San Pedro Creek Watershed Pilot Assessment

ONLY RAIN IN THE STORM DRAIN

San Mateo Countywide Stormwater Pollution Prevention Program

Final

December 17, 2001

Contents

Figures 2
Tables 2
Executive Summary 3
Introduction 5
Background 5
Watershed Characterization 6
Physical Setting 6
Land Use Changes 8
Hydrologic and Geomorphic Conditions 10
Hydrologic Conditions 10
Geomorphic Conditions 14
Biological Condition 17
Fishes and Frogs 17
Physical Habitat 18
Riparian Vegetation 19
Water Quality 21
Stream Classification and Stream Function 24
Recommendations for Monitoring Strategy 27
Identify Data Needs and Sampling Locations 27
Sediment Sources and Channel Morphology 27
Physical Habitat and Biological Condition 28
Water quality 29
Comparison of Existing and Proposed Monitoring to RMAS 31
Recommended Two-Year Monitoring Program 31
References 33
Appendix A: Creek Channel Modification Categories. 35
Appendix B: Restoration and Monitoring Projects 36
Restoration Projects 36
Monitoring Projects 37
Appendix C: Level 1 Geomorphic Characterization 39

Figures

Figure	Title	Page
1	Streams in San Pedro Creek.	7
2	Geological features of San Pedro Creek Watershed.	9
3	Channel modifications in San Pedro Creek.	11
4	Land use in San Pedro Creek Watershed.	12
5	Cumulative percent watershed imperviousness and location of stormdrains and major outfalls in San Pedro Creek Watershed.	13
6	Reaches surveyed for 1999 geomorphic study in San Pedro Creek.	16
7	Riparian vegetation rating for fish and wildlife value in San Pedro Creek.	20
8	Water quality sampling locations in San Pedro Creek.	22
9	Stream classification reaches for San Pedro Creek.	25

Tables

Table	Title	Page
1	Variables used for classifying stream reaches in San Pedro Creek.	26
2	Type and location of data needed to complete watershed assessment in San Pedro Creek.	30
3	Timing, Frequency, staffing requirements and estimated costs of recommended 2-year monitoring design in San Pedro Creek.	32

Executive Summary

STOPPP performed an initial pilot evaluation of the San Pedro Creek watershed as a participant in the pilot-scale implementation of the San Francisco Regional Water Quality Control Board's (Regional Board's) Regional Monitoring and Assessment Strategy (RMAS). The specific objectives of the evaluation were to characterize the condition of the watershed using existing information, identify questions we want to answer regarding potential impacts and the data required to help answer those questions, and to develop a monitoring design and associated budget and staff requirements.

Using existing information, we characterized the land use, hydro-geomorphic, biological and water quality factors that influence the health of the San Pedro Creek watershed. Over the past 217 years since European settlement, there have been significant impacts to the creek. These impacts have been driven by land use changes, including conversion to agriculture, cattle grazing and urbanization, resulting in increased streamflows and sediment supply to the mainstem. Bed and bank erosion in the mainstem has also been caused by channel modifications, which include the construction of a ditch in the lower 0.8 mile of San Pedro Creek, the construction of a 640 foot long concrete-lined channel above the Capistrano Drive bridge and road culverts. Historical diversion dams and bank revetment failures also have contributed to erosion in the mainstem. These changes have all contributed to channel instability resulting in a deeply incised channel and higher sediment yields.

San Pedro Creek has historically supported a relatively large steelhead population for a watershed of its size. However, degradation of physical habitat and the presence of fish barriers such as bridge culverts and a diversion dam may threaten the steelhead population. An initial evaluation of physical habitat indicates the amount of fine substrate in the channel is in the same range of other viable steelhead streams in the San Francisco Bay area. Other channel measurements indicate a lower than expected amount of large woody debris and natural pools in some reaches of the creek. The riparian condition, rated in terms of canopy cover and dominance of native species, varied widely throughout San Pedro Creek. A steelhead habitat assessment was recently conducted in tributaries to San Pedro Creek, but the results of the survey were not available in time for this assessment. In general, insufficient biological information is available to assess how sediment supply and physical habitat condition have impacted the aquatic biota.

The existing physical, chemical and bacterial water quality data from San Pedro Creek show the Water Quality Objectives of the Basin Plan are met and appear to support the designated beneficial uses for non-contact water recreation. However, there are sections of the creek that are used by the public for swimming which exhibited elevated bacterial levels that exceeded standards for contact water recreation. The Regional Board has recommended adding San Pedro Creek and Pacifica State Beach to the 303(d) list of impaired water bodies for pathogens.

A stream classification was developed using existing geomorphic information on San Pedro Creek to help characterize stream structure and function in terms of streamflow and sediment processes. The classification provides a framework for identifying potential impacts to watershed health, it identifies and locates important aquatic resources to protect, and it prioritizes future monitoring locations and parameters to further assess stream condition.

Additional data are needed for a more complete assessment of watershed condition. Current rates and primary causes of instream erosion need to be identified for the San Pedro Creek mainstem. Sediment sources in the tributaries should also be evaluated. A bioassessment using benthic macro-invertebrates would help to identify condition of aquatic biota and potential impacts to the creek. Further investigation into sources associated with elevated concentrations of indicator bacteria should be conducted. Sources of trash in the creek and potential impacts to beneficial uses need to be evaluated.

It is recommended that STOPPP implement a 2-year monitoring design that includes assisting SPCWC conduct a rapid bioassessment using benthic macro-invertebrates, assisting the SPCWC identify sources of bacterial indicators, and identifying the sources and potential impacts of trash to the San Pedro Creek watershed.

San Pedro Creek Pilot Watershed Pilot Assessment

Introduction

This report presents the San Mateo Countywide Stormwater Pollution Prevention Program's (STOPPP's) initial pilot evaluation of the San Pedro Creek watershed. STOPPP performed this evaluation as a participant in the pilot-scale implementation of the San Francisco Regional Water Quality Control Board's (Regional Board's) Regional Monitoring and Assessment Strategy (RMAS). The initial pilot evaluation is also in accordance with Provision 8.b. of STOPPP's NPDES permit, which requires watershed monitoring activities, including "identification of major sources of pollutants of concern; evaluation of the effectiveness of control measures and best management practices; and use of physical, chemical and biological parameters and indicators as appropriate."

Background

In an effort to improve the technical content of the Regional Board's policies and regulatory actions, and in response to improvements at both the national and state level, Regional Board staff developed the RMAS (Version 1.0, October 1, 1999). The main goals of the RMAS are threefold:

1. To identify and address the root causes of regional water quality problems,
2. To develop realistic water quality and habitat goals, and
3. To provide the sound scientific basis necessary to protect resources.

The specific regulatory focus of the RMAS relates to the Regional Board's obligation to complete biennial water quality assessments under the Clean Water Act's section 305(b) and associated 303(d) requirements. The RMAS endorses several approaches to monitoring and assessment, including incorporation of bioassessment data and physical measurements in Regional Board decision making (supported by the 1997 USEPA 305(b) guidelines), coordination of consistent monitoring and assessment efforts and protocols both regionally and nationally, and enhancement of waterbody classification to help improve sampling design. The RMAS is being carried out in a phased manner, beginning with "pilot-scale implementation in selected watersheds," and establishing a schedule for assessing watersheds on a rotating basis that will eventually result in "comprehensive assessment of surface and ground waters in the San Francisco Bay Region."

The Regional Board designated San Pedro Creek as a local municipal stormwater program-lead pilot watershed. This project builds on existing watershed characterization and monitoring efforts by STOPPP and the San Pedro Creek Watershed Coalition (the Coalition). STOPPP has characterized imperviousness and creek channel modifications in the San Pedro Creek watershed. The Coalition is a citizen-based group involved in watershed related activities, including water quality, biological and hydro-geomorphic assessments, restoration, education and outreach and collaboration with regulatory agencies to formulate ordinances to protect the watershed (www.pedrocreek.org). Specific accomplishments of the Coalition include a detailed geomorphic assessment of the San Pedro Creek mainstem, a vegetation survey of riparian plant communities along the creek, a water quality study at eight locations in the watershed, and a steelhead habitat assessment. For this project, STOPPP is working closely with the Coalition, building on existing information to identify data needs and appropriate management activities that will enhance and protect the aquatic resources of the watershed.

The specific objectives of the initial pilot evaluation of the San Pedro Creek watershed are to:

- Compile existing watershed information and characterize and map the land use, hydrologic, geomorphic, biological and water quality factors that influence the watershed's health.
- Identify specific questions we want to answer regarding potential impacts to water quality and the biological health of the watershed and the data needs to help answer those questions.
- Recommend a monitoring design and identify budgetary and staff requirements to implement it.

The Regional Board recently submitted to the State Water Resources Control Board recommendations for revisions to the 303(d) list of impaired water bodies in the San Francisco Bay Area. Based on a review of existing information, the Regional Board recommended adding San Pedro Creek and Pacifica State Beach to the list for impairment by pathogens. The State Board will consider this recommendation in a public process and then submit a final status report and 303(d) list to the U.S. EPA. The Regional Board has also determined that trash threatens to impair water quality in all urban creeks, lakes and shorelines. As part of the San Pedro Creek pilot watershed evaluation, STOPPP will assess existing information and identify a monitoring strategy that addresses regulatory requirements related to potential impairment from pathogens and trash.

The Basin Plan designates five beneficial uses for San Pedro Creek: cold water habitat, fish migration, fish spawning, non-contact water recreation (REC2) and municipal water supply. Pacifica State Beach, located at the outlet of San Pedro Creek, is designated as contact water recreation (REC1).

Watershed Characterization

Physical Setting

San Pedro Creek is a perennial stream that flows westward to the Pacific Ocean through the City of Pacifica, San Mateo County, California (Figure 1). The creek drains roughly 8 square miles of the western side of Montara Mountain and is composed of five major tributaries, all of which contain perennial flows fed by springs (www.pedrocreek.org). The North, Middle and South Forks comprise the upper reaches of the watershed. The North Fork headwaters are comprised of several steep first order streams that drain into an extensive network of underground culverts flowing through an urbanized valley. The Middle and South Fork tributaries also drain steep hillsides into a low gradient stream flowing through the upper end of San Pedro Valley. The North Fork and combined Middle/South Fork drainages are roughly equal in size, about 2.4 square miles each. There are two smaller tributaries in the watershed, Sanchez Creek and an unnamed tributary flowing through Shamrock Ranch (identified in this report as Shamrock Creek), which empty into the lower reaches of the mainstem. The mainstem San Pedro Creek flows for about 2.5 miles through a broad valley floor, which is mostly developed to the banks of the creek.

The San Pedro Creek watershed has a Mediterranean-type climate of dry, mild summers with coastal fog, and wet, cool winters. Mean annual precipitation has been reported to range between 23 inches at the Pacific Ocean to 38 inches at the highest elevations.

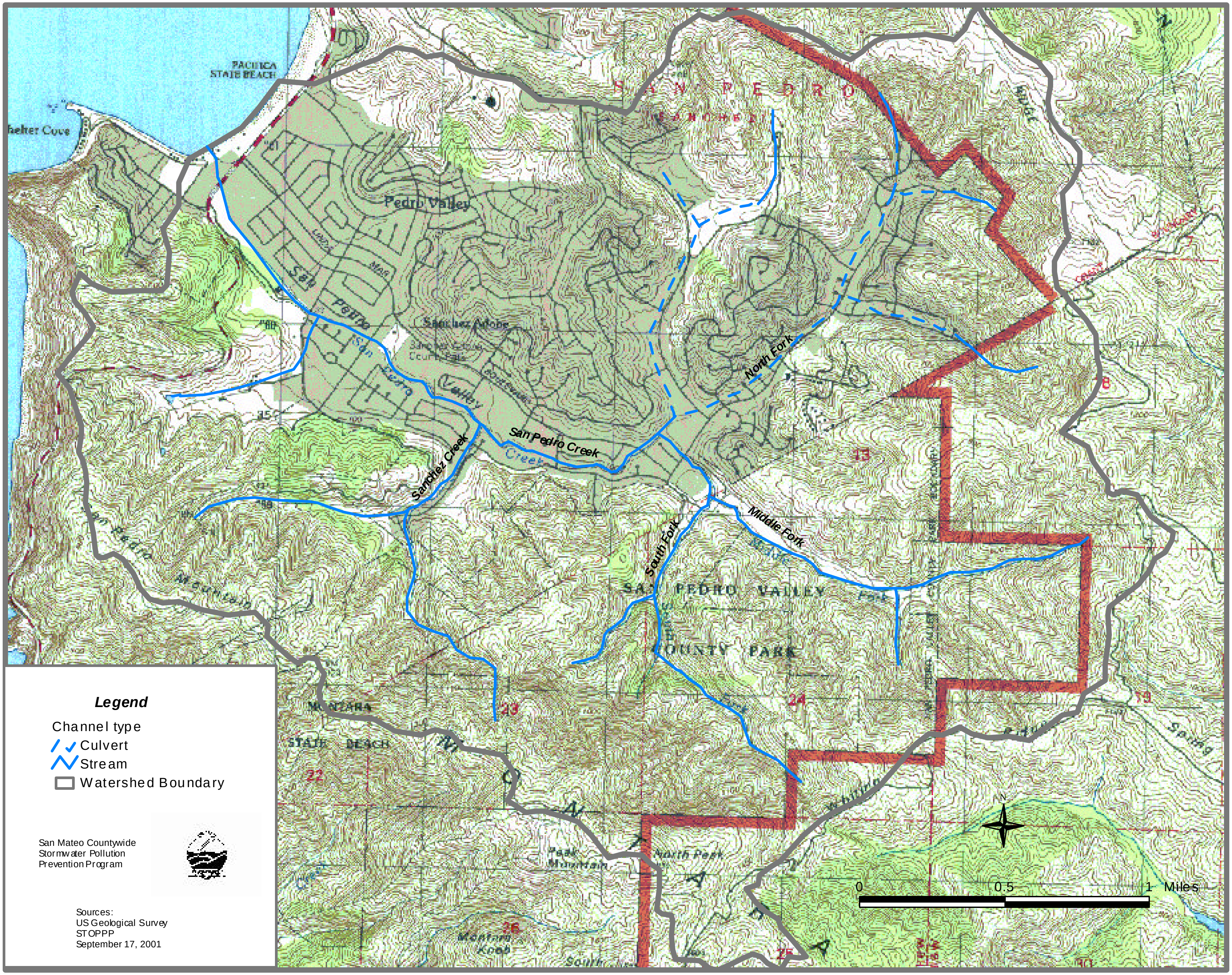

Figure 1. Streams in San Pedro Creek Watershed.

