CHAPTER 4
PROFILE OF THE SUBCLASSES

4.1
Introduction and Overview

Less than two percent of the land surface of California consists of waters/wetlands (Warner and Kendrix 1984). As such, waters/wetlands ecosystems are among the most unique natural features of the state's landscapes. Precipitation, both in the form of rain and snow, drives the hydrologic characteristics of California's major watersheds. While isolated snow falls in the Santa Ynez Mountains can persist up to many weeks in drifts up to 5 ft deep (Smith 1998) and persistent coastal fog, occurring from June to October, can supply significant supplemental moisture, it is rainfall that shapes the hydrologic characteristics of the riverine waters/wetlands in the south coast region of Santa Barbara County (hereafter referred to as "SCSBC").

Drought, also, characterizes many sites within the SCSBC reference domain. Summer conditions, which can last up to six months or longer, are truly arid. Yet the alternation between little to no precipitation and large potential evapotranspiration, and an abundance of precipitation with insufficient heat to evapotranspire the available water can and does occur on a yearly cycle in the SCSBC region, and throughout Mediterranean California. As succinctly stated by Major, in reference to the climate in the Mediterranean landscapes of California, "Precipitation varies not only spatially but also temporally. Drought has been extreme" (Major 1988:34). The extent of cyclic variation in the SCSBC region extends beyond the yearly cycles of winter rain and summer drought. For example, long-term droughts, fires, floods, and earthquakes all cycle on scales that range from months to millennia, with confluence of large scale events (*e.g.,* 100-year flood and 50-year/24,000 acre fire) bringing catastrophic changes at landscape scales. Yet it is precisely these climatic events, overlain on an extremely geologically-active landscape, that shape the waters/wetlands in the SCSBC region. Nowhere else in California, nor throughout the Pacific coast of North America, does the convergence of climatic and geological features so completely dominate the functioning of waters/wetland ecosystems. Thus, from a Pacific Coast Regional perspective, the riverine waters/wetlands in the SCSBC are all the more unique. Not only are they rare (in an absolute sense), but they function in an exceedingly dynamic state.

The most frequent anthropogenic alterations to riverine waters/wetlands in the SCSBC region consist of land clearing for agricultural, commercial, and residential development. Agriculture (including viticulture) probably accounts for the highest areal proportion of such clearing, but commercial and residential development around major population centers (*e.g.*, the Santa Barbara metropolitan area, Goleta) accounts for the majority of regulatory activity in riverine waters/wetlands. Thus, we developed this *Draft Guidebook* with attention to the fact that the defined subclasses were the most extensive and most frequently perturbed riverine waters/wetland types within the SCSBC region.

The following section of this *Draft Guidebook* offers and explains the reference system for the subclasses of riverine waters/wetlands in the SCSBC region that are the focus of this work. In particular, the subclass profiles developed herein focus on the definition and description of the geologic, climatic, and landscape contexts in which the subclasses exist on the south coast. The profile also highlights:

1. the HGM geographic domain
2. definition, identification, and delineation of pertinent HGM classes and subclasses in the field
3. characteristics of each subclass' hydrology, soils, vegetation, and faunal support/habitat characteristics, and
4. discussions of cyclic and/or successional processes associated with each subclass.

Throughout this profile, frequent references are made to "Appendix B" data. These are provided in an attempt to offer *Draft Guidebook* users with a consistent information base and system of reference pertinent to the High, Medium and Low gradient subclasses that are the focus of this *Draft Guidebook*. As discussed elsewhere in this *Draft Guidebook*, and depending upon the questions users may have regarding the subclasses, the reference system can be used along with the assessment protocol as the basis for impact assessment, as a design template, or to develop monitoring programs and reasonable contingency measures in the event that either project targets or project standards are not being met.

4.2 Reference Domain – Definition and Geographic Extent

For the purposes of this *Draft Guidebook*, the geographic extent of the domain is that portion of Santa Barbara County that is bounded to the west by the western boundary of the Wood Canyon watershed, which is located proximate to Point Conception. The East boundary is the eastern boundary of Rincon watershed. The southern boundary is the point nearest the Santa Barbara Channel that is dominated, on an annual cycle, by freshwater runoff from terrestrial ecosystems. The southern (oceanward) extent of the geographic domain can include areas where wave-washed debris is carried by non-tsunami waves or seiches into the mouths of the streams or into the small backbeach lagoons or estuaries that often exist in portions of the tidally-influenced reaches of these streams (*e.g.,* the mouth of Arroyo Burro). Depending on drought cycles, the annual storm climate, runoff conditions, and anthropogenic activity, the mouths of these streams can remain open perennially, or they can close for long duration (*i.e.,* years).

Relatively large lagoonal or estuarine ecosystems that include either natural or anthropogenically altered (*e.g.,* degraded) tidally-influenced "sloughs" or "esteros" (*e.g.,* Devereux Slough, Goleta Slough, the current Mission Creek Estero Bird Refuge, and Carpinteria Saltmarsh systems) exist within the geographic reference domain defined for this study. These systems are specifically excluded from consideration in this *Draft Guidebook* because they are relatively large, regularly and frequently influenced by tides, exhibit variable salinity and temperature in the water column and/or sediments, and are dominated by estuarine ecosystem processes.

Upgradient from the excluded lagoons, the geographic domain boundary consists of those channel reaches and adjacent sites that are dominated by unidirectional (not bidirectional/tidal) freshwater runoff. This tidally influenced freshwater zone can be spatially dynamic because its location depends on drought and tidal cycles, storm climate, and/or anthropogenic influence on water diversion or additions, hydrologic energy, *etc.* In the SCSBC region, the boundary between tidally influenced freshwater riverine and estuarine waters/wetlands can be relatively gradual and diffuse in low gradient reaches that are relatively undisturbed, or abrupt and clear due to the presence of anthropogenic activity (*e.g.,* construction of tide gates, weirs, *etc.*) or natural geologic features (*e.g.,* coastal bluffs).

By definition, from the eastern boundary of the Rincon watershed to approximately the middle of the Gaviota Creek watershed, the northern boundary of the geographic domain is the southern boundary of the Los Padres National Forest. From the middle of the Gaviota Creek watershed west, the reference domain boundary is delineated by the headward extent of the watersheds that originate on the front range of the Santa Ynez. This area consists of the current Hollister and Bixby ranches, and is generally bounded by the 500 ft contour.

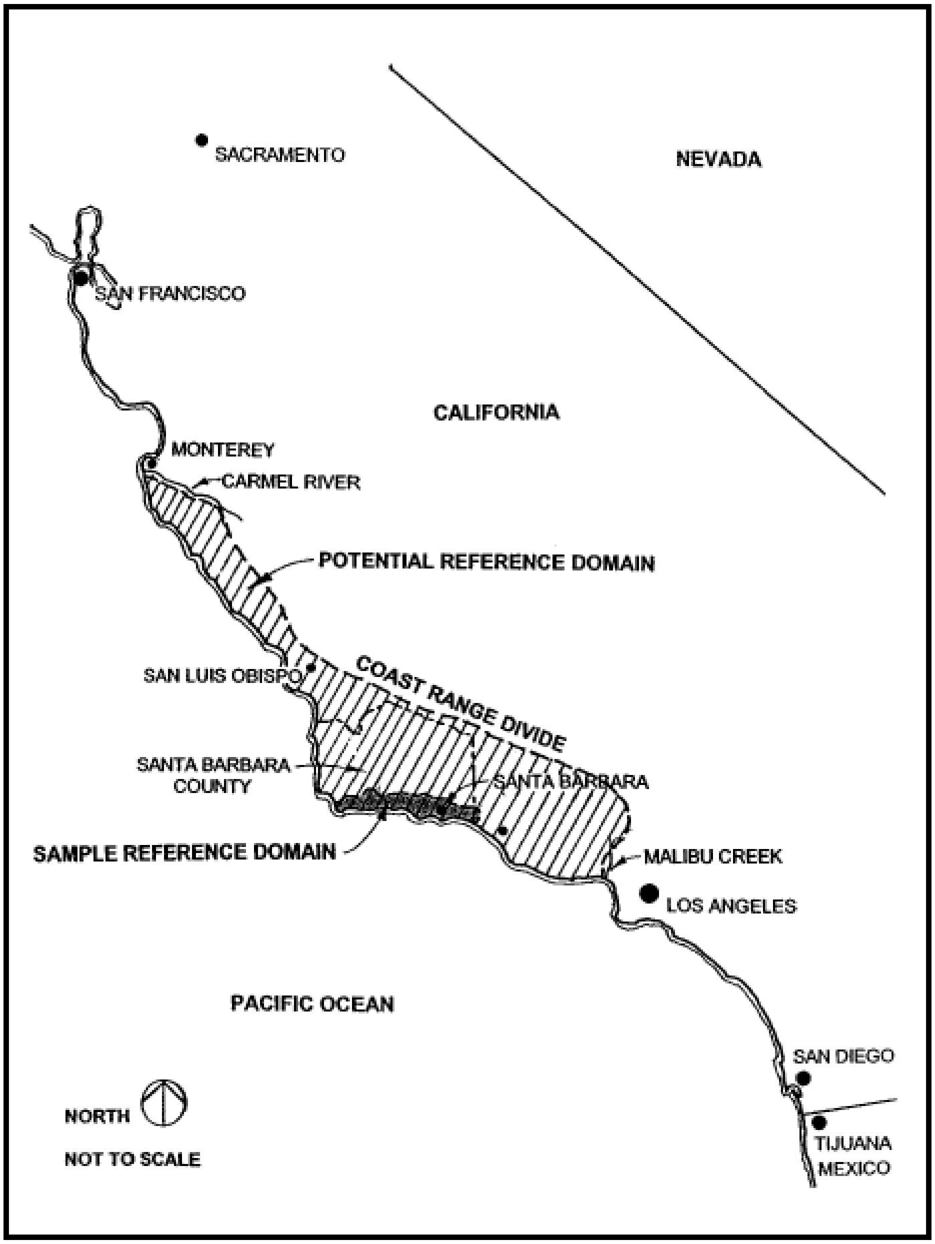
As defined previously, the geographic extent of the domain defined for this study is approximately 60 miles long on the east-to-west axis and 5 miles in width along its north-to-south axis. The total area of the geographic domain is approximately 300 mi^2. Maximum local relief is approximately 1,400 ft.

