that vegetation management activities are carried out in a consistent manner, all workers will need to be properly trained and abide to the protection measures proposed in the WMP.

4.2.2 Monitoring and Performance Measures

Management of vegetation for flood control through the project reach has been conducted annually for the last three years and is expected to continue indefinitely on an annual basis. Because some of the work related to vegetation management is subjective and the level of effort may vary from year to year depending on growth rates, high flow conditions the previous year, and an inherent variability in year to year effort, annual monitoring will be required to direct management activities. The annual monitoring of vegetation conditions is meant to be a key component of an adaptive management strategy that seeks to respond to changing conditions, both from a flood control and natural resource perspective, based on defined performance measures. A summary of the performance measures and monitoring efforts associated with each is provided in Table 3 and are as follows:

- **PM VEG-1:** Finalize the annual vegetation management work plan by July 1. The draft work plan should be submitted for review and comment by the regulatory agencies by May 1 with comments provided by the regulatory agencies by June 1. The final work plan should be in place by July 1 for implementation. If invasive removal is needed, a final work plan just for invasive removal shall be in place by May 1. The work plan will address Performance Measures 2 through 4.
    - **MON VEG-1:** Each year in late spring, a report will be prepared defining the proposed vegetation management work plan to be conducted in the summer and early fall. The work plan will incorporate field notes and maps to define the management actions that will be carried out each year. Issues addressed in the work plan will include proposed areas of revegetation based on mapped gaps in riparian vegetation, locations and densities for focused plantings of non-willow species, areas and species type of non-native removal efforts, and depictions of areas where woody vegetation needs to be removed outside the riparian buffers. The work plan should be detailed and specific enough to provide a year-to-year road map to the group tasked with conducting the proposed activities. Where feasible, woody vegetation outside of the buffer recommended for removal should be flagged to allow independent review by regulatory agency staff.
- **PM VEG-2:** Increase riparian canopy cover. The primary objective of maintaining a riparian buffer is to create a continuous riparian canopy through the project area that provides benefit to terrestrial and aquatic species that rely on cover habitat, cool water temperatures, and other functions provided by a continuous and diverse riparian corridor. The objective of this performance measure would be to maintain or increase riparian canopy cover through the project area.

Activity	Performance Measure	Monitoring Element	Current Status of Parameter	Performance Target	Frequency
Vegetation Management	**PM VEG-1**: Finalize Work Plan	**MON VEG-1**: Prepare vegetation management work plan	Not Applicable	Annual work plan finalized by July 1[1]. Work plan will address PM VEG 2-4.	Annually following adoption of the WMP
	PM VEG-2: Increase riparian canopy cover	**MON VEG-2**: Measure canopy cover through project reach	To be measured following adoption of the WMP and Year 1 vegetation management to establish a baseline	Maintain or increase % canopy cover above baseline conditions.	Every three years following adoption of the WMP
	PM VEG-3: Increase riparian species diversity	**MON VEG-3**: Measure canopy species diversity through project reach	To be estimated following adoption of the WMP and Year 1 vegetation management to establish a baseline	County will consult with agency staff to determine targets based on success of diversity efforts over first 10 years of management	Every three years following adoption of the WMP
	PM VEG-4: Eliminate invasive species	**MON VEG-4**: Map invasive vegetation that occurs within project reach	Invasive species populations not currently mapped. Would be mapped prior to initial vegetation management activities.	1. Provide map of invasive species populations prior to Year 1 vegetation management 2. No net increase of invasive species populations after Year 2015.	Update invasive species map every three years following adoption of the WMP
Sediment Management	**PM SED-1**: Finalize Work Plan	**MON SED-1**: Prepare sediment management work plan	Not Applicable	Work plan finalized by September 1 of year prior to sediment management activities. Work plan will address PM SED 2-5.	As needed according to cross-section and hydraulic modeling results
	PM SED-2: Aggradation does not cause loss of 2-foot levee freeboard	**MON SED-2**: Cross-section monitoring through project reach	Not Applicable	Modeling results show that freeboard still exists above expected level of protection.	As needed according to reconnaissance assessment of sedimentation through flood control reach
	PM SED-3: Project does not result in long-term aggradation of lagoon	**MON SED-3**: Cross-section monitoring of lagoon	Baseline will be surveyed prior to first-year sediment management activities	Lagoon sedimentation patterns are within the range of natural variation.	Every three years following adoption of the WMP
	PM SED-4: Improve cover habitat for salmonids	**MON SED-4**: Evaluate habitat conditions in the project reach (Flosi et al)	Baseline to be established from CCC survey conducted in 2004.	Maintain or increase the cover rating for the project area as compared to baseline.	Every three years following adoption of the WMP
	PM SED-5: Improve maximum pool depth		Baseline to be established from CCC survey conducted in 2004.	Maintain or increase the average maximum pool depth in project area as compared to baseline.	Every three years following adoption of the WMP