The geologic features of the San Pedro Creek watershed are dominated by the Franciscan Complex. The surficial geology is composed of five major materials, including sandstone and sandstone-dominated melange, Montara Mountain granitics, greenstone, alluvium, and conglomerate (Figure 2). There are also scattered outcrops of serpentine and limestone. The greenstone occurs in the North Fork drainage, the granitics primarily occur in the South Fork drainage, while the sandstone rock types, conglomerate and alluvium are fairly ubiquitous in the watershed. There are also significant areas of artificial fill in the lower reaches of the mainstem and portions of the North Fork.

Landslides in San Pedro Creek watershed are relatively infrequent and most of the area in the watershed has previously been mapped as having a low susceptibility for future landslides (Wentworth et al. 1997). However, following an intense rainstorm in 1982, at least 475 landslides occurred in the City of Pacifica (Howard et al. 1982). Most of landslides occurred near the head of first-order drainages, on slopes of 26 to 45 degrees and involved only the soil cover (less than 10 feet deep).

Land Use Changes

The landscape of San Pedro Creek watershed has been dramatically altered since the settlement of immigrants of European descent began in the Valley in the late 1700's. Prior to settlement, the area was occupied by the Ohlone Indians, who actively burned the landscape to control growth of trees and coastal scrub and promote growth of native grasses, which they used for food and clothing (Biosystems 1991). The initial European immigrants described San Pedro Creek as a small running stream that emptied into an extensive marsh and a large lake called Lake Mathilda, which connected to the ocean. The settlers introduced farming and cattle grazing in San Pedro Valley and the surrounding hills. Maps drawn in the mid-1800's show San Pedro Creek flowing into a large willow grove, with no clear connection to Lake Mathilda (Collins et al. 2001).

Increased farming activity occurred in the late 1800's. The lower 0.8 mile of San Pedro Creek was diverted into a constructed ditch and the large willow grove was removed to provide more arable land for farming. It is estimated that the ditch was constructed around 1870 based on evidence from an aerial photo taken in 1928 showing significant growth of riparian vegetation along the ditch and complete removal of the willow thicket (Collins et al. 2001). Most of Lake Mathilda was filled for agricultural use during this time as well. As farming increased, so did the need for irrigation, resulting in the construction of several flashboard dams and diversion pipes throughout San Pedro Creek. There are at least 10 remnant dam or weir structures that once crossed the channel in the mainstem and were used to divert water for irrigation (Collins et al. 2001).

Urbanization began in the 1950's with the construction of 3,000 new homes and the Linda Mar Shopping Center (Collins et al. 2001). In addition to new residences, equestrian facilities were developed, as well as a landfill located in the North Fork drainage. The landfill was covered over and converted into a city park in 1970. The entire North Fork mainstem was placed underground in a box culvert by 1968. As development encroached along the stream channel, the protection of homes and businesses from flooding was a priority, resulting in straightening and armoring of the channel throughout San Pedro Creek. Over 20% of the total length of the mainstem now consists of bank revetments, primarily made of concrete, rip rap and sackcrete (Collins et al. 2001). In the early 1970's, the Capistrano Drive bridge was modified to include a fish ladder and a 600-foot concrete channel upstream. In 1988 the U.S. Army Corps of

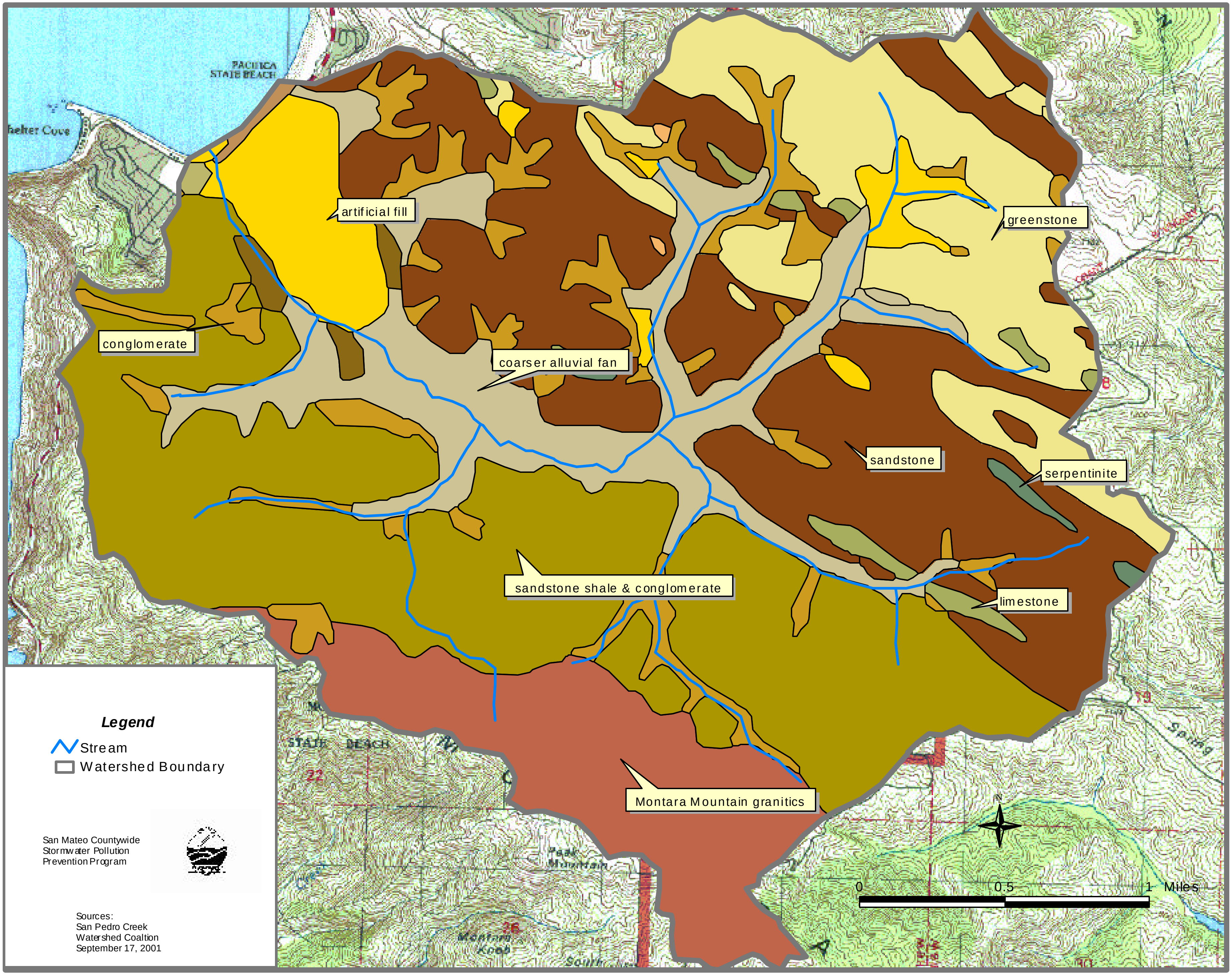

Figure 2 - Geological Features of San Pedro Creek Watershed.

Engineers constructed an earth levee on the north bank of San Pedro Creek, between Highway 1 and Pacific Ocean. Channel modifications made to San Pedro Creek, including the ditch, are shown in Figure 3 (see Appendix A for definitions of channel classes).

The current land use is primarily coastal scrub and rangeland (70%), high density residential (18%), and evergreen forest (6%). Public, quasi-public, commercial, moderate density residential, agriculture and vacant lands make up the remaining six percent of existing land uses (Figure 4). An estimated 15% of the total watershed area is covered by impervious surfaces (EOA, Inc. 2001). The land use making the greatest contribution to watershed imperviousness is high density residential. This land use occurs primarily in the North Fork drainage and the area north of the mainstem. The estimated percent imperviousness for the North Fork drainage is about 19%, while the relatively non-urbanized South Fork drainage is about 2% impervious (Figure 5).

The existing storm drain conveyance system includes over 17 outfalls between the mouth of San Pedro Creek and the confluence of the South and Middle Forks (Figure 5). More than 4 miles of tributary channel have been culverted in the watershed (Collins et al. 2001).

Other changes impacting San Pedro Creek include a dam and water diversion in the South Fork operated by the North Coast County Water District. The South Fork is a water source for the City of Pacifica and in the past has provided 10% of the City's drinking water. The diversion, however, has not been in operation for the last 3 years due to a pending upgrade to the District's water filtration plant.

Hydrologic and Geomorphic Conditions

Land use changes affect stream discharge and sediment supply in stream channels. Soil compaction and vegetation removal from cattle grazing and agricultural practices reduce infiltration rates of rainwater into the ground and increase soil instability on steep slopes and along stream channels (Riley 1999). The construction of impervious surfaces such as rooftops, parking lots and roads, as well as construction of storm drain conveyance systems, also reduce rainwater infiltration and increases the magnitude and frequency of peak flows. In response to higher, flashier flows, stream channels adjust by downcutting and widening their bed and banks. In addition, efforts by humans to attenuate bank erosion by altering channel morphology further reduce a channel's natural ability to dissipate flow and trap sediment. Impacts of increased flows include bed and bank erosion, property loss, sediment deposition (resulting in filling of pools and spawning gravels), loss of riparian vegetation and impairment of water quality (e.g., increased turbidity).

To determine how land use changes have impacted the hydrologic and geomorphic condition of San Pedro Creek, we compiled and assessed existing information on flow, sediment supply and channel condition.