4.3

Geographic Extent of Potential Reference Domain and Applicability of this Guidebook to SimilarRegions

Figure 4.1 illustrates our best judgment concerning the geographic extent of the sampled and potential reference domains for the High, Medium and Low gradient subclasses of riverine waters/wetlands that are the focus of this ***Draft Guidebook***. For several reasons, exact delineations of the geographic extent of the "Central" and "Southern" Coast Regions of California are problematic. However, examination of several sources indicates that the "Central" coast region is generally considered to extend from the San Francisco Bay region to the westernmost extent of the transverse ranges (*i.e.,* the Santa Inez Moun-

Figure 4.1
Geographic extent of sampled and potential reference domains for this *Draft Guidebook*



tains). The "Southern" coast region is usually shown to extend from Point Conception to the USA/Mexican border and then south, to Bahia San Quentin (Barbour and Major 1988, Hickman 1993, Sawyer & Keeler-Wolf 1995, Bailey, 1995). Thus, it is important to note that the potential domain for this *Draft Guidebook* as illustrated in Figure 4.1 represents a transitional area between the drier (southern) end of the California "Central" coast climatic region and the northernmost extent of the "Southern" coast region. Therefore, when compared to more northern Central Coast locations, the SCSBC region (sampled domain) and the potential domain for this *Draft Guidebook* exhibit environmental conditions that are characterized by a decrease in total precipitation and an increase in evapotranspiration and seasonality. This seasonality is marked by extremes of either precipitation or, more frequently, drought. Conversely, when compared to more southern locations, the SCSBC domain is characterized by an increase in precipitation and a decrease in evapotranspiration.

Draft HGM Guidebooks have already been developed for more northern portions of the California Central Coast between Pacifica and Santa Cruz (Lee *et al.* 1996) and for the Santa Margarita River watershed (National Wetland Science Training Cooperative 1997). Given the discussion offered previously concerning the sampled and potential geographic domains for the SCSBC *Draft Guidebook,* it is reasonable to say that it fits "between" the Central Coast and Santa Margarita efforts both in the context of the geographic extent of its sampled and potential domains, and with respect to the types of functions it describes for riverine ecosystems.

With the previous facts in mind, it is our opinion and National Policy that this *Draft Guidebook* should not be used outside the sampled reference domain until regional experts (*e.g.,* the A-team or equivalent) collect additional reference system data throughout the potential reference domain and revise the subclass profiles and functional assessment models accordingly.

4.4

Summary of the Climate Within Geographic Extent of the Reference Domain

Santa Barbara County has a marine-influenced Mediterranean climate, with moderate temperature variations, warm, dry summers, and relatively cooler, wetter winters. Due to the east-west trending Santa Ynez Mountain Range, Santa Barbara County's climate varies considerably between coastal areas and inland valleys, foothills, and higher elevations. Typically, temperatures are mild near the coast and the daily variation range is moderate. Inland, seasonal and daily temperatures have greater variation.

4.4.1 Temperature

In July, the mean average daytime temperature along the coast ranges from the high 60s °F to low 70s °F (15.5 – 21.1 °C). Inland valleys, foothills and mountains can reach 80 °F (26.7 °C), with local variations due to elevation and topographic relief. Nighttime temperatures average approximately 50 °F (10 °C) throughout all areas. In January, the average low temperature along the coast is approximately 40 °F (4.4 °C). Inland and mountainous areas average approximately 30 °F (-1.1 °C) (Shipman *et al.* 1981).

4.4.2 Precipitation

Winter months experience the greatest amounts of precipitation. Santa Barbara County receives approximately 90 percent of its precipitation between November and April. Although thundershowers occur during the summer months in the mountains, they do not substantially contribute to annual rainfall amounts. Coastal areas average approximately 14 in annually, while inland and mountain areas average about 30 in annually. Historical precipitation records show significant yearly variation. Average precipitation in Santa Barbara County is 17.57 in annually (Shipman *et. al.* 1981, Naftaly 1999).

As is true for other coastal areas in California (*e.g.*, Golden Gate Estuary, Monterey Bay) different geomorphic regions within Santa Barbara County have varying average precipitation and temperatures. Nearly level to moderately sloping alluvial fans, floodplains, valleys and tidal flats have elevations that range from sea level to 500 ft. These areas average 15 to 20 in of rain annually, and the average annual air temperature is approximately 60° - 62 °F (15.5° – 16.7 °C). Nearly level to steep coastal terraces and coastal valleys have elevation ranges from 20 to 800 ft. The average annual rainfall for these geomorphic surfaces ranges from 14 to 20 in, with an average annual air temperature of 59° - 61 °F (15° - 16.1 °C). Gently sloping to extremely steep foothills and mountains have elevation ranges from 50 to 4700 ft Average rainfall in these areas range from 16 in for the foothills to 30 in for the mountains (Shipman *et al.* 1981).

4.4.3 Growing Season

The Natural Resource Conservation Service (NRCS) defines the growing season as the "number of days in which the temperature at 19.5 inches below the soil surface is greater than 41 °F (5 °C)." Due to the marine influence on climate, freezing temperatures in the region are relatively infrequent. Therefore, the average growing season is approximately 330 days in the coastal region, lower foothills and valleys, while the growing season is approximately 250 days in the higher elevations of the Santa Ynez Mountains. However, for species native to this region the growing season is essentially year round *(i.e.*, 365 days).

4.5

An Overview of the Geologic and Landscape Settings within the Geographic Extent of the Reference Domain

As discussed in the introductory sections of this Draft Guidebook, portions of the South Coast of Santa Barbara County within the reference domain consist of (a) high gradient steep mountain slopes and foothills associated with the Santa Ynez mountain front uplift ("High gradient subclass"), (b) medium gradient alluvial fans, mesas, and debris flow surfaces on the footslope/toeslope positions to the south of the Santa Ynez Mountain front ("Medium gradient subclass"), and (c) low gradient coastal plain marine terrace and alluvial surfaces that terminate at the Santa Barbara Channel ("Low gradient subclass") (Figure 1.3). The geologic units and geomorphic surfaces within the reference domain strongly influence soil properties, which in turn, provide direct linkages to hydrologic, biogeochemical, plant community, and faunal support/habitat functions.

4.5.1

Geology and Landscape Settings within the high gradient Santa Ynez mountain front Riverine Subclass

The Santa Ynez Mountains are a young, late Cenozoic mountain range. Although the Santa Ynez may have begun to uplift as early as late Miocene time, the major uplift occurred during the Pliocene and into the Pleistocene. This is clearly evidenced by the tilting and displacement of remnant marine terraces. Subsequent downfaulting of the coastal mountain front together with partial submergence was followed by secondary uplift and thrusting that developed in late Quaternary time. These processes continue today (Dibblee 1966, 1987). The Santa Ynez Mountain uplift is an east-trending, transverse geologic structure approximately 117 miles long. The Santa Ynez Mountains are composed of sedimentary rocks deposited from the late Mesozoic to Quaternary time. Lower Tertiary marine formations within the uplift dominate that portion of the Santa Ynez within the High gradient mountain front subclass. The uplifted Tertiary marine formations are predominantly consolidated, fractured, tilted and uplifted sandstones and shale that are Oligocene through Eocene in age. These lower Tertiary formations within the Santa Ynez uplift are as much as 8,000 ft in thickness (Dibblee 1987). Within the High and Medium gradient subclass there are small areas of exposed claystone, shale, and sandstones of the red-bed Sespe formation. The Sespe formation, formed as deltaic deposits, is the only non-marine formation within the thick Cretaceous-Tertiary sequence (Dibblee 1987). Several groups of major and minor faults run throughout the High gradient subclass area within the reference domain.

The crest of the Santa Ynez Range is fairly consistent in altitude. It averages about 3,000 ft above mean sea level. Backslope positions on the Santa Ynez mountain front are extremely steep, with slopes in excess of 100% in many locations. The south-facing front slopes often are dip-slopes with gradients controlled by bedrock structure. Many bedding planes are exposed on this south face. The highest summit ridge and south-trending spur ridges may represent elevated tilted surfaces of marine planation characterized by a discontinuous thin veneer of weathered sandy soils. Those surfaces are markedly different than the much younger, active erosional face of the mountain front itself, where soils are thin or non-existent, and where erosional processes of mudflow, dry ravel, and debris flow are constantly carrying material into the steep-walled, high-gradient headwater watercourses.

Drainage within the Santa Ynez Mountains consists of 0 and 1st order streams (*i.e.*, stream segments that are tributaries to other stream segments, but have no tributaries themselves at a specific scale) (Horton 1945, Strahler 1957) with high drainage density (*i.e.*, stream channel length per area) and steep (> 6%) longitudinal gradients and sideslopes (*i.e.*, slopes > 30% - 100%) at the USGS 1:24,000 mapping scale. Channel reaches in the High gradient subclass have discontinuous deposits of Quaternary alluvium and colluvium (*i.e.*, material moved by gravity) dominated by sandy material with large volumes of matrix-supported (*i.e.*, surrounded by the sandy material) boulders, stones, and cobbles. These channel reaches exhibit step-pool, fall-pool, and alternate fall and run reaches that have little or no residual bed sediments. Creeks within the High gradient subclass have little sinuosity (*i.e.*, bends and meanders) due to the steepness of the mountain front slopes. Low sinuosity and topographic relief of as much as 4,000 ft in less than seven miles, contribute to episodic flow of water and debris that can carry large boulders and stones great distances to the medium and low gradient surfaces.

