SAN PEDRO CREEK WATERSHED SEDIMENT SOURCE ANALYSIS

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Summary

The purpose of this study is to provide current information on sediment sources impacting water quality and habitat for threatened Steelhead Trout in San Pedro Creek, which drains a 21.3 km^2 (8.2 mi^2) watershed in Pacifica and adjacent areas of San Mateo County. Sediment has been identified as a problem in previous studies completed by the City of Pacifica and the San Pedro Creek Watershed Coalition, in particular the *San Pedro Creek Watershed Assessment and Enhancement Plan* (SPCWC, 2002), prepared for the California Department of Fish and Game.

Sources for sediment can be divided into upland hillslopes and channels. Separate studies funded as part of this project looked at each of these components of the sediment yield system. In the first volume of this report, bound together with what you're reading starting on the next page, we introduce the study area, the studies making up Volume II and Volume III, and review previous findings, especially geomorphic analyses of the main stem completed in recent years.

Volume II addresses hillslope sources – primarily gullies and landslides – based on field data, review of previous landslide hazard studies, aerial photographic interpretation and GIS modeling. Hundreds of landslides and gullies were mapped from these sources, and reveal a pattern related to the impacts of land use changes over time. Agricultural land uses, including grazing and cultivation, led to the development of extensive gullies in parts of the watershed, and some of these continue to contribute significant sediment to the stream system; others were built over in residential developments. The most significant remaining gullies result from impervious runoff from roads built into steep hillslopes, especially Coastside Boulevard. Landslides are more episodic, and can clearly be linked in time to major precipitation/runoff events, such as the watershed experience in 1962, 1972, and 1982; in fact, 253 new landslides were mapped in 1983. As many of these slope failures relate to land use impacts, especially impervious road runoff, we can expect more of these landslides in the future, pointing to the need to carefully manage hillslopes to minimize both the hazard and the sediment yield effect of these slope failures.

Volume III looks at tributary channel sources, extending the main-stem survey as far as possible into significant subwatersheds with extant channels. The most significant channel-related sediment source is from the streambank failure, enhanced by channel downcutting and resultant lateral erosion. The stream reaches contributing the most sediment are in the main stem (Collins, *et al.* 2001), especially downstream of the culverted input of the North Fork, which has created 16 feet of vertical incision of the channel at Capistrano Bridge. Yet the surveys reported in Volume III note that even these tributaries with minimal impervious input have many unstable reaches, and many of these are significant contributors of the fine sediment that degrades salmonid habitat.

Finally, Volume IV reports in graphical and tabular form the results of main stem restoration prioritization survey completed by Pacifica's Department of Public Works, identifying areas recommended for a variety of treatment options.

SAN PEDRO CREEK WATERSHED SEDIMENT SOURCE ANALYSIS

Volume I: Background and Synthesis

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Background

The 21.3 km^2 (8.2 mi^2) San Pedro Creek Watershed, located in Pacifica and adjacent areas of San Mateo County, provides habitat to threatened Steelhead Trout.

The purpose of this study is to provide current information on sediment sources impacting water quality and habitat for threatened Steelhead Trout in San Pedro Creek. Sediment has been identified as a problem in previous studies completed by the City of Pacifica and the San Pedro Creek Watershed Coalition, in particular the *San Pedro Creek Watershed Assessment and Enhancement Plan* (SPCWC, 2002), prepared for the California Department of Fish and Game.

Sources for sediment can be divided into upland hillslopes and channels. The three volumes of this report address different aspects of these sources. In the first volume, we introduce the study area, the studies making up Volume II and Volume III, and review previous findings, especially geomorphic analyses of the main stem completed in recent years. Volume II addresses hillslope sources – primarily gullies and landslides – based on field data, review of previous landslide hazard studies, aerial photographic interpretation and GIS modeling. Volume III looks at tributary channel sources, extending the main-stem survey as far as possible into significant subwatersheds with extant channels.

Land Use Changes

Past and current upland land-use impacts, residential development on floodplains, and an inherently unstable hillslope system prone to debris flows and other landslides, are contributors to the sediment in the creek. Sediments include both gravels important to spawning and fine sediment that bury these gravels and degrade water quality. An analysis of background erosion processes and the effect of land-use changes is being used to recommend treatments by land managers (city, county, state and federal) and property owners.