Hydrologic Conditions

The USGS has not maintained long term stream gages in San Pedro Creek. As a result, there are insufficient stream flow data to determine a relationship between stream discharge and land use changes or develop flood recurrence intervals. Flood frequency intervals can be determined, however, using other techniques. Bankfull discharge is the flow of water that fills the active channel until it overtops the streambank into the

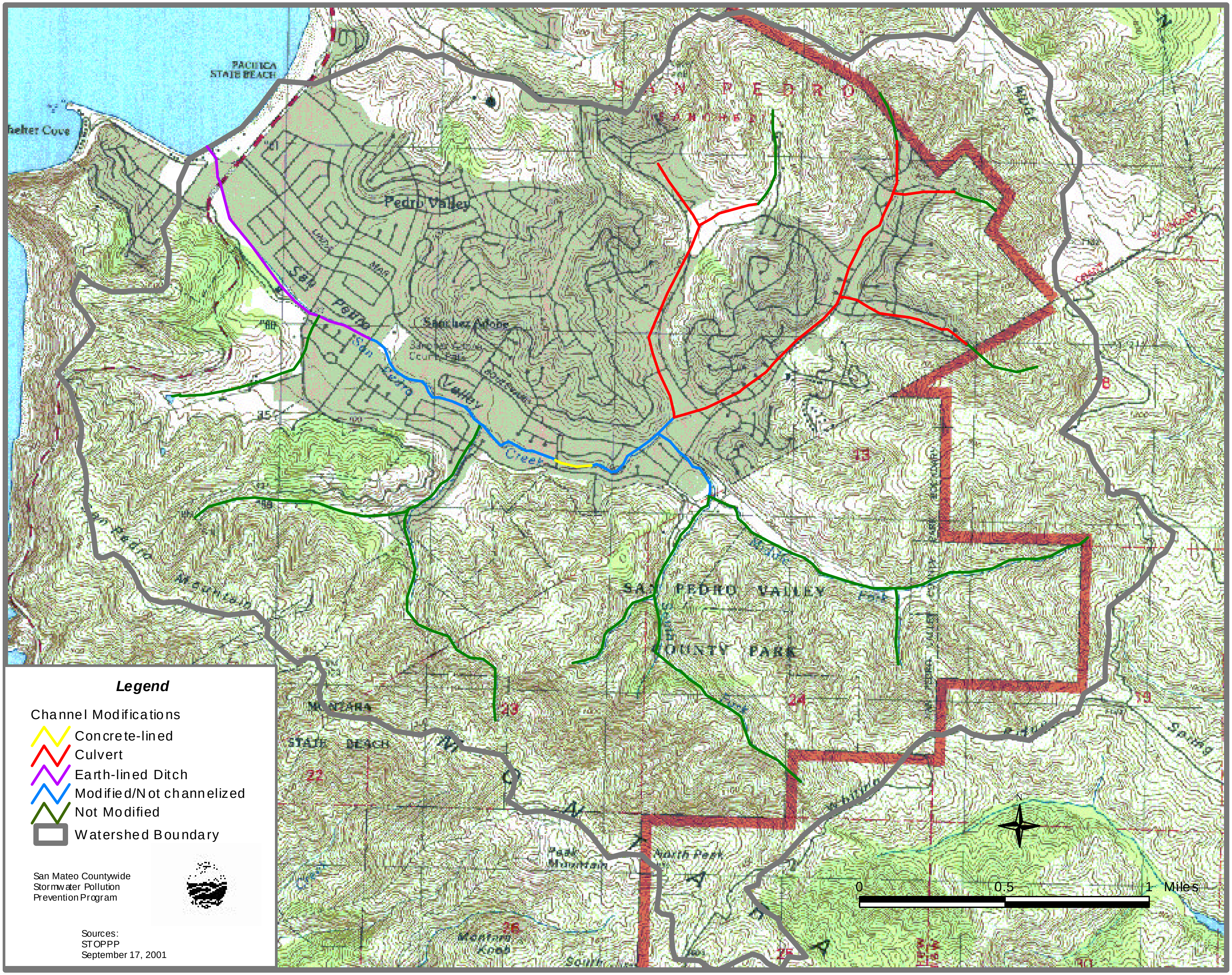

Figure 3 - Channel Modifications in San Pedro Creek.

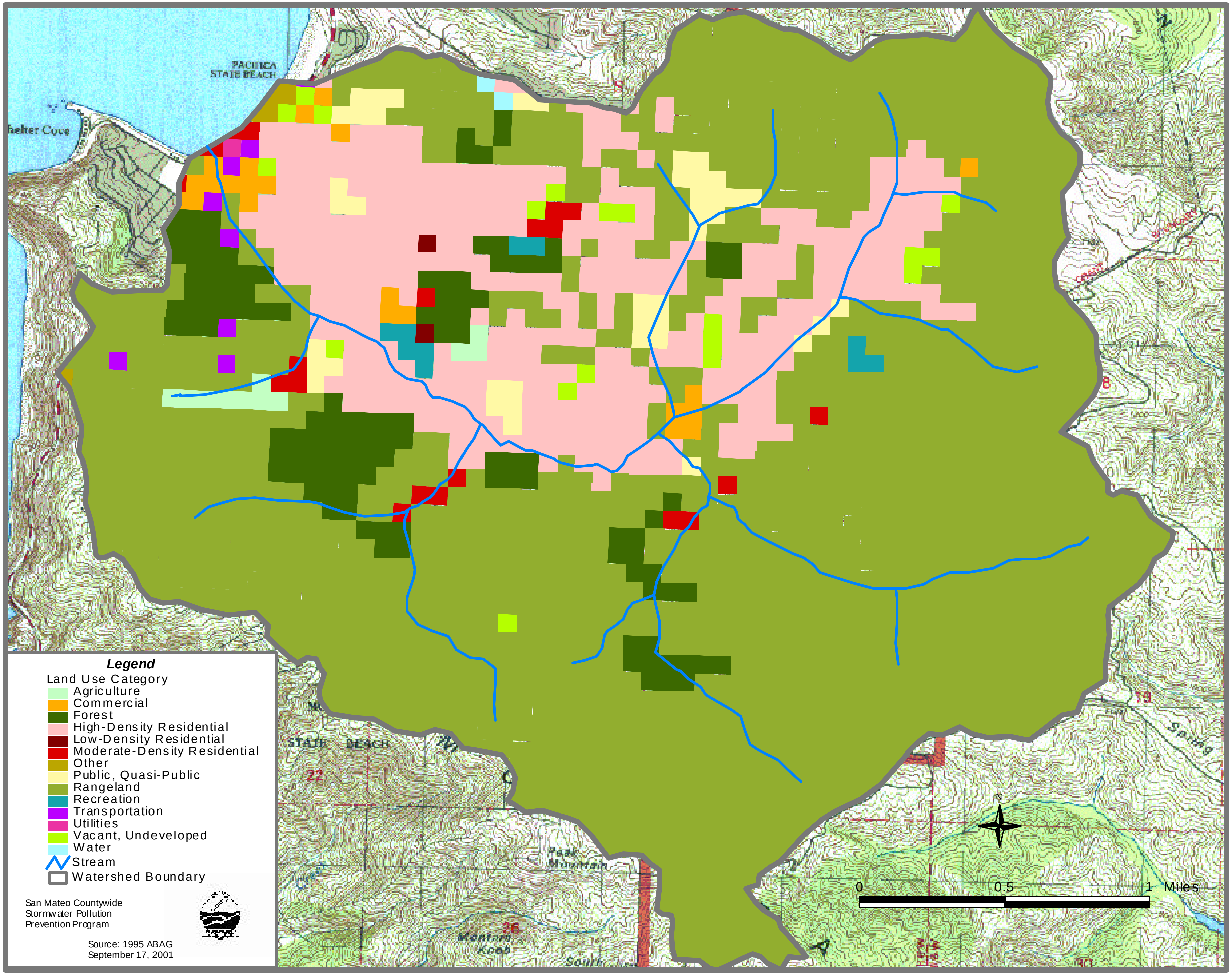

Figure 4 - Land Use in San Pedro Creek Watershed.

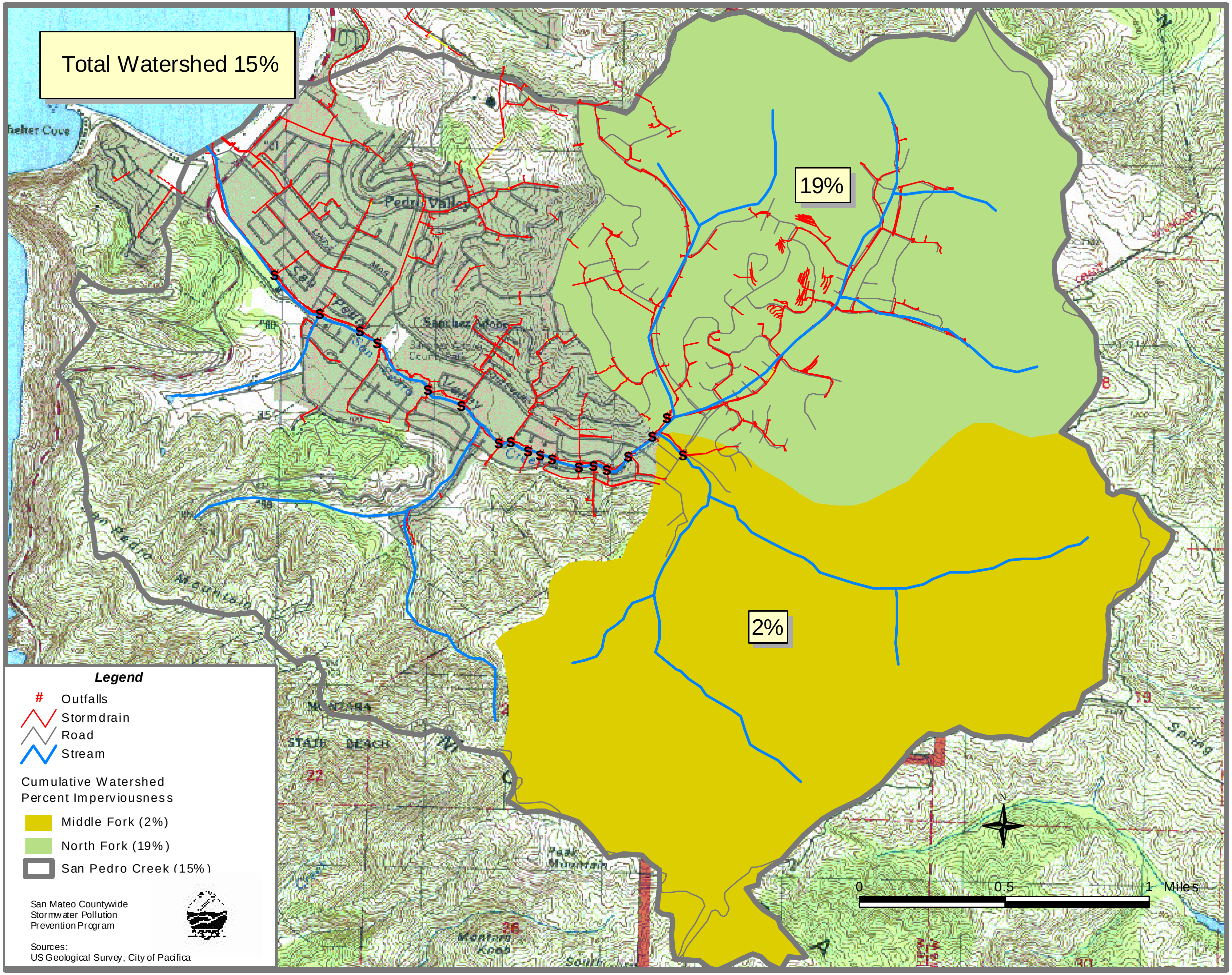

Figure 5 - Cumulative Percent Watershed Imperviousness and Location of Stormdrains and Major Outfalls in San Pedro Creek Watershed.

floodplain (Riley 1998). On average it occurs every 1.5 years. For a watershed the size of San Pedro Creek, bankfull discharge was estimated, using regional curves developed for the San Francisco Bay area, to be about 370 cubic feet per second (cfs) at Highway 1 (Collins et al. 2001). The bankfull channel is important because it represents a dynamic, meandering active channel that is geomorphically stable and is the channel size used for establishing restoration goals. Impervious surfaces, however, increase flows beyond the channel capacity, causing bed and bank erosion until the channel reaches a new equilibrium. The bankfull width for the mainstem of San Pedro Creek below Oddstad Street culvert averaged 21 feet, while bankfull width above the culvert averaged 15.8 feet, showing the influence of the North Fork on the mainstem channel (Collins et al. 2001). The measured bankfull widths were smaller than the values estimated from the regional curves because increased flows from North Fork resulted in channel cross-section increases by downcutting rather than widening.

Flood recurrence intervals have also been estimated using stream discharge records for similar nearby watersheds. The 10, 50 and 100-year floods at the mouth of San Pedro Creek have been estimated to correspond to flows of 1900 cfs, 3000 cfs and 3450 cfs, respectively (USACE 1998). The largest recorded flood on record was in 1982 and had a discharge estimated at 2890 cfs. The Army Corp of Engineers and City of Pacifica are now implementing a flood control project in the lower reaches of San Pedro Creek to provide 100-year flood protection. In addition, the flood control project will restore riverine wetlands to the lower reach by converting the portion of the channel that was straightened and ditched in the 1870's into a reduced gradient, meandering stream and floodplain that will be more geomorphically stable. The Appendix describes this project and other monitoring and restoration projects in the San Pedro Creek watershed. The restored channel will contain large rootwad structures and be revegetated with native riparian plants to provide biological habitat for both aquatic and terrestrial flora and fauna. As part of the flood control and wetland restoration project, the City of Pacifica will monitor the channel to evaluate the effectiveness of the restoration.

Future development is not likely to occur in the Middle Fork drainage since most of this land is owned and managed by the San Mateo County Parks Department. There is some development occurring in the Sanchez Creek drainage that may result in higher runoff during storm events and increased sediment loads to the stream.

SFSU graduate student Paul Amato is currently investigating the impacts of urbanization on stream flow and turbidity (Appendix B). Continuous monitoring of steam discharge and turbidity was conducted for 2.5 months in the Middle Fork/South Fork and 1.5 months in the North Fork. Since the two drainage areas are dramatically different in land use and percent imperviousness, yet are nearly identical in size and topography, the differences in flow and turbidity during storm events can largely be attributed to impacts of impervious surfaces associated with urbanization. The results of this study were not available in time to include in this report.

