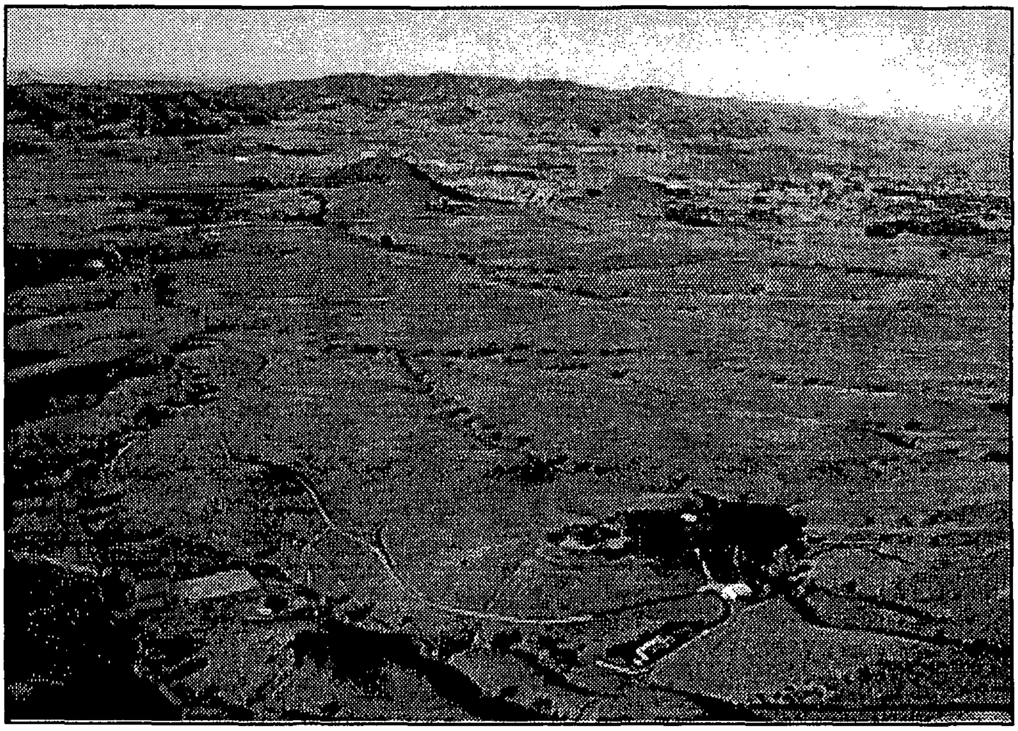
San Luis Obispo Creek Watershed Hydrologic Survey



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EXECUTIVE SUMMARY

The purpose of this study is to assist the Land Conservancy of San Luis Obispo County to identify restoration opportunities along San Luis Obispo Creek and its tributaries in an effort to enhance water quality. Previous studies have addressed a variety of water quality problems within the San Luis Obispo Creek watershed. This report addresses a number of these issues but specifically targets bank erosion and subsequent sedimentation, which adversely affect the ability of the Creek to serve as a viable fishery. The restoration pursued by the Land Conservancy is focused on the sedimentation problem, but will also address any other problems encountered on specific sites.

The Land Conservancy has completed a number of studies related to the Creek and is continuing to undertake studies on issues of importance to riparian restoration. This study on the hydrology of the watershed was considered critical to a broader understanding of the dynamics within the watershed, and of how one restoration project will affect other sections of the Creek.

This study provides a general characterization of the watershed as a whole, and provides a detailed evaluation of the main stem of the Creek, which faces the most immediate needs for restoration.

The Land Conservancy also intends this study to provide a framework for more detailed studies within each sub-watershed and each reach of the main stem of the Creek. It provides the overall context within which future projects may be incorporated. Each of the sub-watersheds is distinct and has it's own dynamics, so one solution for stream bank stabilization will not be universally applicable.

While this study concluded that erosion and sedimentation are problems throughout the entire watershed, the severity and main causes of erosion are variable. In most cases, however, erosion was caused by activities adjacent to the stream banks.

Upstream of San Luis Obispo, erosion of banks is occurring due to the removal of riparian vegetation by cattle and flood control crews. Within the City of San Luis Obispo, and immediately downstream, erosion is resulting from high flow velocities generated by channel constriction (urban encroachment), bank armoring, and vegetation removal.

In addition to the direct sediment loading from San Luis Obispo Creek's banks, sediment is being delivered to the main stem from several of the tributary sub-watersheds. Throughout the East Fork and Davenport Creek sub-watersheds, erosion is resulting from removal of riparian vegetation for agricultural purposes, and by cattle grazing in the riparian corridors. Significant sediment loads are also being delivered from the Froom Creek watershed, where extensive grading has exposed loose soil. Finally, the upper Stenner Creek watershed, due to extensive riparian grazing and the resulting lack of vegetation, is contributing significant sediment loads.

These results point to land use management as a way lessen future impacts on riparian conditions in the watershed, and bank revegetation to rehabilitate those areas already damaged. This report identifies restoration opportunities throughout the watershed.

I. INTRODUCTION

A. PURPOSE OF THIS STUDY

The purpose of this study is to identify restoration and water quality enhancement opportunities in the San Luis Obispo Creek watershed. It presents a comprehensive characterization of the entire watershed in reference to vegetation, soils, land use, ownership, and riparian corridor conditions. It also describes how these watershed characteristics can be opportunities or constraints to the restoration program.

This study is also being used to identify specific restoration sites within the watershed so projects can be planned and implemented. The information in this study will be used to plan enhancement projects that will not adversely impact watershed areas downstream.

B. BACKGROUND TO OTHER STUDIES IN SAN LUIS OBISPO CREEK WATERSHED

The Land Conservancy of San Luis Obispo County and several public agencies have conducted a number of studies in the watershed over the past few years. This hydrologic study complements these other studies. The following is a brief summary of the key studies.

1. Land Conservancy - San Luis Obispo Creek Restoration Plan

The current study expands the scope of The Land Conservancy's previous study on San Luis Obispo Creek entitled "San Luis Obispo Creek Restoration Plan", which was completed in January, 1988. This report identified land use management objectives based on each of the Creek's beneficial uses. It also includes an inventory and ranking of natural and aesthetic resources along the riparian corridors of the main stem of the Creek and the main tributaries.

The current study expands the scope to include all lands within the watershed.

2. Land Conservancy / Central Coast Salmon Enhancement - Steelhead Trout Habitat Inventory & Investigation

A fisheries habitat typing study has been undertaken at the same time as the current study. It presents a comprehensive inventory and characterization of fish habitat types and conditions throughout the main stem of San Luis Obispo Creek. Additional information is presented which provides an historic perspective on fish stocking and water flows. It will be used in conjunction with the current study to evaluate fish habitat restoration and enhancement needs within the watershed.

3. City of San Luis Obispo - Water Re-Use Project EIR

The City of San Luis Obispo recently released an Environmental Impact Report for their Water Re-Use Project. Included in this document are a biological assessment and inventory of the lower San Luis Obispo Creek area, a hydrology and groundwater report, and fish habitat survey.

This study is limited to the section of the Creek south of the City which will be affected by the project plans.

4. City of San Luis Obispo - Waterways Inventory

The City of San Luis Obispo has surveyed all of the drainages within the city for the purposes of flood control analysis. The inventory describes vegetation condition, encroachment level, debris types, culvert and bank reinforcement locations, and possible pollution sources. It also includes pictures of these areas.

5. California Regional Water Quality Control Board/ Coastal Resources Institute - TMDL Study

The California Regional Water Quality Control Board, in May, 1994, published a study by Cal Poly's Coastal Resources Institute (CRI) entitled "Nutrient Objectives and Best Management Practices for San Luis Obispo Creek". This study addressed nutrient loading in the watershed. Issues addressed include watershed features, current land use practices and problems, algal growth, and associated mitigation measures. Specific best management practices (BMPs) were recommended throughout the watershed.

II. METHODOLOGY & ORGANIZATION OF THIS REPORT

This study was conducted at two levels of detail. First, a general reconnaissance survey of the entire watershed and its sub-watersheds was conducted. Second, a detailed study was conducted along the main stem of the Creek from the Cuesta Pass to the Ocean.

The remainder of this study is organized into four parts:

1. An overview of the watershed and its sub-watersheds.
2. Description each of the sub-watersheds.
3. Detailed analysis of the main stem of San Luis Obispo Creek.
4. A summary of a hydrologic model of the watershed.

III. OVERVIEW OF THE WATERSHED

A. LOCATION AND SETTING

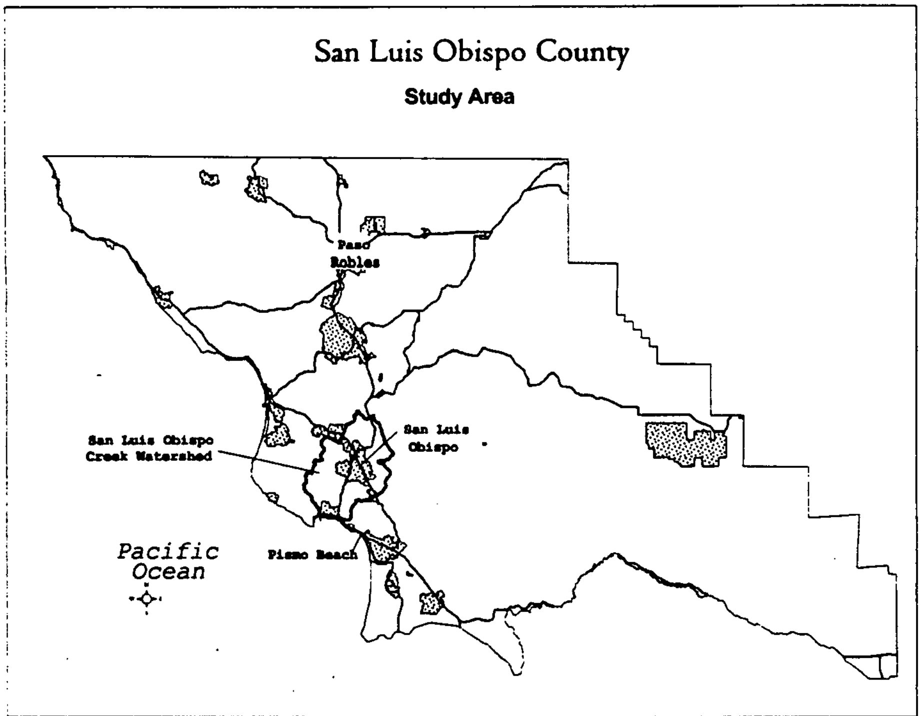


Fig. 1.1 - Sudy Location

The San Luis Obispo Creek watershed drains roughly 84 square miles of land surrounding the City of San Luis Obispo, California and carries the drainage 18 miles to the Pacific Ocean at Avila Beach. The headwaters begin as flow from the Santa Lucia Range and spill onto a small sparsely developed plateau before descending into the City of San Luis Obispo and the Pacific Ocean at Avila Beach.

It is within the City that San Luis Obispo Creek is joined by Stenner Creek, which also carries the drainage of Brizziolari Creek. These tributaries also begin in the Santa Lucia Range and flow through the California Polytechnic State University. These creeks flow through agricultural land surrounding the University and continue through urbanized areas of San Luis Obispo.

South of the City the Creek flows down a narrow agricultural valley, through a gap in the Irish Hills, and out to the ocean at Avila Beach. In this lower stretch the Creek is joined by the East Fork of San Luis Obispo Creek (also called Acacia Creek) and Davenport Creek. These tributaries begin along a small range extending southeast of San Luis Obispo and flow through a mix of grasslands, vineyards, agricultural areas, and the industrial airport area south of the City. Prefumo Creek, which drains Laguna Lake, the southern Los Osos Valley, and the north slopes of the Irish Hills also joins the main stem south of the City. Finally, a series of minor tributaries, the largest being San Miguelito (See Canyon) Creek, join in the lower sections of the main stem.

B. GENERAL DESCRIPTION AND CHARACTERIZATION

1. Geology

The first step in understanding the watershed is to look at the nature of the geologic formations that underlie it. The following overview was obtained through an interview with Dr. David Chipping. The formations beneath the surface of the land are composed of a mixture of volcanic, sedimentary, and metamorphic materials crossed by the Los Osos fault zone. The form of the land when this drainage was in its formative stages probably existed on a uniform sloping terrace extending from the Cuesta Ridge to the ocean. As the coast uplifted, the Creek maintained enough energy to cut through the harder formations along and west of the Los Osos fault.

The secondary tributaries flowing out of the Irish Hills and into the Edna Valley did not have enough energy to cut through the harder rock and turned north or south to drain into the main stem of the Creek. The geology along the west side of the Edna Valley is complex. For not only is there a fault line but the earth has also been uplifting at the same time. The drainage pattern that results from these geologic forces is a combination of the dendritic drainage pattern in the foothills, combined with a trellis like pattern in the flat valleys. When the Creek cuts through the Los Osos fault (near the northbound S. Higuera freeway on-ramp), it enters what is almost a new sub-watershed of its own. The nature of these sub-watersheds will be discussed in greater detail below.

Because the overall lay of the land gradually sloped to the west, as the Edna and Laguna Lake area began to fill with sediment. The layers of sediment were laid down in a large wedge with the thicker side next to Country Club estates. This is where many wells are located. It has been suggested that prior to the development of this area, the ground water in these soils built up and came to the surface where San Luis Obispo Creek crosses the Los Osos Fault. This could have supplied a year-round flow of water in the lower Creek.

In summary, there are two main types of sub-watersheds within the overall watershed. There are foothill watersheds that bring water down from the hills into the flat valleys, and the north and south running watersheds within Los Osos and Edna Valleys that transport water to the main stem where it cuts through the narrows at the Los Osos fault. At this point, the Creek is cutting through what may still be an uplifting zone, within which there are smaller scale zones of cutting and deposition.

2. Hydrology

Hydrology, the study of water flow through a watershed, is a special discipline. The hydrologic research, fieldwork, and modelling were completed by Dr. Brian Dietterick, and Masters candidates Chris Rose and Mark Angelo. Their input was critical to this study.

The phrase that has been used to characterize the hydrologic nature of this watershed is that it is "flashy" with regards to its response to rainfall events. This means that the flow of water moves quickly through the system yielding high peak flows. This is partly due to the watershed's high relief. It descends almost 2,600 feet from Cuesta Ridge to sea level in less than 18 miles. The other contributor is the watershed's urban nature, and the proliferation of impervious surfaces. These surfaces drain quickly to the Creek via storm drains.

The other essential characteristic of the watershed is its vulnerability to very wide ranges in rainfall. As a coastal watershed, it is subjected to heavy costal storms. In addition, the high relief creates differences in rainfall over short distances. A storm that might drop 1" in town could easily drop from 2" to 4" on the ridge.

All of these factors create a watershed that has high potential energy both on the slopes, in the tributaries, and in the main stem of San Luis Obispo Creek. The high energy has resulted in problems with erosion, sedimentation, and flooding.

The problems now being experienced within and near the City of San Luis Obispo are partly created by the dynamics of the watershed itself. The other half of the problem has been a number of urban projects constructed over the years. Highway 101, for example, cuts through the watershed and along the Creek from near the Ocean to the Cuesta Ridge, and has altered historic stream routes. The highway has also confined the Creek's flood plain, which used to extend into a larger agricultural area just west of town, to a narrower section. This has resulted in more destructive, faster moving flood waters.

The vegetation that was historically associated with the Creek below town, as it entered the flood plain, is no longer there. Historic vegetation removal, combined with structural changes within the City, have left an unstable channel which is vulnerable to more frequent flooding. The water now moves faster and has cut the river down to bed rock in many places, and created high banks.

One of the first and most important questions regarding restoration is; Why is damage occurring? Another important decision is whether or not it is necessary to work on the upstream reaches before the downstream reaches. As a result of the hydrologic study and observations of the team lead by Dr. Dietterick, it was determined that most problems appear to arise from the immediate riparian land use condition, and that it is important to address erosion and sedimentation wherever they occur in the watershed.

The condition of the banks has a direct connection to the riparian ecosystem and the morphology of the stream. The erosion of banks is contributing tons of sediment of all different sizes, not just the fine materials. Observations within the stream have indicated that sediments are largely from the adjacent banks. Very little of the recently deposited, coarse-sized, sediments associated with upstream formations are found in the lower reaches.

Erosion from agricultural fields is also a contributor to sedimentation, but the contribution from these sources has not been documented as clearly as stream bank erosion.

Solving the problems of bank erosion will require careful consideration of a number of in-stream variables. Issues such as the flow of water, quantity, velocity, channel capacity, and conditions within the flow line will all have to be considered. A discussion of these issues is contained throughout the report where the varied conditions presented by the sub-watersheds are discussed.

3. Soils and Vegetation

Variations in soils and vegetation throughout the watershed are important determinants of erosion potential. Figure 1.2 shows generalized soil types in the watershed.

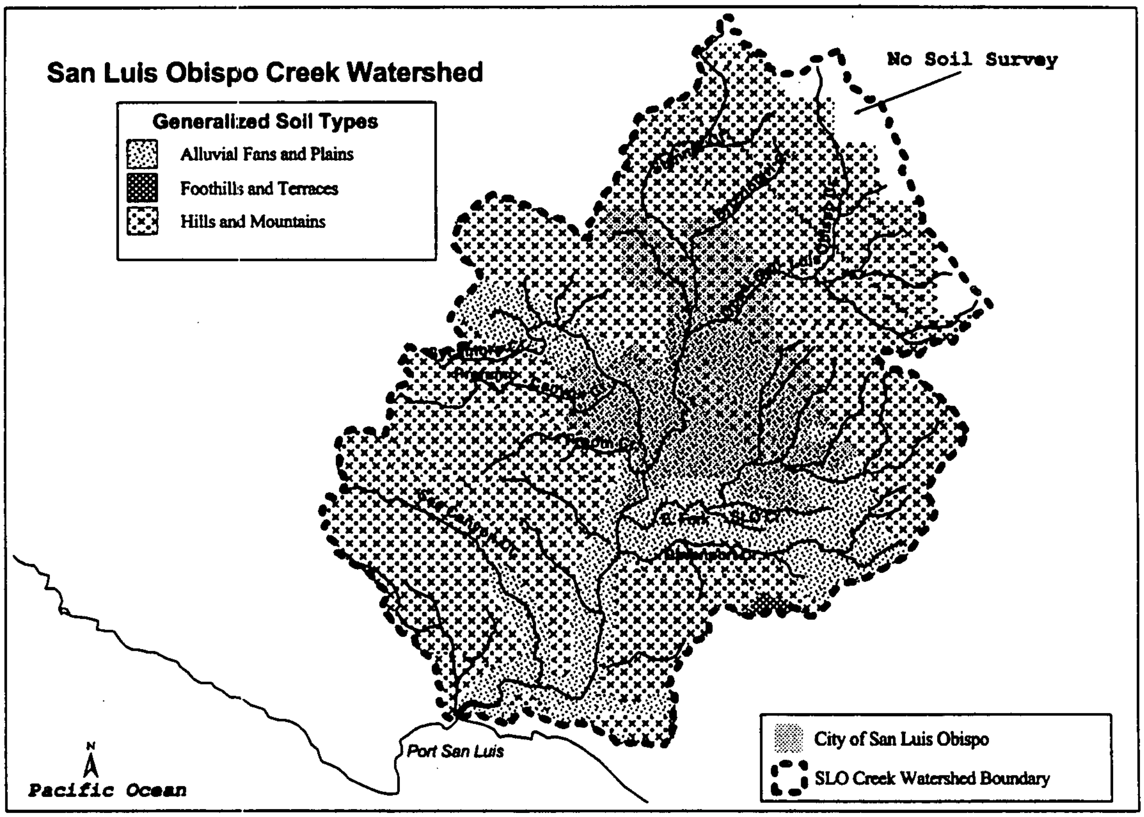


Figure 1.2 - Generalized Soil Types (SCS)

Most of the watershed is laden with soil types typical of hill and mountain terrain. These are generally on moderate to steep slopes in the higher elevations and are well to excessively drained. They are primarily used for open range, dryland farming, and scattered residential development. These lands are mostly at the headwaters of the watershed tributaries.

The map also illustrates how the tributaries flow from these mountainous areas through a swath of alluvial soils found in the flatter areas and basins. These soils are generally deeper and more poorly drained. These alluvial soils are good for irrigated row crops and dryland farming, and are highly erosive. Urban development is also taking place on these soils due to the flat terrain.

Bank erosion is a particular problem in areas with alluvial soils. The sandier of these soils have a very low critical bank height, which means they cannot support high vertical banks. Following saturation from high flows, these soils dry and collapse into the channel. This places sediment directly into the Creek.

The steepest lands are dominated by chaparral and chaparral woodland. The flatter valley lands are primary grasslands and grass woodlands. Land use in some of these areas has resulted in alteration of the natural vegetation types. Much of the grassland has been developed and used for agriculture. Figure 1.3 shows generalized natural vegetation types within the watershed.

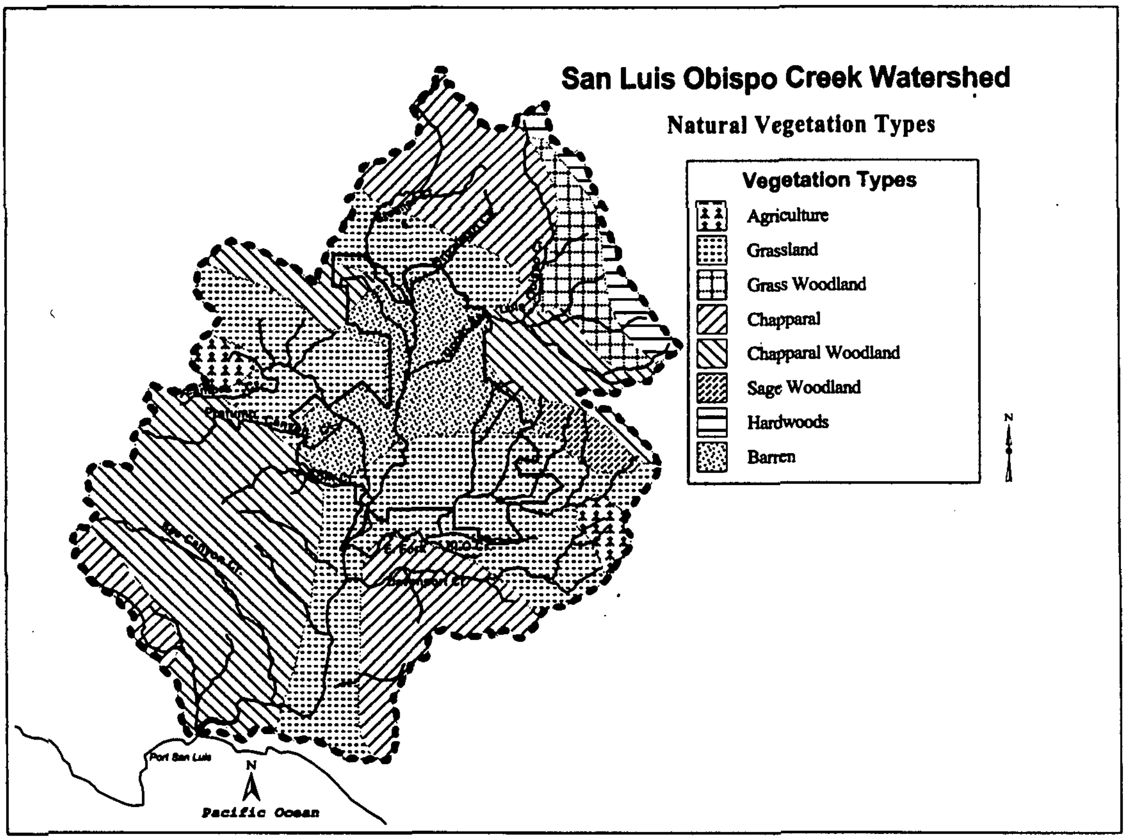


Figure 1.3 - General Vegetation Types

4. LAND USE

Land use is one of the most important factors to consider in watershed enhancement and management. Differing land uses may have dramatically different effects on the land. Even variations within a single category can be significant. This section describes land uses which are planned by the County of San Luis Obispo. Actual land use may vary, and will be discussed in more detail for each sub-watershed.

The Land Use Element of the San Luis Obispo County General Plan describes planned land uses within the San Luis Obispo Creek Watershed. The County General Plan is updated periodically, and generally represents a ten year period. Figure 1.4 illustrates these planning designations. The center of the watershed is dominated by urban development. Much of the surrounding area is zoned in agriculture, open space, and rural lands, which are generally less intensive uses. Scattered residential zones describe areas of variable density.

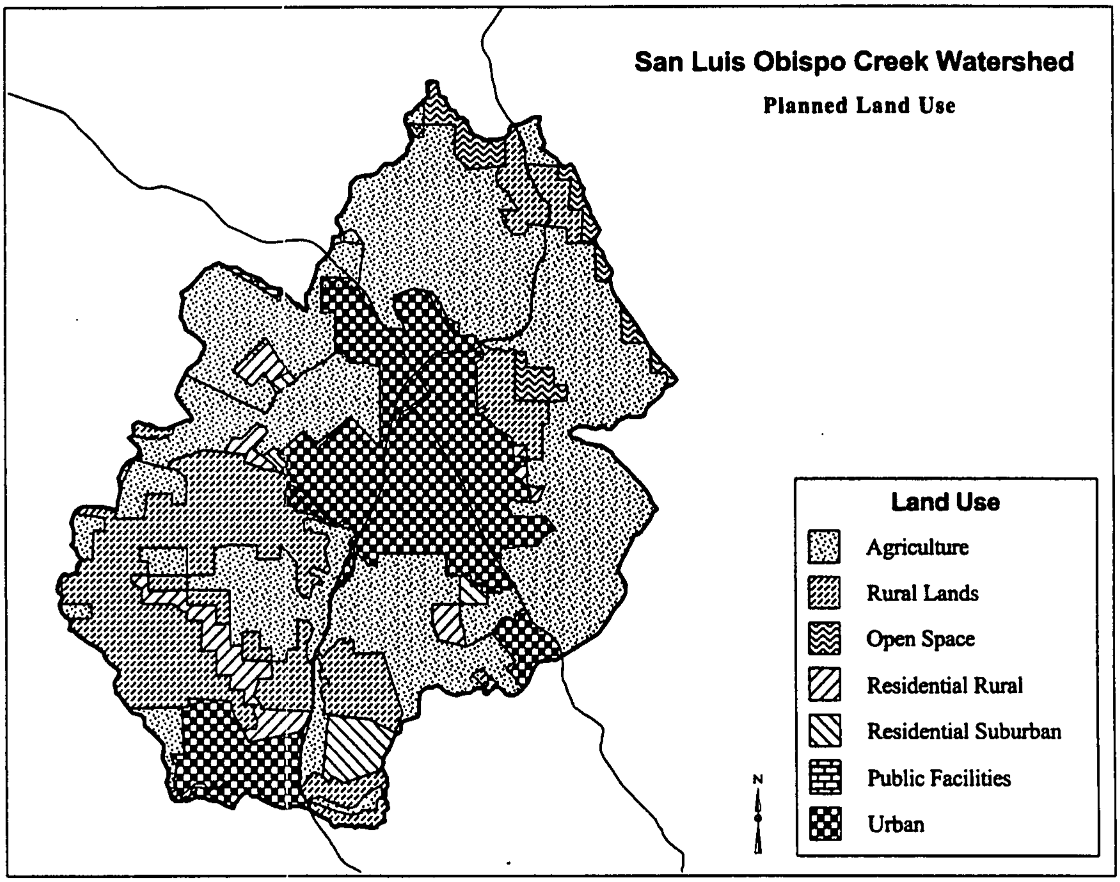


Figure 1.4 - Land Use

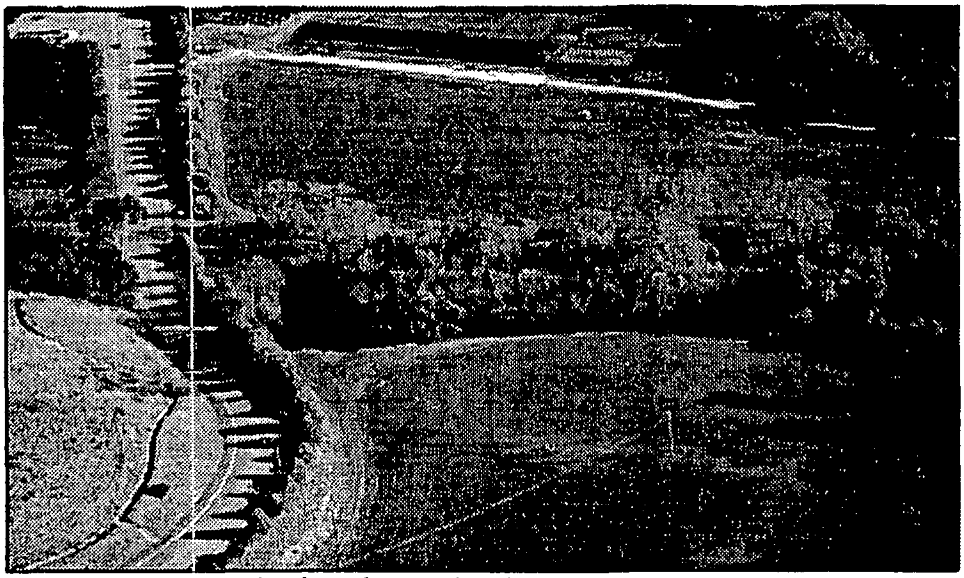
a. Agriculture

Agricultural land encircles the City of San Luis Obispo and is prevalent throughout the watershed. Land zoned in agriculture is developed at low to very low densities. The minimum parcel size in land classified as agriculture can vary between 20 acres and 320 acres, depending on its soil and other factors included in the county's land use ordinance. The kinds of land uses that may be permitted on any one parcel, however, are extremely broad. This reflects a rural county where mining, food processing facilities, and other related agricultural business activities are permitted in agricultural areas.

The impacts of the agricultural operations on watershed quality can be very significant. In areas of intensive crop production, soil disturbance and riparian vegetation removal are common. These activities can lead directly to erosion, sedimentation, and transport of non-point source pollution. In areas dominated by livestock grazing, the primary problems are destruction of riparian corridors by livestock seeking water, and nutrient pollution. Large animals also compact soil in the riparian areas making natural revegetation more difficult. Agriculture is important to the local economy, however, and can be very protective of the Creek when sound land management practices are followed.

The following photographs show two tilled agriculture operations. The first has resulted in destruction of the riparian corridor while the second shows a rich riparian corridor. While the land use is the same, it is clear that management practices differ.

Riparian vegetation disappearing into agricultural field



Healthy riparian corridor through agricultural area

The agriculture category designation also reflects larger parcel sizes, which represent valuable restoration opportunities. Since agricultural lands are where simple and inexpensive changes can lead to significant improvement over fairly large areas, farmers and ranchers are crucial allies in watershed enhancement.

b. Rural Lands

The rural lands category identifies areas where rural residences are the main uses. Minimum lot sizes range from 5 to 15 acres in size. Small agricultural operations area allowed here, but not commercial agriculture. Large parcel sizes provide good restoration opportunities.

Lands with this designation are found in the Irish Hills area along Prefumo and Sycamore Creeks and northwest of San Luis Obispo. While the same effects can occur in this category as in agriculture, they would generally be more limited in area and intensity.

c. Open Space

Open space designation is given to land that is to be protected in a natural state. These lands are in public fee ownership or have open space easements on them. Land use should not be a significant factor in watershed impacts from these lands, although management and effective stewardship may still be important over time.

d. Residential Rural

These are low density residential areas where some agriculture is allowed, but they are clearly a secondary use. Parcel sizes are generally smaller (5 to 20 ac.) than those in agriculture or rural lands. These generally have poorer agricultural soils and lack significant environmental resources. Due to the low density and limited agricultural capabilities, watershed impacts are limited in these areas. Since livestock and agriculture are allowed in this category, there is a still potential for cumulative effects in areas near or adjacent to creeks. Most of the lands in this category are in See Canyon and along parts of Davenport Creek

e. Residential Suburban

The residential suburban category lands in the San Luis Obispo Creek Watershed are found mostly along the urban edge of San Luis Obispo. The main exception is the Squire Canyon area. These lands are similar to residential rural concerning usage, but the density is somewhat higher. Parcel sizes range from 1 to 5 acres in this designation.

f. Public Facilities

Public facilities designation is for land owned by a public agency and used for facilities meeting public needs. There is very little land in the watershed with this designation, so impacts to the greater watershed from these lands are minimal.

g. Urban

The urban designation is for lands within an existing Urban Reserve Line. About 1/5th of the land within the watershed is considered urban. These areas generally have small lot sizes, and the complicated ownership patterns can be a challenge for restoration.

These designations are very general, and actual land use may take many forms. In the analysis of each sub-watershed, the actual land uses will be described in more detail.

5. Land Ownership

Land ownership is important in voluntary watershed protection programs because owners have the most control over land use and management practices. Regions with large ownerships represent the best opportunities for watershed protection and enhancement because larger areas can be affected with the cooperation of fewer people. Areas with smaller lots, conversely, represent restoration challenges. Cooperation with multiple owners, while possible, adds complexity to any enhancement project. In addition, small lots along streams often do not have the space needed for restoration work while maintaining another use.

Lot sizes generally increase with distance from the city. Ownership of the land within the watershed (but outside of the city) is divided into approximately 850 parcels owned by roughly 450 people (Fig. 1.5). While most of this land is privately owned, there are significant public holdings within the watershed. Most notable is the California Polytechnic State University (Cal Poly). With extensive holdings, a mix of urbanized and agricultural lands, and two tributary streams, Cal Poly is a major player in the San Luis Obispo Creek Watershed.

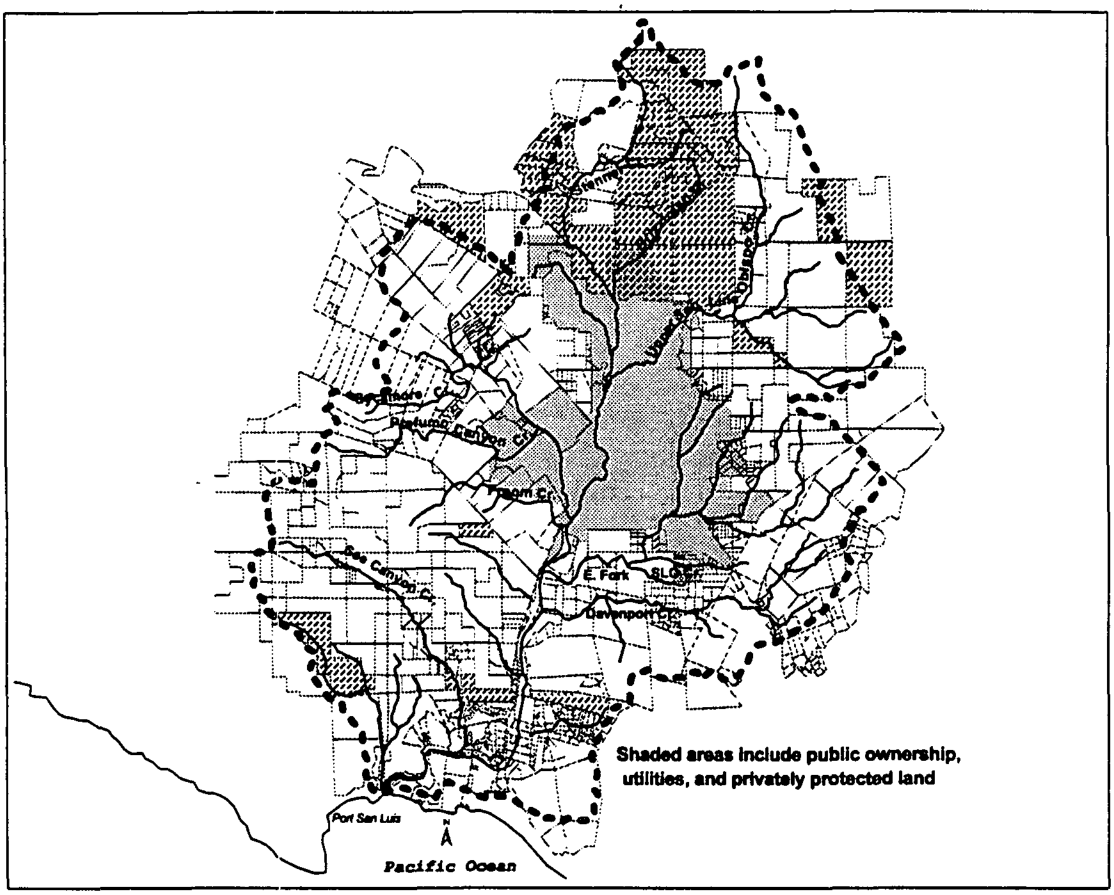


Figure 1.5. - Lot sizes

C. WATERSHED RESOURCES AND BENEFICIAL USES

The Creek and its tributaries have long been significant resources to the community, and habitat for many species of plants, animals and fish. They also provide migration corridors for wildlife, recreational opportunities, a water supply for agriculture, and ground water recharge.