Figure 4.2
Photograph of High gradient subclass reference standard site - Toro Canyon Creek

The geomorphology of the High gradient subclass influences and affects riverine ecosystem functions primarily by the steepness of the mountain front slopes, canyon side walls, and longitudinal stream gradients. These systems yield high velocity, high energy water that is capable of performing significant amounts of "work" on the high gradient channel environment. This work results in the erosion and movement of large volumes of material that can be carried throughout High, Medium, and Low gradient subclasses via stream channel networks. Such flows tend to be episodic and can result in the scouring of the channel environment and removal of riparian vegetation and soils. Typically, materials originating within the High gradient subclass and deposited in canyons, channels, and riparian environments are coarse textured (sandy) with large amounts of cobbles, stones, and boulders. These materials are often "excessively drained" (*i.e.*, water moves rapidly through the soil and is never present at or near the surface) and have little to no available water holding capacity (*i.e.*, water that remains in the soils or sediments after the influence of gravity has drained the larger voids, or pores). High gradient, high energy stream systems have little to no water storage capacity and minimal contact time between water and soil/sediment mineral and organic constituents. Therefore, high gradient stream systems have little assimilative capacity (*i.e.*, the ability to retain and/or biogeochemically process contaminants, metals, nutrients, *etc.*). Therefore, they are unable to perform biogeochemical functions at the same level as portions of the medium or low gradient systems.

4.5.2

Geology and Landscape Settings within the Medium Gradient Dissected and Undissected Alluvial Fan and Debris Flow Surfaces

Landforms and geomorphic surfaces within the Medium gradient subclass are characterized by rolling foothills and nearly level, to gently undulating, alluvial/ colluvial terraces, fans, and debris flows that originate at the base of the steep Santa Ynez Mountain front. Some of these surfaces are locally referred to as "mesas." The medium gradient alluvial terraces, dissected alluvial fans and debris flows are composed of alluvial/colluvial materials that are Quaternary in age and originate within the high gradient Santa Ynez mountain front. These materials are dominated by sand sized particles with an abundance of coarse fragments (*i.e.*, boulders, stones, cobbles, and gravel). Some of the fan units are now isolated from their sources by faulting that has caused incision of the source streams through these deposits. Examples of these isolating faults include Moore Ranch, Mission Ridge, and Arroyo Parida (along East Valley Road) faults.

Because of the catastrophic nature of many the depositional events on the medium gradient surfaces, large boulders and cobbles tend to be matrix-supported. That is, finer sand- and silt-sized material surrounds the individual boulders in major portions of the deposits. The significance of matrix supported boulders is that wherever running water is concentrated for short periods, the fine matrix is removed and boulders are winnowed *(i.e.*, fine particles selectively sorted or removed) out to form residual deposits in and near the channel bottoms or at the base of steeper slopes. Residual boulder deposits are a distinct characteristic of SCSBC channels, where the sizes of boulders in the stream channels are larger than can be carried by even the largest floodwaters.

After winnowing of the finer particles from around a matrix supported boulder, sediment can be transported in a series of short, intermittent movements called "saltation." Within channel systems, saltation consists of sediment moving downstream by the impact of particles bouncing off one another, and/or the movement of sediment downstream by eddy currents that do not possess the energy to retain the particles in suspension. Thus, the particles are consistently returned to the stream bed.

Watersheds within the Medium gradient subclass contain 2nd and 3rd order streams (1:24,000 mapping scale) with moderate drainage density and longitudinal gradients (*i.e.*, channel slope gradients between 2% and 6%). Stream channels in the Medium gradient subclass are dominated by contemporary alluvium and boulder lag deposits. Materials within the medium gradient channels are composed of sandy loam to loamy sand materials that contain large volumes of boulders, stones, cobbles, and gravel.

Figure 4.3
Photograph of Medium gradient subclass reference standard site - Romero Creek

Within the Medium gradient subclass, large areas of alluvial and colluvial Quaternary materials overlay marine shale (*i.e.*, Monterey and Rincon units) of Miocene age (*i.e.*, 6 million to 24 million years before present). Small areas of the non-marine, red bed Sespe formation claystone, shale, and sandstones are exposed within the Medium gradient subclass (Dibblee 1987).

The geomorphology of the Medium gradient subclass has direct and indirect influences and effects on riverine functions and fluvial processes. Reduction in slope gradients relative to the High gradient subclass has resulted in the deposition of large areas of alluvial and debris flow material as a result of the geologic processes described previously. Many of these surfaces subsequently have become dissected as a result of high energy stream flows (see photograph in Figure 4.3). This has resulted in stream systems that are constrained or confined within the steep walls of canyons, dissected alluvial fans, and debris flow surfaces. Within the medium gradient system, channels often are not free to migrate and/or engage their older floodplains, due not only to steep canyon walls, but also to channel banks dominated by large stones and boulders resistant to movement and erosion. Thus, medium gradient channels are laterally controlled and constrained by large boulder beds that are not proportionally adjusted to the historic range of flows of floodwaters. Therefore, medium-gradient land surfaces are the result of two primary geologic processes – deposition by debris flow and erosion by water. It is the interplay of these two distinct processes that controls the gradients and forms of SCSBC stream channels.

Although medium gradient channel systems support flows of less velocity and energy relative to the High gradient subclass, and they are somewhat constrained, they are still capable of performing significant work in the channel and floodplain environment. This work results in the erosion and movement of material that can be carried throughout the Medium and into Low gradient subclasses, via stream channel networks. Flows tend to be episodic and a function of high gradient inputs, which can result in the scouring of the channel environment and removal of riparian vegetation and soils. As described previously, materials originating within the High and Medium gradient subclasses and deposited in the medium gradient channels and riparian environments are predominantly coarse textured and similar to much of the high gradient riparian materials. Although there are increased amounts of finer textured soil and sediment within the riparian areas of the Medium gradient subclass, much of the riparian materials are well drained and have little available water holding capacity. Additionally, while there is an increase in water storage capacity and contact time between water and soil/sediment mineral and organic constituents, riverine systems within the Medium gradient subclass generally have less assimilative capacity than those within the Low gradient subclass. Thus, medium gradient systems are capable of performing more biogeochemical "work" (*e.g.*, improvement of water quality through the removal of dissolved and suspended nutrients, organic matter, and contaminants) than high gradient systems, but perform fewer biogeochemical functions than the Low gradient subclass.

4.5.3 Geology and Landscape Settings within the low Gradient Marine Terraces and Filled Coastal Basin Surfaces

Landforms within the Low gradient coastal surface subclass are characterized by rolling foothills and coastal bluffs in the western and eastern parts of the reference domain. These geomorphic features are a result of folding and uplift of sedimentary strata. Nearly level to gently undulating marine terraces are characteristic in the central part (*e.g.*, the Santa Barbara Coastal Plain) of the low gradient coastal surfaces within the reference domain. In the Low gradient coastal subclass, large areas of alluvial and colluvial Quaternary materials overlay marine shale of Miocene age (*i.e.*, Monterey and Rincon units). These alluvial and colluvial surficial deposits are Quaternary in age and originate within the High and Medium gradient subclasses. Low gradient coastal surfaces can transition to tidally-influenced freshwater or estuarine systems.

Most of the wave-cut terrace platform surfaces that occur in the SCSBC Region are highly modified by active faulting, folding, and deposition of alluvial deposits. Because the late Quaternary marine terraces are tilted, faulted, and masked by younger slopewash, alluvial fan, and estuarine deposits, reconstruction of a sequence of marine transgressions and regressions superimposed upon an uplifting Santa Ynez Mountain block is not easily done (LaJoie *et al.,* 1979). Thus, streams crossing the low gradient surfaces do not have uniform gradients. In fact, they have very complex histories. For example, the Moore Mesa/Hope Ranch area has been uplifted, while adjacent Goleta and Santa Barbara areas have not. Streams in the western half of the reference domain are being tilted southward and are incised into their alluvium-covered terraces and resistant bedrock ridges. This phenomenon gives rise to high "stream gradient indices" (Keller 1986) where oversteepened streams have more erosional and transportational capacity than would be expected for the size of the drainage area. Those stream reaches from Goleta eastward are incised in their headwaters and intermediate gradient sections, but flow to the sea over low gradient coastal plains and drowned sinking basins (*e.g.*, Goleta Slough, Carpinteria Basin), where rates of alluvial filling barely keep ahead of rates of tectonic sinking. Thus, marine terrace remnants are found at many different elevations along the coastal plains and bluffs. Drainage channels such as those that transverse across Moore Mesa are cut off from their headwaters and are overfit. That is, the capacity of the valley in which the present stream flows is larger than the stream that now occupies it. These exceptionally steep coastal basins are few in number and now have only small watershed areas. They have been included here in the Low gradient subclass for convenience.