<u>Geomorphic Conditions</u>
Sediment production and transport are important processes to identify in a watershed assessment. Excessive sediment can impair water quality by increasing water turbidity and temperatures. Sediment deposition can reduce instream fish cover by filling in pools and spawning gravels, impede the flow of water and dissolved oxygen to developing salmonid eggs and embryos, and impact production of aquatic invertebrates, an important food source for fish. Potential sediment sources in a watershed include

surface erosion (sheet and rill erosion), gully erosion, channel erosion and mass wasting (e.g., landslides, debris flow) (NCWAP 2001). There are natural and human factors that drive sediment production and transport. Natural factors include geology, soil composition, slope steepness, vegetation types, rainfall intensity and duration, and fire. Human factors include activities that cause surface disturbance and modification and vegetation removal (e.g., cattle grazing, agricultural practices, construction activities and stream channel maintenance).

A recent geomorphic study indicates that there has been a significant supply of sediment from instream sources in the San Pedro Creek mainstem since European settlement of the valley began around year 1782 (Collins et al. 2001). A survey of bed and bank condition was conducted in 1999 between the Highway 1 crossing of San Pedro Creek and the confluence of the South Fork with the Middle Fork, covering a total stream length of 2.6 miles. The geomorphic condition was reported for six reaches within the study area (Figure 6). The total volume of sediment supply from bed and bank was measured for the mainstem. Length and volume of bank erosion were measured for both below and above the bankfull channel (also called terrace bank). Other parameters measured in the study included sediment particle size, condition and type of revetment, size, abundance and type of pools, and abundance and type of large woody debris. The survey did not identify or measure sources of sediment from upstream tributaries (e.g., landslides).

The results of the channel survey indicated that 37% of the bank channel for the entire mainstem is in an eroding condition, and only 43% of the bank channel is stable. The remaining 20% contained revetments. Since 1782, the long-term rate of sediment supply from combined bed and bank erosion in the mainstem was an estimated 388 cubic yards per year. Sediment supply from terrace banks was nearly three times the amount supplied by the bankfull banks. Sediment supply from channel bed exceeds total bank erosion sediment production by a factor of more than seven. The bed of the channel is deeply entrenched, as much as 16 feet in some areas. Entrenched streams are no longer able to send flows to their floodplains, are confined by their banks and continue to erode vertically (Riley 1998). Incised channels also result in lowering of the water table elevation, which can impact riparian vegetation along the banks. Collins et al. (2001) estimate that at least 60% of this erosion in San Pedro Creek is related to anthropogenic activities.

The study reported sediment supply from bed and bank erosion combined was highest in the Adobe and Linda Mar reaches (Figure 6). The high amount of sediment supply in the Adobe reach can be attributed to historical changes in channel morphology. The straightened and ditched section of San Pedro Creek is directly below the Adobe reach. The construction of the ditch created a steeper channel gradient resulting in upstream migration of bed erosion. The Adobe reach has the highest amount of sediment supply from bed erosion. Adobe reach is below the 640-foot concrete-walled channel and 15-foot high box culvert at Capistrano Drive bridge, both of which would contribute to higher flow velocities resulting in downstream bed and bank erosion. The Linda Mar reach had the highest sediment supply, which appears to be strongly related to increased flows from the culverted North Fork tributary. The least amount of sediment supply occurs in the ditched section of channel downstream of the Adobe reach.

The SPCWC conducted a longitudinal profile of the mainstem channel in Fall 2001. The survey provides accurate ground elevations along the channel to establish monumented

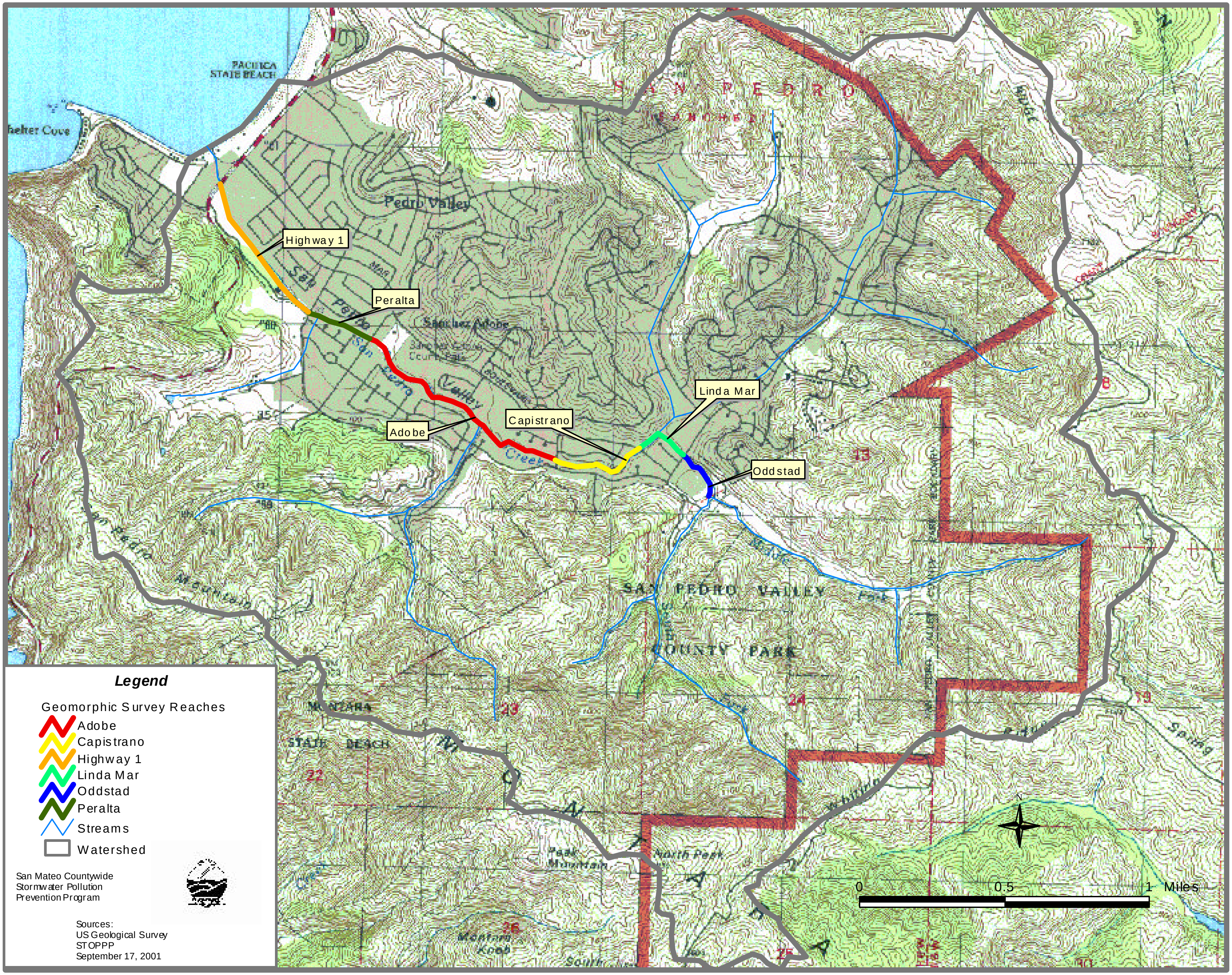

Figure 6 - Reaches Surveyed for Geomorphic Study in San Pedro Creek.

sites to monitor changes in bed elevation and correctly define terrace heights and stream gradient. The channel profile along with the geomorphic survey of bed and bank condition provides a baseline data layer describing the channel geometry, substrate and other habitat parameters for the mainstem.

A comprehensive survey for identifying sediment sources in the tributaries of San Pedro Creek has not been conducted. There was evidence of gullies in the hillsides from an 1853 map by the U.S. Coast Survey, probably caused by cattle grazing. No information on gully or instream erosion was available for the tributary reaches. There were a significant number of landslides in the winter of 1982, but the amount of sediment these landslides contributed to San Pedro Creek was not estimated.

Biological Condition

<u>Fishes and Frogs</u>
San Pedro Creek contains the northern-most run of naturally producing steelhead trout (*Oncorhynchus mykiss*) population in San Mateo County. Current steelhead population estimates are about 300 adults and several thousands of juveniles (City of Pacifica, 2000). Other fishes known to be present in the lower reaches of San Pedro Creek include Prickly sculpin (*Cottus asper*), Threespine stickleback (*Gasterosteus aculeatus*), Yellowfin goby (*Acanthogobius flavianus*) and the Pacific lamprey (*Lampetra tridentata*).

The Department of Fish and Game conducted intermittent steelhead population surveys in the creek for 20 years beginning in the early 1970's (Titus et al. 2000). Population surveys reported high densities of juvenile trout, which were comprised of both 0+ and 1+ age classes. Low numbers of 1+ trout indicate the main smolting age of steelhead in San Pedro Creek is age 1. Steelhead spawning habitat was noted as abundant in the Middle Fork and limited in the North and South Forks. Most of the spawning occurred within the County Park boundary. Adult steelhead have been observed spawning in the creek, with as many as 40 pairs of adults within a 30 meter reach observed in 1985.

Juvenile steelhead have been reported above all the culverts on the mainstem and Middle Fork and in the short section of North Fork below the culvert outlet (Titus et al. 2000). Steelhead have not been reported above the water diversion dam in the South Fork, or in Sanchez or Shamrock Creeks. The diversion dam, as well as several culverts in the mainstem, have been identified as potential fish barriers. Some of these culverts have been replaced or modified to improve fish passage. A culvert on the Middle Fork was replaced in September 2001 to improve steelhead passage above Weiler Ranch trail crossing. In addition, a boulder weir structure was built at the base of the Capistrano Drive bridge culvert to improve fish passage through existing fish ladder (see the Appendix). A steelhead barrier has also been reported at the mouth of Sanchez Creek (Matuk 2001).

There have been several fish kills between 1970 and 1987 attributed to garbage dumping and illicit discharges. In 1987, about 600 individuals comprised of fry, juvenile and adult steelhead were killed in the North Fork and two kilometers of the mainstem by a suspected illicit discharge of chlorinated swimming pool water (Titus et al. 2000).

Other aquatic species of special concern observed in the San Pedro Creek include the red-legged frog (*Rana aurora*). One individual was observed in the lower reaches above Highway 1 and other frogs have been reported in ponds located in the Shamrock Ranch

(Peggy Fiedler 2001, personal communication). There have also been non-native bullfrogs reported in the lower reaches of the creek.

There was no existing information on aquatic benthic macro-invertebrate (BMI) species composition or abundance for San Pedro Creek. Benthic macro-invertebrates are good indicators of water quality and habitat condition and are an important food source for native fishes. The Regional Board and Department of Fish and Game are using BMI bioassessments to assess water quality throughout the San Francisco Bay Region. Macro-invertebrates are indicators of water quality for many reasons, including their large number of species offers a wide range of responses to environmental stressors, their sedentary nature allows effective spatial analysis of pollutants or disturbances, responses of many common species to different types of pollution have already been established and sampling is relatively easy and inexpensive (Jim Harrington and Monique Born 1999). Macro-invertebrates are currently being sampled in other coastal streams in San Mateo County for water quality monitoring (www.coastal-watershed.org).

Physical Habitat

A salmonid physical habitat inventory has recently been conducted for San Pedro Creek tributaries (Appendix B), but the results of the study were not available in time for this assessment. Some physical habitat parameters that were measured in the geomorphic study described earlier were available for assessment of the mainstem. Frequency, size and types of pools and large woody debris (LWD) and size and distribution of sediment were surveyed for the mainstem of San Pedro Creek (Collins et al. 2001). Pools are an important component of fish habitat, providing summer rearing and winter refuge to steelhead and protection from predation. LWD plays several important roles for salmonid fish, including pool formation, instream habitat cover and complexity, trapping gravels useful for spawning and reducing sediment transport rates.

There were a total of 128 pools with greater than 1-foot depth, occurring on average once every 108 feet of channel length in the San Pedro Creek mainstem. The pool spacing observed in the study is expected for the size and type of channel (Collins et al. 2001). Thirty-eight percent of these pools were formed by man-related structures and over 55% were caused by woody debris and other natural causes. A disproportion of naturally caused pools indicates the lack of LWD and mature riparian vegetation (Collins et al. 2001). In addition, the influence of straightened and ditched portions of the channel reduces the natural pool making process of a geomorphically stable channel. The survey reported most of the prime pool habitat in terms of numbers, volume and depth of pools is found in the lower half of the mainstem (downstream of the Capistrano Drive bridge). The lowest number of pools and fewest deep pools occur in the upper half of the mainstem (upstream of the Linda Mar Boulevard bridge). The study also indicated that pool volume did not appear to be reduced by sediment deposition.