The history of land-use changes in San Pedro Valley has created a complex matrix of erosional systems in the watershed. Reviewed in Volume II, Chapter 2, of this report, in Collins *et al.* (2001), and covered most thoroughly in Culp (2002), the watershed's history includes 5000 years of Ohlone occupation and over 200 years of Spanish and then American settlement. The Ohlone culture left their mark in a scattering of shell mounds and artifacts, and a conversion of much of the coastal scrub and possibly forest to grassland through a fire regimen; grassland soils – mollisols – thus dominates the soilscape (Vol. II, Fig. 9). One of the first valleys in the Bay Area to be farmed, San Pedro provided food to the first mission in San Francisco from the late 18th century; this and the subsequent Sanchez Rancho added extensive grazing and exotic species introduction to the impacts on erosion and sediment yield. Dairy and truck farming followed as Anglos took over the valley in the latter half of the 19th century, adding drained wetlands and ditched creeks to the impacts. Finally, from the 1940's through the 1970's much of the farmlands were converted to suburban residential areas (Culp, 2002), and we can see the impact in increased peak flows from impervious runoff (Amato, 2003).

Today, roughly a third of the watershed is built up, with primarily residential but also limited commercial and other urban land uses (Vol. II, Fig. 37e.)   Most of the residential development is on the valley floors, though until the Pacifica's Hillside Preservation District was established in the 1980s many hillslope sites were experiencing new development, especially in the 1960s and 1970s (in Vol. II, compare Fig. 37b for 1955 with Fig . 37c for 1975.) Today, much of the uplands are protected from development as county, state and federal recreation and park lands. There are also remnants of horse ranching activities in private ranches (one inactive at present) and stables.

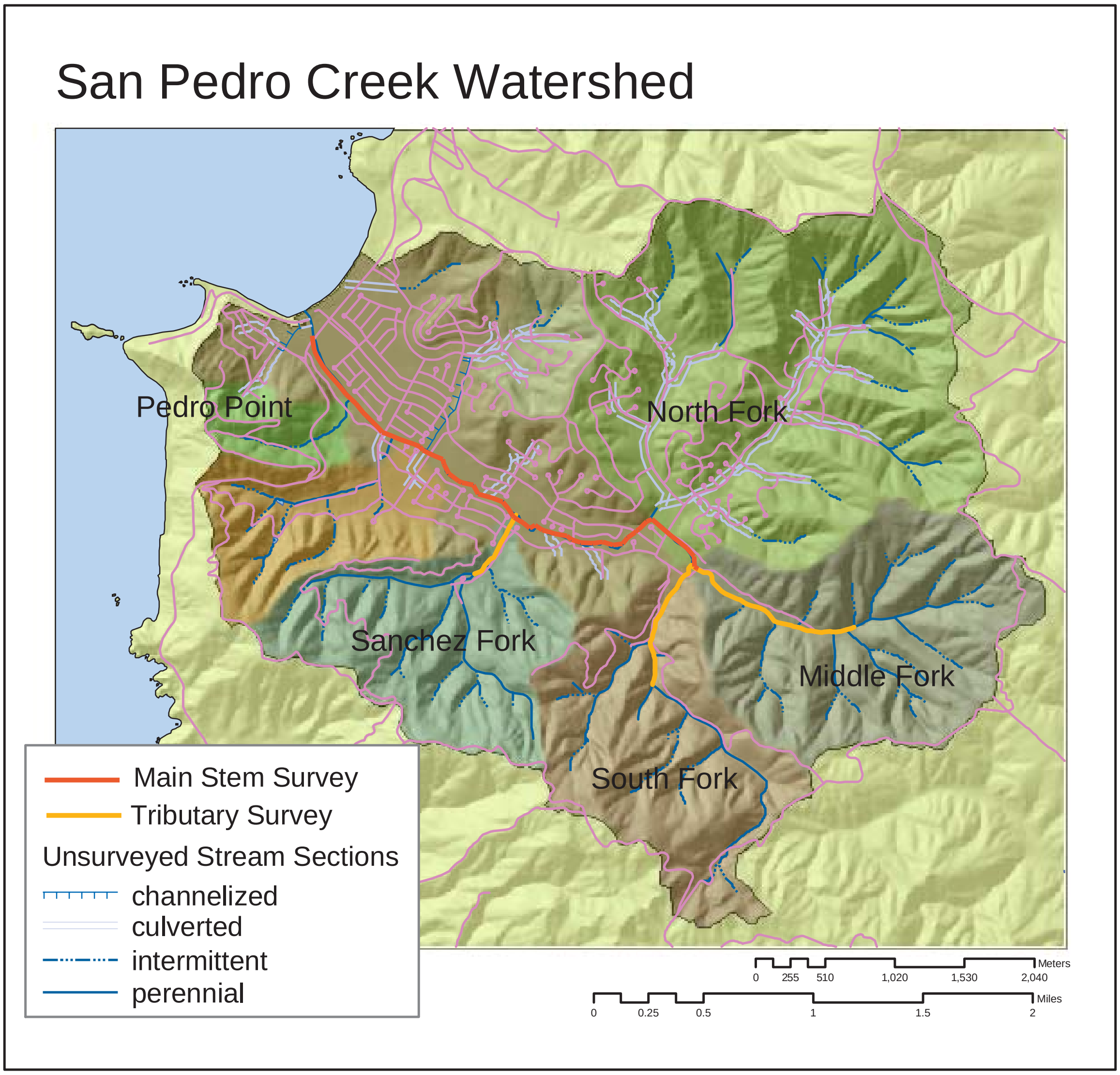

Figure 1. San Pedro Creek Watershed, and major tributary subwatersheds. Shows the extent of the Collins et al. (2001) main-stem geomorphic assessment, and the tributary study reported in this document. Roads are shown in light purple.

