THE EFFECTS OF URBANIZATION ON ARROYO CORTE MADERA DEL PRESIDIO, MILL VALLEY, CALIFORNIA

A research project submitted to the faculty of
San Francisco State University
In partial fulfillment of the
requirement of the degree

Master of Arts in Geography

By

Andy Peri

Fairfax, California

May 12, 2005

TABLE OF CONTENTS

TABLE OF FIGURES AND MAPS

HABITAT ASSESSMENT OF ARROYO CORTE MADERA DEL PRESIDIO, MILL VALLEY, CALIFORNIA

Andy Peri
San Francisco State University
2004

The Arroyo Corte Madera del Presidio, like many of the streams in the San Francisco Bay Area has been impacted by urbanization. Impacts include habitat loss for native species, diminished water quality and habitat fragmentation. Many species including native anadromous fish, because of their high sensitivity to environmental degradation, have been impacted as a result of urbanization with some populations either depleted or completely gone. This study quantifies several aspects of Mill Valley's stream habitat for the purpose of assessing urban impacts on streams. The organization that was responsible for initiating this study had the dual purposes of both habitat study and of creating community involvement in the process, thereby enabling the Mill Valley community to effect change through informed action into the future.

I certify that the Abstract is a correct representation of the content of this research project.

______________________________________ _________________

Chair, Culminating Experience Committee Date

CHAPTER 1- INTRODUCTION AND BACKGROUND

The Mill Valley Watershed Project (MVWP) was formed in Mill Valley, California in 1994, to provide leadership in watershed stewardship. The organization facilitated community meetings, public presentations and stream walks to inform the community and determine their interests regarding protection and restoration of Mill Valley streams. Recognizing that steelhead is an indicator species representing the health of the watershed, the founders of the MVWP sought to assess the factors that were limiting steelhead population and, ultimately, to support actions that would help enhance stream habitat quality. The creation of the MVWP and the decision to conduct this stream survey were borne out of a desire by the Mill Valley community to quantify and geographically locate stream characteristics that demonstrate degraded stream habitat and function.

Mill Valley streams have historically been home to salmonid populations that include both steelhead and salmon. Mill Valley's streams were impacted by logging beginning in the mid 1800's and continue today; urbanization has had and continues to have adverse impacts on its watersheds, resulting in degraded stream habitat. The last several decades have seen declines of steelhead populations and the complete elimination of salmon in Mill Valley streams due to urbanization. There is, however, a growing movement to reverse this trend.

Efforts have been undertaken at national, state and local levels to protect water and stream habitats. Water quality protection dates back as far as the Clean Water Act (CWA) of 1972. Along with its amendments, CWA requires the preparation of approaches that help control non-point source (NPS) pollution (USEPA, 1994a:3). Recognizing the complex nature of NPS pollution, the US Environmental Protection Agency (EPA) has adopted a watershed approach to NPS pollution management. The Clean Water Action plan of 1998 states that the watershed approach envisions, "a new, collaborative effort by federal, state, tribal, and local governments; the public; and the private sector to restore and sustain the health of watersheds in the nation. The watershed approach is the key to setting priorities and taking action to clean up rivers, lakes, and coastal waters" (USEPA, 1998:ii). This holistic approach has helped set the stage nationally for watershed management activities that consider the vastly complex interaction between all human activity and natural ecology. Community-based involvement is a fundamental component of watershed management and is promoted by government as an integral part of the watershed approach.

The number of community-based watershed groups exploded in California during the 1990's. The creation of community-based programs has been fueled by factors that include a growing recognition of the importance of our urban streams by communities and government agencies alike. Some groups and individuals are pulled toward getting involved because of flooding issues, some because they see increasing destruction of stream habitat from development, some as a way of protecting and developing a deeper connection to the beauty that surrounds them.

Also fueling the growth of watershed groups during this period was the considerable injection of government and private funding available in California to supports watershed characterization, protection and restoration (California State Coastal Conservancy, 1997). Community watershed groups in California continue to grow in number with nearly five hundred being documented in California in 1998 (University of California, Davis, 1998). Many of these factors influenced the creation of the Mill Valley Watershed Project during its relatively recent creation, but current watershed activity has it roots in changes to Mill Valley lands that took place long ago.

Mill Valley History

Mill Valley is nestled among redwood trees in the valley southeast of the Mount Tamalpais East Peak approximately 7 miles north of San Francisco, California as shown in Figure 1 (TOPO!, 1999).

The 2,571-foot (784 m) East Peak lies at the Western boundary of the North American Plate along the San Andreas Fault. Mount Tamalpais' East Peak is the highest mountain along the 250-mile (400 km) Coast Range (Spitz, 1997:1).

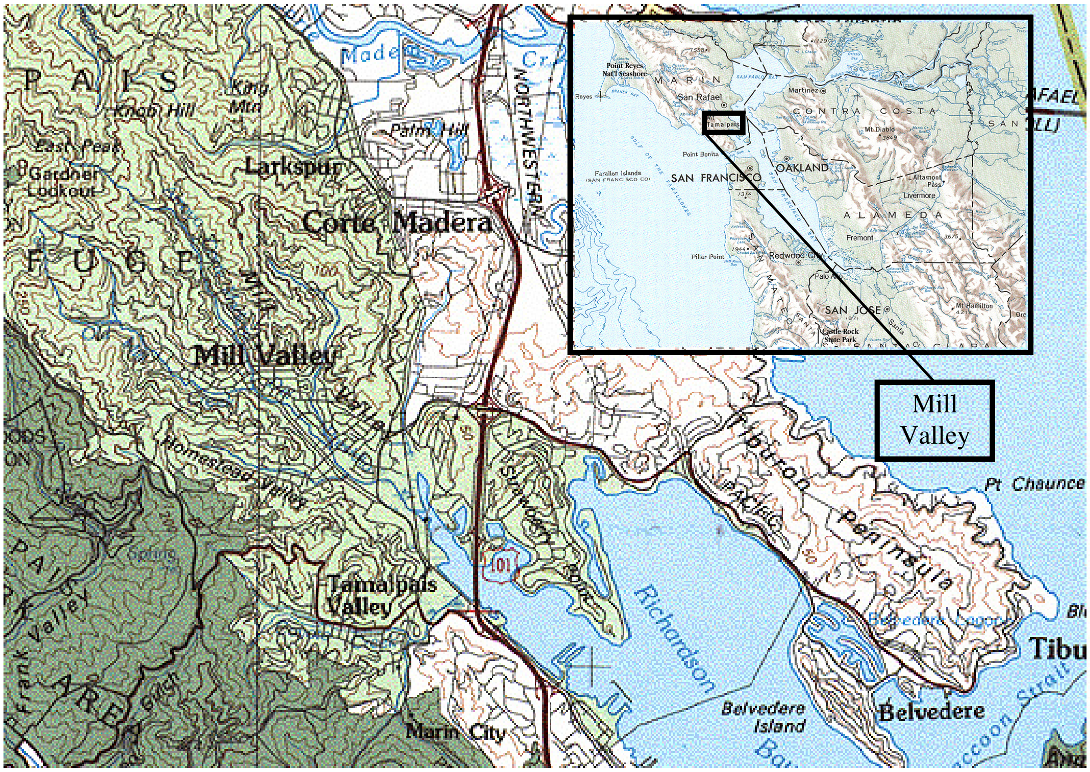


Figure 1- Map of Mill Valley and Vicinity (TOPO!, 1999)

The Coast Range formation that underlies Mount Tamalpais is from the Mesozoic period between 150 million and 65 million years ago (Schoenherr, 1992: 264). The Coast Range was formed as a result of the North American plate riding over the adjacent plate to the west, the Farallon plate, resulting in a complex tangle of marine sediments including sandstones, mudstones, and shales. The sandstone greywacke is the single most abundant rock on Mount Tamalpais (Spitz, 1997:1).

The smaller valleys that make up the study area are the result of erosion of the Mt. Tamalpais land mass and deposition of alluvium to the lowlands (Spitz, 1997:2).

Native biotic resources that I have observed through hikes throughout Mill Valley include redwood groves, mixed stands of broad-leaf evergreens, oak woodland, chaparral, coastal scrub, grasslands, pickleweed, cordgrass and saltgrass marshes and mudflats. In addition to these communities, there are substantial non-native invasive communities that inhabit the area including Scotch and French broom, English ivy, acacia, fennel and eucalyptus.

The earliest known peoples to inhabit the Mill Valley region were the Coastal Miwok who lived in the region beginning over 5,000 years ago. The Miwok lived on the abundant plant and animal life including acorns, waterfowl, fish and shellfish. The most prominent evidence of the Miwok's presence in the area are the large shell mounds, which are scattered throughout Mill Valley and adjacent areas (Spitz, 1997: 4).

Shell mounds in Mill Valley and surrounding areas have within them a wealth of historic information about the Coastal Miwok. These areas were used as seasonal camps as well as burial grounds, making them rich in Miwok artifacts (Spitz, 1997:5). Although the land saw transformation by the Coastal Miwok's use of fire in the vicinity, it was not until 1816 that the Mill Valley region's waterways would see the first of a series of dramatic adverse anthropogenic changes to its watersheds.

Commercial logging in the region began in 1816 in what is today the city of Larkspur, located in the watershed just north of Mill Valley. Trees were cut for fuel wood for the Spanish troops based at the Presidio (Fairly, 1987:16). The legacy of logging has left us with the several geographic place names in the Mill Valley vicinity, including Corte Madera (cut wood) Creek, the town of Corte Madera, and the Arroyo Corte Madera del Presidio (Creek of cut wood for the presidio), the main creek that runs through Mill Valley. Logging intensity increased over the next decades beginning with the establishment of several Mexican land grants.

In 1834, John Thomas Reed received a grant from the Mexican government for Rancho Corte Madera del Presidio. This land grant included all of the

Tiburon peninsula and much of present-day Mill Valley and its adjacent cities, Corte Madera and Larkspur. Two years later, in 1836, William Richardson was granted Rancho Saucelito, which contained the remaining parts of Mill Valley. That same year, John Reed built a sawmill on Cascade Creek in Mill Valley, the remnants of which still reside in Mill Valley's Old Mill Park (Fairly, 1987: 16).

The era of commercial logging of the east-Marin watersheds had begun. Reed's mill was initially built for the purpose of supporting his ranching operation but ultimately it, and a subsequent mill built on Rancho Saucelito, became part of a large commercial logging operation. Both of these mills provided lumber that would become the buildings that continue to stand today at the San Francisco Presidio (Fairly, 1987:16). The first recorded environmental effects of logging were soon to appear.

By the 1850's logging in Mill Valley had produced enough siltation in Richardson Bay (the receiving waters of Arroyo Corte Madera del Presidio) to make it impassable by the barges and flat-bottomed schooners that had transported lumber to San Francisco (Fairly, 1987:16). Up to this time, transport vessels were able to travel to the location where today's Tamalpais High School resides; today, much of this area is developed landfill and pickleweed marshland. It was during this period that a new, modern, steam-powered mill on Rancho Saucelito rendered Reed's mill obsolete. (Some thirty years later the inoperable Reed Mill, still intact, began to be called the "Old Mill" and the adjacent creek as "Old Mill Creek". These names remain to this day (Spitz, 1997:21). Logging continued in Mill Valley until 1952 when all of the best redwoods had been removed (Fairly, 1987:16).

During the logging era, much of the land on the Ranchos was also used for livestock grazing. Reed and Richardson both kept sizeable herds of cattle and sheep. Cattle hides and tallow were traded or sold during this time, but dairies soon began to dominate the landscape. During the 1850's, Samuel Throckmorton (Richardson's successor), began leasing sections of Rancho Saucelito to dairy ranchers. This was the beginning of Marin's great age of dairying. By the 1930's over a dozen dairy ranches covered the hills and valleys of Mill Valley and its adjacent areas (Spitz, 1997: 32).

After the death of Samuel Throckmorton in 1883, the first steps were taken to subdivide Throckmorton's land. Later that decade surveyor Michael Maurice O'Shaughnessy laid out the most prime land for development. The maps produced by O'Shaughnessy covered 600 acres with nearly 500 building sites (Spitz, 1997:48). The stage was set for the building of what is today the heart of Mill Valley with all of its beauty but it was not without continuing stream habitat problems.

Problem/Justification for Study

The 100-plus years of urban development that began with O'Shaughnessy's work have left their mark on Mill Valley's watershed and stream ecology. Mill

Valley is, to a great extent, built-out; most of the parcels that were easiest to develop are already developed. Because of its steep slopes, and its confinement by publicly-owned land including, county-owned open space, national park lands and county water district lands, it will not likely see a great deal of urban growth in the future. Despite this fact, the incremental effects of urbanization continue to degrade the habitat quality of the watershed with pressure to expand existing homes and develop the handful of ever-more-sensitive parcels in the watershed.

Several aspects of stream ecology continue to be adversely affected by this development in Mill Valley's watersheds. One continuing threat to stream ecology is that of siltation. Although the logging era is long past, fine silt continues to enter streams from harmful construction practices such as rainy-season grading, improper sediment control structures in disturbed areas and improperly maintained roads and culverts in the upper watershed. Silt periodically chokes stream gravel, making it inhospitable to many species of fish (especially salmonids) and aquatic insects, which are a vital part of the stream's food web.

Mill Valley's streams also continue to be adversely affected by the past and present use of concrete and steel for the purpose of building bridges, flood control structures and stream bank stabilization. The construction of concrete stream banks and beds necessitates the destruction and removal of biologically important stream zone vegetation. Stream zone vegetation performs a number of important functions that help keep the stream ecosystem healthy.

Concrete bridge abutments and aprons built in creeks are, at times, barriers to fish migration. These and other concrete features, many of which eliminate *all* meaningful in-stream, habitat are ubiquitous throughout Mill Valley's watershed. Several reaches of surveyed streams have been forced through large culverts eliminating most if not all habitat required for fish and plant survival. Luckily, these most extreme habitat-destroying types of structures are relatively few in Mill Valley and are surrounded by reaches of relatively intact in-stream habitat.

An even more detrimental (and far more insidious) phenomenon is the creation of impermeable surfaces within and outside the stream zone throughout urbanized watersheds. Stream habitat is adversely impacted when impervious (impenetrable) surfaces such as roads, parking lots, rooftops and driveways replace natural permeable surfaces. The negative consequences of increased impermeable surfaces are manifold. The first is that rain events produce a greater quantity of runoff because water is rapidly conveyed over roads, through gutters, pipes and culverts to stream channels instead of being absorbed into soils. Such rapid runoff events can increase downstream flooding and increase channel damage because of increased peak flows, especially during large storm events. The rapid conveyance of runoff water to storm drain systems and into creeks also reduces the infiltration into the groundwater system, reducing base flow in streams during dryer times.

Figure 2 shows the effects of urbanization on stream hydrology (Shulman and Johnson, 1994: 5). The water balance of surface and ground water is shown in part a; surface water runoff increases in the “Urban/Suburban” diagram are indicated by a large arrow. In part b, the hydrograph of surface flow is shown for both small and large storms. The “post-development” hydrograph shows higher volume, flashier peak flows during storm events as compared with the “pre-development” curve, which shows a smoother, less dramatic maximum flow with water remaining in the system for a greater period of time. Part c shows the pre-development and post-development floodplain elevation that results from urbanization; this includes an altered stream channel cross section and a higher flood plain limit. Part c also shows reduced summer flow levels after development due to rain water being removed from the system as a result of increased impervious surfaces.

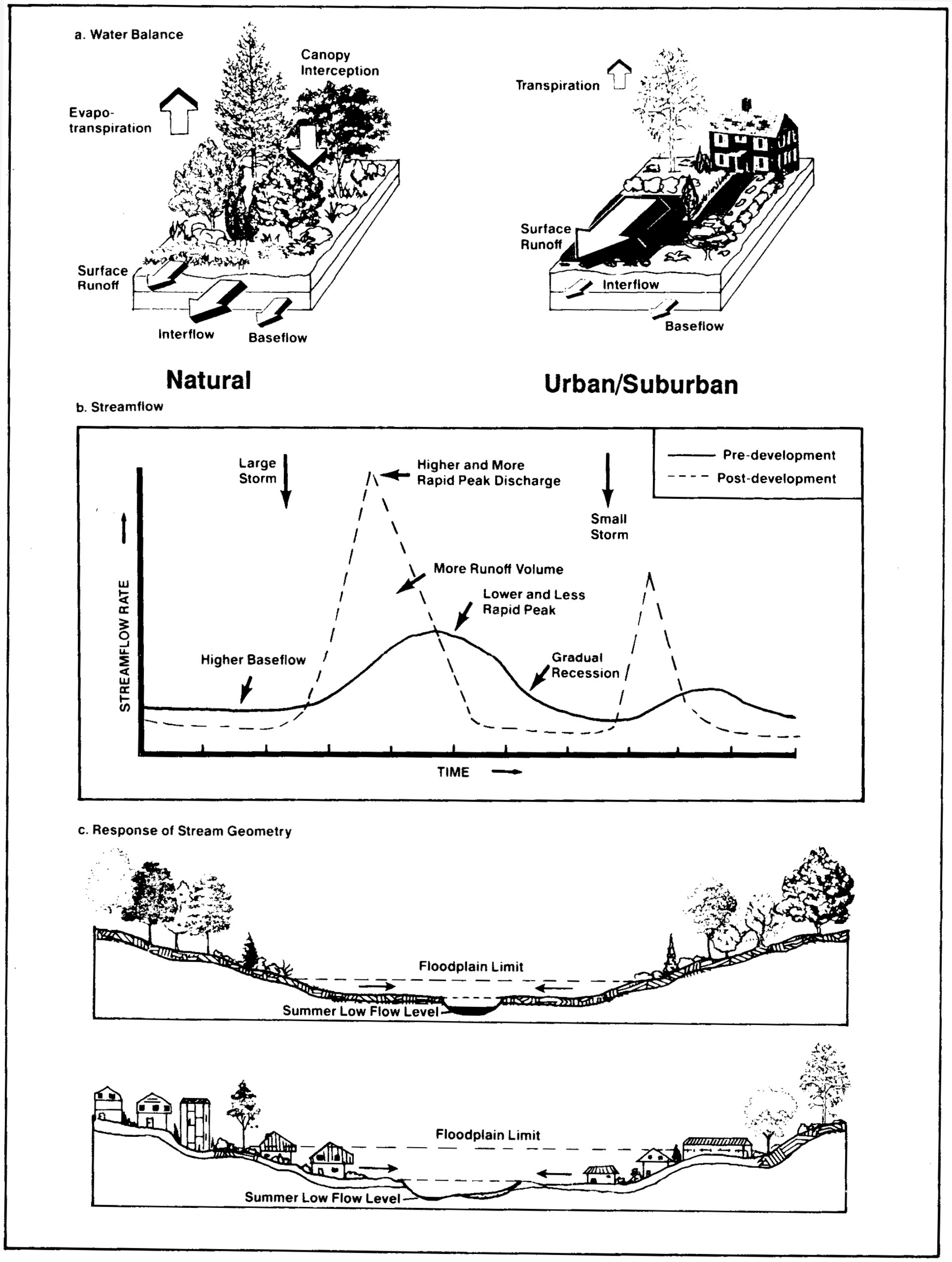


Figure 1.—Changes in watershed hydrology as a result of urbanization. ***Source: Metropolitan Washington Council of Governments, 1987.***

Figure 2- Hydrograph
(MWCG, 1987 in Schulman and Johnson, 1994:5)

Stream channels change to accommodate the newly created hydrological regime by incising and/or widening. The altered hydrological regime often results in stream bank habitat destruction and property loss. In densely urbanized areas and where real estate values are high, loss of property to a stream is rarely acceptable. The result has been the use of hard in-stream structures that often utilize steel and/or concrete to stabilize creek banks. Such structures not only replace vital streamside vegetation, but because of their often smooth and hard surfaces can also increase water velocities thereby increasing the water's kinetic energy, which can cause secondary erosional effects downstream (Collins, 1998:30).

Another significant source of problems to Mill Valley's stream habitat is non-point-source (NPS) pollution. Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water (USEPA, 1994c). Figure 3 shows some NPS pollution and some point-source pollution sources (although Mill Valley does not have any industrial dischargers, the watershed does have a wastewater treatment plant discharging into Richardson Bay). Many NPS pollution sources are not easily nor readily identified because they are often small and diffused

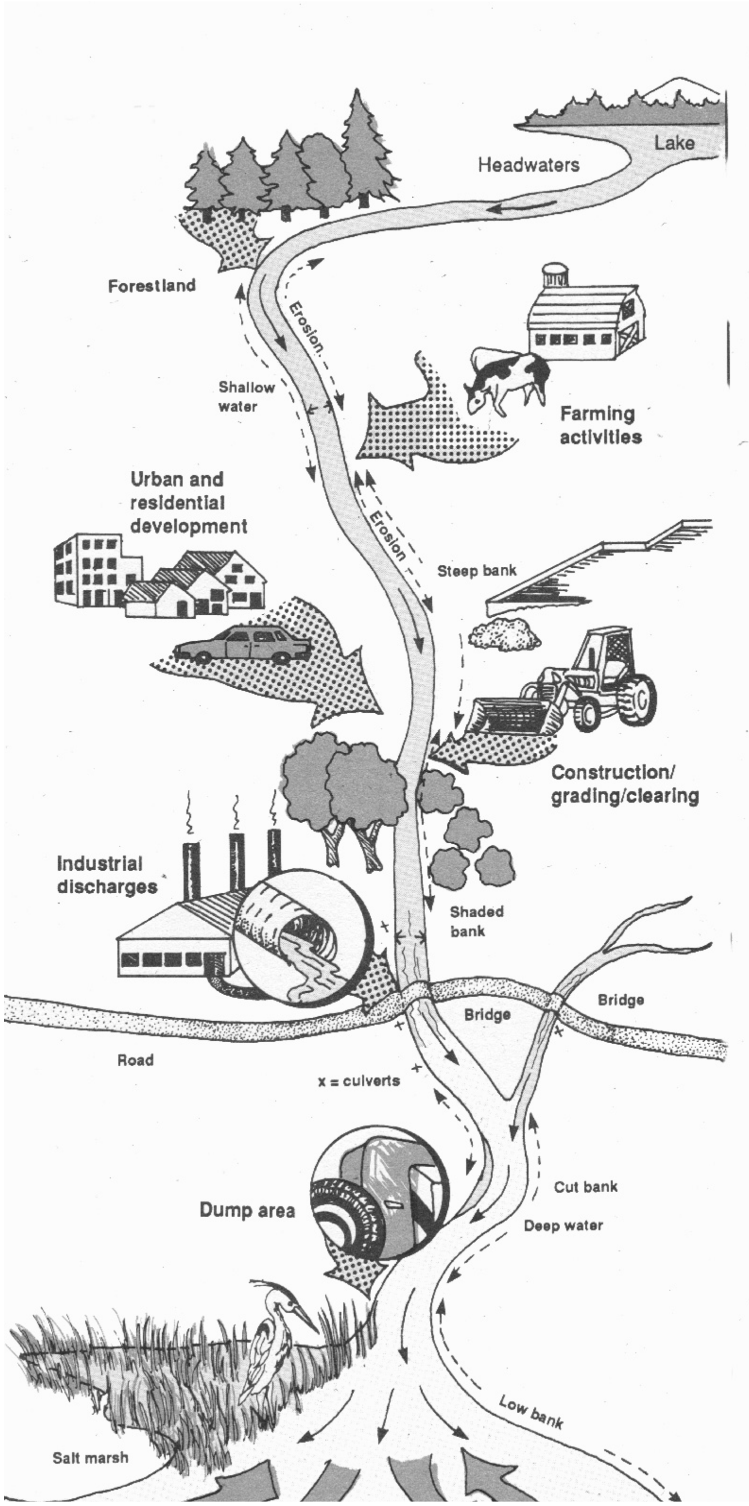


Figure 3 -Point and Non-point Pollution Sources
(From Michaud and Noel, 1991:38)

through out the watershed. The NPS pollutants of concern in Mill Valley include (Resource Conservation District of the Santa Monica Mountains, 1999):

- Oil, gasoline and grease from cars and trucks, copper from automotive brake pads and other heavy metals from tires, etc., flowing into streams from streets, parking lots and driveways
- Illegal or inadvertent dumping of paint, oil and solvents directly into creeks, or into gutters and stormdrain catchments (which flow *directly* into streams, bays or oceans)
- Leaking sewer lines
- Runoff from gardens or agricultural areas using fertilizers, pesticides and herbicides
- Nutrients and biological contaminants from corralled animals (manure and other animal wastes, etc.)
- Silt and sediment from unstable slopes or construction and grading activities

Another adverse impact to streams from urbanization is the removal of vegetation from riparian areas. Streamside vegetation is of particular importance because it provides a host of important ecological functions, including protection from predators, food at the base of the food chain and shade, which is vital for the survival of fish and other aquatic organisms that require cool water temperatures (Prunuske Chatham, Inc, 1997: 25).

In-stream large woody debris is another vital component of fish habitat that is lacking in Mill Valley's streams. In an effort to keep culverts and bridges from becoming clogged with fallen trees and branches, flood control agencies and creek-side residents have routinely removed such material from streams. Old trees or snags are often removed before they have the opportunity to fall and become in-stream habitat. Large woody debris provides low-flow refuge for salmonids against predators and provides resting areas during high flows. Fallen trees, their root wads and other log structures often have a significant influence on channel morphology by creating scour pools and by providing sediment retention which is important for salmonids and other in-stream fauna (Flosi and Reynolds, 1994:VII-30).

Each of these issues individually has been detrimental to habitat quality and to the health of the riparian ecosystem. This study describes and quantifies the effects of urbanization to Mill Valley's creeks through an analysis of compiled data collected during a community-based stream survey with the intention of supporting efforts of habitat protection and restoration in the future.