The total number of LWD greater than 8 inches in diameter was 198 with a spacing of one LWD every 70 feet. Almost 82% of the LWD was composed of native willows and alders, with almost 10% originating from non-native species and lumber. The size of LWD found in the mainstem was relatively small, which is likely due to the relatively young aged riparian vegetation growing along the banks (Collins et al. 2001). In addition, most of the larger woody debris has historically been removed from the channel to maximize the transport of flood waters and sediment. Entrenchment of the channel also reduces the residence time of LWD in the mainstem. The absence of floodplains or terraces results in most of the LWD residing in the active channel, thereby increasing its rate of breakdown or transport out of the system. The number of LWD was highest in the Highway 1 and Adobe reach and lowest in the Peralta reach.

The geomorphic survey also measured bedload sediment particle size and distribution for the mainstem of San Pedro Creek. Distribution of sediment particle size can help determine the contribution of sediment from tributaries and other sources and potential sediment impacts on fish habitat (Collins et al. 2001). The presence of fine sediments impacts fisheries by filling in pools and spawning gravels, while coarse/very coarse gravel substrate can indicate potential fish spawning areas. The study reported coarse/very coarse gravels comprised 35% of the total sediment class of the mainstem and 22% was sand and fines. Sediment becomes finer in the downstream direction, with the reaches below Capistrano having the highest percentage of sand and fines. The Oddstad reach contained the highest amount of coarse to very coarse gravels. The overall amount of sand and fines (22%) is considered low compared to other Bay Area streams and within range of other streams in the region containing viable steelhead habitat (Collins et al. 2001).

Hagar Environmental Science has recently conducted a steelhead habitat assessment for the SPCWC. The assessment includes a salmonid habitat survey using California Department of Fish and Game methodology, as described in the California Salmonid Stream Habitat Restoration Manual (Flosi et al. 1998). Habitat quality was evaluated using many parameters, including depth and type of pools, distribution of spawning gravels, sources and impacts of sediment and riparian condition. The assessment also evaluated potential fish barriers to determine the extent and quality of available steelhead habitat. The survey will focus on the Middle and South Forks, Sanchez Creek and Shamrock Creek and a more general reconnaissance will be done for the mainstem. Restoration work improving fish passage has recently been implemented at Capistrano Street Bridge crossing the mainstem and on the Middle Fork in the San Pedro Valley County Park (Appendix B).

<u>Riparian Vegetation</u>
Vasey (2000) surveyed riparian vegetation of the San Pedro Creek mainstem and the lower branches of its tributaries during the summer of 1999. The survey established a geo-referenced baseline of riparian plant species diversity and assessed and mapped the occurrence of non-native invasive plant species along the lower reaches of the creek. In addition, the survey identified native plant species assemblages for use in future habitat restoration efforts.

The results of the vegetation survey indicate San Pedro Creek contains more exotic plant species than native (75 exotic to 65 native), but native species occur twice as often and constitute over two-thirds more vegetative coverage. These values are averages for the entire study area; substantial variation among different reaches of the stream was found. Riparian vegetation was sampled at 205 locations between the mouth and upper Middle and South Forks. The creek was subdivided into reaches and each reach was evaluated for fish and wildlife habitat value (high, moderate, or low) (Figure 7). Habitat value was based on the presence of canopy cover and the dominance and richness of indigenous species. The ranking of fish and wildlife values for the four major reaches were as follows: (1) the lower mainstem was high between the creek mouth and Peralta, but low between Peralta and the Adobe Drive bridge; (2) the middle mainstem was generally rated moderate throughout the reach; (3) the upper mainstem was generally rated moderate and (4) the upper forks had high fish and wildlife values.

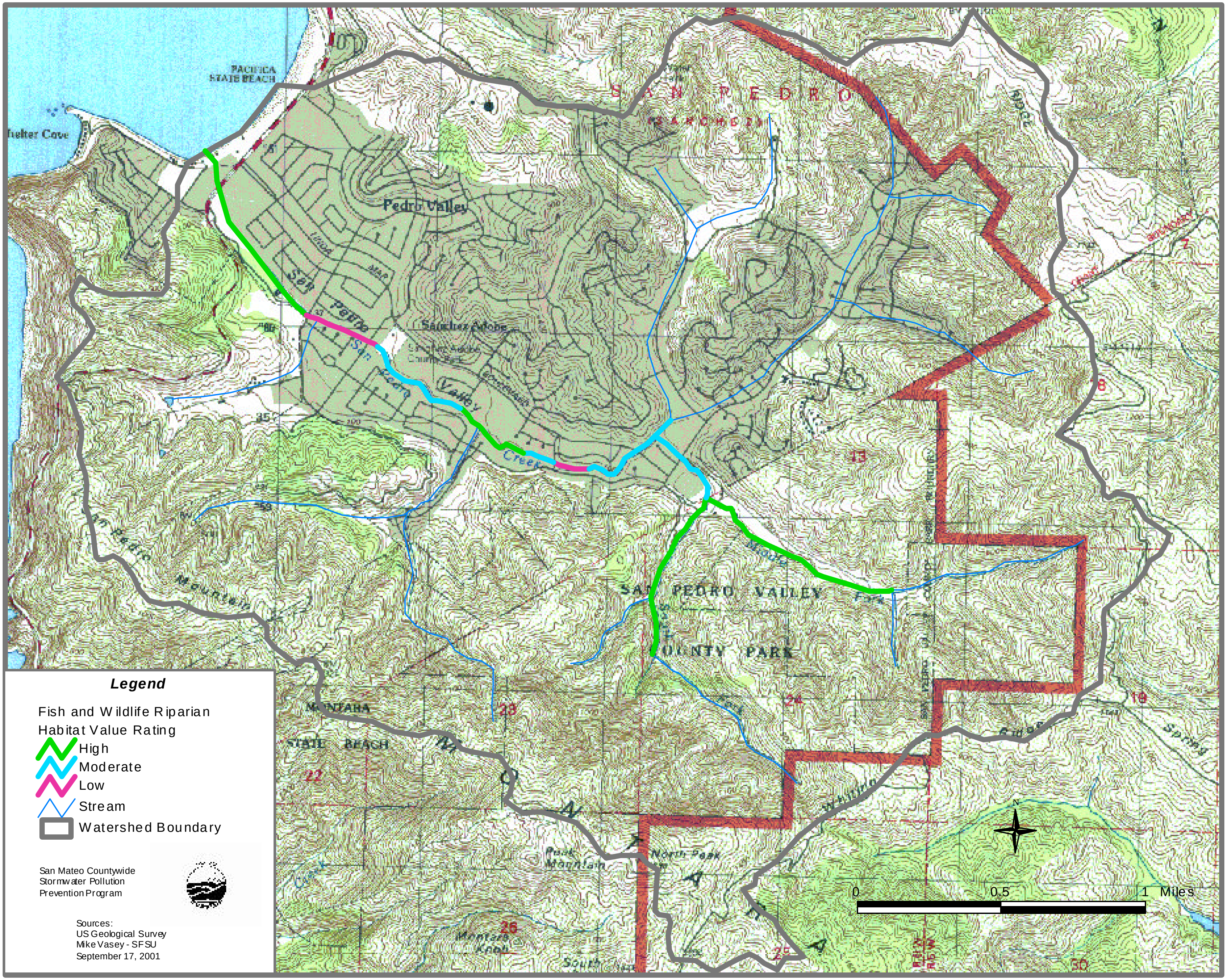

Figure 7 - Riparian Vegetation Rating for Fish and Wildlife Value in San Pedro Creek.

There is an ongoing non-native species removal and native re-vegetation project in the San Pedro Creek mainstem, just downstream of the Capistrano Drive bridge (Mike Vasey 2001, personal communication). Past projects include removal of non-native *Arundo donax* between the North Fork confluence and Oddstad Boulevard bridge and removal of cape ivy and poison hemlock along the South Fork (Appendix B).

Water Quality

There are many possible impacts to water quality associated with anthropogenic activities in the San Pedro Creek watershed. Urban runoff potentially introduces pollutants (e.g., petroleum hydrocarbons, detergents, and sediment) into surface waters that may impact aquatic life and habitat. Leaky sanitary sewers and septic tanks and runoff from equestrian facilities and cattle ranches could introduce pathogens to surface waters and pose a human health risk. Runoff from the closed landfill in the North Fork drainage could introduce metals that may be toxic to aquatic life. Removal of riparian vegetation for channel maintenance and development could result in higher water temperatures and increased sediment loads to the stream, potentially impacting aquatic biota and habitat conditions. We collected and assessed existing water quality data to attempt to determine if water quality is degraded, identify the source of degradation and inform future monitoring strategies.

We compiled and assessed water quality data from two sources. The first was a water quality study conducted by SFSU graduate student Vivian Matuk in the year 2000 as part of her Master's thesis. The study measured physical (water temperature, TSS and turbidity), chemical (pH, alkalinity, hardness, conductivity, dissolved oxygen, nitrates, nitrites, nitrogen ammonia, phosphorus and metals) and microbial indicator (total and fecal coliform, *E. coli* and enterococcus) water quality parameters at weekly intervals for four two-month time periods (January - February, April - May, July - August and October - November). Sampling occurred at seven locations in the watershed, two sites in the Pacific Ocean near the outlet of San Pedro Creek, three sites in the mainstem and one site each in the North Fork and Middle Fork (Figure 8). In addition, we compiled and assessed coliform data collected by the San Mateo County Health Department (SMCHD). SMCHD measured fecal and total coliform at weekly intervals from 1997 to 2000.

The study conducted by Matuk (2001) found seasonal variations in the physical, chemical and biological water quality parameters. The dry and warm climate in the summer influences the water quality of the creek. The highest values of alkalinity, hardness, electrical conductivity and pH were reported during the April-May and July-August sampling periods. The lowest value of water temperature and highest values of turbidity and dissolved oxygen occurred during the winter sampling period. Higher flows and colder ambient temperatures influence these patterns. The microbial indicator values were also highest in the spring and summer sampling periods, indicating that stormwater runoff was not required to transport bacteria to surface waters.

A comparison of the values of the physical, chemical and microbial water quality parameters among the different sampling locations also reveals spatial variations (Matuk 2001). The highest water temperature, pH, alkalinity, hardness, electrical conductivity and bacteriological values occurred at the North Fork site. The lowest values for these parameters occurred at the Middle Fork site. The lowest values of turbidity and dissolved oxygen were reported at the North Fork site, while the highest values for these parameters occurred at the Middle Fork. Urbanization, inputs from sanitary and storm

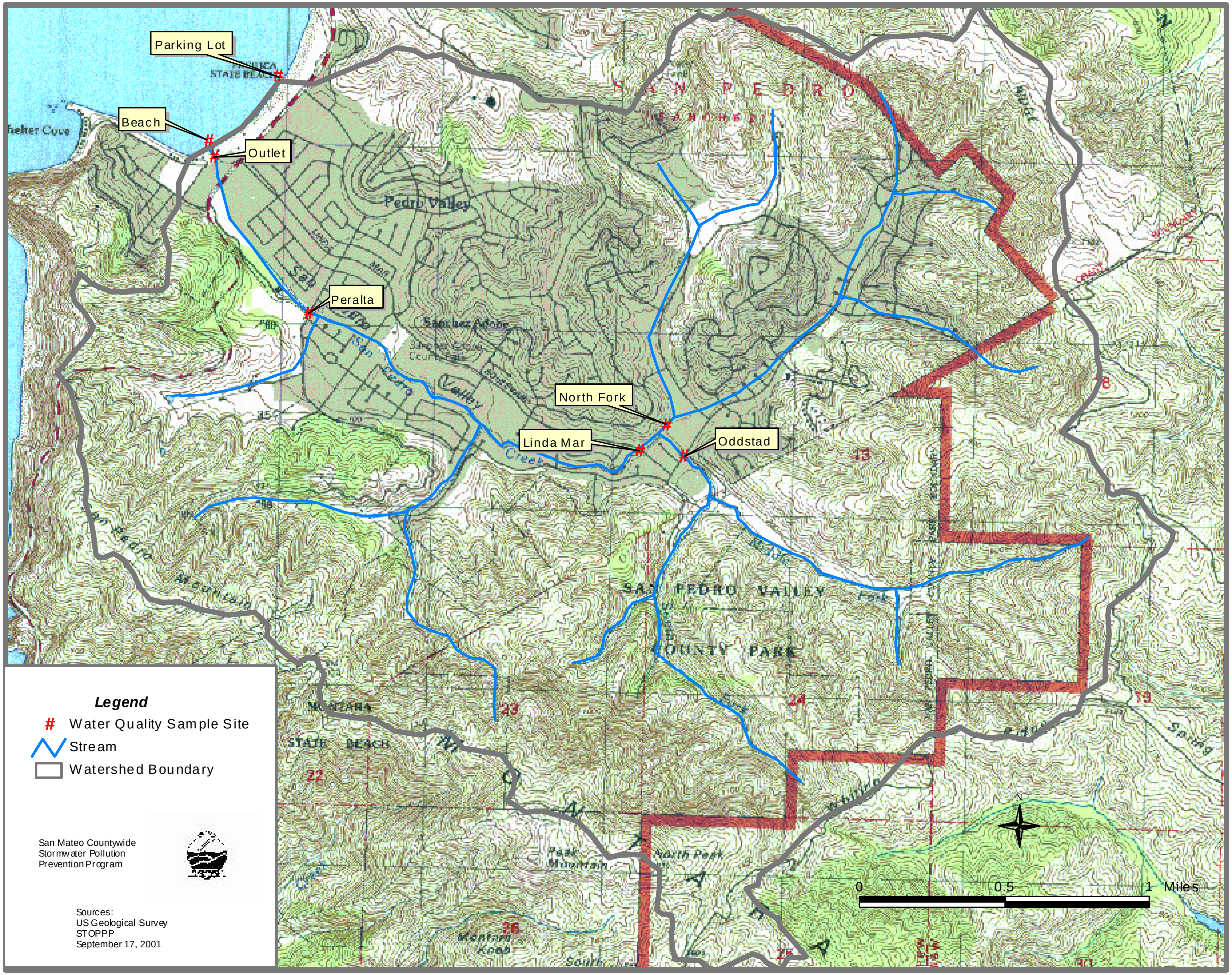

Figure 8 - Water Quality Sampling Locations in San Pedro Creek.

drain systems, and geology are probably the most important factors causing the spatial variation observed in this study. Similar values for all of the water quality parameters were measured at the Linda Mar, Peralta and Outlet sampling sites.