Sediment Yield

The primary elements of the sediment yield system in San Pedro Creek Watershed results from the effects of the current and historical land cover patterns, coupled with the existing conditions of steep slopes especially on soils with high susceptibility to erosion and landslides (Vol. II, Figs. 41 and 42). Hillslope areas experience slope erosion in the form of slopewash, rilling, gullying, and an array of mass movements (landslides and other downslope gravitational movements). These sources are especially a concern where connectivity with a stream channel is established; connectivity is analyzed in Volume II, Chapter 5.

Channels erode beds and banks, and may also consume older terrace deposits where exposed by excessive bed incision and resultant over-steepened banks. Channel erosion has increased dramatically in the watershed, resulting largely from a dramatic increase in effective drainage density in some subwatersheds (Vol. II, Table 8), ranging from approximately 6 km/km^2 in the subwatersheds of minimal impact (South and Middle Forks) though higher due to the trail network, to nearly 17 km/km^2 at Pedro Point (while more significant due to its total area and headward position in the watershed is the 11 km/km^2 of the North Fork.)

As described in Volume II of this report, upland areas have experienced numerous impacts influencing sediment yield. Expansion of grazing pressure onto the hillslopes in the 18^{th} and 19^{th} centuries created soil compaction, resulting in increased overland flow and soil erosion. Gullies are visible in aerial photography dating back to the 1920s (Collins *et al.* 2001; and Vol. II, this report), and likely were caused by overgrazing and possibly crop planting of steep slopes in some areas. A history of off-road motorcycle use has created even greater damage, especially in Pedro Point and South Fork subwatersheds. Most of this happened between 1960 and 1990, and the effects can still be seen today in active slopewash, gully and landslide areas. Restoration efforts starting in the 1990s, especially in the Pedro Point Headlands are starting to decrease sediment from these sources, but better protection is needed.

New gullies are not as common as new landslides: in 1941, the first aerial photograph analyzed, 21% of erosion features were gullies, 79% landslides; in 1955, 1975, and 1983, nearly all (97-100%) of newly observed features were landslides (Vol. II, Table 4). The year 1982 was prominent for landslides (including one resulting in fatalities in the watershed); 253 new landslides were recorded on the 1983 air photo. There has not been another widespread threshold-exceedance precipitation event since 1983; only 10 new landslides and 1 new gully were observed in the 1997 aerial photograph (Vol. II, Table 4). While gullies are decreasing in significance relative to landslides, and some have been built over by housing developments (Vol. II, Chap. 5), some continue to contribute significant sediment to the creek, especially where old road surfaces in steeper terrain direct impervious flow onto down-slope shoulders.

Landslide scars mapped in repeat aerial photography in decades from the 1940s demonstrate that this process has dominated hillslope sources in the past, and continue to do so today (Vol. II, Chap. 5). Causes range from natural – especially on steep slopes with poorly consolidated bedrock – to anthropogenic, due to many of the same causes as gullies -- road and trail runoff, overgrazing, and off-road vehicle use – since concentrated flows draining into susceptible soils are more likely to exceed slope stability thresholds. Many, if not most, landslides cannot be confidently placed into natural or anthropogenic categories – in Volume II, only slides with clear anthropogenic causes are classified as such. Uncertainties of the significance of historical impacts and limited visibility in aerial photography necessitate this approach, though these estimates probably underrepresent the true extent of human causes. Detailed mapping of gullies and landslides in Volume II and the GIS datasets created by this project will be used by the City of Pacifica to recommend treatments.

San Pedro Creek Channel Sources

One of the first projects of the San Pedro Creek Watershed Coalition after its initial organization in late 1998 was to gain a better understanding of the creek: its biotic communities, water quality, and geomorphic development. Long-term residents not only had observed changes in its fish population, which until 1950 also included Coho salmon in addition to Steelhead, but could also see that the habitat degradation was increasingly the result of changes to the stream channel. The effects of culverting of a large subwatershed – the North Fork – not only removed those reaches as areas of spawning and rearing, but also increased erosion downstream. Streamside residents reacted to losing their back yards to bank erosion by installing riprap, gabions, concrete and other hardened revetments along the creek. Erosion rates have been very high in some areas, with up to 15 feet (4.6 m) of vertical incision, so the reaction of residents is understandable. Unfortunately, hardened surfaces exacerbate erosion problems in adjacent areas, and substantially degrade in-stream habitat for fish, by disrupting natural pool and riffle habitats and replacing valuable riparian vegetation systems. Practices of large woody debris (LWD) removal, intended to reduce flooding, also degrades habitat. Many residents, including members of the newly formed coalition, could visualize a vicious cycle of habitat degradation, as more and more of the channel is bordered by revetments, as homeowners try to save their property in a piecemeal fashion. Clearly the community needed to find a way to better understand the creek, in its entirety, in order to see the effect of past impacts and take a more sensible approach into the future.