Drainages within the Low gradient coastal subclass generally consist of 3rd, 4th, and 5th order streams (Strahler 1957, 1:24,000 mapping scale) with low drainage density and gentle longitudinal gradients (*i.e.*, gradients < 2%). Drainage systems within the Low gradient subclass are dominated by deposits of Quaternary alluvium and colluvium. The alluvial and colluvial materials are composed of silt and sand-sized material(s), with fewer boulders and stones and increased proportions of gravel relative to the High and Medium gradient subclasses. Infrequent, large-magnitude flood flows scour these channels to elevations that are at or below today's mean sea level. Because the channels in the basin areas like Santa Barbara, Goleta, and Carpinteria represent sediment-filled deeper basins cut at lower sea-level stands, finer-grained channel-filling sediments generally cover coarse gravel and cobble basal sediments carried in the channels during major (25- to 50-year return period) floods. Thus, the stream beds that one sees today in the SCSBC Region represent only an interim condition that reflects particle grain sizes carried by water during most years, but not all years. Had this survey been conducted after a major flood event, such as occurred in January of 1995 and March 2001, we would have seen a gradual decrease in gravel and cobble size materials carried in the channels across the low gradient areas. These materials would be graded from areas just below the coarse lag of boulders at the intermediate gradient boundary all the way to the beaches or lagoons that receive those stream waters, such as those of Santa Monica Creek.

The geomorphology of the Low gradient subclass has profound influences and effects on riverine functions and processes. Further reduction in slope gradients relative to the Medium gradient subclass has resulted in the deposition of large areas of finer textured alluvium and debris flow material. Many of these surfaces are lightly dissected and are generally unconstrained (laterally) by canyon walls or boulder-dominated channel banks. Thus, within the low gradient system, channels often are free to migrate and/or engage their floodplains except where artificially constrained by hardened, engineered structures. Throughout the SCSBC Region, the low gradient channels are most often controlled and constrained by anthropogenic structures.

Low gradient channel systems support flows of less energy relative to the High and Medium gradient subclasses, and are able to engage riparian areas and floodplains that have greater amounts of finer textured soils (see photograph in Figure 4.4). Soils and sediments of the Low gradient subclass have increased pore space relative to the High and Medium gradient subclasses. Additionally, these soils and sediments have a larger distribution of smaller pores and thus have greater water holding and assimilative capacities, with increased time of contact between water and soil/sediment mineral and organic constituents, relative to the medium and high gradient systems. Thus, low gradient systems are capable of performing more biogeochemical “work” relative to the medium and high gradient systems.

Ironically, due to several decades of efforts to control flooding, most of the Low gradient Riverine ecosystems in the SCSBC Region are hardened, highly engineered, and completely cut off from their floodplains (*i.e.,* their biogeochemical engines). Under present management, and especially in consideration of public demands for flood protection, it appears that the SCSBC Region’s commitment to hardened and highly engineered Low gradient Stream Channels is/will be irreversible. These types of management choices have direct and significant impacts on the ability of Low gradient stream ecosystems to contribute to the improvement of water quality.

Figure 4.4
Photograph of loamy riparian soil within the Low Gradient Subclass - Rincon Creek

4.6

HGM Class and Subclass Definitions

4.6.1 The Riverine Class

The national definition for the riverine HGM class is offered in Table 2.2. It follows Brinson *et al.* (1995) and Whigham *et al.* (National Reference Guidebook In Prep.). Definitions for each subclass of riverine water/wetland in the SCSBC geographic domain are developed and discussed below. As outlined in the *Introduction* (Chapter I of this *Draft Guidebook*) only the (1) high gradient streams on the Santa Ynez mountain front, (2) medium gradient streams on dissected and undissected debris and alluvial fan surfaces, and (3) low gradient streams on marine terrace and filled coastal basin surfaces are addressed herein. High gradient coastal streams on elevated terraces and bedrock fault block surfaces are relatively rare and were not the focus of our efforts. This riverine subclass is not treated in this *Draft Guidebook*.

4.6.2 **Subclass Definition:** High Gradient Streams on the Santa Ynez mountain front Subclass

Stream ecosystems characteristic of the high gradient portions of the Santa Ynez mountain front have very steep side slopes (> 30% - 100%). Their longitudinal gradient (*i.e.* channel slope) also is steep (*i.e.*, > 6%). Channels are narrow and usually ephemeral, and they have little or no residual bed sediments. Instead, step-pool, fall pool, or alternate fall-and-run reaches carry runoff during and immediately after precipitation events. These channels only rarely exhibit perennial flow (*e.g.*, Cold Springs Creek). High gradient streams have few or no seasonal springs or seeps within the channel or in the adjacent streamside (riparian) zones. Most of these high gradient streams gain discharge down slope. On standard U.S. Geological Survey maps (1:24,000 mapping scale), high gradient streams usually are recognizable as the headwardmost extent of channel systems that are, in their lowermost reaches, indicated by continuous blue lines. As such, high gradient stream reaches receive virtually all their water input from upgradient portions of channel networks (*i.e.*, “0” order basins or colluvial hollows) and from adjacent hillslopes and gullies.

4.6.3 **Subclass Definition:** Medium Gradient Streams on Dissected and Undissected Debris and Alluvial Fan Surfaces

Dissected and undissected alluvial and debris flow stream ecosystems are characterized by channel reaches dominated by large and small boulders and cobbles that alternate with pools. The riparian system is either a Live oak woodland (*Quercus agrifolia*), live oaks with White alder (*Alnus rhombifolia*) and Western sycamore (*Platanus racemosa*), or mixed willow plant community type (*Salix lasiolepis*, *S. laevigata*, *S. lucida* subsp. *lasiandra*). Most streams will be 3rd order (1:24,000 mapping scale). Stream flow will decrease most often downstream between tributaries. Flows are intermittent, seasonal, or perennial. Springs, seeps, and residual pools (*tenajas*) occur in the streambed and along the sides of incised canyons. Sediments are derived from erosion of streambanks and from upstream storm runoff.

In stream reaches that are not highly modified and confined vertically and laterally (*i.e.,* channelized) by anthropogenic activity, channels are highly mobile. For example, when sediment loads are high as after a recent fire, channels may aggrade, move laterally, and incorporate large woody debris. During intervals between fires and where the channel is incised initially or where it can become incised into newly deposited sediment, the channel location is relatively fixed and sediment is transported seaward. Where channels are incised, they may serve as major debris storage features. Stream channels may become aggraded for several centuries, followed by decades of sediment removal as sediment is conveyed seaward.

In the SCSBC Region, medium gradient streams have longitudinal slopes of two to six percent. Because these channels are laterally confined, they cannot meander except in their lower reaches where they flow in a relatively lower gradient, wide valley. In all but unusual geologic situations, the streams are not highly sinuous because they are on such steep slopes. Consequently, medium gradient streams either flow in circuitous, but low sinuosity paths through narrow canyons, or they flow across active debris fans. Within any given reach, the direction of stream flow usually is determined through deflection of flow by boulders, large woody debris, or by tectonic features (*e.g.*, Mission Creek by the Mission Ridge fault). The exception occurs when a stream reoccupies a channel formed in the past (*e.g.*, San Antonio Creek near Goleta, lower Rincon Creek). Upland surfaces adjacent to medium gradient streams that occur on dissected or undissected alluvial and debris fan surfaces may be permeable or relatively impermeable as a function of the presence of fine geologic strata (*i.e.*, paleosols). Where these surfaces are permeable, significant recharge may occur and give rise to hyporheic flow in the unsaturated zone above the water table, which in turn, maintains (a) flow in the streams late into the dry season, and (b) deeper vadose zone flow that recharges aquifers in the coastal and offshore areas.

On standard U.S. Geological Survey maps (1:24,000 mapping scale), medium gradient streams usually are recognizable as the 2nd and 3rd order channel systems flowing on debris and alluvial fan surfaces. They are usually indicated by continuous blue lines. As such, these stream reaches receive their water inputs from upgradient portions of channel networks (*i.e.*, “0” order basins or colluvial hollows, 1st and 2nd order basins and channel networks) and from adjacent hillslopes and gullies.

4.6.4 Subclass Definition: Low Gradient Streams on Marine Terrace and Filled Coastal Basin Surfaces

Low gradient streams that occur on marine terrace and filled coastal basin surfaces flow in low gradient channels (0 - 2%). They can include tidally-influenced freshwater to brackish water reaches (*e.g.*, Arroyo Burro, Arroyo Paredon), or they can flow directly into tidally-influenced estuarine systems at their lowest points (*e.g.,* San Jose Creek; San Antonio Creek, a tributary to Maris Ygnacio Creek). Low gradient coastal stream sediments are dominated by silt and sand-sized particles. However, these streams may transport (via water or mudflow) any size material (silt to boulders), especially after floods, fires, or some combination thereof. Low gradient coastal stream discharges may be intermittent, seasonal, or perennial. Except where they empty into historic estuaries, smaller coastal channels often have steeper longitudinal gradients (*i.e.,* channel slopes) nearest the coast, because they flow over or through gaps in coastal bluffs that are caused by sea-cliff retreat (*e.g.,* Arroyo Burro).

Throughout the SCSBC Region, the coastal area is folded and faulted. Consequently, stream channels are typically incised. Many are confined in artificial floodways. Thus, most of the flood zones of low gradient coastal streams are constrained with respect to their ability to meander laterally. Active floodplains are rare. Little recharge of surface water to ground water occurs in the coastal zone because of the fine-grained streambeds and because of the restricted floodprone areas. Where they occur, riparian plant communities are highly variable. They are often absent, or, if they exist, are either dominated by invasive weedy species or are highly manipulated/cultivated systems associated with private homes, business parks, *etc.* Native low gradient communities can include riparian forests, scrub/shrub or persistent and non-persistent emergent wetland plant community types.

On standard U.S. Geological Survey maps (1:24,000 mapping scale), low gradient coastal streams are usually recognizable as the 3rd, 4th and 5th order channel systems that flow on marine terraces and filled coastal basin surfaces, and are indicated by continuous blue lines. As such, low gradient coastal stream reaches integrate their water inputs from upgradient portions of channel networks (*i.e.*, “0” order basins or colluvial hollows, 1st, 2nd, 3rd order basins, and channel networks), from adjacent hillslopes and gullies, and from discharge of groundwater to the riverine ecosystem.