1 - If invasive removal is proposed on Los Berros prior to June 15, that portion of the annual Work Plan will need to be finalized by May 1.

TABLE 3
Summary of the performance measures and monitoring efforts.

- **MON VEG-2:** Measure canopy cover every three years and report the percent cover in the annual Vegetation Management Workplan. The area of measurement shall include that between the centerlines of the north and south levees and the east and west project boundaries, as shown in Figure 1.

- **PM VEG-3:** Increase riparian species richness and density in the project area. Candidate species include but are not limited to sycamore, alder, and cottonwood. A performance target will be adapted as necessary during annual consultation with regulatory agencies.
  - **MON VEG-3:** Preparation of the first Vegetation Management Workplan shall include (1) a description of the number and approximate diameter at breast height (DBH) of the existing candidate species within the project area and (2) a planting plan for candidate species. Each subsequent annual workplan shall include an update of the number of individual candidate species, the DBH, and a planting/maintenance plan, as applicable.

- **PM VEG-4:** Achieve a riparian corridor that is free of invasive non-native species. Non-native invasive species are prevalent throughout the project reach although they have not been mapped. Consequently, a baseline will need to be established in the summer of 2010 and an eradication strategy will need to be developed and discussed in the annual work plan. The performance target would be to conduct most of the eradication efforts prior to 2015 with no net increase in infected areas beyond 2015. Key species to eradicate would be Arundo, ivy, Himalayan blackberry, and castor bean. Removal techniques may include application of herbicide, removal by hand of plant and rootballs, or the use of goats.
  - **MON VEG-4:** Map the presence of significant areas of non-native invasive species within the project area.

4.3 Sediment management

4.3.1 Goal

The goal of sediment management activities is to increase and maintain flood capacity through the project reach while at the same time improving instream aquatic habitat and reducing the need for maintenance dredging in the future. These goals will be achieved through an initial dredging of previously built up sediment to create secondary channels and integration of habitat enhancement structures consisting of large wood. Sediment management activities, including Year 1 and future activities, incorporate Best Management practices, monitoring activities, and performance measures that are well tested and have proven to be important as part of an overall strategy to adaptively manage channel conditions.

4.3.2 Monitoring and Performance measures

Monitoring of the sediment management portion of the project is directly related to the performance of the elements of the sediment management plan. Secondary channels are being proposed to enhance sediment transport through the reach and reduce the frequency of dredging activities. Concerns were also raised about the impact sediment management activities in the flood control reach will have on sediment transport into and through the lagoon.

Performance measures for the sediment management portion of the project are focused on preparation of the work plan and assessing the quality of instream aquatic habitat and how aquatic habitat function changes over time in response to sediment management activities. Aquatic habitat conditions were last surveyed in 2004 and relative fish abundance sampled in 2006. These studies would act as a baseline to evaluate the benefits of the proposed sediment management activities moving forward. The results from these studies suggest that the Arroyo Grande Creek Channel is primarily used by steelhead adults as a migratory corridor and marginally as rearing habitat for juveniles. Monitoring and performance measures summarized in Table 3 and included below address these concerns through a monitoring program that directly responds to management actions that address sediment reduction and habitat enhancement activities.