Main-stem San Pedro Creek

A study by Laurel Collins, Paul Amato, and Donna Morton -- the *San Pedro Creek Geomorphic Analysis* – was completed in 2001 for the Coalition. This study looked at the entire main stem of San Pedro Creek from the mouth at Pacifica State Beach into San Pedro Valley County Park at the junction of the Middle and South forks. The Collins *et al.* study provides detailed longitudinal quantification of: (1) the length of stable, eroding and revetted stream banks, including the type of revetment; (2) bankfull widths; (3) terrace heights; (4) natural and human-derived sources and volumes of sediment supply to the channel; (5) sediment size characteristics of the streambed; (6) estimates of bed incision and bank erosion; (7) the frequency, volume and causes of pools; (8) the distribution of LWD, including interpretation of LWD recruitment processes; and (9) Rosgen classification of reaches.

Figure 2 and Table 1 summarizes two measures for both the main stem and significant tributaries (reported in Volume III): overall normalized bank erosion (sediment volume normalized by distance, units ft^3/ft) and the relative percentage of each reach currently eroding, stable, and revetted.

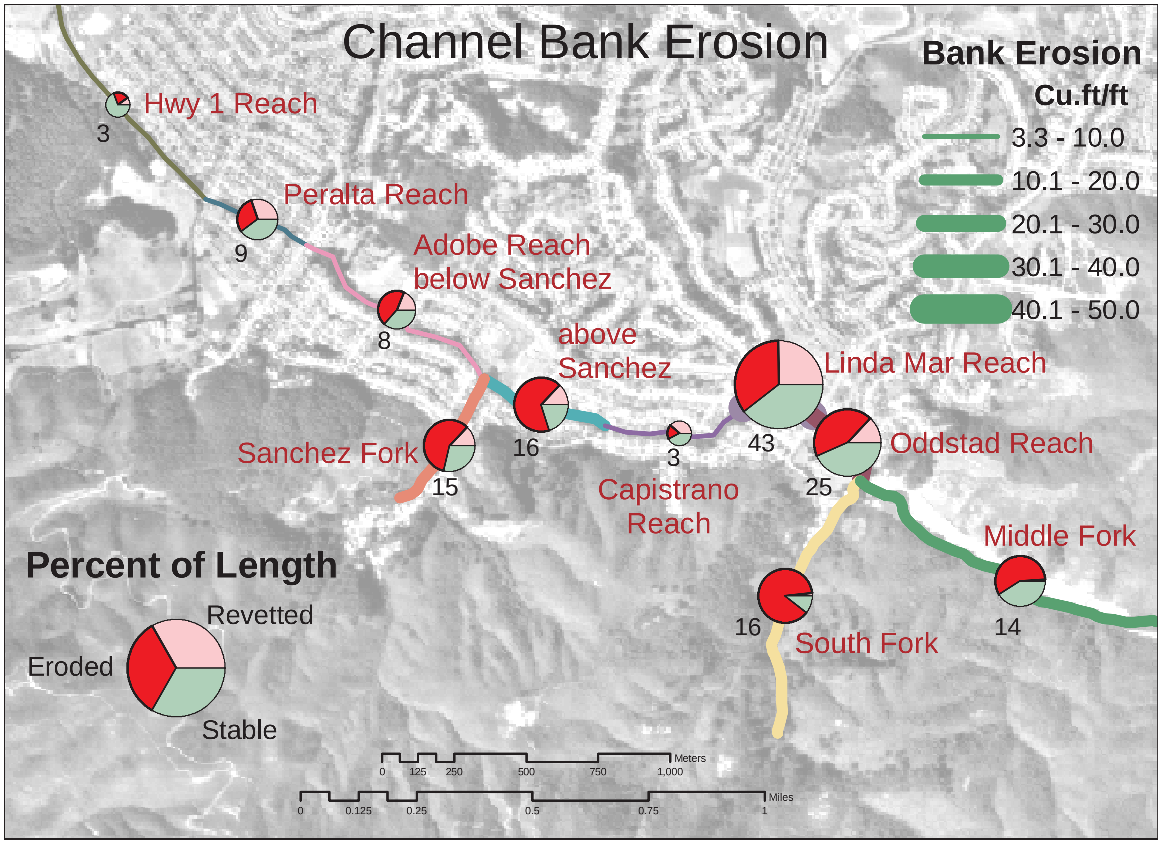

Figure 2. Bank Erosion: Normalized volume (ft^3/ft) and percent of length revetted, eroding, and stable. Circles also proportional to normalized bank erosion volume.