4.6.5
Subclass Definition: High Gradient Coastal Streams on Elevated Terraces and Bedrock Fault Block Surfaces

High gradient coastal streams generally pass from uplands directly to the coastal backbeach zone at gradients of 3 - 10% or more, when measured as an average rise over half their blue-line lengths. Sediments may or may not be present in the channels, but are most often locally derived and reflect local bedrock and terrace deposit sources. Flow is intermittent or ephemeral (*e.g.*, Canyon del Gato near Point Conception), except where augmented from anthropogenic sources (*e.g.*, Las Palmas Creek at Hope Ranch). Some small riparian ecosystems such as the unnamed drainage channel flowing northward off Moore Mesa, carry runoff augmented by development. This runoff is derived from seasonally perched water tables that have been drained through site development. Other, more natural channel systems carry rainfall runoff that may include seasonal flow augmented by livestock grazing and road building. Such activities alter rainfall-to-runoff ratios over uplands adjacent to these riparian systems.

On standard U.S. Geological Survey maps (1:24,000 mapping scale), High Gradient coastal streams are relatively rare, but usually are recognizable as the 1st and 2nd order channel systems that flow on marine terraces and filled coastal basin surfaces, and are indicated by continuous blue lines. As such, High Gradient coastal stream reaches integrate their water inputs from upgradient portions of channel networks (*i.e.*, “0” order basins or colluvial hollows) and from adjacent hillslopes and gullies. As explained previously, the High Gradient coastal streams subclass is not part of this *Draft Guidebook*.

4.7 Hydrology of Stream Channels in the South Coast of Santa Barbara County

4.7.1 Introduction

Approximately two thirds of the earth's surface is covered by water. Nineteen percent of the earth's water is found within the voids (pore space) of rocks and soils, one percent is ice, 0.002 percent is in streams and lakes, and only 0.0008 percent is in the atmosphere. The remaining, approximately 80 percent, is found in the oceans (Garrels and Mackenzie 1971). The way that water moves into and through these various environments is commonly referred to as the hydrologic cycle. Although rivers and streams make up less than 0.002 percent of water stored, water residence time is short, and movement through these systems (flux) is very rapid relative to the other environments. Therefore, streams are higher energy systems that are capable of doing work in their environment.

The work of a stream is the transport of sediment. The streams of Santa Barbara County transport sediment within two general kinds of media: water and mudflow/debris flow materials. Contrary to popular public perception, the streams of the south side of the Santa Ynez Mountains are not simply formed by water as channels for water, but are, in fact, areas where water may be concentrated sufficiently to transport some of the sediment that is always being eroded off the mountain front. This difference is not simply semantic. In the SCSBC Region, a channel cannot be altered to carry more water without simultaneous accommodation for additional sediment. The science of hydrology and stream restoration in the SCSBC region must focus on sediment supply and transport, and not simply on water.

Within channel systems, water and mud/debris-flow are the components available to do work, such as the mobilization and transport of sediment. The supply of sediment determines the shape and function of the stream channels and alluvial fans. Therefore, the shape of the channel should reflect the conditions of balance between sediment supply and the capacity of the stream to transport sediment. Where sediment is accumulating faster than it can be carried downstream, channels will aggrade (*i.e.,* build up, or increase the elevations of their beds). Under such conditions, water and sediment may spill from, or abandon, an old channel, and this may result in the formation of a new one. Where the supply of sediment is less than the capacity of fluids that transport sediment, the stream will cut its bed, banks, or both, and re-entrain sediment that was deposited decades or millennia earlier. The cutting of the channel bed and banks is a function of a stream that is adjusting its equilibrium in balance with its erosive capacity.

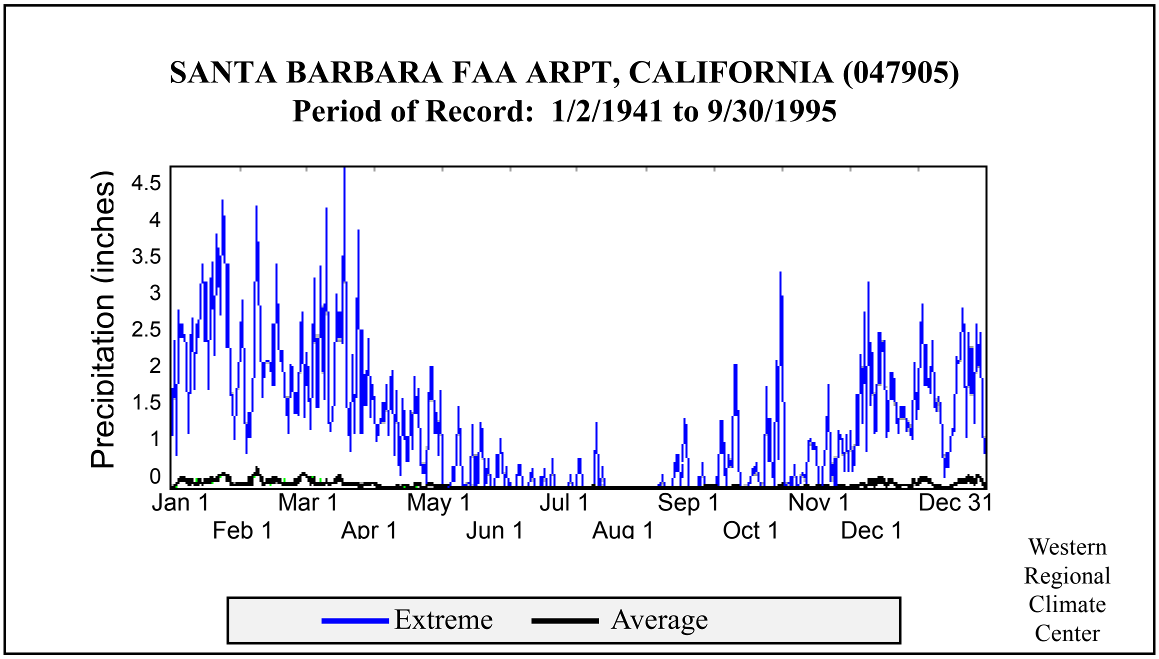
Unlike the mid-continent or eastern United States, water volumes are not significant predictors of stream flow or flood damage potential in SCSBC. Floods that can damage property (*e.g.*, Montecito, January, 1969) can occur at times of only modest rainfall and runoff, while times of very heavy rainfall (March, 1995) may cause floods with less property damage. Flood control activities in Santa Barbara County are largely focused on sediment control. Sediment basins that trap rocks while passing water change the balance between sediment load and transport capacity below those basins. Stream channels below those basins then become unstable and erode their banks and beds, trying to compensate for excess energy and transport capacity. The *Draft Guidebook* provides Santa Barbara County staff assessments and reactions to the 1995 major flood event compared with earlier events.

4.7.2 Episodic Flows

Neither sediment supply nor stream flow are very regular or predictable in the SCSBC region. It is well recognized that the year-to-year variation in annual precipitation is high (Figure 4.5). Climate stations on the south side of the Santa Ynez Mountains are among the most variable from year-to-year of any station within the state of California. This same pattern of variability is reflected in daily and monthly precipitation extremes. While Santa Barbara's mean annual rainfall is 17.57 inches, 1 standard deviation (a measure of the variability) is ± 8.13 inches or about 45%. By contrast, San Diego is 40%, Monterey is 37%, Pismo Beach is 41%, and even Mt. Wilson in the western Transverse Ranges with the highest known rainfall intensities (26.12 inches in 24 hours January 22, 1943, at Hogees Camp) has a variability of only 51%. A summary of the historic annual precipitation for Santa Barbara is shown in Figure 4.6.

The fact that SCSBC has an unbroken mountain front immediately above it, as does the San Gabriel mountain front area in the Los Angeles Basin, creates the conditions for "wringing" the maximum amount of moisture out of a saturated air mass. This condition is termed "orographic precipitation" (*i.e.,* precipitation caused by orographic lift) and is illustrated in Figure 4.7. In the SCSBC region, episodic precipitation leads to episodic runoff. Santa Barbara's rainfall in 1995 was 49 inches and was 310 percent of normal. On January 10, the rainfall intensity in the city of Santa Barbara reached a minimum of 7.45 inches in 24 hours. In the early morning hours of January 10th, 1995, a high intensity rainstorm struck Santa Barbara. With the soil nearly saturated from the moderate amounts of rain from the previous couple days, almost all of the water poured out of storage within the hillsides, bringing the streams rapidly to flood stage. Mission Creek crested its banks early in the morning and flooded most of downtown. Some meteorologists reported a rainfall total at 9 inches in a 24-hour period, with high intensity bursts of 1 inch per hour.