In summary, San Pedro Creek was characterized as having stable water temperature, relatively "hard" and alkaline properties, and well-oxygenated and moderately conductive water (Matuk 2001). In addition, there were elevated values of indicator bacteria, primarily originating from the highly urbanized North Fork. These values however, met Water Quality Objectives for non-contact recreation (REC2) beneficial uses. Overall, the physical, chemical and microbial parameters measured during the study generally met Regional Board, U.S. EPA and literature standards for freshwater habitat. Only some alkalinity values reported for the North Fork exceeded the standards reported in the literature.

Total and fecal coliform data collected by SMCHD along San Pedro Creek also met Water Quality Objectives for REC2 uses (Randall 2001). However, the values frequently exceeded Water Quality Objectives for contact recreation (REC1) beneficial uses, such as swimming. The public has been known to use sections of the creek above the beach area and along the Peralta Bridge for swimming and wading (Vivian Matuk 2001, personal communication). SMCHD has posted signs at the beach and the Peralta Road bridge warning the public of water contamination in the creek. There have also been recommendations that the beneficial use be changed from REC2 to REC1 to reflect the actual public use of the creek and that water quality standards be raised to protect the waters from continued contamination (Matuk 2001).

Bacterial indicator data collected by Matuk (2001) and SMCHD at Pacifica State Beach show the Water Quality Objectives for REC1 use are generally met, except for some winter months when bacterial levels are high enough to close the beach (Randall 2001). Analysis of SMCHD fecal coliform data collected between November 1998 and January 2001 at the Beach site closest to the creek showed out of 110 samples (geometric mean of 5 samples collected within a 30-day period), only 3% exceeded water quality standards for fecal coliform of 400 MPN/100ml.

Physical, chemical and microbial parameters will continue to be monitored in San Pedro Creek. A long-term volunteer monitoring program has been established by the SPCWC, which will involve weekly sampling of physical and chemical water quality parameters in the San Pedro Creek watershed. In addition, the SPCWC has proposed to begin sampling coliform and optical brighteners at 10 locations in San Pedro Creek starting November 2001 to determine source of pathogens (Appendix B). The SMCHD will also continue their sampling program for pathogens on a weekly or biweekly basis at the mouth of San Pedro Creek and two sites along Pacifica State Beach (Hartsell, 2001, personal communication).

The SPCWC has conducted several Creek Clean-up events to remove trash in San Pedro Creek. The amount of trash collected from the creek was not documented until summer of 2001 when approximately 150 pounds of trash was removed between Highway 1 and the beach. Most of the trash observed in the creek occurs downstream of bridges and at the outlet of the North Fork (Bernie Halloran, SPCWC, personal communication, 2001). Trash was significantly reduced at the North Fork outlet after Safeway went out of business, although homeless encampments continue to produce trash along this reach of San Pedro Creek.

The SPCWC has also expressed interest in improving outreach efforts to educate the public in San Pedro Creek watershed about Best Management Practices (BMPs) for car washing activities (Halloran, SPCWC, personal communication, 2001). One idea developed by SPCWC is to construct a public car washing facility that provides soap and water in a lot designed with drainage to a sewer line. The SPCWC has also expressed interest in enhancing outreach efforts to educate the public about BMPs for pesticide use. SPCWC has not tested creek water for pesticides in the past because of the high costs for laboratory analysis.

Stream Classification and Stream Function
Existing information related to the stream structure and function was compiled to develop a classification system for streams in the San Pedro Creek watershed. The purposes for developing a reach classification are to provide a framework for identifying potential impacts to watershed health, identify and locate important aquatic resources to protect, and to prioritize future monitoring locations and parameters to further assess stream condition.

Twenty reaches were classified in the San Pedro Creek watershed (Figure 9). Seven variables were selected from existing geomorphic and biological data, as well as information derived from USGS topographic quadrangle maps, to classify reaches in the San Pedro Creek watershed (Table 1). The following variables were used:

- Level 1 Rosgen stream classification (Rosgen 1994): most basic level of established geomorphic classification that is based on channel slopes and shape (e.g., sinuousity, braided, straight). We used Rosgen classes identified by Collins et al. (2001) for the mainstem and estimated Rosgen classes for the tributaries using channel slopes derived by USGS topographic maps.
- Gradient: Obtained from Collins et al. (2001) for reaches in the mainstem and derived from USGS topographic maps for tributaries.
- Channel Modifications: Compiled existing information, with field verification, to create this GIS layer.
- Instream Sediment Supply Rating: Stream reaches were rated high, moderate and low using estimates of total sediment supply provided by Collins et al. (2001).
- Riparian Condition Fish and Wildlife Value: Obtained from Vasey (2001).
- Ocean/Tributary Influence: Used major tributary confluences and tidal influence to define changes in stream function and structure.
- Special Status Species: Estimated distribution of steelhead and red-legged frogs from literature and phone interviews. Special status species are the most important aquatic species that need to be protected.

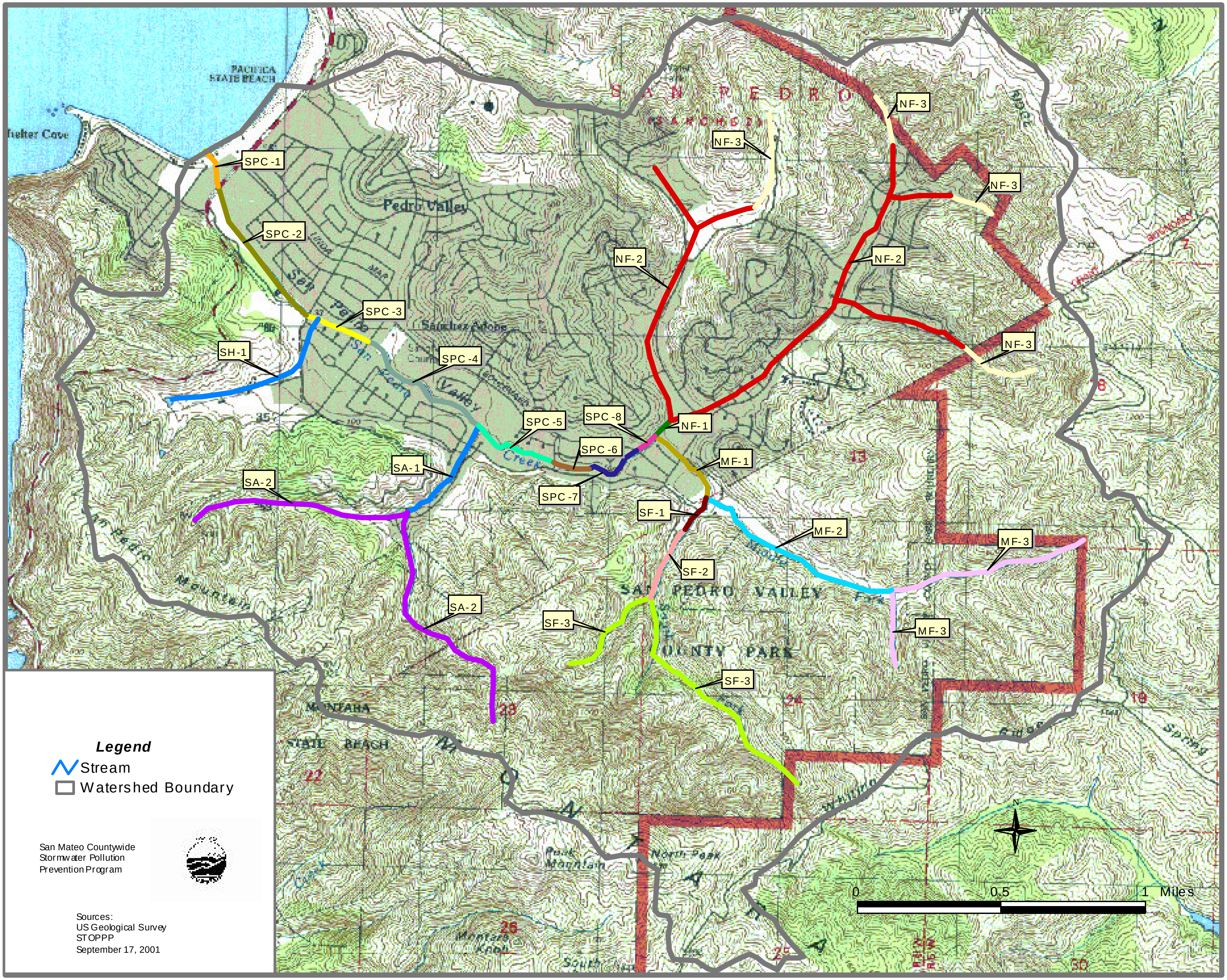

Figure 9 - Stream Classification Reaches for San Pedro Creek.

Table 1. Variables used for classifying stream reaches in San Pedro Creek

	Reach[1]	Description	Rosgen Class[2]	Gradient (% slope)	Channel Modifications[3]	Instream Sediment Supply	Riparian Condition[4] (Fish & Wildlife Value)	Ocean/ Tributary Influence	Special Status Species
Mainstem	SPC-1	Mouth to Highway 1 Bridge			Earth-lined		High	Tidal	Steelhead, RLF[5]
	SPC-2	Highway 1 to Peralta Bridge	B,G,E	0.44%	Earth-lined	Low	High	Shamrock Cr	Steelhead, RLF
	SPC-3	Peralta Bridge to Adobe Bridge	B	0.70%	Earth-lined	Low	Low		Steelhead
	SPC-4	Adobe Bridge to Sanchez Cr	G,B	1.12%	Modified/ Not channelized	High	Moderate	Sanchez Cr	Steelhead
	SPC-5	Sanchez Cr to Capistrano	G,B	1.12%	Modified/ Not channelized	High	High		Steelhead
	SPC-6	Capistrano to upper end of concrete channel	NA	1.55%	Concrete-lined	Not Applicable	Low		Steelhead
	SPC-7	Concrete channel to Linda Mar	B	1.55%	Modified/ Not channelized	Moderate	Moderate		Steelhead
	SPC-8	Linda Mar to NF confluence	B,G	1.62%	Modified/ Not channelized	High	Moderate	North Fork	Steelhead
Middle Fork	MF-1	NF confluence - SF confluence	B	1.28%	Modified/ Not channelized	Moderate	Moderate	South Fork	Steelhead
	MF-2	SF confluence - Shamrock confluence	B	3.10%	Not modified			Unnamed	Steelhead
	MF-3	Tributaries	A+	10-20%	Not modified				
South Fork	SF-1	SF confluence - Diversion Dam	B	3.50%	Not modified		High		Steelhead
	SF-2	Diversion - Brooks Cr confluence	A	5.20%	Not modified			Brooks Cr	
	SF-3	Tributaries	A+	10-20%	Not modified				
North Fork	NF-1	MF confluence to culvert outlet	B	1-2%	Modified/ Not channelized		Moderate		Steelhead
	NF-2	Major stormdrain culverts	culverted	NA	Culvert				
	NF-3	Tributaries	A+	7-22%	Not modified				
Sanchez	SA-1	Mainstem to Shamrock confluence	A	5.20%	Not modified		High		
	SA-2	Tributaries	A+	8-10%	Not modified				
Shamrock	SH-1	Mainstem to pond	B	4.00%	Not modified				

Notes:
[1] See Figure 9
[2] See Appendix C
[3] See Figure 3
[4] See Figure 7
[5] RLF - Red-legged Frog

The classification can be used to help select appropriate monitoring sites and determine what perturbations might affect a particular site. For example, if there were significant differences in benthic macro-invertebrates populations between sites located above and below Shamrock Creek, one could investigate how stream functions for these reaches may be different. In this case, the geomorphic condition for these reaches are very similar, but the lower reach is influenced by a tributary and also has higher values for riparian condition. Table 1 also shows data types that are missing by reach, which may be used to target future monitoring efforts. The next section identifies a range of questions regarding the condition of the San Pedro Creek watershed and the types of data needed to answer these questions.

