CHAPTER 4 – METHODS

Previous and Concurrent Studies

This study builds on previous works of other researchers that considered changes to the culture, water quality, and physical changes as well as current conditions of the San Pedro Creek watershed. A considerable amount of attention has resulted from an active community watershed group and an academic interest driven to better understand the past and how it has affected the present and future of a still relatively intact urban stream.

The cultural landscape was reported by Culp (2002) in an attempt to piece together several phases of cultural history in the San Pedro Valley, starting with the Native Americans and ending with present conditions. Culp examined landscape changes with each series of cultural periods including the Ohlone Landscape, the Mission Period Landscape, the Rancho Landscape, the Truck Farming Landscape, the Early Suburban Landscape, the Modern Suburban Landscape, and Today.

Matuk (2001) looked at seasonal water quality data from San Pedro Creek in an attempt to characterize physical, chemical, and biological parameters and found that the urban landscape was a significant contributor to water quality impacts in all three areas.

Eisenberg, Olivieri, and Associates (EOA 1998) had been hired by the San Mateo Countywide Stormwater Pollution Prevention Program to assess impervious surfaces in five different watersheds in San Mateo County; one of which was the San Pedro Creek watershed. EOA used digitized 1995 land use data generated by the Association of Bay Area Governments (ABAG) to calculate the total impervious area for the watershed (ABAG had designated twenty land use categories and estimated their total area within the San Pedro Watershed based on aerial photos flown in 1997). Impervious surfaces were digitized and displayed for direct measurement and assigned an impervious percentage category of 0, 30, 45, 60, 65, 70, and 100 percent. EOA performed some field checks to ground truth their determinations and to increase the overall accuracy of their measurements.

Collins, Amato, and Morton (2001) surveyed 2.6 miles (4.2 km) of main stem from the mouth at the Pacific Ocean to the upstream confluence with the South Fork tributary, and conducted historical ecology research combined with field data of physical conditions to describe the evolution of the human and natural landscapes, and to assess present fluvial geomorphic conditions. Detailed survey data were collected to describe bed and bank conditions including erosion, incision, sediment size class distribution, in-stream habitat features, and stream reach classification based on Rosgen (1994). Observations and results of this geomorphic investigation elucidated the importance of a more detailed understanding of the influence of urbanization on San Pedro Creek and further emphasized a need to monitor the storm response of the Middle and North Fork watersheds.

Methods Specific to this Study

To compare how the North and Middle Forks responded differently in storms, data for several watershed variables were collected. Percent cover of impervious surfaces and length of artificial channels were quantified; monitoring equipment was installed to collect continuous precipitation, water level, and turbidity data; discharge was measured in the field to estimate continuous storm response; and longitudinal profiles and cross-sections were surveyed before and after the 2000 rainy season to demonstrate short-term channel response. Bank erosion data was previously assessed under a separate study.

Engineered drainages were measured using ArcView geographic information system (GIS) software and street and stormdrain data from the U.S. Geological Survey and City of Pacifica respectively. Engineered drainages included street gutters, mapped ditches for hillside drainage, and stormdrains. Pre-urbanization drainage density was derived by dividing the pre-development channel length by drainage area. Post-urbanization, or current drainage density was derived by combining the measured length of natural and artificial channels and dividing by the drainage area.

A rain gage tipping bucket was placed at the ridgeline near the headwaters of each drainage, as shown in Figure 5, to record precipitation during the course of the study as well as during storm events. The buckets were factory calibrated to record an event after collecting 0.01 inch (1.37 mm) of rain. Data loggers were installed in the rain gages to record date, time, and event, and to allow for periodic data downloading. This data was collected and rainfall events were plotted over time, showing total rainfall and intensity for a given period based on the frequency of each recorded event.

Water level and turbidity stream gage stations were established at representative sites near the downstream terminus of both tributaries, just upstream of their confluence (Figure 5). Gage location selection criteria consisted of the site’s ability to represent stream response due to the land use of the sub-watershed, physical characteristics of the watershed, proximity to the downstream end of the individual tributary, channel stability along bed and banks, access, and protection from vandalism. Most pertinent to this study was the location’s ability to represent the effects of land use on the response of flow and turbidity during storms.

The Middle Fork gage station was located in San Pedro Valley County Park upstream from the urbanized portion of the watershed. The only man-made structures upstream of this station were a small maintenance yard and two small bridges located upstream of the gage. Residential and commercial facilities in the lower 1,300 feet (396.2 m) of stream contribute urban stormwater runoff to the Middle Fork and were thus excluded from the study area so that data collected at the gage would more accurately represent the undeveloped open space that dominates the Middle Fork watershed. The maintenance yard and pedestrian bridges were expected to have negligible influence on the stormwater runoff response and turbidity levels in the Middle Fork. The effects of trails on runoff and turbidity rates were considered beyond the scope of this study.