	Normalized Bank Erosion		Percent of Length:		
reach	ft^3/ft	m^3/m	revetted	eroded	stable
Hwy 1	3.3	0.3	10	21	70
Peralta	9.0	0.8	30	30	40
Adobe below Sanchez	7.9	0.7	19	45	36
Adobe above Sanchez	16.3	1.5	13	67	20
Capistrano	3.4	0.3	39	20	42
Linda Mar	42.9	4.0	25	35	39
Oddstad	25.1	2.3	13	43	43
South Fork	16.3	1.5	2	88	11
Middle Fork	14.0	1.3	1	58	41
Sanchez Creek	14.7	1.4	13	58	29

Table 1: Normalized bank erosion and percentage of length revetted, eroded and stable.

Clearly, much of San Pedro Creek has experienced significant erosion, with the greatest concentration attributable to the effect of impervious urban runoff, especially the Linda Mar Reach at the confluence of the largely culverted North Fork. This reach includes sections downstream and upstream of the confluence, and has experienced 42.9 ft^3/ft of bank erosion. No significant difference was noted between upstream and downstream sections; incision at the confluence is clearly influencing both sections. The Capistrano reach immediately downstream experiences much less erosion, stabilized as it is by a grade control structure at Capistrano Bridge, but below this structure erosion dramatically increases, where 2/3 of the channel length is eroding, with 15 feet (4.6 m) of incision in the last 50 years. This has created the greatest barrier to steelhead migration in the system.

The Capistrano Bridge grade control structure can be clearly seen in a longitudinal profile of the main stem from Peralta Bridge into San Pedro Valley County Park (Figure 3).

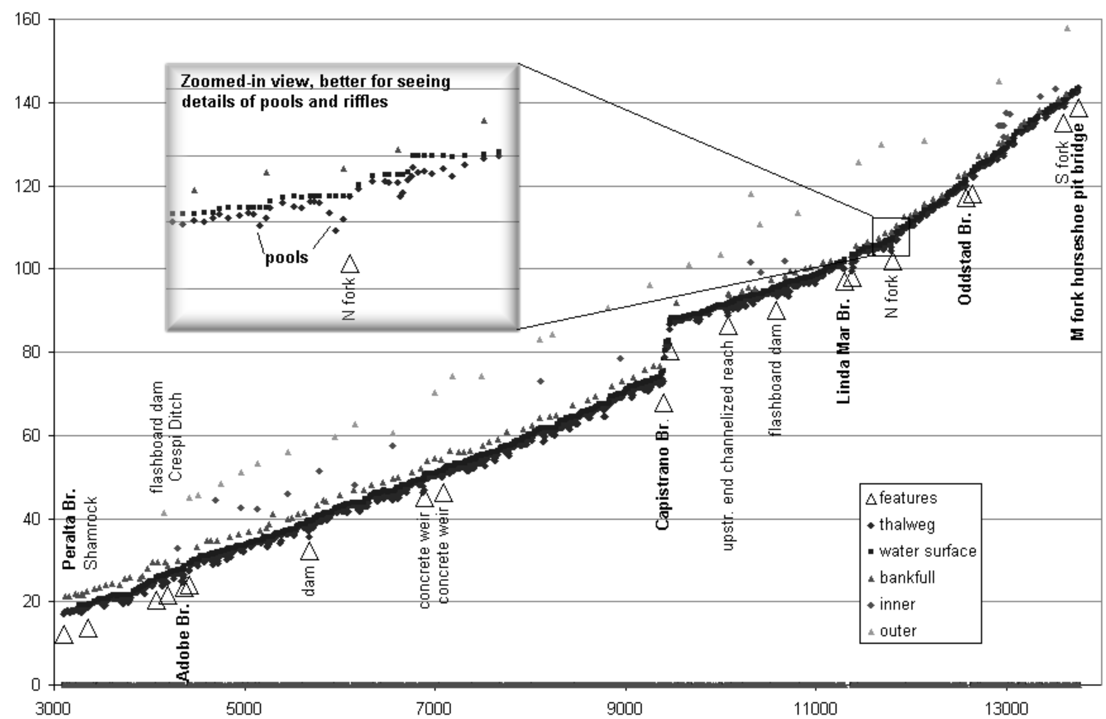

Figure 3. Main stem longitudinal profile. 2002 survey by Jerry Davis and Laurel Collins.