- **PM SED-1:** Finalize a work plan for sediment management activities by September 1 of year prior to when activities are expected to occur. The work plan should be submitted for review and comment by the regulatory agencies by August 1 with comments provided by the regulatory agencies by August 15. The work plan will address Performance Measures 2 through 5.
    - **MON SED-1:** Prepare, review and finalize work plan for sediment management.
- **PM SED-2:** Sedimentation in the project area does not reduce capacity in any one location beyond the defined freeboard.
    - **MON SED-2:** Cross-section monitoring will be conducted periodically in the flood control reach to determine if sediment accumulation in the secondary channels has reduced conveyance to the extent where additional sediment management is required. Cross-section monitoring data will be used in conjunction with the hydraulic model to determine if the levee freeboard has been compromised. Freeboard has been defined as 2-feet under all modeled alternatives in the Alternatives Study. For example, under the action that only includes vegetation and sediment management, the flood control channel is expected to provide protection up to the 4.6 year event with 2 feet of freeboard. In any given year, if the cross-section data and modeling results show that a

4.6 year event cannot be contained without the freeboard, Zone 1/1A would prepare a sediment management plan, based on the cross-section monitoring data, to remove sediment from the secondary channels to achieve 4.6 year flood protection with 2 feet of freeboard. Cross-section monitoring and preparation of a sediment management work plan would consist of the following:

1. Permanent cross-section locations will be established and monumented along the project reach following Year 1 sediment management activities. Cross-sections will be established every 500 feet along the channel and at the upstream and downstream sides of each of the bridges.
2. All of the established cross-sections will be measured Year 1 and roughness will be estimated for each to establish a baseline. A report will be produced and a database established.
3. Periodically, at the discretion of the District, Zone 1/1A, a portion of the cross-sections will be re-surveyed to evaluate the degree of sedimentation. The cross-sections surveyed in any given year will be incorporated into the hydraulic model along with the roughness estimates and a determination will be made regarding the need for dredging of any secondary channels.
4. Re-surveying of established cross-sections should occur as early as possible following the cessation of winter rains (i.e. – April/May). A report cataloging the results of the survey will be used to determine if a sediment management plan is necessary.
5. If sediment management is required, a sediment management plan will be prepared outlining where sediment management is needed, what quantity of sediment will be removed, when the activity will occur, and what equipment and approach will be used. The sediment management plan will be submitted to the agencies for review and comment.
6. If a sediment management plan is prepared, it should be submitted for comment to the agencies by August 1 of the year prior to any proposed dredging activities. Agency comments shall be received by August 15 following submittal of the sediment management plan.

- **PM SED-3:** Sediment management activities in the project area do not result in long-term aggradation in the lagoon and loss of lagoon volume. Evaluation of this performance measure will require a survey of the lagoon prior to the first year of sediment management activities to establish a baseline condition. The performance goal will be to not reduce the lagoon volume

by more than 25% from the baseline based on a six year moving average of measured conditions.

- **MON SED-3:** To evaluate potential long-term sediment impacts on the lagoon from sediment management activities in the flood control reach, cross-sections will be established in the lagoon.
    1. A total of four cross-sections will be established, approximately equally spaced throughout the lagoon. The cross-sections will be established in 2010 to develop a baseline and to understand year-to-year natural variability in lagoon morphology prior to initiation of long-term sediment management activities.
    2. The four cross-sections will be monitored every 3 years following the first year sediment management activities and a report will be prepared.
    3. If after 9 years sediment management shows no effect on the lagoon, then cross-sections monitoring will be reduced, following discussions with regulatory agencies.

- **PM SED-4:** Increase or maintain the cover rating through the project reach. Cover habitat is important for rearing juvenile steelhead, especially with the known presence of non-native predatory species, as well as providing refuge areas for adult steelhead during high flow conditions. A baseline of the cover rating will need to be established for the project area. The last comprehensive habitat survey of the project area was in 2004 by the CCC's. Depending upon the timing of first year sediment management activities additional surveys may be required to establish baseline conditions.
    - **MON SED-4:** To evaluate changes in aquatic habitat conditions along the Arroyo Grande Creek Channel, habitat assessments will be conducted through the project reach every three years using protocols established in the California Salmonid Stream Habitat Restoration Manual (Flosi et al, 1998). The habitat assessment will repeat the work conducted by the California Conservation Corps in 2004 or a later survey if it is determined to represent a better baseline condition. The assessment work will be conducted in late summer/early fall of each monitoring year with a report prepared and submitted by December 1. The report should also include recommendations for adaptive management.

- **PM SED-5:** Increase or maintain average maximum pool depth through the project reach. Deep pool habitat is important for steelhead and is currently lacking in the project reach. Most of the pools are shallow, bordering on glide habitat with little to no complexity. A long-term goal of the project would be to improve local scour to enhance pool formation. A baseline of average maximum pool depth will need to be established for the project area. The last comprehensive

habitat survey of the project area was in 2004 by the CCC's. Depending upon the timing of first year sediment management activities additional surveys may be required to establish baseline conditions.