1. Fisheries and Aquatic Species Habitat

Species of concern along the creeks in this watershed include the western pond turtle, red-legged frog, and two-striped garter snake. San Luis Obispo Creek is also one of the southernmost habitats for the southern steelhead trout. In addition, king salmon have been known to travel upstream from a breeding facility in Port San Luis to spawn in the creek. More information on fish habitat conditions can be found in The Land Conservancy's recent report entitled "San Luis Obispo Creek Steelhead Trout Habitat Inventory and Investigation, 1996".

2. Wildlife Habitat

Numerous mammals and bird species frequent the creek banks in this watershed. A 1986 U.S. Fish & Wildlife study found over 75 different species during a brief period. Many of the species found are considered to have special status, meaning that they are protected by the Federal or State governments, or are considered rare enough to be considered for protection. Notable species include birds of prey such as the cooper's, sharp-shinned, and red shouldered hawks, kingfishers, and blue herons. Additional special status birds include the western bluebird and the yellow warbler. Mammals found along the creeks include opossum, grey squirrel, ground squirrel, pocket gopher, raccoon, weasel, and pacific blacktail deer. Amphibians such as the pacific tree frog, bull frog, western fence lizard, and southern alligator lizard have also been observed.

3. Plants

The San Luis Obispo Creek watershed is also home to a number of special status plant species. The following table lists these species.

Common Name	Scientific Name
San Luis Obispo Star Tulip	Calochortus obispoensis
San Luis Obispo Dudleya	Dudleya abramsii ssp. murina
Brewer's Chorizanthe	Chorizanthe breweri
Chorro Creek Bog Thistle	Cirsium fontinale var. obispoensis
Betty's Live-forever	Dudleya bettinae
Jones Layia	Layia jonesii
Hoffman Sanicle	Sanicula hoffmanii
Cuesta Pass Sidalcea	Sidalcea hickmanii var. anomala

Source: "San Luis Obispo Creek Restoration Plan", The Land Conservancy of San Luis Obispo County. 1988.

Vegetation along creek banks is important as habitat for terrestrial and aquatic wildlife and for bank stabilization. Trees found along the creek corridors include willow, alder, walnut, sycamore, oak, cottonwood, elderberry, bay laurel, and eucalyptus. Trees shade the creek, keeping water temperatures low enough to support cool-water fisheries. Trees also provide cover for the numerous bird species and mammals. Common groundcover plants include coyote bush, monkey flower, blackberry, sedges, rushes, cattails, and chamise. The roots of these plants and trees serve to hold soil together and add strength to the banks.

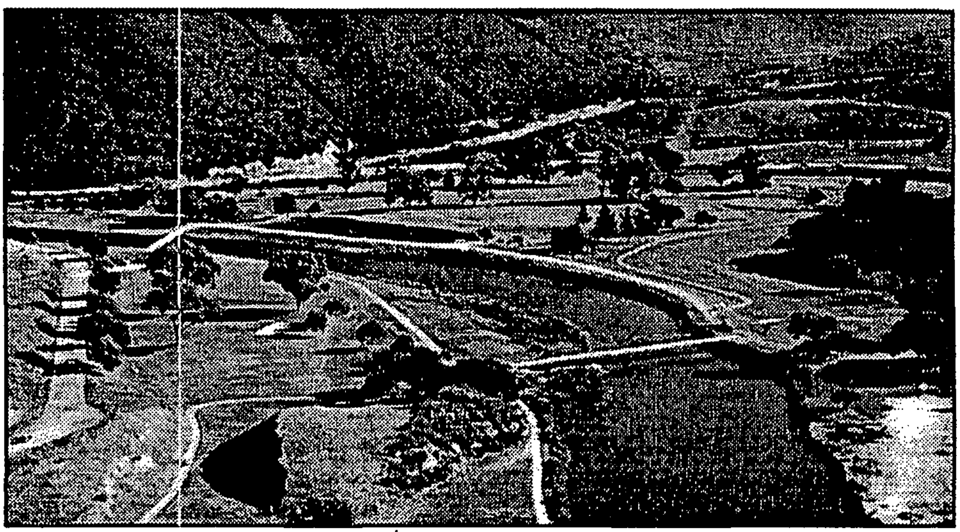
There are also a number of invasive, non-native plants common in disturbed areas. These include giant reed, castor bean, sweet fennel, nasturtium, and various thistles. These species outcompete the native riparian species, yet do not provide the same protective functions. Giant reed (Arundo donax) has become a problem in the creek corridors by constricting the flow and causing potential flood problems and erosion.

4. Water supply

San Luis Obispo Creek has traditionally been an important water source for area agriculture. Most of this diversion and pumping occurs south of San Luis Obispo. It is estimated that roughly 580 acre-feet per year is diverted for agricultural use. The groundwater basin under the lower reaches is recharged by San Luis Obispo Creek, but may also contribute flow to the Creek depending on the relative water levels in each. This groundwater supply is also important as nearly 409 acre-feet per year are pumped out of this aquifer for agriculture. The municipal water supply for San Luis Obispo, however, is primarily imported, and supplemented by groundwater pumping during times of drought. (Hydrology and Ground-Water Modeling of Lower San Luis Obispo Creek for the City of San Luis Obispo Water Re-use Project, Stetson Engineers, April 1995). The imported municipal water is added to the Creek at the Wastewater Treatment Facility located at the southwest edge of the City, and makes up a significant portion of summer flows.

5. Recreation

San Luis Obispo Creek and its tributaries also have significant recreational value. As the creeks flow through Cuesta Park, Santa Rosa Park, Laguna Lake Park, and Mission Plaza, they enhance recreational activities for the area users. Along the creeks in the upper watershed, riparian areas provide an excellent environment for hiking and jogging, and in the lower section, a golf course is enhanced by the creek. In addition, the numerous bird species make the creeks in the watershed excellent areas for birding. Finally, the area at the mouth of San Luis Obispo Creek at Avila Beach is a popular swimming area.



Golf courses provide recreation

D. WATERSHED PROBLEMS

1. Erosion

Erosion of lands within the San Luis Obispo Creek watershed, and along the creek banks, is one of the most challenging dilemmas faced in the watershed. Erosion is a natural process throughout the watershed, but land use in certain areas has accelerated the process to a destructive level. Erosion impacts the streams in numerous ways, depending on where in the watershed it is occurring. Eroded sediment laden with pollution or nutrients can be carried into the streams, contributing to water pollution. Deposited sediment degrades fish habitat by covering the gravelly channel bottoms necessary for spawning. Sediment carried in the water can add erosive force, or be deposited in the channel causing the diversion of flows into the banks, thus causing more erosion.

Disturbed soils, particularly in agricultural and industrial areas, can be laden with pesticides, herbicides, fertilizers, and other compounds. Water running off this land carries the pollution-laden soils to the creek where the chemicals can be released to the water and directly impact riparian species. Fertilizers contribute nutrients to the water, and can result in an over abundance of nitrogen and phosphorus compounds in the water, a condition known as eutrophication. These nutrient compounds contribute to excessive algae growth, which when decaying, consume dissolved oxygen needed by fish.

In addition to carrying pollution, the eroded sediment causes problems of its own. After entering the streams, the sediment eventually settles out onto the creek bottoms, covering the previously rocky bottoms with fine sediments. Most fish, including the southern steelhead, need rocky creek bottoms for spawning. Excessive sedimentation has already resulted in the loss of most quality spawning grounds in the watershed.

Willows: Good or bad?

Opinions vary on the value of willows in the riparian corridors. When established on the creek banks, willows are critical to bank stabilization. Their thick matted roots hold banks together, and the stems and branches decrease water velocities along the banks, reducing surface erosion. Problems occur, however, when willows become established in the active creek channel and constrict flows. This "choking" of the creek channel can result in flooding and severe bank erosion. Willows become established in the channel as a result of reduced flow velocities, excessive sedimentation, and the pioneering nature of this species.

Sedimentation results from erosion due to poor bank vegetation and surface disturbance. This sediment enters the creeks and is carried downstream until the water velocity is too slow to hold the material. The sediment is then deposited in these areas. Most of the larger gravel bars are formed during high winter flows in areas where the water velocity slows. These become exposed as the water level drops, and can be colonized by willows.

Willows, therefore, are a good plant which can grow in the wrong place. In order to protect the creek banks, it is best to promote willow growth on creek banks while clearing them from the active channel. Ultimately, however, it is most desirable to promote the establishment of larger woody species which shade out the willows, thus decreasing encroachment into the active channel.

Primary Erosion Sources

Erosion in the San Luis Obispo Creek watershed has several primary causes including cattle grazing, agricultural tilling, construction projects, vegetation clearing, and urban channelization. Where cattle have creek access, riparian vegetation is degraded. Regeneration of vegetation is made more difficult in these areas due to soil compaction caused by the weight of the animals. Riparian species have difficulty growing in this compacted soil. Construction of off-creek watering stations, can help alleviate this problem. Cattle can then be limited to only certain locations away from riparian corridors.

Cattle compact soil, cause erosion, and denude banks.

Erosion is also caused by construction grading, vegetation clearing, and agricultural tilling which disturb soil surfaces and leave stream banks unprotected. Construction and flood control activities, however, are usually temporary, and can be mitigated or modified to lessen impacts. Agricultural tilling is a long term activity, but tilling methods stressing soil conservation can be affective in minimizing erosion and sedimentation.

In urban areas, development has encroached on the Creek's banks resulting in a narrow channel which is often artificially created. The narrow channels constrict flows and increase water velocities to a level where even previously vegetated banks can wash out. This problem is discussed further under "urban impacts".

Additional erosion is occurring throughout the upper watershed from eroded rivulets at the headwaters. These small washes are often devoid of vegetation due to clearing and grazing. Left unprotected, these will continue to grow and produce more sediment.

Small unvegetated rivulets contribute to sedimentation

2. Urban Impacts

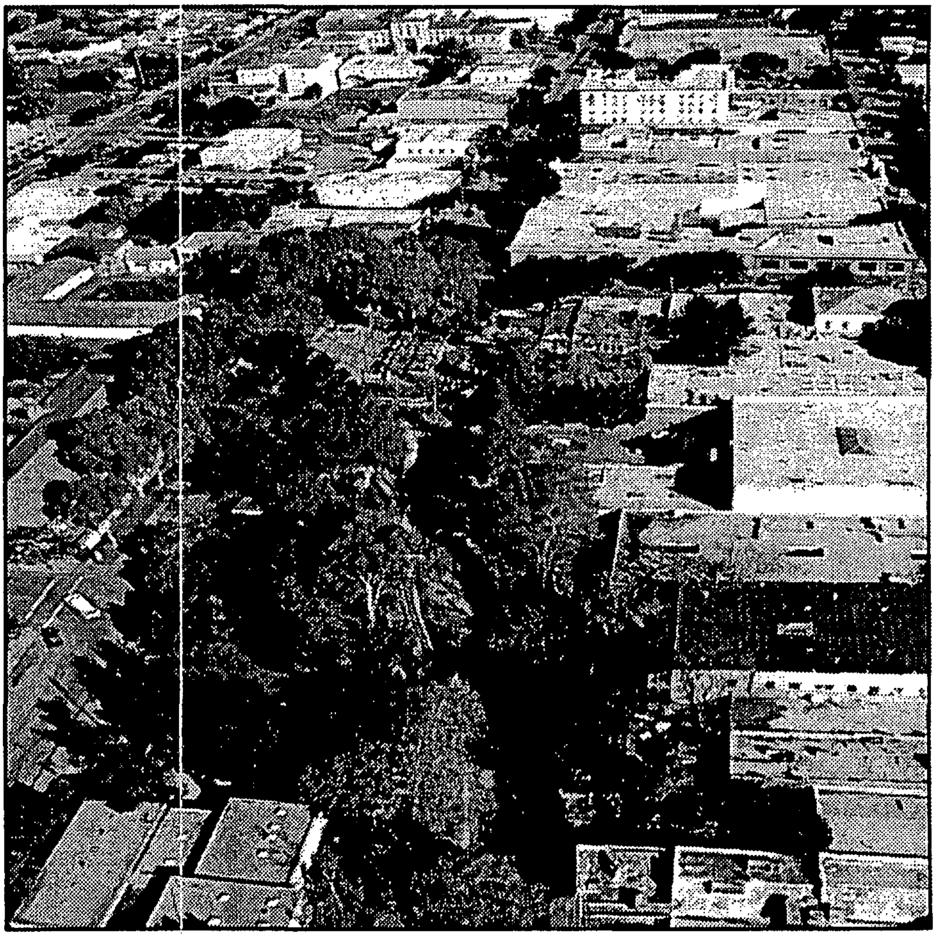
The San Luis Obispo Creek Watershed is an urban impacted watershed. The main stem of San Luis Obispo Creek flows through the City and, at some points, under the City. In addition, two major tributaries, Stenner and Brizziolari Creeks, flow through the City and the University. The urban activities that result in impacts to the waterways include flood control maintenance, channelization, increased runoff, and urban pollution.

In these urbanized areas, the Creek poses a dilemma pitting the restoration of the riparian corridors against the protection of property from flooding and bank loss. Both the City and County of San Luis Obispo have programs for Creek maintenance centered on flood control. These often involve clearing debris from the stream channels. Unfortunately, these have also resulted in stream bank clearing which has left banks vulnerable to erosion. In addition, removal of all debris from a channel results in the loss of fish habitat, as the woody debris contributes to pool formation. With minor modification to channel clearing methods, flood control could be better balanced with the needs of the creek banks and fish.

Within the urban area, the Creek has been highly channelized with a patchwork of concrete channels, gabions, riprap, and cement sacks which have stabilized the banks but are suspected of increasing the velocity of flows during storm events. Since there is little space on the banks for stabilizing work, the stabilizing materials often encroach into the channel, thus constricting flows further. Channelization problems could be addressed with stream setback ordinances, aggressive revegetation efforts, and project coordination. There are also a number of bank stabilizing methods that incorporate the use of vegetation and natural materials. These are often equally successful and considerably less expensive than traditional methods while offering the advantage of preserving wildlife and fish habitat and slowing the flow velocities.

Urban influences also include pollution from storm drain runoff and litter ranging from candy wrappers to abandoned vehicles and furniture. Protecting the creek from these impacts requires constant maintenance and pubic education. Storm drain stencils with slogans such as "No dumping, drains to creek", and events like "Creek Clean-up Day" are good example of education efforts.

Despite the challenges to urban restoration (small ownerships, encroachment), private landowners and the City of San Luis Obispo are planning bank stabilization projects. Opportunities exist to cooperate with landowners and agencies to coordinate projects and minimize further impacts associated with channelization.

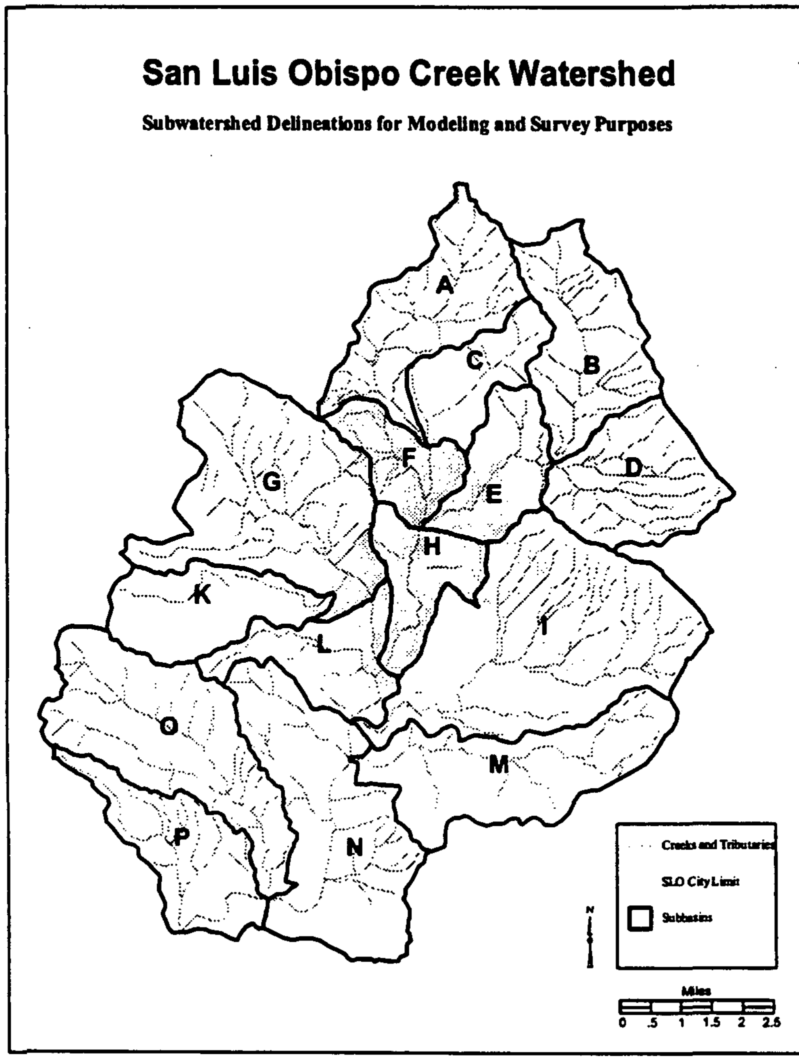


San Luis Obispo Creek flowing through Mission Plaza

IV. OVERVIEW OF SUB-WATERSHEDS

The San Luis Obispo Creek watershed is divided into 15 sub-watersheds. The remainder of this part of the report provides a characterization of each sub-watershed as identified on figure 1.6. The upper watershed survey was conducted to identify restoration opportunities above the main stem of San Luis Obispo Creek. Another goal was to determine sources of suspended sediment in San Luis Obispo Creek and to note the overall condition of the watershed. Of particular interest was soil stability along the channel banks.

Each of the sub-watersheds was analyzed with respect to soils, land use, vegetation, and riparian conditions. Sub-basin H is an urban basin which drains directly into the main stem, and is discussed in the main stem analysis. Some of the information was determined using map overlays in a geographic information system (GIS), while the riparian conditions were determined by field surveys from publicly accessible sites. In addition to the ground surveys, each of the sub-watersheds was viewed and photographed from the air.



Legend	
A	Upper Stenner Cr.
B	Upper SLO Cr.
C	Brizziolari Cr.
D	Reservoir Canyon
E	North SLO City
F	Low er Stenner Cr.
G	Laguna Lake
H	SLO City
I	East Fork SLO Cr.
K	Upper Prefumo
L	Low er Prefumo Cr.
M	Davenport Cr.
N	Low er SLO Cr.
O	San Miguelito
P	Harford Canyon

*Fig. 1.6 - Sub-Watershed Delineations * Note: Sub-watershed J was combined with basin L for analysis*

A. UPPER STENNER CREEK

1. *General characteristics and land use*

The land within the upper Stenner Creek watershed is dominated by rolling open range lands that extend up into the Santa Lucia Range, where the land becomes steep and wooded with chaparral.

The land use is primarily grazing on the open rolling land with some scattered buildings. The ownership is dominated by Cal Poly, but the sub-watershed also contains land owned by the U.S. Forest Service (Los Padres National Forest), Southern Pacific Railroad, and several private individuals.

The Highway 41 Fire in the summer of 1994 burned the steeper upland area and resulted in continuing delivery of fine sediment into the lower portions of the Creek. In 1995, the Chorro Valley Pipeline was constructed in this sub-watershed, and after two wet winters, the chapparal is recovering. In addition, the State Water Project has just entered the upper watershed in January, 1996. Planned construction through this sub-watershed has the potential to contribute significant sediment loads to Upper Stenner Creek. Mitigation measures have been planned and their relative success will have a direct bearing on the future quality of this area.

2. Issues and opportunities

a. The land in the upper watershed is steep, sandy in origin, and produces a large amount of sediment in its natural state. This has been compounded by the fire, and may soon be impacted again by the State Water Project.

b. The riparian channel through the open grassland portions of the watershed is unstable overall due to grazing, and requires bank stabilization. Numerous small rivulets with no vegetation may contribute sediment to the stream.

c. The vegetation along the lower sections of the sub-watershed, where the Creek runs through a mountainous pass, is well established but is being impacted by an adjacent road.

d. Additional problems related to fish passage have been identified in other reports.

e. The large ownerships and access to the land provide an opportunity for long-term restoration and stewardship along the Creek and adjacent land.

3. Field survey notes

Field observations were conducted at the following locations (Figure 1.7) and are described in Table 1.1.

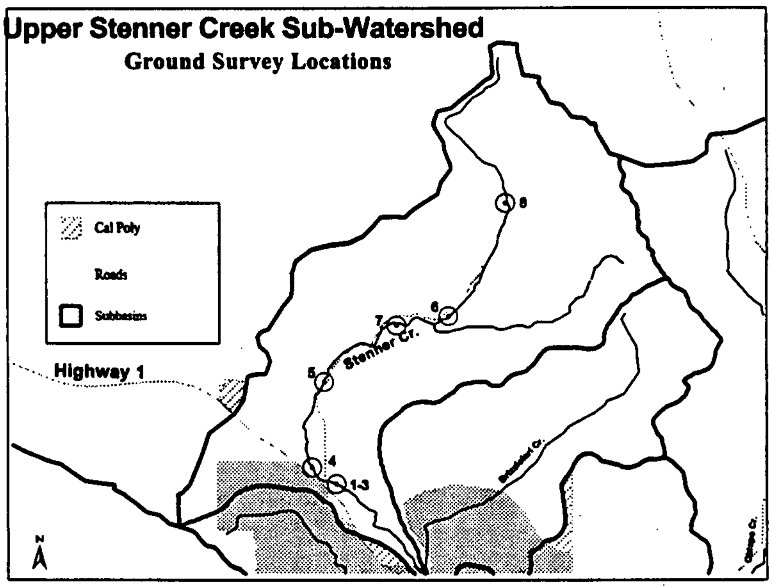


Figure 1.7 - Upper Stenner Creek Survey Locations

Survey Locations

1. The intersection of Stenner Creek Rd. and Highway 1.
2. 100-300' downstream from the bridge at Hwy. 1.
3. 0-100' downstream from the bridge at Hwy. 1.
4. 0-300' upstream from the bridge at Hwy. 1.
5. Adjacent to RR trestle at the road leading to the filtration facility.
6. 500' upstream from the wooden bridge.
7. Approx. 1,500' downstream of the wooden bridge.
8. Near bridge at headwaters.

Table 1.1

Loc.	Vegetation	Bank Condition	Substrata	Notes
1	Grasses along the banks with few established trees. <10% total cover	Severely eroded/ vertically cut banks.	Primarily coarse (sand and gravel). Some embedding, cobbles on bank.	Eroded banks are unvegetated. Further erosion is inevitable.
2	Some established trees. < 10% cover.	Eroded banks. 8' high.	Thalweg-sand and gravel. Active channel- cobbles. Exposed bedrock in channel.	Further bank erosion is inevitable.
3	Established willows and sycamores. >60% cover.	Some bank erosion. Concrete slabs on west bank. Better than downstream.	Geologic structure in thalweg.	
4	Established vegetation. >60% cover	Some erosion.	Geologic structure in channel.	
5	Some sycamores and grasses. <30% cover.	Flat, no banks. Active channel and road are the same elevation.	Embedded gravel and cobble.	Flow restricted by concrete bridge. High flood potential.
6	Established hardwoods. 70% cover on left bank. No vegetation along right bank.	Eroded and vertically cut. Exposed roots.	Coarse material in thalweg and active channel. Some exposed fines.	150' of exposed banks.
7	Minimal Vegetation. <10% cover	Extreme bank erosion.	Fines along banks, not geologic structure.	200' of exposed bank adjacent to a house. Further erosion inevitable
8	Established laurels and sycamores.	Stabilized by geology and vegetation.	Coarse materials including gravels, cobbles and boulders. Large alluvial deposits.	Stable area.

B. UPPER SAN LUIS OBISPO CREEK

1. General characteristics and land use

The Upper San Luis Obispo Creek watershed is characterized by steep hillsides, one deep valley, and a mixture of dense oak woodland and chaparral. The upper portions of the watershed have been affected by the Highway 41 fire (1994). The sides of the canyon contain the railroad and Highway 101 as they extend up the Cuesta Grade.

The land use designations for this area are primarily agriculture, with significant portions in the rural lands category. Some of the perimeter lands are planned for open space. Actual land use is mostly grazing and scattered houses. Generally, this is a sparsely developed area with excellent restoration opportunities.

The land ownership is in a few large individual holdings and public ownership. Parcel sizes seem to decrease closer to the creek. Among the public owners are the Federal Government (Los Padres National Forest) and Cal Poly.

On the western side of the watershed, vegetation is mostly chaparral. The eastern side is made up of scattered hardwoods on the upper slopes and grass woodlands on the lower slopes. In some locations, there are heavy stands of mature riparian vegetation located next to other areas with very poor cover. The condition of the riparian corridor is generally better as the creek approaches the Highway 101 undercrossings.

Barren hillsides left by the fire have contributed to erosion and damage to Stagecoach Rd. Several projects were undertaken by San Luis Obispo County to repair the road damage. These utilized riprap and sandy fill material. Without revegetation, some of these areas will probably wash out again. These projects also left numerous culverts protruding from the roadsides that lack energy dissipation devices. These are already causing erosion and gully formation.

The State Water Project is also planned to come through the lower section of this watershed, and the relative success of the planned mitigation measures will determine the severity of possible impacts. The soil profile for the flatter sections is very deep and highly erodible. Mitigation measures must be closely monitored to determine the impacts of this project.

2. Issues and opportunities

a. This area is characterized by many vertically eroded banks.

b. Tributary channels from the east side of the Creek are laden with coarse alluviated material, fines, and gravels that are transported downstream.

c. Erosion processes in this sub-watershed have apparently been aggravated by the severe damage done by the Highway 41 fire.

d. The consolidated land ownership provides an opportunity for long-term restoration and stewardship. The focus will have to be on all land, not just riparian corridors.

e. The State Water Project will cross San Luis Obispo Creek in this area, and the highly erodible soil will be a challenge to contain and stabilize.

3. Field survey notes

Field observations were taken along Stagecoach Rd. Measurements are in miles upstream of Highway 101.

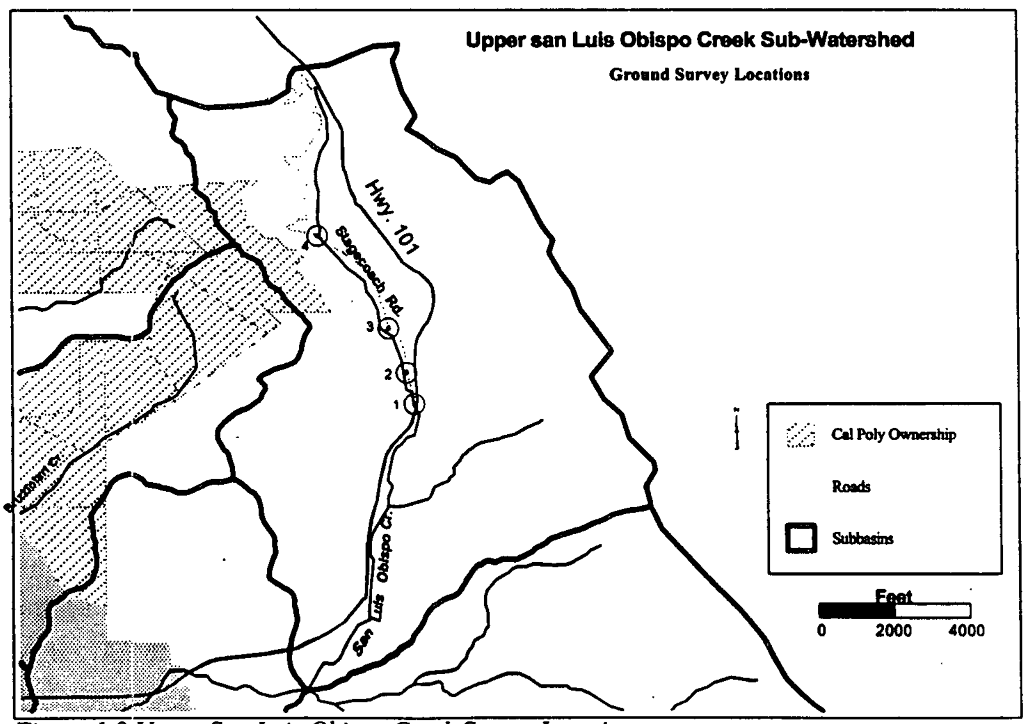


Figure 1.8 Upper San Luis Obispo Creek Survey Locations

Survey Locations

1. Intersection of Highway 101 and Stagecoach Rd.
2. .2 miles.
3. .55 miles.
4. 1.2 miles.

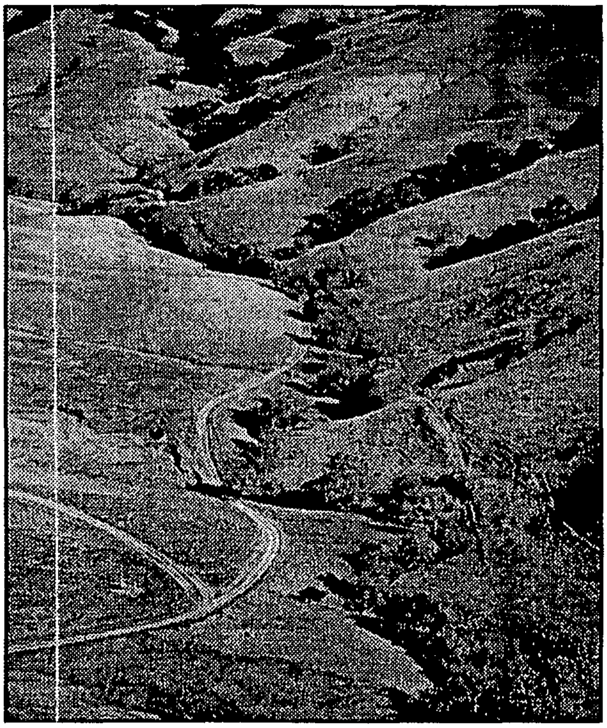
Table 1.2

Loc	Vegetation	Bank Condition	Substrata	Notes
1	>60% cover with mature canopy. Less developed understory.	Very little erosion with some terracing.	Cobbles.	Concrete in west bank, and road run-off is creating a gully. Culvert crosses under Hwy. 101.
2	Some woody vegetation and sparse, herbaceous understory	West bank has moderate erosion. Newly exposed roots. East bank is riprap.	Cobbles.	Riprap does not cover the eroded area. Backfill soil is extremely sandy and may continue to wash out.
3	Uniform vegetation cover. Woody canopy with herbaceous ground cover	Generally stable, some minor erosion.	Cobbles with some gravels.	Creek meanders more in this area.
4	Intermittent woody vegetation with non-native herbaceous cover.	Less stable area with erodible soils and slumping banks. Culverts cross under Stagecoach Rd.	Gravels 90% embedded in fines. Fines may be a product of fire damage.	Tributary confluence point. Higher gradient, and proliferation of algae. 2 of 3 culverts are clogged with fines and gravels.

C. BRIZZIOLARI CREEK

1. General characteristics and land use

The watershed of Brizziolari Creek is similar to that of Stenner Creek. The Creek begins on the steep chaparral covered hills of the Santa Lucia Range, flows through rolling grasslands and cuts through a narrow opening in the hills to the Cal Poly Campus. The State Water Project will pass through this watershed, and any impacts will depend on the relative success of the planned erosion control measures.



Land use is designated for agriculture throughout the entire watershed. The existing land use is grazing. Cattle have access to the channel in most of the upper watershed, and have led to deterioration of channel banks in some of the most accessible areas.

Land ownership is dominated by Cal Poly with smaller parts of two other large ownerships. The hills at the southwest of the watershed are part of the Los Padres National Forest. The consolidated ownership presents a unique restoration opportunity.

2. Issues and opportunities

a. Despite grazing impacts, the vegetative condition along the entire Creek is generally good. The channel is generally stable due to bedrock banks, but small eroded and unvegetated rivulets may contribute to sedimentation.

b. A few isolated problem areas exist where cattle are in the Creek and road development has occurred. Bank erosion is a problem in these areas.

c. Long-term opportunities because of ownership.

3. Field survey notes

Field observations were conducted at the following locations (Figure 1.8) and are described in table 1.2. Only a limited number of observations were taken in this section due to the generally uniform conditions and limited physical access.

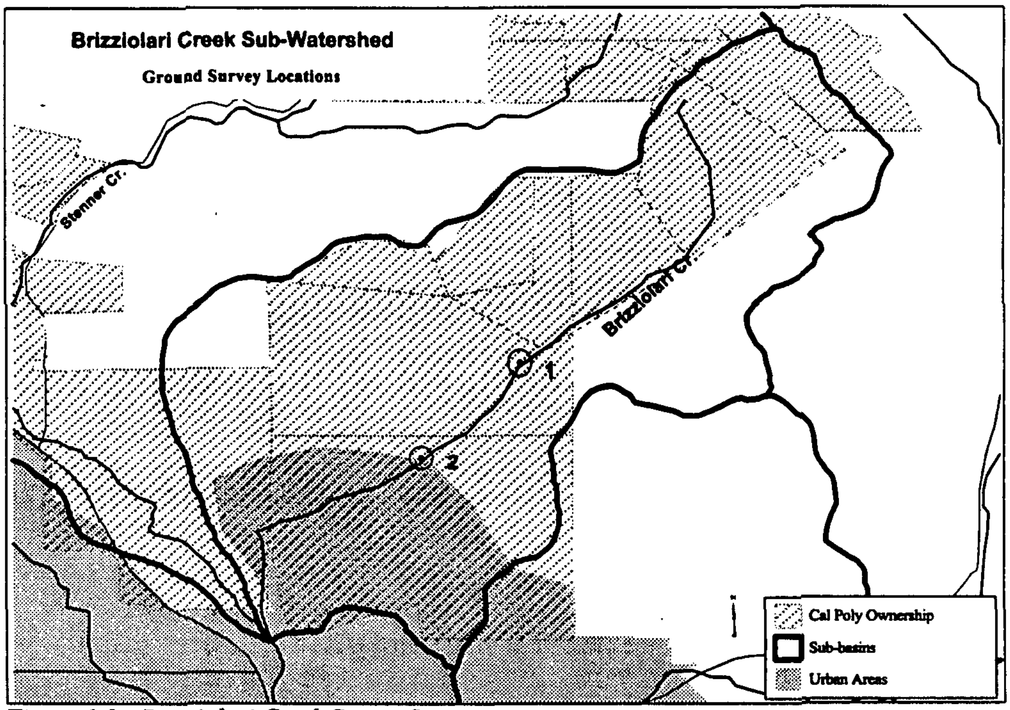


Figure 1.9 - Brizziolari Creek Survey Locations

1. On Cal Poly campus adjacent to buildings at end of road in Poly Canyon.
2. Where the road crosses the Creek near the parking lot at the opening of Poly Canyon.