A **longitudinal profile** is a graph used to study the gradient of creeks and rivers at various locations along its path from its headwaters to its mouth. This profile stops at Peralta Bridge because the Flood Control Project a short ways downstream contains a stream/wetland restoration that establishes a new design profile; ongoing studies will look at how that changes in the coming years. The profile shows multiple measurements along the channel: (1) the thalweg; (2) the water surface at base flow; (3) the bankfull elevation; and (4) various terraces. Some of the major features seen in the profile follow:

1. The grade control structure at Capistrano Bridge. Below the structure fifteen feet of vertical erosion downstream of the structure has created a serious barrier to fish migration, and severe bank erosion downstream. A succession of largely ineffective fish ladders have been installed, but this barrier remains and addressing it is a top priority for improving passage to important habitat upstream.

2. Both downstream and upstream of Capistrano, the creek's gradient has eroded to a lower gradient than must have existed before settlement. The average baseflow gradient below the Capistrano fish ladders and above Adobe Bridge is 0.91%, with a similar gradient (0.90%) at the bankfull level. In this reach, the uppermost terrace, which appears to relate to the bankfull level before settlement, has a gradient of 1.07%. The lowered channel gradient is likely the result of erosion from more frequent peak flows from urban runoff (rainfall on paved areas runs off quickly.) The potential for further erosion will depend upon whether this profile is flat enough to be in dynamic equilibrium with the flashy urban runoff it is provided. Unfortunately, the likelihood is that it is not, and even more erosion will occur unless something is done to decrease the flashiness of the runoff.

3. Most of the bridges serve as grade control structures, and this can be seen by looking at the profile at these points. Bridges at Adobe, Capistrano, Linda Mar and Oddstad all force the creek through concrete box culverts, creating a limit to downward erosion at that point in the profile. This invariably creates a fish migration barrier as a steep step and deep pool develops downstream.

4. Below the North Fork confluence and extending downstream to the next grade control structure at Linda Mar Bridge, the gradient has similarly been flattened as a result of urban runoff, primarily from the North Fork watershed and delivered by its system of culverts draining Park Pacifica. While the upper terrace gradient is 1.85% in this reach, the water surface and bankfull gradients are 1.09% and 1.07% respectively.

5. For the same reason, the main-stem upstream of the North-Fork confluence has been *steepened* to a gradient of 1.8%. This is because the downcutting below the confluence creates a steeper gradient in the main channel draining into it. This steeper gradient will no doubt create a headcut, which will migrate upstream until it reaches the next grade control structure at Oddstad Bridge. This is where we should expect the next major barrier to fish migration, as a deep pool develops downstream of the concrete pad under the bridge.

The Oddstad reach, which starts at the Middle-South Fork confluence, is interesting in that despite having no significant impervious runoff in its watershed, primarily in the San Pedro Valley County Park, it is second only to the Linda Mar reach in normalized bank erosion. Yet incision of the downstream Linda Mar reach due to its integration of impervious North Fork flow cannot be the cause, since the Oddstad Bridge box culvert (defining the downstream end of the reach) is a grade control structure, preventing the influence of any headcut from the North Fork confluence downstream. In repeated longitudinal profiles, Amato (2002) also noted significant bed incision in this reach. While urban runoff is perhaps the biggest culprit in creating accelerated bed and bank erosion in the overall stream system, high erosion rates in the Oddstad reach and its two tributaries, with no significant urban runoff, requires further investigation.

North Fork vs. Middle/South Fork Hydrologic and Turbidity Response

The focus of a study by Amato (2002) was the contrast in response of the two largest tributaries -- North Fork and the combined Middle and South Forks -- to rainfall events. With nearly identical catchment areas, and similar precipitation amounts, the primary variable distinguishing these two tributaries is land cover and especially extent of impervious cover. The Middle/South subwatershed drains San Pedro Valley County Park, with very limited areas of impervious cover. While the channel system has been impacted by land use decisions in the past, and continues to respond to these impacts, the extent of alteration is minimal in comparison to what has happened to the North Fork, with its major channels culverted since the late 1960s.

Response of the two branches provide a classic illustration of these two types of land cover/stream management approaches, and documents the nature of the overall sediment yield for these subwatersheds that represent more than half of the study area. Not surprisingly, the extent of impervious cover in the North Fork created much shorter lag times and higher peak flows in hydrographs. Yet turbidity levels recorded during these runoff events indicate much greater suspended (fine) sediment yield from the Middle/South Fork subwatershed. While much of the erosion creating the elevated turbidity levels may come from upland hillslope and trail erosion, much likely comes from bed and bank erosion of the North and South Forks and their tributaries. This is the focus of the Tributary Survey in Volume III.

Tributary Survey

Volume III attempts to complete the channel survey to include the three major tributaries that have significant natural channels: the Middle Fork and South Fork in San Pedro Valley County Park, and the Sanchez Fork. (The North Fork is culverted, with very little remnant natural channel remaining.) Similar detailed parameters were collected in the tributary survey, and can be reviewed in Volume III.