Recommendations for Monitoring Strategy

Identify Data Needs and Sampling Locations

Sediment Sources and Channel Morphology

Existing geomorphic information shows that there has been increased sediment supplied to the mainstem of San Pedro Creek by both bed and bank erosion over a 217 year time period. These impacts have been driven by land use changes, including conversion to agriculture, cattle grazing and urbanization, resulting in increased streamflows and sediment supply. Erosion in the mainstem has also been caused by channel modifications, which include the construction of a ditch in the lower 0.8 mile of San Pedro Creek, the construction of a 640 foot long concrete-lined channel above the Capistrano Street bridge and road culverts. Historical diversion dams and bank revetment failures have also caused erosion. These changes have all contributed to channel instability resulting in a deeply incised channel and higher sediment yields.

Based on the total volume of sediment supply over 217 years, the average yearly supply of sediment from bed and bank erosion in the San Pedro Creek mainstem was estimated to be 388 cubic yards (Collins et al. 2001). It is not known how accurately this estimate represents the current sediment supply in the mainstem. The annual rate of sediment supply has probably not been constant over the 217 years due to high variation in streamflows and dynamic changes to the channel in response to these flows. The channel has been adjusting to higher flows and channel modifications for over 50 years since urbanization began and 130 years since construction of the ditch. Entrenched channels continue to erode until they develop flatter gradients and eventually establish a new equilibrium between sediment load and flow energy (Riley 1999).

The primary causes and the rates of bed and bank erosion presently occurring in the San Pedro Creek mainstem could be determined by periodically measuring channel dimensions. Measuring longitudinal profiles in the mainstem over time would provide information about how channel morphology is responding to current streamflows and channel modifications, including restoration projects. Measurements could be made following high flow events where bank erosion is evident, or over regular 5-10 year intervals along specific reaches. It would make sense to monitor the Adobe and Linda Mar reaches (Figure 6), which have historically produced the greatest amount of sediment to the channel. Reaches containing potential habitat for steelhead and other sensitive species could also be monitored to determine if beneficial uses are being threatened. Reaches that have been restored, such as the flood control project above

Highway 1, could be monitored to determine if restoration work was effective at stabilizing the stream channel. Longitudinal profile measurements are recommended rather than channel cross sections because a baseline profile already exists, and they provide information on channel geometry along greater lengths of stream.

The amount and source of sediment originating from the tributaries to San Pedro Creek are also unknown. Historical photos show evidence of gully erosion in the hillsides occurring in the 1850's, probably from cattle grazing. Landslides have also impacted the watershed, including the 475 landslides resulting from the 1982 winter storm. Previous landslides, gullies and tributary channels should be evaluated for past and potential supply of sediment. Landslides occurring since 1982 should be evaluated for their relationship to land use practices (e.g., roads, off road vehicle use) versus natural perturbations (e.g., intense rainfall on steep slopes). Potential management actions for sediment sources related to human activities should be identified. A proposal to evaluate sediment sources in the upland areas was developed by SPCWC and recently submitted to RWQCB for funding under the Proposition 13 grant.

<u>Physical Habitat and Biological Condition</u>
In an effort to determine the impacts of increased sediment supply to watershed health and the attainment of the designated beneficial uses such as the cold water habitat and fish spawning, it is important to evaluate the condition of aquatic biota and physical habitat. Despite historical sediment supply in the San Pedro Creek mainstem from instream channel erosion, the current percentage of fine sediment is relatively low (22%) compared to other Bay Area streams. This percentage is in the same range as other streams containing viable steelhead populations (Collins et al. 2001). Increased sediment supply due to human activities could potentially be transported quickly out of the watershed and as a result, have limited impacts to the native biota.

A direct assessment of steelhead populations is not feasible because they are protected under the Endangered Species Act. Permits from the National Marine Fisheries Service are required to conduct studies to quantify their population size and composition. The steelhead habitat assessment report (Appendix B) should identify potential impacts of sediment to fish populations. Salmonid habitat surveys typically provide information on the amount of embeddedness of substrate (percentage of coarse gravels or cobble substrate embedded in fine sediment) and qualitatively assess impacts of fine sediment on available spawning gravels and instream fish cover. The habitat survey focused on tributaries to the San Pedro Creek. To the extent possible, the study will also assess steelhead habitat condition for the mainstem using existing data obtained from the 1999 geomorphic study (Collins et al. 2001).

The assessment will also identify limiting factors to steelhead populations other than sediment (e.g., physical barriers, lack of instream cover, food source). These factors may influence future monitoring efforts. For example, if migration barriers were identified, restoration projects could be implemented to improve passage and upstream reaches could be visually surveyed to determine if fish are utilizing reaches above the barrier. Monitoring should be a part of any restoration project to determine effectiveness of restoration.

Sampling benthic macro-invertebrate (BMI) populations would help determine impacts of water quality changes, including increased sediment supply, to aquatic biota. The California Stream Bioassessment Procedure (CSBP) has established a point source and non point source sampling design for selecting BMI sampling locations that are effective in assessing watershed condition (J. Harrington and M. Born, 1999). Abundance and composition of species assemblages can provide information on the type of stressors that are potentially impacting the habitat. For example, many BMI species have already been identified as being either tolerant or intolerant to fine sediment (Harrington, 2001, personal communication). A complete species list from each sample location can produce metrics used to rate the condition of the site. The total score of the metrics can then be compared to other sites in the watershed, as well as other sites in similar watersheds to determine the overall health of the stream. The Watershed Coastal Council has been collecting BMI data for their water quality monitoring program for several coastal streams in San Mateo County (www.coastal-watershed.org).

Selecting appropriate sampling locations for BMIs is critical for identifying potential sources of impacts to the watershed. For example, sampling locations above and below a tributary confluence can identify differences in BMI populations and reveal potential stressors coming from a tributary or outfall (e.g., sediment or nutrient loading). A physical habitat assessment is also conducted at each sampling site to help characterize the habitat condition and identify potential impacts. Cost of sampling and data analysis are also important factors to consider when selecting sites. The CSBP field sampling methodology is recommended for citizen monitoring groups because it is relatively easy and inexpensive to implement. The major cost is identification of BMIs and data analysis, which should be done by experts that can assure quality control. The San Pedro Creek Watershed Coalition has expressed interest in participating in a bioassessment monitoring program using BMIs (Bernie Halloran 2001, personal communication).

BMIs should be collected at a minimum of 4-5 locations in San Pedro Creek. Four of the sites would be similar to the water quality sampling locations used by Vivian Matuk (Peralta, Linda Mar, North Fork and Oddstad shown in Figure 8). These sites already have valuable water quality information that can be related to metrics generated from the BMI assessments. The Oddstad site should be evaluated to determine if it is the best representation for a reference site in the watershed (site with least amount of human impacts). In addition, we recommend sampling between the Adobe Drive bridge and the Sanchez Creek confluence. The site above the Adobe Drive bridge would be useful to identify the condition of BMIs in a reach that appears to have a significant sediment supply. The CSBP protocol calls for collection of three separate samples of macro-invertebrates in riffle type habitats. These samples are combined and subsampled for insect identification. Sampling of BMIs should occur in the spring (April-May) to standardize sampling protocols used in other BMI sampling efforts in the San Francisco Bay Area.

<u>Water quality</u>
The existing physical and chemical water quality data for San Pedro Creek shows that the Water Quality Objectives of the Basin Plan are met and appear to support the designated beneficial uses (Matuk 2001). Continued monitoring for these parameters by volunteers coordinated by SPCWC will provide additional information on water quality trends and help to identify threats to water quality in the event that measurements exceed standards.

Existing data on bacterial indicators also appear to meet Water Quality Objectives of the Basin Plan for the non-contact water recreation beneficial use. However, there are sections of the creek that are used by the public for swimming which exhibited elevated bacterial levels that exceeded standards for contact water recreation. In addition, water quality objectives are occasionally exceeded at Pacifica State Beach, which has resulted in closure of beaches (Randall 2001). The Regional Board has recommended both San Pedro Creek and Pacifica State Beach be placed on the 303(d) list for impairment due to pathogens. If San Pedro Creek is listed, it will initiate the Total Maximum Daily Load (TMDL) process. As part of this process, sources of pathogens in the watershed will need to be identified.

Existing data show the highest concentration of bacterial indicators in the watershed comes from the North Fork. It has yet to be determined if the bacteria in the creek originate from a human or animal source. If the source is human sewage, then the creek water could be contaminated by human pathogens, which could pose a public health risk to people swimming in the creek. The San Pedro Creek Watershed Coalition is planning a study using optical brighteners to determine if the source of bacteria is from leaky sewers. Optical brighteners are fluorescent white dyes added to most laundry soaps and detergents. (Optical Brightener Handbook – www.thecompass.org/8TB). The study will involve taking monthly samples, between November 2001 and October 2002, for total and fecal coliform and optical brighteners at ten locations in the watershed, including 4 locations in the North Fork. The RWQCB has contributed funding for the purchase of some equipment and data analysis, but SPCWC needs additional funding to purchase sampling equipment and conduct the fieldwork.

The RWQCB also has determined that trash threatens to impair water quality in all urban creeks, lakes, and shorelines in the San Francisco Bay Region (RWQCB 2001). As part of the pilot watershed assessment, sources and quantity of trash found in the creek should be identified. It would also be useful to evaluate trash in terms of potential impacts to beneficial uses. This information could be used by municipal storm water programs to identify better ways for controlling trash discharges. An assessment of trash would be needed primarily in the urbanized section of San Pedro Creek, from the Oddstad Boulevard bridge and the North Fork culvert outlet downstream to the mouth of the creek at Pacifica Beach.

The data needs for developing a long-term monitoring design are listed in Table 2.

Table 2. Type and location of data for recommended additional watershed assessment in San Pedro Creek.

Current Data Needs	**Location**	**Status**
Longitudinal Channel Survey	Mainstem	Initial profile measured by SPCWC in fall 2001. Future channel measurements not currently planned.
Sediment Supply (Landslide, Gullies, Instream Sources)	Tributaries	SPCWC recently submitted proposal to RWQCB, currently under review.
Physical Habitat Assessment	Mainstem and Tributaries	Completed by SPCWC in October 2001, report in preparation.
Macro-invertebrate Bioassessment	Primarily Mainstem	STOPPP to perform in coordination with SPCWC and volunteers.
Pathogen Source	North Fork, Mainstem	STOPPP to provide funding to SPCWC to complete 1-year study.
Trash Assessment	Mainstem	STOPPP to perform.

Comparison of Existing and Proposed Monitoring to RMAS

The Regional Board's RMAS classifies potential monitoring parameters into two tiers. Tier 1 includes measurements that allow a screening-level of assessment of physical, chemical and biological condition of the watershed. Tier 1 measurements include general water quality (temperature, pH, electrical conductivity, dissolved oxygen and turbidity), rapid bioassessment, and visual assessment of physical habitat. Tier 2 includes measurements that help to answer specific questions about land uses and the potential impairment of beneficial uses. Tier 2 measurements are more detailed and include nutrients, bacteria indicators, sediment, toxicity, and organic and inorganic contaminants.

Previous studies in San Pedro Creek, including the steelhead habitat assessment, have included both Tier 1 and 2 types of measurements. Tier 1 parameters already measured include general water quality parameters and assessment of physical habitat. Rapid bioassessment measurements using benthic macro-invertebrates are Tier 1 data not previously collected. We recommend collection of this data during future monitoring efforts in the San Pedro Creek watershed. Tier 2 data already collected in the San Pedro Creek watershed includes bacterial indicators, some nutrient and metal measurements (only for spring season) and geomorphology (sediment supply measured in the mainstem). Other Tier 2 measurements that are recommended for future monitoring include identifying sources of bacteria, identifying sources and potential impacts of trash, evaluating sediment sources in the tributaries and monitoring changes to channel morphology in the mainstem.

Recommended Two-Year Monitoring Program

It is recommended that STOPPP implement a 2-year monitoring program that includes the following:

- Assist the SPCWC to conduct a rapid bioassessment using benthic macro-invertebrates.
- Assist the SPCWC to identify the source of bacterial indicators.
- Identify the sources and potential impacts of trash to the San Pedro Creek watershed.

BMIs should be sampled one time during the spring season for two consecutive years. A one-year optical brightener study is scheduled to start in fall 2001. A trash study should be scoped in FY 2001 and implemented in FY 2002. Monitoring changes to channel morphology and upland sediment sources is a part of a long-term monitoring strategy that could potentially be funded through a Proposition 13 grant. The frequency, timing, staffing requirements and estimated costs to STOPPP of the recommended monitoring efforts for the next two years are shown in Table 3.