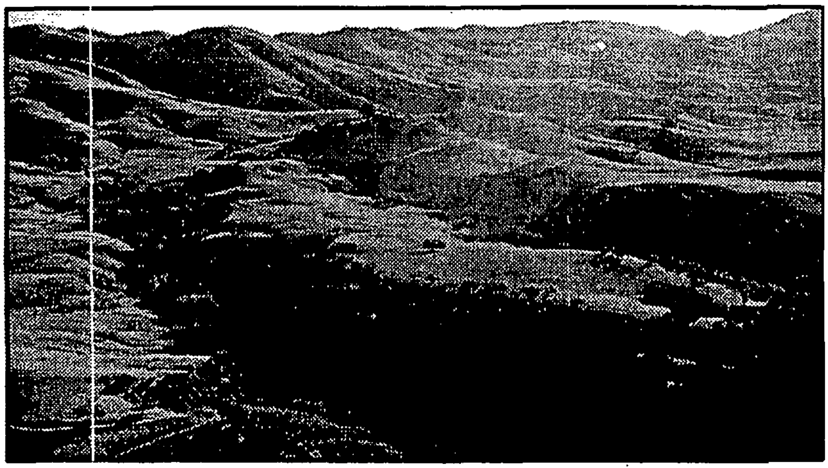
Table 1.3

Vegetation	Bank Condition	Substrata	Notes
Sparse vegetation where erosion is occurring.	Eroded. banks comprised of fine materials. Exposed bare soil.	Embedded gravels.	Cattle allowed in creek contributing to degradation.
Established hardwoods, but overall, little cover.	Intermittent bank undercutting. Exposed roots.	Coarse material. Area stabilized by exposed bedrock.	Flow constricted by culvert.

D. RESERVOIR CANYON

1. General characteristics and land use

Most of this area has good riparian vegetation consisting of mature trees. The upper canyon is mostly stable due to good vegetative cover and deeper soils. The vegetation is mostly chaparral woodland with a swath of grass woodland between the steeper ranges. This watershed will also be bisected by the State Water Project. Due to the deep soil profiles and high erodibility of the soils, the relative success of mitigation measures will be important.



The land is zoned for agriculture and open space and is largely undeveloped. This canyon has the most intact and protected natural resources of any within the watershed. Several houses are located near Highway 101.

The land in this watershed is owned almost entirely by one owner. The City of San Luis Obispo also owns one parcel which is the site of an old water supply reservoir.

2. Issues and opportunities

a. Long term opportunities for stewardship over a large natural area under a single ownership.

b. Some exposed areas were found in the lower canyon near the freeway. These areas have poor vegetation and a deep soil profile.

c. Some restoration will most likely be necessary following the water project construction.

3. Field survey notes

Field observations were conducted at the following locations (Figure 1.10) and are described in table 1.4.

1. End of public road.
2. Lower canyon near the white house (Reservoir Canyon Rd.)

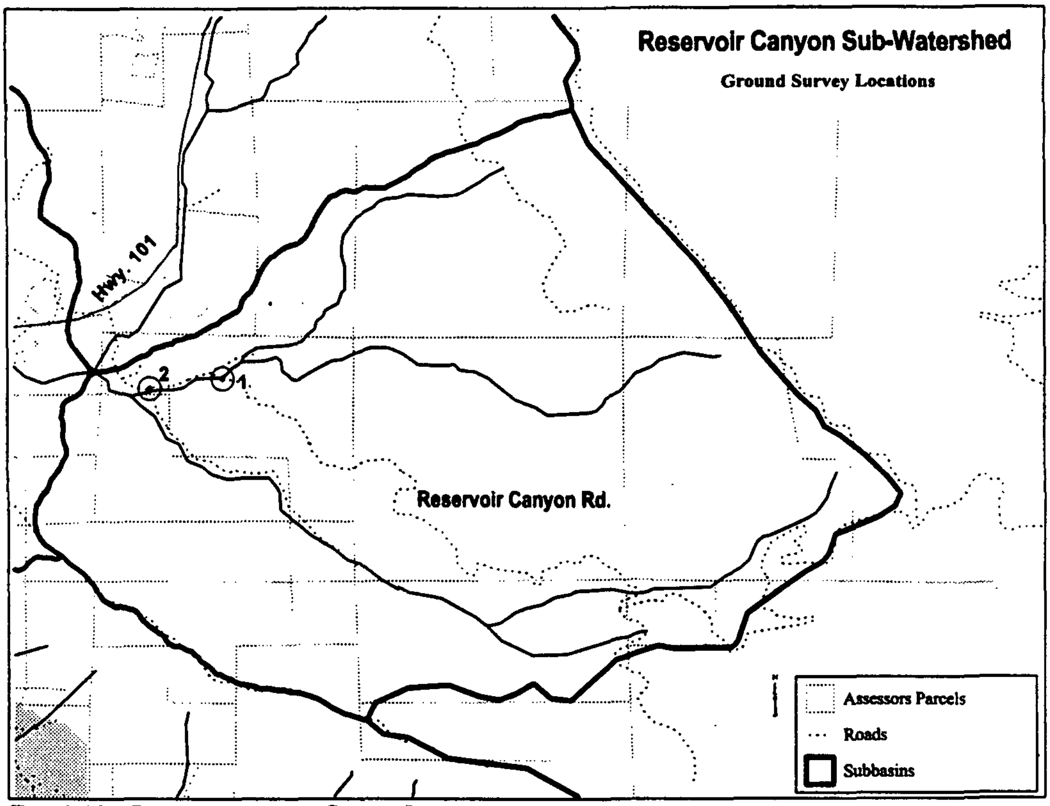


Fig. 1.10 - Reservoir canyon Survey Locations

Table 1.4

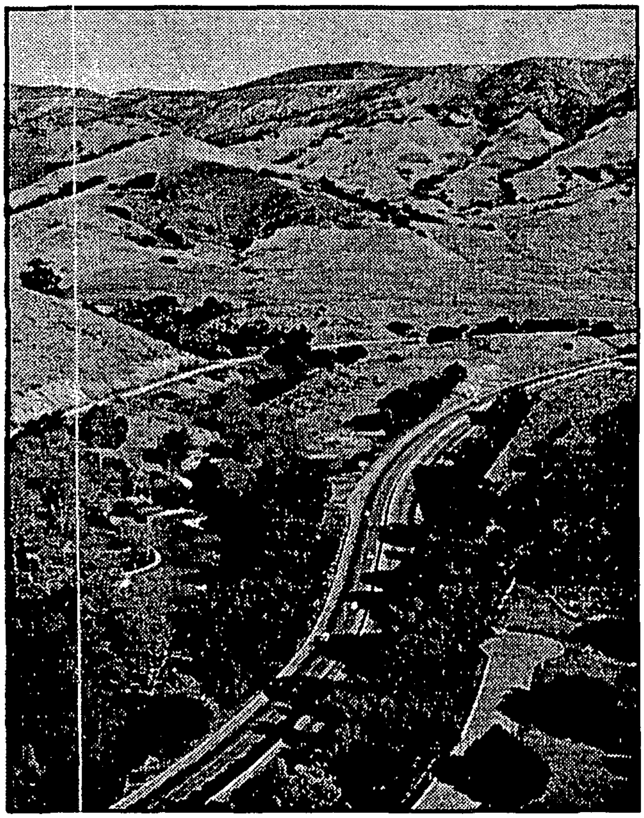
Loc.	Vegetation	Bank Condition	Substrata	Notes
1	Mature riparian vegetation.	Erosion minimal. Some areas with exposed geology (serpentine).	Cobbles and gravels on sand banks.	
2	Grasses only.	Extreme vertical bank erosion.	(Access to survey was limited)	

E. NORTH SLO CITY

1. General characteristics and land use

This sub-watershed contains part of the City of San Luis Obispo. The area outside the city is in good condition overall. Vegetation is diverse and mature consisting of chaparral woodland and grassland. Much of the upstream area was not accessible, but there is little evidence of silt transport in the lower sections. The healthy vegetation has protected the moderate to highly erodible soils. This area will not contribute large amounts of fines to San Luis Obispo Creek.

The area within the City is densely developed, and the channel has been modified to some degree. See reach 13 of the main stem analysis (p.99).



The land outside the City is zoned for agriculture and rural lands. It is currently grazed on the north side of Highway 101 and open space on the hillside south of Highway 101. It is hill and mountain terrain and includes the pass where the Creek and the highway enter the city.

The land ownership outside of the city is mostly in one ownership north of the freeway and in several moderate sized ownerships to the south. Cuesta Park is located north of the freeway. Within the city, ownership is in numerous small urban lots.

2. Issues and opportunities

a. This sub-watershed is in good condition overall. The need is for ongoing stewardship in order to maintain the existing conditions.

b. The portion within City is all developed. There are individual opportunities where banks are still unprotected. See reach 13 of the main stem analysis (p.99).

3. Survey Locations

Field observations were conducted at the following locations (Figure 1.11) and are described in table 1.5.

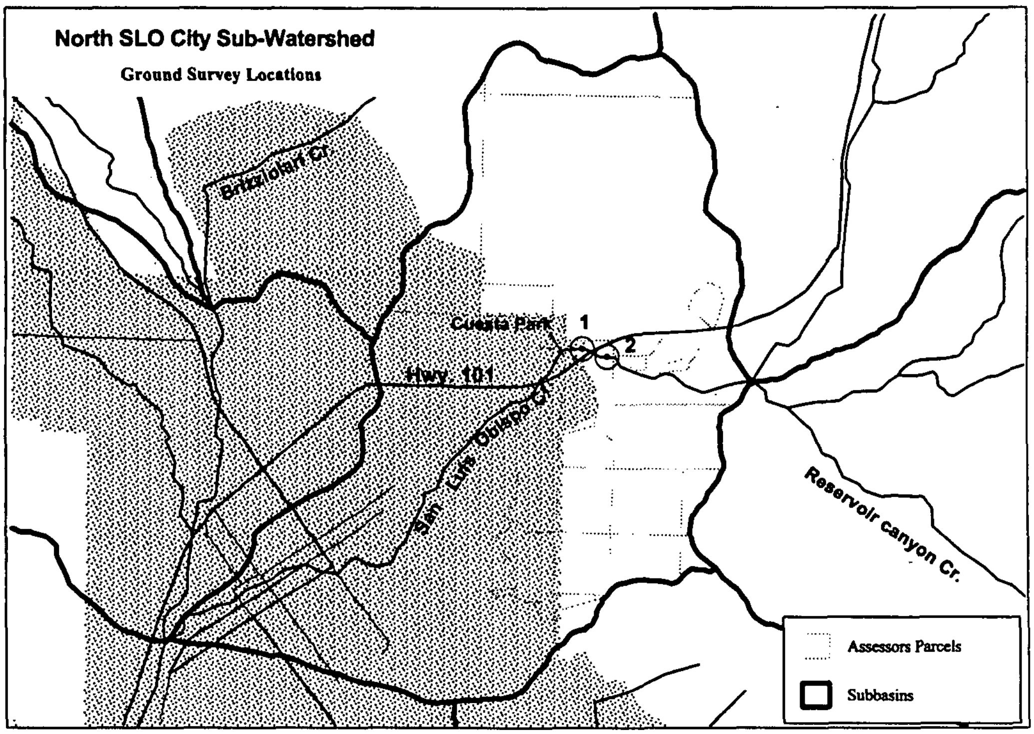


Figure 1.11 - North SLO Creek Survey Locations

1. 600' upstream from the bridge crossing SLO Creek adjacent to Cuesta Park.
2. Confluence of ephemeral stream North of the park.

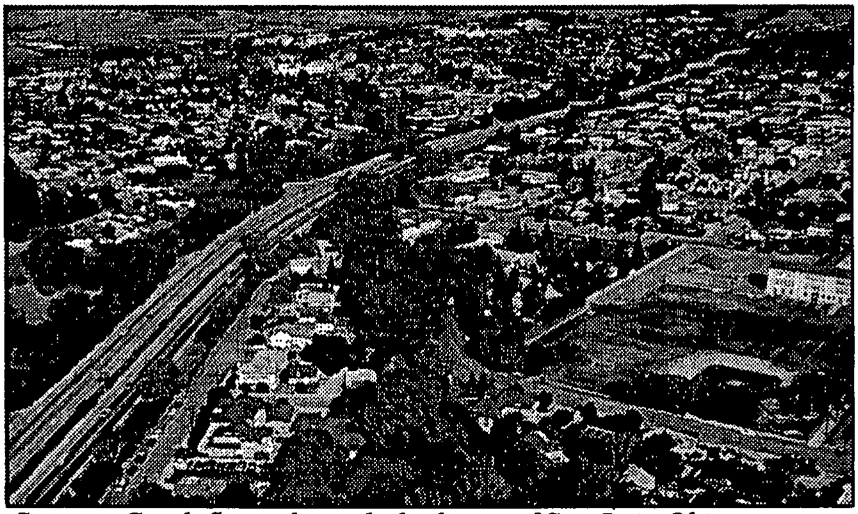
Table 1.5

Loc	Vegetation	Bank Condition	Substrata	Notes
1	Mature riparian vegetation. Sycamore, oak, and redwood.	Vertically eroded, roots exposed.	Gravels	
2	150' upstream of tributary are small willows. Channel is choked upstream.	Some vertical erosion at confluence of stream, minimal erosion upstream.	Sand and Gravels.	

F. LOWER STENNER CREEK

1. General characteristics and land use

This sub-watershed is mostly developed, and the channel is often artificial. Impervious surfaces may create flashy flows, but sediment loads are minimal. The increased flow may contribute to erosion downstream. This area has a lower gradient than most of the other sub-watersheds, so flows are slower. Brizziolari and Old Garden Creeks join Stenner Creek in this sub-watershed, adding to flows.



Stenner Creek flows through the heart of San Luis Obispo

Riparian vegetation in this watershed is sparse to nonexistent. Because much of this watershed is impervious, the erodibility of soils is only significant along the channels. Away from the creeks, vegetation consists of grass lawns and ornamentals.

The land use is mostly urban residential and commercial development. Ownership is in multiple small lots as is common throughout the urbanized area within San Luis Obispo. The urban uses in this sub-watershed contribute to pollution of runoff, as automobile waste, home gardening waste, and litter enter the Creek during rain events.

2. Issues and opportunities

a. This sub-watershed is largely developed, and the channel is often artificial. Restoration opportunities are remedial and related to enhancing riparian habitats within the urban setting.

b. There are opportunities to work with the City of San Luis Obispo and Cal Poly on cooperative revegetation and bank stabilization projects.

3. Field survey notes

Field observations were conducted at the following locations (Figure 1.12) and are described in table 1.6.

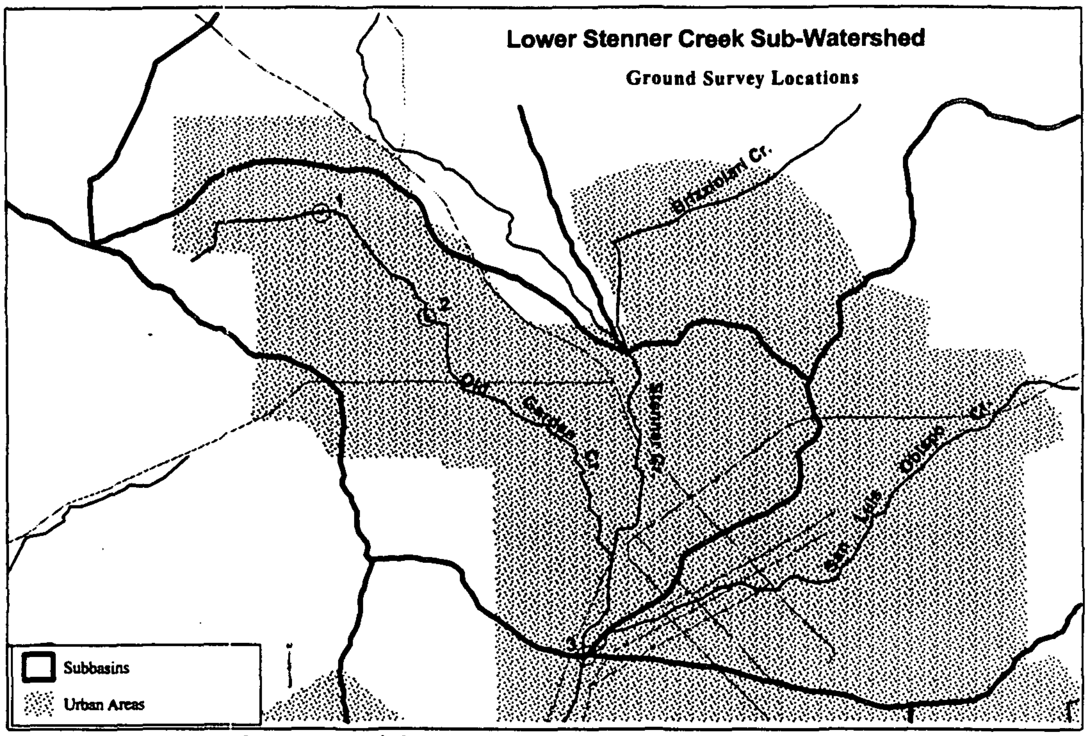


Figure 1.12 - Lower Stenner Creek Survey Locations

1. 1.5 blocks north of the intersection of Old Garden Creek and Patricia Dr.
2. Along Highland Dr.
3. At confluence with SLO Creek.

Table 1.6

Loc.	Vegetation	Bank Condition	Substrata	Notes
1	Channel lined with concrete. No vegetation.	Artificially channelized.		
2	Sparse Vegetation.	No banks noted.		
3	Some established riparian vegetation.	Minimal erosion. Banks artificially protected in many places.	No deposition noted.	

G. LAGUNA LAKE

1. General characteristics and land use

Open grasslands and grazing lands dominate this sub-watershed. The Lake and some nearby wetlands are also unique features in this area. Vegetation conditions are good in Sycamore Canyon and poor in the lower sections approaching the Lake. Eroded sands and fines are moved from the heavily grazed areas off O'Connor Rd. and Foothill Blvd. into Laguna Lake, not San Luis Obispo Creek.

The designated use for most of this area is agriculture, and grazing is the main use in the undeveloped areas. Several pockets of residential rural exhist along O'Connor Rd. near Foothill Blvd., and in Sycamore Canyon. The developed area immediately along Foothill Blvd. at O'Connor Rd. is zoned residential suburban. Much of the area around the Lake, however, is considered urban.

Except for several clusters of small lots, the ownership is made up mostly of large lots ranging from 100 to over 400 acres.

In Sycamore Canyon and on the slopes of the Morros, vegetation is mainly chaparral woodland, while the valley floors are generally grasslands. The soils in the flatter lands are not highly erodible. The hillside soils, however, are vulnerable to considerable erosion.

2. Issues and opportunities

a. Establishing vegetation in the lower sections approaching the lake.

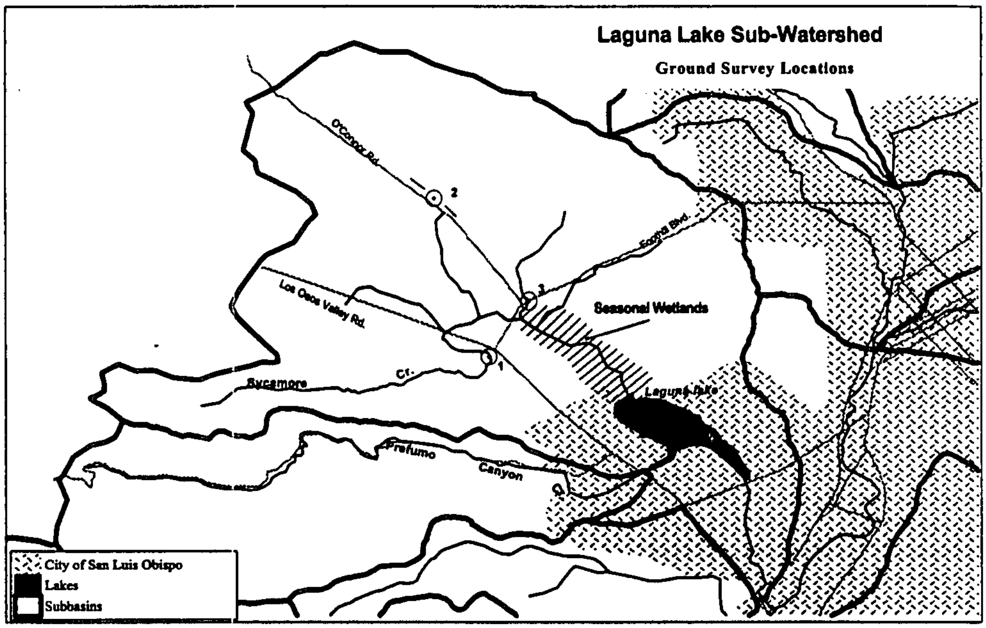
b. Maintaining and using the Lake as a sediment trap with periodic sediment removal.

c. Wetland restoration along the lower reaches within open grazing land.

3. Field survey notes

Field observations were conducted at the following locations (Figure 1.13) and are described in table 1.7.

Fig. 1.13 - Laguna Lake Survey Locations



1. Intersection of Los Osos Valley Rd. and Foothill Blvd.
2. O'Connor Rd.
3. East of O'Connor Rd. where small tributary crosses under Foothill Blvd.

Table 1.7

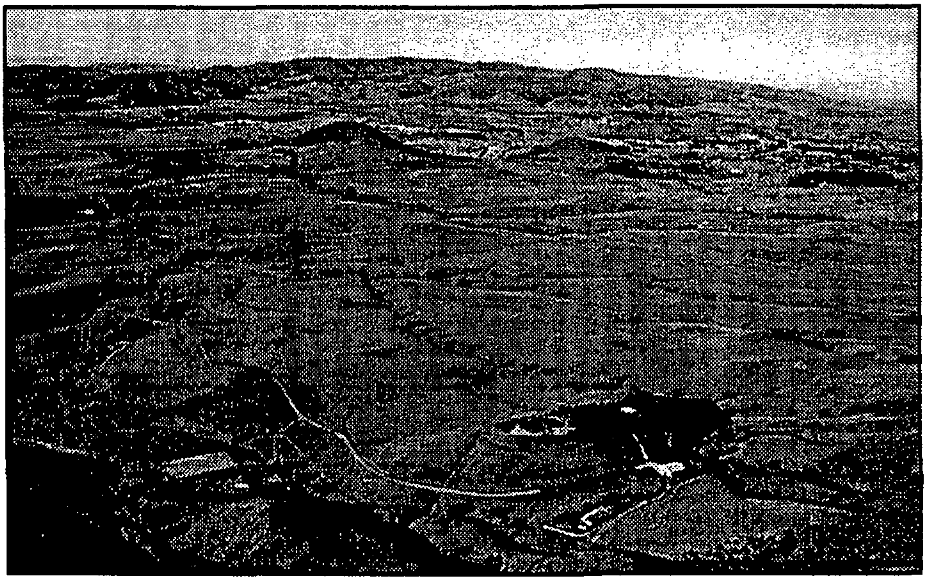
Loc	Vegetation	Bank Condition	Substrata	Notes
1	Mixed hardwoods along ephemeral channel	Some bank cutting.	*	Drains to Laguna Lake.
2	Primarily grasses and a few willows.. Vegetation on banks of tributaries varies with ownership.	Some bank erosion, but minimal.	*	Drains to Laguna Lake.
3	Grasses.	Intermittent vertical erosion	*	Drains to Laguna Lake.

** - Data not available due to access limitations*

I. EAST FORK SAN LUIS OBISPO CREEK

1. General characteristics and land use

This is the largest sub-watershed and has three main components; the hillsides of the Santa Lucia Range, the flat agricultural valley, and a better established riparian system along the west side of the valley.



Almost 1/3 of this sub- watershed is zoned for urban uses, while the remaining land is zoned primarily for agriculture. Much of the urban zoned area is not yet built out.

The land use is made up of scattered homes, agriculture, and grazing in the upper watershed. Agriculture in this area is a unique mix of products including wine grapes and avocados. Throughout these areas, riparian vegetation has been removed and degraded.

The middle watershed is characterized by urban development including the airport and associated industrial uses. In the lower watershed, southeast of the airport, the land use returns primarily to farming and grazing.

The land ownership is mixed with large parcels in the upper watershed and close to the main stem and small urban sized lots in the middle. Restoration, therefore, must take a variety of approaches with different groups of landowners.

The differing land uses and management practices between different ownerships have had significant effects on the quality of the riparian areas. The main stem of the East Fork is variable in its condition. While some areas have rich riparian corridors, adjacent areas are devoid of vegetation. Cattle have access to the creek in numerous areas and have had a noticeable effect on the vegetation along the banks. The many smaller channels of the East Fork are narrow, poorly defined, and dominated by vineyards, grazing, and urban influences of the airport area.

The vegetation in the foothills is mostly chaparral and sage woodland and becomes grassland as the topography becomes flatter. Included in this area is the La Lomita Ranch, a significant expanse of open grassland north of the airport. Current land use has changed much of the natural vegetation.

The soils in this sub-watershed are moderate to highly erodible. Fine sediments from this sub-watershed can be transported to San Luis Obispo Creek. Erosion in this area is primarily land use caused.

2. Issues and opportunities

a. Working with owners of large parcels along the foothills on revegetation. The middle sub-watershed is a good place for sediment traps.

b. Restoration within urban areas.

c. Major restoration efforts and stewardship should focus on expanding the good section of the East Fork, near the intersection of Vachel Ln & Buckley Rd., and helping to stop sedimentation there.

d. Address the damage done to the riparian corridors by cattle in the lower watershed by implementing conservation oriented management practices.

3. Survey Locations

Field observations were conducted at the following locations (Figure 1.14) and are described in table 1.8.

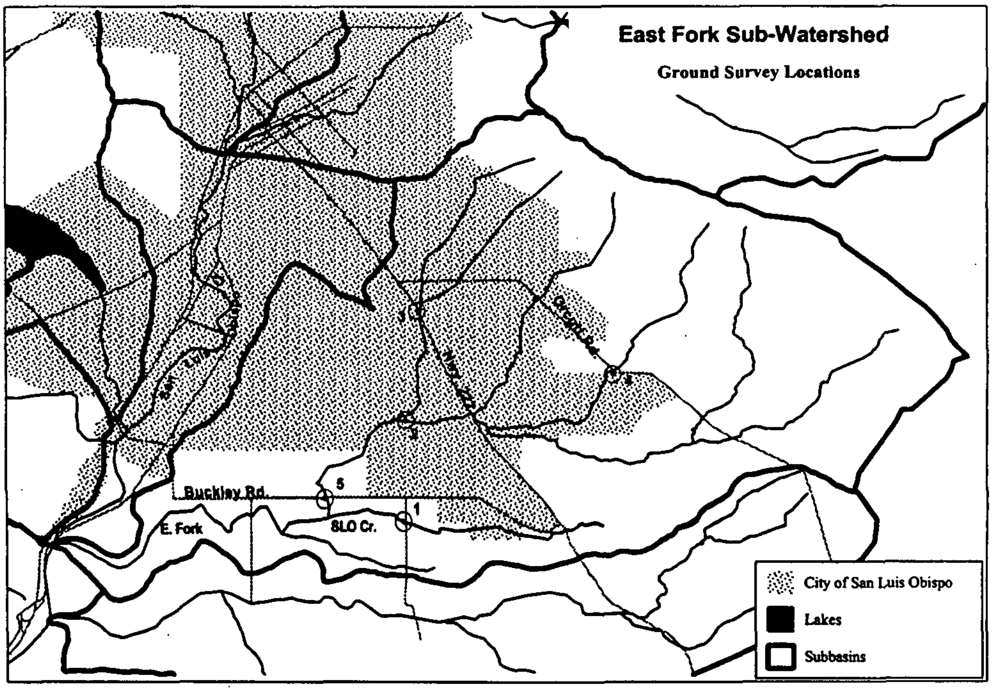


Fig. 1.14 - East Fork Survey Locations

1. Davenport Creek Rd. where it crosses the Creek.
2. Where unnamed tributary crosses Santa Fe Rd.
3. Where same tributary crosses Hwy. 227.
4. Where stream crosses Orcutt Rd at the intersection with Tank Farm Rd.
5. Where the channel crosses Buckley Rd.

Table 1.8

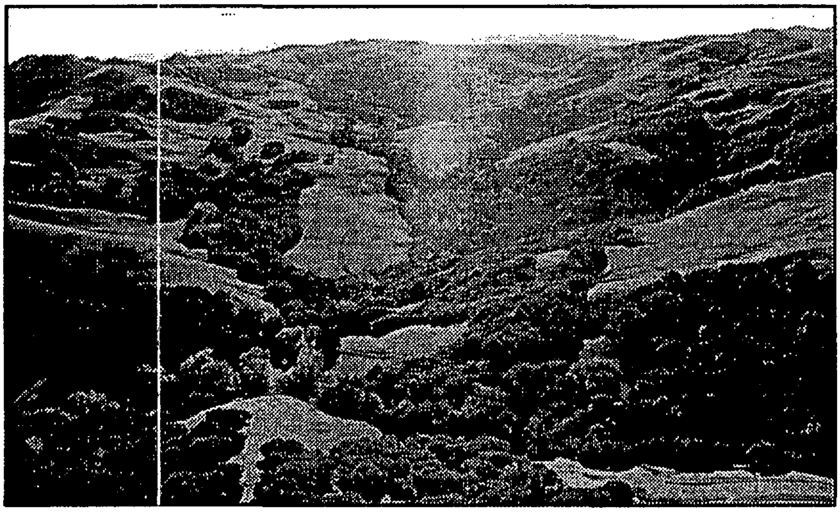
Loc.	Vegetation	Bank Condition	Substrata	Notes
1	Grasses, no trees	Vertically eroded 5.5'	*	
2	Mature willows, sycamores and walnuts.	Minimal erosion, mostly stable	*	Possible vegetation encroachment problem in the future. Grazed to channel
3	Established riparian vegetation.	Minimal erosion.	*	
4	Grasses	Minimal erosion, some undercutting.	*	Cattle have access to the channel on the north side of the road. New park on S. side.
5	Grasses on east side, willow on the west where there are no cattle. Some cottonwood and walnut.	Vertical bank erosion.	*	Cattle in the channel on the east side of the bridge. Artificial debris dam west of bridge.

* - Data unavailable due to access limitations

K. PREFUMO CREEK

1. General characteristics and land use

This is a steep and wooded area in the Irish Hills with some scattered home site development. The predominant vegetation regime is chaparral woodland.



The zoning designation is rural lands for most of the watershed, with some zoned for agriculture. At the base of the watershed, there is a mix of urban, residential rural, and residential suburban zoning. The land use is primarily grazing and open space. Residential development is limited to a few scattered homes. More development is imminent in the lower watershed as part of the Emerald Hills subdivision. Application has also been submitted for the subdivision of another large parcel along the creek.

The ownership is in large blocks away from the city with smaller lots and a trailer park in the lower watershed. Prefumo Creek also flows through the Laguna Lake golf course, where the riparian vegetation has been removed, and the banks are badly eroded.

The soil types in this watershed have a high to very high potential for erosion. Good vegetative cover has mitigated erosion problems in most of this basin.

Riparian vegetation in this sub-watershed is good overall with a mix of established trees. Some grazed areas have been left unprotected, but the problem areas are isolated. There is some potential for sediment transport from this area, but it would be deposited into Laguna Lake rather than San Luis Obispo Creek.

2. Issues and opportunities

a. Restoration where the Creek enters the city, and through the golf course.

b. Work with landowners to improve grazing practices and trying to save the remaining high quality areas.

c. Reduce fish barriers where the Creek enters urban areas.

3. Field survey notes

Field observations were conducted at the following locations (Fig. 1.15) and are described in table 1.9. Measurements are in miles downstream from where Prefumo Canyon Rd. pavement ends.

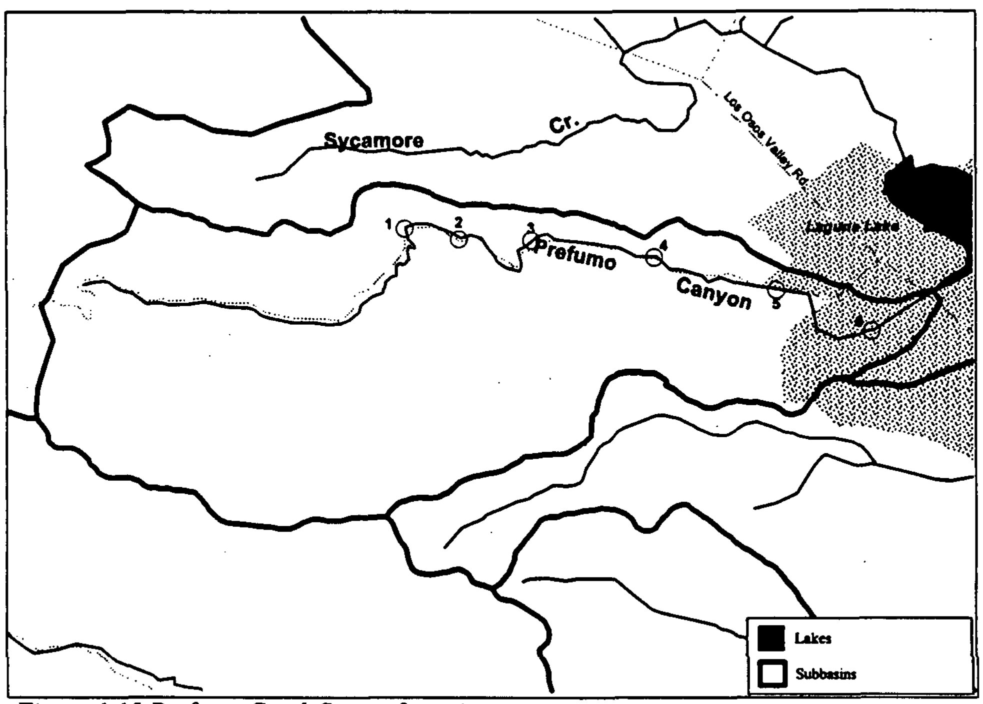


Figure 1.15 Prefumo Creek Survey Locations

Survey Locations

1. .1
2. .4
3. .9
4. 1.4
5. 1.9
6. 2.6

Table 1.9

Loc	Vegetation	Bank Condition	Substrata	Notes
1	(R): Sycamores, oaks, and willows. (L): Grasses only	12' vertical banks on left	Gravel / Cobble	Configuration geologically controlled
2	(R): Sycamore, Willow, Oak. (L): Home, Sycamore.	Minimal erosion.	Sand, Gravel, Cobble	Home seems to be built on mid-channel bar. Stream splits.
3	(R): Oak, Laurel, Willow. (L): Road, Willow, Sycamore.	(R): Undercut banks 6', roots exposed. (L): Riprap	Cobbles / Boulders.	Mid-channel boulders increase streem depth leading to saturation and bank failure.
4	(R): Chaparrral (L): Willow.	(R): 12' vertical erosion. (L): No erosion.	Gravels / Sands	(R):800' of exposed soil and bank failures.
5	(R): Sycamore, Oaks (L): Willow	Minimal erosion.	Cobbles / Gravels.	Mid-channel bar splits flows and may cause erosion near road. Some riprap.
6	(R) Sparse upper canopy. (L): Few Oaks	Intermittant erosion.	Gravels	Lack of woody veg. near mobile home park.