Thesis Question

The problems that Mill Valley's watershed faces inspired the creation of the Mill Valley Watershed Project and the subsequent survey of Mill Valley's streams. This report on that survey addresses:

1. What is the extent of habitat degradation due to urbanization in Mill Valley's major creeks?
2. Can a community group with the intention of conducting stream protection and restoration effectively protect and improve habitat quality?

The first question required that qualitative and quantitative data be collected so that Mill Valley's creeks could be adequately characterized. The second raised fundamental questions regarding communities participating in the conservation and protection of their own watershed. These include the capacity for community members to effect change through helping to create a dialogue in their community, working within the local political process and developing enough technical skills and understanding to meet their goals of watershed stewardship.

Mill Valley Watershed Project Origin

The vision behind the Mill Valley's Watershed Project's creation was to help foster a deeper understanding of the watershed and the health of streams amongst members of Mill Valley's community. The vision served as a catalyst in attracting an active and committed group of community members who could act as ambassadors between Mill Valley's beautiful natural ecology and the residents and policymakers that reside there. The Project was funded by the Center for Ecoliteracy (CFE), located in Berkeley, California.

Funds from CFE were used to hire consultants from Forest, Soil and Water, an environmental consulting firm located in Healdsburg, California and one full-time staff person. Forest, Soil and Water was responsible for the design and initial drafts of the Mill Valley Watershed Project Stream Survey Manual (Roques, 1997a) used to collect data for this thesis. Dominic Roques (the primary consultant for the MVWP) and I completed later drafts that included changes to protocol methods and procedures.

The initial steps in realizing the MVWP vision included convening a series of community meetings to hear from and educate the community about issues concerning the watershed. The subsequent steps included preliminary planning, development of a data collection protocol, and a volunteer survey (Appendix 2) of the watershed's stream and stream zone.

The primary purpose of the survey was to collect baseline information on the conditions of Mill Valley's streams and to pinpoint areas most in need of restoration or protection (Roques, 1997a). The survey was also a component of the Mill Valley Watershed Project's expressed broader goal of building long-term community support for restoring the ecological function of the streams in the communities of Mill Valley. This included involving the community in the process of selecting, designing and implementing projects that increase community stewardship (Roques, 1997a).

The primary purpose of the survey was met along with the broader goals of the Mill Valley Watershed Project. Baseline information was collected and analyzed, which is the topic of this paper. The broader goals were achieved beginning with early community meetings, which formed the foundation of what is now a thriving watershed group. Early meetings, along with the actual stream survey, allowed for more intensive community training classes and various watershed walks. The goal of building long-term community-based support for the watershed was realized in 1999 when Nancy Dempster, one of the original volunteers for the Mill Valley Watershed Project, along with a committed group of community members, formed a new organization, the Mill Valley StreamKeepers (MVSK), which continues to be very active on many fronts in the watershed today.

Specific goals of the Mill Valley Watershed Project included (Roques, 1997a:2):

- Increasing community awareness and knowledge of the Mill Valley watershed as an ecological system whose vitality, stability and productivity is, to a great extent, a function of peoples' actions in the watershed

- Involve the community in the process of selecting, designing, and implementing projects that produce data, increase community stewardship and improve conditions for the steelhead fishery

Many goals were met in initial meetings by involving scores of community members in community meetings, various talks and training classes. Early meetings of the MVWP gave community members an opportunity to express both their concerns and their love of their watershed. It also allowed them to express what they regarded as the highest priority actions that should be taken. Some of the more general goals have been achieved or are on-going.

There was particular interest by all parties (CFE, Forest, Soil and Water and members of the community) in ensuring that collected data would help identify factors that were limiting steelhead populations and general stream habitat quality. Despite easily observable urban effects in stream zones (channelization, erosion, discharge pipes, degraded stream channel vegetation), much of the data collected during the MVWP survey had never before been collected systematically in Mill Valley's streams. Volunteers and I collected quantitative and qualitative habitat data that I have subsequently evaluated for preliminary reports and for this thesis. I also briefly evaluated the effectiveness of collecting data using volunteers and the effectiveness of this grass-roots, community-based watershed organization in meeting project goals.

Research Area Profile Detail

The geographic focus of this thesis is exclusively on the portion of Mill Valley that is within the city limits of Mill Valley (as opposed to the adjacent Tam Valley, whose residents hold Mill Valley addresses but are actually under Marin County's jurisdiction). Research for this thesis is focused on Mill Valley's Arroyo Corte Madera del Presidio watershed, which drains approximately 6 square miles southeastward to Richardson Bay.

Steep coastal ridges, many of which have been preserved as open space, separate neighboring Mill Valley communities. These ridges afford protection from development to the headwaters of Mill Valley's streams. Mill Valley's hills and valleys, however, support numerous single-family residential neighborhoods with commercial and more intensive residential uses clustered on the flat lowlands. In the year 2000 census there were 6,286 total housing units with an average household size of 2.2 and a total population of 13,000 (Mill Valley General Plan Steering Committee, 1990).

The main transportation corridor through Mill Valley is Highway 101, a segment of which runs adjacent to the entire eastern edge of Mill Valley. Because it lies east of the region where Arroyo Corte Madera meets Richardson Bay, it has little influence on Mill Valley's streams. Adjacent to Highway 101 and around Richardson Bay in the lower watershed, fragments of bay-front lands have been left undeveloped. These provide important wetland habitat as well as unobstructed visual beauty and recreational access to the margins of Richardson Bay.

Figure 4 shows the greater Mill Valley Watershed along with its subwatershed boundaries and survey plot locations. The subwatersheds of Arroyo Corte Madera del Presidio and Old Mill Creek are shown in the upper left portion of the map. The basin contains four sub-basins: Warner Creek, Reed Creek, Arroyo Corte Madera del Presidio Basin and Old Mill/Cascade Creek. Green Info Network developed this map with funding from the Marin County Stormwater Pollution Prevention Program (MCSTOPPP) in an effort to help the Mill Valley StreamKeepers with their stewardship efforts.

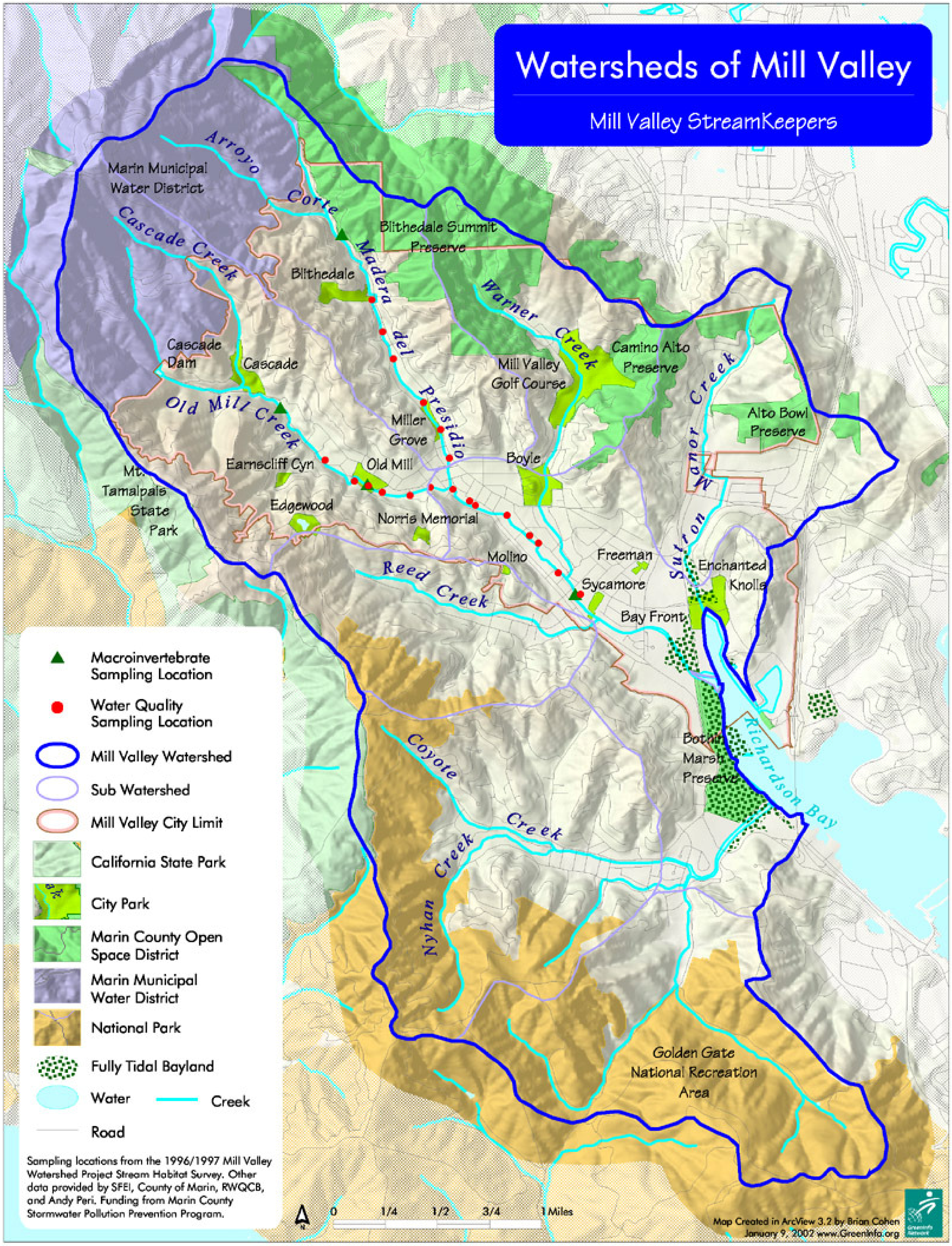


Figure 4- Watershed Boundary and Survey Plot Locations

Geographic Extent

Mill Valley Watershed Project's area of focus was the Arroyo Corte Madera del Presidio (henceforth Arroyo Corte Madera) watershed. Arroyo Corte Madera's primary tributaries include Cascade Creek, Old Mill Creek, Warner Creek and Reed Creek. Because of limited resources, the survey focused on the main stem of Arroyo Corte Madera creek and its largest tributary, Old Mill Creek. Figure 5 (Roques, 1997b) shows the Mill Valley Watershed Project boundaries. The study area is labeled as the Mill Valley Watershed on the map.

The first survey plot was determined based upon the desire to find the most downstream region that had no saltwater mixing. A small dam installed by the United States Geological Survey as part of a stream gauging station was chosen as the downstream datum of the stream survey; twenty survey plots were selected and surveyed along a linear transect upstream from this datum. Figure 10 indicates the locations where detailed survey data were collected. The limitation that 20 sites would be surveyed dictated the upstream extent of the survey. The table in Figure 6 identifies survey plots by name, survey date and the site location (to the nearest bridge or other feature).

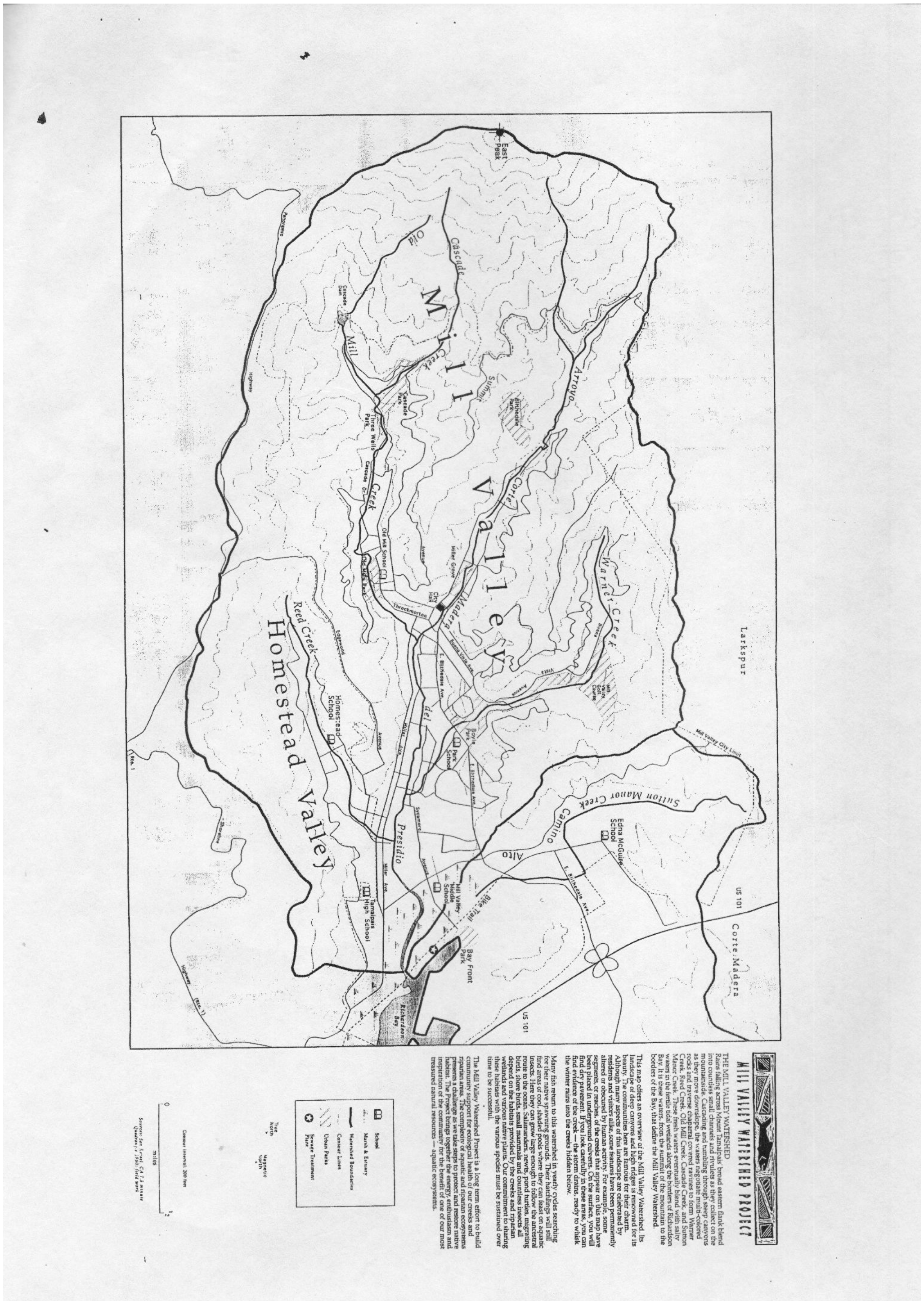


Figure 5- Mill Valley Watershed Project Watershed Boundary
(Roques, 1997b: Mill Valley Watershed Project Map)

Stream Section/Plot	Survey Date	Location of Downstream End of Survey Plot
Arroyo 2A	07/03/1996	100 feet upstream of bridge near Marin Theatre Company
Arroyo 2B	07/11/1996	196 feet upstream of Locust Ave. bridge
Arroyo 2C	07/24/1996	1196 feet upstream of Locust Ave. bridge
Arroyo 3A	08/07/1996	192 feet downstream of downstream end of Park St. bridge
Arroyo 3B	10/03/1996	568 feet upstream of upstream end of Park St. bridge
Arroyo 3C	10/25/1996	68 feet upstream of Mill Valley Lumber Company bridge
Arroyo 4A	08/23/1996	250 feet upstream of Mill Valley Lumber Co. Bridge
Arroyo 4B	09/05/1996	110 feet downstream of Old Mill & Arroyo Corte Madera confluence
Arroyo 4C	10/04/1996	273 feet upstream of upstream end of Arroyo C.M. culvert
Arroyo 5A	10/14/1996	740 feet downstream of Eldridge Street bridge (near Hillside Ave.)
Arroyo 5B	10/14/1996	43 feet upstream of Eldridge Street bridge
Arroyo 6A	08/01/1996	266 feet downstream of King Street bridge
Arroyo 6B	10/19/1996	224 feet downstream of Corte Madera Ave. bridge
Arroyo 6C	11/10/1996	100 feet downstream of West Blythedale at Blythedale Park
Old Mill 1-2A	09/27/1996	100 feet upstream of upstream-most end of large downtown culvert
Old Mill 1-2B	10/24/1996	75 feet upstream of Ethel bridge center
Old Mill 1-2C	11/07/1996	329 feet downstream of Cascade Ave. bridge (in lower Old Mill Park)
Old Mill 3A	11/13/1996	150 feet upstream of Old Mill Park Cascade Ave. bridge
Old Mill 3B	12/04/1996	3 feet upstream of Cascade Ave. bridge (near Laurel St.)
Old Mill 3C	03/20/1997	59 feet upstream of Cascade Ave. bridge (just upstream of private bridge)

Figure 6- Stream Survey Site Locations

Review of the Literature

Stream and watershed assessment is a broad area of study that draws upon many highly technical disciplines, including botany, geomorphology, geology, soils science, entomology, ichthyology, hydrology, cartography, geographic information systems and other related specialized disciplines. This review focuses primarily on the literature concerned with volunteer-based assessment and does not attempt to cover the literature of all of the above-related disciplines individually.

Regarding stream assessment, characterization, inventories and monitoring, an important distinction should be made between methods that are practical enough to be used by volunteers and ones that are used by professionals working in the field. Volunteer assessment protocols need to be simple enough to be taught in a few training sessions and in a relatively short amount of time (three to six hours), so that inexperienced members of the volunteer team are able to collect useful and reliable data. For most of the protocols used in the Mill Valley Watershed Project survey, there are analogous protocols far more rigorous and complex that are geared for professionals/scientists. The literature discussed below reflects these distinctions.

Despite volunteer protocols being less rigorous, there is a high potential for volunteers to collect important and useful data from their watersheds.

Volunteer protocols can produce vitally important data for comprehensive watershed assessment. Volunteer protocols exist for data collection in various fields of plant and animal biology, hydrology, geography and geomorphology.

There has been a great breadth of data collection done in streams nationwide by volunteers due in part to the development of volunteer protocols. One excellent example is a set of protocols developed by graduate students working in Contra Costa County north east of San Francisco. Protocols were developed that utilized global positioning system (GPS) equipment for the collection of many differing kinds of in-stream data, including bridges, outfalls, debris jams, dams, drop structures, invasive plants, vegetation and channel bank composition (Contra Costa Watershed Forum: 2001). Because this effort included the use of GPS technology and the development of detailed data dictionaries, the data could easily be transferred to a GIS system, eliminating the need for manually inputting field data.

Protocols components contained within *Streamwalk- A Stream Monitoring Tool for Citizens* (United States Environmental Protection Agency, 1994b) are simple and observation-based and fulfill the project criteria expressed above. This project used a modified version of the *Streamwalk* protocol. Modifications included the addition of several more quantitative elements, thereby making our protocol somewhat more rigorous than the original.

The California Stream Bioassessment Procedure, a macroinvertebrate biological sampling protocol, contains a stream assessment component that is suitable for use by volunteers (California Department Of Fish And Game, 2002). Although this protocol is becoming more and more commonly used as the CSBP grows in popularity, this stream assessment component is weak in its conception. It combines several differing stream qualities and asks the surveyor to score a variety of differing qualities, in some cases on the same scale. The protocol also is very reductionist in that, in the end, it gives a stream reach a single numeric habitat quality value.

Habitat assessment information for community-based watershed activities is abundant in the literature. General information about hydrology, geomorphology, land use issues, watersheds and policy can be found in a number of publications. *A Watershed Assessment Primer* (USEPA, 1994a) presents an excellent overview of the general issues related to watershed assessment. The *Oregon Watershed Manual* (Watershed Professionals Network, 1999) is another excellent comprehensive document on watershed assessment. It is an excellent reference book for those wishing to become more informed about watershed processes and watershed assessment, as a means of learning how to collect and evaluate information about a watershed and as a reference of procedures for watershed assessment. This document is not too difficult for the inexperienced community member interested in watershed assessment to comprehend but is fairly detailed, containing several hundred pages of informative information about watershed processes.

Those interested in getting involved in watershed assessment for the first time might select literature that is geared toward citizen assessment and monitoring such as *A Citizen's Streambank Restoration Handbook* (Firehock and Doherty, 1995), which presents a shorter and far more user-friendly presentation of general watershed assessment. This document focuses on basic stream processes, diagnosis of stream health and planning restoration projects. Like many Izaak Walton League publications, it is well written.

Where more extensive monitoring is of interest, *Volunteer Stream Monitoring: A Methods Manual* (USEPA,1997) is a good choice for introducing volunteers to various stream assessment/monitoring techniques including basic watershed and survey site characterization, biological sampling using benthic macroinvertebrates and water quality testing.

CHAPTER 2- SURVEY METHODS

Survey Design and Execution

Initial data needs for the MVWP survey were identified by community members and project consultants. The protocol should provide enough data to evaluate the quality of Mill Valley's stream channels and the adjacent stream zones while being practical enough (ease of use, etc.) for use by volunteers. MVWP project consultants from Forest, Soil and Water considered a number of factors in determining the data collected in protocols, including the consultant's own experience in stream assessment, the specific interests of community members living in the watershed, and the availability of appropriate protocols suitable for Mill Valley's watersheds. The U.S. Environmental Protection Agency Protocol "Streamwalk- A stream Monitoring Tool for Citizens" (USEPA, 1994b) was ultimately used as a template for the MVWP protocol. After a number of additions and enhancements, the Mill Valley Watershed Volunteer Stream Survey Manuel was created; the manual is included in Appendix 2 (Roques, 1997a).

Along with project consultants, I determined the survey extent and locations based upon several factors, including the data needed to assess the streams along with the organization's financial constraints. Ultimately the survey would cover seven survey reaches, each approximately 2,000 feet long, totaling 2.65 miles (4.24 km). I determined survey reaches using City of Mill Valley "Blue Book" parcel maps acquired from the City of Mill Valley Public

Works (Mill Valley Public Works: Blue Book Parcel Maps). An enlarged 11X17 parcel map for each of the seven reaches was produced. Figure 7 shows the “Blue Book” map for survey section 2 in the lower watershed.

Within each of the 2000-foot survey reaches, volunteer surveyors (myself included, in most of the surveys) established three 100-foot survey plots. The survey plots for each of the stream reaches were established using linear transects at 100-200 feet, 900-1000 feet and 1800-1900 feet from the datums that were established for each survey reach. Fifteen percent of the stream distance was surveyed using the detailed survey methods (300 feet were surveyed in each of the 2000 foot reaches). If it was not possible to survey the site because site location coincided with a closed culvert, for example, the survey team was instructed to move the survey plot upstream 100 more feet in order to ensure that data collected were representative of habitats that support ecological functions within the creek ecosystem (culvert lengths and locations were documented in the survey as well).

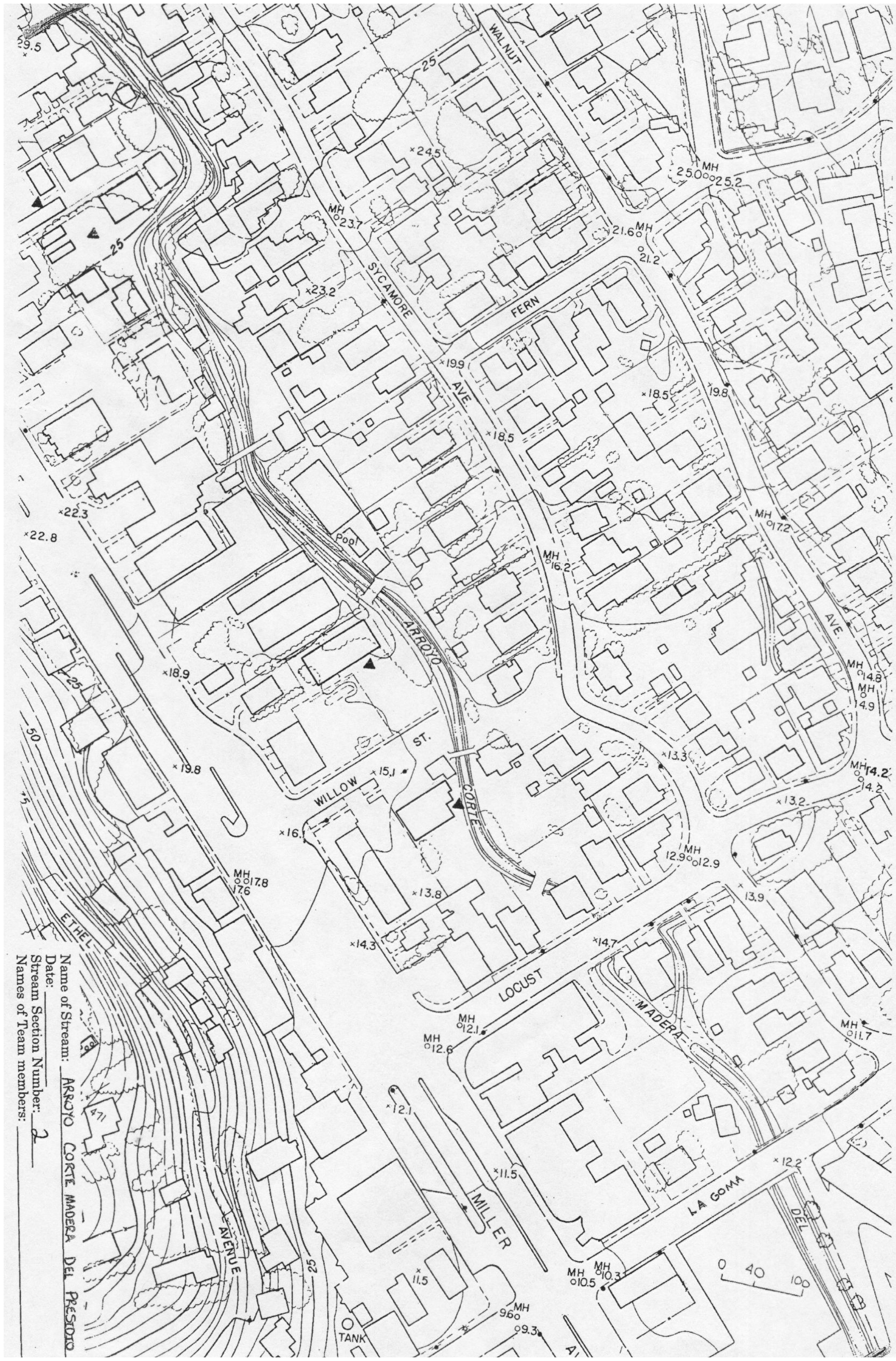


Figure 7- Survey Reach 1 of Arroyo Corte Madera del Presidio
Mill Valley Public Works "Blue Book" Parcel Maps
City of Mill Valley Public Works

Both the use of the line transect and the 100 foot adjustment instructions were established to randomize site selection and minimize volunteers selecting convenient sites which might bias the data. After each of the survey plots was established, detailed data were collected in four major categories:

- Water- The qualitative data collected for this category was limited to answering four questions about the visual quality of water and some visual aquatic biology factors.
- Stream Channel- This category contains several different measurements and estimates that include stream bankfull measurements, stream channel shape, pool size, stream substrate composition, barriers to fish migration and woody debris presence or absence.
- Stream Zone- Estimates for this category include bank condition, artificial bank protection, bank vegetation types and average width, overhanging vegetation, percent shade and adjacent land use descriptions.
- Steam Condition Summary/Impacts- This short summary section is simply a checklist of a number of common urban features that were observed.