The gage station was located on the north bank at the end of a long riffle with earthen banks and gravel substrate. The bed and bank at the gage were relatively stable but did exhibit some signs of active erosion. As shown in Photo 4, sensors were housed in a black 5-inch (127 mm) diameter PVC pipe mounted perpendicular to the channel bed. Several holes were drilled into the bottom of the pipe to allow water-level equalization and through-flow while protecting the sensors from debris and sediment impact during storm flows. The sensors were connected to a data logger in a waterproof bucket hidden in a pit in the terrace above the channel, an accessible but secure location that allowed for regular data downloads and maintenance while protecting the equipment from tampering or theft. A staff gage was placed next to the sensors for calibrating the water level data measured by the sensor with actual measured water level.

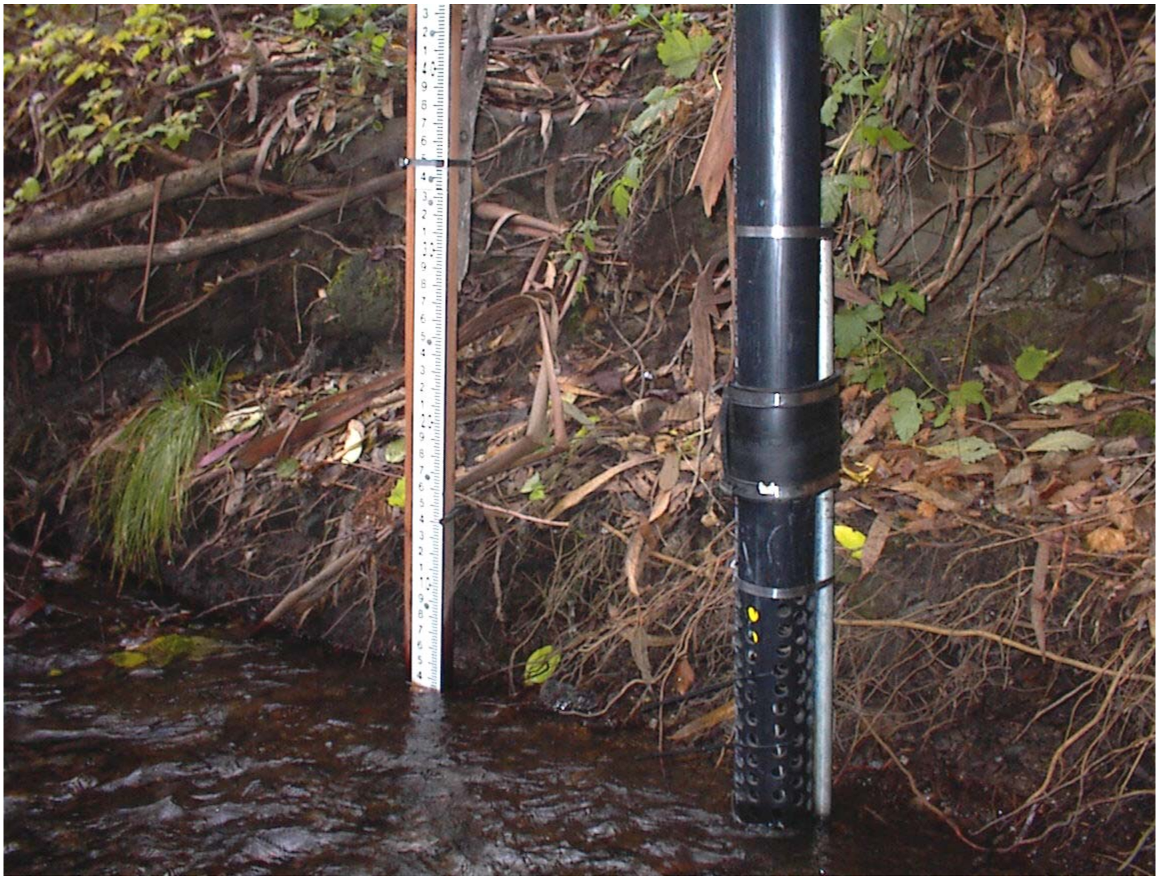

Photo 4. Middle Fork Gage Station

The North Fork gage station was located inside the 8-foot (2.4 m) diameter concrete pipe that forms the lower reach of the tributary, approximately 350 feet (106.7 m) upstream of its confluence with the Middle Fork. As shown in Photo 5 and 6, sensors were installed inside the pipe, 50 feet (15.2 m) from the end so they would be out of sight and safe from potential vandalism by juveniles and transients known to frequent the area. The need for this precaution was reinforced by personal encounters and observations of conditions at the site. The sensors and data cables were bolted to the concrete pipe and routed to a waterproof bucket containing the data logger. A PVC sensor well was originally installed but was washed out by minor storm flows prior to installation of the sensors, providing a timely indication of the velocities at which the culvert conveys flow. The sensors were re-mounted near the bottom of the concrete pipe without any housing.