- **MON SED-5:** Same as MON SED-4.

4.4 Protection measures

The following measures have been proposed to protect natural resources within the project area during all proposed activities included within the WMP:

- **PM-1:** RLF are assumed to occur throughout the AG Creek flood control channel during the season that vegetation management activities are likely to happen. To protect RLF, the following protection measures must be adhered to:
    1. To allow for the potential disturbance of habitat or the necessary temporary relocation of RLF during maintenance and/or construction activities, take protection for RLF must be obtained as part of the 404 process with U.S. Army Corps of Engineers. This process will require consultation with U.S. Fish and Wildlife Service who will issue a Biological Opinion for the project. The Biological Opinion may contain protection measures in addition to those outlined in this section that must be adhered to.
    2. A Service-approved biologist will survey the project site no more than 48 hours before the onset of work activities. Given the length of time that vegetation management activities are likely to occur, daily surveys may need to occur that precede work in any particular section of the channel. If any life stage of the California red-legged frog is found and these individuals are likely to be killed or injured by work activities, the approved biologist will be allowed sufficient time to move them from the site before work activities begin. The Service-approved biologist will relocate the California red-legged frogs the shortest distance possible to a location that contains suitable habitat and will not be affected by activities associated with the proposed project. The Service-approved biologist will maintain detailed records of any individuals that are moved (e.g., size, coloration, any distinguishing features, photographs (digital preferred) to assist him or her in determining whether translocated animals are returning to the original point of capture.
    3. Before any management or construction activities begin, a Service-approved biologist will conduct a "worker awareness" training session for all personnel involved in the

activity. At a minimum, the training will include a description of the ecology of the California red-legged frog and its habitat, its protected status, and the specific measures being implemented for this project to avoid harm to and conserve the California red-legged frog for the current project, and the boundaries within which the project may be accomplished. Brochures, books and briefings may be used in the training session, provided that a qualified person is on hand to answer any questions.

4. During maintenance or construction activities, if a RLF is observed within an area where activities are occurring, all activities will cease and qualified biologist will be contacted. Activities can not resume until the qualified biologist has either temporarily relocated the RLF or the amphibian has been identified as another species.
5. Weed whackers will NOT be used by maintenance crews so as to reduce the risk of harming RLF.
6. A monitoring report and completion form will be prepared by the qualified biologist and sent to the Ventura Fish and Wildlife Office following completion of the activity.

- **PM-2:** For any work performed between February 15 and August 15, a qualified biologist will conduct the necessary surveys for nesting birds. If active nests are identified, work in those particular areas will be delayed until after August 15 or the biologist has determined the young have fledged.
- **PM-3:** When feasible, all work activity occurring within the active low flow channel shall be conducted when the channel is dry or at its lowest flow condition (late summer).
- **PM-4:** If management or construction activities require the temporary dewatering and relocation of fish, these activities will utilize gravity flow and will be constructed, operated, and removed according to the following conservation measures:
    - Where diversions are appropriate, they will be constructed independently for each project element, or group of project elements, so as to minimize the duration that any particular segment of stream channel is dewatered.

- **PM-5:** Dewatering activities may require the temporary relocation of fish. To protect fish resources the following measures will be adhered to in order to minimize potential steelhead mortality during relocation activities:
    1. Block nets will be placed at the upper and lower extent of the diversions or coffer dams to ensure that salmonids upstream and downstream do not enter the areas proposed

for dewatering. Block nets will not be removed until installation of all cofferdams, bypass pipes or channels, diversion dams or other facilities designed to dewater or divert flow, are completed.