The causes of these elevated levels of bed and bank erosion in the Middle and South Forks, mentioned above, require evaluation. Impervious runoff is not likely a significant cause, since San Pedro Valley County Park has very limited paved areas. While the trail network is a concern for direct sediment yield, the contribution of impervious surfaces to channel erosion should be minimal. One hypothesis is an ongoing response of the fluvial system to a history of accelerated deposition from the farming and ranching periods. Other fluvial adjustments related to purposeful alteration of drainage systems: evidence can be seen in both forks of a history of ditching of smaller tributaries, commonly done by farmers to drain wetlands and increase areas for field cultivation (Collins, pers. comm.) The ongoing instability of the stream system can be seen in the increased significance of streamside landslides in these tributaries as compared to downstream main-stem reaches. It may be some time before the effects, including elevated sediment yield, to decrease in significance for these two forks.

The South Fork illustrates additional causes of accelerated erosion. Water diversions, probably initiated in the 1950s in the development of a trout farm by John Gay, forced the thus straightened lower reaches of the creek into over-steepened condition. Berms created at this time are currently maintained to make room for a dirt road, but prevent the creek from using the larger floodplain, and bed and bank erosion results. Sections of this reach are also eroding into old clay deposits, seen in a change of the stream to a Rosgen G classification; erosion of these clays is a major source of fine sediments. The 1962 debris flow and flood (related to a history of road construction in steep upslope areas) that wiped out this trout farm appears to have carried significant sediments downstream into the Oddstad reach, where Alders dating to this event document the creation of a stream terrace that the creek is now rapidly incising.

Recommended Treatments

Volumes II and III contain recommendations for the reduction of excess sediment generation in upslope and tributary channel sources.

The Technical Advisory Committee has been useful in designing and will be helpful in implementing the treatments recommended. Since land management ranges from public (city, county, regional, state and federal) to private, the TAC includes representatives from public agencies – the City of Pacifica (Gary Lackey and Scott Holmes), San Mateo County Parks and Recreation (Doug Heisinger), the San Mateo County Resource Conservation District (RCD) (Mike Ednoff), the North Coast County Water District (Bob Vetter), the SF Regional Water Quality Control Board (Carmen Fewless), and the U.S. Environmental Protection Agency (Paul Jones) – and also a representative homeowner (Bill Bassett) living on the creek. The San Mateo County RCD also supports erosion control efforts on private land, so Mike Ednoff is a particularly valuable member.

Treatments will range from those easy to accomplish to much more difficult tasks. In San Pedro Valley County Park, the extensive network of trails that contribute minor amounts of sediment to the creek can be maintained via water-bar installations to limit the potential for connectivity to stream channels. Gullies created on private land will be more difficult, especially those resulting from the former Coastside Boulevard passing through upslope areas of Sanchez subwatershed. Treatment may require replacement of paved remnants with alternative materials, and it will likely be difficult or expensive to maintain this road in such a way as to prevent gully erosion; on the other hand, the need is urgent both in terms of sediment yield and the future usability of the road, which is likely to be washed out in a short period of time.

The following table lists some of the more important treatment recommendations, most of which with moderate to high priority. Some treatments listed as having low priority are given due to their higher priority from other perspectives, such as safety. Hillslope and tributary channel treatments are given here. Main-stem channel treatments are not (with the exception of non-native invasive removal), as these are the focus of the City of Pacifica, with maintenance responsibility for these reaches, and are to be included as Volume IV of this report.

Table 2. Summary of Sediment Yield Problems and Potential Treatments. Priorities are related to sediment delivery concerns.

Problem	Location	Figures	Potential Treatment	Priority
Erosion from dirt road surfaces	Picardo Ranch (North Fork)	Vol. II: 47, 48	Decommission as many unused roads as possible, with revegetation; create water bars on others	Moderate
"	Pedro Point II	Vol. II: 13, 101	"	Moderate
Gully erosion from historical causes	San Pedro Valley County Park	Vol. II: 46d	Maintain to avoid future connectivity with stream channel; avoid contribution from adjacent trails	Moderate
"	On private land (North Fork)	Vol. II: 22	"	Moderate
Rill erosion from trail surfaces	San Pedro Valley County Park (various trails)	Vol. II: 30, 46c, 46d	Water bars and other design changes	Moderate
"	Trails on private land adjacent to Coastside Blvd. (Sanchez, Shamrock, unnamed subwatersheds)	Vol. II: 18, 29, 36, 46b,	Decommission and revegetate excess trails; Otherwise install water bars	High
"	Other trails on private land	Vol. II: various	"	Moderate
Gullies from paved road runoff	Coastside Blvd (Higgins Rd.)	Vol. II: 104, 105, 106	Replacement of paved surfaces with alternative surface (see Vol. II, Fig. 103), with careful attention to drainage	High
Ineffective treatments (plastic sheeting)	Sanchez, off-drainage from Coastside Blvd.	Vol. II: 104, 105	Removal of plastic, then revegetation using native plants appropriate to site soil moisture conditions	Moderate
Rill and gully erosion related to terracing of over-steepened cut slopes	North Fork: features 5, 9, 10 on Figure 47, Vol. II	Vol. II: 6, 47, 51	Relandscaping of terraces to avoid drainage issues; treatment of gullies where connected to streams or threatens property.	Moderate