Figure 4.5
Year to year variation in annual precipitation for Santa Barbara



Western
Regional
Climate
Center

Figure 4.6
Historic annual precipitation in Santa Barbara

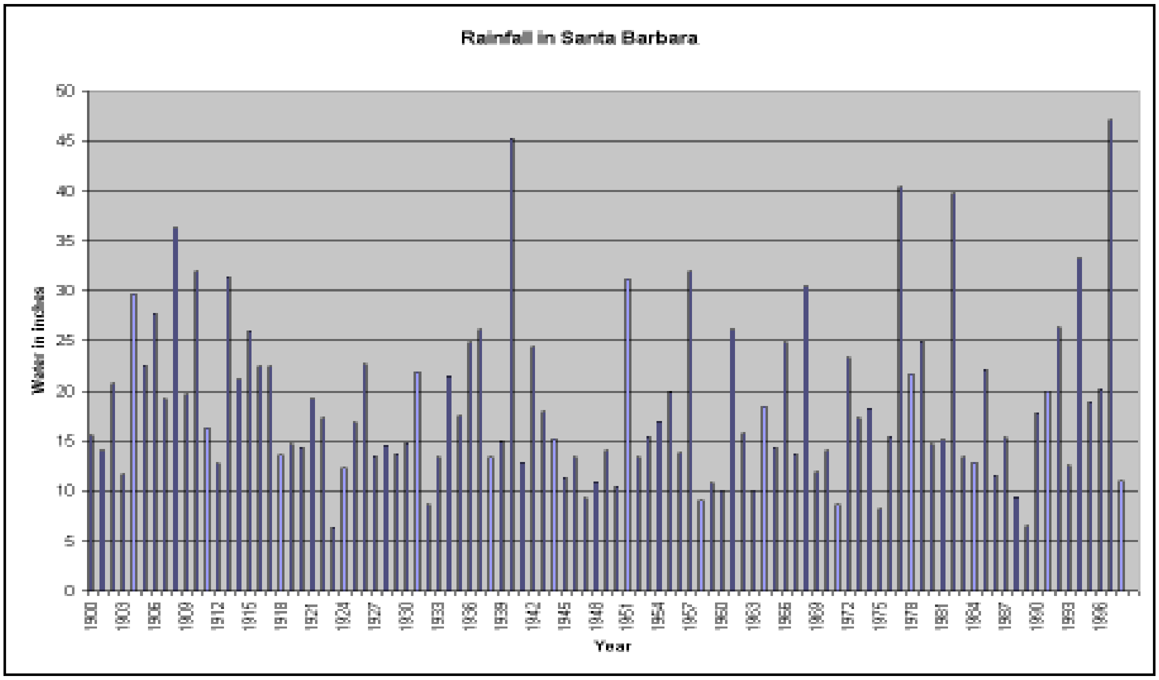
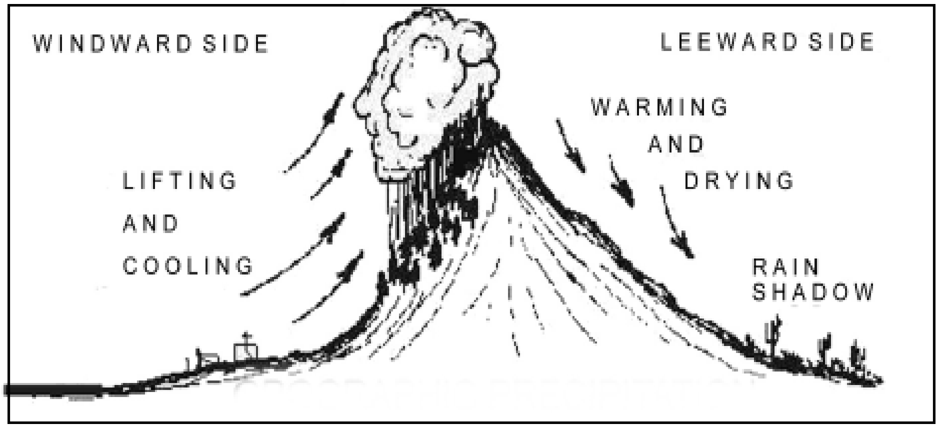


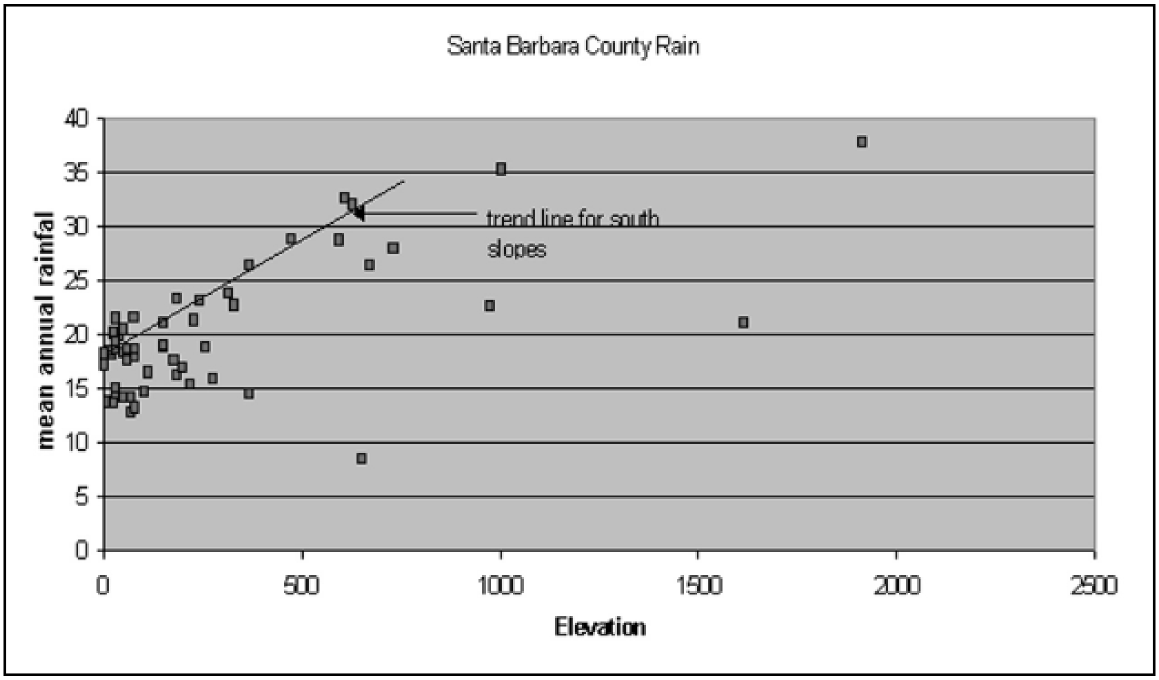
Figure 4.7
Orographic precipitation



Channels within the high and medium gradient portions of the geographic Domain are directly linked to their adjacent hillslopes. It is these hillsides that are the primary sources of sediment. These sediments enter the channels during most winter precipitation seasons, but are only transported down-channel during extreme precipitation events. In the SCSBC region, it is often the shape of the watershed that determines the response of its channels to high runoff events. Because geology, groundwater, vegetation, soil types, and relief are similar for most of the high gradient mountain-front watersheds, the primary variable that controls the response of a watershed to rainfall is its shape. For example, longer narrower watersheds with lower ratios of watershed area to channel length, discharge water and sediment at a slower rate than do nearly circular-shaped watersheds with higher drainage density (*e.g.,* lower verses upper Las Vegas Creek). In these systems (*e.g.,* upper Las Vegas Creek), water is rapidly routed from the many smaller tributaries to a central point.

Because the extremes of daily precipitation events drive channel conditions, the following figure (Figure 4.8) best illustrates the high rainfall conditions that occur in Santa Barbara County, and it reflects the extreme range of precipitation events that bear little or no relationship to average precipitation conditions.

Figure 4.8
Annual rainfall compared to elevation in Santa Barbara County



4.7.3 Natural and Human Alterations to SCSBC Channels

Natural channels are delicately adjusted to carry the sediment loads supplied to them in extreme events with the water available to do work over the gradients that the natural channels must traverse (Leopold 1994). In the SCSBC region, channels are not adjusted to average conditions, but to the extreme conditions that help shape the channel. Fluvial geomorphologists generally recognize that a runoff event (*i.e.,* sediment load plus water) that has a return period on the order of 50 to 100-years, is a “channel forming event”, and that the shapes of natural channels are largely defined by these more extreme events (Leopold 1994).

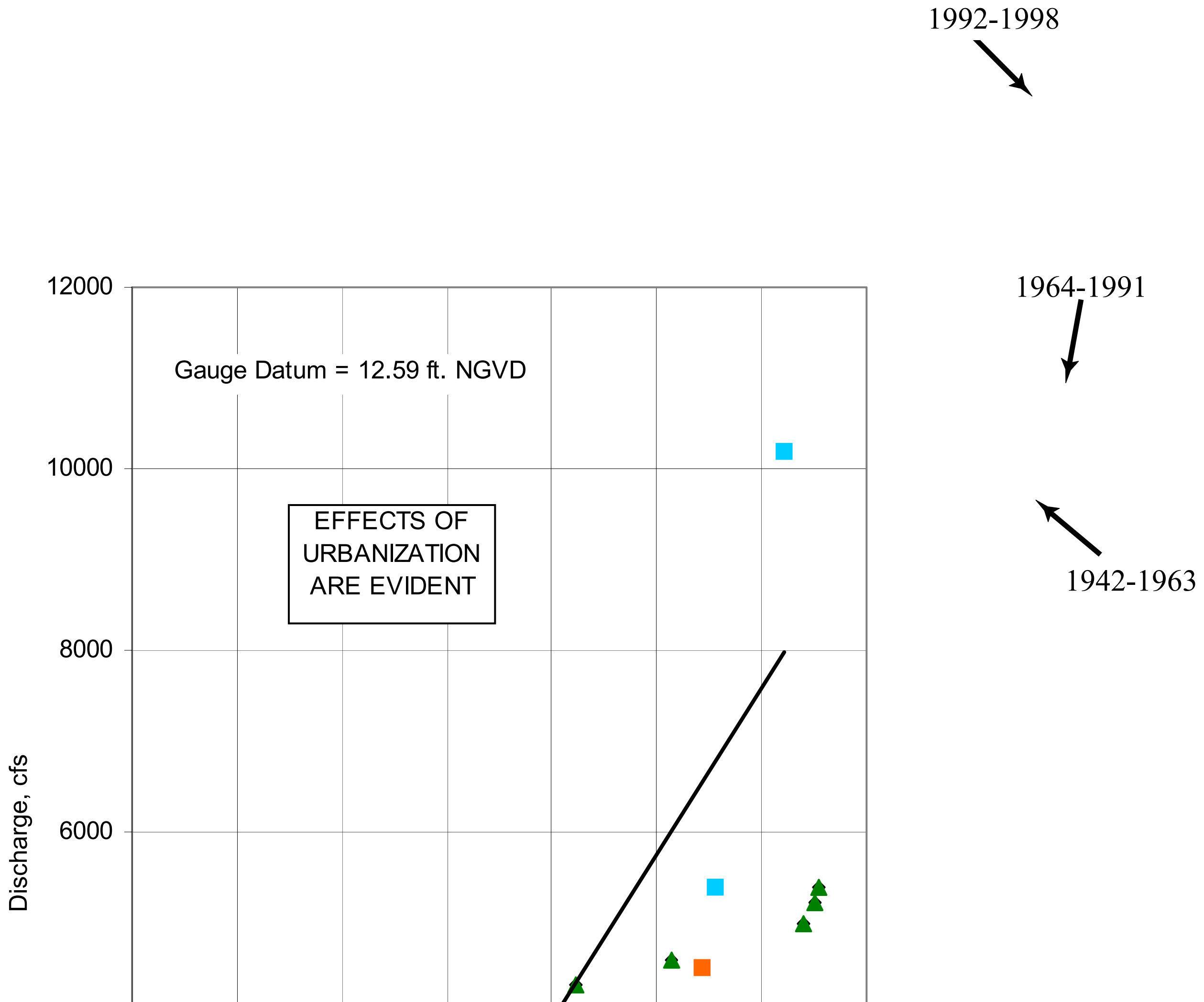
Sediment transport to, within, and from stream channels, can be expected when precipitation intensity equals or exceeds 2.5 to 3-inches in 24 hours. As data in Figure 4.4 shows, there have been many such events within Santa Barbara County during the last 50+ years. Hillslope steepness is adjusted to refill the channel system between such high intensity flushing events. This adjustment and refill of channels may obscure the evidence of channel dynamics on the high gradient Santa Ynez mountain front (Coppus and Imeson 2000).