L. FROOM CREEK

1. General characteristics and land use

The Froom Cr. watershed is a hidden, steep, and chaparral covered area. Considerable erosion is taking place along this perennial creek. A road has been constructed along the length of the Creek, apparently by blasting into the rocky hillsides. Gravel from the road construction fills the channel bed. A large mound of accumulated alluvium is piled up at the base of the canyon. This area drains to a lowland west of Highway 101 and is subsequently piped under the freeway to the main stem, downstream of Los Osos Valley Rd.

Vegetation consists of chaparral woodland on the steep slopes and grassland on the flatter lowlands. In addition, serpentine endemics can be found on the rocky outcroppings. The soils range from high to very high in erosion hazard, and disruption of vegetation caused by road construction has led to severe erosion.

The land use is open space on the upper slopes and grazing on the lowlands. Along Los Osos Valley Rd. and Highway 101, the land is zoned for urban uses, while the remaining lowlands are zoned for agriculture.

The ownership is divided up into several moderate to large holdings. Most of the erosion is isolated in very few ownerships centered around Froom Creek and the canyon area.

2. Issues and opportunities

a. Ownership of the most damaged areas is in a single ownership.

b. Important plants in the area include serpentine endemics.

c. The lower flat land, between the hills and Los Osos Valley Road, is serving as a sediment trap. This will need to be considered in future land uses for this parcel.

3. Field Survey notes

Field observations were not conducted in this watershed due to private ownership and access limitations. Aerial survey provided some of the above information.

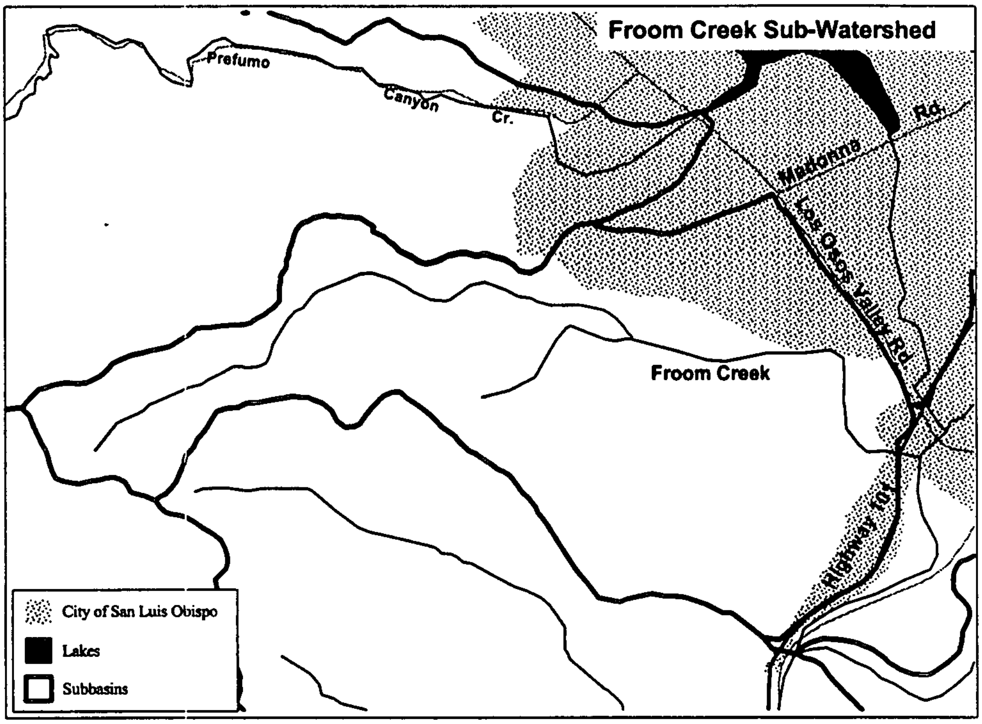


Figure 1.16 Froom Creek Sub-Watershed

M. DAVENPORT CREEK

1. General characteristics and land use

This watershed extends from the vineyards and agricultural lands east of Highway 227, through the country club area, and out into another agricultural area. The vegetation is grassland on the flatter valley floor, while agricultural crops dominate along the headwaters near Orcutt Rd. Through the Davenport Hills, the vegetation is mainly chaparral. As Davenport Creek approaches San Luis Obispo Creek, riparian vegetation conditions are extremely poor.

The land use designation is agriculture for the area east of Hwy. 227, and urban near the airport and country club. West of the airport, the land use designation returns to agriculture. There are isolated pockets of residential rural zoning along Davenport Cr. Rd. Current land uses include vineyards, grazing, commercial uses, and residential.

Much of the land in this sub-watershed has been extensively grazed, and where grazing is occurring, erosion is present. Cattle in the channel are a substantial problem in this sub-watershed.

The ownership pattern is made up of mostly large parcels ranging from 200-400 acres. Much of the upper and lower watersheds are in single ownerships. The middle watershed is dominated by the country club area with numerous small lots. Lot sizes are also generally small along Davenport Creek Rd. These range from 10-40 acres.

This watershed is primarily lowland and has a deep soil profile. Erosion hazard in the upper watershed is generally slight. The soils have a higher erosion potential as they approach San Luis Obispo Creek.

Land use and management practices vary considerably between different ownerships. In several locations riparian vegetation seizes at the property line.

Due to the combination of heavy grazing, farming, and notable erosion, this watershed may be contributing significant sediment loads into San Luis Obispo Creek. The confluence of Davenport Creek with SLO Creek showed little evidence of silt deposition at the time of the survey, although it is possible that recent high flows carried the sediment downstream.

2. Issues and opportunities

a. There is an opportunity in an area upstream of the confluence with San Luis Obispo Creek to enhance its ability to act as a sediment trap. Reestablishing vegetation in this marshy area could enhance deposition of sediment by slowing the water velocities.

b. Work with owners on grazing practices, perhaps by providing off-creek watering facilities and fencing riparian corridors. Revegetation of degraded banks.

c. Work with vineyard operators to limit vegetation removal and revegetate channels.

3. Field survey notes

Field observations were conducted at the following locations (Fig. 1.17) and are described in table 1.10.

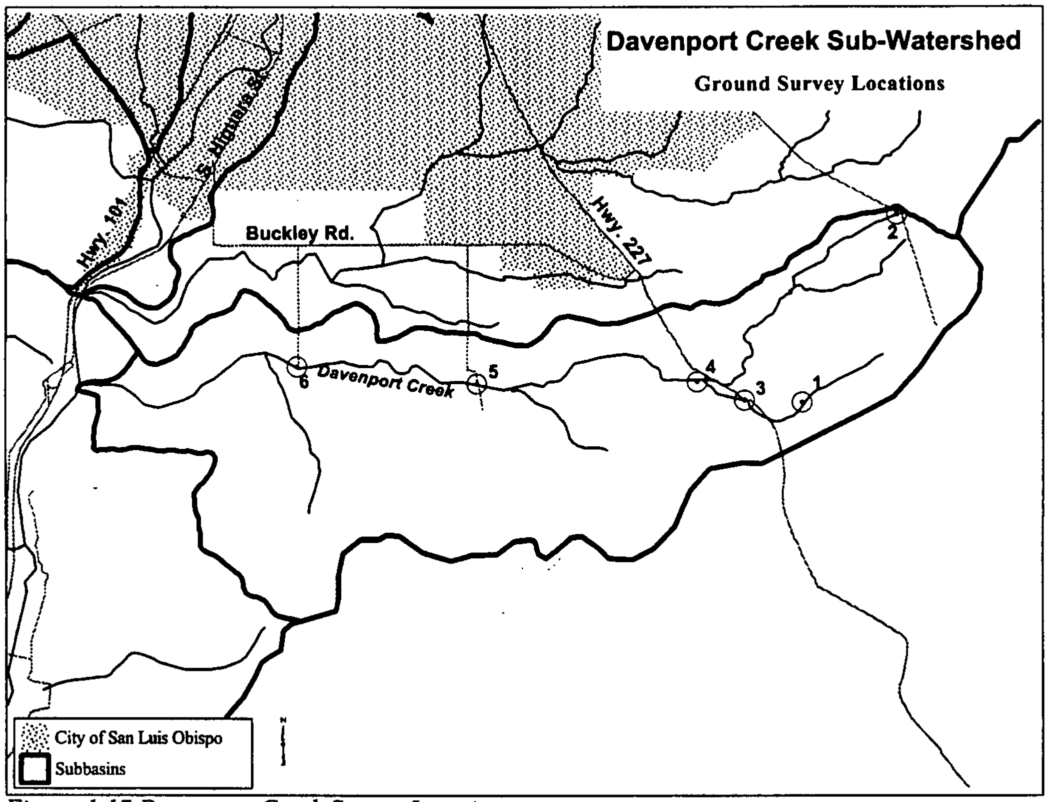


Figure 1.17 Davenport Creek Survey Locations

1. Where tributary of Davenport Creek crosses Biddle Ranch Rd.
2. Where headwaters of Davenport Creek cross Orcutt Rd.
3. Where Hwy. 227 crosses the railroad tracks.
4. Intersection of Davenport Creek and Los Ranchos Rd.
5. End of Davenport Creek Rd.
6. Intersection of Davenport Creek and Jesperson Rd.

Table 1.10

Loc	Vegetation	Bank Condition	Substrata	Notes
1	Intermittent sycamores along active channel. Soils has been plowed into the channel on the north side.	No discernible banks.	*	Irrigated agriculture.
2	70% cover with willows and sycamores.	Extreme bank erosion on the west bank, where there is no vegetation.	*	Grazing, cattle allowed in the Creek.
3	Intermittent vegetation.	None noted.	*	
4	Willows. Channel completely choked.	None noted.	*	
5	Willows. 15-20' tall. Encroaching in the stream channel.	Minimal erosion.	*	Grazing on both sides of the creek.
6	All grasses on the east side, and maturing willows on the west.	Vertical erosion on the east with minimal erosion on the west.	*	Grazed.

* - Data unavailable due to access limitations

N. LOWER SAN LUIS OBISPO CREEK

1. General characteristics and land use

This watershed includes two very different types of land, evenly divided by the main stem of San Luis Obispo Creek and Highway 101 (that follows the creek).

The east side of the freeway includes flat bottomland that is in active agriculture and wooded hillsides that include a substantial number of home sites. Vegetative cover throughout the sub-watershed is good, and exposed bedrock has stabilized the tributary channels. No evidence of sediment loading or deposition were found in the lower elevations. There is, however, considerable deposition and bank erosion occurring along San Luis Obispo Creek in this area.

The land west of the freeway includes mainly hillsides and narrow riparian areas in the bottom of the valley. This side is very different from the east side. There is significantly less vegetative cover. Fine materials from the west side have piled up along Ontario Rd., but due to limited access, the cause could not be completely investigated.

The land use designations are a hodgepodge of agriculture, rural lands, residential rural, residential suburban, and urban. The actual land use is housing in Squire Canyon and areas approaching Avila Beach, grazing and open space west of the freeway, and agriculture in the valley along the Creek.

The ownership is a mix of large and small holdings. Parcel sizes decrease closer to the creek and in the Squire Canyon area.

The varying land uses and numerous owners present a challenge to widespread restoration efforts. The best opportunities for restoration are the agricultural areas along the main stem of San Luis Obispo Creek where bank erosion is most common.

2. Issues and opportunities

a. Restoration should focus on immediate bank work and the establishment of large canopy trees.

b. This section of the main stem faces a possible decline in water levels due to the future reclamation of treated wastewater. This may affect restoration opportunities.

3. Field survey notes

Field observations were conducted at the following locations (Fig. 1.18) and are described in Table 1.11.

1. Squire Canyon
2. Castro Canyon
3. Small canyon entrance west of Hwy. 101 at the Higuera St. Exit.
4. Near confluence of unnamed stream with SLO Creek
5. At 3-way intersection where unnamed stream crosses Monte Rd.

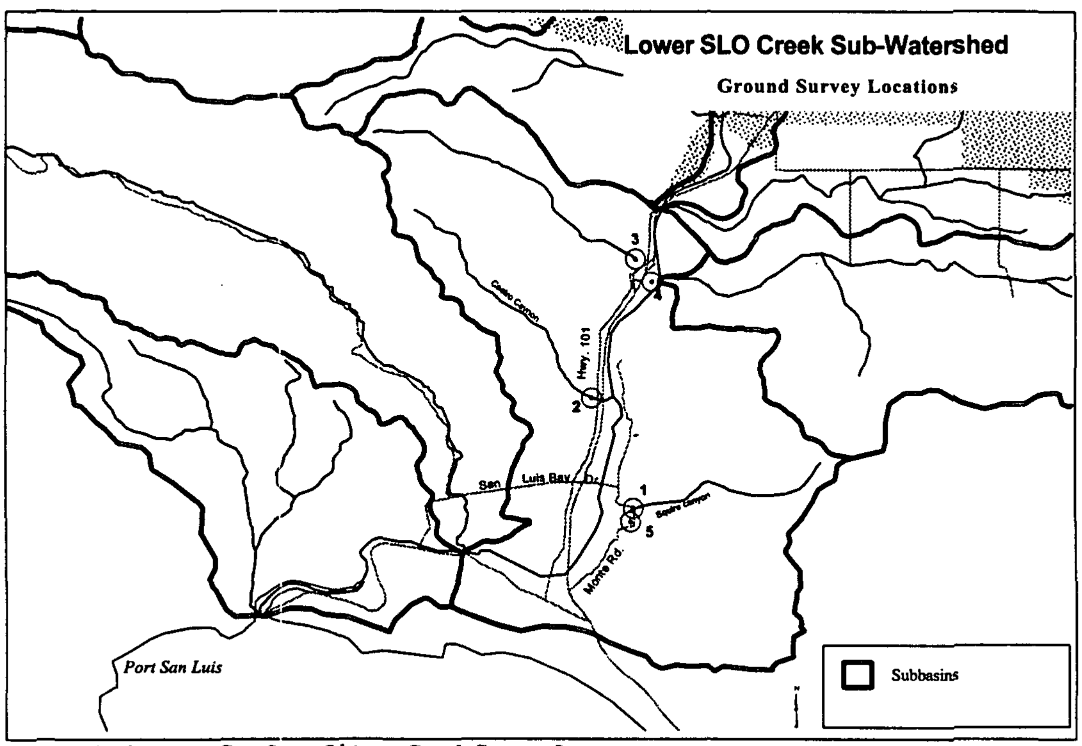


Figure 1.18 Lower San Luis Obispo Creek Survey Loactions

Table 1.11

Loc	Vegetation	Bank Condition	Substrata	Notes
1	Upper watershed 70% oaks, 20% manzanita. Lower watershed mostly oaks.	Minimal erosion. Some alluviated fine in an ephemeral channel (isolated problem)	Thin soils and exposed bedrock.	
2	Sycamores and oaks.	No signs of alluviated material.	Exposed bedrock in upper watershed.	Some flooding in 1995 storms.
3	Intermittent vegetation. Oaks and sycamore.	Some erosion. Alluvial material is collecting where ephemeral stream meets Ontario Rd.	*	This watershed most likely delivers significant sediment loads to SLO Creek.
4		Minimal erosion.	Sands and gravels.	No evidence of deposition in lower reach.
5	Willows encroaching in upstream area. Downstream areas have minimal vegetation.	No erosion seen.	Thin soils and exposed bedrock.	

** - Data unavailable due to access limitations*

O - SAN MIGUELITO (SEE CANYON) CREEK

1. General characteristics and land use

See Canyon extends inland with apple orchards in the lower section and steep wooded hillsides and grasslands in the upper watershed. The vegetation throughout the watershed is mostly chaparral woodland. The lower creek is heavily impacted by adjacent farming and residential development. It is, however, one of the best sub-watersheds for fish.

The land use designations are residential rural for the bottom of the canyon and rural lands on the upper slopes. Land use in this watershed in primarily open space with scattered residential dwellings located in the canyon along the Creek. These are small lots and houses, so minimal grading has taken place. Orchards dominate in the lower watershed.

The ownership pattern is one of multiple small lots in the lower slopes of the watershed. The steep slopes in the upper watershed are generally in larger holdings.

The soils on the steep slopes north of the Creek are moderate to highly erodible, while the area south of the creek is characterized by less erodible soils.

Vegetative conditions along the creek are generally fair to good. Unvegetated areas, particularly along the road are experiencing erosion. While erosion is taking place, most of the material is fairly coarse, so fine sediment deposition is minimal. Any restoration efforts would have to include multiple owners.

2. Issues and opportunities

a. Focus on individual sections of the Creek with individual landowners.

b. Opportunity because of interested landowners.

3. Field survey notes

Field observations were conducted at the following locations (Figure 1.19) and are described in table 1.12.

The following observation points are measured in miles from the intersection of See Canyon Rd. and San Luis Bay Dr. heading upstream.

1. .6
2. 2.2
3. 2.6

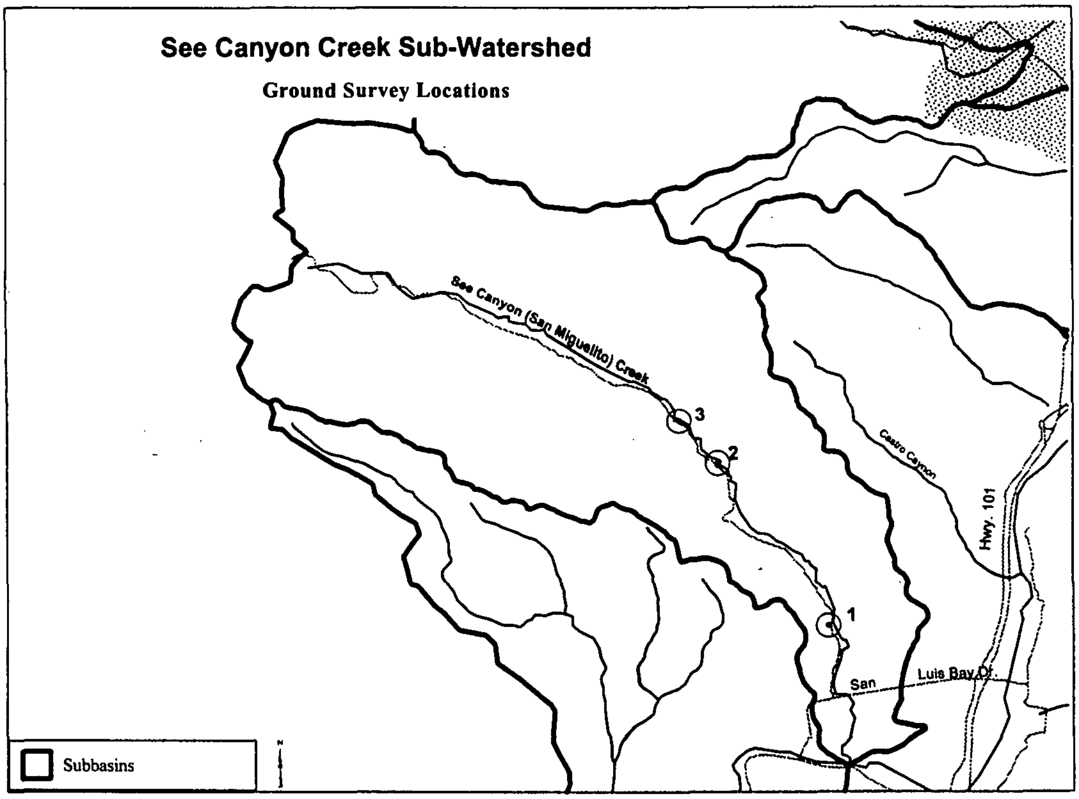


Figure 1.19 See Canyon Survey Locations

Table 1.12

Loc	Vegetation	Bank Condition	Substrata	Notes
1	Highly established walnuts, oaks, and sycamores.	Bank severely eroded. 25' vertical. Some undercutting.	Gravel, cobble, and some fines.	
2	Established vegetation on the east side. Grasses only on the west side.	Severely eroded section 20' deep and 120' long.	Fines , sand, and cobble along the banks. Cobbles and gravels in the thalweg.	Rip-rap placed downstream of eroded bank may have constricted flow, causing pooling. Highly unstable area.
3	Established mixed hardwoods.	Severe undercutting along the road.	*	Road falling from undercut at outer turn in the Creek.

** - Data unavailable due to access limitations*

P. HARFORD CANYON

1. General characteristics and land use

This watershed is very different from all others. It is coastal and dominated by development and a golf course.

The land use designations from the County General Plan are urban for the lower watershed and rural lands in the upper canyon. There is also a strip of area zoned for agriculture along Harford Canyon Creek, west of the golf course. The land use consists of a country club type facility with a golf course and hotel.

The ownership is generally in large holdings except for the San Luis Bay Estates area . Much of the upper watershed is owned by The Nature Conservancy, a national nonprofit conservation organization.

Vegetation consists primarily of chaparral and chaparral woodland in the areas not developed for the golf course or town. Most of the lowlands along the golf course are grasses with very poor to nonexistent riparian vegetation. Riparian vegetation improves dramatically above the golf course.

Soils in the entire watershed are highly erodible. The confluence of the riparian channel of this sub-watershed and San Luis Obispo Creek is very close to the mouth of SLO Creek, so any fines or sands that are carried in the stream will be deposited in the ocean.

2. Issues and opportunities

a. The ownership pattern provides an opportunity.

b. Planned developments may offer open space.

c. Work with golf course to control fertilizer runoff.

3. Field survey notes

Field observations were conducted at the following locations (Figure 1.20) and are described in table 1.13.

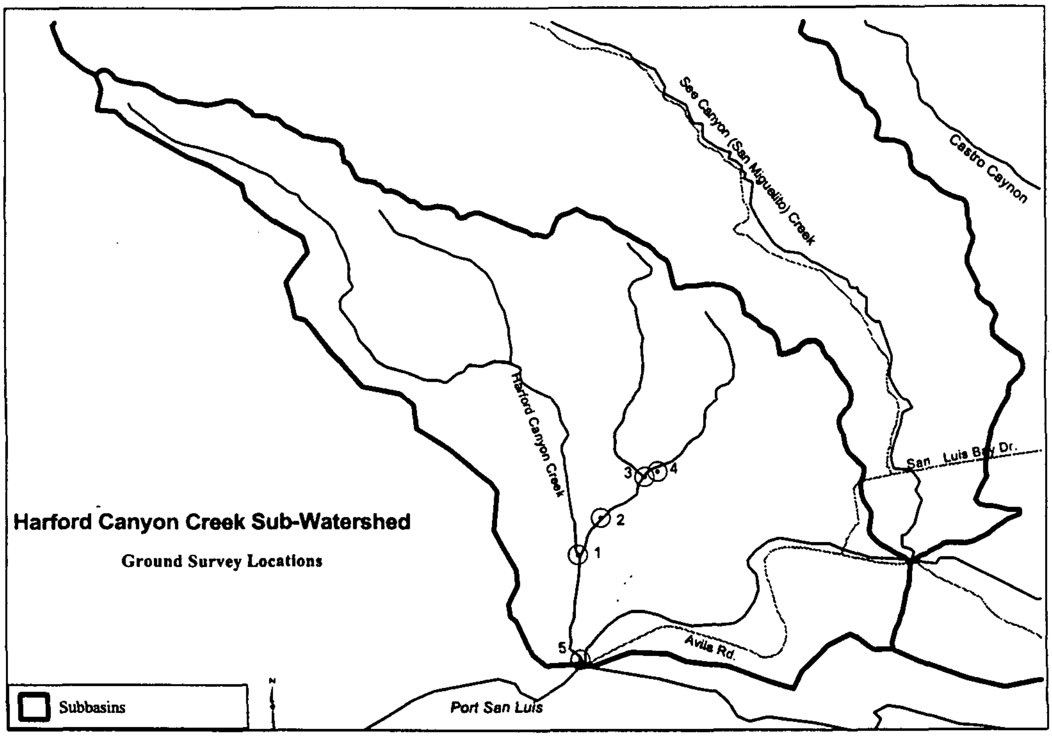


Figure 1.20 Harford Canyon Survey Locations

Survey Locations

1. Fork in stream.
2. Foot bridge near above location.
3. Confluence of two main tributaries.
4. Right tributary facing north.
5. Mouth of stream from Harford canyon.

Table 1.13

Loc	Vegetation	Bank Condition	Substrata	Notes
1	Mainly sycamore and willow.	L. Some vertical erosion. R. Vertical bank 7' high.	Sands, gravels, and cobbles.	Golf course.
2	Grasses only.	Vertically eroded bank 8' high. Some rip-rap.	Sands, gravels, and cobbles.	
3	Mature riparian vegetation.	Gravel deposition along banks.	Gravels.	24 " culvert under cart path.
4	Willows in thalweg. Also oaks and sycamores.	Sand and gravel deposition around willows in channel. Banks are in good condition.	Sand and gravel.	
5		Some remaining signs of vertical bank erosion. New culverts installed.	Sand and gravel.	

Q. SUMMARY OF SUB-WATERSHED EVALUATION

Each of the above sub-watersheds has been evaluated for the condition of the riparian vegetation, problem areas for erosion, and its potential to deliver sediment loads to San Luis Obispo Creek. The main indicators of sediment loading in the sub-watersheds are the degree of erosion and the amount of deposition found in the lower stretches of the sub-watershed stream channels. The amount of sediment deposition was determined by visual survey, not a scientific method. Several of the evaluated watersheds were found to be capable of delivering fine sediment loads to San Luis Obispo Creek.

Upper Stenner Creek has a high potential to deliver sediment. Extensive grazing and a lack of riparian vegetation are the main problems. Several sections were identified as having severe erosion problems. Bank stabilization should be done along the banks of this stream. The Upper San Luis Obispo Creek sub-watershed, which is experiencing fire and construction induced erosion, may also contribute to sediment problems. Grazing has led to erosion in the lower sections of this basin. The consolidated ownership provides an opportunity to address grazing impacts, and the construction impacts may be mitigated depending on the success of mitigation plans.

Grazing damage to bank vegetation has also left much of the East Fork and Davenport Creek sub-watersheds vulnerable to erosion, and the lack of cover will contribute to high water temperatures. In addition, cattle in the Creek channels and adjacent farming operations present potential nutrient loading problems. These areas will certainly deliver sediment to San Luis Obispo Creek and, possibly, warm nutrient laden water. Most of these problems, however, can be addressed with innovative management techniques, and can be implemented in cooperation with local land owners.

Analysis of the sub-watersheds has shown that most of the instability has been land use induced, and that the problem areas are primarily the lower reaches of each sub-watershed. As historic catchments of upstream sediment, these areas generally have deeper soil profiles and higher erosion potential. These are also areas with development potential and good grazing land, and these activities have aggravated erosion problems.

Figure 1.21 illustrates the sub-watersheds and their relative potential for sediment loading into the main stem. The designations were based on visual survey of the main tributaries near the confluence with the main stem, and the relative size amount of deposited material. These ratings address the amount of coarser sediment delivery (sand and larger), rather than the fine suspended sediment load which would be carried downstream.

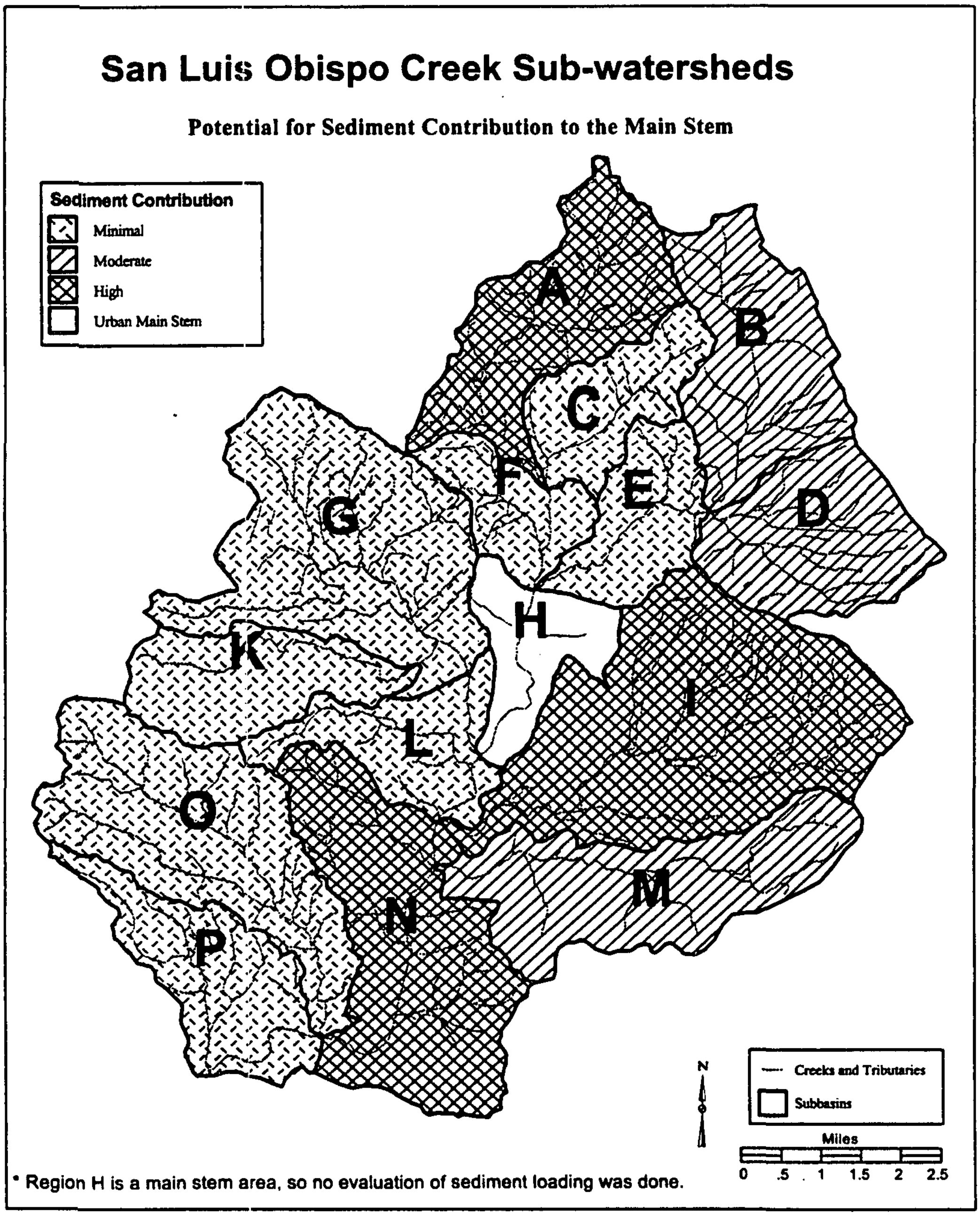


Figure 1.21 Sediment Delivery Potential

V. MAIN STEM EVALUATION

The main stem of San Luis Obispo Creek has been experiencing significant bank erosion and problems related to sediment deposition. The purpose of this section is to identify the problem areas, potential causes, and restoration priorities within each main stem reach.

To obtain a detailed picture of the problems and restoration opportunities, the entire length of the main stem was surveyed in the field. The first step in this process was to divide the Creek into identifiable reaches for the purposes of data organization. Figure 2.1 shows the reach designations. The reach delineations were created, primarily, as a practical unit of data storage and were based on factors such as slope breaks, significant changes in vegetation or land use (often indicative of ownership change), landmarks, and tributary confluence points.

Once the reaches were delineated, they were mapped and photographed from the air. The reaches were then walked and data was gathered for representative areas. Data for this report represent conditions during the survey, which was undertaken between October and December, 1995.

DATA VARIABLES AND COLLECTION METHODS

The variables for which data was gathered included field distance, dominant vegetation, minimum and maximum depth, width to depth ratio, wetted perimeter, slope, bank condition, D_{50} (substrate), channel features, and land use. Definitions for these variables, and collection methods are described below. These were chosen to characterize the riparian conditions of the Main Stem of San Luis Obispo Creek. They were also interpreted to fit a Stream Reach Inventory and Channel Stability Evaluation Model used by the USDA Forest Service. Several extra variables were added to build a more complete picture of channel conditions and restoration opportunities along each reach of the Creek.

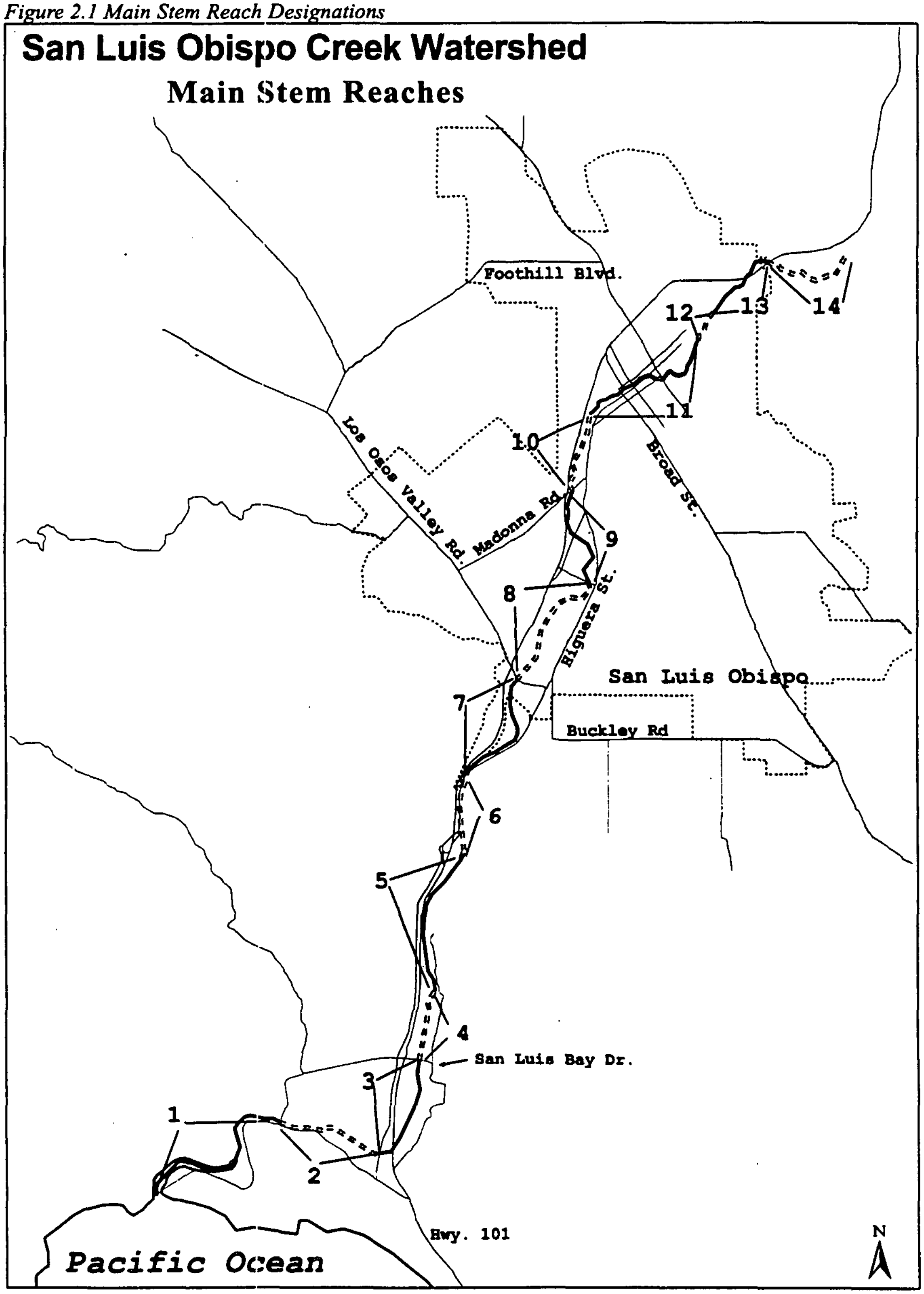
Field Distance
The length of each reach, in feet, measured in the upstream direction. The parameters observed for each of the reaches were sampled on even intervals, usually 300 feet.