Existing and potential landslides from terracing over-steepened cut slopes	North Fork: features 4, 6, 7, 8 on Fig. 47, Vol. II.	Vol. II: 47	Relandscaping of terraces to avoid drainage leading to existing and potential landslide sites	Moderate
Existing and potential landslides partially caused by other sources of impervious drainage from above	Entire watershed, especially Crespi, North Fork, Sanchez Fork	Vol. II: 24, 105	Also difficult at this stage. Relandscaping to direct runoff to areas not susceptible to failure may help, but each requires special study. Prevent further development in these areas.	Moderate (from a sediment perspective, high from a safety perspective)
Existing and potential landslides partially caused by erosion of the slope toe	North Fork and other areas	Vol. II: 21-24, 47	Difficult at the stage – should have been avoided during development. Drainage and careful planting of potential landslide sites may help avoid some disastrous slides, but there are no sure solutions other than home removal and establishment of buffer zones to capture sediment after failure.	Low (from a sediment perspective, high from a safety perspective)
Streambank failure	Sanchez Fork	Vol. III: 38,	Where possible, lay back banks, biotechnical treatment	Moderate
"	Middle Fork	Vol. III: 44	"	Low (the Middle Fork probably has room to adjust)
Undercutting of culvert	Sanchez Fork	Vol. III: 39-42	Removal of culvert, replacement by larger-span bridge well above bankfull	High
Other armored structures creating erosion in adjacent areas	Sanchez Fork	Vol. III: 37	Removal of armored structures, replaced by biotechnical methods	Moderate
Gully Erosion on stream banks	Middle Fork	Vol. III: 46	Biotechnical revegetation methods	High

Incision into fine sediments due to ditched channel	South Fork	Vol. III: 43	Restoration of meandering system with a lower gradient	High
Erosion of main stem due to excessive peak flow from impervious surfaces	North Fork at its confluence with the main stem		Partial daylighting of the lower North Fork, and creation of multipurpose flood zone on city property above the confluence. Possible daylighting of upper sections at existing Oddstad School and other available sites to create high-friction floodplain storage, decreasing peak flows downstream.	High
Non-native invasive species infestation on streambanks: Giant reed (*Arundo donax*)	Middle-South section, also main stem		Eradication and replanting with fast-growing natives (willow)	Moderate
Cape Ivy on streambanks	All streams, especially in San Pedro Valley County Park	Vol. III	Eradication, possibly with replanting	Moderate

Policy Recommendations

Many of the erosion problems identified in this report can be attributed to policy failures from the past, though most predate the incorporation of the City of Pacifica in 1957 and the activity of other land management agencies such as County Parks in the 1970s. We cannot reverse the effect of most of these decisions, but we can seek ways to avoid exacerbating the problem in the future. San Pedro Creek exists as a Steelhead stream due to the fact that a major part of its watershed – 2/3 – has remained undeveloped. The tenuous nature of its health suggests that this may be a highly critical proportion. Any significant increase in impervious surfaces and other characteristics leading to habitat degradation may cause this system to fail. Thus we must consider our actions very carefully.

While extensive development projects are no longer pursued in this watershed, we must carefully consider the effects of even "infill" projects. Many infill projects will have little to no effect, though any increase in impervious runoff adds to the problem of streambank erosion, which not only degrades habitat but endangers homes. For the same reason, development of any sites on the floodplain or terraces close to the creek should also be avoided. Development of moderate to steep sites should especially be avoided, as these either feed runoff too rapidly to storm drains and the creek, or create substantial landslide hazards in down-slope areas to which they drain.

The State Water Resources Control Board and the San Francisco Bay Regional Water Quality Control Board encourage dischargers to participate in holistic management programs that consider erosion and sediment control as one of several habitat and water quality enhancement actions and may be considered resources for identifying specific policy change. Policy guidelines for local government agencies have also been developed by the FishNet 4C program (http://fishnet.marin.org) – a salmonid protection and habitat restoration program developed by the six Central California Coastal Counties (4C) of Marin, Mendocino, Monterey, San Mateo, Santa Cruz, and Sonoma. Coordination and cooperation with groups such as this, and with other cities in the Bay Area currently developing runoff policies, will be important in developing policies and programs that work. Pacifica, which has more than its share of hazards and which has seen their devastating effects on its citizens, should become a leader in establishing an intelligent runoff policy, not just for the health of its streams and their threatened species, but also for the safety and well-being of its citizens.

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