Our work in SCSBC region revealed that there were very few channels that had characteristics that would be expected to reflect infrequent channel-forming events. Even though our field investigations were conducted within a decade of such a channel-forming event, historic channelizations, sediment trap basins, engineered hardening of natural banks, and manipulation of channel bed and sediments, all combine to create a non-equilibrium state for most parts of the lower and middle-gradient channels in our study area.

For example, in Santa Barbara County, channelization around the airport (*e.g.,* San Jose Creek) has (1) lengthened those channels, (2) reduced their gradients, and (3) caused deposition of fine textured materials. This condition has necessitated continued channelization to reduce roughness within the system, and to allow the transport of sediment along the reduced gradients within the Low gradient subclass. Carpinteria Creek and Santa Monica Creek are examples of streams that are “defeated” (*i.e.,* have had their gradients reduced) by a combination of down-dropping of their mouths from tectonic and/or seismic activity, and rising sea levels. These systems, therefore, tend to build larger floodplains. However, in Santa Barbara, these stream ecosystems are artificially constrained by levees and channels to compensate for tendencies toward expanded floodplains. The current condition and state of these systems makes it essential for continuous dredging and alteration to maintain the current “equilibrium.” Intact, naturally functioning waters/wetlands within the Goleta and Carpinteria sloughs would likely alleviate the need for such intensive management of these riverine systems.

Additionally, the effects of urbanization and anthropogenic alteration can be observed in graphs of stream discharge versus gauge height. With increases in area of impervious surfaces and channel hardening, stream discharge can dramatically increase even though precipitation and input to channel systems may be the same or similar to those of earlier periods. (Refer to Figure 4.9, Atascadero Creek discharge versus gauge height at lower Atascadero Creek).

Figure 4.9
Discharge versus gauge height at lower Atascadero Creek



Natural alluvial (*i.e.* stream borne) channels rapidly adjust their channel geometry to respond to artificial or natural changes in discharge of sediment and/or water. An alluvial channel is one that has been naturally constructed of materials transported by the stream in various stages of flooding. The channels within the SCSBC region are all alluvial, although bedrock is exposed in many areas in most of the upper steep gradient channel systems. The Santa Ynez Mountain block channels have formed from those sediments carried by water within the stream channels, and by mud in the form of debris flows that can overwhelm and completely fill channels formed exclusively by water and its sediment load. This fact suggests that Santa Ynez Mountain front channels and portions of the Medium Gradient channels can behave as though they are not entirely of alluvial origin. Mud and debris flows transport very heavy and large blocks of rock in these systems. In essence, a multi-ton boulder can "float" in a matrix of mud and other boulders. As the mass moves, smaller boulders strike larger boulders more often than larger boulders strike smaller boulders. This creates a dispersive stress that tends to move the largest boulders to the top of the moving mass. Therefore, sorting of grain sizes in these mass flows is the reverse of that in water-borne sedimentary deposits, with coarsest (largest) materials on top and finer materials near the base of each discrete debris flow tongue.

After a major mudflow/debris-flow event in the foothills of the Santa Ynez Mountain block, water can reoccupy the old channels, or form new channels and erode the matrix-supported mudflow deposits. However, the channel water may not have enough tractive force (*i.e.* drag or shear forces developed on the wetted area of the streambed and acting in the direction of flow) and competence (*i.e.* the ability of a fluid to transport particles in terms of size, rather than amounts) to move the boulders that could be carried by mud. This situation can create a lag of large boulders in the bed of a stream, such as occurs in Mission Creek in the Mission area. Boulders become "permanent" components of the channel, moving only in small increments by saltation, if at all, in larger flood events that are dominated by waterborne sediments. Thus, over time, the lower steep-gradient and upper medium gradient channels become dominated by boulders that are too large to be moved by fluvial processes (*i.e.* streamflow). In some SCSBC channels, boulders are buried between mudflow events in aggrading channels. An example of this can be observed at Tuckers Grove County Park below San Marcos Pass. In other channels, such as Mission Canyon at the Botanic Gardens, boulders are partly buried and comprise significant roughness elements within the channel.

It is unknown how frequently the major mudflow/debris-flow events may reoccur in any given watershed. However, based on the examination of the ages of mature oak forests and the examination of residual soil profiles, the frequency of reoccurrence of mudflow/debris-flow events may be on the order of 500 years, and probably is associated with those El Niño events that closely follow fire (noting the almost ubiquitous preservation of charcoal in the debris-flow deposits).

4.7.4 Natural and Human Caused Changes in Channel Equilibrium

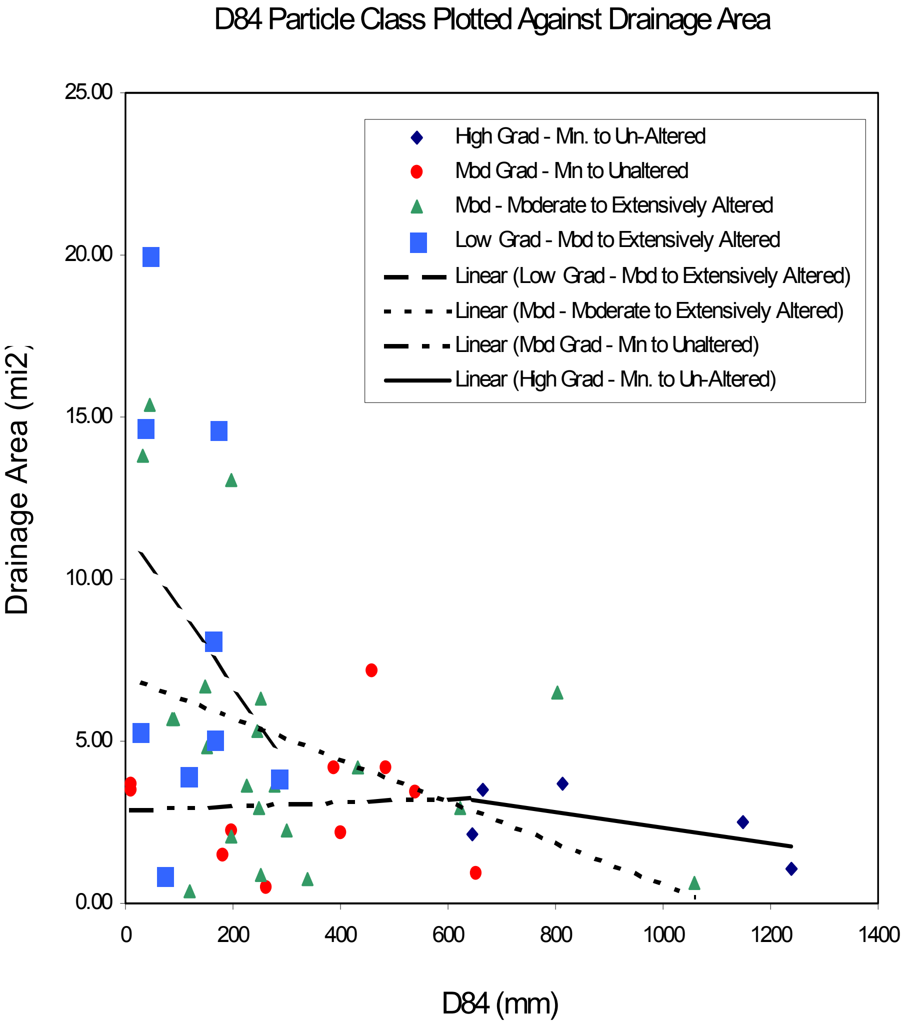
Given the episodic nature of flood flows and debris flows on the south slope of the Santa Ynez mountain front, and the fact that fire patterns may bear little or no relationship to areas of subsequent high rainfall, it is not reasonable to create a table of regional characteristics of local natural stream channels. As discussed previously, few sites could be found where current channels reflected natural conditions unaltered by human activity within the SCSSBC region. Thus, there are inadequate numbers of reference sites to allow a complete characterization of these systems. Additionally, it is not clear that data would be meaningful in the context of the mosaic of highly altered and unaltered sites that have been subject to such different histories of disturbance and sediment dynamics. In short, due to the high level of background variation, it is not realistic to expect that one could characterize standard channel geometries (*e.g.,* the width-to-depth ratio at bankfull discharge) of all stream channels as a function of gradient and/or watershed area. Our reference system data and measured channel characteristics are tabulated (see Appendix B) and have provided us the ability to assess our observed range of channel conditions associated with natural and altered channels.