Minimum Depth
The shallowest thalweg depth, in tenths of feet, observed within the reach. These were logged at the current flow during the survey.

Maximum Depth at Bankfull
Estimated in the field as the maximum depth when the channel is at bankfull. This, combined with width is representative of channel capacity.

Width to Depth Ratio (W/D)
This is the width divided by the depth, and was estimated in the field. Generally, width to depth ratios should increase downstream as flows increase. This number can also be

Figure 2.1 Main Stem Reach Designations



interpreted as an indicator of erosion. Banks with more erodible soils will generally have a higher width to depth ratio since the width increases when banks erode. Vegetation along creek banks can prevent erosion and lead to a narrowing of the channel and, thus, a lower W/D. Finally, a high W/D with no current bank erosion may be an indicator of past susceptibility to erosion. These areas should be monitored regularly for maintenance.

The validity of this parameter is, however, questionable in an incised channel such as SLO Creek's. It is included here for comparative, rather than absolute purposes.

Wetted Perimeter
This is the wetted area measured (in feet) from both the active channel and the thalweg (line of greatest slope). These were measured in representative transects at the current flow during the survey.

Bank Slope
Measured in degrees of the right and left banks (looking upstream).

D_{50}
A measure of the channel substrata particle size. The D_{50} is the median particle size. Visually estimated at regular intervals.

Dominant Vegetation
Information on tree species used to evaluate vegetative bank protection. Maturing willows refers to trees between 20-30 feet tall, mature willows are those over 30 feet. Mature riparian vegetation is a variety of well-established mature species.

Bank Condition
Notes on the condition of the banks taken in damaged areas. Information is broken out between upper and lower, and left and right banks (looking upstream).

Land-Use
The land use adjacent to the creeks. Some land uses have more severe impacts on bank conditions, and contribute to the delivery of varying amounts of sediment.

CHANNEL STABILITY EVALUATION AND MODELING

The data gathered for these Creek reaches was also interpreted to fit into a modified Stream Reach Inventory and Channel Stability Evaluation Model used by the USDA Forest Service. This model was originally designed for mountain streams and was modified for this coastal stream by dropping out variables which were not germane to coastal study. The model used 7 of the original 15 parameters. Since this model has been modified to fit the San Luis Obispo Creek Watershed, the results should only be used to compare each reach with other reaches, rather than comparing them to the results from other coastal streams. Table 2.1 describes the indexing of variables and table 2.2 shows the reach scoring matrix.

Table 2.1

Item Number	Item Description	Excellent	pts.	Good	pts.	Fair	pts.	Poor	pts.
1	Bank Slope	<30%	2	30-40%	4	40-60%	6	> 60%	12
2	Occurrence of eroded banks	0-6	3	7-13	6	14-20	9	> 21	12
3	Vegetative Protection	Mature, Variety > 90% Cover	3	Some mature 70-90% cover	6	Nearly monotypic, 50-70% cover	9	Herbaceous plants, < 50% cover	12
4	Bankfull Channel Capacity	W/D < 7	1	W/D 8-15	2	W/D 15-25	3	W/D > 25	4
5	Occurrence of bank cutting	Little or None	4	Some, intermittent	6	Significant	12	Frequent failures	16
6	Occurrence of deposition	Little or None	4	Some, intermittent	8	Moderate	12	Extensive deposits	16
7	Bottom size distribution	No change along reach	4	Slight dist. change	8	Moderate changes	12	Marked dist. change	16

Table 2.2

	Reach													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Item 1	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Item 2	12	3	9	6	6	6	6	9	9	3	6	3	6	9
Item 3	12	3	6	9	6	9	9	9	12	12	12	9	6	6
Item 4	2	1	2	2	1	1	1	1	2	2	1	2	2	3
Item 5	16	4	12	6	6	6	6	16	12	6	6	4	6	16
Item 6	8	4	8	16	8	12	8	12	12	8	8	4	8	12
Item 7	12	12	12	12	12	12	12	8	4	4	4	4	4	12
Total	74	39	61	63	51	58	54	67	63	47	49	38	44	70
Rank	1	13	6	4	9	7	8	3	5	11	10	14	12	2

This reach evaluation gives a general indication (rank) of the relative severity of erosion problems along the reaches of the main stem of San Luis Obispo Creek. The rank listed in the above table represents the susceptability of each reach to erosion. A ranking of one indicates the most severe case of channel instability using this method.

A. REACH ONE - AVILA BEACH TO SAN LUIS BAY DRIVE

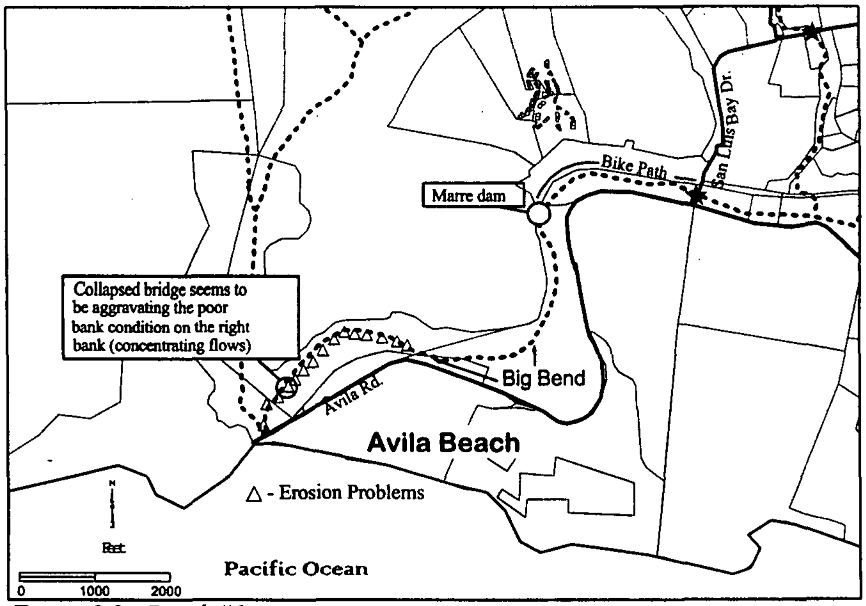


Figure 2.2 - Reach #1

1. Location and general description

Reach one extends from the mouth of the Creek in Avila Beach to the bridge at San Luis Bay Dr. (Figure 2.2). The lowest section of this reach flows through the San Luis Bay Golf Course, and is brackish due to tidal influences. The Marre Dam forms a barrier to tidal inundation and holds much of the Creek behind it. This has lead to extensive pooling upstream of the dam. The lower flow velocities generated by the pooling have allowed fine sediments to be deposited, leaving a channel bed which is primarily sand, silt, and clay.

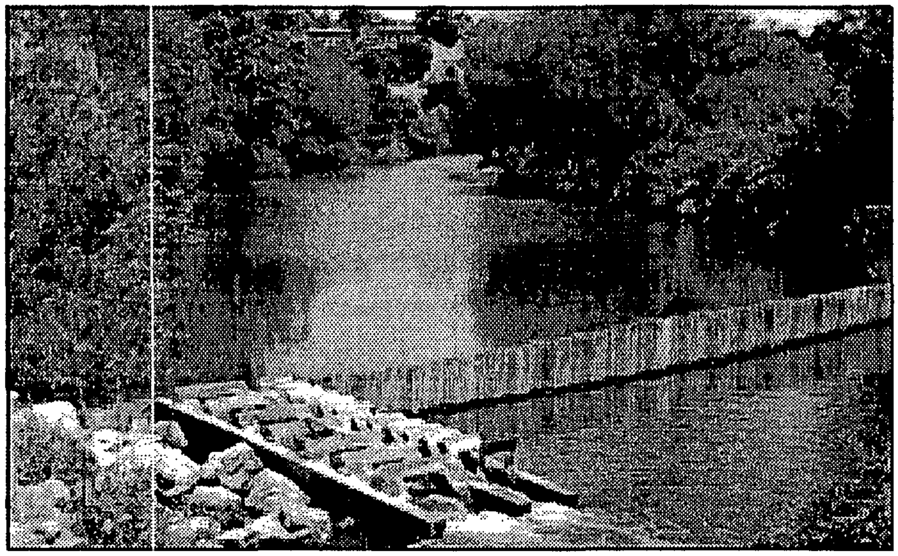
In the upper portion of this reach, above the dam, the Creek is bordered by a residential subdivision and bicycle path on the north side. The south side of this reach is bordered by Avila Road. The vegetation in this section is more mature than the downstream area, and consists of poplar, an occasional oak, and willow.

Below the dam the Creek flows through a narrow corridor with native oaks on the north side and disturbed willows and nonnative castor bean on the south side. The channel then widens out and becomes flatter at the first golf course bridge. From this point towards the ocean, the Creek is bordered on both sides by a golf course.

There is severe bank erosion at two points in the golf course. The first is on the outside of a big bend in the river on the south side. The second is on the north side of the Creek opposite Avila Road. Severe erosion due to the storms of 1995 caused the collapse of bridges throughout the golf course and a concrete pathway to fall into the Creek at these locations.

✓ Bank cutting and associated erosion are a significant source of sedimentation into the estuary, which is scarce habitat for several species including the Tidewater Goby.

Above Marre Dam the bank condition improves markedly and the banks are generally in good condition.



This picture shows Marre Dam, the fish ladder on the northern side of the creek and the thick riparian vegetation upstream of the dam.

Another feature of the Creek in this reach that will require long-term monitoring is the constriction caused by the bridge at the intersection of San Luis Bay Dr. and Avila Road. Debris dams build in this area and may cause upstream flooding and increase flow velocity in the immediate area.

Width and depth measurements were not taken for this section of the Creek due to the extensive pooling.

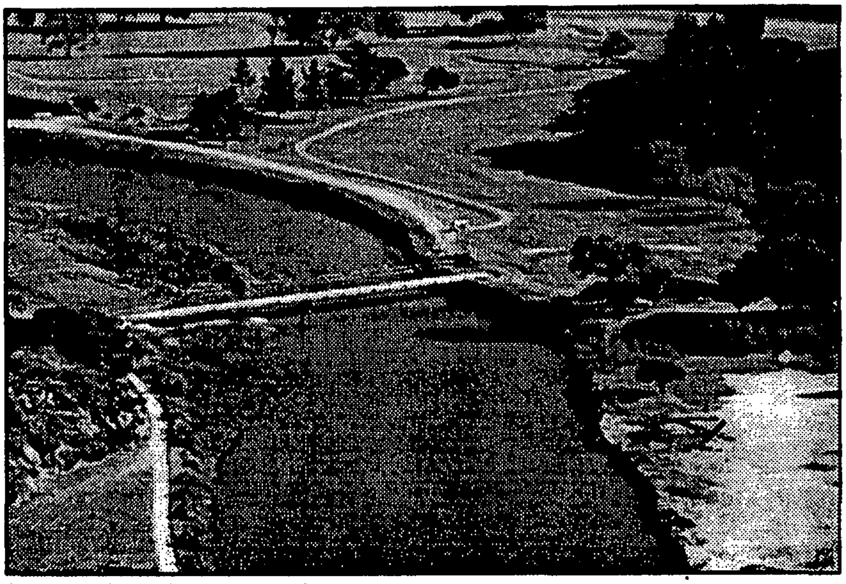
Adjacent Soil Summary

Unit Number	Soil Type	Length	Relative Depth	Erosion Potential
138	Elder Sandy Loam	1359'	Very Deep	Slight
156	Lopez Very Shaly Clay Loam	126'	Shallow	Very High
194	Riverwash	7138'		Variable
223	Xerorthents Escarpment	247'		Variable

2. Problems and Opportunities

a. Bank stabilization

1) Bank stabilization work is necessary in two places on this reach. The severity of the erosion and the height of the bank, coupled with high flood flows and tidal fluctuation may require structural solutions. The are a number of bio-technical methods that could provide the necessary bank protection. The two locations would be at the "big bend" (pictured) and at the "narrows" as described above.



Erosion along the "Big Bend"

b. Invasive Species

1) The castor bean that is located on the south side of the Creek just down stream of Marre dam does not provide significant bank protection, and is out-competing native plant species. This could be removed and the bank stabilized with native and deep rooted species. Phased removal and planting will protect banks throughout the restoration process.

c. Restoration

1) At the estuary of San Luis Obispo Creek, there is an opportunity to plant native riparian vegetation along a strip of land on the south bank, between the Creek and the golf course. There is an area here that was graded as part of the golf course construction that is unused for this activity. This strip of land could be planted with little grading of the immediate bank.

2) At the "narrows" there is an opportunity to restore the native riparian vegetation and stabilize the bank along the north side of the Creek opposite Avila Road.

3) At the "big bend" there are opportunities for restoration in association with erosion control measures.

4) Remedial restoration between the third an fourth bridge. Restoration efforts undertaken two years ago, as a pilot project in this area, suffered severe flood damage and should be replanted.

5) The removal of the castor bean and other exotics just downstream of Marre Dam could be associated with the planting of native riparian vegetation to help hold the Creek bank.

3. Summary of field measurements

Field measurements were not taken for this reach due to depth.

B. REACH TWO - FROM SAN LUIS BAY DR. BRIDGE TO THE ONTARIO ST. BRIDGE

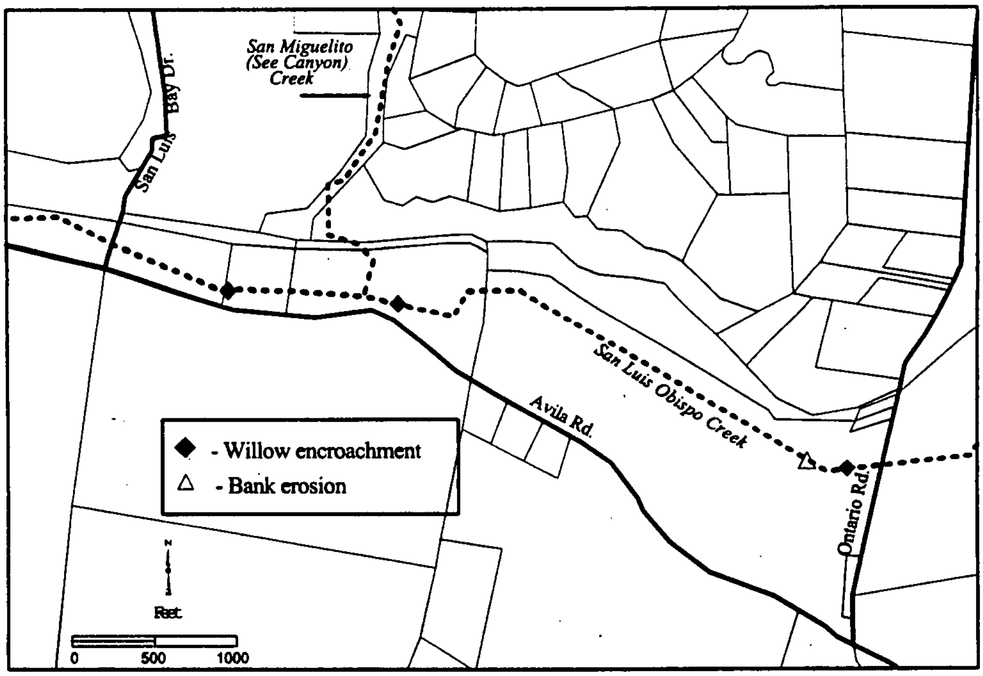


Figure 2.3 - Reach #2

1. Location and general description

Reach two begins at the San Luis Bay Dr. bridge and extends upstream to the Ontario St. bridge (Figure 2.3). Along the first 600 feet of this reach the water is still pooled from the Marre Dam, and the channel is highly uniform.

The riparian vegetation along this reach is generally dense and includes mature sycamore and an understory of willow. Adjacent land use in this area is primarily agriculture or undeveloped land just beyond the edge of the riparian vegetation. Avila Road parallels the south side of the Creek downstream of the Sycamore Hot Springs Resort. Adjacent land use has apparently not impacted the Creek corridor in this area.

The depth in this stretch ranges from a minimum of .75 inches to a maximum of 11 feet (at bankfull), with an average measured depth of 1.2 feet. The width to depth ratios (W/D) varied from 8.7 to 3.6, which are generally considered good to excellent by the U.S. Forest Service Channel Stability Evaluation Model (CSEM). The variation between these ratios indicates that some areas are worse than others.

Moderate amounts of silt and fine sand have been deposited in the lower section of the reach due to decreasing velocity behind Marre Dam. The substrata improves upstream as velocities increase, but is still considered poor for steelhead spawning.

The vegetation in this section is made up of mostly mature riparian forest, 85% of which are mature willows and 15% are mature sycamores. The vegetation is less mature in the area immediately downstream of the Ontario Rd. bridge. Willow encroachment is occurring at distances of 750', 1250' and 2350' up from the San Luis Bay Drive bridge. The channel is narrowing in these areas leading to some incision. Generally, the vegetation along this reach is good to excellent in the CSEM.

The banks in this section are a model of bank stability due to the mature riparian vegetation. Some isolated areas, however, are experiencing very minor erosion. Average bank slopes are 55-70 degrees which are considered fair to poor in the Forest Service model, but the vegetation seems to have mitigated any adverse effects of slope. The overall erosion hazard in this section is relatively low.

Additional channel features include the confluence of San Luis Obispo Creek and San Miguelito (See Canyon) Creek, which is contributing a low flow of cool water (60°).

The ownership of adjacent lands is divided into 5 holdings. Additional development is planned for an expansion of the Sycamore Mineral Springs. This development will also include another bridge over the Creek. The construction of the bridge may require some removal of vegetation but the project is not expected to have direct impacts on the riparian vegetation. Soil disruption during construction has the potential to erosde and be deposited into the Creek. Mitigation measures should be monitored closely on this site.

Adjacent Soil Summary

Unit Number	Soil Type	Length	Depth	Erosion Potential
170	Marimel Silty Clay Loam	255	Very Deep	Slight
194	Riverwash	4952		Variable

2. Problems and Opportunities

a. Bank stabilization

The banks in this reach are generally quite stable. Enhancement should center on helping land owners to clear the channel in ways that preserve bank stability.

b. Invasive Species

This section is particularly impacted by the spread of Giant Reed (Arundo donax), an invasive species. These plants are contributing to significant channel constriction. This species is very difficult to eradicate, but could be controlled by working with the land owners on special Giant Reed eradication methods.

c. Restoration

Restoration opportunities exist in the area of the Ontario St. Bridge. This area was disturbed during the construction of the new bridge.

3. Summary of field measurements

Active Channel				Mean			
Mean Width	Mean Depth	Max Depth @ Bankfull	Max Depth Measured	Slope L	Slope R	W.P. Act. Chan.	D_{50}
19.2'	1.2'	11"	3.7'	55 deg	70 deg	36	sand

C. REACH THREE -ONTARIO ROAD BRIDGE TO SAN LUIS BAY DRIVE

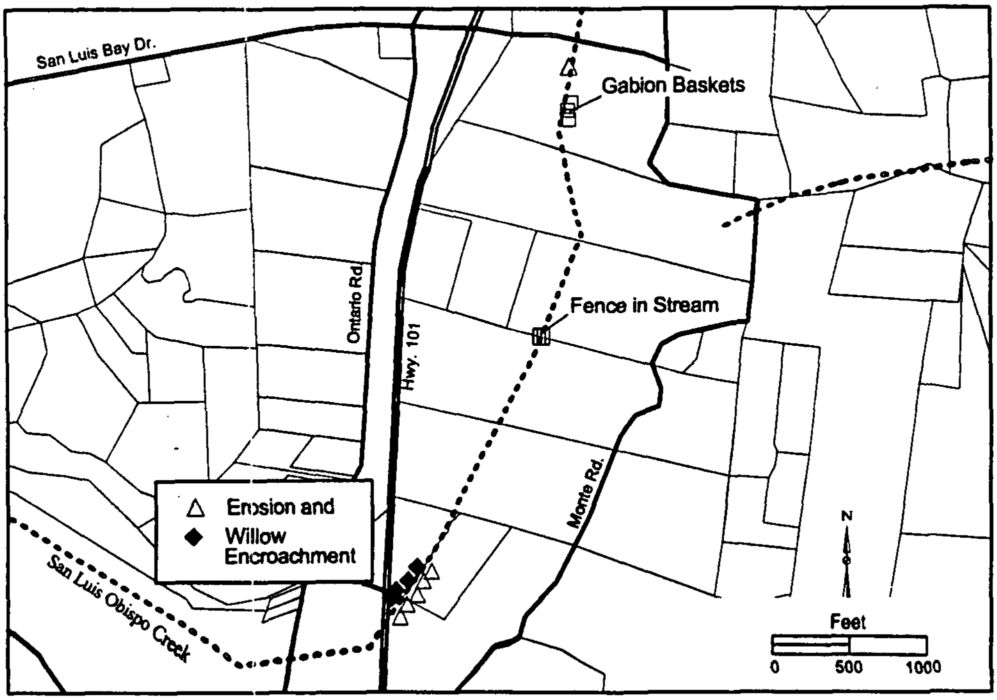


Fig. 2.4 - Reach # 3

1. Location and general description

Reach three extends from the Ontario Rd. bridge, under the Highway 101 bridge, and up stream to the San Luis Bay Drive bridge (Figure 2.4). The adjacent land use is mostly agriculture, except for an area between Highway 101 and the Ontrario Street bridge where a recreational vehicle park abuts the Creek.

The downstream end of this reach is similar to Reach #2 with mature riparian vegetation. Upstream, however, the vegetation is predominately young to maturing willow. In several places, willow encroachment has the potential to restrict flow. Vegetation cover along the edge of the Creek ranges from 90% to 100% indicating excellent cover. At several isolated points, however, only grasses cover the banks. Based on a review of aerial photographs from the 1950's, this reach was apparently channelized into a narrow corridor. Sparse vegetation existed along this reach during that time period. Over the past 40 years, the Creek has continued to widen and willow vegetation along the creek has returned. There are, however, no mature sycamore as are found both upstream and downstream of this reach.

While the vegetative cover is good, willow encroachment is becoming a problem. This is happening partly as a result of the depositional nature of this area. Water slows down near the Highway 101 undercrossing and sediment is being deposited. Willows are colonizing the deposition areas.

The banks in this stretch are generally well protected in the downstream areas. In the upstream section, there are a number of vertically eroded banks where grasses are the only bank protection. The most impacted areas are those where agriculture is practiced right up to the stream bank. In one section, cattle are allowed access to the creek. Willow encroachment is also contributing to erosion in this area. The bank slopes are relatively steep, which is considered poor in the Forest Service channel model. The good vegetative cover, however, has kept these areas mostly stable.

Width to depth ratios range from 4 to 11.8 which fall into the good to excellent range, but exhibit significant variability. The higher width to depth ratios correspond to those areas on the map showing erosion problems.

Other channel features include a fence across the stream at 2020' which has the potential to cause a debris dam depending on flows. The water temperature measured in this reach was 72° F which is considered high. This is indicative of a lack of canopy upstream. Near the upstream end of this reach, gabion baskets have been used to control erosion. These artificially turn the stream at one point and are causing some erosion on the opposite bank.

The ownership is mixed with parcels extending across the Creek. There are about 6 owners in this area, and each manages the land somewhat differently. This has provided an outdoor laboratory in land management strategies. Those landowners that have let the land lay fallow have experienced less stream bank erosion. Land left in grassland for cattle has experienced little surface erosion but has been associated with some stream bank erosion where cattle access the Creek for water. Properties with a history of cultivation have experienced various degrees of bank erosion and land loss depending on the proximity to the Creek and land management techniques. Those areas that have been cleared of willows have experienced the most bank erosion and subsequent loss of adjacent land for agriculture.

Adjacent Soil Summary

Unit Number	Soil Type	Length	Depth	Erosion Potential
169	Marimel Silty Clay Loam	3218'	Very Deep	Slight
194	Riverwash	1711		Slight

2. Problems and Opportunities

a. Bank stabilization

The primary opportunity for bank stabilization along this reach is the area is at the Kruse property. This is the second owner up stream of the Highway 101 bridge. The height of the banks are relatively low at this point but the lack of vegetation along the Creek has caused the creek bank to erode and consume adjacent farmland. After the creek passes through the Kruse property it enters a dense willow thicket on the Tannahill property where the flood waters disperse into a broad area.

b. Invasive Species

There are significant problems with Giant Reed (Arundo donax) in the area where the Creek crosses Highway 101. The reed is, however, restricted to this one area of the reach.

c. Restoration

Large trees can be planted all along this entire reach to eventually provide shade on the water. This would lower water temperatures, and enhance the fishery resource. The dense willow thicket at the Highway 101 bridge can be enhanced with some grading and restoration to provide a wetland area away from the flowline of the Creek itself. This will require land acquisition to achieve this level of restoration.

Additional work could include clearing willows to reform an active center channel. Careful study of the flows necessary to maintain an active channel must precede this type of work.

3. Summary of field measurements

–Active Channel–				Mean			
Mean Width	Mean Depth	Max Depth @ Bankfull	Max Depth Measured	Slope L	Slope R	W.P. Act. Chan.	D_{50}
18.9'	1.1'	8'	5'	75_{deg}	80_{deg}	30	sand

D. REACH FOUR - SAN LUIS BAY DRIVE TO THE WOODEN BRIDGE

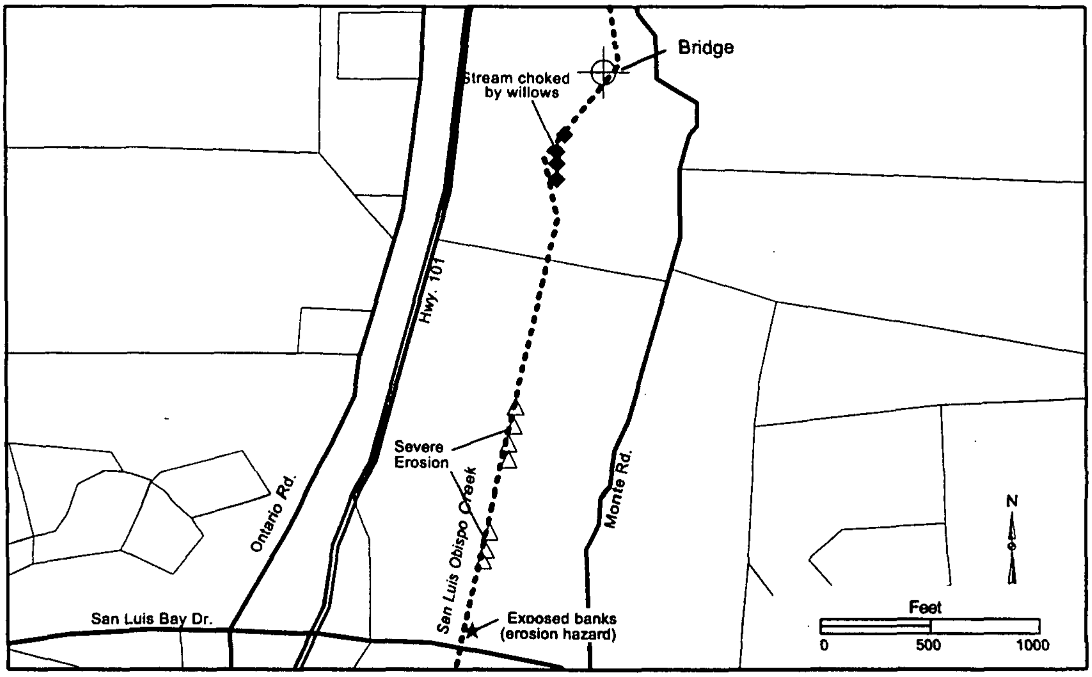


Figure 2.5 - Reach # 4

1. Location and general description

Reach four extends from the San Luis Bay Drive bridge east of Highway 101 to an agricultural wooden bridge located about 3,200 feet upstream of the San Luis Bay Drive bridge. Land use adjacent to the Creek in this area is in agriculture. An apple orchard was planted along both sides of this reach in 1994.

The vegetation in this reach changes dramatically as the Creek moves upstream. The lower section is largely barren with some immature willow growth on the banks. The upstream portion contains a more complete cross section of riparian species and age structure.

Within the Creek, however, willows are encroaching and becoming established on bars. The bars are a result of sediment deposition from upstream and within the reach, and act to divert the water into the banks. This has resulted in severe erosion in a number of spots along the reach. The vegetation in this reach is ranked as fair by the CSEM.

Banks in this section are generally in poor condition. Vertically eroded banks are common and a significant amount of bank cutting is evident. Concrete slabs have been placed on the banks at several locations which have had some success in protecting those areas, but have also prevented riparian vegetation growth and constricted the flow of the Creek.

Width to depth ratios range from 6.3 to 14.7. These are slightly higher than the other stretches but still fall into the good category in the channel stability evaluation. They are, however, mostly high. The low 6.3 measurement is in a short, vegetated, portion of this reach.

Channel instability in the lower part of this reach could be caused by a number of factors. Historic straightening of the channel may have upset the channel equilibrium. Alterations on the floodplain, such as road embankments, may also be contributing to this instability.

The ownership is consolidated, and the landowner's support of restoration provides a substantial opportunity for long-term enhancement of the riparian corridor.

Adjacent Soil Summary

Unit Number	Soil Type	Length	Depth	Erosion Potential
169	Merimel Silty Clay Loam	3406	Very Deep	Slight

2. Problems and Opportunities

a. Bank stabilization

Bank stabilization is necessary in several severely eroded areas. With the cooperation of the single landowner, this is a unique opportunity. This reach of the Creek may require in-stream modification. This means possibly clearing the willows from within the channel, as well as, adding channel features which create the pools important for fish.

b. Invasive Species

Invasive species are only a minor concern in this area.

c. Restoration

Restoration should include the planting of large canopy trees. This can be incorporated with the bank stabilization plans.

3. Summary of field measurements

Active Channel				Mean			
Mean Width	Mean Depth	Max Depth @ Bankfull	Max Depth Measured	Slope L	Slope R	W.P. Act. Chan.	D_{50}
21.2'	1.1'	10'	3.6'	30deg	30deg	52'	sand

E. REACH 5 - THE WOODEN BRIDGE TO ACCESS ROAD

1. Location and general description

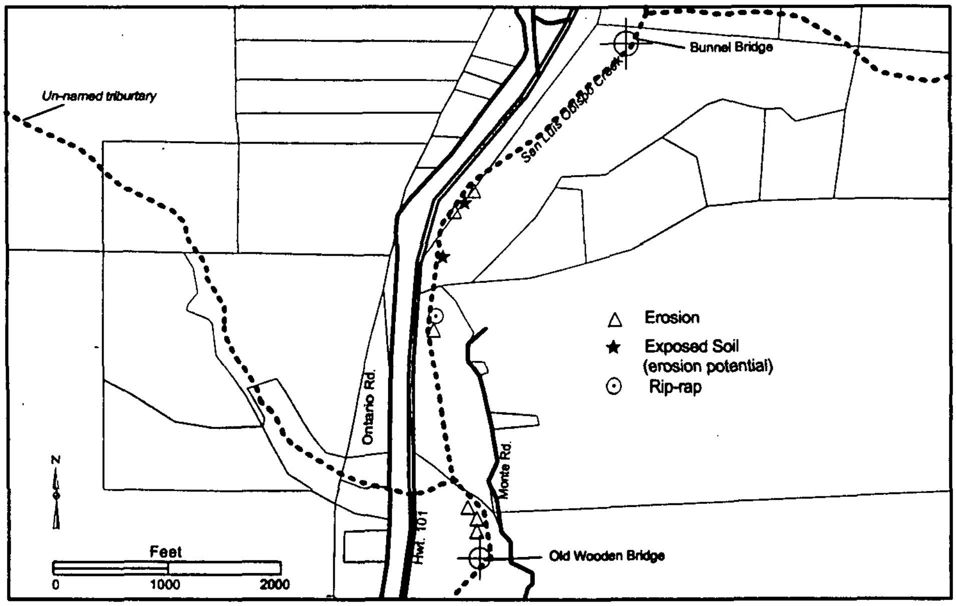


Fig. 2.6 - Reach # 5

Reach five encompasses the stretch of the Creek north of the Maino bridge to a second bridge that provides access to the Ray Bunnnell home. The adjacent land uses are grazing and farming.

Vegetation along this section consists of a mix of mature and maturing willows and sycamore with 70% - 90% coverage. This reach has the best mix of species and age structure between the City and the lower reaches of the Creek near Sycamore Hot Springs. A review of historical photographs show the riparian vegetation along this reach has expanded greatly. The Creek is incising (cutting deeper) throughout this reach, but a number of overflow channels have created a broader riparian corridor. One unique aspect of this reach is that it flows through a narrow opening in the coastal mountain range. This brings a number of differing vegetation types together into a small area creating a zone rich in biological diversity.

While the banks are generally stable, some areas of erosion and undercutting are evident. The bank slopes are less steep in this section compared to other sections, but are still considered steep.

The width to depth ratios range generally between 4 and 5, which is considered excellent, and the variation in W/D is low. There is also some evidence of sediment deposition, but it is mostly intermittent. Generally, reach five is one of the more stable reaches in the lower Creek.

The adjacent land is owned by only two owners. Both have indicated an interest in maintaining and enhancing the Creek.

Adjacent Soil Summary

Unit Number	Soil Type	Length	Depth	Erosion Potential
169	Merimel Silty Clay Loam	2804	Very Deep	Slight
198	Salinas Silty Clay Loam	3013	Very Deep	Moderate
210	Still Gravelly Sandy Clay Loam	2313	Very Deep	Slight

2. Problems and Opportunities

a. Bank stabilization

The banks in this reach are generally stable. There are isolated areas of erosion and undercutting, but the problems are not severe.

b. Invasive Species

There are invasive species in this reach, but the problem is not as critical as in other reaches.

c. Restoration

Restoration could involve planting of some larger canopy trees, but this is generally a low priority considering the problems in the other reaches.