2. If electrofishing techniques are utilized during fish relocation activities, at least one member of the field crew will be familiar with NMFS electrofishing guidelines and have a minimum of 100 hours of field experience with electrofishing techniques.
3. Electrofishing may not be performed if water temperatures exceed 18° Celsius, or could reasonably be expected to rise above this temperature during the activities.
4. Electrofishing shall not be utilized in areas where water conductivity is greater than 350 uS/cm. Only direct current (DC) shall be used. At least one assistant shall aid the biologist during electrofishing by netting stunned fish and other aquatic vertebrates.
5. Each electrofishing session must start with all equipment settings (voltage, pulse width, and pulse rate) set to the minimums needed to capture fish. These settings should be gradually increased only to the point where fish are immobilized and captured, and not allowed to exceed the specified maxima: Voltage = 100V (Initial) – 400V (Max); Pulse width= 500 uS (Initial) – 5 uS (Max); Pulse rate = 30 Hz (Initial) – 70 Hz (Max).
6. A minimum of three passes with the electrofisher will be utilized to ensure maximum capture probability of salmonids within the area proposed for dewatering, unless the number of fish captured in the second pass is less than 10 percent of the first pass. In that case, two passes are adequate. If steelhead are present on any pass, a minimum of 20 minutes will separate the beginning of each pass through the Project reach to allow time for fish that are not captured to become susceptible to electrofishing again.
7. All captured fish will be held in water with temperatures not greater than ambient in-stream temperatures. If cooling is used, water temperatures will be maintained not more than three degrees Celsius less than ambient in-stream temperatures. All captured fish will be held in well oxygenated water, with a dissolved oxygen level of not less than seven parts per million. Prior to release, the following information shall be recorded: 1) Enumerate fish by species, 2) Visual determination of age of steelhead, 3) Enumerate steelhead injuries and fatalities by age class, 4) Enumerate successfully relocated steelhead by age class for each relocation site, and 5) Date and time of release of steelhead to each relocation site. Steelhead shall be subject to the minimum handling and holding times required. All captured fish will be allowed to recover from electrofishing and other capture gear before being returned to the stream. All captured fish will be processed and released prior to any subsequent electrofishing pass or netting effort.

8. All captured fish will be released upstream of the block nets to facilitate redistribution into dewatered areas following construction activities.

- **PM-6:** During all management or construction activities, Best Management Practices, consistent with those recommended by the Regional Water Quality Control Board and the California Department of Fish and Game, should be adhered to. They include the following:

  1. The contractor shall only use the approved access routes shown on the plans. No persons, equipment, or material shall be allowed outside the designated limits of disturbance.
  2. The stockpile areas for removed sediment that are adjacent to the levee and have potential for entering the active channel shall be fully enclosed with silt fence and boundary fence.
  3. All equipment shall be stored, maintained and refueled in a designated portion of the stockpile area. The contractor shall adhere to a spill prevention plan, to be prepared by the contractor and submitted for review by the engineer.
  4. Contractor shall immediately stop all operations and devote all on-site personnel to the containment and clean up of any fuel, fluid or oil spill, to the satisfaction of the engineer.
  5. The contractor shall be responsible for continuous dust control in accordance with the conditions of the permits. The contractor shall be responsible for the regular cleaning of all mud, dirt, debris, etc., from any and all adjacent roads and sidewalks.
  6. All excess soil shall be disposed of off-site or at locations to be designated in the permit documents.
  7. No debris, rubbish, creosote-treated wood, soil, silt, sand, cement, concrete, or washings thereof, or other construction-related materials or wastes, oil, or petroleum products or other organic material or earthen material shall be allowed to enter into, or be placed where it may be washed by rainfall or runoff into the creek. Any of these materials placed within or where they may enter the creek shall be removed immediately. When construction is complete, any excess material shall be removed from the work area so that such materials do not wash into the creek.
  8. Adequate erosion control measures shall be constructed and maintained to prevent the discharge of earthen materials to the creek from disturbed areas under construction and from completed construction areas. All disturbed areas of bed and bank shall be

stabilized, winterized, and vegetated with appropriate native vegetation prior to the end of the work window.

9. No equipment shall be operated in areas of flowing or standing water. No fueling, cleaning or maintenance of vehicles or equipment shall take place within any areas where an accidental discharge to the creek may occur; construction material and heavy equipment must be stored outside of the ordinary high water mark. All work done within the creek shall be completed in a manner so as to minimize impacts to beneficial uses and habitat; measures shall be employed to minimize disturbances along the channel that will adversely impact the water quality of the creek.

4.5 Beaver management

The beaver is an important mammal to California, as well as to North America, from a historical and aesthetic perspective. Beaver can be beneficial elements of the ecosystem by creating wetland habitat for a variety of wildlife species including fish, birds, amphibians, reptiles, and other mammals. This variety of wildlife is in turn valued for recreational, scientific, educational and aesthetic purposes. This increase in biodiversity of wildlife is a great asset to open space areas and is often highly valued by trail users and residents. In some areas beaver activity is also helpful in retaining storm water runoff and improving water quality by trapping sediment, nutrients, and pollutants. The dams act as natural check dams during floods and high water, reducing erosion and slowing the water enough to encourage sediment deposition. Water behind beaver dams also create additional shoreline and enable water-loving plants and trees to grow and thrive.