A Global Water WL300 Water Level Sensor Pressure Transducer was used at both gage stations to record water depth, or *stage* (Photo 7). Stephenson (1994) used pressure transducers for measuring runoff from water depth in a similar watershed comparison near Johannesburg, South Africa. The WL300 creates an output in milliamps (mA), which must be calibrated to actual depth of water. The water level on the staff gage in the Middle Fork, and water depth measurements in the North Fork were observed at specific times during various depths and compared to the mA output recorded at the same time.

Photo 5. North Fork Gage Station Inside Culvert

Photo 6. North Fork Culvert

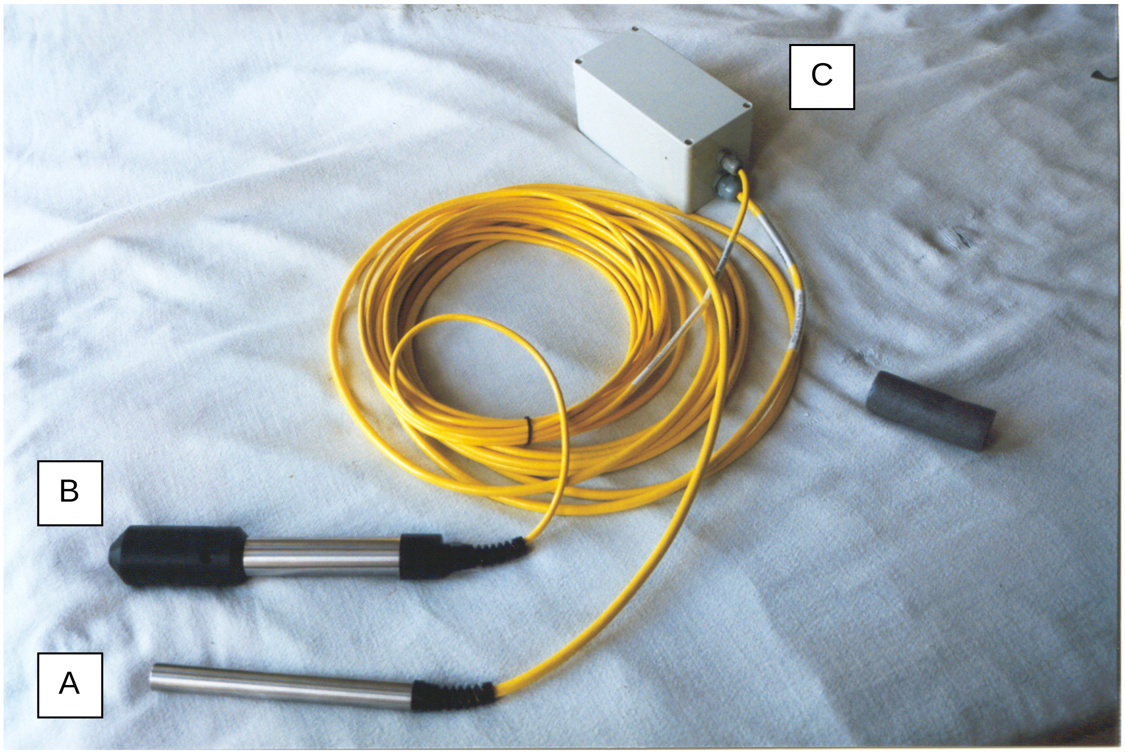

Photo 7. A) Pressure Transducer B) Turbidity Sensor C) Data Logger

Records in mA were converted to stage by running a regression analysis of actual measured water depths at various flows against water level sensor outputs in mA recorded at or within minutes of the same time. A strong correlation of r^2=0.98 in the Middle Fork, and a weaker correlation of r^2=0.69 in the North Fork were used to estimate discharge in both basins during the study period.

Turbidity was measured using a Global Water WQ700 Turbidity Sensor (Photo 7). The WQ700 is factory calibrated to measure turbidity in nephlometric turbidity units (NTUs) with a range of 0 to 2000.

> Particles scatter light through defraction, refraction, and reflection in all directions. A detector with a limited EPA (Environmental Protection Agency)-specified acceptance angle collects light at 90° to the focused beam resulting in a measurement of particle concentration or water cloudiness. The measured light level is converted to an electrical signal, filtered and displayed, resulting in the raw 4-20 mA output (Global Water 1999).