3. Summary of field measurements

— Active Channel —				— Mean —			
Mean Width	Mean Depth	Max Depth @ Bankfull	Max Depth Measured	Slope L	Slope R	W.P. Act. Chan.	D_{50}
21.1'	.9'	13'	2.8'	50deg	60deg	35	18mm

F. REACH 6 - FROM THE ACCESS ROAD TO THE 101 ONRAMP

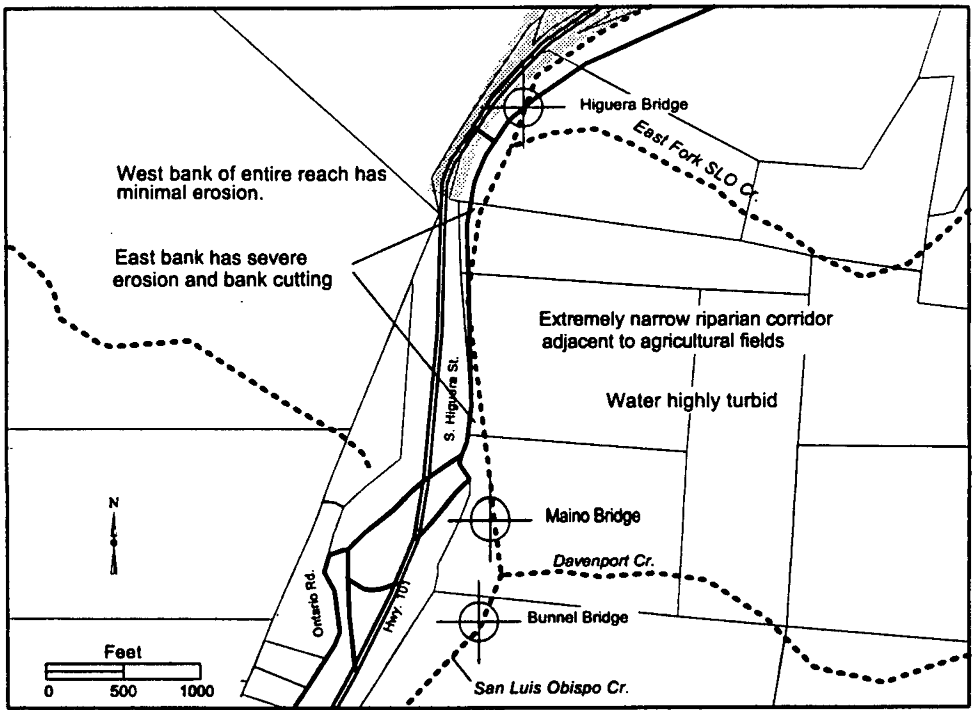


Fig. 2.7 - Reach # 6

1. Location and general description

Reach 6 extends from the bridge that provides access to the Ray Bunnell property to the bridge at South Higuera Street where there is an on-ramp to Highway 101.

Land use in this area is agriculture on the west side while lower Higuera and Highway 101 border the Creek on the east side. This section of the Creek that parallels Higuera is relatively short and was moved into its present alignment with the construction of Highway 101. The realignment of this reach has caused continuing bank erosion problems on the west bank.

The bank stabilization problems along this reach are compounded by a serpentine rock outcrop that is located at the confluence with Davenport Creek. This occurs at the same place where the South Higuera Street bridge crosses the Creek, and where existing underground pipelines cross through the narrow opening between the rock outcrop and South Higuera. Pipelines are now exposed at this location.

Vegetation in this reach is primarily willow, with 85% coverage. Several areas adjacent to agricultural uses lack vegetation. These areas are also experiencing severe bank erosion. At the southern end of this reach, a single line of conifers has been planted on the top of the west bank. They provide canopy, but due to their shallow root structures they do not provide much bank stabilization.

Where the riparian corridor is well established, the banks are in good condition. The bank slopes are, however, very steep in the upper section of the reach and subject to some intermittent bank cutting. Some sections of the left bank have been stabilized with riprap.

The width to depth ratios range near 3.5, the lowest of any reach in the lower creek. It is also the deepest channel in the lower Creek.

The water in this section is very turbid and there is evidence of significant silt deposition.

The ownership is divided among four people. As with other reaches of this main stem of the lower Creek, the participation of landowners provides a long-term opportunity for restoration and bank stabilization.

Adjacent Soil Summary

Unit Number	Soil Type	Length	Depth	Erosion Potential
169	Marimel Silty Clay Loam	828	Very Deep	Slight
131	Diablo & Cibo Clays	378	Moderate	Moderate
197	Salinas Silty Clay Loam	1886	Very Deep	Slight

2. Problems and Opportunities

a. Bank stabilization

Bank stabilization is necessary along most of the south side of the Creek (or the right side as you progress upstream). The section shown on the following page suffered damage in the 1995 storms, and remains unstable. There is no riparian vegetation to stabilize the banks, and no upper canopy trees to shade the water. This section floods under higher flows, and the high flow velocities contribute to scouring of the topsoil. With a single owner, this is a good restoration opportunity.

The most critical need in this reach is to develop a coordinated restoration approach for the intersection of Davenport Creek and San Luis Obispo Creek. There are a number issues and constraints to address in this area including exposed pipes, channel constriction by roads, and a steeper flow gradient.

b. Invasive Species

A minor problem in this area.

c. Restoration

This section, too, has few established canopy trees, and would benefit from more riparian vegetation.

Severe erosion and scoured agricultural land.

3. Summary of field measurements

— Active Channel —				— Mean —			
Mean Width	Mean Depth	Max Depth @ Bankfull	Max Depth Measured	Slope L	Slope R	W.P. Act. Chan.	D_{50}
19.1	1.1'	15'	3.2'	65 $_{deg}$	70 $_{deg}$	30'	10 $_{mm}$

G. REACH 7 - HIGHWAY 101 ONRAMP TO LOS OSOS VALLEY ROAD

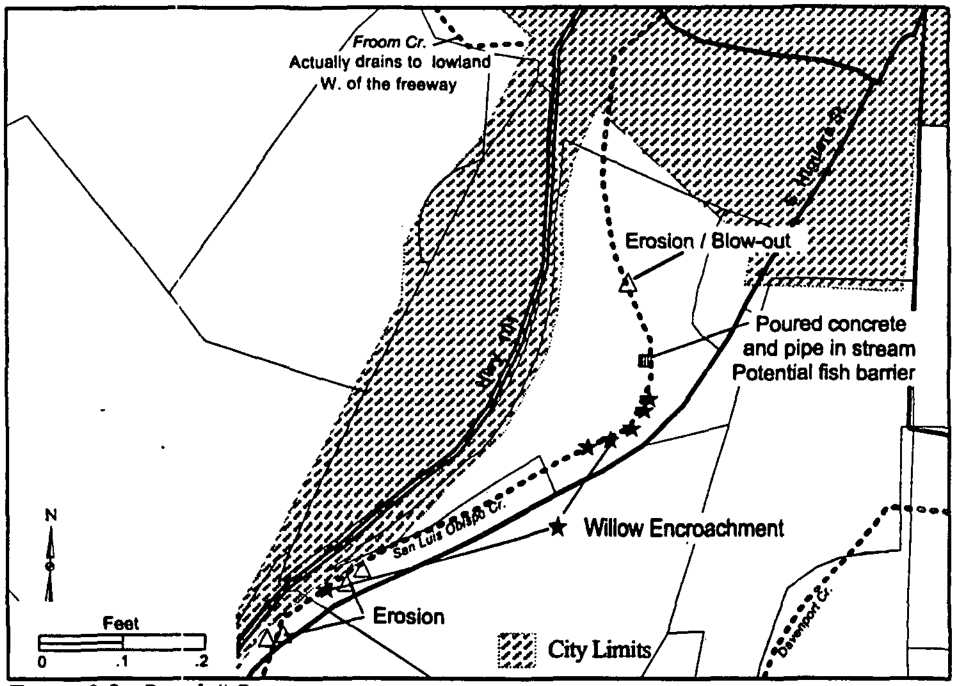


Figure 2.8 - Reach # 7

1. Location and general description

Reach 7 begins at the South Higuera Street bridge and ends at Los Osos Valley Road.

This reach is divided into three separate sections. The lower section parallels South Higuera and is sparsely vegetated. The middle section passes through agricultural fields on both sides and has a narrow band of riparian vegetation. The vegetation in this section is composed largely of native species but the strip of vegetation is very narrow and lacks canopy cover. The upper section, where it approaches the Los Osos Valley intersection, is composed of dense willow vegetation and giant reeds.

Land use in this section is agriculture. The Creek is shallower and wider in this reach than the others. The channel, however, is incised and relatively deep. This stretch also meanders more than the previous reaches.

The riparian vegetation along this reach is generally thin and provides only fair bank protection. A large section of the middle portion of this reach suffered severe erosion during the winter storms of 1995. Several areas are only covered by grasses and are experiencing significant erosion. Willow encroachment has the potential to choke the Creek if not cleared back.

The banks are mostly in good shape, but are cut in several areas where grasses are the only bank protection. Some intermittent sediment deposition is occurring as well. Bank slopes are lower in this area than other areas, but are still considered fair to poor in the CSEM. Width to depth ratios range from 5 to 10. The higher ratios correspond to areas of degraded bank vegetation and erosion.

The adjacent lands in the undeveloped part of this reach are owned by only two people. The lots are small where the Creek enters the city.

Adjacent Soil Summary

Unit Number	Soil Type	Length	Depth	Erosion Potential
169	Marimel Silty Clay Loam	1614	Very Deep	Slight
197	Salinas Silty Clay Loam	4244	Very Deep	Slight

2. Problems and Opportunities

a. Bank stabilization

Bank stabilization is the greatest need in this reach. Heavy rains during the storms of 1995 lead to numerous bank failures. Flooding is common in this area, and in order for the banks to withstand future floods, they should be restored. Flooding at this point poses a very high erosion threat to the tilled agricultural soils.

These banks have been damaged by fast moving water. Revegetation will reduce the risk of future damage

b. Invasive Species

There are many invasive species in this reach. The section near Los Osos Valley Rd. is particularly impacted.

c. Restoration

Restoration is necessary throughout this reach. Large canopy trees could be planted along with bank stabilizing plants. Willow removal from the main channel near Los Osos Valley Rd. is also suggested.

3. Summary of field measurements

— Active Channel —				— Mean —			
Mean Width	Mean Depth	Max Depth @ Bankfull	Max Depth Measured	Slope L	Slope R	W.P. Act. Chan.	D_{60}
19.2	1.3'	6'	4.4'	65 deg	50 deg	23'	23 mm

H. REACH 8 - LOS OSOS VALLEY ROAD TO PRADO ROAD

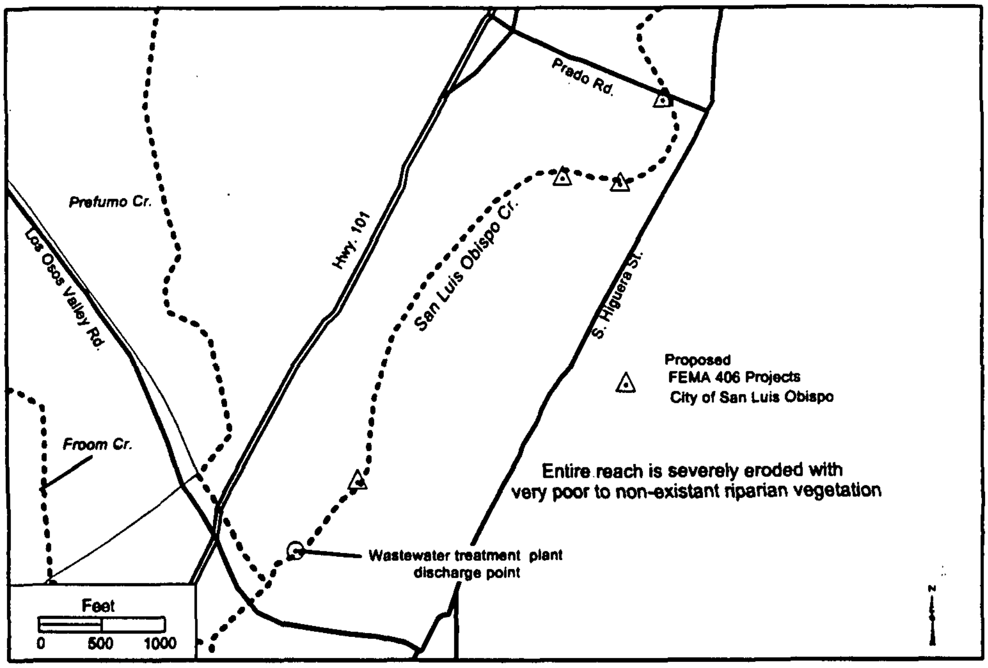


Fig. 2.9 - Reach # 8

1. Location and general description

This section begins at Los Osos Valley Rd. and ends at Prado Rd. Land uses include agriculture, housing, and public facilities. This reach is visibly the most impacted section of San Luis Obispo Creek.

Vegetative protection in this reach is particularly poor , consisting of scattered maturing willows. Areas of development have left the banks devoid of vegetation creating severely unstable conditions. Canopy cover is sparse to nonexistent which is contributing to unusually high water temperatures (70-80°F). Periodic removal of vegetation in this area for flood control has also exacerbated erosion problems.

Bank conditions are very poor in this area with vertically cut banks along most of this reach. In some areas, vertical banks reach as high as 20 feet and 100 feet long. In many places along this reach the channel bottom has reached bedrock, so high flows tend to cut banks rather than continue to incise an already incised channel. Channel incision has also confined the flows within the channel, increasing flow velocity and erosion potential.

The ownership along this reach is divided between city ownership on the north side, which facilitates some access to the Creek, and many smaller lots (mobile home park plus established residential subdivision) on the south side that complicates access to this side.

The history of erosion in this reach has resulted in a series of proposed projects by the City to stabilize the banks. There are a number of critical areas where public and private property is being threatened.

A critical spot that can be seen from the adjoining public roads is where the Creek approaches Prado Road. The strawberry field on the south side of the Creek is immediately adjacent to a high vertical bank that will continue to erode and cut into the agricultural field. (see photo p.89)

Adjacent Soil Summary

Unit Number	Soil Type	Length	Depth	Erosion Potential
127	Cropley Clay 0-2% slope	1444'	Very Deep	Slight
197	Salinas Silty Clay Loam	4775'	Very Deep	Slight

2. Problems and Opportunities

a. Bank stabilization

Bank stabilization is critical in this reach. As the photo illustrates, erosion is threatening many creekside activities. Much of the erosion in this area is so severe that stabilization will probably require bank grading and artificial protection. These projects should utilize methods that combine the protection of the lower banks to prevent undercutting and planting the upper banks to provide stabilization and habitat cover. In addition, rock protrusions from the base could be incorporated to decrease flow velocities and create scour pools for migrating fish.

The City of San Luis Obispo is currently pursuing four bank protection projects in this reach. These are marked on figure 2.9. The Land Conservancy will be working with the City to provide additional information necessary for permit approval. We will also attempt to find and propose innovative project designs which will enhance the riparian corridor and protect property while meeting the City's engineering standards.

High vertical banks are common in this reach.

b. Invasive Species

Invasive species are present along this reach but are the least of the problems. As individual restoration projects are undertaken, there will be opportunities for the removal of exotic species.

c. Restoration

Restoration efforts should focus first on protecting the very few areas that are in acceptable condition now. Areas that have been improperly cleared in the past could be restored fairly easily. Since there is little riparian vegetation in this reach, and the highest temperatures were taken here, it is clear that canopy cover should also be established.

3. Summary of field measurements

—Active Channel—				—Mean—			
Mean Width	Mean Depth	Max Depth @ Bankfull	Max Depth Measured	Slope L	Slope R	W.P. Act Chan.	D_{50}
10.5'	.07'	7'	3.8'	55deg	40deg	35'	6mm

I. REACH 9 - PRADO ROAD TO MADONNA ROAD

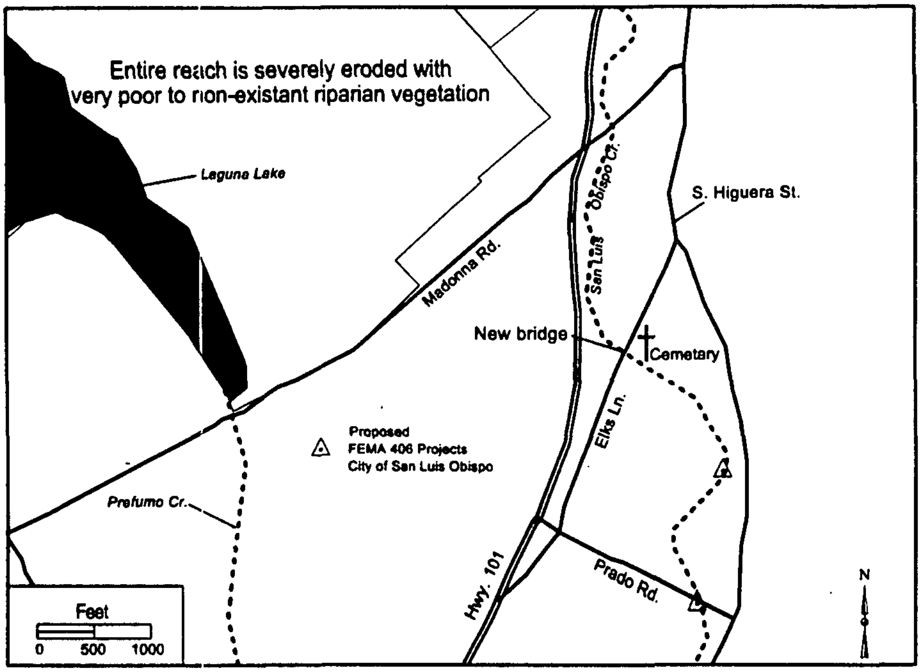


Fig. 2.10 - Reach # 9

1. Location and general description

Reach 9 begins at Prado Rd. and extends up to Madonna Rd.. Adjacent land uses include some agriculture, commercial development, public facilities, and the cemetery. This section is much like reach 8, with most of the banks suffering from erosion and bank cutting. Encroaching development is more dense in this section, and much of the riparian vegetation has been removed or degraded.

Vegetation is sparse to nonexistent in this reach. Not only has this contributed to the extreme erosion, but it has left most of the Creek without a canopy. The water temperature was very high (80° F), which is significantly warmer than downstream reaches. Willow encroachment on lateral bars within the channel are a problem in the lower section of this reach. Some channel constriction caused by Giant Reed is evident in this reach, most notably in the section just downstream of the Madonna Rd. bridge.

The channel is incised for most of this entire reach, and the banks are very unstable. The width to depth ratios range from 8.5 to 10.7, and are among the highest in the watershed. This indicates that erosion and bank failure is more consistent in this reach than in most of the others. Deposition is occurring on lateral bars in areas where the channel is wider and flows are slower. The banks here are also a popular dumping ground and there is a significant amount of concrete and garbage in the channel.

The ownership is various and complicated. Several significant reaches, however, are under single ownership which provides some restoration opportunities.

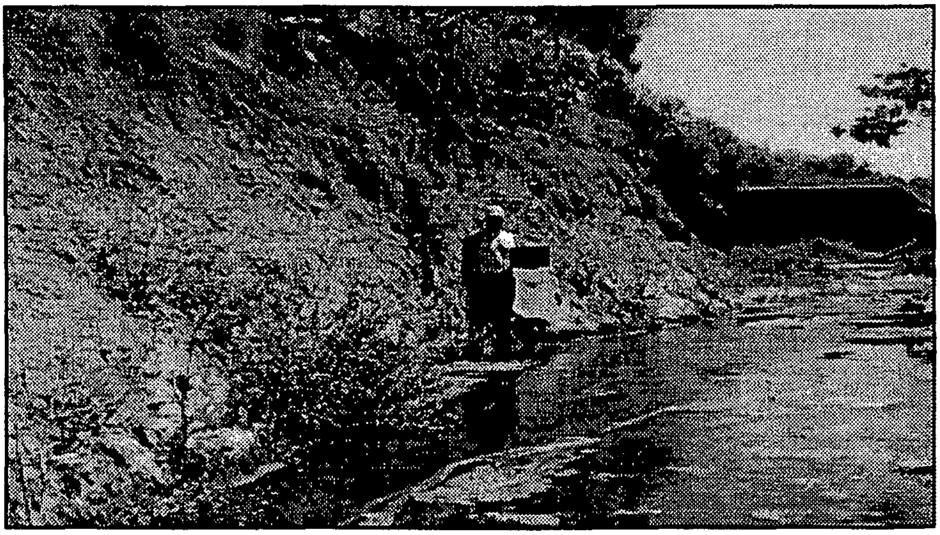
Adjacent Soil Summary

Unit Number	Soil Type	Length	Depth	Erosion Potential
197	Salinas Silty Clay Loam 0-2% slopes	5000'	Very Deep	Slight

2. Problems and Opportunities

a. Bank stabilization

As with the previous reach, bank stabilization is necessary along much of this area.



Some eroded banks are over 20 feet tall.

The vertically cut banks and severe erosion in this reach are among the worst in the watershed. Along many of these banks development has encroached to a point where there is very little space in which to undertake restoration. The Valley Vista Mobile Home Park, for example, has no more than 2 feet of bank top left. In order to restore areas like this, either the channel must be partially filled in or the trailers will have to be moved back to allow grading of an appropriate slope.

b. Invasive Species

Giant Reed is a problem in this reach. Work on removal of these plants has been unsuccessful to date. Repeated spraying has not significantly affected these plants. These plants need to be physically removed with caution, so as not to let plant remnants enter the Creek. The stumps can then be sprayed with greater effectiveness.

c. Restoration

Restoration in this area should concentrate on establishment of upper canopy cover. Bank restoration could accompany any stabilization projects as well.

3. Summary of field measurements

Active Channel				Mean			
Mean Width	Mean Depth	Max Depth @ Bankfull	Max Depth Measured	Slope L	Slope R	W.P. Act. Chan.	D_{50}
10.3'	.08'	7'	3.8'	55deg	40deg	35'	6mm

J. REACH 10 - MADONNA ROAD TO STENNER CREEK

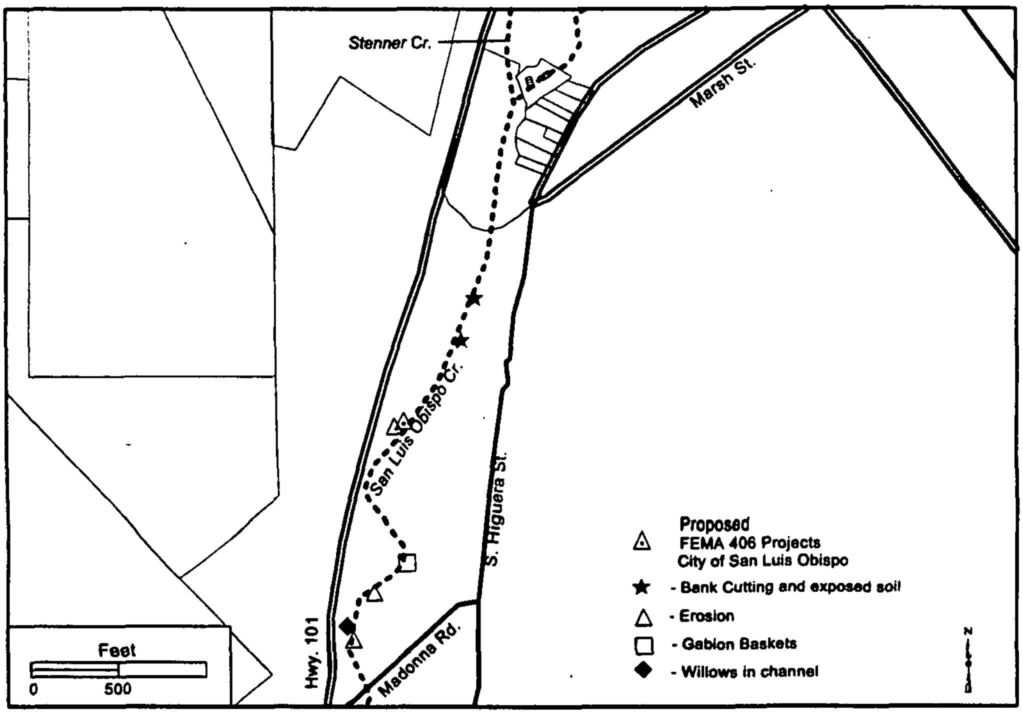


Fig. 2.12 - Reach # 11

1. Location and general description

Reach 10 extends from the Madonna Rd. bridge at Hwy. 101 to the confluence of Stenner and San Luis Obispo Creeks (near the intersection of Marsh and Higuera Streets). Land use along this stretch is primarily commercial and residential development. In most sections, development occurs right up to the banks.

Vegetation is sparse with a few areas containing mature riparian plants. Most of the banks are covered with herbaceous plants. These do not, however, provide significant canopy and the temperatures measured were very high (75-80 degrees F). Willow encroachment is also occurring in several places, and nuisance algae is prominent.

The channel is incised for almost the entire reach , and width to depth ratios range from 8.5 to 10.7. The channel appears to be more stable than the W/D numbers indicate due to the prevalence of bank protection structures (gabion baskets, concrete walls, cement sacks, etc.). All the bank protection has lead to higher flow velocities which tend to do more damage to adjacent unprotected banks, and banks in the downstream reaches. The increased velocities are also responsible for a decrease in sediment deposition.

The City of San Luis Obispo has recently purchased a large piece of land along the banks south of the Marsh St. freeway off-ramp that will be restored and used as a park. This will involve removal of numerous buildings and much debris from the area immediately along the bank. This will leave the banks exposed temporarily, but could result in a vastly improved riparian corridor depending on the restoration design.

Adjacent Soil Summary

Unit Number	Soil Type	Length	Depth	Erosion Potential
198	Salinas Silty Clay Loam 2-9% slopes	3842	Very Deep	Slight - Moderate

2. Problems and Opportunities

a. Bank stabilization

Bank stabilization is important in this reach, but encroachment has left very little space for restoration efforts. Since the channel is narrow and deep, with high water velocities, some bank protection will be necessary.

The City of San Luis Obispo is currently pursuing a project in this reach, but it is currently on hold pending some additional study. The proposed site may require some structural reinforcement, but could include biotechnical designs, revegetation of the upper banks and provision of fish habitat improvements.

b. Invasive Species

There are significant stands of Giant Reed throughout this reach, some of which are contributing to channel constriction. These are not routinely removed by flood control crews because of the risk of their speading.

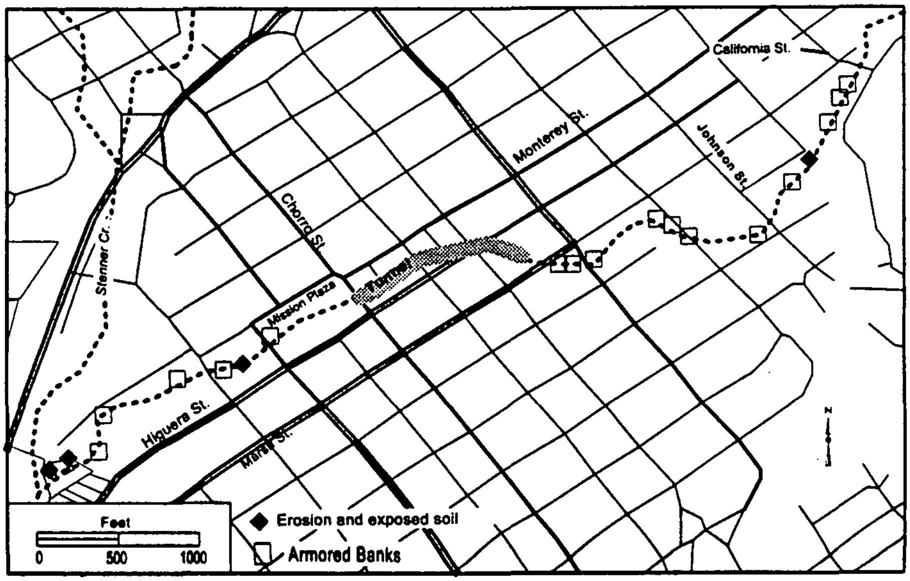
c. Restoration

Restoration opportunities are slim in this reach because it is so highly encroached upon. Planting of upper banks could enhance any bank repair.

3. Summary of field measure-

Active Channel				Mean			
Mean Width	Mean Depth	Max Depth @ Bankfull	Max Depth Measured	Slope L	Slope R	W.P. Act. Chan.	D_{50}
11.2'	.08'	8'	2.3'	80_{deg}	75_{deg}	40'	gravel

K. REACH 11 - STENNER CREEK TO THE CALIFORNIA STREET BRIDGE



1. Location and general description

Reach 11 encompasses the area from the confluence of Stenner Creek to the California St. bridge at San Luis Dr. The Creek runs under the City through part of this reach from the Mission Plaza to the area between Marsh and Higuera Streets (see map). Surrounding land use is urban development.

The banks throughout this reach are mostly armored, and vegetation is sparse to nonexistent. Much of the sparse vegetation is made up of invasive, nonnative species. Vegetative canopy cover is variable. Erosion is minimal due to the extensive artificial bank protection. Sediment deposition is also minimal as the channel has been narrowed to the extent that the high velocities carry the sediment downstream.

The width to depth ratios are low for this reach because development has created narrower and deeper channels.

The ownership is varied with numerous small lots. This makes any large-scale restoration effort difficult. In addition, the high flow velocities, and variability of flow in storm events, will pose a threat to any restoration efforts that involve vegetation planting.

Adjacent Soil Summary

Unit Number	Soil Type	Length	Depth	Erosion Potential
198	Salinas Silty Clay Loam 2-9% slopes	1335'	Very Deep	Slight - Moderate
197	Salinas Silty Clay Loam 0-2% Slopes	350'	Very Deep	Slight
120	Concepcion Loam 2-5% Slope	2782'	very deep	Slight
162	Los Osos-DiabloComplex	2291	Moderately Deep	Moderate

Note: Much of this has been paved and developed

2. Problems and Opportunities

a. Bank stabilization

Bank stabilization projects in this reach will be difficult to successfully implement due to the varied ownership and high flow velocities. In order to secure banks in this reach, bank protection should employ modern bio-technical methods. The City of San Luis Obispo tracks problems in this area, and is currently pursuing the expansion of Mission Plaza between Broad and Nipomo Streets. This project will result in bank stabilization, and can incorporate revegetation.

b. Invasive Species

Invasive species are common in the section of this reach that have vegetation. They are not, however, causing flow constriction and erosion. They channels are regularly cleared for flood control purposes.

c. Restoration

Restoration opportunities are very limited in this reach.

3. Summary of field measurements

—Active Channel—				—Mean—			
Mean Width	Mean Depth	Max Depth @ Bankfull	Max Depth Measured	Slope L	Slope R	W.P. Act. Chan.	D_{50}
8.3'	.5'	8'	2.2'	80deg	65deg	26'	gravel

L. REACH 12 - CALIFORNIA STREET BRIDGE TO ANDREWS ST. BRIDGE

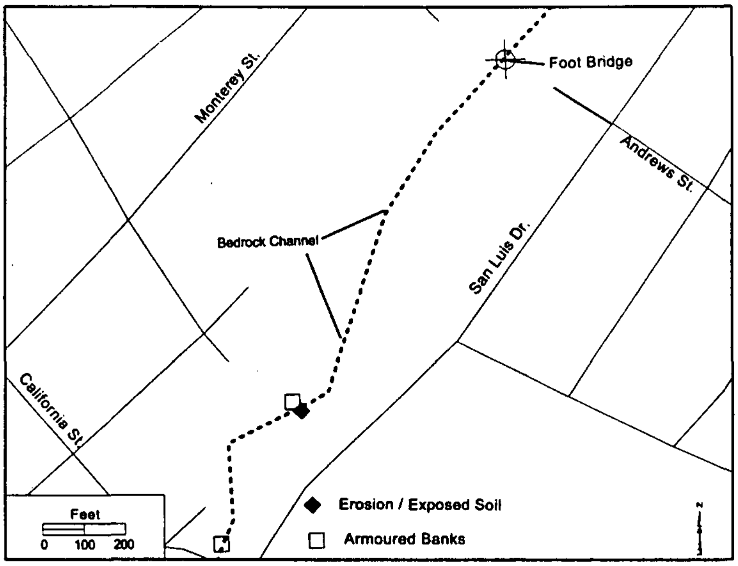


Fig. 2.13 - Reach # 12

1. Location and general description

This reach begins at the California St. Bridge and ends at the Andrews St. bridge. It is the shortest of all the reaches studied. Land use in this section consists of residential development which has been built right up to the Creek banks.

Much of the channel in this reach has been vertically cut, and flow velocities are high. The bridges at each end of this reach constrict flows, and are contributing to localized bank erosion problems. Relative to reaches 10 and 11, however, this section has a higher channel capacity and more bedrock in the channel. It is, therefore, a little more stable.

Along sections with artificial bank protection, there is an absence of vegetation. Where left unprotected, the lack of woody vegetation has left banks eroded. Invasive species are also present in vegetated areas, but like reach 11, they are periodically removed for flood control.

The ownership is highly varied which limits larger scale restoration efforts. There are also many owners with water pump intake pipes in the Creek. The water is being withdrawn for landscape watering. The cumulative water withdrawal is unknown.

Width to depth ratios are among the lowest in the whole watershed, indicating stable banks. This is due mostly to bedrock in the channel and artificial bank protection. There is, however, less bank protection in this reach than in reach 11.

Adjacent Soil Summary

Unit Number	Soil Type	Length	Depth	Erosion Potential
121	Concepcion Loam 5-9% Slope	1164'	Very Deep	Moderate
197	Salinas Silty Clay Loam 0-2% Slopes	278'	Very Deep	Slight

2. Problems and Opportunities

a. Bank stabilization

Bank stabilization projects will be difficult to implement in this reach because of the multiple ownerships and high flow velocities. Stabilization in this reach will most likely require artificial bank protection. Modern bio-technical methods may be an option as well.

b. Invasive Species

Invasive species are prominent in this reach, but regular clearing for flood control has decreased their impacts.

c. Restoration

Any restoration work would be placed in jeopardy by the high flow velocities during storm events. The lack of adequate restoration space would inhibit restoration efforts.

3. Summary of field measurements

Active Channel				Mean			
Mean Width	Mean Depth	Max Depth @ Bankfull	Max Depth Measured	Slope L	Slope R	W.P. Act. Chan.	D_{50}
6.6'	1'	5'	2.5'	85 deg	85 deg	24'	gravel

M. REACH 13 - ANDREW STREET BRIDGE TO HIGHWAY 101 CULVERT

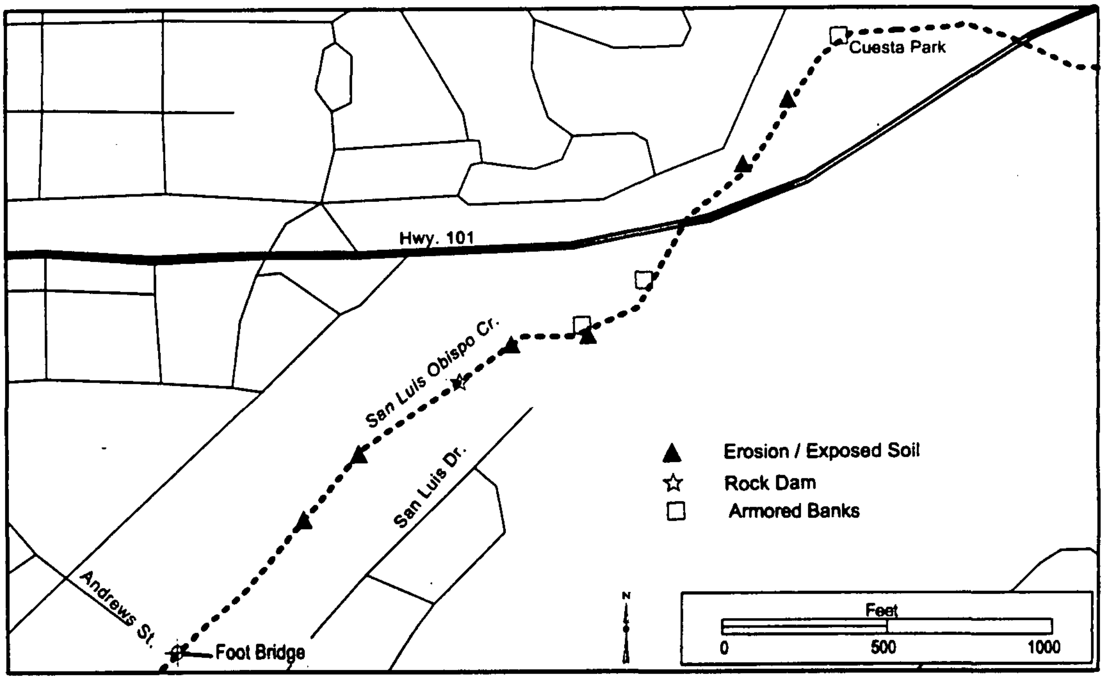


Fig. 2.14 - Reach # 13

1. Location and general description

This reach extends from the Andrew St. bridge to the Highway 101 tunnel above Cuesta Park. Land use in this area is primarily residential development on the lower part, Cuesta Park in the middle section, and Highway 101 on the upper part.