The blank field data sheets used in this survey, along with instructions for data collection are contained within the Mill Valley Watershed Stream Survey Manual in Appendix 2 (Roques, 1997a: Survey Plot Data Sheet section).

In addition to the detailed data collected at each of the survey plots, additional data were collected within *and* between the 100-foot survey plots. As volunteers walked the stream from one plot to the next, they pulled a 100-foot tape to measure distance along the center of the stream channel, following the natural sinuosity of the stream. Beginning at the datum (the zero foot marker for the respective survey reach) volunteers also noted various stream features such as:

- Barriers to fish migration
- Dumping of yard waste or garbage
- Unique or significant vegetation (invasive, fallen trees, etc)
- Abnormal water quality conditions (sheen, discoloration, murkiness, etc.)
- Pipes of stormwater outfalls
- Failing creek banks
- Pumps or other water diversions devices
- Any fish and/or wildlife
- Erosion or in-stream sediment
- Locations of bridges

Each time a notable feature was found, volunteers logged both the location from the tape and information about the feature. A table of all such data is included in Appendix 3. Volunteer surveyors were trained to note and document the following stream features along all of their assigned 2000 foot reach (Roques, 1997a: Survey Observation Sheet):

The volunteer surveyors that worked on this project contributed a great deal of energy and time to collecting data. Forest, Soil and Water consultants trained volunteers during one formal classroom session and two formal field sessions. Subsequently, they were trained and supported by me as the staff coordinator for the Mill Valley Watershed Project. I participated in nearly all of the stream surveys and provided ongoing support and training to volunteer surveyors throughout the data collection period.

CHAPTER 3- DATA HANDLING, MANAGEMENT AND ANALYSIS

Data Analysis Introduction

I began the data analysis by selecting data requiring further, in-depth analysis. Some of the data collected indicated that, for example, a condition was ubiquitous throughout the system (clear water conditions), and therefore required no further analysis. Below are descriptions, graphs and data tables that highlight the findings from volunteer-collected data.

Stream Channel/Bank Shape

The stream channel/bank shape data indicate the shape and composition of a cross sectional profile of the stream channel. The channel and bank shape parameter provides information about stream habitat quality and helps provide some information about the stream's past, especially with regard to human-made changes of the channel. These include the presence or absence of structures such as concrete or riprap or channel cross-section reconfiguration. Figure 8 shows the five categories from which volunteers had to choose (From Roques, 1997a: Survey Plot Data sheet section).

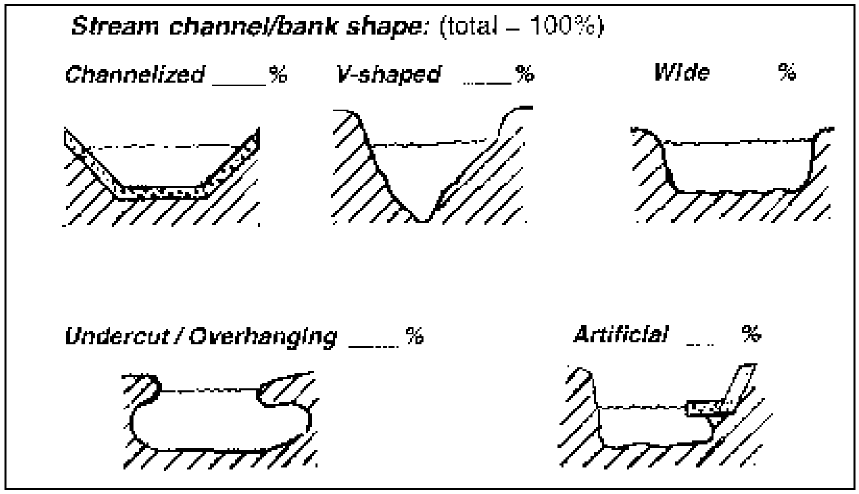


Figure 8- Stream Channel/Bank Shape (from Roques, 1997a)

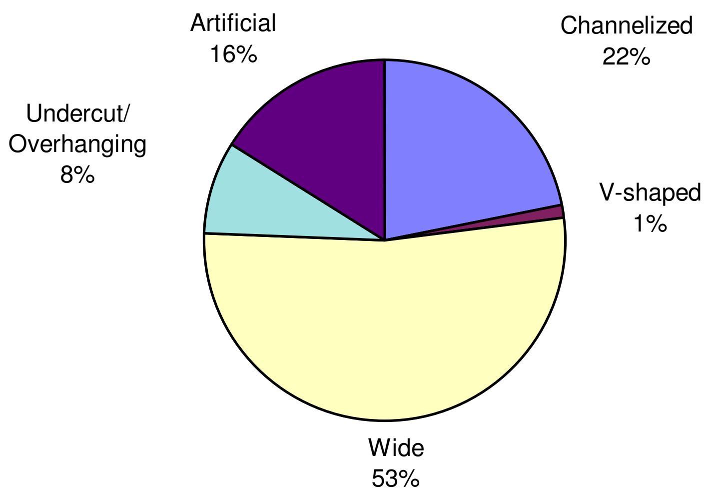


Figure 9- Stream Channel Shapes Distribution

Figure 9, derived from collected data, indicates the distribution of channel shapes from survey plots. Channels classified as “wide” (53%), often coincided with higher quality habitat features such as riffles, runs and deep pools, although some of the areas characterized as wide have been altered by channel straightening and/or vegetation removal. Survey plot Arroyo 2A, in the vicinity of Marin Theater Company, was correctly classified as wide based upon volunteer training instructions, but upon further examination the site should probably have been classified as channelized. The stream reach has a uniform trapezoidal cross-section and is unnaturally straight. The reach lacks both the pool/riffle/run sequences and the sinuosity (wavelength to width ratio of 10 to 14 widths per wavelength) that would be expected in a natural system (Leopold, 1994: 58).

The 8% classified as “undercut/overhanging” contains some of the best habitat; these areas exists most frequently where there are pools. Undercut banks provide refuge for fish from predators and from high stream flows- very important considering the fact that there is a near-absence of woody debris in the system, which would otherwise provide such refuge.

The 16% classified as artificial and the 22% classified as channelized (Figure 9) indicate the lowest quality habitat. Both of these channel types lack low-lying streamside vegetation and associated functions provided by such vegetation. Concrete stream beds produce high water velocities that can, depending on their length, act as a barriers (or inhibitors) to fish migration, whereas naturally occurring in-stream structures such as rocks, woody debris and root wads provide eddies and pools that can be used for resting places during high flows and as refuge from predators. Also, concrete stream channels can produce higher than natural water temperatures during warmer summer months that coincide with lower flows, the combination of which can be lethal to temperature-sensitive fish and other aquatic organisms.

Ironically, some of Mill Valley's stream habitat classified as "artificial" contained beneficial habitat. Many concrete walls, footings and concrete-covered streambeds damaged by age, downcutting and hydraulic wear have been undermined, resulting in the formation of undercut areas. These undercut features, some reaching under the banks several feet horizontally, provide excellent refuge for fish.

Finally, v-shaped channels, typical of steeper sloped stream reaches, were only present on 1% of the survey plots, due mainly to the fact that the survey was conducted in the lower to middle ranges of the stream network. V-shaped channels are more typical of steeper upstream reaches.

Figure 10 shows the locations of dominant channel/bank shapes for each of the survey plots. Many of the survey plots were classified as having two or more channel shapes. The features that are mapped represent the channel type that dominates the survey plot (other channel shapes may or may not exist within these survey plots). Arroyo 4b is unique in that it had two channel types in equal parts that are dominant, so the map indicates that it is "Wide/Artificial".

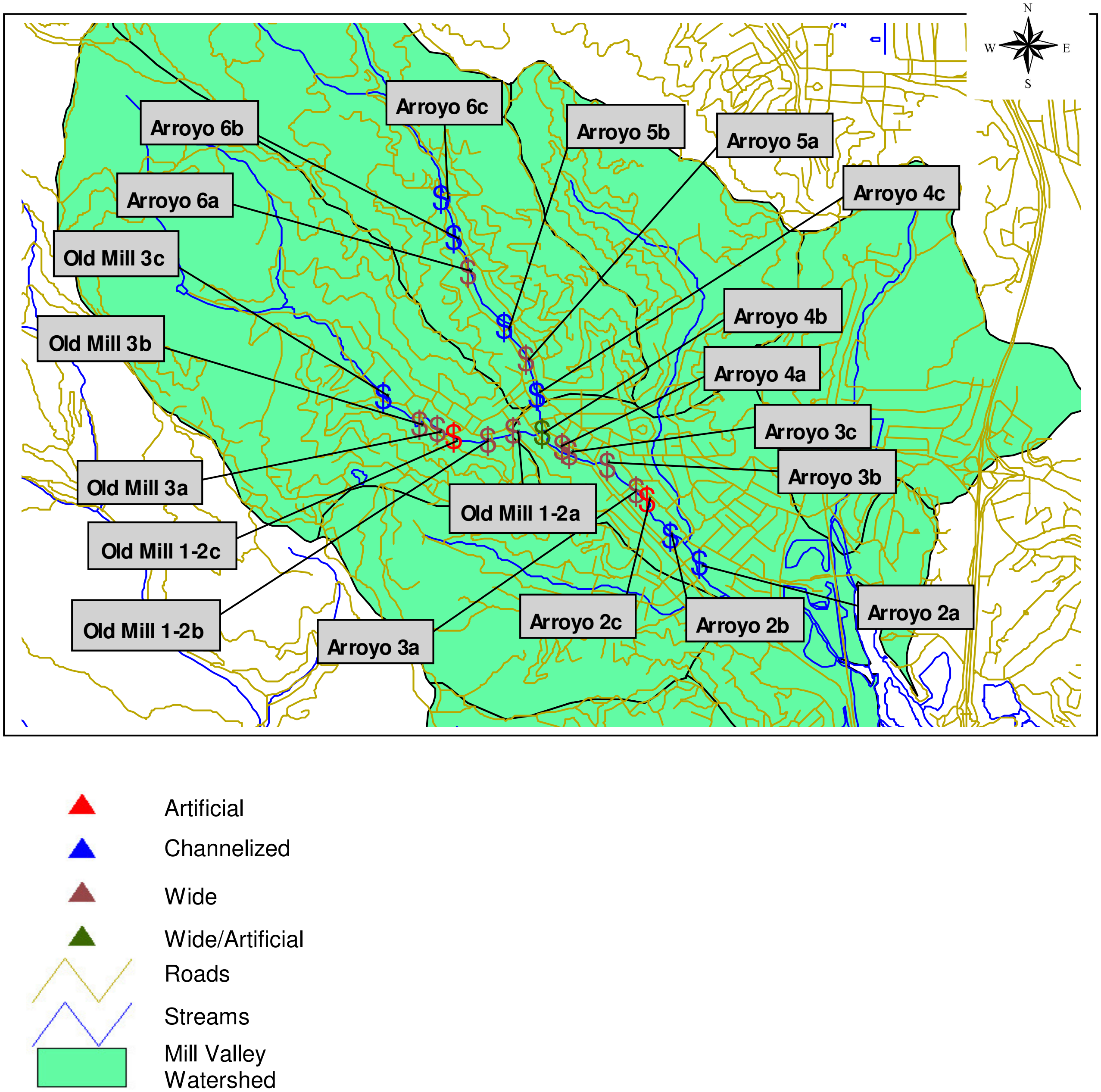


Figure 10- Dominant Stream Channel/Bank Profiles

Artificial Bank Protection

The percentage of artificial bank protection is considerable in Mill Valley's streams. Surveyors estimated the total percentage of concrete bags, walls, bridge abutments, flashboards, culverts, foundations, riprap and wood structures that have replaced natural stream banks and their functions. On the average, 41% of the stream banks were artificially protected with wood, or some form of concrete. This value is within a few percentage points of the value expressed above in the “stream channel shape” above, which was assessed in a separate part of the survey. The sum of the two channel types, “Channelized” and “Artificial” (see Figure 9) equal 38%.

The longest continuous reach of channelization in Mill Valley is in the vicinity of Mill Valley Lumber Company. This reach has over 450 feet of tall concrete walls that confine the stream channel. The channel contains very large boulders of concrete, some several feet across, and is spanned by several buildings that create areas that are dark with no vegetation. This reach of the creek extends from Millwood road to a point just upstream of the Mill Valley Lumber Company’s trans-channel buildings. Despite the major human impacts to this reach, the streambed itself does provide some good pool and refuge habitat for fish.

Other large channelized areas include the reach just upstream from the confluence of Arroyo de Corte Madera and Old Mill creeks on Arroyo Corte Madera del Presidio and a number of smaller bank revetment projects, which were built on what are now individual or small groups of parcels. While these smaller projects destroy some habitat functions, they are preferable to large scale, US Army Corps of Engineers-type channelization projects that frequently leave little if any riparian habitat in place to provide beneficial ecological functions.

Although bank protection efforts often meet their intended engineering goal of bank stabilization, they often have detrimental consequences to adjacent banks. Structures can produce eddies that erode banks in both the upstream and downstream vicinities. Hard bank stabilizing materials such as concrete and riprap can act as reflectors of fast moving water thereby causing erosion on the opposite downstream bank of the stream. Also, smooth flat surfaces offer less friction to water flows, resulting in increased velocities. Increased velocities result in water flows containing higher kinetic energy and the capacity for the water to do more work, namely eroding banks downstream. The use of such technologies can result in additional stream bank damage, which in turn creates a propagation of hard structures for property protection by homeowners. Such structures cumulatively result in significant habitat destruction of stream banks and habitats (Bay Area Action, 1993)

There are a number of so-called biotechnical bank stabilization technologies available that actually enhance wildlife habitat, while shoring up eroding banks and minimizing adverse downstream effects. Biotechnical methods accomplish this by utilizing living structures in some cases such as willow walls and willow revetments or by designing structures that can accommodate vegetation in their design (Flosi and Reynolds, 1994: VII-76). These methods are, from a biological perspective, much more beneficial to the stream system. It is these types of technologies that should be utilized where possible for future stream bank restoration projects in Mill Valley streams by landowners and government agencies conducting or permitting such work.

Bank Condition/Bank Vegetation

Several sections of the stream survey protocol required stream bank data to be collected. Stream bank vegetation is of fundamental importance to the health of a stream from both a biological and geomorphic perspective. Functions of vegetated stream banks include (Watershed Professional Network, 1999:22):

- Holding soil in place with roots and reducing/preventing erosion
- Filtering overland water flows which removes nutrients and traps sediment and pollutants that would otherwise be deposited into the stream.
- Providing shade that keeps streams cool; a necessity for steelhead and other temperature sensitive species
- Creating a damper for noises such as traffic that can disturb wildlife
- Providing food in the form of detrital material and insects for both terrestrial and aquatic organisms including fish

- Dissipating the energy of flood or high waters thereby reducing erosion

The quantity and width of stream bank vegetation varies dramatically throughout Mill Valley's streams. Riparian vegetation is most often degraded or eliminated near buildings, roads and parking lots although 71% of the banks are vegetated to some extent (Figure 11). Of the non-vegetated banks, 22% were characterized as "artificially unvegetated", which indicates that current and/or past human-made structures are responsible for the absence of vegetation. Such structures include trails, roads, residential landscaping and riprap banks or concrete retaining walls. The remaining 7% includes areas where vegetation is absent or nearly absent due to erosion or other natural disturbances.

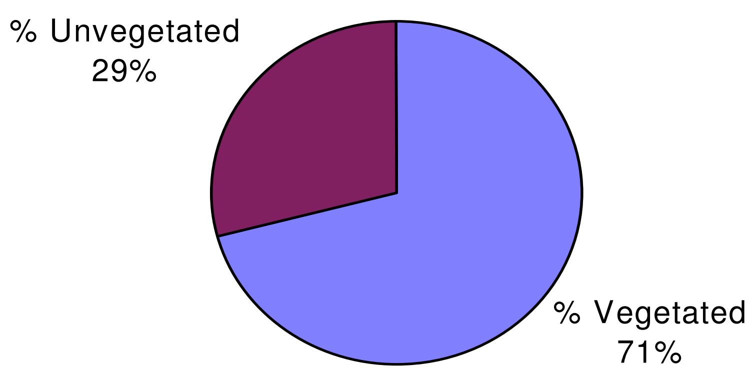


Figure 11- Overall Stream Bank Vegetation

Although tall vegetation (>6 feet) covers bankfull area in 60% of the survey plots, shorter vegetation (< 6 feet) was virtually absent over the bankfull area. This low-lying vegetation provides important habitat for aquatic organism by providing cover during medium to high flows for fish and providing detrital material and encouraging the presence of insects, both of which are important aquatic organism food sources.

Thirty percent of the survey sites had some areas that were actively contributing sediment to the stream (Arroyo sites 2C, 3C, 4B, 5A, 6A, Old Mill sites 3A and 3B). These sites need to be more fully characterized and monitored to determine if their contribution of sediment is significantly degrading local in-stream habitat in the vicinity by smothering gravel areas that could be potential spawning sites for steelhead; also, these sites may be good candidates for restoration projects.

Width of Vegetation

This variable estimates the average width in feet of continuous vegetation (of all sizes and types) from the stream channel to the outer reaches of the stream riparian zone. The intention for this parameter's measurement was primarily to determine the vegetation's capacity to act as a buffer and filter for overland flow of urban runoff.

Width estimates included a wide range of vegetation from low-lying ground cover to large redwood trees; vegetation width was measured regardless of whether or not it was native. The width varied from as little as one foot to greater than 150 feet.

In areas dominated by redwoods but having little understory vegetation (such as in Old Mill Park), the vegetation was estimated to include all the redwood tree-covered area because although there is not a lot of understory vegetation to filter overland flows, the floor of the redwood groves is rich in detrital material that serves this same function. Vegetation width estimates were made for both the left and right banks, looking upstream (Figure 12).

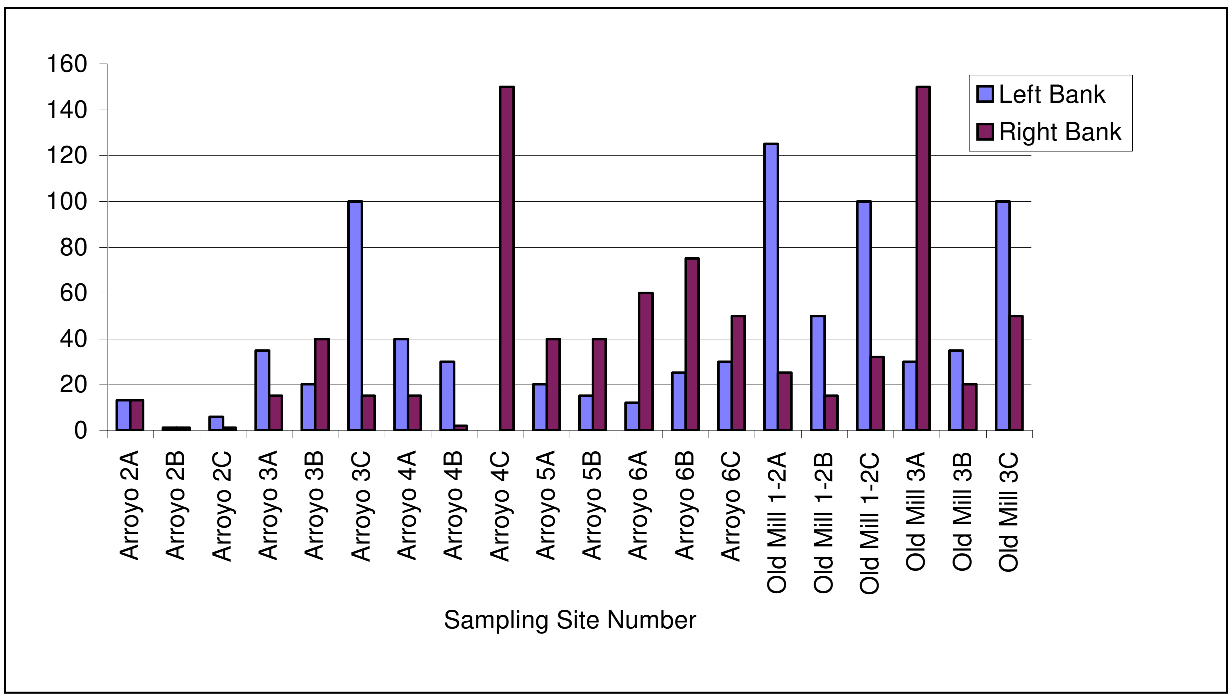


Figure 12- Average Width of Streamside Vegetation in Feet

Percent Shade

Another indirect measure of vegetation estimated was percent shade in the stream region. Shade is a crucial factor in maintaining cool temperatures in stream pools. Without adequate shade, especially during summer months, pools temperatures can increase to levels lethal to fish and other temperature-sensitive aquatic organisms. Shade was estimated as “percent shade” between 10 am to 3 pm from four possible categories, 0-25% shade, 25-50% shade and 50-75% and 75-100%. Figure 13 shows overall percentages of shade estimates.

Most of the upper portions of the watershed are densely forested with California laurel and redwood trees, which provide considerable shade for the stream. In the lower portion of the watershed, many tall trees have been removed over the years in the process of residential and commercial development as well for the construction of roads and, in some cases, for aesthetic reasons, for example, to enhance views and increase sunlight. The table in Figure 14 shows the percent shade categories for each survey site.

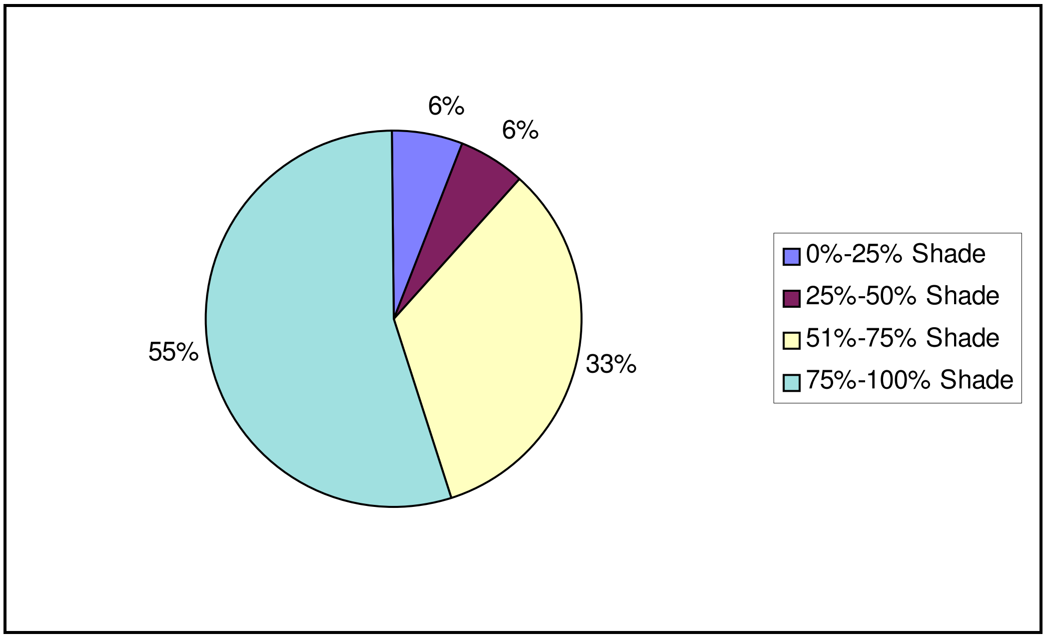


Figure 13- Percent Shade for Mill Valley Creeks

Survey Section/ Plot	Percent Shade
Arroyo 2A	0-25
Arroyo 2B	50-75
Arroyo 2C	25-50
Arroyo 3A	75-100
Arroyo 3B	0-25
Arroyo 3C	75-100
Arroyo 4A	50-75
Arroyo 4B	75-100
Arroyo 4C	75-100
Arroyo 5A	75-100
Arroyo 5B	75-100
Arroyo 6A	50-75
Arroyo 6B	75-100
Arroyo 6C	50-75
Old Mill 1-2A	75-100
Old Mill 1-2B	50-75
Old Mill 1-2C	75-100
Old Mill 3A	75-100
Old Mill 3B	50-75
Old Mill 3C	75-100

Figure 14- Percentages of Shade by Survey Plot

Vegetation Types

Vegetation types were surveyed qualitatively. Volunteers noted the presence of about a dozen different plant species along the stream zone. California coast redwood (S*equoia sempervirens*) and California laurel (*Umbellularia californica*) are the dominant vegetation types in the stream zones of the Mill Valley watershed. Redwoods are found in 80% and California laurel are found in 75% of the stream zones in Mill Valley. Native maples, oaks and various species of ferns are also common throughout the stream system as are non-native Himalayan blackberries.