Beaver activity can also have detrimental effects. Their actions can sometimes lead to flooding of roads and trails, the loss of trees and shrubs, and the destruction of both public and private property. Their impacts often occur suddenly and dramatically. Beavers are usually not noticed in an area until valuable trees have been felled or flooding occurs. When beavers and their dams are deemed a nuisance, the initial response is to breach the dam. Although this can be a quick fix solution, the dams are usually rebuilt fairly quickly.

In the case of the flood control channel, the presence of beaver dams causes sediment to accumulate in the channel, especially in overbank areas that may not be scoured if the dams are breached. The accumulation of sediment results in less conveyance during a flood event and an increased need to periodically remove sediment.

With regard to aquatic habitat, anecdotal evidence suggests that the beaver dams may enhance rearing habitat for juvenile steelhead by creating deeper pools with complex cover habitat around flooded willows. The downside of the beaver ponds are that they tend to not persist through the entire low flow summer season and they may inhibit outmigration of adult steelhead in the spring, as was the case in the summer of 2008.

The impacts the beaver dams have on flood control in the Arroyo Grande Creek Channel is dramatic. Not only do the dams directly reduce flood conveyance due to the impoundment of water, they result in significant deposition of coarse bed material that builds up in the channel and reduces flood conveyance long term. Because of the confined nature of the constructed flood control channel, loss of conveyance in one area dramatically impacts conveyance upstream for a considerable distance as the zone of sediment deposition propagates upstream. Beaver also may threaten the efficacy of achieving a diverse, continuous, riparian corridor along the Arroyo Grande Creek Channel as they cut down larger trees and create gaps in the canopy.

Although the numbers of beavers currently using the Arroyo Grande Creek Channel and their distribution in the Arroyo Grande system are unknown, their existing and expected future impact is significant enough to warrant active management of the beaver. The District and Zone 1/1A, have, and will, be making a considerable investment in flood management and habitat enhancement measures. Consequently, it has been recommended during preparation of the WMP that active beaver management be included as a tool to ensure that flood control is maintained and that future sediment management activities are not compromised by beaver activity.

Beaver management activities allowed under the WMP would include capture and relocation, removal of existing dams, and where necessary capture and euthanization of individual beavers. If euthanization is used as an alternative to capture and relocation, a depredation permit would be necessary from the California Department of Fish and Game. Beaver management activities will be conducted in a way as to be sensitive to the local community. Beaver management activities in any given year, where feasible, will be specified in the annual work plan prepared for vegetation management activities. Removal of beaver dams will require the same environmental protection measures as vegetation management activities including use of non-mechanized equipment and RLF surveys prior to conducting work. A biological monitor, with a federal permit to handle steelhead, should also be present during dam removal activities in case fish are stranded as a result of the action.

5.0 REFERENCES

Brown, R. 2002. Story of the Arroyo Grande Creek. Published by Robert A. Brown.

Bulger, J. B. 1999. Terrestrial activity and conservation of California red-legged frogs (*Rana aurora draytonii*) in forested habitats of Santa Cruz County, California. Report prepared for Land Trust of Santa Cruz, dated March 2, 1999.

Central Coast Salmon Enhancement. 2005. Arroyo Grande Creek Watershed Management Plan. Prepared for California State Department of Fish and Game. March 2005.

Close, B. and S. Smith, 2004. *Stream Inventory Report, Arroyo Grande Creek Summer 2004*. Prepared for Central Coast Salmon Enhancement.

Cooper, A.C. 1965. The effects of transported stream sediments on the survival of sockeye and pink salmon eggs and alevin. Publ. no. 18. International Pacific Salmon Fisheries Commission; 71 p.

Daykin, P. N. 1965. Application of mass transfer theory to the problem of respiration of fish eggs. Journal of the Fisheries Research Board of Canada 22(1): 159-171.

Dvorsky, J. 2004. Arroyo Grande Creek Watershed Management Plan: Geomorphic and Hydrologic Conditions Assessment – Final Technical Report. Prepared for: Central Coast Salmon Enhancement. December, 2004.