The banks have been reinforced by gabions in several places where erosion is occurring. There is also an increase in bedrock in the channel in this reach, which due to it's irregular shape, slows down the flow somewhat. This, in turn, has lead to more silt deposition. Vertical bank erosion is evident in areas where there is no artificial bank protection.

Riparian vegetation improves in this reach compared to the downstream reaches. Canopy cover increases towards the upstream section of this reach, near Cuesta Park.

The ownership, like the other urban reaches, is divided up into multiple small holdings. Like reach 12, many of the landowners along the Creek are pumping water for landscape irrigation.

Adjacent Soil Summary

Unit Number	Soil Type	Length	Depth	Erosion Potential
121	Concepcion Loam 5-9% Slope	3690'	Very Deep	Moderate

2. Problems and Opportunities

a. Bank stabilization

Encroachment and varied ownership would make significant bank stabilization in this reach difficult.

b. Invasive Species

Not a significant problem in this reach. Vegetation is regularly cleared.

c. Restoration

Restoration opportunities are limited to small areas in single ownership. Encroachment and channelization are major obstacles to restoration in this reach.

3. Summary of field measurements

Active Channel				Mean			
Mean Width	Mean Depth	Max Depth @ Bankfull	Max Depth Measured	Slope L	Slope R	W.P. Act. Chan.	D_{50}
11.3'	.6'	7'	1.7'	85deg	85deg	29.5'	gravel

N. REACH 14 - HIGHWAY 101 CULVERT TO RESERVOIR CANYON ROAD

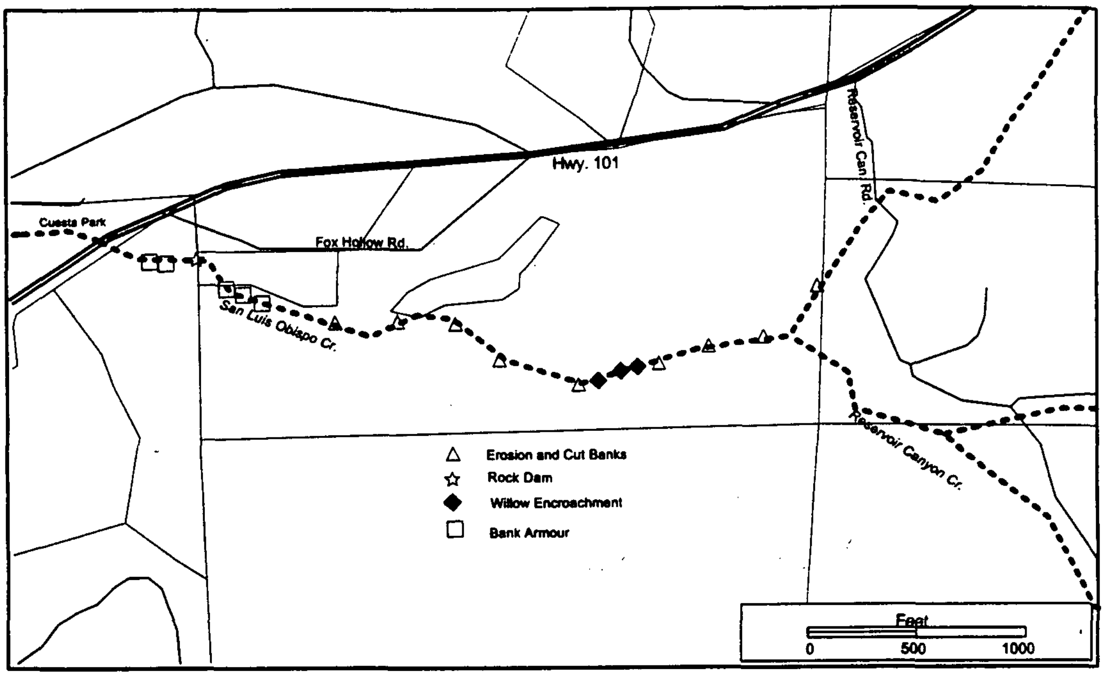


Fig. 2.15 - Reach # 14

1. Location and general description

From the Highway 101 tunnel above Cuesta Park, Reach 14 continues to Reservoir Canyon Rd. This reach is upstream of the urban development of San Luis Obispo, and land use is mostly grazing and open space.

Bank condition is variable in this section, and is reflected in variable width to depth ratios from 6.3 to 14.7. Areas of severely eroded banks coincide with cattle grazing, and have higher width to depth ratios. Improving riparian vegetation in some sections has stabilized the banks fairly well. Concrete slabs which have been placed on the banks in several places have held those banks.

Most of the adjacent lands in this reach are in a single ownership, which presents an excellent restoration opportunity if the owner is willing to participate.

This reach will be particularly impacted by upcoming construction and grading associated with the State Water Project. If erosion control measures are not effective, the relatively low water velocities in this reach will allow sediment to be deposited. Two other projects in this area will compound this problem. One project will involve grading and soil removal for the placement of a UNOCAL oil pipeline from the Santa Margarita Ranch area to San Luis Obispo. Another is the reopening of a culvert which allows flow from the hills alongside Highway 101 to continue under the freeway. The culvert has been blocked by excessive sedimentation (30' deep). Opening the pipe may let significant sediment loads to continue out of the current sediment trap and into the Creek.

Adjacent Soil Summary

Unit Number	Soil Type	Length	Depth	Erosion Potential
183	Obispo-Rock Outcrop Complex 15-75% Slope	1500'	Shallow	Very High
194	Riverwash	2200'		Slight

2. Problems and Opportunities

a. Bank stabilization

Bank conditions vary widely in this reach and stabilization is necessary in several degraded sections. The single ownership of the adjacent land makes larger scale stabilization efforts possible, if the owner is interested in cooperating. Since there is little development encroachment, there is ample space for stabilization efforts.

b. Invasive Species

Invasive species can be found in this reach, but are more isolated. They are not posing a significant encroachment threat.

c. Restoration

Restoration in this section can include changes in management practices. An off-Creek water supply should be developed away from the channel so cattle can be restricted from the Creek. The single ownership makes this a good possibility.

3. Summary of field measurements

—Active Channel—				Mean			
Mean Width	Mean Depth	Max Depth @ Bankfull	Max Depth Measured	Slope L	Slope R	W.P. Act. Chan.	D_{50}
9.3'	.5'	8'	1.0'	65deg	60deg	45'	gravel/ cobble

O. SUMMARY OF RIPARIAN CONDITIONS

Riparian conditions were surveyed throughout the San Luis Obispo Creek Watershed. More emphasis was placed on the main stem of San Luis Obispo Creek because there were fewer access limitations, and because funding limited extensive study of the tributaries. The tributaries were, however, surveyed at a cursory level.

The main stem analysis was undertaken to identify trouble spots along San Luis Obispo Creek and address the causes of these problems. The results suggest that the most adversely affected areas are downstream of the San Luis Obispo urban area, and that most of the degradation along the whole main stem is human induced. The primary problems are bank erosion and subsequent sedimentation. Encroachment by willows is also a common problem. In more isolated areas invasive species such as Arundo donax (giant reed) are choking the stream and out-competing native species.

Within the City of San Luis Obispo, structural encroachment has led to narrowing of the stream channel and an increase in water velocities. The prevalence of impervious surfaces has also contributed to increased flows. These factors are responsible for much of the bank erosion in these reaches and immediatly downstream of the City. In areas outside of the City, cattle grazing and agricultural grading has resulted in significant degradation of riparian vegetation and subsequent erosion. Along most of the main stem, vegetation clearing for flood control has contributed to erosion as well.

As a result of the main stem study, the reaches have been ranked for their relative restoration needs. Reaches 8 through 10, downstream of the city, were rated as the worst in riparian corridor condition. This is where main stem restoration activities should be concentrated. Much of the restoration can be acomplished with revegetation, while some severely eroded sections can be approached with innovative bio-technical solutions.

Together with the main stem analysis, the sub-watershed analysis was used to evaluate restoration needs, opportunities, and constraints. Each of the subwatersheds, except those draining into Laguna Lake, have the potential of delivering fine sediment to the main stem of San Luis Obispo Creek. Several sites along tributaries were identified as needing restoration work.

Much of the East Fork tributary and Davenport Creek are being affected by cattle grazing and channel clearing for agriculture. They have been left devoid of vegetation, resulting in erosion and high water temperatures, and are sources of excessive sediment loads resulting from cattle access and farm run-off. These problems can be addressed with management practices in combination with revegetation.

Reaches of Stenner Creek on the Cal Poly campus have been identified as severely eroded. This sediment can be transported to the main stem of San Luis Obispo Creek. An excellent oportunity exists to work with Cal Poly to improve conditions along Stenner Creek.

VI. THE HYDROLOGIC MODEL

A. METHODOLOGY

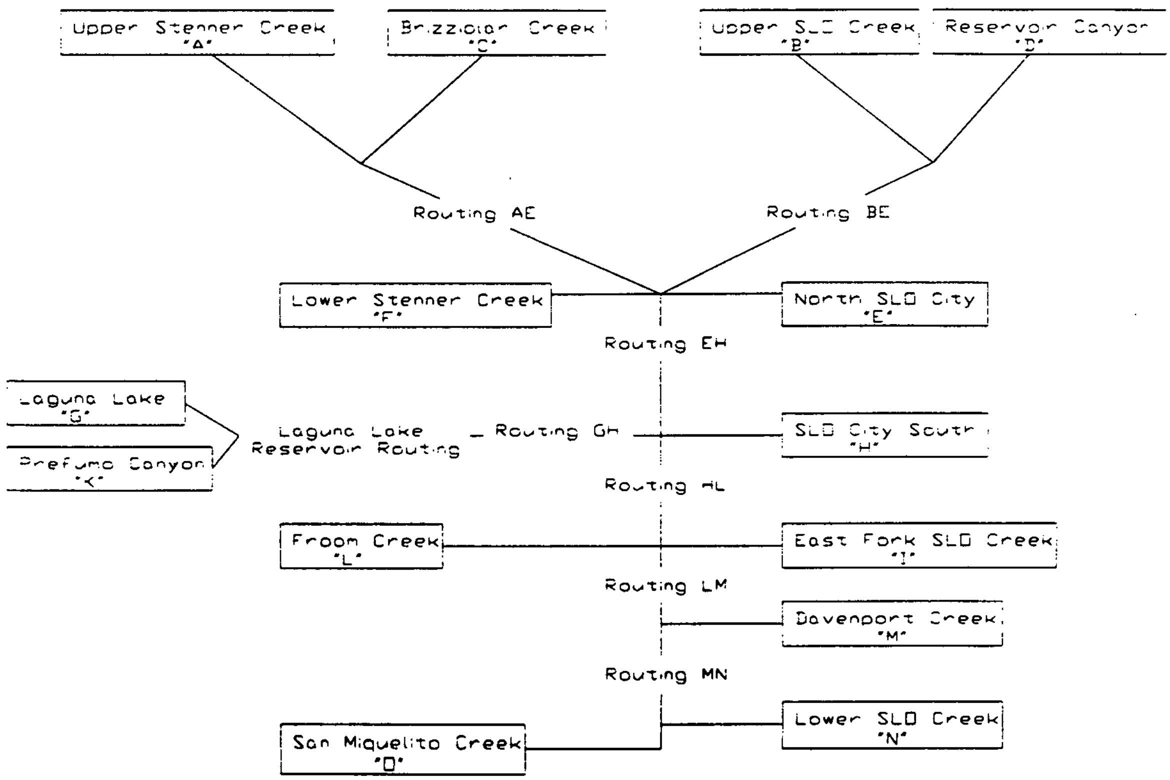
In addition to the field studies of the riparian corridors, hydrologic modeling analysis was applied to the watershed using a model developed by the Army Corps of Engineers.

The modeling simulates the existing conditions for comparison with simulated discharges from a pre-urbanized watershed condition. The purpose of this modeling was to determine two things. 1) Did the urbanization aggravate the peak flow of the floods and; 2) Would the urbanization of the watershed send the flood waters downstream before the flooding from above hit the city.

The figures below illustrate that urbanization has increased the peak flood flows. If the urbanization had an impact on the timing of peak flows hitting the city, we would expect to find two flood peaks in the model. On this point the results of the modeling were not conclusive, and only 1 peak flow was observed.

Hydrographs were generated for lower San Luis Obispo (SLO) Creek, between the confluence of SLO Creek and Prefumo Creek and the confluence of SLO Creek and San Miguelito Creek. The analysis was run for a 10 yr., 6-hr. storm and a 10 yr., 24-hr. storm. The two separate scenarios analyzed were: 1) Using the existing land use, and 2) Simulating a natural condition by replacing existing developed and agricultural fields with a combination of natural cover consisting of equal parts of woodland, grassland and chaparral. This was done to in order to approximate the effects of man-made changes on the storm response of the watershed. This is not a detailed analysis and the values derived during the analysis should be used only for relative comparisons. Although the model output has been checked against flow estimates based on field observations, there has been no systematic verification of the model output with actual data collected in the field. While it gives a good representation of the watershed's dynamics, a more detailed model is required if more accurate results are desired.

The model was developed using the U.S. Army Corps of Engineers HEC-1 "Flood Hydrograph Package" computer program. The watershed was divided into 15 subbasins (see sub-watershed analysis) and one reservoir (Laguna Lake). A schematic of the final model is shown in Fig. 3.1.



San Luis Obispo Creek Watershed
Figure 3.1 – Hydrologic Model Schematic

Note that there is no "J" sub-basin. This was combined with the "L" sub-basin during the analysis process. Also note that Harford Creek Sub-basin was not included in the analysis since it is downstream of the area of interest and empties into the intertidal zone. Lastly, the hydrographs at the confluence of SLO Creek and San Miguelito Creek do not include the discharge from San Miguelito (See Canyon) Creek.

Basic data for the sub-basins is given in table 3.1. The equation for calculating the "time of concentration"[1] for the sub-basins is as follows:

$$Tc = 0.00013\ L0.77\ S\text{-}0.385$$

One of the key parameters within the model is the Soil Conservation Service (SCS) curve number for each Sub-basin. The SCS curve number is a function of the hydrologic soil group and land use. The curve number determines the rate and amount of runoff. The higher the curve number, the higher the amount of, and the faster the rate of, runoff. Curve numbers were developed for each Sub-basin by overlaying a soils map with a land use map to obtain the percentage area of each Sub-basin covered by each hydrologic soil group and land use category. Based on these percentages, a cumulative curve number was arrived at for each Sub-basin. These curve numbers were then used in the model. The watershed is chiefly composed of hydrologic soil groups C and D. Groups C and D have slow infiltration rates and thus have a high runoff potential. The land use categories consisted of woodland, grassland, chaparral, developed and agricultural fields. The curve numbers used in the model are listed in table 3.2.

For the simulated natural condition, the developed and agricultural fields were assumed to be equal parts woodland, grassland and chaparral. Theoretically, this assumption gives lower values for the Sub-basin curve numbers which can cause decreases in the peak flows and can cause the peaks to occur later than the peak flows for the existing conditions. Table 3.3 shows the SCS curve numbers[2] used for each Sub-basin and each analysis scenario.

Table 3.2

Sub-Basin Name	Basin Area (sq.mi.)	L - Length of Longest Channel	S - Slope of Channel	Tc - Time of Concentration
A - Upper Stenner Creek	5.73	30000	0.07	0.993
B - Upper SLO Creek	5.43	23000	0.08	0.795
C - Brizziolari Creek	2.91	18000	0.07	0.674
D - Reservoir Canyon	4.86	18500	0.13	0.549
E - North SLO City	3.08	18000	0.03	0.941
F - Lower Stenner Creek	2.41	16000	0.09	0.577
G - Laguna Lake	9.5	24000	0.04	1.109
H - South SLO City	2.73	17000	0.07	0.654
I - East Fork SLO Creek	12.3	38000	0.02	1.846
K - Prefumo Creek	3.9	24000	0.06	0.931
L - Froom Creek	3.4	23000	0.04	0.985
M - Davenport Creek	6.85	34000	0.02	1.928
N - Lower SLO Creek	8.74	31000	0.04	1.29
O - San Miguelito Creek	7.97	31500	0.04	1.253
P - Harford Creek	4.45	24000	0.07	0.858

Laguna Lake was modeled as a reservoir routing. The lake was assumed to be full and even with the lake's outlet (118 ft. elevation). The outlet's elevation was obtained from Wayne Peterson of the City of San Luis Obispo. The outlet width was measured as 44 ft. and the coefficient of discharge was assumed to be 4[3]. The support structures under Madonna Road were not modeled. Good correlation between the predicted outlet discharge and known data was obtained, with predicted discharges of 915 cfs at 121 ft. stage and 1030 cfs at 121.25 ft. stage versus an actual discharge of 1000 cfs at 121.2 ft. stage.

Table 3.3

	SCS Curve Number	
Sub-Basin	Existing Conditions	Simulated Natural Conditions
A - Upper Stenner Creek	81	81
B - Upper SLO Creek	78	78
C - Brizziolari Creek	81	79
D - Reservoir Canyon	80	79
E - North SLO City	84	79
F - Lower Stenner Creek	86	76
G - Laguna Lake	82	81
H - South SLO City	87	79
I - East Fork SLO Creek	84	80
K - Prefumo Creek	77	77
L - Froom Creek	81	79
M - Davenport Creek	82	78
N - Lower SLO Creek	80	79
O - San Miguelito Creek	77	77
P - Harford Creek	76	76

B. SUMMARY OF HYDROLOGIC MODELING ANALYSIS

Hydrographs for the four scenarios analyzed in this report are presented in charts 3.1.1 - 3.2.2. The hydrograph analysis is summarized in table 3.4 below.

Table 3.4

Land Condition	Confluence of Prefumo Creek and SLO Creek			Confluence of SLO Creek and San Miguelito Creek		
	Time of Peak	Peak Flow (cfs)	Tot. Vol. (cu. feet)	Time of Peak	Peak Flow (cfs)	Tot. Vol. (cu. Feet)
10 Yr., 6-hr						
Natural	Day 1, 0405	7,384	105,588	Day 1, 0625	10,507	187,321
Existing	Day 1, 0405	8,624	117,799	Day 1, 0615	11,988	212,961
Change	0 min.	16.80%	11.60%	-10 min.	14.10%	13.70%
10 yr., 24-hr						
Natural	Day 1, 1300	10,949	257,382	Day 1, 1445	15,753	455,447
Existing	Day 1, 1300	11,967	275,129	Day 1, 1445	17,204	492,777
Change	0 min.	9.30%	6.90%	0 min.	9.20%	8.20%

Peak flows have increased about 15% for the 10 yr., 6-hr. storm, and about 9% for the 10 yr., 24-hr storm, between the simulated natural conditions and the existing conditions. Storm flow volumes have increased about 12.5% for the 10 yr., 6-hr. storm, and about 7.5% for the 10 yr., 24-hr storm, between the simulated natural conditions and the existing conditions. This indicates that development and agriculture have increased storm runoff compared to natural conditions, thereby contributing to higher peak flows and higher storm flow volumes during storm events.

There is no significant shift in the time of peak between the existing and natural conditions for the storm events analyzed. This indicates that the rate of runoff may be controlled more by the geometry of the watershed and its subbasins than by the various land uses and corresponding hydrologic soil groups.

The model output for a 25 yr., 24-hour storm was compared with peak flow estimates for the March 10, 1995 storm which flows were estimated to be equivalent to a 25 year storm event. The peak flows were estimated using Manning's equation and data collected in the field. The peak flow estimate for the Stenner Creek, due north of the KVEC Radio Tower, was 3,577 cfs using Manning's equation versus an estimate of 3,129 cfs using the model for the Upper Stenner Creek Subbasin. The peak flow estimate for SLO Creek, north of San Luis Bay Drive, was 32,725 cfs using Manning's equation versus an estimate of 25,826 cfs, summing all flows at the outlet of Davenport Creek in the model. Given the uncertainties in both the model and the estimates obtained using Manning's equation, there is a reasonable correlation between the model and some of the estimates made using Manning's equation.

Conclusion

This modeling effort has shown that flood peaks may have been exacerbated to some extent due to urbanization of the middle and lower SLO Creek Watershed. The assumptions made in the model, hoever, leave some uncertainty in the results. What cannot be ascertained is just how significant these peak flow increases with respect to increases in flood elevation and erosion along lower SLO Creek. However, this analysis does suggest that the present degraded channel condition may have been aggravated by rapid urbanization over the last decade. Additional analysis may be warranted to evaluate whether urban stormwater detention would significantly reduce in flood elevation and erosion in lower SLO Creek.

[1] Brooks, Kenneth N., etal. 1991. *Hydrology and the Management of Watersheds*. Iowa State University: Ames, Iowa. Pg. 326.

[2] USDA Soil Conservation Service, 1986. *TR 55 - Urban Hydrology for Small Water sheds*. Pgs. 2-5 through 2-8.

[3] Albertson, Maurice L., etal. 1960. *Fluid Mechanics for Engineers*. Prentice Hall, Inc.: Englewood Cliffs, New Jersey. Pg. 475.

[4] Reis, Gregory J., 1995. *The Estimation of Peak Flows During the March 10, 1995 Storm on San Luis Obispo Creek, Tassajara Creek, Stenner Creek, Chorro Creek and Brizziolari Creek Using the Manning Equation.* California Polytechnic State Univer sity: San Luis Obispo, California. Student Senior Project. Pg. 33 and 44.

CHART 3.1.1
10 yr., 6-hr Storm Hydrograph
Confluence of San Luis Obispo Creek and Prefumo Creek

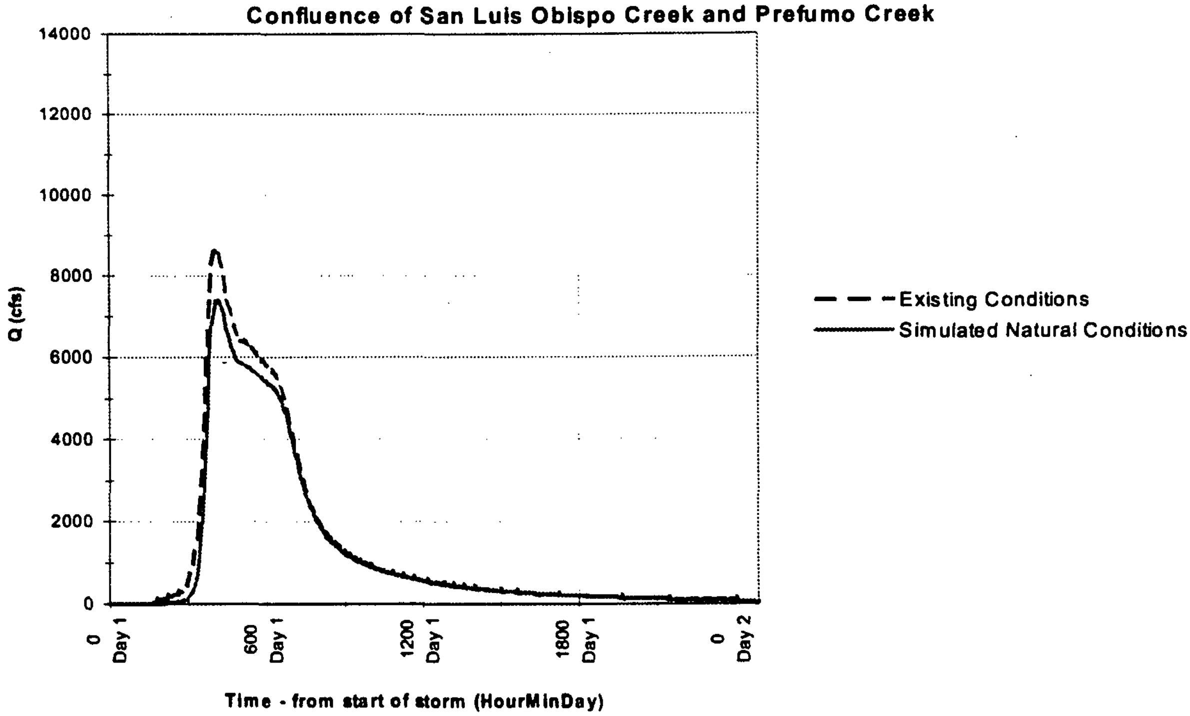


CHART 3.1.2
10 yr., 6-hr Storm Hydrograph
Confluence of San Luis Obispo Creek and San Miquelito Creek

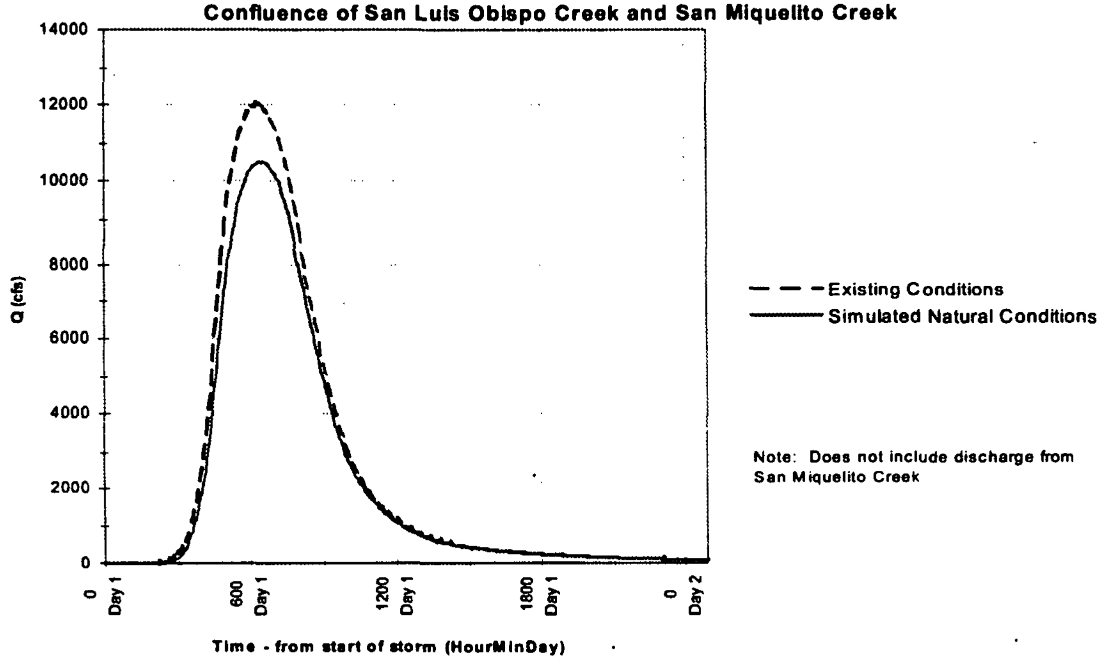


CHART 3.2.1
10 yr., 24-hr Storm Hydrograph
Confluence of San Luis Obispo Creek and Prefumo Creek

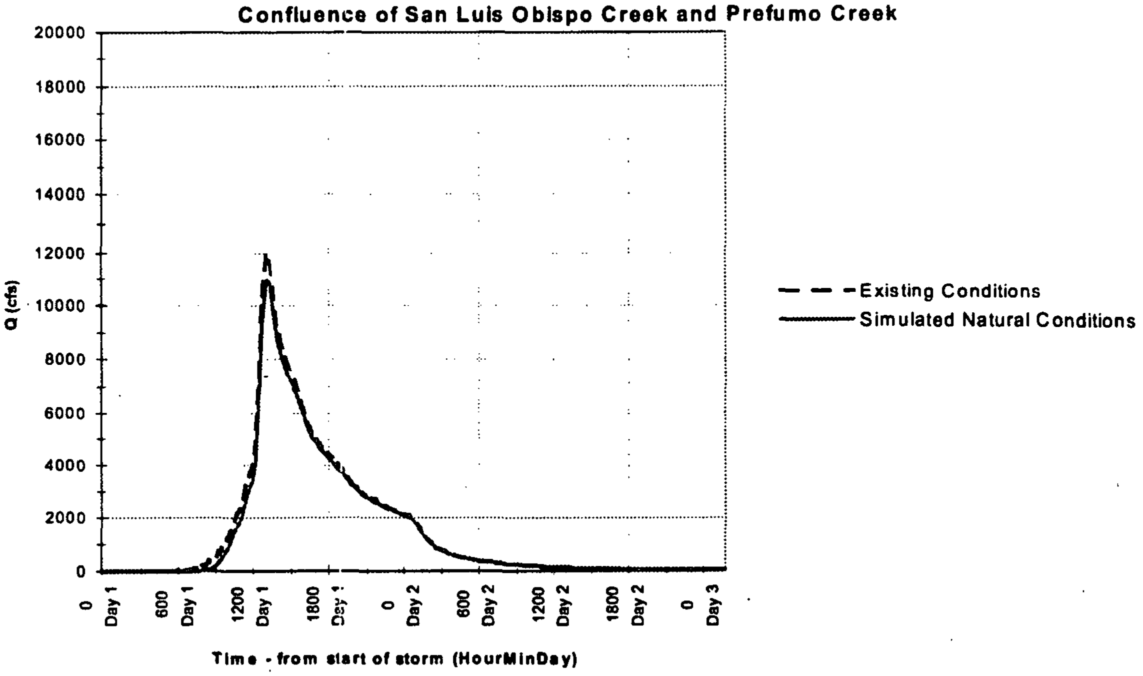
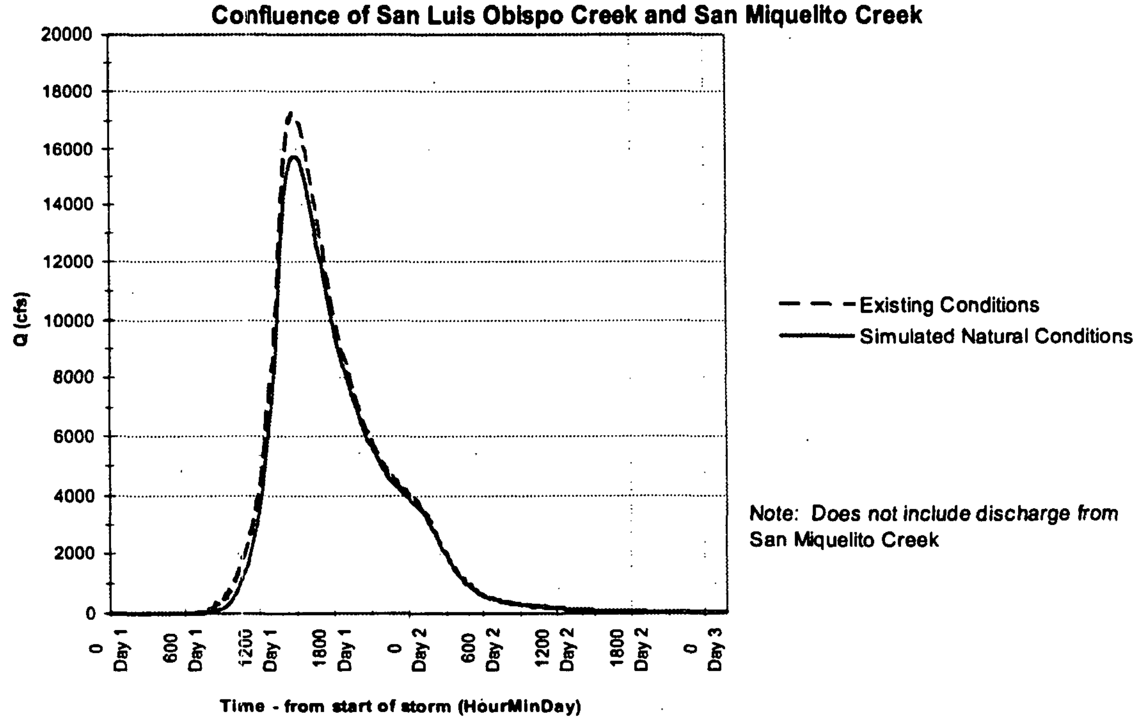


CHART 3.2.2
10 yr., 24-hr Storm Hydrograph
Confluence of San Luis Obispo Creek and San Miquelito Creek



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SAN LUIS OBISPO CREEK STEELHEAD TROUT HABITAT INVENTORY & INVESTIGATION 1995

August, 1996

Prepared for:

California Regional Water Quality Control Board
Central Coast Region
Contract No. 4-106-253-0

NRPI

Prepared by:

Paul A. Cleveland
Certified Fisheries Scientist
Land Conservancy of San Luis Obispo County
Central Coast Salmon Enhancement

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EXECUTIVE SUMMARY

The purpose of this study is to assist the Land Conservancy of San Luis Obispo County to identify restoration opportunities along the main stem of San Luis Obispo Creek. The Land Conservancy has completed two studies related to San Luis Obispo Creek and is continuing to undertake studies on issues of importance to water quality and habitat improvement. This study on Steelhead Trout habitat is considered critical to establishing baseline information and providing a specific characterization of habitat needs.

In this study, Steelhead Trout habitat and habitat components are inventoried by walking the main stem of San Luis Obispo Creek and using measurement methods developed by the California Department of Fish and Game. Research and interviews are conducted to investigate historical Steelhead Trout population sizes, fish stocking activities, and archived pre-1963 documents.

Habitat inventory indicates a severe lack of pool habitat. Sixteen miles of main stem San Luis Obispo Creek have 719 habitat units consisting of 14% riffles, 52% flatwater, 28% pools, and 6% dammed pools. The stream measures a mean width of 14.3 feet and mean depth of 0.9 feet. Stream width and habitat greatly varies above and below the City of San Luis Obispo's wastewater treatment facility.

Habitat components rate low. Most habitat types are only 13% covered with litle instream shelter. Vegetation covers only 40% of the stream banks and overhead canopy is present in only 30% of the stream. Substrate is filled with sediments that embed spawning gravel 50-100%. Invasive non-native vegetation is common throughout the study area.

Flood control, while necessary in urban areas, appears to be the major causative factor driving the removal of hard, pool creating objects, the associated proliferation of sediment from eroding stream banks, and the lack of instream shelter and related cover. A more selective procedure for clearing vegetation at the water's edge could meet the needs of both flood control and fish habitat. Efforts to incorporate pool creation (strategically placed boulders and logs) into flood control management and stream bank stabilization projects could prove very beneficial.

In addition, instream shelter and cover can be created by restoring a continuously vegetated riparian corridor along the creek. Riparian restoration should include planting a wide variety of understory and tree species, especially Sycamore trees which have been found to contribute substantially to trout habitat. Temporary log matts could also provide seasonal shelter and cover.

Eight potential fish passage barriers include a weir, check dams, culverts, and natural

cascades. Temporary passage barriers made from hand-stacked rocks are also present. These barriers can be improved by cutting a notch in the weir, adding additional check dams, baffling culverts, creating step pools below the cascades and removing illegally hand-stacked rock barriers.