The incidence of other non-natives, many of which are invasive, is high in some areas. Common invasive species include various species of acacia, English ivy (*Hedera helix)*, and a drooping sedge identified by Marin County biologists as *Carex pendula*, which grows adjacent to the water's edge in the stream channel. *Carex pendula* grows large enough to alter stream flow and has become a nuisance, especially in Old Mill Park where it has established a significant colony.

German ivy (*Senecio Mikanioides)* is also common along Mill Valley's creeks as is English ivy; these plants have a high preference for well-shaded stream bank areas and easily self-propagate. Both types of ivy are undesirable in that they displace native plants and animals. They also have shallow roots and provide little bank stability. Also frequently found in the watershed, although less common than ivy in the stream zone, are Scotch broom (*Sytisus scoparius*) and French broom (*Genista monspessulana)*.

Streambed Substrate Composition

Streambed substrate is a vitally important component of a stream system. Healthy aquatic habitat for steelhead and other native aquatic organisms requires stream substrates that contain predominately gravel and cobbles and are relatively free of fine sediments such as silts, clays and sand (Flosi and Reynolds, 1994:II-14). Steelhead redds (the "nests" into which steelhead lay their eggs) are composed primarily of gravel and cobble substrates. When steelhead redds become covered with fine sediment such as silt or clay, their eggs are deprived of water flow through the gravel and can suffocate from lack of oxygen. Gravel substrates that are free from silt and sand are also very important for various benthic macroinvertebrates that depend on clean gravels and clean water for their survival and well being; these organisms are a critical component of a stream's food web. The California Stream Bioassesment Procedure, a biological monitoring protocol that uses benthic macroinvertebrates, is being used to assess habitat quality in Mill Valley watersheds. This protocol, in addition to helping to determine if temperature and pollution are impacting stream habitat quality, can be used to determine if the stream system is being impacted by fine sediment (California Department of Fish And Game, 2002).

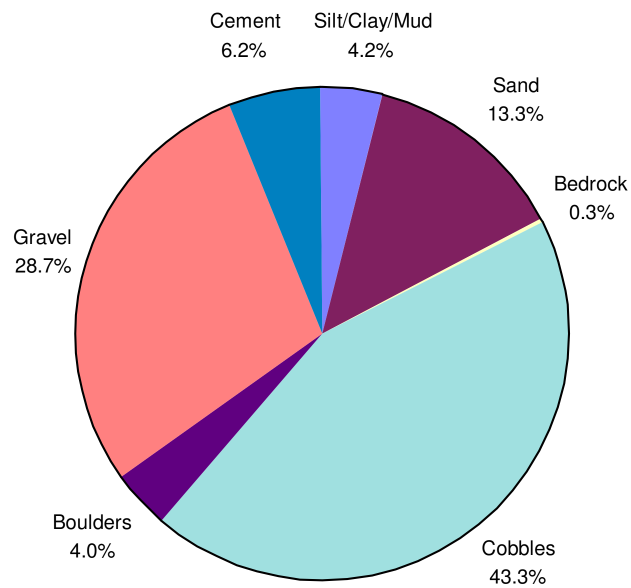


Figure 15- Overall Streambed Substrate Composition

Mill Valley's streams contain a relatively low percentage of silt/clay/mud (4.2%) while containing a high percentage of both gravel (28.7%) and cobbles (43.3%), totaling 71% of optimum stream substrates (Figure 15). The more than 6% of cement streambed in this system provides the lowest quality habitat value unless damaged as explained above; most are intact and provide little if any habitat for fish and other native organisms. Boulders occur 4% of the time. Large boulders function as agents of pool scour and create eddies in the stream both of which are beneficial for fish living or migrating in the stream. Also, boulders help oxygenate the water by causing oxygen-enriching disturbances in stream water. *Large* boulders are rare in the system, however. Figure 16 shows substrate data from each of the plots surveyed.

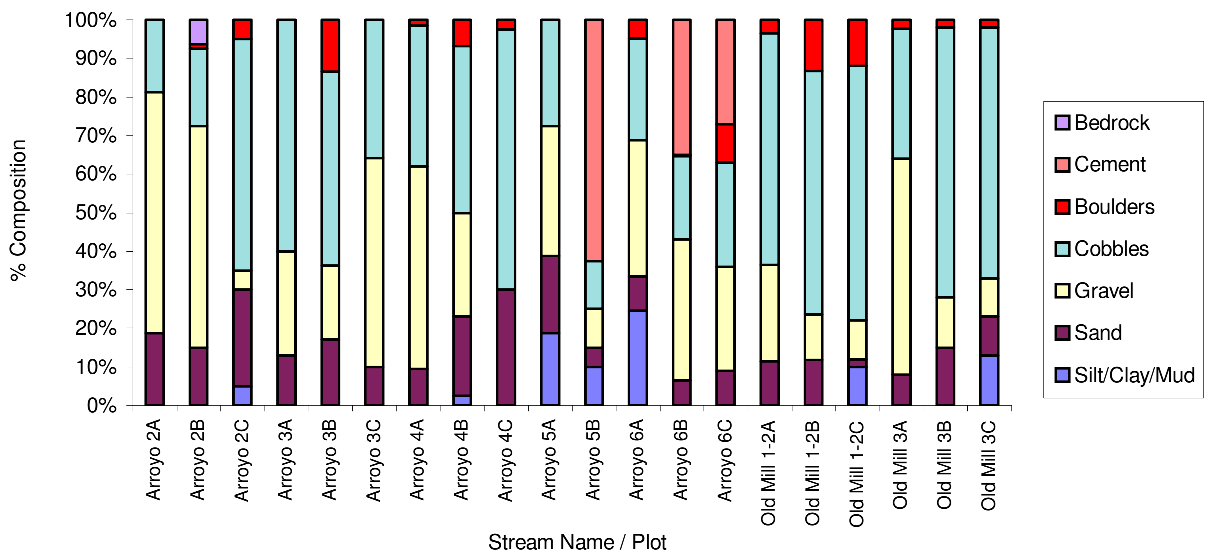


Figure 16- Stream Substrate Composition

The overall presence of silt, clay and mud was 4.2% but plots Arroyo 5A and Arroyo 6A had significantly higher levels of "silt/clay/mud" reaching 19% and 25% respectively. Silt in Mill Valley's streams is mostly in the upper reaches of the system (sites Arroyo 5A, 5B, 6A and Old Mill 3C- Figure 16). Combining the list of site data that indicates observed silt in the stream with areas that were observed to be sources of fine sediment entering the stream (unstable stream banks, etc.) produces the following list of sites: Arroyo 2C, 3C, 4B, 5A, 6A, and Old Mill 1-2C, 3A, 3B and 3C. I recommend further investigation into these sites to determine the extent of silt entering the stream and the potential for restoration if necessary.

Pools

Pools throughout the Mill Valley Watershed represent important habitat for steelhead and other native fish species. Figure 17 shows both the number of pools for each survey reach and the total length of each pool. For each respective survey site shown, the bar graph shows one, two or three pools. The average number of pools per 100-foot survey plot is 1.4. Figure 18 shows the total length of pool habitat per for each 100-foot survey plot, which averages 57%.

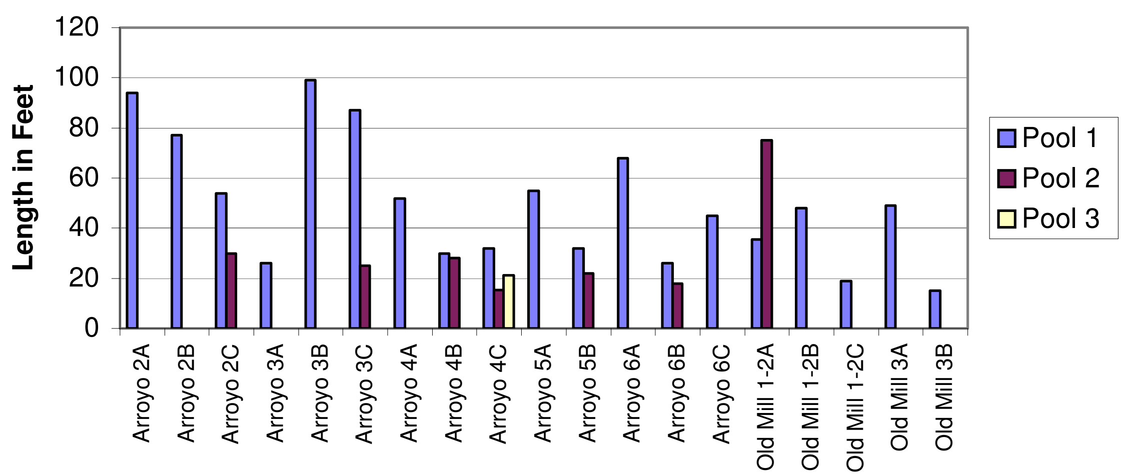


Figure 17- Individual Pool Lengths

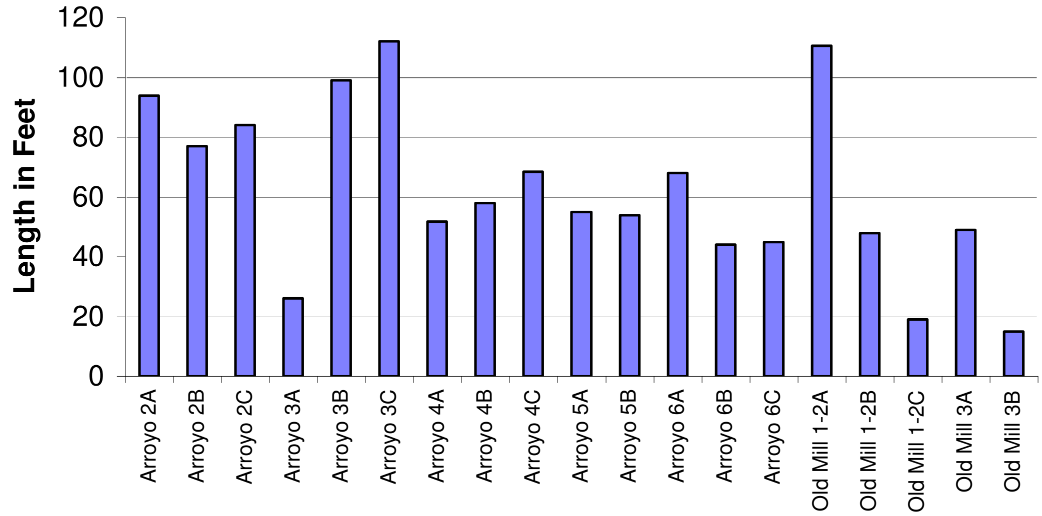


Figure 18- Total length of Pool Habitat

Some of the largest and deepest pools are found downstream of bridges and have been formed as a result of bridge designs that utilize concrete as their base in the bottom of the stream channel. Concrete streambeds do not allow down cutting to occur. Any upstream-moving head-cuts are arrested by in-stream concrete structures, which form waterfall-like features just downstream of the bridge. This construction design is common in Mill Valley and large, deep pools can be observed just downstream of many bridges, as a result.

Pool depth and corresponding pool volume demonstrate important qualities of in-stream habitat, especially for fish that utilize deeper waters for refuge against birds and other predators. Figures 19 shows pool volumes and Figure 20 shows maximum pool depth for each pool.

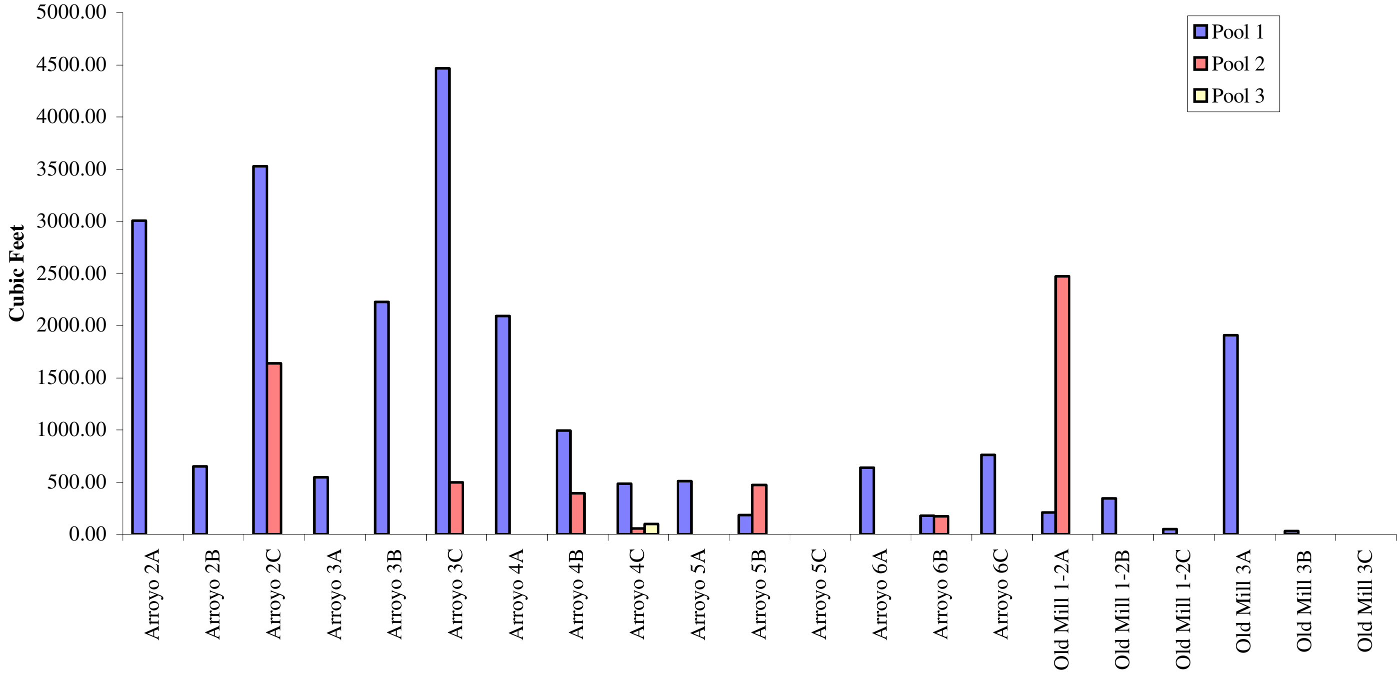


Figure 19- Pool Volumes

The larger pools tend to be in the lower reaches of the stream. Pool volumes were estimated by multiplying their maximum length, width and depth and dividing by two, making a rough estimate of pool volume by assuming pools are wedge shaped.

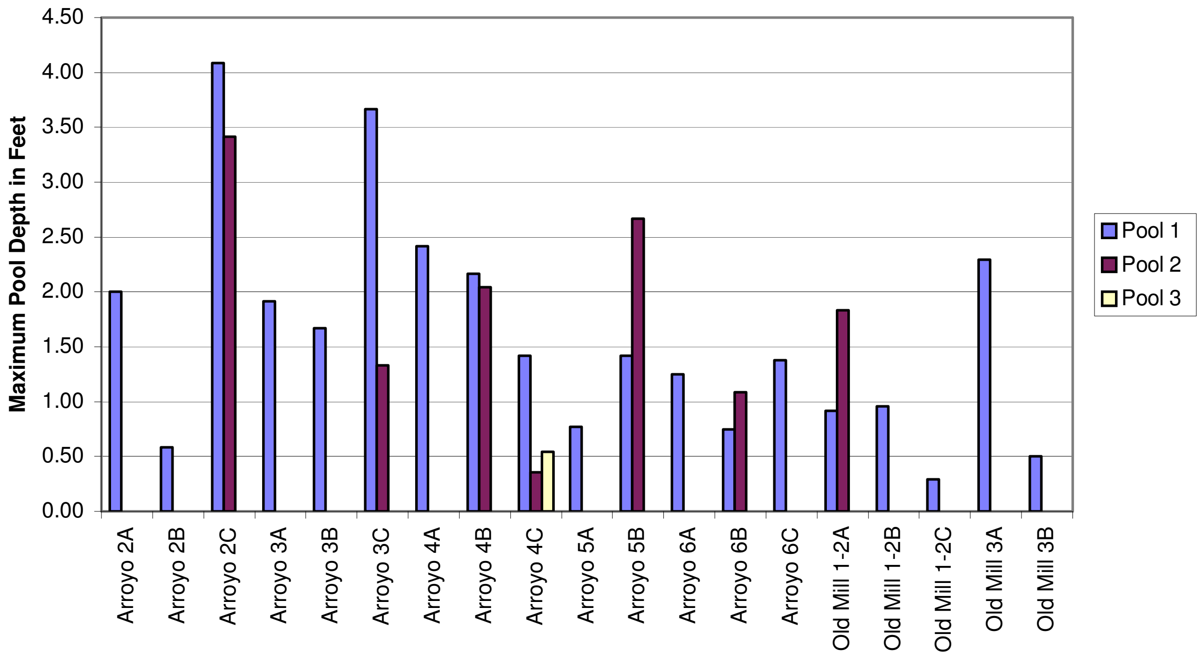


Figure 20- Maximum Pool Depth

Barriers to Fish Migration

Despite considerable alteration to the streams, there are currently no absolute barriers to fish migration in the Mill Valley survey area. All of the weirs that were part of logging operations or private swimming holes have been either disassembled or worn down by weathering and/or hydraulic forces and none have been replaced. All of the existing remnants of concrete weirs and other structures in the streams are small enough for fish to navigate easily both in the upstream and downstream direction, given adequate stream flows. There are several places within the survey area that are of concern during low flows, however.

The main culverts that convey water under the central portion of Mill Valley are constructed of 5-foot diameter cylindrical concrete pipes. Although not an outright barrier to fish passage (steelhead are commonly seen above these culverts) these types of culverts make fish passage difficult during both high and low flows. Concrete or steel culverts tend to produce high-velocity concentrated flows that lack naturally occurring in-stream structures (boulders, root wads, woody debris, etc.) that provide resting places for fish during high flows. During summer low flows there is often not enough water for fish passage through culverts.

A site that is of some concern is beneath the bridge on Cascade Drive in Old Mill Park. The apron on the upstream side of the bridge is a barrier to fish passage at low flows. This site, just downstream of survey plot Old Mill 3A (Figure 6), would be an idea site for a restoration project that would increase the ease of fish passage by constructing a fish ladder or a series of step pools to create a more gradual incline, making fish movement possible during low-flow periods.

Another site that deserves monitoring is a small dam that is installed during the summer months under a building that spans Old Mill Creek about 40 feet upstream of the culvert that connects Old Mill Creek to Arroyo Corte Madera. The residents of that building build the dam to “create habitat” for fish and to flood the location where youth congregate to socialize under their building.

The dam is constructed on wood and large sheets of plastic and presents a barrier to fish during low flow, summer periods. Additionally, the plastic sheets used in dam construction present a pollution issue if the dam is not removed prior to the first large storm of the fall/winter.

Another issue related to fish and water in the system is water diversion for landscape irrigation. Several residences along the survey area had diversion systems that ranged from small, portable submersible pumps to more elaborate permanently installed systems (Appendix 3 contains surveyor descriptions of observed systems). Systems were found:

- Just downstream of Arroyo 3A, approximately 270 feet downstream of Park Street bridge- diversion pipe entering waterway was observed.
- In the survey plot Arroyo 6B. Equipment consisted of a permanently installed, concrete mounted pump and plumbing system.
- About 425 feet upstream of the beginning of the Old Mill 1-2A survey plot- screened water diversion pipe in pool.
- Approximately 520 feet above of the beginning of the Old Mill 1-2A survey plot- a diversion system that may be defunct.
- In survey plot Old Mill 1-2B- two electric submersible pumps connected to garden hoses.

I have observed the flow of Mill Valley's streams to be very low during the driest part of the summer and fall (in some cases less than one gallon per minute surface flow). Irrigation systems are typically used during this same dry part of the season and present a significant removal of water in a system that is already impacted because of development and the presence of impervious surfaces. Residents using these systems are likely trying to reduce their water bills by irrigating with stream water. Education of streamside residents regarding this issue would be of great benefit to fish and Mill Valley's aquatic stream ecology.

Large Woody Debris

Large woody debris is very limited in Mill Valley's streams. Out of 20 survey plots representing 2000 feet of stream length, surveyors observed only 4 pieces of woody debris greater than 12 inches in diameter and ten pieces between 6 and 12 inches in diameter. This quantity of woody debris is negligible, especially for a system dominated by large trees in the upper watershed.

The lack of woody debris is a reflection of the practices employed by streamside residents and city and county flood control agencies. Fallen trees and branches are routinely removed from streams by flood control agencies to prevent the clogging of streams at bridges and culvert entrances, which can result in upstream flooding and erosion of nearby stream banks. Fallen trees and branches are also removed because they can create flow diversions within the stream channel that can cause destruction of stream banks in the vicinity. Because of the nature of urbanization and the practice of building structures and/or landscaping right up to the stream's edge, such damage is deemed unacceptable and the trees are, more often that not, removed.

Fish

Fish were visible at approximately 25% of the survey sites. Sightings were usually of small numbers of fish (less than five). Because the survey protocol was not rigorous regarding fish, and because no fish survey equipment (shockers, diving equipment, etc.) were utilized, this data only indicates an anecdotal presence of fish.

Four native species of fish are commonly found in Mill Valley's streams. Species include the three-spine stickleback (*Gasterosteus aculeatus)*, California roach *(Lavinia symmetricus)*, prickly sculpin *(Cottus asper)* and steelhead *(Oncorhynchus mykiss)*. Each of these native species was observed in Arroyo Corte Madera del Presidio in 1997 during the most recent fish surveys conducted in Mill Valley. (Leidy, 1999: LF114-LF117, LF119, LF140, LF143).

Steelhead hold a special fascination for many because they are a popular sport fish and because they are understood to be indicator species. Indicator bspecies, by definition, are sensitive to changes in their environment and like the "canary in the coal mine", are affected by subtle changes in their environment. The decline of steelhead demonstrates that the ecological system is in the process of failing in fundamental ways. The health of a steelhead fishery directly corresponds to the health of the watershed and is therefore the focal point of many watershed protection/restoration efforts in Mill Valley.

Despite the decline of Mill Valley's steelhead fishery, there is still a viable, albeit small, population of steelhead in Mill Valley's streams. Of the four species native to Mill Valley, steelhead are the most sensitive whereas, California roach, three-spine stickleback and sculpin can tolerate many of urbanization's effects, including warm temperatures and a variety of substrate types. Steelhead, for example require dissolved oxygen levels of greater than 7 mg/L for temperatures less than 15 degrees C, and 9 mg/L for temperatures greater than 15 degrees C; they prefer temperatures of less than 12 degrees C for most of their life cycle. In contrast, California roach can tolerate temperatures of 35 degrees C and dissolved oxygen level as low as 1-2 mg/L (Rich, 1995: 11). Because dissolved oxygen levels are connected with water temperature (the lower the temperature the higher the capacity for water to hold oxygen), well-shaded streams along with cool water inputs (especially during summer months) are essential for steelhead survival.

CHAPTER 4- RESULTS & DISCUSSION OF WORK

Project Limitations Overview

The Mill Valley Watershed Project Stream Survey has provided a data set that is both unique and useful as baseline data and for future stream management efforts. The survey data is not without a number of limitations and shortcomings, however. I and a group of committed, dedicated volunteers conducted this effort. Despite the fact that training classes took place, many of the volunteers learned as they conducted this survey. Some of the estimates that volunteers were asked to make were difficult and values varied significantly during discussions in the field; indeed some of the estimates sparked debates between professionals during the training classes. Below is an attempt to identify general areas of data shortcomings along with suggested remedies for future data collection efforts by volunteers.

The Mill Valley Watershed Project Stream Survey had two primary objectives. The first was to collect habitat information on the streams of Mill Valley in order to assess the factors that were limiting steelhead populations. The second objective was to foster community involvement. In many ways, these two objectives are at odds with one another.

To collect optimum habitat data in a stream system and adjacent watershed, the ideal circumstance would be to have professional biologists, hydrologists, and geomorphologists, etc., conduct a detailed survey and report on their findings. This approach would have satisfied the first objective but would not have necessarily helped develop community involvement. Also, the costs of having professionals conducting such habitat surveys would have been prohibitive under the project's funding limitations.

Regarding data quality, with the exception of one of the survey sites, no replicate data collection was conducted at survey sites. Such replicates would have provided an opportunity for developing error margins for some of the data that was collected and would have helped "calibrate" the volunteers, helping to determine data reliability and error tolerances for data. This process was not included within the study design and was therefore not incorporated in the survey. Despite the lack of replicate surveys, similar data was collected in various parts of the survey and in some cases allowed for data to be verified and, to an extent, validated. One such example of this is in question 2 in the "Stream Channel" section, which asked one similar to question 1 in the "Stream Zone" section (Appendix B- MVWP Stream Survey Manual).

Some of the original methods and survey forms given to volunteers were changed during the survey. This may have introduced additional error into the data set. One such change was the *Streambed Substrate Composition* portion of the survey. Initially, volunteers were asked to estimate the overall percent of each of six different substrate types- silt, sand, gravel, cobbles, boulders and bedrock. This task is very difficult to do, even after considerable training. After watching volunteers flounder on this task, I chose to give volunteers a new data sheet containing a table that allowed them to break the 100 foot survey site into smaller "bite-size" pieces. This allowed volunteers to take, for example, a 25% area and estimate the six substrate types, then do the same for the remaining 75% of the area (or break it up 33%, 33%, 34%, etc., see data form.). Although this method of estimating made estimating a little easier (albeit perhaps slower), it is still far too complicated. A preferable method for this particular data variable is to simply allow surveyors to select from a few ranges, e.g. 0-25%, 26-50%, etc. This would allow for more accurate estimates (it is easier to make an estimate from four categories than estimating an value between 1% and 100%).