Figure 4.8 illustrates a plot of elevation against mean annual precipitation. A large scatter of the points due to the fact that some sites are in (1) rain shadows, (2) north and west of the Santa Ynez mountain front, and (3) at high elevations. The significance of this is that the South Coastal watersheds receive the greatest 1-hr, 2-hr, and/or 24-hour precipitation intensity of any stations in Santa Barbara County. These data show that precipitation within the SCSBC region is reasonably consistent, and a function of orographic uplift and a steep lapse rate (*i.e.,* the rate at which some atmospheric property (usually temperature) decreases with elevation or altitude) that results in increased precipitation with increase in elevation.

In natural alluvial channels formed on uniform substrates with only one form of sediment transport to form those channels (*i.e.* water or mud), we would expect to see a relatively predictable pattern of changes in channel geometry and bed material sediment size as a function of the stream gradient and watershed area . However, faulting, uplift, and large debris blocks left by past mudflows complicate the conditions observed in SCSBC region. A plot of grain size of the coarse fraction of the sediment (D-84) versus drainage area is shown in Figure 4.10. Here we see a pattern where finer grained sediments characterize low gradient channels, no matter what area they may drain, while high gradient channels move the coarsest (*i.e.,* largest) sediment. In fact, this plot reflects the grain size that resided on the streambeds during the summer of 2000, and may not reflect what actually moves in low gradient channels during peak flood events.

When observing, and especially when preparing restoration plans for stream channels in the SCSBC region, it is important to recognize the two levels of process occurring in these channels (*i.e.,* “average” or annual alluvial processes, verses episodic, large scale mudflow/debris flow events). Figure 4.10 shows two families of streambed cobbles (a bimodal distribution). Those channels characterized by large channel materials (*e.g.,* D-84’s) of less than about 300 mm are not armored and can move that sediment in flood events. Those channels with D-84’s of greater than about 300 mm probably reflect dual modes of deposition with mudflow deposits contributing a lag of larger clasts (*i.e.,* cobbles, stones, boulders) to the streambed. Therefore, rapid assessment and design of stream channels in the SCSBC region can be problematic due to the fact that (1) these channels do not necessarily reflect predictable patterns of change in channel geometry and bed material, and (2) field indicators are complex and may reflect the “average” or annual condition, or they may reflect very infrequent, larger scale episodic events (*e.g*., March 2001).

Figure 4.10
D84 particle size class plotted against drainage area



4.7.5 Hydraulic Geometry

Channel characteristics

A goal of the HGM assessment is the characterization of the hydraulic functioning of stream ecosystems within the SCSBC region in terms of their stability and equilibrium status. A channel that is adjusted by stream flows in such a way that allows it to carry all the sediment supplied to it, with its available water, and over the current gradient, is said to be balanced, or in equilibrium (Miall 1978). Because of the episodic nature of sediment and water runoff within the SCSBC region area, most natural channels will store sediment until infrequent flood events mobilize and transport it. Reference data presented in Appendix B illustrates the "reference" reaches or stable channel configurations/ conditions for high, medium, and low gradient systems. Using reference standards, we can estimate the departure of any channel section from that "ideal", or reference standard condition. Each class of channel has differing equilibrium conditions dependent upon geomorphic location. Every site has a characteristic morphology, longitudinal profile, embeddedness, sediment load, gradient, and grain size.

In addition, channels can easily change their width and depth to adjust to the current sediment load and gradient, and over long periods of time, they can even adjust their gradient (*i.e.,* longitudinal profile). However, channels cannot change the (1) amount of sediment delivered, (2) size distribution of that sediment, or (3) amount of runoff available to transport that sediment.

When human intervention changes any of the inherent channel characteristics by hardening a bank, channelization, building sediment retention basins, or changing gradient, sinuousity, and/or roughness, the channel characteristics will tend to resist the human induced change, or will be forced to adjust other variables (*e.g.,* width, depth, gradient) to rebalance its equilibrium transport dynamics. Capturing sediment in an artificially constructed basin creates "hungry" (*i.e.,* sediment deprived) water downstream that will erode channel bed and/or banks to make up for the artificial sediment deficit. Channelization often reduces the ability of a channel to widen its bed and store sediment that it cannot transport with a given flood flow. It may then be forced to accelerate the transport of that sediment downstream to areas that are not channelized (*i.e.,* more sinuous), and where the sediment is then likely to be deposited suddenly. Channelization also frequently reduces bank roughness and, when accompanied by channel straightening, increases the slope or gradient of the channel bed. These changes can lead to scour and higher transport capacity, which is often the goal of channelization efforts. In the SCSBC Region, if a channel becomes too constrained, the higher transport capacity must be controlled all the way to the ocean. Again, this type of confinement (hydrologic enhancement) features flood control at the expense of all other Riverine ecosystem functions, with a greatly reduced capacity for improvement of water quality, or amelioration of degraded water quality arising from storm runoff.

By classifying each study reach by degree of alteration and by carrying those sub-classifications through the channel geometry assessment, we can consider and assess how human alteration affects, or potentially affects, water quality, the replenishment of beach sand, and flood hazard as related to the channels in the SCSBC region.

4.7.6 Channel Characteristics by Subclass

High Gradient Santa Ynez mountain front Channels

High gradient mountain front channel systems, including their source watersheds, are characterized by narrow channels in small watersheds with steep to very steep gradients. The 0th and 1st order drainages (Horton 1945, Stahler 1957) on the steep mountain front surfaces have low sinuosity and thus convey materials removed by erosion and/or slope failures and debris flows to the lower channel reaches. Streambed materials observed within the High gradient subclass are combinations of bedrock and sandy-skeletal materials with little, to no fine textured material within the bed or riparian areas (Figure 4.11 and 4.12).

Figure 4.11
Percent observed SSK/Bedrock material or loamy or finer material observed in stream channels for High, Medium and Low gradient subclasses

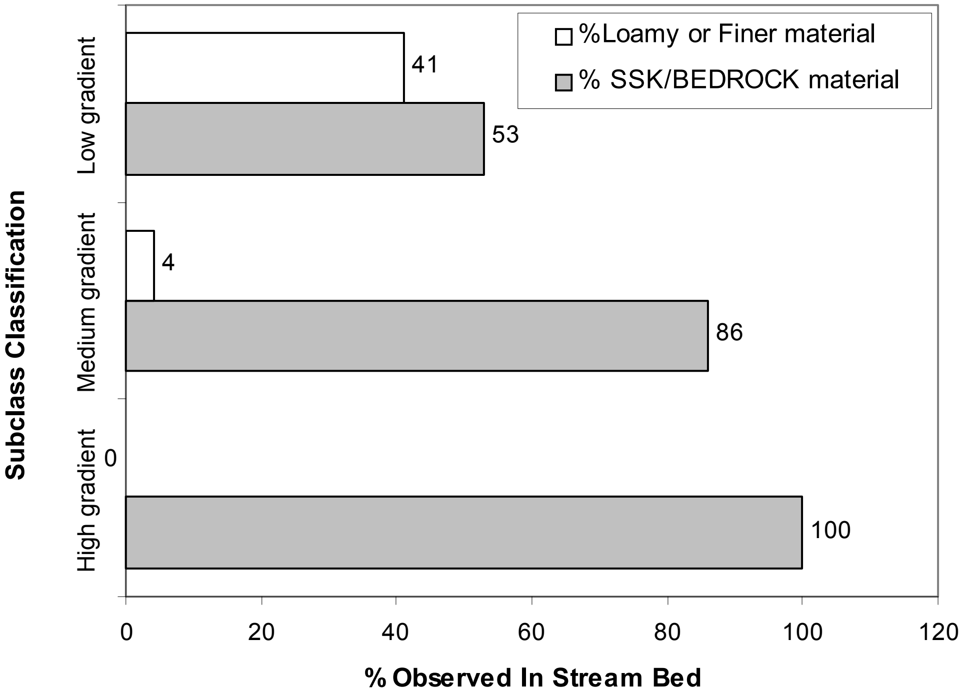


Figure 4.12
Photograph of High gradient subclass (Mission Creek)

Width-to-depth ratios for the high gradient channels vary from 7 to approximately 14 with a mean of 8.47 (Appendices B and C). When plotting the width-to-depth ratio of the channel against the drainage area that supplies that point, we find the trend line for the High gradient subclass to have the steepest slope (Figure 4.13). However, the highest width-to-depth ratios are all within the low gradient subclass. This would be expected for low gradient depositional reaches where sediments are being stored in the flood plains and channel reaches. A plot of channel width at OHW versus the watershed area that drains to that point shows the same trend (Figure 4.14).

The D-84 size class ranges from 650 mm to 1240 mm with a mean of 902 mm, within the high gradient channels (Appendices B and C). The larger class size (D-84's) indicates that there is a lag of debris-flow-derived boulders, and that mass (gravity) transfer processes are playing as much a role in the transport work of moving clasts into and down channels as water transport processes. The plot of watershed area that drains to the specific channel location, versus D-84 size class reflects a trend for the largest D-84 sizes to be found in the channels that are fed by the smallest drainage areas (Figure 4.10).