Table 3. Timing, frequency, staffing requirements and estimated costs of recommended 2-year monitoring design in San Pedro Creek.

Study	Sampling Frequency	Number of samples	Staffing	Estimated costs to STOPPP
FY 2001/2002				
Optical Brightener	Monthly	12	SPCWC	$6,000
BMI Rapid Bioassessment	Yearly (Spring)	15	EOA/SPCWC	$21,000
Design Trash Study	NA	NA	EOA	$10,000
FY 2002/2003				
BMI Rapid Bioassessment	Yearly (Spring)	15	EOA/SPCWC	$16,000
Implement Trash Study	Summer/Fall	NA	EOA	$25,000

Costs for the first year rapid bioassessment include a one-time training of volunteers associated with SPCWC to collect BMI and physical habitat data and the purchase of sampling equipment, for a total of approximately $5,000. The remaining bioassessment budget will cover taxonomic identification, QA/QC and metrics for approximately 5-6 sites, and an interpretive report explaining the results. Costs for the optical brightener study are primarily for SPCWC staff to conduct fieldwork for 1 year. Costs associated with the trash study include development and implementation of a monitoring design and assessment of impacts of trash to beneficial uses.

References

BioSystems Analysis Inc., 1991. 1990 Archeological Investigation of Sanchez Adobe Park Historic District, for San Mateo County, Department of Environmental Management, Parks and Recreation Division.

CRWQCB, 2001. Proposed Revisions to Section 303(d) List and Priorities for Development of Total Maximum Daily Loads (TMDLs) for the San Francisco Bay Region. August 24, 2001 Draft Staff Report.

City of Pacifica and U.S. Army Corps of Engineers, 2000. San Pedro Creek Flood Control and Ecosystem Restoration Project, Pacifica, California. Prepared by L.C. Lee & Associates, Inc., Seattle, Washington.

Collins, L., P. Amato and D. Morton, 2001. San Pedro Creek Geomorphic Analysis, report for the San Pedro Creek Watershed Coalition.

EOA, Inc., 2001. Characterization of Imperviousness and Creek Channel Modifications for Seventeen Watersheds in San Mateo County. *In preparation.*

Fiedler, P. 2001. Personal communication, July 25 phone conversation. L.C. Lee & Associates.

Flosi, G., Downie, S., Hopelain, J., Bird, M., Coey, R., and Collins, B. 1998. California Salmonid Stream Habitat Restoration Manual, Third Edition. California Department of Fish and Game, Inland Fisheries Division, January 1998.

Halloran, B. 2001. Personal communication. San Pedro Creek Watershed Coalition.

Harrington, J. and M. Born 1999. Measuring the Health of California Streams and Rivers: A Methods Manual for Water Resource Professionals, Citizen Monitors, and Natural Resource Students. Copyrighted by Sustainable Land Stewardship International Institute, Sacramento, California.

Hartsell, S. 2001. Personal communication. San Mateo County Health Department

Howard, T.R., J.E. Baldwin II and H.F. Donley, 1982. Landslides in Pacifica, California, caused by the storm, pages 163-183, in Ellen, S.D., and G.F. Wieczorek eds., Landslides, floods and marine effects of the storm of January 3-5, 1982, in the San Francisco Bay Region, California. Professional Paper 1434. Washington: U.S. Government Publishing Office.

Matuk, V., 2001. Personal communication. San Pedro Creek Watershed Coalition.

Matuk, V., 2001. Water Quality in San Pedro Creek Watershed, Pacifica, California. Masters Thesis submitted at San Francisco State University, March, 2001.

NCWAP 2001. North Coast Watershed Assessment Program Draft Methods Manual, from www.ncwatershed.ca.gov.

Randall, P. 2001. Response to Recommendation by Water Keepers of Northern California for San Pedro Creek to be Added to 303(d) list of Fecal, Coliform, Total Coliform and Sedimentation. Memorandum to Bob Davidson, STOPPP. July 27, 2001.

Riley, A.L. 1998. Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens. Island Press, Washington DC.

Rosgen, D., 1994. Applied River Morphology: Wildland Hydrology, Pagosa Springs, and Colorado.

Titus, R.G., D.C. Erman and W.M. Snider 2001. History and Status of Steelhead in California Coastal Drainages South of San Francisco Bay. *In preparation.*

Vasey, M. 2000. Vegetation Survey of San Pedro Creek Progress Report submitted to San Pedro Creek Watershed Coalition, June 30, 2000.

Vaesy, M. 2001. Personal communication, August 31 e-mail correspondence. San Francisco State University.

Wentworth, C.M., S.E Graham, R.J. Pike, G.S. Beukelman, D.W. Ramsey, and A.D. Barron, 1997. Summary Distribution of Slides and Earth Flows in the San Francisco Bay Region, California. Department of the Interior U.S. Geological Survey Open-File Report 97-745 C.

Appendix A: Creek Channel Modification Categories.

Culvert:

- Creek runs underground in a culvert for distances greater than approximately 500 feet.

Concrete-lined Channel:

- Creek is generally channelized in a concrete structure.
- Parts of creek may be culverted for distances less than approximately 500 feet (e.g., passing beneath roads).

Earth Channel:

- Creek is generally in an earth channel.
- Parts of creek may be culverted for distances less than approximately 500 feet (e.g., passing beneath roads).

Modified but Not Channelized:

- Creek generally does not appear to be channelized.
- Parts of creek may be culverted for distances less than approximately 500 feet (e.g., passing beneath roads).
- Creek generally has erosion control structures (e.g., gabion, riprap) or treatments (e.g., plastic sheeting) in some areas.
- Creek banks may have been filled in some areas.

Unmodified Channel:

- Creek generally does not appear to be channelized.
- Parts of creek may be culverted for distances less than approximately 500 feet (e.g., passing beneath roads).
- Creek generally does not have erosion control structures or treatments.

Appendix B: Restoration and Monitoring Projects

Restoration Projects

Project: San Pedro Creek Wetland Restoration and Flood Control Project (City of Pacifica and USACE, August 2000)

Location: The first phase of the project affects area adjacent to the lower one-half mile reach of San Pedro Creek, from Pacifica State Beach to Linda Mar Convalescent Hospital. Later phases of the project could impact the entire mainstem of San Pedro Creek, all the way up to San Pedro Valley County Park.

Description: This project, sponsored by City of Pacifica and U.S. Army Corps of Engineers, combines flood protection and restoration of riverine wetlands for San Pedro Creek. Phase 1 of the project will create a new meandering channel in a 10-acre region east of Highway 1 and the adjacent flood plain to increase channel capacity for flood flows. The wetland region will include construction of "microdepressions" to improve water storage capacity and habitat complexity. In addition, large woody debris will be placed along the meandering steam channel and native riparian vegetation will be planted throughout the wetland area. Other work includes removing a levee on the north side of channel to the west of Highway 1 to reconnect the stream with a portion of its original floodplain. This phase is scheduled to be complete in early 2001. In Phase 2, approximately two years following completion of Phase 1, water from the existing channel will be diverted into the newly constructed stream channel and the old channel will be backfilled, graded and planted with native riparian vegetation. This phase involves restoration of San Pedro Creek up to Peralta Road bridge. Phase 3, schedule to begin in 2002, involves further restoration up to Adobe Drive bridge, including replacement of the bridge to widen the existing floodplain. Phase 4 involves increasing channel widths to permit flood flows and enhance steelhead habitat, upstream to the San Pedro Valley County Park. City of Pacifica will be monitoring the restored lower reaches of San Pedro Creek for a minimum of five years.

Project: Replace Fish Ladder at Capistrano Drive bridge

Location: Section of San Pedro Creek below Capistrano Drive bridge.

Description: In the summer of 2001, the City of Pacifica removed large boulders and built a series of rock weirs below the Capistrano Drive bridge to created a step pool complex at the base of the existing fish ladder. The step pools are intended to provide deep pool habitat to enhance steelhead passage through the bridge culvert. The City is trying to secure additional funding to entirely replace the fish ladder and enhance fish passage over the long-term.

Project: Replace Bridge Culvert at Weiler Ranch Road Crossing

Location: Middle Fork San Pedro Creek in San Pedro Valley Park

Description: Replacement of bridge culvert that created a seven-foot drop that was potentially a fish barrier. New bridge culvert will be installed in fall 2001. Stream banks will be revegetated using bioengineering techniques.

Project: Re-vegetate native riparian vegetation and removal of non-native plants

Location: South bank of San Pedro Creek at Creekside Townhouse just downstream of Capistrano Drive bridge.

Description: Exotic species are being removed and native plants were planted in effort to improve habitat and close canopy cover. There are plans to do the same on the north side of the bank. There have also been projects to remove non-native *Arundo donax* along the right bank between the North Fork confluence and Oddstad Boulevard bridge. Another project involved removal of non-native cape ivy and poison hemlock along the South Fork in the County Park.

Monitoring Projects

Project: San Pedro Creek Water Monitoring for Optical Brighteners

Location: Ten sampling locations throughout San Pedro Creek, including the North Fork, Middle Fork and South Fork tributaries.

Description: Monitoring water quality to determine the presence and distribution of optical brighteners in San Pedro Creek as a means of detecting sewage leaks. Monthly water sampling at the 10 sites will occur between November 2001 and October 2002. Bacteria levels (total and fecal coliform) and optical brighteners (associated with laundry detergent) will be measured from samples to determine if there is correlation between the two parameters.

Project: Monitoring Discharge and Turbidity During Storms in an Urbanized and Unurbanized Watershed.

Location: Near the mouths of the North Fork and Middle Fork of San Pedro Creek.

Description: Continuous measurements of stream discharge and turbidity were taken at County Park in the Middle Fork between December and end of February 2000 and in the North Fork outfall between mid-January and the end of February 2000. Measurements were taken using Global Water pressure transducers and Hobo data loggers. Rainfall was measured using tipping buckets and Hobo data loggers in the upper part of each drainage for roughly the first six months of 2000. Longitudinal profiles were also measured for parts of the North Fork and the Middle Fork.

Project: Steelhead Habitat Assessment for the San Pedro Creek Watershed

Location: Complete survey of Middle and South Forks, Shamrock Creek, Sanchez Creek and a reconnaissance of the mainstem San Pedro Creek.

Description: A salmonid habitat survey will be conducted in all of the major tributaries using California Department of Fish and Game methodology as described in the California Salmonid Stream Habitat Restoration Manual (Flosi et al. 1998). Habitat typing will be done at Level IV classification using a 10 percent sampling protocol. All habitat units will be identified by type and length for each tributary. Maximum depth, pool tail crest depth and pool tail embeddedness will be measured for all pools encountered. Canopy density will be measured for every third habitat. In addition, potential fish barriers will be identified, photo documented and mapped. Survey data, as well as data from existing sources, will be used to conduct a limiting factor analysis to identify factors that limit steelhead production for each of the study reaches. This assessment will be conducted by Hagar Environmental Science for the San Pedro Creek Watershed Coalition.

Appendix C: Level 1 Geomorphic Characterization
(Table 4-1, Chapter 4, Page 5 from Applied River Morphology, Rosgen 1994)

Stream Type	General Description	Entrenchment Ratio	W/D Ratio	Sinuosity	Slope	Landform/ Soils/Features
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.	<1.4	<12	1.0 to 1.1	>.10	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls.
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	<1.4	<12	1.0 to 1.2	.04 to .10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step/pool bed morphology.
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	>12	>1.2	.02 to .039	Moderate relief, colluvial deposition, and/or structural. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate w/scour pools.
C	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains.	>2.2	>12	>1.4	<.02	Broad valleys w/terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channels. Riffle/pool bed morphology.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	n/a	>40	n/a	<.04	Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment, w/abundance of sediment supply. Convergence/divergence bed features, aggradational processes, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.	>2.2	Highly variable	Highly variable	<.005	Broad, low-gradient valleys with fine alluvium and/or lacustrine soils. Anastomosed (multiple channel) geologic control creating fine deposition w/well-vegetated bars that are laterally stable with broad wetland floodplains. Very low bedload, high wash load sediment.
E	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	>2.2	<12	>1.5	<.02	Broad valley/meadows. Alluvial materials with floodplains. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width/depth ratios.
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio.	<1.4	>12	>1.4	<.02	Entrenched in highly weathered material. Gentle gradients, with a high width/depth ratio. Meandering, laterally unstable with high bank erosion rates. Riffle/pool morphology.
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients.	<1.4	<12	>1.2	.02 to .039	Gullies, step/pool morphology w/moderate slopes and low width/depth ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials, i.e., fans or deltas. Unstable, with grade control problems and high bank erosion rates.

TABLE 4-1 General stream type descriptions and delineative criteria for broad-level classification (Level I).