Data for "percent shade" was collected in four broad categories, which made estimates easy as indicated in the above discussion but the instructions ask for surveyors to estimate the shade between the hours of 10 AM and 3 PM. These instructions were problematic in that it is difficult to accurately estimate the path of the sun without a compass (surveyors were not equipped with compasses) and even more difficult to estimate the angle of the sun and how sunlight would enter the stream channel during a window of time for which surveyors were not present. This parameter was further complicated by the fact that survey continued into the winter at which time the angle of sunlight is significantly smaller than during the summer. To collect meaningful data for this parameter, data needs to be collected during a shorter time period and using better measurement tools such as densiometers.

Although stream flow data were not collected during this survey, the system's altered stream flow regime is considered to be a significant factor influencing the steelhead fishery (Rich, 1995). Additionally, there were several private pumping systems found in the creek during the survey, one of which is a permanently installed system, complete with a concrete-mounted pump and plumbing system. Eliminating diversion systems from the creeks would increase summer flows thereby benefiting native aquatic organisms.

Although Arroyo Corte Madera has a USGS gauging station on the creek in the lower watershed, it only collects data during medium and high flows. The station's was originally installed for flood control purposes and is not suitable for low-flow measurements. If the gauging station could be modified to collect low-flow data, additional valuable data would be available for future hydrological assessments in the watershed. Additionally, low-flow summer conditions lend themselves to volunteer efforts to collect stream flow data. Simple methods using a 5-gallon bucket and a stopwatch allow for adequate low-flow measurements, which could provide valuable baseline data for the watershed.

The Mill Valley Watershed Project never formally attempted to quantify the success of community involvement in any systematic way beyond the activities that were taking place during the project's funding period. The Project did, however, help create a group of deeply committed community activists that continue to meet and work to this day. The group that followed, Mill Valley StreamKeepers, works on many fronts in the city of Mill Valley to protect stream regions, water and habitat quality. They work within the planning structures of the City of Mill Valley; they provide educational and hands-on activities for the community and function as an overall watch-dog group on behalf of stream protection.

CHAPTER 5 -SURVEY CONCLUSIONS

The streams of Mill Valley have been impacted significantly by urbanization during their history. Development during the last 120 years has significantly affected Mill Valley's streams and stream zones. The construction of roads, parking lots, bridges, businesses, homes and apartment buildings have altered Mill Valley's stream directly and have indirectly altered its hydrology.

In general, development has resulted in stream channel alteration including straightening stream channels, the removal of vegetation, the alteration of the watershed's hydrology and the armoring of stream banks, all of which either eliminates or drastically reduces the quality of stream zone habitat. Furthermore, Mill Valley's streams are affected by poor land use practices that allow sediment to enter streams. Practices include construction projects that don't adequately address silt runoff, improperly maintained roads, stream channels, trails and neglected erosion sites.

Some of the most notable findings and features where habitat has been adversely altered or are in need of attention include:

- Survey sites 2A and 2B where the stream has been channelized and buildings and parking lots have been built up to the edge of the stream bank. These reaches lack overhanging vegetation that provides shade to keep water cool and a vegetated buffer that functions as a filter for overland flows.
- The region of Arroyo Corte Madera del Presidio that surrounds Mill Valley Lumber Company (just downstream of Survey Plot 3C) where 450 feet of the stream banks have been armored with high walls of concrete.

- The in-stream structure under the Cascade Avenue bridge at Old Mill Park, 150 feet downstream of Survey Plot “Old Mill 3A”. This bridge’s accompanying in-stream drop structure impedes both adult and juvenile migrating steelhead because of its damaged apron.

- Stream plots where silt and sand exist in the stream channel and areas where banks are contributing fine sediment to the stream. Areas requiring further investigation include Arroyo 2C, 3C, 4B, 5A, 6A and Old Mill 1-2C, 3A, 3B and 3C (Figure 21).

- The area that surrounds the confluence of Old Mill Creek and Arroyo Corte Madera. Downstream of the confluence there is significant concrete stream bank and streambed stabilization structures that have removed natural habitat. Upstream of the confluence, the stream has been forced through long underground culverts, eliminating virtually all habitat.

- The absence of woody debris throughout the whole survey area suggests the need for changes in public works management practices and education of streamside homeowners.

- Overall there are minimal significant barriers to fish migration with the exception of the drop structures in Old Mill Park and the temporary structure that is built during summer months just downstream of survey plot Old Mill 1-2A.

- The installation of diversion systems that remove water from a system that already is deficient in summer/fall flows, 5 of these were found in or near survey plots Arroyo 3A, Arroyo 6B and Old Mill 1-2B.

Figure 21 shows several of the sites described above. All of the sites shown in Figure 21 present opportunities for future community involvement, including further assessment, monitoring and/or restoration.

Restoration of riparian vegetation, especially at the water’s edge, would enhance the aquatic habitat by providing increased cover for fish to hide. The addition of woody debris would enhance pool development and cover for fish. A continuation of programs by both the City of Mill Valley and local non-profits to educate the community about stream, habitat and water quality protection is vital to the future of Mill Valley's streams. Such a program must include educating the community about the detrimental effects of pumping water from the stream during low flows and about the implications of planting invasive exotic plants that displace native vegetation/habitat versus planting native plants. More ambitious restoration projects could include the removal of concrete streambeds in some areas, which would restore the natural streambed and provide native streambed habitat.

The overall volunteer effort for this project was a complete success at many levels. From the perspective of the survey itself, the team was a vital part of the data collection effort, an effort that could not have been completed without them. I am deeply indebted to each and every one of the volunteers that I had the pleasure of working within the creeks.

Volunteers have been part of awakening the community of Mill Valley to issues surrounding their own creeks and how to protect them. Initial meeting that were held as educational and community-organizing events set the stage for the birth of the Mil Valley StreamKeepers, which was created in 1998. What began as a consultant-funded top-down project has turned into a grassroots organization with a strong voice in the community regarding Mill Valley's ecological environment.

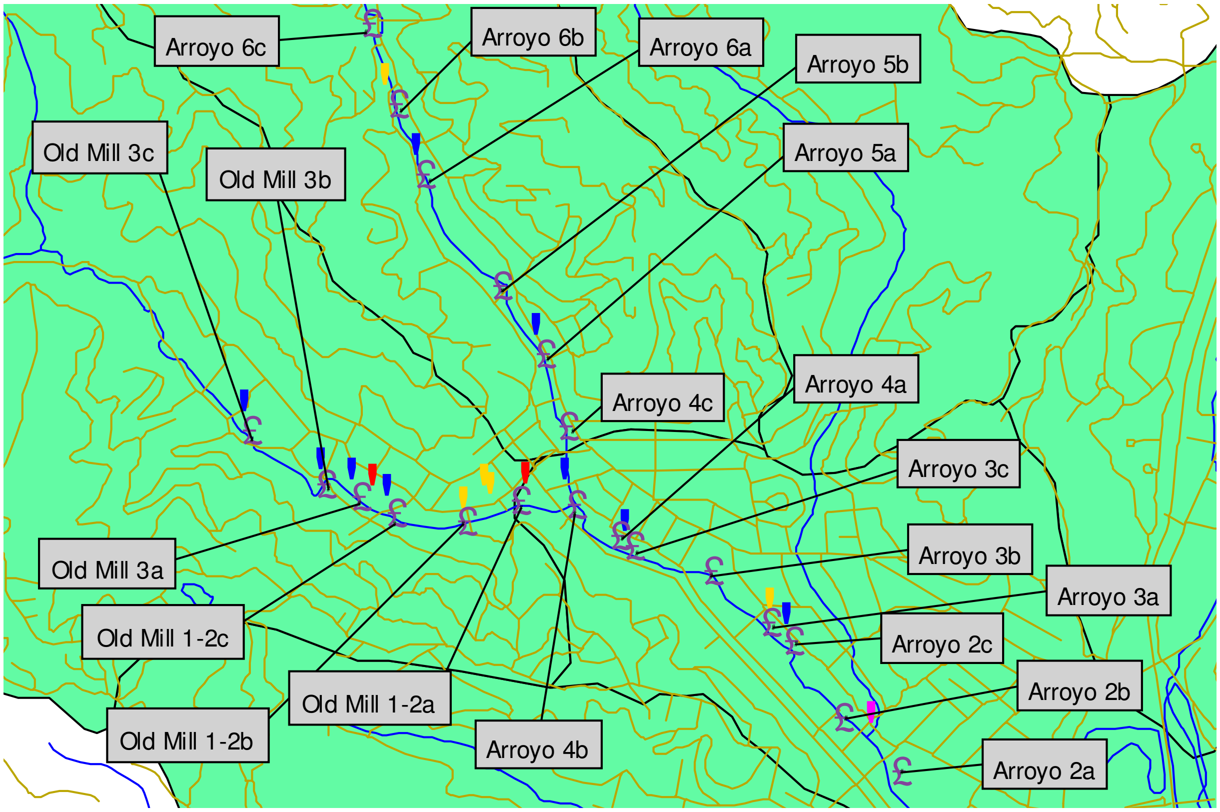
Although many people are responsible for the creation and continued existence of the Mill Valley StreamKeepers, there was one volunteer, Nancy Dempster who worked to spearhead the creation of an independent, highly effective non-profit organization that continues to act as the heart and soul on behalf of Mill Valley's watershed.

Mill Valley StreamKeepers grew from what remained of the Mill Valley Watershed Project after its funding was terminated. It has become the voice of the watershed, working at any and all levels of stream protection, community education and policy work, all in the interest of maintaining and protecting the integrity of Mill Valley's watersheds.

Mill Valley StreamKeeper's work has included victories fighting developments on steep, sensitive slopes, engaging in non-native vegetation removal and native plant restoration, community meetings, and stream walks and, in general, providing a place for members of the community to get active or get information about protecting stream and watershed ecology.

This organization has become such a significant force regarding Mill Valley policymaking that developers are sometimes asked to talk to Mill Valley StreamKeepers prior to being issued permits by the city as a means of addressing environmental issues early in the process.

Volunteers for the Mill Valley Watershed Project stream survey combined with Mill Valley StreamKeepers efforts in the watershed over the past 6 years have demonstrated that community groups can be a powerful force in protecting and improving their community's ecological habitat.



- Survey Plots
- Fish Barriers
- Water Diversions
- Sediment/Revegetation Sites
- Revegetation Sites
- Roads
- Streams
- Mill Valley Watershed Boundary

Figure 21- Mill Valley Watershed Problem/Opportunity Areas

APPENDICIES

APPENDIX 1- ACRONYMS

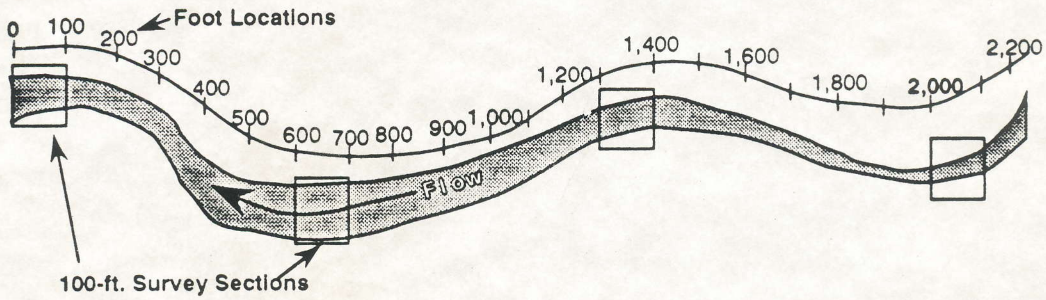
CFE	Center for Ecoliteracy
MVWP	Mill Valley Watershed Project
MVSK	Mill Valley StreamKeepers
NPS	Non-Point Source
USEPA	United States Environmental Protection Agency

APPENDIX 2- MVWP STREAM SURVEY MANUAL

THE MILL VALLEY WATERSHED

VOLUNTEER STREAM SURVEY MANUAL

Figure 1: Plan View of Stream with Survey Sections



JANUARY 1997
MILL VALLEY, CALIFORNIA

PREPARED BY

THE MILL VALLEY WATERSHED PROJECT

A PROJECT OF THE CENTER FOR ECOLITERACY

DEDICATION

to the memory of Lindsay Rehm who gave generously of her talent and energy to this project

ACKNOWLEDGEMENTS

The Mill Valley Volunteer Stream Survey Manual and training workshops are made possible by the generous financial support of the Center for Ecoliteracy in Berkeley, California. The Marin County Stormwater Pollution Prevention Program (MCSTOPPP) provided funds for the printing of this manual. The contributions of many individuals are integrated into the survey design. We wish to thank Eric Larson, Julia Crawford, Kallie Kull, our friends at the Coyote Creek Riparian Station, and all of the volunteers who performed the pilot survey.

SURVEY DESIGN

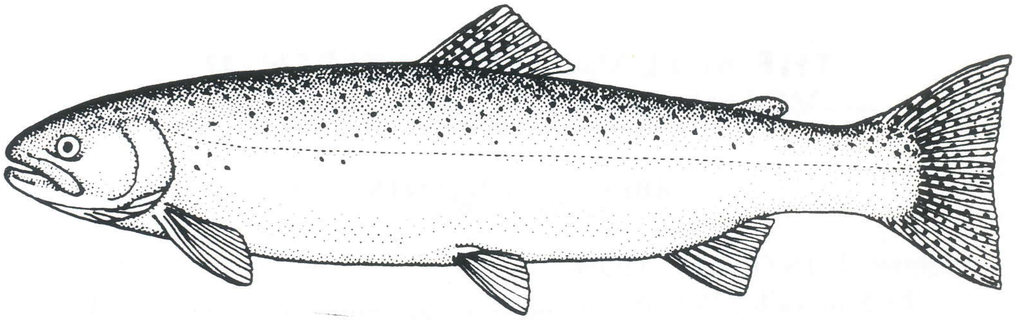
Dominic Roques
Fred Euphrat, Ph.D.

SURVEY MANUAL

Dominic Roques
Andy Peri

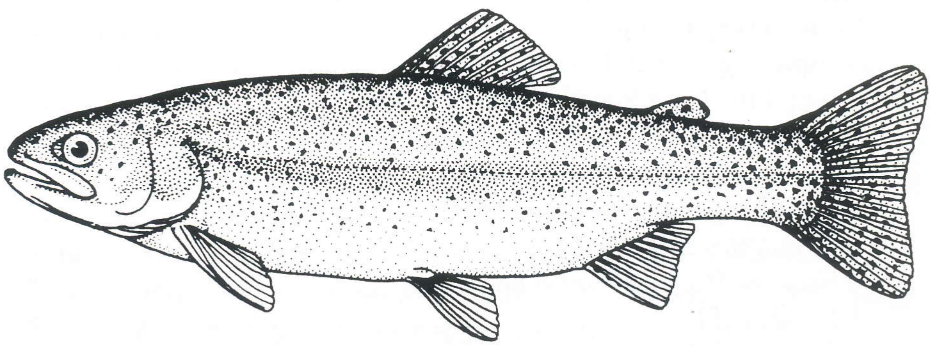
THE MILL VALLEY WATERSHED VOLUNTEER STREAM SURVEY

TABLE OF CONTENTS



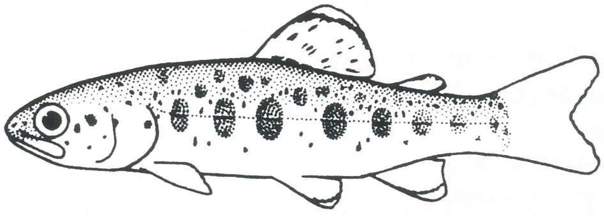
Steelhead Rainbow Trout, Salmo gairdneri gairdneri (native)

Color may range from very silver, with only faint dark spotting, to darker dorsal coloration with faint lateral red band and heavier spotting. No red slashes on lower jaw; maximum total length 109 cm, maximum weight 19.1 kg. Distribution: most coastal streams in California.



Rainbow Trout, Salmo gairdneri (native)

Conspicuous light red band on lateral body; heavy black spotting on dorsal body and on dorsal, adipose, and caudal fins; color variable, but generally darker overall than Steelhead. World records for sport fishes list only one weight and length for this entire species: total length 109 cm, weight 19.1 kg. Distribution: most freshwater habitats in California.



Rainbow (Steelhead), Salmo gairdneri

Numerous dark spots on body and dorsal fin; parr marks nearly round; adipose fin with black, broken border; to sea at 12 - 25 cm.

Freshwater Fishes of California, Samuel M. McGinnis, University of California Press, 1984

Section 1
INTRODUCTION

The Mill Valley Watershed

The streams of the Mill Valley Watershed drain the east side of Mount Tamalpais and an approximately six-square mile area that includes the City of Mill Valley and the unincorporated community of Homestead Valley in Marin County, California. The watershed's trunk stream, the Arroyo Corte Madera del Presidio, flows into Richardson Bay—an embayment near the Golden Gate of San Francisco Bay. The Arroyo is fed by three named tributaries, including Old Mill Creek, Warner Creek, and Reed Creek (See pull-out map at end of manual). The Mill Valley Watershed constitutes roughly one-third of the entire 12,200-acre Richardson Bay Watershed. The health of this ecosystem, and of the larger San Francisco Bay-Estuary, can only be improved through the concerted efforts of people living in the surrounding watersheds.

The Mill Valley Watershed has both naturally robust and highly altered aquatic environments. The effects of urbanization are most apparent at the Bay margin and in the mid- to lower-floodplain portions of the watershed. Headwater areas for the Arroyo and three of its five named tributaries are in good condition—in part due to the steep slopes that have limited development there, but also because large areas are under public ownership. However, even in these steep upland areas new home construction continues, and recreational use of the Mount Tamalpais trail system is growing.

The watershed's once flourishing steelhead fishery is now affected by the variety of impacts that came with settlement of the area. The redwood groves which once supplied woody debris to the streams were first harvested from the ecosystem beginning in the mid-1800s (thus the name Arroyo Corte Madera del Presidio, meaning, "the stream where wood is cut for the Presidio"). Today, where the groves have regrown, large pieces of wood are prevented from entering the stream for flood control and aesthetic reasons. Insufficient quantities of woody debris in stream channels are a major problem for fish since wood

provides both food and habitat. The streams are also inundated with fine sediment derived from un-surfaced roads, informal trails, bank erosion, construction sites, and areas of intensive recreational use. Urbanization has required channelization and other structural modifications to stream channels that render streams efficient for floodwater conveyance, but compromise their habitat and other biological values. Regrettably, the town's central plaza and railroad depot obscure the confluence of the Arroyo and Old Mill Creek, eliminating this potentially unifying element of the urban landscape. Ultimately, the steelhead's future in the watershed will be possible only if there is enough water. Today, an undetermined amount of water is diverted from streams to supply landscaped yards and gardens of creekside residents.

The Mill Valley Watershed Project
The Mill Valley Watershed Project (MVWP) is an effort to build long-term community support for restoring the ecological function of the streams in the communities of Mill Valley and Homestead Valley. It is a project of the Center for Ecoliteracy, a non-profit organization. The MVWP brings together the energy, enthusiasm, and ideas of the community to protect and restore the watershed of the Arroyo Corte Madera del Presidio. We are striving to re-integrate the city with the streams that run through it so that these waters become the heart of the community for future generations.

The broad goals of the Mill Valley Watershed Project are as follows:

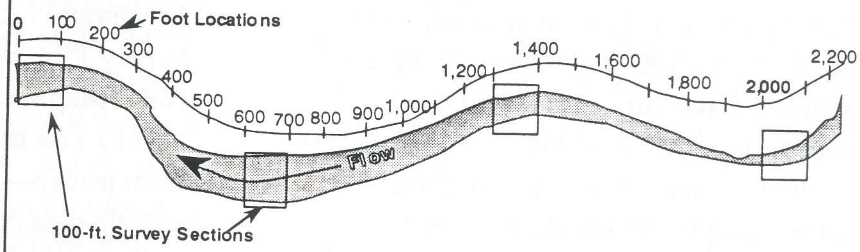
- Increase community awareness and knowledge of the Mill Valley Watershed as an ecological system whose vitality, stability, and productivity is a function of peoples' actions in the watershed;
- Involve the community in the process of selecting, designing, and implementing projects that increase community stewardship, and improve conditions for the steelhead fishery.

Section 2
SURVEY GUIDELINES

Survey Purpose
Thank you for being a part of this first ever watershed-wide assessment of Mill Valley's creeks. The primary purpose of the Mill Valley Watershed Project Volunteer Stream Survey is to have volunteers from the community collect baseline information on the conditions of Mill Valley streams, and to pinpoint areas most in need of restoration or protection. Our objective is to complete the survey for the Arroyo Corte Madera del Presidio, and for its three main tributaries, Old Mill Creek (including Cascade Creek), Warner Creek, and Reed Creek. Streams impacted by illegal dumping, encroachment, water diversion, or other problems will be identified for further investigation by the appropriate agency. Before beginning the survey, please read the Safety Sheet, sign the attached waiver form and return it to your Team Leader, then take a few minutes to review this manual; it introduces concepts which are important to understand before going into the field.

Basic Concept Behind Survey
The Volunteer Stream Survey is designed to collect: 1) a *sample* of very specific conditions that occur in streams, and 2) a

Figure 1: Plan View of Stream with Survey Sections



Each 100-ft. Survey Section is studied in detail to give a representative sample of the 2,000-ft. section of stream.

qualitative record of the general condition of these streams. The first—a sample—is a detailed inspection of a small segment of stream which turns up facts about the stream that are not apparent upon casual inspection. It produces *quantitative* results that are the basis for future actions to improve conditions in the stream. Quantitative results also provide the basis with which to make accurate comparisons of present, or, baseline conditions with future conditions. For example, if we measure several deep pools in a stream segment this year, we have a number (pool volume) to compare with the next time we measure pools in that segment. The quantifiable difference between the two measured pool volumes will tell us whether fish are loosing or gaining in the habitat game.

The reason we take a sample is simply that there are too many miles of stream in the Mill Valley Watershed to survey the entire system in detail. Our objective is to sample 15% of the total length of any one stream and to assert that what we find in that 15% is representative of what we would find throughout the entire stream. When you do the math, it turns out that 300 feet is 15% of 2,000 feet. So, for every 2,000 feet of stream, we will sample three 100-ft. segments. These 100-ft. segments will be called Survey Plots (Figure 1).

We do not want to miss any important creek features in between our 100-ft. Survey Plots, so we will inspect those in-between areas as we are walking upstream. This is where the second type of information, qualitative, is collected in this survey. This information is descriptive —we won't actually measure anything. By carefully recording our observations of say, oily water entering the stream from a parking area, or, the location of an unvegetated stream bank, we can produce a comprehensive record of the general condition of the stream and identify the places requiring immediate attention.

Our survey is complete when we have collected both a quantitative sample of stream conditions, and a qualitative description of the entire stream.

Survey Contents

The Volunteer Stream Survey includes the following forms and maps for data collection:

Base Map: this map, on 11x17 paper, shows our 2,000-ft. stream segment and helps us locate ourselves in the field relative to familiar landmarks; it indicates the preferred location of three 100-ft. Survey Plots (if you must change the location of a 100-foot Survey Plot for any reason, make sure to note the new location on this Base Map); used together with the Survey Observation Sheet, the Base Map provides a place to draw in the things we observe on portions of the stream located *between* each 100-ft. Survey Plot (the Survey Plot has a map of its own).

Survey Plot Data Sheet: we use this sheet to record the sample of detailed information from the 100-ft. Survey Plot.

Survey Plot Sketch: starting from scratch, we will create a detailed map for our 100-ft. Survey Plot on graph paper. The graph paper is based on a 1/10th-inch grid to enable us to keep our drawings to scale. An example sketch is included at the end of this manual.

Survey Observation Sheet: on this sheet we record our observations made on stream segments between 100-ft. Survey Plots. Anything of interest should be described on this sheet, however pay special attention to pumps and pipes entering the creek channel, regardless of whether or not they are flowing. Pipes are common in Mill Valley's creeks and an inventory of pipes will help efforts to identify point sources of pollution.

Survey Teams

The survey is designed to be conducted by a team of four volunteers. Responsibilities can be divided into three parts to increase efficiency and accuracy: 1) Survey Plot Data Sheet recording, 2) Survey Plot Sketching, and 3) Observers (Base Map and Survey Observation Sheet.) You might find it useful to select a team leader—one person to keep track of all field data collected by the team.

Equipment List

Item	Purpose
Forms and maps from this Manual	recording data
Meter sticks	water depth measurements
Pencil	in the field it is mightier than the pen and the sword
Camera	photo-document each Survey Plot and other special features
Long tape	measure stream distance and width of riparian vegetation
Measuring tape	measure width of stream
Marks-a-lot	sign-making for photos
Waders or rubber boots	unless you are comfortable in wet wool socks & shoes
Calculator	calculating averages, distances, etc.
Flashlight	looking into dark spaces (culverts, pipes)
Surveyor flags	marking the boundaries of Survey Plot and bankfull channel
Safety whistle	for each surveyor to use when necessary.

Establishing Reference Points

With our equipment and field sheets we can enter the field. First we assemble the team at the downstream end of the 2,000-ft. stream segment shown on the Base Map. Take a look around to see if there are any obstacles to starting the survey here. Install the first Survey Plot at foot location 0 and 100 feet by pulling the tape along the center of the stream (Figure 1). Place surveyor flags at 0, 50, and 100 feet to serve as reference points while you are completing the Survey Plot Data Sheet. When a Survey Plot location falls in a culvert or other subterranean location, estimate the length of the structure, or the distance to the place where you can re-enter the channel for surveying. If an accurate measurement (to within 20 feet) of this distance can not be determined, then establish a new starting point, and start the 100-ft. Survey Plot at this new point making clear notes on your Base Map.