Fish stocking records estimate 25,000 trout stocked per year from 1967 to 1991 into Laguna Lake on the Prefumo Creek tributary. These fish had access to San Luis Obispo creek during winter months when the lake overflowed. Catfish and carp have also been stocked. The carp have proliferated in the lower stretches and their eradication could provide an opportunity for native trout to re-establish.

Steelhead Trout population surveys were conducted for various portions of the creek from 1966 to 1994. The annual adult run of steelhead was estimated at 200 fish in 1972, 117 fish in 1973 and 179 fish in 1975. The juvenile trout population was estimated for areas above the wastewater treatment facility and in stretches above the City of San Luis Obispo. Above the wastewater treatment facility population estimates ranged from thirteen to twenty-six trout per 100 meters in 1966 and again in 1975. Upstream from the City of San Luis Obispo, a 1975 survey found 174 trout per 100 meters; a second 1975 survey found 269 trout per 100 meters; and a 1985 survey estimated 186 to 311 trout per 100 meters. Due to residual chlorine and un-ionized ammonia toxicity, no trout were found downstream of the wastewater treatment facility effluent prior to 1994 [In 1994, water quality improvements were operational].

INTRODUCTION

Natural production of Steelhead Trout (Oncorhynchus mykiss) in California has greatly declined as the result of many projects which have provided valuable economic growth. Such projects have reduced fish populations by affecting their habitat, adjacent riparian vegetation, spawning areas, migration routes, and most significantly, water flows (California Department of Fish and Game (CDFG), 1995).

Fish are an important public resource with significant economic, environmental, recreational, aesthetic, and educational values. The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act declares that it is the policy of the State of California to increase the state's salmon and Steelhead Trout resources. This is to be accomplished by improving and protecting stream habitat (CDFG, 1995).

In order to make recommendations about the most effective and cost-efficient restoration needs, it is imperative to know the location of fishery resources, relative population sizes, the quantity and quality of available habitat, and the most significant factors limiting fish production.

San Luis Obispo Creek is one of several streams in San Luis Obispo County which historically and cyclically has had a large, self-sustaining population of Steelhead Trout. As recently as the early 1930s, during the Depression years, "if one had nothing else for dinner, there were always the fish in San Luis Obispo Creek. During those disastrous years, the creek literally fed many people, just as it had once fed the Mission Padres and the Chumash Indians" (McKeen, 1988).

Because of land use and instream activities which have adversely affected instream habitat as well as increasing demands on water resources, the Steelhead Trout population has been severely reduced. To better understand the existing condition of steelhead resources, an extensive evaluation of habitat, historical records (Appendix A), passage barriers, and fish stocking records has been completed. This report describes the results of this inventory and investigation.

People and Fish Use the Watershed

The creeks in the San Luis Obispo Creek watershed provide many functions and are viewed in different ways depending on who is asked. Flood control interests view the creeks as an obstacle-free conduit of water. Sewage facility operators see the creeks as a laboratory for maintaining water quality. Agriculturists find a source for irrigation water. Landowners are mixed between protecting a public resource and clearing a view for themselves. Biologists value the ecology and importance of fish and wildlife habitat. Residents and tourists are charmed by the rippling flow.

Since the founding of the City of San Luis Obispo in the mid 1800's there has been disagreement over which of these functions is most important. A newspaper clipping from 1874 calls the creek nothing more than a sewer that is taking up too much space in the city (The Tribune, 1874). In the 1930's the creek was a liability if flooding and only useful for irrigation, watering stock and fishing. By the mid-1950's there was a gallant effort to center the town plaza around a flowing stream (McKeen, 1988). It was not until 1989 that the Water Quality Control Plan for the Central Coast Region first established a list of beneficial uses in the watershed that were to be protected and respected by all interests.

The 84 square mile San Luis Obispo Creek watershed is surrounded by rough mountainous terrain that drains in a southwesterly direction. It is characterized by slightly compacted granular clay loam in the upper watershed and fine sandy loam in the lower reaches. San Luis Obispo Creek originates at an elevation of approximately 2,200 feet in the Santa Lucia mountain range near Cuesta Pass (Hallock et.al., 1994). In its eighteen mile descent to the Pacific Ocean it is joined by the three perennial tributaries of Reservoir, Stenner, and See Canyon Creeks; the four seasonal tributaries of Prefumo, Froom, East Fork, and Davenport Creeks; and several seasonal minor drainages. Effluent from the City of San Luis Obispo sewage treatment facility also contributes to the flow.

In these streams very few species of fish are present simply due to the fact that they can not reach San Luis Obispo except by ascent from the sea (Jordan, 1895). In fact, only five native species reside in this watershed (Steelhead Trout, Prickly Sculpin, Threespine Stickleback, Speckled Dace, and Pacific Lamprey). Although there is not a great variety of fish, we do know that the local creeks have a history of good trout fishing.

A 1954 creel census (fishermen survey) indicated that San Luis Obispo Creek had more angling effort than any other stream in the region (except the Russian River) when a Steelhead Trout catch of 2,685 fish was sampled (CDFG, 1955). In that same year, popular account describes a deep pool in Mission Plaza "where anyone could catch a fish. You could almost drop a line from the sidewalk." (McKeen, 1988). If fishing was that successful in 1954, one can only imagine how good it was prior to 1861 when "trees of large size lined the banks of all streams in the region." (Daily Republic, 1890).

Adult Steelhead Trout were not counted in the watershed until 1972 when CDFG estimated a good year run of 200 fish. Juvenile trout were first counted in 1966 with findings of 13 to 26 trout per 100 meters in the main stem (Titus, 1996).

Numerous other fish surveys have been completed over the past thirty-five years, each of them finding Steelhead Trout in local streams (Tamagni, 1995). Few of these recent surveys have extensive coverage or detail and because of the lack of historical data, we may never know the amount of fish production that once occurred in the watershed.

Habitat Types and Components

The focus of this report is on trout habitat and the components that enhance this habitat. The three basic habitat types are pools, riffles and flatwaters.

In general, pool habitat is the areas of calm water, typically located along the margin of streams, which provide calm cool surroundings for large and small fish. Riffle habitat is swiftly flowing stretches with exposed rocks that provide a niche for small fish, mix oxygen into water, and produce an important food source of insects. Flatwater habitat is moderately flowing stretches with little or no flow obstructions that, if deep and swiftly flowing, can provide territory to larger fish.

For this study, each of these habitat types was further subdivided (Level IV Classification) into nine types of pools, three types of riffles, and three types of flatwater, as listed in the Results section.

Each of these habitat types can be enhanced, thereby making them more desirable to fish, by the presence of attributes, or components of habitat. These components include substrate, instream shelter, cover, stream bank vegetation and overhead canopy.

Substrate is the material that forms the bed of the stream such as boulders, gravel, cobble, sand, silt, and bedrock. Instream shelter is the material within the water column that provides a place for fish to rest, protection from predation, and a separation of fish territories. It may include undercut banks, woody debris, root mass, aquatic and terrestrial vegetation, bubble curtains, and boulders. Cover is the area of a habitat that is occupied by instream shelter when looking down at the unit (or looking up if you are a fish). Stream bank vegetation is the unique riparian plant life that provides leaf litter and woody debris for primary productivity. It can filter sediments and contaminants from water entering the stream and reduce water flow to trap spawning gravels. It can also contribute to instream shelter, cover and overhead canopy. Overhead canopy is the vegetative mass produced by trees and large shrubs that inhibits solar radiation and maintains a cooler water temperature.

A variety of measurements are made to describe each of these habitat types and habitat components. Habitat types are measured by length, width and depth. Pools have two additional measurements of tail pool crest and substrate embeddedness. Tail pool crest is the depth where water exits the pool, measured from the top of the pool to the surface of the water. This measurement allows one to predict how deep a pool would be if there were a cessation of stream flow. Substrate embeddedness refers to the amount of sediment surrounding the substrate at the pool tail. Because trout typically spawn at the tail of a pool, less embedded pool tail substrate is higher quality spawning gravel.

Habitat components are measured by percentage of occurrence and dominant occurrence. In addition, an instream shelter complexity rating is made based on the quantity and composition of the instream shelter. In other words, the rating takes into account the cover provided by instream shelter and the diversity of this shelter (ie. undercut banks, woody debris, root mass, aquatic and terrestrial vegetation, bubble curtains, and boulders).

METHODS

Habitat Inventory

Methodology followed guidelines presented in the second edition of the California Salmonid Stream Habitat Restoration Manual (Flossi and Reynolds, 1991). Habitat inventory was modified using Sampling Levels For Fish Habitat Inventory (Hopelain, 1994).

The main channel of San Luis Obispo Creek was divided into fifteen reaches in the San Luis Obispo Creek Hydrologic Survey (Land Conservancy, 1996). A graphic delineation of these reaches is provided in Figure 1 and the linear distance of each reach is given in Figure 2.

Each habitat, as defined in the Restoration Manual, was identified and measured by length. Level four classification separates riffles on the basis of water surface gradient; flatwater on the basis of depth and velocity; and pools by either location within the channel or the cause of scour (ie. boulder, bedrock, rootwad, or log) (Nelson, 1994).

Inventory components were collected by walking the stream from the bridge at San Luis Bay Drive and Avila Beach Road to Stagecoach Road at Highway 101 on the Cuesta Grade. The inventory took place during the months of November and December, 1995.

For every ten individual habitat units identified, one was randomly selected with the following parameters measured: length, mean width, mean depth, maximum depth, primary and secondary substrate components, percent instream shelter, instream shelter complexity, percent total canopy, dominant right and left bank composition and percent vegetated, depth and substrate embeddedness of the pool tail crest, and comments. Stream slope was also measured in descriptive areas. Equipment for making measurements included a measuring tape, stadia rod, spherical densiometer (for measuring total overhead canopy), and sight mark level.

Historical Records

Historical data in relation to San Luis Obispo Creek was found at the San Luis Obispo County Museum, the Department of Fish and Game, and by interview.

Passage Barriers

Barriers to fish passage were identified while making inventory measurements. For the purpose of this survey, a barrier was defined as any structure, natural or manmade, that had the potential to inhibit the up or downstream movement of small or large fish.

Fish Stocking

Jim Adams, California Department of Fish and Game's Fillmore Hatchery Manager was contacted by telephone for fish stocking records.

RESULTS

Habitat Inventory

Sixteen miles of main stem San Luis Obispo Creek had 719 habitat units which consisted of 13.9% riffles, 51.7% flatwater, 28.5% pools, and 6.2% dammed pools (Figure 3).

The stream measured a mean width of 14.3 feet, mean depth of 0.9 feet, and maximum depth of 5.0 feet. Inventory components are summarized for each reach and the entire study length in Appendix B.

As shown in Figure 4, the stream width varied greatly above and below the treated sewage effluent of the Wastewater Reclamation Facility (WRF). This facility provided records to indicate an approximate stream flow (for November, 1995) above the facility of 2.0 cfs and a flow of 12.1 cfs downstream of the facility (Fairchild, pers. comm.). Accordingly, the description of predominant habitat types, flatwaters and pools, also differ (Figure 5).

Above the wastewater facility, 44 pools had a mean length of 26.2 ft, width of 9.7 ft, and depth of 0.9 ft. Maximum pool depth was 3.8 ft. Tail pool crest averaged 0.4 ft with embeddedness of 50 - 75%. The mean pool unit cover was 11.9%. The 212 flatwater habitats had an average length of 167 ft, width of 8.8 ft, and depth of 0.5 ft. The mean flatwater unit cover was 6.2%.

	Above WRF	Below WRF
No. of Pools	44	166
Mean Pool Length (ft)	26.2	57.1
Mean Pool Width (ft)	9.7	17.8
Mean Pool Depth (ft)	0.9	1.4
Maximum Pool Depth (ft)	3.8	5.0
Mean Pool Cover (%)	11.9	23.6
Number of Pools > 3.0 ft	1	15
Tail Pool Crest (ft)	0.4	0.7
Embeddedness (%)	50 - 75	75 - 100
No. of Flatwaters	212	246
Mean Flatwater Length (ft)	167.0	111.0
Mean Flatwater Width (ft)	8.8	17.7
Mean Flatwater Depth (ft)	0.5	0.7
Mean Flatwater Cover (%)	6.2	12.9

Below the wastewater facility, 166 pools had a mean length of 57.1 ft, width of 17.8 ft, and depth of 1.4 ft. Maximum pool depth was 5.0 ft with only fifteen pools 3.0 ft or greater. Tail pool crest averaged 0.7 ft with embeddedness of 75 - 100%. The mean pool unit cover was 23.6%. The 246 flatwater habitats had an average length of 111 ft, width of 17.7 ft, and depth of 0.7 ft. The mean flatwater unit cover was 12.9%.

Instream Shelter Complexity Rating

Habitat units were 13.4% covered, predominantly by aquatic watercress vegetation. Because this cover was created by only one or no instream shelter components, the instream shelter value averaged 0.7. By multiplying the percentage of cover by the instream shelter value, a mean instream shelter complexity rating of 9.4 was calculated out of a possible range of 0 to 300 (Figure 6).

Overhead Canopy

Overhead canopy (Figure 7) averaged 30.2% with prominent species of willows, walnuts, sycamores, and oaks. In addition, the lower reaches (2 & 3) had many box elders and cottonwoods, while middle reaches (8 & 9) and the upper reach (15) had numerous mature eucalyptus.

Stream Bank Vegetation

The creek banks had a dominant composition of silt, clay or sand and a dominant vegetation of brush or deciduous trees. Overall, right and left creek banks were 40% vegetated, leaving 60% as bare eroding soil, bedrock, or revetment.

Throughout the study area an invasion of non-native pests included giant reed and german ivy. Castor bean was common in the areas of reaches seven through nine.

Historical Records

An annotated bibliography in Appendix A provides a summary of pre-1963 newspaper clippings, interviews, Fish and Game files, and a book.

Passage Barriers

Eight potential barriers to fish passage included the Marre Dam in Reach 1; fish ladder under Highway 101 in Reach 3; small check dam near Bianchi Lane in Reach 10; 4' bedrock cascade under the city in Reach 11; check dam and culvert at Highway 101 below Cuesta Park in Reach 13; 5' bedrock cascade in Reach 15; and culvert at Highway 101 and Stagecoach Road in Reach 15. Temporary passage barriers made out of hand-stacked rocks were found in Reach 13.

Fish Stocking

Department of Fish and Game fish stocking at Laguna Lake, in the San Luis Obispo Creek watershed occurred from 1967 to 1991. Approximately 25,000, one-third pound, trout were planted every year between the months of November and April. These trout were of a strain originating at Coleman and Mt. Whitney hatcheries.

Fish stocking from miscellaneous receipts obtained in CDFG files have also been found which indicate that there are additional stockings left undiscovered. Known fish stockings are as follows:

Date	Stocking Site	Species	No. of Fish	Hatchery Source
1967-1991	Laguna Lake	Trout	25,000/yr	Fillmore
Aug. 17, 1971	Laguna Lake	Catfish	16,000	?
July, 27, 1978	Laguna Lake	Catfish	15,000	Imperial Valley
April 16, 1979	See Cyn Bridge	Steelhead	4,500	Mad River
April 23, 1980	See Cyn Bridge	Steelhead	1,500	Mad River
Oct. 1, 1980	Laguna Lake	Catfish	1,140	Imperial Valley

Steelhead Trout Population Estimates

Titus (1996) researched and compiled CDFG population surveys of San Luis Obispo Creek which are presented in this section. He reports that visual surveys in 1958 and 1960 found rearing habitat in the lowermost creek and spawning gravel in the upper reaches. While trout populations were not estimated, heavy angler pressure was noted. In a 1966 survey (commonly called the "Nokes Study"), Titus describes a cresol sample that estimated trout populations in the lower creek to range from thirteen to twenty-six trout per 100 meters. During this same survey, a bioassay showed that trout could survive only one-half hour below the wastewater treatment facility discharge due to residual chlorine toxicity.

Adult Steelhead Trout were not counted in the watershed until 1972-73 when CDFG estimated an good year run of 200 fish. This study was repeated in 1973-74 with an estimate of 117 adult fish. During these surveys, adult fish were found to range from three to five years age with sizes ranging from fourteen to thirty inches.

The first watershed-wide juvenile trout count took place in 1975 under the direction of Cal Poly professor, Dr. Barclay. This survey found an average of thirteen trout per 100 meters in main stem San Luis Obispo Creek downstream of the Stenner Creek tributary. The upper stream and perennial tributaries averaged 174 trout per 100 meters. This disparity in trout counts was attributed to the poor water quality of the lower stream due to effluent from the wastewater treatment facility.

A second 1975 survey, conducted by CDFG, estimated the trout population in upper San Luis Obispo Creek to average 269 trout per 100 meters. Calculations of the adult population required to produce these offspring was estimated at 179 adult steelhead.

A 1985 CDFG survey had findings similar to those in 1975 with findings in the upper creek that ranged from 186 to 311 trout per 100 meters. No trout were found below the wastewater effluent discharge point.

The latest qualitative survey, conducted by CDFG in 1994, observed juvenile trout in lower San Luis Obispo Creek below the wastewater discharge. No population estimates were made.

DISCUSSION

Steelhead Trout Lifecycle

Adult Steelhead Trout enter San Luis Obispo Creek between January and March during the subsidence of highwater storm flows. In all accessible areas they find suitable gravel and lay eggs that hatch in about 20 days (at 58°F). Within two to three weeks after hatching, fry emerge from the gravel and, if necessary, emigrate to perennial streams (Barnhart, 1986).

Small schools of young trout fry live along the stream banks in shallow water. As they grow, the schools break up and individual fish defend their territory. Most steelhead tend to inhabit riffles during their first year with the larger fish inhabiting deep fast runs or pools (Barnhart, 1986).

After approximately two years of feeding on a variety of aquatic and terrestrial insects, some steelhead migrate to the ocean. All steelhead do not migrate and those that remain in the stream are called "resident" Rainbow Trout. Little to no genetic variation has been found between these two forms of the same fish (McEwan, 1996).

In the ocean, steelhead grow rapidly for one or two years before returning to spawn. Their distribution in the ocean is not completely known but some evidence suggests they roam north and south along the Continental Shelf. Most Steelhead Trout will repeat their migration to spawn two to three times (Barnhart, 1986).

Habitat Types and Components

Physical and chemical features of instream habitat are closely related to land uses in the surrounding landscape. The habitat needs of trout are rather precise and alteration of this landscape can have profound impacts on the creation or destruction of different habitat types and their attributes (Meehan, 1991).

The following discussion will present the habitat types and habitat components inventoried in this study, their use by Steelhead Trout, and the impact of land use activities.

Pools

Pools appear to be created and maintained by water continuously hitting hard objects, thereby causing a turbulence (eddy current) which scours depressions in the stream bottom. Such hard objects include boulders in the stream and branches that extend over the waters edge. Inventory results show that only one-quarter of the habitat is pools (50% is preferred), most of which are shallow (less than three feet deep), without instream shelter, and therefore, of poor quality. The majority of these pools, 166 out of 210, are located below the Wastewater Reclamation Facility in a seven mile stretch to the ocean.

Probable cause for the low percentage of pools is the removal of vegetation and other hard, pool creating objects, by municipalities and landowners, under Fish & Game agreement, for flood control.

The most complex and desirable pools were formed by rootwads of large trees, especially sycamores. These pools, continually maintained through natures design, provide deep, covered, complex instream shelter.

Dammed Pools

Dammed Pools are created by manmade barriers such as the Marre Dam in Avila Beach, and several handmade cobble dams in the City of San Luis Obispo, that create pools for pumping water. They do not appear to provide good habitat. They have poor shelter, silt substrate, and limit upstream passage if a small fish should happen to move below the barrier. If the dams creating these pools were removed, the resulting habitat would most often be flatwater. Therefore, these Dammed Pools have not been included in the Pool category. Inventory results show that Dammed Pools comprise 6.2% of the habitat.

Riffles

Riffles are created when cobbles and boulders are deposited in the stream channel. Their deposition appears to occur during the initial subsidence of storm water flows and in the eddy currents created by pool forming turbulence. Inventory results show that 13.9% of the stream consists of riffles. These are food producing areas and provide habitat to very small fish (Chamberlin, 1991). They are characterized as shallow, swiftly flowing turbulent reaches with exposed substrate (Flossi and Reynolds 1991). The turbulence in a riffle appears to mix oxygen into the water and supply it to downstream pools.

Riffles were found in downstream reaches four through seven and upstream reaches ten through thirteen. They were also found in reach fifteen. While this author is not familiar with a preferred percentage for riffle habitats, it does appear that the addition of riffles in lacking reaches would be beneficial. The cause for an apparent shortage of riffles may be associated with an abundance of silt substrate, a lack of pools and vegetation, and the absence of large cobble or boulders.

Flatwater

Flatwater predominates San Luis Obispo Creek with 51.7% of the habitat units in this category. Comprised of glides, runs, and step runs, flatwater is moderate to swiftly flowing reaches with little surface agitation and lacking major flow obstructions. The majority of flatwater is evenly divided between runs and glides. These sub-habitat types differ only slightly in morphology with runs having shallow, agitated flows and glides having calm surface waters, a wide uniform channel bottom, and a variety of water depths.

Flatwater can provide habitat to larger fish if it is deep and swiftly flowing (Barnhart, 1986). The mean flatwater depth of 0.7 ft below the wastewater facility and 0.5 ft above this facility would probably not qualify as "deep". No trout were seen in these habitats, although an abundance of dace and stickleback were observed. Also contributing to the lack of trout was the poor instream shelter in flatwater habitats, ranging from 6.2% upstream to 12.9% downstream of the WRF, which may increase chances for predation.

As with riffles, this author is not familiar with a preferred percentage for flatwater habitat. It does appear that overall habitat could be improved by breaking the long stretches of flatwater with pool and riffle habitats. An example of this can be found in reach fifteen where one flatwater habitat is nearly two miles long - this is a lengthy distance for a fish to swim without a pool to rest or a riffle to add oxygen.

Substrate

Clean gravel substrate, required for spawning, is found only in Reach 15, a two mile flatwater habitat up Cuesta Grade. The dominant substrate throughout the remaining fourteen miles of stream consists of silt, clay and sand. While gravel or cobble is often the co-dominant substrate, it is 75 - 100% embedded with sediment, making it poor for spawning (less than 20% sediment is preferred). The winter rains may flush the gravel long enough for fish to spawn, but continuing erosion can quickly fill interstitial spaces and smother deposited eggs. Substrate is also important to the production of an insect food source and it has been found that an increase in fine sediments will lead to a decrease in insect productivity (Bjornn and Reiser, 1991).

The source for much of these sediments in San Luis Obispo Creek appears to come from eroding creek banks due to vegetation removal (flood control), cattle access, and encroaching development. Additional sources include runoff from agriculture fields and erosion resulting from the "Highway 41 Fire" of 1994. This sediment does not enter the stream continually, but during episodic events such as large storms (Swanston, 1991).

Instream Shelter Complexity Rating

Habitats in San Luis Obispo creek have very little cover, averaging 13.4%, and poor complexity, averaging 0.7 (from a range of 0 - 3). While the mean instream shelter complexity rating is 9.4 there is a notable increase to 62.2 in Reach 4. This reach is different from other reaches for one pronounced reason: no flood control measures have been taken to remove instream or stream bank vegetation and woody debris.

Elsewhere, the majority of instream shelter consists of aquatic vegetation, mostly watercress, followed by overhanging terrestrial vegetation, root mass, and undercut banks. Woody debris, in the form of broken branches and logs, is almost completely absent. This is a significant missing feature because woody debris not only provides instream shelter and cover, but it also forms the basis for primary productivity in the food chain and nitrogen fixation (Meehan, 1991).

Overhead Canopy

In its contribution to fish habitat, overhead canopy, produced by trees and large shrubs, is vital to reducing solar radiation and maintaining a cooler water temperature. Overhead canopy was the least dense from a point one-mile upstream of San Luis Bay Drive to the Marsh/Higuera Street intersection (Reaches 5 through 10). Hallock (et.al., 1994) found that this section of stream has significantly higher water temperatures than other sites - the primary reasons for which are the lack of canopy and warm water effluent from the wastewater treatment facility. Their suggestion for reducing temperature is to restore and maintain a continuous riparian corridor along the stream.

Overhead canopy also provides important cover and instream shelter (leaf litter and woody debris) as well as stream bank stabilization. Under Pools, above, tree roots and branches were identified as responsible for forming the most complex and desirable pools. Observations indicate that Sycamore trees are also the most capable of reaching long branches across streams and providing all of the attributes associated with canopy.

Bank Vegetation

The relationship between stream bank, or riparian, vegetation and healthy trout habitat is a strong one. Riparian vegetation is unique to wetlands, such as stream banks, and influences stream ecology in many ways. Its deep root system helps stabilize banks against erosion and maintain undercut areas that trout utilize as instream shelter. Its roots, branches and leaves act as a buffer that filters sediment and contaminants from water before it enters the stream. It provides leaf litter and woody debris. It causes roughness that slows water velocity, traps gravel for use in spawning, and harbors insects that drift into streams to feed trout.

A local newspaper story (White, 1996) provides anecdotal information which sums the contribution of bank vegetation to stream bank integrity and erosion control. In this story, a bridge washed out after vegetation was removed:

During the heavy storms a year ago in January, the bridge held firm. In February, the county cleaned out the creek bed, removing vegetation and debris from the Highway 41 fire to prevent potential flooding. Then in March, more torrential rain came. The creek was bare and clean and the water moved much faster. On March 10, the mud in the creekbed turned to goo and the foundations for the bridge sank. Then the rushing water began to eat away at the dirt sides of the banks and the bridge fell in.

In San Luis Obispo Creek the stream bank vegetation is fragmented throughout the study area. Most lacking of vegetation is the downtown city stretch from the Marsh/Higuera Street intersection upstream to Cuesta Park (Reaches 11 & 12). Also lacking stream bank vegetation are Reach 6, downstream, and Reaches 13, 14, and 15, upstream.

Stream Width and Depth

The depth of the stream remains fairly constant throughout the study area at an average of 0.9 feet. The average width, however, changes considerably in two stretches. Below Los Osos Valley Road (Reach 8-1), the average width almost doubles from eleven feet to twenty-one feet. Above Cuesta Park, in Reaches 13 &14, the average width doubles from six feet to twelve feet.

These width increases appear to have natural and man induced causes. The natural causes are the merging of tributary streams that increase flow rates and carry away erosive soils during flash flood episodes. In the downstream stretch, this natural process seems to be exacerbated by non-porous paving in the City of San Luis Obispo which increases runoff and associated erosion.

The main cause of the upstream width increase, and contributing to the downstream stretch, is possibly due to years of improper livestock grazing practice, the impacts of which are well documented.

Away from the stream, livestock change vegetative composition and compact soil, thereby increasing runoff and erosion. Near the stream, livestock compact soil and trample vegetation which weakens the stream bank integrity. In San Luis Obispo Creek, the stream banks have a high content of clay which, when compacted, tends to break off in large clumps. The combination of increased erosion, reduced vegetation, and stream bank instability, lowers the water table and causes streams to become wider and more shallow (Meehan, 1991).

Barriers to Fish Passage

Barriers in San Luis Obispo Creek cause two negative effects. They inhibit the opportunities for fish to freely travel up and downstream. They also alter habitat by creating dammed pools, as previously discussed.

Most barriers in the main stem of San Luis Obispo Creek are probably not what is frequently referred to as a "migration barrier," as they do not impede the upstream movement of adult fish during episodes of high water. Two possible exceptions are the culverts that cross under Highway 101 above Cuesta Park and at Stagecoach Road on Cuesta Grade. These "velocity barriers" can impede adult fish migration by causing water flows in excess of a fishes ability to swim against the current. They can easily be improved by adding baffles to create areas of backwater.

Another possible "migration barrier" that deserves special recognition is the Marre Dam in Reach 1. In 1969, this steel plate dam was constructed to produce a source of freshwater by preventing seawater intrusion into the ground and surface waters. A ladder for fish passage was not installed until two years after construction of the dam. That fish ladder was ineffective and later replaced by a DeNil fishway which today is rusted through and functional only at higher tides. A possible solution to the passage problems created by this dam would be to cut a low flow notch in the steel plates (Leggett, 1994).

All of the other barriers are more of a problem for small fish during summertime low flows. Trout are very territorial. If food is limited, big fish chase small fish away. When a barrier is present, small fish can move only downstream. Once a fish drops below a barrier there is no going back.

Of the six low-flow barriers inventoried in San Luis Obispo Creek, two have fish ladders, two are natural bedrock cascades, and two are manmade check dams (all locations given in Results section). The check dams maintain a gradient that prevents the creekbed from eroding at the base of culverts. At the time of their installation they work well, but after a period of time, they create their own barrier as water erodes away the creekbed below them. Installation of additional check dams would improve conditions by creating a series of steps that small fish can pass over. This approach would also improve the bedrock cascade barriers.

Fish Stocking

Although most of the estimated 625,000 stocked trout were planted in Laguna Lake on the Prefumo Creek tributary, they did have access to San Luis Obispo Creek whenever the lake overflowed during the rainy season. In 1991, a new area Department of Fish and Game Biologist put a stop to stocking in the watershed since this practice was in direct conflict with Steelhead Trout policies. Such guidelines were established based on salmon studies that found fish stocking tended to introduce competition for space and food, disease that could transfer to wild fish, and a false sense of stream health [assumption: if a stream has fish, it is healthy](McEwan, 1996).

Recreational fishing is very popular and receiving increased attention in waters with thriving fisheries (Hunter, 1991). If a thriving fishery is the goal for San Luis Obispo Creek, three options could be considered. Habitat can be improved to increase natural production; habitat can be improved to support stocking, at a risk of replacing natural production; or fishing can cease - it is already limited to a short season in the lower creek.

Interference with Habitat

Carp, a non-native fish flourishing in the lower reaches are known to interfere with native fish habitat. They dig up aquatic plants, disturb substrate, and increase suspended matter in the water (Moyle, 1976). The stretch of creek below the wastewater treatment facility was directly toxic to Steelhead Trout from either chlorine or un-ionized ammonia for nearly twenty-five years. During this time, hardy carp had an opportunity to proliferate and it appears they were successful. While this inventory did not specifically look for fish, many large carp were seen in downstream reaches 2 through 8. Now that water quality has been greatly improved in this area, it might be effective to try and eradicate carp so that the native trout will have a better chance to re-occupy the area.

CONCLUSION

Steelhead Trout on the Central Coast are an opportunistic species with precise habitat needs. They require clean gravel for spawning, deep cool pools to survive the heat of summer, instream shelter to hide them from predators throughout the year, and lively riffles to produce an insect food source.

Findings that limit Steelhead Trout production in San Luis Obispo Creek are described as follows:

€ The most limiting habitat type is pools.
€ One most likely cause for the lack of pools is the removal of hard objects that create them and the high sediment loads that fill them.
€ All habitat types lack instream shelter and associated cover.

€ Habitat could be improved by selective vegetation removal and restoration of a continuous riparian corridor, especially with Sycamore trees.

Flood control, while necessary in urban areas, appears to be the major causative factor driving the removal of hard objects, the proliferation of sediment from eroding stream banks, and the lack of instream shelter and associated cover. A more selective procedure for clearing vegetation at the water's edge could meet the needs of both flood control and fish habitat. Modified clearing and maintenance practices should strive to create a central, deep, narrow thalweg (flowline) within the stream channel and well vegetated stream banks.

Of the fifteen reaches inventoried, none provided exemplary habitat. Downstream reaches 2 through 8 offered pools and riffles, but lacked gravel substrate, complex instream shelter, and continuous riparian vegetation. An exception in this lower creek stretch was Reach 4. At the time of inventory it had not had its vegetation cleared, and as a result, provided a substantial amount of diverse habitat.

Measures to improve habitat deficiencies in downstream reaches should include modifying vegetation removal practices for flood control activities, as described above, and restoring a continuously vegetated riparian corridor. Riparian vegetation restoration should include planting a wide variety of understory and tree species, especially Sycamore trees. Since trees grow relatively slowly, a short-term understory should be planted that will provide characteristics associated with riparian vegetation yet will not out-compete the growing young trees.

Upstream reaches 8 through 13, in the City of San Luis Obispo, lacked pools, riffles, complex instream shelter, gravel substrate, and a continuous riparian corridor. Stream channelization and maintenance has removed hard pool-creating objects. Urban encroachment has replaced riparian vegetation with revetments, gabions, cement sacks, and rip-rap, as well as destructive exotic plant species, decks, and storage sheds.

Since many of the upstream reaches are within the urban boundary of the City of San Luis Obispo, flood control activities must be given suitable management priority. However, measures to improve habitat might include modification of flood control activities, as described above, and strategic placement of rip-rap boulders used for stream bank stabilization. Boulders are preferred over concrete revetments because of their ability to create pools and support vegetation, if properly maintained. Efforts to incorporate pool creation and vegetation into flood control management and stream bank stabilization projects could prove very beneficial.

Upstream from the city, habitat in reaches 14 and 15 was similar to urban reaches with an exception of clean gravel substrate in Reach 15. A severe lack of instream shelter and pool habitats limit the habitat value in these reaches.

There are three short-term restoration practices that will provide immediate benefit to the

Steelhead Trout in San Luis Obispo Creek. These are bank-placed boulders, log shelter structures and carp eradication. Because of the swift currents produced by "flash-flood" events, most fish habitat structures would not remain in the stream. Boulders and log shelters will last only if strategically placed and well anchored with cables. Temporary small log matts that provide shelter can be installed during the summer and removed prior to winter rains. Carp, if eradicated from the lower stretch of creek, may provide trout with an opportunity to inhabit the area.

This report would not be complete without some mention of maintaining a minimum stream flow and limiting water diversions in the creek. If San Luis Obispo Creek is to be managed as a Steelhead Trout stream, as recognized by the Department of Fish and Game, present and future water diversions should be limited to maintain a minimum summer flow. In other words, no water should be taken from the stream, through riparian rights or other means, unless instream uses by fish are first adequately provided. Adjudication is a viable option.

RECOMMENDATIONS FOR FURTHER STUDY

Fish Surveys

Two fish surveys will compliment this study through outmigrant trapping and electrofishing. Outmigrant trapping will determine timing and general morphological characteristics of Steelhead Trout smolt and parr movement. Electrofishing will assess fish population sizes (for all species) and, possibly, associate life stages with habitat types.

Stream Hydrograph

A stream flow hydrograph can be prepared from wastewater facility records and supplemented with additional data collection. A hydrograph can also be prepared by relating an unguaged stream to a gauged one. Data from a hydrograph can be used to determine what is normal flow and what is a reasonable minimum flow.

Tributary ,Upstream and Estuary Inventory

Because inventory of main stem San Luis Obispo Creek did not reveal a tremendous amount of habitat, perennial tributaries, upstream reaches, and the estuary (Reach 1) should be evaluated for habitat value. Perennial tributaries historically important to fish production include See Canyon, Stenner, and Brizziolari. Two miles of main stem San Luis Obispo Creek were not inventoried in this current study and may offer habitat if the velocity barrier under Highway 101 were improved. Additionally, it is not unusual to find abundant numbers of Steelhead Trout in estuary environments. The San Luis Obispo Creek estuary in Avila Beach is not known to harbor trout and an investigation may provide useful information for improvements.

Verify Source of Sediments, Flood Control Impacts, Livestock Impacts, and Pool Creation

This inventory made observations and estimations for the source of sediments, impacts of flood control and livestock, and the natural process for creating pools. Studies should be conducted or references researched that support and verify these observations.

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