Consistent with criteria used by Lewis (1996) the sensors were installed close enough to the channel bottom to try and ensure they would remain submerged during all flows of interest.

Data output was recorded using a custom-built computer from Electronically Monitored Ecosystems. The computer was needed to turn on the water level and turbidity sensors three seconds prior to the preprogrammed data logger recording interval to allow for the manufacturer's required sensor warm-up time. Once the event was recorded, the computer turned the sensors back off until three seconds before the next recording event. Turning the sensors off between recording intervals was necessary to preserve the 12-volt power supply, avoiding power supply changes, and to prevent missed data collection. Onset Computer Hobo event loggers and Boxcar Pro Version 3.5 software were used for data recording from the sensors and the rain gages.

Data logging intervals for water level and turbidity were originally set for every ten minutes at both the Middle and North Fork stations. Lewis used the same interval in Caspar Creek, a small, mountainous, coastal stream in northern California (Lewis, 1996). This interval was thought to be frequent enough to capture the changing water levels in these small drainages. Visual observations of rapid water level rise and fall in the North Fork led to an increased frequency recording interval resolution of every five minutes in the North Fork only, to better capture system response. The Middle Fork recording interval remained ten minutes for the duration of the data collection period.

Discharge was measured at various flows using a Swoffer Instruments model 2100 flow meter, and multiplying measured velocity by the cross-sectional area of water in the channel. Continuous water depth (stage) was derived by establishing the relationship of observed stage on a staff gage to mA outputs responding to water depth (pressure) at the same time. Continuous discharge was then derived by plotting derived stage over discharge measured in the field at the same time. This effort yielded estimated discharge only due to the inability to measure enough discharge calibration points during a wide enough range of flows. Many storms occurred at night when measurement in the stream was difficult or unsafe, and mechanical breakdown and repair of the flow meter mid-study meant that the instrument might have had a different calibration before and after repair.

Longitudinal profiles and cross-sections were measured in the same reaches where the stream gages were located. Monumented surveys were done in 1999, prior to the study period, and in 2000, following data collection. The intent of the surveys was to plot the channel thalweg and cross-sections to see if channel geometry changed during the course of the study. It was important to survey cross-sections at the Middle Fork gage to measure any significant changes in geometry that could influence stage throughout the study period. Several previous studies (e.g., Leopold 1973; Ebisemiju, 1989; Odemerho 1992; and Gregory et al. 1992) have used channel geometry surveys to measure channel change.

Profile surveys were measured using a survey level and stadia rod for elevations, and a 100-meter (328.1 ft) tape measure for marking discrete points, or “stations” along the channel bed. Both the 1999 and 2000 surveys started and ended at the same fixed elevations (at concrete box culverts) so they could be plotted together and assessed for change. By recording fixed elevations at the upstream and downstream extent, changes in the elevations and features of the earthen channel in between could be measured. The level was mounted on a tripod and elevations were sighted on the rod at locations in the thalweg that defined the upstream and downstream extent of riffles, pools (including maximum depth), distinct changes in bed elevation, knick points, and concrete bridge aprons for elevation control. Stations on the tape measure were recorded for each elevation sighting. Points were then plotted for comparison.

Cross-sections were surveyed using the same method and equipment as for the longitudinal profile with the addition of rebar stakes for elevation control points. Once the cross-section locations were identified, rebar benchmarks were hammered into the ground on opposite banks. The measuring tape was stretched between the stakes to designate stations across the channel. The level was set up and sightings were taken on the rod at stations that represented changes in bed elevation. Like the profile data, cross-section data were plotted for comparison. These methods are commonly used for surveying stream geometry and have been described in several studies (e.g., Leopold 1973; Harrison 1994; and Rosgen 1996).

Bank erosion had been measured in 1999 as part of a geomorphic assessment of the San Pedro Creek Watershed. The author of this thesis assisted Laurel Collins, a local geomorphologist, and Donna Morton in measuring several in-channel characteristics related to physical conditions of the creek. Eroding bank sections were identified and referenced to continuous longitudinal stations along the centerline of the channel. Banks were separated into segments including bank, below the bankfull elevation; and terrace, landslide, or gully above bankfull. Depth, length, and height of bank erosion were estimated for the period since European settlement of the area in 1782 when land use impacts were believed to have begun affecting the channel. Bank erosion per linear foot was then determined by dividing cubic yards of eroded bank by linear feet of the channel reach. The Linda Mar reach extending from the confluence of the Middle and North Fork to the Linda Mar Bridge approximately 510 feet (155.4 m) downstream, was observed for bank erosion effects of the North Fork flows. The 764 linear feet (232.9 m) North Fork Confluence reach and the 1,217 linear feet (370.9 m) Oddstad reach were considered to be comparative reaches in the Middle Fork upstream of the influence of North Fork flows.