Avoid Trespassing

Landowners who have not granted us permission to pass through their property are noted on the map. Please pay special attention and avoid these areas. When stream access is blocked, walk onto an adjacent street, enter the stream zone at the next point of public access, and walk back downstream as far as you can without trespassing.

Completing Survey Forms

Once we've established the location of our first Survey Plot, we will complete the Survey Plot Data Sheet, draw a detailed Survey Plot Map, and take a photograph. The photograph should be taken facing upstream from the 0-foot location. Using a thick pen or marks-a-lot, make a placard showing the name of the creek and the foot location, and hold it up while your team photographer takes the shot. The photograph will confirm the exact location of the Survey Plot, and provide a snapshot of the sample, so try to include water, stream banks, vegetation, and other critical features in the scene.

After completing the Plot Data Sheet and Sketch for the first sample, we will assess stream conditions as we walk upstream to the location of our next Survey Plot, using the Observation Sheet and the Base Map, and pulling the long tape as we go. We can take photographs of any point of interest, numbering the photographs and recording the number and corresponding notes on the Observation Sheet. Features to note on the Base Map include:

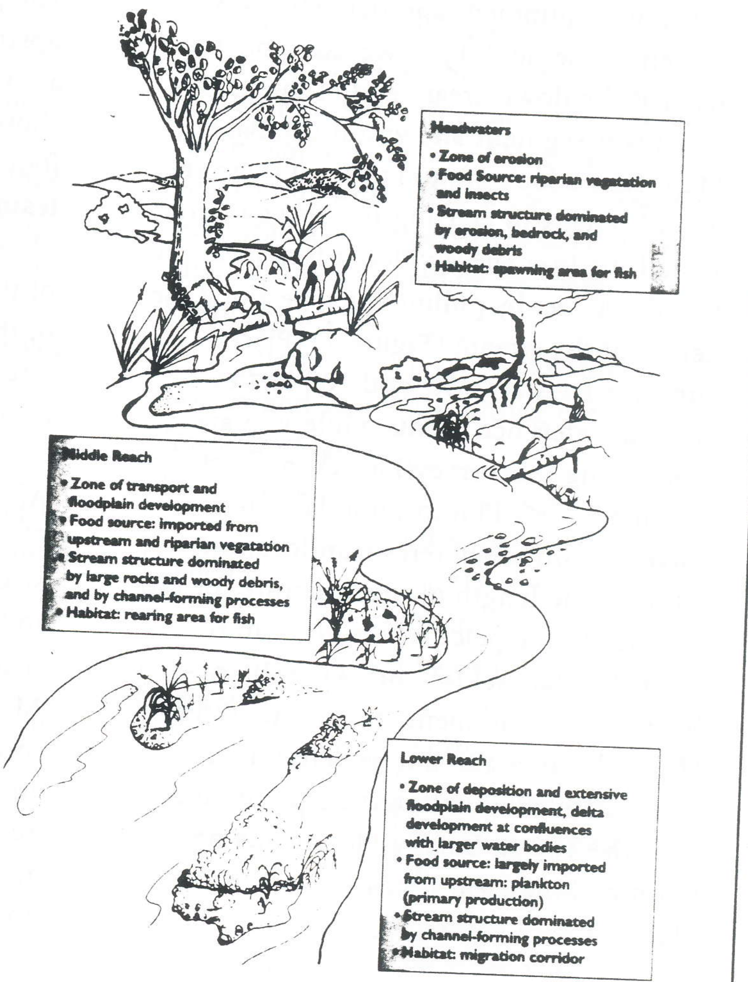
- entry point of any polluting substances, such as leaking pipes, street runoff, major trash piles, slimy algae (may indicate garden fertilizers are getting into stream), piles of garden debris;
- severely eroding banks, or sources of sediment;
- denuded banks that would benefit from planting;
- pipes that appear to be drawing water from the stream, including pumps for yard/garden irrigation;
- invasive vegetation (black acacia is especially worth noting).

- tributaries (well-defined channel entering the stream—wet or dry).

Survey Plot Data Sheet

The Survey Plot Data Sheet has four sections to help organize an approach to collecting data: I. Water, II. Stream Channel, III. Stream Zone, and IV. Condition Summary. While it is useful to break the Survey Plot into these categories, we must keep in mind that we are still examining one system interconnected with many other systems. The link between water in the stream and riparian vegetation, for example, is an obvious one. As you survey, consider other links between these elements, and between the headwaters, middle reach, and lower reaches of the stream system (Figure 2).

Figure 2: Stream Characteristics for Watershed Analysis



The following provides the rationale (why?) and the method (how?) for most elements in this quantitative portion of the Mill Valley Volunteer Stream Survey. Some elements are self-explanatory and are not discussed. Please carefully review these explanations, following along with the Survey Plot Data Sheet.

I. <u>Water</u>

Presence, Fish, Clarity, Algae

Why? Fish need clear water to survive. Cloudy water is caused by fine material (sediment) in the water. Water clarity is usually poor after storms that bring runoff into the stream. When the water remains cloudy or murky long after a storm, there may be another source of sediment. A rainbow sheen indicates surface pollutants such as oil in runoff from streets and parking lots. A large amount of algae can indicate the presence of nutrients (nitrogen and phosphorus) in the stream from sources such as fertilizers and animal feces.

How? Visual inspection.

II. Stream Channel

The Stream Channel is the portion of a stream environment where water normally flows. It is thus distinct from the flood plain which is only occasionally inundated with water.

Identifying Bankfull Channel

Why? The bankfull channel is the portion of the stream channel containing water when the stream is full to its banks but not overflowing them. We can calculate normal seasonal discharge (cubic feet per second) based on the bankfull width and depth. Bankfull channel width is defined as the distance between the points on opposite banks where the water reaches just as it begins to overflow into the active floodplain. The active floodplain is defined as the flat area adjacent to the channel constructed by the stream and overflowed by the stream approximately once every two years.

How? To determine bankfull width consider only "non-pool" portions of the stream and look for:

- the low limit of perennial vegetation on the bank, or a sharp break in the density or type of vegetation. Willow and alder often form lines near bankfull stage.
- the lower limit of mosses or lichens on rocks or banks, or a break from mosses to other plants;
- place on stream bank where the perennial vegetation forms a dense root mat;
- the change from a vertical bank to a horizontal surface;
- undercuts in the bank, which usually reach an interior elevation slightly below bankfull stage;
- a change in the particle size of bank material; breaks from coarse, scoured, and water-transported particles to a finer matrix that may exhibit some soil structure or movement; the boundary between coarse cobble or gravel and fine-grained sand or silt;
- frequent inundation water lines on rocks marked by sediment or lichen; stain lines or the lower extent of lichens on boulders.

Once the location of the bankfull channel has been determined, mark it with surveyor flags in three locations: beginning, middle, and end of the 100-foot Survey Plot. Then, run a level tape measure across the stream and record the distance between the flags on the Survey Plot Data Sheet. Leave the flags in the bank while you complete the survey—they will be reference marks for other measurements.

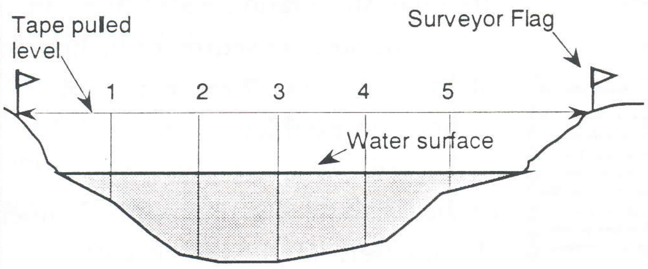
Estimating Bankfull Depth

How? Using the same three cross-sections established for measuring width, record the bankfull depth at five evenly spaced points on each cross-section (Figure 3). It is easiest to just divide the total width by six and use the result to move across the stream along the tape at measured intervals. Remember to measure the distance from the *tape stretched level and tight* across the bankfull channel to the bottom of the streambed, not from the water surface.

The measured depth will be greater than the observed water depth, unless you happen to be surveying when the stream is at bankfull. Then record maximum depth on the Survey Plot Data Sheet. Repeat for each cross-section.

Figure 3. Bankfull Depth Measurement

Measure depth from tape to stream bottom at five locations and calculate the average.



Shape of Stream Channel and Bank

Why? Streams are channelized in urban areas to reduce the uncertainty associated with natural processes like flooding and erosion. Methods of channelization include rip-rap on banks, concrete stream beds, and other hardened surfaces along banks and channels. Because channelization is meant to constrain natural processes, some of the more desireable attributes of streams are lost, like fish habitat, riparian vegetation and aesthetic values. Stream banks that have not been channelized offer a variety of habitat values depending on their shape.

How? Compare what you see to the illustrations in the data sheet and estimate the percentage of the sample plot that is channelized (has artificial surfaces controlling the stream), V-shaped, wide, or undercut. Also indicate where channelized segments have been undercut by the power of stream flows to offer hiding places for fish.

Number of Pools

Why? Instream pools function to provide fish with a cool area for resting and feeding, to trap or hold sediment as it moves down through the stream channel, and to provide rearing habitat for young fish. Pools are usually formed around stream bends or obstructions such as logs, root wads or boulders. Turbulent water at the head of a pool collects food carried from upstream and provides cover and an area with a higher dissolved oxygen concentration. Fish wait in pools for drifting insects.

How? Unless you are a fish, pools may be hard for you to see. A good way to know if you're looking at a pool is to ask yourself, "If I turned off the water, would there be a pool of water remaining in the channel?" Pools can be defined according to the following criteria:

- water velocity in the pool is slower than the average velocity of the stream in the Survey Plot;
- countervailing currents (eddies occurring at the downstream tail of pool);
- flat surface at low flow (bathtub stillness);
- pools are typically deeper than the depth of the deepest part of the stream averaged for the entire segment.

Count the number of pools and measure the maximum length, width, and depth of each pool. Also measure the riffle-crest depth in three locations. The riffle-crest is usually the shallowest place at the downstream end of a pool. At low flow, when the pool surface is nearly flat, the riffle-crest is the shallowest continuous line (usually not straight) across the channel close to where the water surface becomes continuously riffled.

Streambed Substrate Composition

Why? The streambed is the part of a stream over which water moves, and its composition determines the types of habitat and aquatic life found in a stream. Substrate is the mineral or inorganic material that forms a streambed. Boulders are 10 inches or more in diameter and are the largest substrate materials. Cobbles, ranging from 2.5 to 10 inches, stabilize the bottom of streams and provide habitat for fish rearing. Most fish food is produced in cobbled areas. Gravel is 0.1 to 2.5 inches. It provides the ideal substrate for spawning, egg incubation, and homes for aquatic invertebrates. Gravel must remain clean and porous so circulating water can bring enough oxygen to embryonic fish.

How? Looking at the streambed, estimate as best you can the percentages of different materials dominating the substrate. Consider each class of materials going row by row through the substrate table on the data sheet.

Barriers to Fish Migration

Why? Fish passage upstream is most critical under high flows (winter), and passage downstream is critical under low flows (summer). Not all structures or steep drops in the stream channel prevent fish passage (fish can jump as high as five feet), but if you see a potential problem, describe it.

How? Note the height and width of each fish barrier in the Survey Plot. Describe the material it is made of and indicate its location on the Survey Plot Sketch; barriers observed along the creek between sections are recorded on the Observation Sheet.

Woody Debris

Why? The presence of woody debris in the stream is important to fish habitat. It helps stabilize the streambed, traps gravel, creates pools and resting areas, affords hiding places, and supports insects. However, woody debris is often removed by flood control folks to maintain the capacity of the stream channel to convey floodwaters quickly downstream. Woody debris can be placed into different categories based on its size and how it functions in the stream.

Substrate Materials

Material	Inches	Texture
Bedrock		Concrete channels are recorded as bedrock
Boulders	>10	
Cobbles	2.5 - 10	Size of grapefruits and melons
Gravel	1/10 - 2.5	Size of peas and tangerines
Sand	<1/10	Grainy, gritty
Silt/Clay/Mud		No grains, slick, slippery or soapy when wet

- *Functional:* embedded into the banks or streambed or affecting the flow of water at or below bankfull stage.
- *Non-functional:* not in the water, but lying within six feet of the water and poised to fall into the bankfull channel.

How? Tally the number of pieces of large woody debris in the bankfull channel (between the flags). Separate into two size groups (6-12 inches and greater than 12 inches) and categorize as "functional" or "non-functional." Sizes are based on the diameter at the largest point on the piece of debris.

III. Stream Zone

The stream zone is the area extending beyond the stream channel that includes the transition from riparian vegetation to terrestrial vegetation. It encompasses the aquatic ecosystem and adjacent terrestrial areas directly affecting the aquatic system.

The stream zone's width varies with hydrology, geomorphology, vegetation, and upland conditions and processes. Riparian systems are very sensitive to disturbance and the stream zone buffers these systems from outside influences, acting to filter out sediment and pollutants from upslope areas, noises that disturb riparian wildlife, and also providing thermal control for the stream environment. The stream zone is also a source of food and organic material, including large woody debris. It serves as a corridor for movement of animals between habitats.

This survey examines three key elements of the stream zone: stream banks, vegetation, and adjacent land use. Data collection in the stream zone requires that you get comfortable with percentages. Your entire Survey Plot is 100%. Each bank is 50%. The following diagram might be useful (Figure 4).

Bank Condition

Why? Bank stability is one of the most common problem areas on streams. Where banks are collapsing into the stream, valuable vegetation can't get established, sediment is washed into the stream, and property loss can occur.

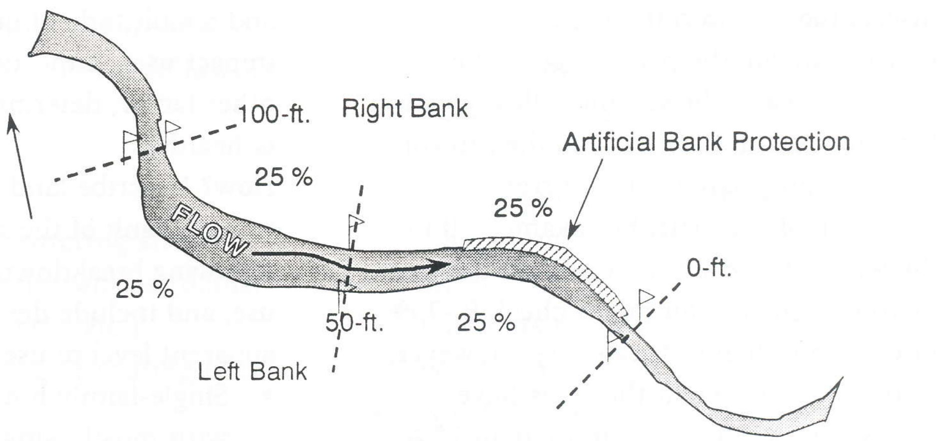
How? Estimate the percentages of the following bank conditions, baring in mind that these conditions are not mutually exclusive and your percentages may total to more than 100%.

- Collapsed: stream bank has fallen into the stream channel
- Actively contributing sediment to stream
- Vegetated: stream bank is predominately covered with vegetation
- Unvegetated—natural: stream bank is predominately bare of vegetation
- Unvegetated—artificial: stream bank is bare because it is concrete.

Percent of Artificial Bank Protection

Why? Artificial protection includes channelization as well as smaller reinforcements along the banks. Materials used in bank protection include: concrete bags, walls, bridge abutments, flash boards, culverts, bridge foundation, rip-

Figure 4: Visualize the Survey Section as Four Quadrants to Help in Calculating Percentages



rap, wooden railroad ties, and logs. It is a necessity in urbanized watersheds. It protects property, prevents bank erosion, and often serves to mitigate the impacts of land uses in the watershed. However, it provides none of the benefits of a natural stable bank, unless it is undercut and serves as a refuge for fish and other critters.

How? Estimate the percentage of the stream bank that has artificial protection. Facing upstream estimate the percent for both the right and left banks. Percentages must total 100%. Figure 4 shows 0-25% extent of artificial bank protection.

Bank Vegetation Type and Density

Why? A dense mixture of bank vegetation will provide a variety of benefits to the stream, including: branches, logs and leaves, a filter for sediment and pollution coming in from nearby land, shade to keep the water cool, habitat for the many creatures that depend on and influence the stream, and bank stability.

How? Estimate the amount of bank covered by the following vegetation types:

- root wads
- trees
- shrubs - less than 20 ft. high
- vines
- grasses

If possible, identify the prominent species.

Width of Vegetation Corridor

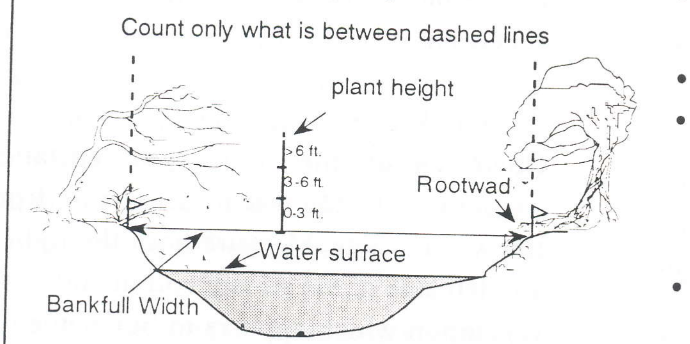
How? Measure the width of the vegetation corridor perpendicular to the stream from the water's edge. Measure both the right and left side of the stream and include any vegetation which appears to buffer the stream. Do not bother measuring the width if the vegetation extends uninterrupted beyond 150 feet. Where the width varies, take a few measurements and record their average.

Overhanging Vegetation

Why? Overhanging vegetation actually hangs out directly over the stream. It can include root wads, small plants and grasses, shrubs, and even trees whose branches extend over the stream. Overhanging vegetation offers protection and refuge for fish and other organisms, it shades the stream and keeps the water cool, and it provides "launching" areas for insects that fall into the stream.

How? Estimate the percentage of the bankfull area of the stream with vegetation hanging over it. Please check the category that is appropriate for the current condition of your site. For example, if in the winter there are no leaves on the trees in your segment you might check 0 -25% in the more than 6 ft. category. However, in the summer when the trees have leaves, you might check more than 75% (Figure 5).

Figure 5. Estimating Percentage of Bankfull Width Covered by Overhanging Vegetation



Percent Shade

Why? Shading is most important in the summer when water in unshaded portions of the stream can get too hot for fish.

How? Estimate the percentage of the water surface in the section that is shaded during the hours of 10 AM and 3 PM.

Adjacent Land Use

Why? Any property which is improved in any way to facilitate the presence or activities of people has a land use. Improvements can include graded footpaths, parking areas, pump houses, streets, fence lines, pipe rights-of-way, and a multitude of other apparently low-impact uses. Land use, more than any other factor, determines whether a stream is healthy.

How? Describe land uses directly adjacent to each bank of the stream. Use the following breakdown to describe the land use, and include descriptive notes about apparent level of use. The land use will be:

- Single-family housing: Residential area with mostly single family residences
- Multi-family housing: Apartments or other high density housing
- Commercial uses
- Paved lot: Lot that is paved with asphalt
- Unpaved lot
- Construction site: Lot that is currently under construction. Both renovation and new construction should be included in this category.
- Golf Course: Any facilities or lands directly associated with a golf course
- Parks.
- Open Space (Reserve): Currently undeveloped lands with no buildings, municipal structures, or maintained/improved trails. May include biological preserves or other natural areas with limited public access.
- Roads: Roads include both paved and dirt roads. Please note the road surface type.

IV. Stream Condition Summary

This final assessment of overall conditions will help to identify areas that need further attention. Looking at your 100-ft. Survey Plot, assess the overall condition of this section of stream by assigning a numerical value (1 if present, 2 if impact seems severe), to the following conditions:

Stream Channel

- Mud/silt/sand in or entering stream
- Artificial stream modifications (dams, channelization, culverts, etc.)
- Algae or scum floating or coating rocks
- Foam
- Oily sheen
- Garbage/junk in stream
- Pumps in stream, other diversions

Stream Zone

- Natural streamside vegetation degraded Banks collapsed/eroded
- Banks artificially modified
- Garbage/junk adjacent to stream
- Organic debris (garbage, grass clippings, yard waste)
- Actively discharging pipe(s)
- Other pipe(s) entering
- Ditches entering

Survey Plot Sketch

In addition to completing the Survey Plot Data Sheet, the team will draw a map or sketch for each 100-ft. Survey Plot. Using the provided graph paper make a detailed map of the site which is as close to scale as possible. An example sketch is included at the end of this manual. Features to include:

- Overall channel shape, including length and width of Sample Survey.
- Position of channel in surrounding valley/floodplain.
- Dominant obstructions in or along channel (i.e. boulders, logs, bedrock projections).
- Vegetation in and out of channel (identify acacia and redwoods).
- Pools drawn and numbered corresponding with Survey Plot Data Sheet.
- Positions of gravel bars, sandy beaches and large overhanging banks.
- North arrow and direction of stream flow.
- Other features which may be useful in understanding what is happening in this stream reach, what types of influences have shaped the channel, or anything else you find of particular interest to note or draw.
- Position of any tributary entering the stream.

Tributaries

Tributaries are small creeks that flow into larger creeks. Record each tributary by its location and the bank (right or left looking upstream) it drains from. Note the effects on the stream, including any visible changes in water quality or sediment deposits in the main channel. These effects can range from "virtually unnoticeable" to "significant sediment deposition" to "significant scouring."

Section 3
REFERENCES

Portions of this survey packet have been adapted from the following sources:

Santa Clara County Stream Inventory Protocols and Parameters, Coyote Creek Riparian Station, Alviso, California, 1994.

Streamwalk, United States Environmental Protection Agency, Water Division, Seattle, Washington, 1991.

The Stream Scene, Oregon Department of Fish and Wildlife, Portland, Oregon, 1992.

Stream Channel Reference Sites: An Illustrated Guide to Field Technique, USDA, US Forest Service, Fort Collins, CO, 1994.

Section 4
SAFETY SHEET

- This survey will be done at public access points only. Do not cross property lines or go into areas that have not been clearly designated on your teams map.
- Always work with your team. Do not attempt to collect data on your own.
- Do not put yourself, or your team in danger to gather survey information. Be careful of ticks, poison oak, nettles, insects. Wear long pants and boots.
- Watch out for irate dogs.
- The water is not safe to drink.
- Do not walk on unstable banks; your footsteps could speed erosion.
- Be alert for spawning areas (redds) in the stream. Do not walk on them. They will look like a round or elliptical areas of clean gravel about 1-3 ft long. During fall through spring, when redds are evident, try not to walk in the stream. In the summer, if you are careful, the stream bed might be the easiest route for conducting your stream survey. Be aware that the stream bed can be very slippery and uneven, sometimes at unpredictable times and places.
- Do not attempt to walk across streams that are swift and above the knee in depth. These can be dangerous.
- Be careful of streamside vegetation- disturb it as little as possible.

IF FOR ANY REASON YOU FEEL UNCOMFORTABLE ABOUT THE STREAM CONDITIONS OR SURROUNDINGS, PLEASE STOP YOUR SURVEY. YOU AND YOUR SAFETY ARE MUCH MORE VALUABLE THAN ANY OF THE OBJECTIVES OF THE STREAM SURVEY!

If you have questions or concerns, please contact the Mill Valley Watershed Project at (415) 455-4852.

Stream Survey Data Collection

Mill Valley Watershed Project
July 1996

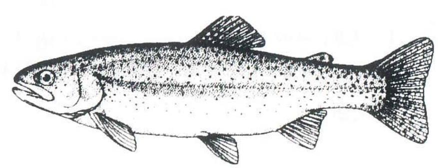
Introduction

The survey will begin on each stream from a fixed point (a datum), referenced to at least two stationary objects that can be identified on a provided map. The approximate beginning point for your 2000' survey section will be indicated on the map included in your survey packet. From that point you will walk upstream, measuring as you go, and keeping a record of the total number of feet measured.

Begin your survey by quietly walking up the stream and looking for fish; by doing this early on, you will increase the probability of seeing fish that will likely be hiding while the survey is underway.

Teams will walk upstream and sample 100' plots at the 100'–200' location, the 900'–1000' location and at the 1800'–1900' location. Team members should reference the locations of certain features in the stream corridor by both distance along stream (based upon the established datum), and the nearest cross streets (if possible). If the stream location is incorrect on the provided map, the surveyor should make corrections in pencil. If symbols are used to show features such as pipes and fences, please clearly identify their meaning in a legend.

If your sampling location falls in a culvert/subterranean location that is inaccessible, measure to the downstream terminus of the structure, then estimate the length of the structure, or the distance to the place where you can reenter the channel for surveying. If an accurate measurement (to within 20') of this distance cannot be determined, then establish a new datum (zero out your accumulated length) at the point of reentry. Reference the new datum as you did the original datum for the stream you are surveying.



A critical requirement of this survey is that it be a random sample of the creeks; this will ensure that the data collected is an accurate representation of the whole watershed. If there are obstructions or barriers that make your 100' survey plot inaccessible, please choose the ***next*** 100' plot (i.e. the 200'–300' or the 1000' –1100', etc.). This will maintain the random nature of the survey and reduce the error that can arise when surveyors choose sites based upon personal preferences such as sunny or shallow water areas.

Landowners who have not granted us permission to pass through their property are noted on the map. Please pay special attention and avoid these areas. When stream access is blocked, attempt to get onto street level and walk up to the next point of easy public access and walk back downstream as far as you can without trespassing. Follow the same procedure described above for establishing your new datum.

Features to be noted on the map include:

- Entry point of any polluting substances, such as leaking pipes, street runoff, major trash piles, slimy algae (may indicate garden fertilizers are getting into stream), piles of garden debris
- Severely eroding banks, or sources of sediment
- Denuded banks that would benefit from planting
- Pipes that appear to be drawing water from the stream, including pumps for yard/garden irrigation
- Make as many notes and sketches as you like.