Dvorsky, J. and J. Hagar. 2008. Arroyo Grande Creek Steelhead Distribution & Abundance Study - 2006. Prepared for Central Coast Salmon Enhancement in association with Hagar Environmental Science. March 20, 2008.

Essex Environmental. 2002. 2002 Postsconstruction Monitoring Report for the Arroyo Grande Creek Sediment Removal Project. Prepared for San Luis Obispo County Engineering Department. November 2002.

Flosi, Gary, et al. 1998. California Salmonid Stream Habitat Restoration Manual (3rd edition). Sacramento: State of California Resources Agency Department of Fish and Game.

Hayes, M. P. and M. R. Jennings. 1988. Habitat correlates of distribution of the California red-legged frog (*Rana aurora draytonii*) and the foothill yellow-legged frog (*Rana boylii*): implications for management. *In* R. C. Szaro, K. E. Severson, D. R. Patton (tech. Coords.), Management of Amphibians, Reptiles, and Small Mammals in North America. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Gen. Tech. Rep. RM-166, Fort Collins, Colorado.

Jennings, M. R., and M. P. Hayes. 1994. Amphibian and reptile species of special concern in California. California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova.

McNeil, W. J., and W. H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed material. U.S. Fish and Wildlife Service Special Scientific Report Fisheries 469.

Moyle, P. B. 1973. Effects of introduced bullfrogs, Rana catesbeiana, on the native frogs of the San Joaquin Valley, California.

Rischbieter, D. 2006. Aquatic Survey Arroyo Grande Creek and Lagoon; Oceano Dunes SVRA, Pismo SB Dunes Preserve. February 26-27. California State Parks.

Rischbieter, D. Lower Arroyo Grande Creek and Lagoon Fishery and Aquatic Resources Summary Monitoring Report. December 2004. Oceano Dunes SVRA, Pismo Dunes State Reserve. California State Parks.

Rischbieter, D. Lower Arroyo Grande Creek and Lagoon Fishery and Aquatic Resources Summary 2005 Monitoring Report. January 2006. Oceano Dunes SVRA, Pismo Dunes State Reserve. California State Parks.

Stebbins, R.C. 1985. A field guide to western reptiles and amphibians, 2nd ed. Houghton-Mifflin Company, Boston, Massachusetts.

Stetson Engineers, Inc. 2004. Arroyo Grande Creek Habitat Consercation Plan (HCP) and Environmental Assessement/Initial Study (EA/IS) For the Protection of Steelhead and California Red-Legged Frogs. Prepared for County of San Luis Obispo, Ca. February 2004.

Swanson Hydrology + Geomorphology. 2006. Arroyo Grande Creek Erosion, Sedimentation and Flooding Alternatives Study. Prepared for Coastal San Luis Resource Conservation District. January, 2006.

Swanson Hydrology and Geomorphology, Native Vegetation Network, and Hagar Environmental Sciences. 2002. Lower San Lorenzo River and Lagoon Management Plan. Prepared for: City of Santa Cruz Redevelopment Agency in conjunction with San Lorenzo River Urban Task Force and the State Coastal Conservancy. January, 2002.

Terhune, L.D.B. 1958. The Mark VI Groundwater Standpipe for Measuring Seepage Through Salmon Spawning Gravel. Canada Fisheries Research Board Journal, 15:1027-1063.

U. S. Army Corps of Engineers, Los Angeles District. 1999. Report on Hydrologic Analysis of San Luis Obispo, Santa Rosa, and Arroyo Grande Creeks. Discharge-Frequency Analysis. San Luis Obispo County, California. pp 48 +

U. S. Army Corps of Engineers, Los Angeles District. 2001. HEC-RAS Modeling for Arroyo Grande Creek. San Luis Obispo County, California. pp 75 +

U.S. Census Bureau. (2000). *State & county Quickfacts: San Luis Obispo County, CA.* Retrieved from http://quickfacts.census.gov.

US Fish and Wildlife Service. 2005. Revised Proposed Designation of Critical Habitat for the California Red-Legged Frog (*Rana aurora draytonii*); Proposed Rule. 70 FR 66905 67064. November 3, 2005.

Vaux, W.G. 1962. Interchange of stream and intragravel water in a salmon spawning riffle. US Fish Wild. Serv. Spec. Sci. Rep. Fish. No. 405. 11p.