Equipment List

100' measuring tape	Survey Section Map
Yardstick	Survey Manual
AAA map of Mill Valley	Survey Data Sheets
Clipboards	Observation Sheets
Flagging tape	Graph paper for sketch
Ink markers	MVWP door hangers
Pencils	Hiking shoes/boots with thick wool socks
Flashlight	Waders
Camera	

Survey Plot Data Sheet

Surveyors' Names: ____________________

Stream Name: ____________________ Date: __________

Record the following at each 100' Survey Plot:
Foot Location at beginning of plot ________ At end of plot ________
Station is upstream or downstream
of: ______________________________
Nearest cross streets or bridge

☐ **Take a photo with placard showing stream name and section number.**
☐ **Make a sketch of the survey plot.**

I. Water

1. ***Is water present?*** ☐ Yes ☐ No
   If yes, is water flowing? ☐ Yes ☐ No

2. ***Do you see any fish?*** ☐ None ☐ 1 - 5 ☐ 6 - 10 ☐ 11 - 20 ☐ >20
   If yes, how big? (no fish stories now) ____ inches

3. ***Clarity – water appears:***
   ☐ Clear ☐ Cloudy
   ☐ Rainbow sheen on water surface
   ☐ Other qualities: ____________________

4. ***Do you see algae?***
   ☐ Green hairy ☐ Orange slimy
   ☐ Brown algae on submerged gravel
   ☐ Other: ____________________

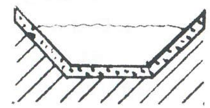
II. Stream Channel: Portion of stream where water normally flows

1. ***Bankfull Width and Depth:*** Measure bankfull at the beginning, middle, and end of the plot. Note measurement location in table. Do not make measurements in pools. Divide stream width by 6 to determine five measurement intervals.

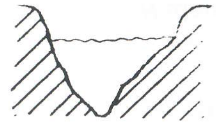
		Depth Measurements					
Measurement Location	Width	1	2	3	4	5	Maximum Depth
____ feet							
____ feet							
____ feet							

2. ***Stream channel/bank shape:*** (total = 100%)

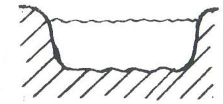
Channelized ____ %



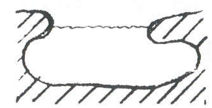
V-shaped ____ %



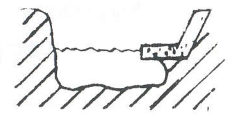
Wide ____ %



Undercut / Overhanging ____ %



Artificial ____ %



3. ***Pool Measurement Data:*** Measure maximum length, depth, width and three riffle crest depths.

Pool #	Survey Plot Foot Location	Max Length	Max Depth	Max Width	Riffle Crest Depths
1					
2					
3					
4					

4. ***Streambed Substrate Composition:*** This is a visual estimate of the percent of underwater areas which are dominated by the following sizes.

Size	0	1%-5%	6%-25%	26%-50%	51%-75%	>75%
Silt/Clay/Mud						
Sand (>0.1")						
Gravel (0.1" - 2.5")						
Cobbles (>2.5")						
Boulders (>10")						
Bedrock						
Concrete						

Stream name: ______________ **Date:** ________ **Survey team:** ______________ **Survey Section #:** ________

5. ***Barriers to fish migration: upstream during high flow/ downstream during low flow:***

   1. Height____ ft., Width ____ ft. 2. Height____ ft., Width ____ ft.

Describe ***and*** show location on map: ______________________

____

____

____

____

6. ***Woody Debris***

Count the number of logs or Large Organic Debris (LOD) in stream, that are functional and non-functional:

Diameter Size	Functional	Non-functional
6 - 12 inches	________	________
>12 inches	________	________

III. Stream Zone: Stream channel and adjacent upland area

1. ***Bank Condition***: estimate percentages of the following (may total more than 100% for the section):

   ________ Collapsed
   ________ Actively contributing sediment to stream
   ________ Vegetated
   ________ Unvegetated—natural
   ________ Unvegetated—artificial

2. ***Percent of artificial bank protection:*** includes concrete bags, walls, bridge abutments, flashboards, culverts, foundations, rip rap and logs. ________%

3. ***Bank Vegetation:*** Type and Density

	None	Occasional	Common (3 or more)
Trees			
A) Coast Redwood	____	____	____
B) White Alder	____	____	____
C) Calif. Laurel (Bay)	____	____	____
D) Black Acacia	____	____	____
E) ________	____	____	____
F) ________	____	____	____
G) Other/Unknown	____	____	____
Shrubs			
A) Blackberry	____	____	____
B) Willow	____	____	____
C) ________	____	____	____
D) ________	____	____	____
E) ________	____	____	____
F) Other/unknown	____	____	____
Ground Covers/Vines			
A) English Ivy	____	____	____
B) Periwinkle	____	____	____
C) ________	____	____	____
D) Other/Unknown	____	____	____
Grasses			
A) Dalis	____	____	____
B) Other/unknown	____	____	____
Rootwads	____	____	____

4. **Average width of vegetation measured from water's edge.** Include any vegetation that has the capacity to reduce sediment entry into stream.

Facing upstream looking left: ____ feet ☐ Greater than 150 ft.
Facing upstream looking right: ____ feet ☐ Greater than 150 ft.

5. **Percent of *bankfull area* covered by overhanging vegetation:** *(Check appropriate box)*

Height of Vegetation Above Bankfull	0 - 5%	6% - 25%	26% - 50%	51% - 75%	>75%
0 - 3 feet					
3 - 6 feet					
> 6 feet					

6. ***Percent Shade.*** Estimate the percentage of water surface shaded during the hours from 10 AM - 3 PM.

<u>Percent Shade:</u>

0 - 25% ☐
26 - 50% ☐
51 - 75% ☐
76 - 100% ☐

7. ***Adjacent Land Use.***
What land uses can you see from the stream corridor?

☐ Single-family housing
☐ Multi-family housing
☐ Commercial
☐ Paved lot
☐ Unpaved lot
☐ Construction site
☐ Golf course
☐ Park (landscaped)
☐ Open Space
☐ Roads
☐ Other

8. ***Other:***
Briefly describe any visual impacts to the stream zone:

____
____
____

IV. Stream Condition Summary–Impacts

Check "1" if occasional (<3) or "2" if common (equal to or >3)

None	1	2	Stream channel
☐	☐	☐	Mud/silt/sand in or entering stream
☐	☐	☐	Artificial stream modifications (dams, channels, culverts, etc.)
☐	☐	☐	Algae or scum floating or coating rocks
☐	☐	☐	Foam
☐	☐	☐	Oil sheen
☐	☐	☐	Garbage/junk in stream
☐	☐	☐	Pumps in stream

None	1	2	Stream Zone
☐	☐	☐	Streamside vegetation degraded (trampled, cut down, etc.)
☐	☐	☐	Banks collapsed/eroded
☐	☐	☐	Banks artificially modified
☐	☐	☐	Garbage/junk adjacent to stream
☐	☐	☐	Organic debris (garbage, grass clippings, yard waste)
☐	☐	☐	Actively discharging pipe(s)
☐	☐	☐	Other pipe(s) entering
☐	☐	☐	Ditches entering

Survey Observation Sheet

Mill Valley Watershed Project

Stream name & number_______________________________________

Date: ____________

Survey team member names ______________________

____

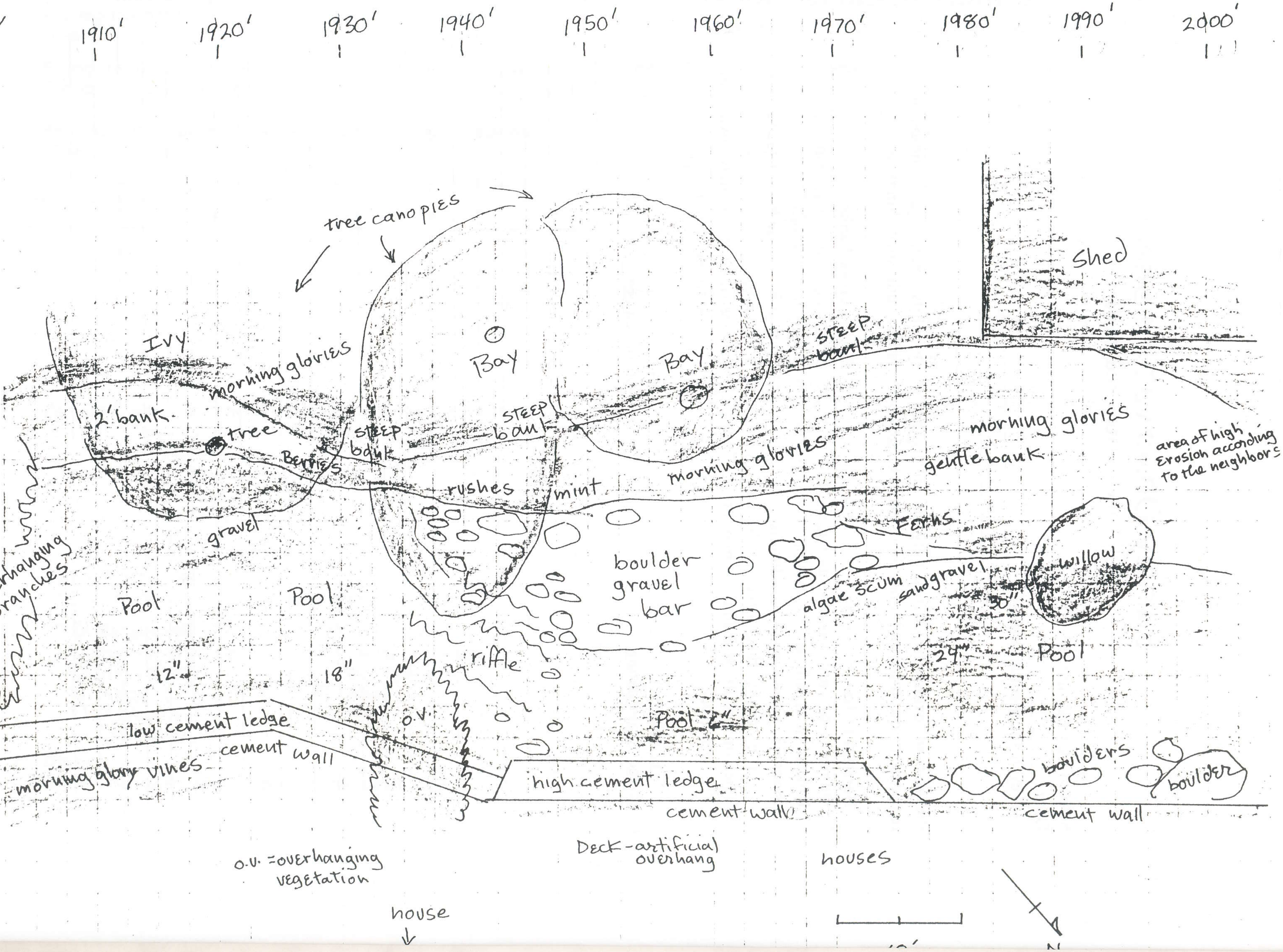
____

Please note features of interest between and within survey plots. Please take photos of features if you think they may be useful. Features should include such things as:

* Barriers to fish migration
* Dumping of yard waste or garbage
* Unique or significant vegetation
* Abnormal water quality conditions (i.e. murky, discolored, or sheen)
* Pipes or outfalls that may or may not be active
* Failing creek banks
* Pumps or pumping systems
* Any fish and wildlife
* Erosion or any sediment (sand or silt) in stream
* Bridges (note if privately owned or give street name)

Location (# of feet from datum)	Description of feature observed

Arroyo 2
1900-2000



APPENDIX 3- SURVEY OBSERVATION SPREADSHEET

STREAM NAME	DISTANCE FROM DATUM (FEET)	NOTE	FEATURE TYPE	LATITUDE	LONGITUDE
Arroyo 2A	0	Datum for Sect. 2A. Upstrm side of ped. bridge. Ped bridge is downst. of La Goma.	Datum	37.8973660000	-122.5346110000
Arroyo 2A	48	Concrete Check dam 11 inches tall, 11 feet wide.	Dam	37.8974640000	-122.5347180000
Arroyo 2A	50	USGS Gauging flow station. Water level is at 3 feet on station gaurge.	misc	37.8974710000	-122.5347240000
Arroyo 2B	305	La Goma Brige, downstream side.	Bridge	37.8980000000	-122.5353000000
Arroyo 2B	322	Inlet pipe under bridge 1.5 ft diameter- Left side	Outfall	37.8980380000	-122.5353330000
Arroyo 2B	350	Upper edge fo La goma bridge	Bridge	37.8981020000	-122.5353900000
Arroyo 2B	360	Stream narrows to appr. 10 ft-= Water 3ft deep. Long pools in this area.	misc	37.8981260000	-122.5354080000
Arroyo 2B	519	Inlet; tributary. Right side 4 ft wide.	confluence	37.8984820000	-122.5357240000
Arroyo 2B	550	Major pine tree root wad left side	rootwad	37.8985550000	-122.5357830000
Arroyo 2B	651	Locust Ave Bridge	Bridge	37.8987810000	-122.5359810000
Arroyo 2B	704	Upper end of Locust St Bridge	Bridge	37.8988630000	-122.5361320000
Arroyo 2B	750	Inlet pipe 8 inches	Outfall	37.8989350000	-122.5362680000
Arroyo 2B	900	Large redwood tree on right. Stream width 12 ft. 4. 5 feet deep.	Outfall	37.8991580000	-122.5367130000
Arroyo 2B	965	Pipe inlet	Outfall	37.8992770000	-122.5368820000
Arroyo 2C	1000	Stream Width 7ft 4 inches depth 4 "	misc	37.8993560000	-122.5369560000
Arroyo 2C	1207	Private auto bridge 7 ft above water.	bridge	37.8997850000	-122.5373850000
Arroyo 2C	1300	6" storm drain on left hand side 8' above water	outfall	37.8999850000	-122.5375870000
Arroyo 2C	1314	5" drain- Possibly waste or sewer line.	outfall	37.9000150000	-122.5376170000
Arroyo 2C	1350	Pedestrian footbridge over creek.	bridge	37.9000970000	-122.5376990000
Arroyo 2C	1420	Vertical walls and concrete base	retaining wall	37.9002480000	-122.5378490000
Arroyo 2C	1435	4" dam in stream	dam	37.9002800000	-122.5378750000
Arroyo 2C	1455	Footbridge across creek 10' clearance to water	bridge	37.9003220000	-122.5379200000
Arroyo 3A	0	Section 3A datum. Datum appears in Arroyo 2C on this map.	datum	37.9013370000	-122.5389260000
Arroyo 3A	22	Water diversion pipe	diversion	37.9013810000	-122.5389860000

STREAM NAME	DISTANCE FROM DATUM (FEET)	NOTE	FEATURE TYPE	LATITUDE	LONGITUDE
Arroyo 3A	75	Large buckeye overhanging left bank	misc	37.9014980000	-122.5391020000
Arroyo 3A	85	Concrete rubble in stream	Debris	37.9015200000	-122.5391250000
Arroyo 3A	108	White corragated discharge pipe	outfall	37.9015710000	-122.5391620000
Arroyo 3A	133	Black corragated discharge pipe	outfall	37.9016250000	-122.5392260000
Arroyo 3A	180	Black corragated discharge pipe	outfall	37.9017200000	-122.5393230000
Arroyo 3A	200	Large alders growing on stream bank- right side+ Black Corragated Pipe	Outfall	37.9017640000	-122.5393620000
Arroyo 3B	225	Night heron spotted in tree, 2 mallards in large pool	Wildlife	37.9018170000	-122.5394170000
Arroyo 3C	1000	1000 Location	misc	37.9030410000	-122.5415960000
Arroyo 3B	241	Small unknown fish in pool (fish transparent, orange color visible inside fish)	Fish	37.9018560000	-122.5394430000
Arroyo 3B	214	Large bay tree w/ rootwad in stream	rootwad	37.9017940000	-122.5393940000
Arroyo 3B	292	Beginning of Park St. Bridge	bridge	37.9019650000	-122.5395620000
Arroyo 3B	331.5	End of bridge (Park St.)	bridge	37.9020340000	-122.5396630000
Arroyo 3B	254	Green slimy floating plant matter in water.	Water Quality	37.9018810000	-122.5394750000
Arroyo 3B	300	Storm drain outfall under bridge	outfall	37.9019840000	-122.5395790000
Arroyo 3B	321	Municipal outfall, under Park St. bridge	outfall	37.9020230000	-122.5396340000
Arroyo 3B	342	Five 4 inch pipes right bank	outfall	37.9020500000	-122.5396950000
Arroyo 3B	400	Undercutting on Bank	Erosion	37.9021390000	-122.5398600000
Arroyo 3B	415	Old water heater close to bank edge.	debris	37.9021640000	-122.5399120000
Arroyo 3B	456	Capped outfall	outfall	37.9022390000	-122.5400460000
Arroyo 3B	494	Old tank at edge of bank (water heater?)	debris	37.9022900000	-122.5401620000
Arroyo 3B	540	Silty, bank eroding between 540-550	water quality	37.9023670000	-122.5402980000
Arroyo 3B	491	PVC, 1 inch to creek running up to house (sic)	Pipe	37.9024240000	-122.5404190000
Arroyo 3B	612	2" pipe into water from bank	pipe	37.9024570000	-122.5404790000
Arroyo 3B	657	PVC 2" pipe	Pipe	37.9025250000	-122.5406080000
Arroyo 3B	680	Old rusty tank in creek	debris	37.9025580000	-122.5406720000

STREAM NAME	DISTANCE FROM DATUM (FEET)	NOTE	FEATURE TYPE	LATITUDE	LONGITUDE
Arroyo 3B	847	Rock wall undercut at creek level	undercut	37.9028080000	-122.5411570000
Arroyo 3B	969	Metal pipe 2" diameter from retaining wall.	Outfall	37.9029960000	-122.5415050000
Arroyo 4A	0	Datum at upstream end of short retaining wall on rt side. White wood (Miller av.) guard rail just above on same side.	Datum	37.9038900000	-122.5442430000
Arroyo 3C	1110	Deck of house over stream;erosion underneath.	Erosion	37.9032770000	-122.5417370000
Arroyo 3C	1254	Roof Downspout rt side	Outfall	37.9033570000	-122.5420830000
Arroyo 3C	1300	Bridge from 1300-1350. Large amounts of silt under bridge. Stream channalization begins here.	Erosion	37.9033410000	-122.5422430000
Arroyo 3C	1315	Outfall under bridge; rt side	Outfall	37.9033260000	-122.5422660000
Arroyo 3C	1396	Bridge 1396-1428	Bridge	37.9033070000	-122.5426050000
Arroyo 3C	1389	Concrete stream bed begins	misc	37.9033040000	-122.5425620000
Arroyo 3C	1399	Outfall; left bank	Outfall	37.9033140000	-122.5426280000
Arroyo 3C	1430	Overhead pipes crossing stream	misc	37.9033470000	-122.5427290000
Arroyo 3C	1434	10" outfall	outfall	37.9033540000	-122.5427450000
Arroyo 3C	1439	10" outfalls	Outfalls	37.9033500000	-122.5427570000
Arroyo 3C	1442	Concrete stream bed ends	misc	37.9033610000	-122.5427620000
Arroyo 3C	1547	MV lumber bridge.	Bridge	37.9035850000	-122.5434110000
Arroyo 3C	1681	Heavy vegetation on right bank	vegetation	37.9036250000	-122.5435190000
Arroyo 3C	1751	Willow thicket begins on left bank.	Vegetation	37.9037010000	-122.5437430000
Arroyo 3C	1780	Storm drains outfall high on left bank.	outfall	37.9037340000	-122.5438390000
Arroyo 3C	1787	Concrete wall failing left bank	Erosion	37.9037430000	-122.5438610000
Arroyo 3C	1790	Low concrete wall in stream.	misc	37.9037460000	-122.5438710000
Arroyo 3C	1816*	Beginning of bridge *MAPINFO POINTS INACCURATE	Bridge	37.9037490000	-122.5438830000
Arroyo 3C	1822*	end of pool 1700-1822	Pool	37.9037510000	-122.5438890000
Arroyo 3C	1832*	end of bridge	bridge	37.9037530000	-122.5438940000
Arroyo 3C	1835*	Begin MV lumber building	building	37.9037540000	-122.5438970000
Arroyo 3C	1846*	outfall pipe left bank high	outfall	37.9037550000	-122.5439000000
Arroyo 3C	1852*	natural bank begins	misc	37.9037560000	-122.5439030000

STREAM NAME	DISTANCE FROM DATUM (FEET)	NOTE	FEATURE TYPE	LATITUDE	LONGITUDE
Arroyo 3C	1854*	out fall pipe left bank low	outfall	37.9037570000	-122.5439060000
Arroyo 3C	1857*	end of building	building	37.9037590000	-122.5439100000
Arroyo 3C	1881*	large pittosporen; left bank	vegetation	37.9037610000	-122.5439170000
Arroyo 3C	1895*	house/shed cantilevered over stream on rt.	misc	37.9037620000	-122.5439200000
Arroyo 4A	100	Debris in stream water from apartment. Debris also on upstream side of apartment, tree cuttings, branches, etc.	debris	37.9041330000	-122.5443610000
Arroyo 4A	150	Tree fell in mid Oct storm across stream.	debris	37.9040930000	-122.5444930000
Arroyo 4C	969	Confluence of Old Mill and Arroyo	Confluence	37.9046040000	-122.5454030000
Arroyo 4B	216	Plastic culvert pipe 18" dia. small discharge of water w/ algae	outfall	37.9040980000	-122.5447000000
Arroyo 4B	289	Branches and debris in channel and on bank.	debris	37.9041420000	-122.5448240000
Arroyo 4B	296	Scum in water (yellow-green 7 odorous)	Water Quality	37.9041500000	-122.5448480000
Arroyo 4B	361	361-381 Pool w/ 7 trout 2"-4"	Pool Fish	37.9041870000	-122.5449110000
Arroyo 4B	314	Outfall pipe 12" dia.	Outfall	37.9041600000	-122.5448690000
Arroyo 4B	456	Concrete wall outfall	Outfall	37.9042830000	-122.5448900000
Arroyo 4B	461	Rusty 2" metal pipe, poss. unused	outfall	37.9042910000	-122.5448790000
Arroyo 4B	479	Patio outfall, debris in stream	Outfall, debris	37.9043010000	-122.5448690000
Arroyo 4B	512	2" coragated drip lines; rt side. @515 ft storm discharge pipes	outfall	37.9043200000	-122.5448450000
Arroyo 4B	583	Muni outfall w/ yellow hairy algae near outfall.	Outfall	37.9044490000	-122.5447640000
Arroyo 4B	583	10-12 fish .5-.75 inch	Fish	37.9044510000	-122.5447560000
Arroyo 4B	613	Gelatinous orange algae at edge of water	algae	37.9044760000	-122.5447660000
Arroyo 4B	657	debris (logs and leaves) dumped into stream	Debris	37.9045230000	-122.5448270000
Arroyo 4B	721	2"-3" black flex pipes from hot tub area under deck.	outfall	37.9045340000	-122.5449080000
Arroyo 4B	724	vegetative debris in channel	debris	37.9045360000	-122.5449210000
Arroyo 4B	823	Undercut concrete shelf rt. side.	undercut	37.9045190000	-122.5450870000

STREAM NAME	DISTANCE FROM DATUM (FEET)	NOTE	FEATURE TYPE	LATITUDE	LONGITUDE
Arroyo 4B	888	Outfall w/ soapy water discharging, poss washing machine. Alex Lazzarini's owner says "maybe I was washn car..."	Water quality	37.9046370000	-122.5451000000
Arroyo 4B	900	Nest ground nesting bird on top of bank, left side.	wildlife	37.9046520000	-122.5451470000
Arroyo 4B	944	thick green brown algae	algae	37.9046220000	-122.5453210000
Arroyo 4C	1025	Culvert junction not intact, small seep coming in to culvert.	Seep	37.9047430000	-122.5454900000
Arroyo 4C	1105	Yard clippings in stream from residence; overflowing debris pile on bank.	Debris.	37.9049380000	-122.5456140000
Arroyo 4C	1170	Pool filled with silt.	Erosion	37.9053940000	-122.5458970000
Arroyo 4C	1191	end of tunnel- grey particulate scum in water in 3 dimensions.	Water quality	37.9054690000	-122.5459450000
Arroyo 4C	1202	Storm drain, direct outfall to stream.	outfall	37.9056180000	-122.5460470000
Arroyo 4C	1236	12-16" muni outfall	outfall	37.9056960000	-122.5460950000
Arroyo 4C	1241	Catchment basin, repair underway. Gravel and concrete in creek.	Debris	37.9057140000	-122.5461040000
Arroyo 4C	XXXX	this should be the confluence. Strm lyer had errors 969 feet meas. frm throckmrtn @ 1567	misc	37.9051080000	-122.5457250000
Arroyo 4C	1567	End of tunnel. Upstream side of throckmorton ave.	bridge	37.9066180000	-122.5465090000
Arroyo 4C	1253	end of tunnel	bridge	37.9058120000	-122.5461430000
Arroyo 4C	1389	Roof outfall	outfall	37.9061560000	-122.5462960000
Arroyo 4C	1419	outfall from gutter	outfall	37.9062350000	-122.5463330000
Arroyo 4C	1438	patio drain	outfall	37.9062800000	-122.5463570000
Arroyo 4C	1438	Pair of pipes rt. bank	outfall	37.9062860000	-122.5463490000
Arroyo 4C	1446	outfall	outfall	37.9063120000	-122.5463650000
Arroyo 4C	1556	Outfall	outfall	37.9065920000	-122.5464940000
Arroyo 4C	1580	City outfall	outfall	37.9066460000	-122.5465020000
Arroyo 4C	1589	Outfall 1.5'	Outfall	37.9066780000	-122.5465060000

STREAM NAME	DISTANCE FROM DATUM (FEET)	NOTE	FEATURE TYPE	LATITUDE	LONGITUDE
Arroyo 4C	1600	Flower shop debris in stream. Dozens of rubber bands + old flowers. Contact Annabella owner.	Debris	37.9067100000	-122.5465140000
Arroyo 4C	1614	Drain opening in wall at flower shop w/ algae growth.	outfall	37.9067490000	-122.5465220000
Arroyo 4C	1622	Outfall opening in wall w/ algae	outfall	37.9067700000	-122.5465230000
Arroyo 4C	1606	Outfall opening in wall w/ algae	outfall	37.9067300000	-122.5465180000
Arroyo 4C	1663	Crayfish in stream	Fish	37.9068490000	-122.5465350000
Arroyo 4C	1686	Grayish foam in water in rocky area.	Water quality	37.9069140000	-122.5465440000
Arroyo 4C	1717	4 inch PVC pipe outfall w/ algae	Outfall	37.9070010000	-122.5465560000
Arroyo 4C	1721	2 ground water seeps coming thru concrete wall, algae below left side.	seeps	37.9070120000	-122.5465590000
Arroyo 4C	1734	2 inch metal outfall left side.	Outfall	37.9070490000	-122.5465640000
Arroyo 4C	1760	4 inch new black plastic pipe	outfall	37.9071190000	-122.5465740000
Arroyo 4C	1800	6 inch black pvc pipe outfall	outfall	37.9072030000	-122.5465870000
Arroyo 4C	1849	Undercut concrete wall.	undercut	37.9073350000	-122.5466040000
Arroyo 6A	0	Datam for Arroyo 6. At foot of rdwd deck. Jst. dwnstrm of chaninlink fnce	Datum	37.9140780000	-122.5506100000
Arroyo 6B	376	Bridge 366-386	Bridge	37.9150620000	-122.5509760000
Arroyo 6A	150	Dead rat	Wildlife	37.9144790000	-122.5507270000
Arroyo 6B	209	Outfall; 3 ft diameter; no flow	Outfall	37.9146310000	-122.5507710000
Arroyo 6B	223	223-237 Driveway Bridge	Bridge	37.9146710000	-122.5508000000
Arroyo 6B	248	Outfall 1.5 ft Diameter	Outfall	37.9147410000	-122.5508170000
Arroyo 6B	251	251-267 Driveway Bridge	Bridge	37.9147710000	-122.5508170000
Arroyo 6B	296	296-308 Driveway Bridge. Erosion under bridge	Erosion & Bridge	37.9148620000	-122.5508590000
Arroyo 6B	500	500 foot location for data entry	misc	37.9153840000	-122.5511100000
Arroyo 6B	398	2 Crawfish	wildlife	37.9151160000	-122.5509960000
Arroyo 6B	437	Concrete dam	dam	37.9152240000	-122.5510380000
Arroyo 6B	513	Concrete Dam	Dam	37.9154110000	-122.5511380000

STREAM NAME	DISTANCE FROM DATUM (FEET)	NOTE	FEATURE TYPE	LATITUDE	LONGITUDE
Arroyo 6B	531	Inflow or outflow pipe + heater ? attatched.	outfall	37.9154500000	-122.5511750000
Arroyo 6B	566	566-574; Driveway Bridge	Bridge	37.9155260000	-122.5512520000
Arroyo 6B	582	Outfall 2 ft. Diameter	Outfall	37.9155600000	-122.5512860000
Arroyo 6B	600	Data entry marker	misc	37.9155990000	-122.5513240000
Arroyo 6B	627	Erosion on rt. bank; held in check by wire mesh	Erosion	37.9156530000	-122.5513850000
Arroyo 6B	637	Rubber hose outfall	Outfall	37.9156760000	-122.5514070000
Arroyo 6B	720	Overhead Pipe crossing stream	misc	37.9158560000	-122.5515800000
Arroyo 6B	762	Outfall 1ft. diameter	Outfall	37.9159460000	-122.5516690000
Arroyo 6B	775	775-779 Footpath and hose line overpass	misc	37.9159730000	-122.5516960000
Arroyo 6B	900	Diversion Pump and plumbing	Diversion	37.9162900000	-122.5518430000
Arroyo 6B	953	9 Concrete Cylinders protruding up from concrete streambed	misc	37.9163450000	-122.5518710000
Arroyo 6B	980	Weir in Stream causing heavy upstream sediment deposition	dam	37.9163850000	-122.5518820000
Old Mill 3A	0	Datum for Old Mill Section 3 @ Isabelle Kauer Bench on right bank.	Datum	37.9049320000	-122.5525660000
Old Mill 1-2A	0	Datum for Old Mill 1-2	Datum	37.9050190000	-122.5473240000
Arroyo 6C	1030	Historic railroad bridge (driveway bridge now)	Bridge	37.9164050000	-122.5518850000
Arroyo 6C	1051	Outfall	outfall	37.9164160000	-122.5518870000
Arroyo 6C	1105	12" wide black PVC outfall	outfall	37.9164410000	-122.5518940000
Arroyo 6C	1109	outfall	outfall	37.9164450000	-122.5518940000
Arroyo 6C	1124	Corte Madera Ave. Bridge	Bridge	37.9164520000	-122.5518960000
Arroyo 6C	1186	outfall	outfall	37.9165990000	-122.5519260000
Arroyo 6C	1235	Erosion on Bank	Erosion	37.9167340000	-122.5519030000
Arroyo 6C	1322	Erosion	Erosion	37.9169740000	-122.5519300000
Arroyo 6C	1566	erosion	erosion	37.9175330000	-122.5521420000
Arroyo 6C	1661	human made dam	dam	37.9177790000	-122.5522210000
Arroyo 6C	1623	Marguerite Bridge	bridge	37.9176780000	-122.5521970000
Arroyo 6C	1769	stream confluence, pipe under road	misc	37.9181120000	-122.5522830000
Arroyo 6C	1778	Human made dam (park bench)	dam	37.9181450000	-122.5522850000

STREAM NAME	DISTANCE FROM DATUM (FEET)	NOTE	FEATURE TYPE	LATITUDE	LONGITUDE
Old Mill 1-2A	36	Dowds Co. builds dam ech sprng. wood & visquene plast 2 ft tall. Regrds dam/pool importnt fsh hab.	Dam	37.9050620000	-122.5473770000
Old Mill 1-2A	56	End of Bldg	Culvert	37.9050970000	-122.5474990000
Old Mill 1-2A	74	Concrete Bulkhead start, left side	misc	37.9051210000	-122.5475780000
Old Mill 1-2B	311	311-336 Retaining wall drain outfalls	Outfall	37.9049690000	-122.5482170000
Old Mill 1-2B	333	Overhanging pipe	Misc	37.9049450000	-122.5482860000
Old Mill 1-2B	358	A 4" and a 6" pipe overhead	Misc	37.9049190000	-122.5483760000
Old Mill 1-2B	200	Construction debris, Mill Valley Hotel remodel	Debris	37.9050330000	-122.5479980000
Old Mill 1-2B	400	Outfall, Pipe buried in stream	Outfall	37.9047980000	-122.5489430000
Old Mill 1-2B	475	Sink in stream 6" above water line	debris	37.9047810000	-122.5490520000
Old Mill 1-2B	492	silt in pool	silt	37.9047760000	-122.5490960000
Old Mill 1-2B	640	Small channel entering stream	Confluence	37.9047090000	-122.5493370000
Old Mill 1-2B	524	Water diversion pipe w/ screen in pool	diversion	37.9047710000	-122.5491330000
Old Mill 1-2B	540	Woody Debris on Bank	Debris	37.9047670000	-122.5491740000
Old Mill 1-2B	600	Silt in pool	Silt	37.9047540000	-122.5492440000
Old Mill 1-2B	619	Old irrigation pumping system; probably defunct	Diversion	37.9047420000	-122.5492780000
Old Mill 1-2B	672	Outfall, 6" terra cotta pipe 12' above H20 line	Outfall	37.9046860000	-122.5493860000
Old Mill 1-2B	686	Outfall defunct pipe at vegetation line	Outfall	37.9046810000	-122.5493990000
Old Mill 1-2B	722	Silt in stream	Silt	37.9046530000	-122.5494530000
Old Mill 1-2B	728	White 4" outfall, 4' above water line.Drip irrigation lines on bank.	Outfall	37.9046470000	-122.5494680000
Old Mill 1-2B	758	Yard clippings thrown over fence into stream (ladder in place to get debris over fence)	Debris	37.9046320000	-122.5494990000
Old Mill 1-2B	878	Center of Ethel Bridge	Bridge	37.9045950000	-122.5495740000
Old Mill 1-2B	825	Retaining wall w/ some erosion problems	erosion	37.9046110000	-122.5495410000
Old Mill 1-2B	889	Pipe overhead in stream	misc	37.9045890000	-122.5495860000
Old Mill 1-2B	928	Two submersible pumps w/ hoses & extention cords all in stream	Diversion	37.9045770000	-122.5496950000
Old Mill 1-2B	944	Culvert 2' diameter	Outfall	37.9045730000	-122.5497800000

STREAM NAME	DISTANCE FROM DATUM (FEET)	NOTE	FEATURE TYPE	LATITUDE	LONGITUDE
Old Mill 1-2B	944	944-989 Right side concrete wall w/ 7 drainage pipes thru wall.	outfall	37.9045690000	-122.5498520000
Old Mill 1-2B	937	Broken MMWD supply pipe, pipe was repaired in Oct '96.	misc	37.9045740000	-122.5497230000
Old Mill 1-2B	1346	Concrete gutter dripping water. 15 ft from stream	outfall	37.9045820000	-122.5508650000
Old Mill 1-2C	1045	1045-1100 Lots of Dalis growing on rt side.	vegetation	37.9045680000	-122.5501430000
Old Mill 1-2C	1143	Rootwad	Vegetation	37.9045660000	-122.5503130000
Old Mill 1-2C	1239	1239-1257 Log overhanging and parallel to left side of stream	vegetation	37.9045360000	-122.5505270000
Old Mill 1-2C	1410	Pipe overhead, 20 feet above stream	misc	37.9045910000	-122.5509570000
Old Mill 1-2C	1400	Redwood rootwad	vegetation	37.9045870000	-122.5509360000
Old Mill 1-2C	1500	Storm drain entering stream thru retaining wall.	outfall	37.9046270000	-122.5511650000
Old Mill 1-2C	1575	Greyish scum w/ bubbles on the water surface	Water Quality	37.9046510000	-122.5513240000
Old Mill 1-2C	1741	1.5 ft weir	misc	37.9047480000	-122.5519040000
Old Mill 1-2C	1795	Old Mill Monument	Misc	37.9047840000	-122.5520760000
Old Mill 1-2C	1810	Large log in stream	Vegetation	37.9047910000	-122.5521100000
Old Mill 1-2C	1834	Large log in stream	Vegetation	37.9048150000	-122.5522200000
Old Mill 1-2C	1853	Brown foam in water	Water quality	37.9048260000	-122.5522710000
Old Mill 1-2C	1935	1929-1944 Cascade Bridge	Bridge	37.9049140000	-122.5525160000
Old Mill 1-2C	1970	Outfall, city; from under ground	outfall	37.9049290000	-122.5525580000
Old Mill 3A	20	Log in stream, many paths, dirt entering stream	erosion	37.9049510000	-122.5526160000
Old Mill 3A	200	Sharp turn in creek at end of survey section	misc	37.9051870000	-122.5531930000
Old Mill 3B	279	Bank sliding, sediment	erosion	37.9052390000	-122.5534230000
Old Mill 3B	452	lots of sand and mud in stream	silt	37.9055580000	-122.5537030000
Old Mill 3B	507	507-519 driveway bridge	Bridge	37.9056900000	-122.5536990000
Old Mill 3B	586	sediment in pool	silt	37.9058280000	-122.5539240000
Old Mill 3B	677	677 sandy sediment in pool	silt	37.9059050000	-122.5540760000
Old Mill 3B	681	beginning of retaining wall (landmark)	misc	37.9058710000	-122.5541440000

STREAM NAME	DISTANCE FROM DATUM (FEET)	NOTE	FEATURE TYPE	LATITUDE	LONGITUDE
Old Mill 3B	765	765-783 cascade dr bridge (near Laurel)	bridge	37.9057980000	-122.5543210000
Old Mill 3B	797	foot bridge adjacent to Cascade dr bridge	Bridge	37.9057940000	-122.5543310000
Old Mill 3B	820	Municipal outfall	outfall	37.9057460000	-122.5543880000
Old Mill 3B	895	Lots of Dalis plants, left bank+ more woody debris	Vegetation	37.9055720000	-122.5544880000
Arroyo 5A	0	Datum for survey section 5	Datum	37.9090760000	-122.5468750000
Arroyo 5A	1	Outfall pipe from hillside av.	outfall	37.9090810000	-122.5468780000
Arroyo 5A	50	Three fallen trees above stream; one deterioration & two alive	debris	37.9092080000	-122.5469200000
Arroyo 5B	147	12 in diameter tree across stream	debris	37.9094600000	-122.5470420000
Arroyo 5B	161	5 ft boulder in stream center	debris	37.9094900000	-122.5470580000
Arroyo 5B	230	large patch of Wandering Jew plants	vegetation	37.9096240000	-122.5472210000
Arroyo 5B	300	20 ft section of severely eroded bank	erosion	37.9097600000	-122.5473870000
Arroyo 5B	330	wide, deep pool w/ undercut bank	pool	37.9098190000	-122.5474500000
Arroyo 5B	439	10 in pipe across sttream. Rt bank has chain link fence retaining wall	misc	37.9100490000	-122.5477070000
Arroyo 5B	491	begining of cement retaining wall	misc	37.9102130000	-122.5478790000
Arroyo 5B	500	start of deep pool 4 ft deep	pool	37.9102280000	-122.5479010000
Arroyo 5B	539	529-548 cement overpass	Bridge	37.9103070000	-122.5479820000
Arroyo 5B	549	10 in drain pipe enters stream	outfall	37.9103290000	-122.5480080000
Arroyo 5B	607	2 4 inch drain pipes, left bank	outfall	37.9104530000	-122.5481380000
Arroyo 5B	637	6 in drain pipe left bank	outfall	37.9105270000	-122.5481750000
Arroyo 5B	647	2 4 in drain pipes, left bank. Concrete retaining wall common in this part of stream	outfall	37.9105560000	-122.5481780000
Arroyo 5B	800	800 foot gis marker	misc	37.9109400000	-122.5481470000
Arroyo 5B	835	Numerous small outfall pipes	outfall	37.9110170000	-122.5482160000
Arroyo 5B	850	840-857 Eldridge street bridge	Bridge	37.9110850000	-122.5483170000
Arroyo 5B	864	10 in outfall pipe on left bank	outfall	37.9111120000	-122.5483550000
Arroyo 5B	893	Outfall pipe left bank	outfall	37.9111680000	-122.5484280000
Arroyo 5B	1000	End survey plot.Marked by 3 in dia. root protrudin frm left bank. Retaining wall 6 ft above strmbed.	misc	37.9113670000	-122.5487020000

STREAM NAME	DISTANCE FROM DATUM (FEET)	NOTE	FEATURE TYPE	LATITUDE	LONGITUDE
Arroyo 4C	1916	12 in outfall, left bank	Outfall	No Data	No Data
Arroyo 4C	1945	Foot Bridge	Bridge	No Data	No Data
Arroyo 4C	2000	End of survey section @ end of red apt building. Young alder tree. Start of pickett fence.	misc	No Data	No Data
Old Mill 3C	920	tree in stream, leaning over stream	vegetation	No Data	No Data
Old Mill 3	981	Outfall, right bank 6" corrugated	Outfall	No Data	No Data
Old Mill 3	1010	corrugated outfall, left side	Outfall	No Data	No Data
Old Mill 3	1054	Driveway bridge	Bridge	No Data	No Data

APPENDIX 4- FIELD DATA FORM DESCRIPTIONS

Below are descriptions of data that were collected and entered into spreadsheets for analysis. Data are not included in this paper but are available upon request from Andy Peri (andyperi@yahoo.com)

<u>Spread sheet Heading</u>	<u>Description of Data in Field</u>
Stream/Survey Plot	This is the name of the survey plot. Name designations begin with the stream name and are followed by a number and a letter. Arroyo2C means: • Arroyo Corte Madera del Presidio • The 2 indicates that this is section 2 of the stream survey (the survey sections begin with 2 because section 1 was a tidally influenced section of the stream and outside of the freshwater system being surveyed; there are seven sections in all). The sections are numbered sequentially beginning with the downstream most section • The C indicates that this is the third survey plot in the survey section.
Date	Date is in the form, MM/DD/YYYY
Location	A short narrative of the survey plot location. This corresponds to "nearest cross street or bridge" field on data sheet.
Section/Feet	This corresponds to the starting and ending foot location of the survey plot. Each 2000 survey section began at a datum, which was designated zero feet. Surveys plots were located at foot location 100-200, 900 to 1000, and 1800 to 1900, except in cases where survey fell in a culvert or other man-made structure that made habitat surveying impossible.
Water Present Water Flowing	Both of these fields have either a "y" or an "n" corresponding to yes or no.
Crayfish	Number of crayfish observed.
Number of Fish	Number of fish observed (non-crayfish).
Fish size	Average fish size in inches
Water Clarity	Survey was conducted, for the most part, during the

	low flow season. The water was therefore clear in all cases.
Green Hairy Algae Orange Algae Brown Algae on Gravel	The presence of any of these algae in the stream is noted by the presence of an "x" in the spreadsheet.
Other Algae	Description of other algae.
Bankfull Width (ft) 0' Bankfull Width (ft) 50' Bankfull Width (ft) 100'	This is the measured width of the stream at bankfull. This measurement was taken in three location for each survey plot at the 0', 50' and the 100' foot locations.
Bankfull Depth1 (in) (0') Bankfull Depth2 (in) (0') Bankfull Depth3 (in) (0') Bankfull Depth4 (in) (0') Bankfull Depth5 (in) (0')	These measurements were taken at equally spaced intervals across the stream's width from the bankfull height. These depth measurements were also taken at the 50' and the 100' location of each survey plot (only the 0' foot locations are shown to the left).
Maximum Depth (in) (0')	Maximum Bankfull Depth on the line that transects the stream at 0', 50' and 100' (only the 0' is shown at left).
Stream Channel/Bank Shape- Channelized V-shaped Wide Undercut/Overhanging Artificial	Percentage of stream that corresponds to one of the shapes shown and described in the Survey Manual. Sum of values should equal 100 (100 %).
Pool Data- Maximum Length, Maximum Depth, Maximum Width, Riffle Depth.	These measurements were placed into the spreadsheet as reported by stream surveyors. These measurements, by virtue of being maxima, overestimate the volume of pools. These fields are repeated in the spreadsheet two additional times for additional pools that sometimes occur within survey plots (there were never more than three pools in a

	given plot).
Stream Substrate	This section contains fields used to evaluate stream substrate composition. The fraction of 100' section field is followed by the substrate types, silt/clay/mud, sand, gravel, cobbles, boulders, cement and bedrock. This sequence of fields is repeated four times. The "Streambed Substrate Composition" table in the data sheet shown in the MVWP Volunteer Stream Survey Manual (Appendix 2) is different than the one used during earlier surveys.
Barriers to Fish Migration	The database contains the letter 'n' for all records indicating that no absolute barriers were found.
Woody Debris	Database contains quantity of woody debris found in survey plots. There are three categories, functional 6"-12", functional >12" and non-functional 6"-12".
Bank Condition	These field contain percentages of banks that are collapsed, actively contributing sediment, vegetated, unvegetated-natural and unvegetated-artificial. Because of the overlapping nature of these questions the total for this section can be greater than 100%
Percentage of Artificial Bank Protection	Total percentage of artificial bank protection within survey plot.
Bank Vegetation	Database contains either "o" for occasional or "c" for common. If field was left blank, there was none of the vegetation type observed.
Average Width of Vegetation	This value was taken directly from field datasheets. As per the field data sheet, the "Av. Width Left" and "Av. Width Right" values were reported looking *upstream*.
Percentage of Bankfull Area Covered by Overhanging Vegetation	This portion of the spreadsheet is separated into three vegetation heights, one for 0'-3', 3' to 6', and >6'. The absence of a marking indicates the absence of such vegetation and an "x" in the field indicates its presence.
Percent Shade	Percent shade values are taken from the field data sheet. The categories are 0-25, 25-50, 50-75 and 75-100.
Adjacent Land Uses	The spreadsheet has columns that correspond to the

	categories listed in the field data sheet. An “x” in the field indicates the presence of that land-use feature.
Stream Condition Summary	Each of these fields correspond to the lists from the field data sheet. Fields contain 1’s or 2’s corresponding to “occasional” or “common”, respectively. The absence of a value indicates that the feature was not seen.
Notes	Any relevant field notes.

APPENDIX 5- MVWP STREAM SURVEY VOLUNTEERS

I would like to make a special acknowledgment to Lindsay Rehm whose life was tragically cut short during the survey period. I would also like to acknowledge Nancy Dempster who reignited the flickering torch of the Mill Valley Watershed Project and whose vision lighted the way for the creation of the Mill Valley StreamKeepers, a vibrant, action-oriented and wonderfully effective grass-roots watershed organization.

It is with deepest gratitude that I acknowledge the support of all of the Mill Valley Watershed Project supporters and volunteers that made this project and this research project possible.

Julia Crawford
Kallie Kull
Dominic Roques
Nan Breidenstein
Nancy Dempster
Ted Daum
Shannon Fitzgarald
Tammie Grant
John Haskins
Dale Hopkins
Olivia Jacobs
Margaret Johnston
Sue Markusfeld
Chris McDuff
Annette Nibley
Harry Seraydarian
Gwen Sterritt
Lindsay Rehm
Dominic Roques
John Rich

REFERENCES

Bay Area Action 1993: A Creek Runs Through It: The Story of San Francisquito. Palo Alto, Ca. Video- (30 min)

California Department Of Fish And Game 2002: Quality Assurance Project Plan For The California Stream Bioassessment Procedure (CSBP). Water pollution control laboratory, aquatic bioassessment laboratory. Revision date – September 18, 2002

California State Coastal Conservancy 1997: Funding Coastal Resource Conservation, Restoration and Enhancement in California. California State Coastal Conservancy, Oakland, California, November, 1997

City of Mill Valley Public Works: City of Mill Valley “Blue Book” Parcel Maps.

Collins, Laurel 1998: Sediment Sources and Fluvial Geomorphic Processes of Lower Novato Creek Watershed. Report to Marin County Flood Control And Water Conservation District. July, 1998, p. 30.

Contra Costa Watershed Forum 2001: Data Collection Parameters and Protocols. Contra Costa Watershed Forum, Summer 2001

Fairly, Lincoln 1987: Mount Tamalpias- A History Scottwall Associates, San Francisco, CA

Firehock, Karen and Jacquiline Doherty 1995: “A Citizen’s Streambank Restoration Handbook.” Izaak Walton League, January, 1995.

Flosi, Gary and Forrest L. Reynolds 1994: California Salmonid Stream Habitat Restoration Manual State of California Resources Agency and the Department of Fish and Game.

Leidy, R.A. 1999: “Leidy Fish Survey 1992-1998- Bay Area Stream Fishes” Version 1.2 San Francisco Bay Ecoatlas, San Francisco Estuary Institute. Released July 9.

Leopold, Luna B. 1994: A View of the River Harvard University Press, Cambridge, Massachusetts.

Michaud, Joy P and Sandra Noel 1991: A Citizen’s Guide to Understanding and monitoring Lakes and Streams. Washington State Department of Ecology Publication Office, Publication # 94-149.

Mill Valley General Plan Steering Committee 1990: "1990 Mill Valley General Plan" City of Mill Valley.

Mill Valley Public Works: Blue Book Parcel Maps. City of Mill Valley.

Prunuske Chatham, Inc. 1997: "Lagunitas Creek Sediment and Riparian Management Plan" Marin Municipal Water District (February)

Resource Conservation District of the Santa Monica Mountains 1999: "Stable and Horse Management in the Malibu Creek Watershed" Resource Conservation District of the Santa Monica Mountains, Topanga, California

Roques, Dominic 1997a: "The Mill Valley Watershed Volunteer Stream Survey Manuel" The Mill Valley Watershed Project, Mill Valley, CA. January.

Roques, Dominic 1997b: Mill Valley Watershed Project Map. Mill Valley Watershed Project, Mill Valley, CA.

Schoenherr, Allan A. 1992: A Natural History of California. University of California Press, Berkeley, California.

Schulman, Roberta F. and Jessica A. Johnson 1994: Urbanization and Water Quality, A Guide to Protecting the Urban Environment, Terrene Institute, Washington DC. March, 1994.

Spitz, Barry 1997: Mill Valley, the Early Years Potrero Meadow Publishing Company, Mill Valley, CA

Topo! 1999: Interactive Maps on CD ROM. Wildflower Productions, San Francisco, California.

University of California Davis 1998: Information Center for the Environment (ICE) website. Project is a cooperative effort of environmental scientists at University of California, Davis and collaborators at over thirty private, state, federal, and international organizations. Website address is: http://endeavor.des.ucdavis.edu/groups/

USEPA 1994a: A Watershed Assessment Primer. United States Environmental Protection Agency, December, 1994

USEPA, 1994b: Streamwalk- A Stream Monitoring Tool for Citizens. U.S. Environmental Protection Agency Water Division. EPA910-B-94-002, July.

USEPA ,1994c: EPA Brochure EPA-841-F-94-005, 1994.

USEPA, 1997: Volunteer Stream Monitoring: A Methods Manual. United States Environmental Protection Agency, Office of Water, November, 1997

USEPA, 1998: “Clean Water Action Plan: Restoring and Protecting America’s Waters” EPA-840-R-98-001.

Watershed Professionals Network, 1999: “Oregon Watershed Assessment Manual”. Prepared for the Governor’s Watershed Enhancement Board, Salem, Oregon. June 1999.