The Malibu Creek Watershed:

A Framework for Monitoring, Enhancement and Action

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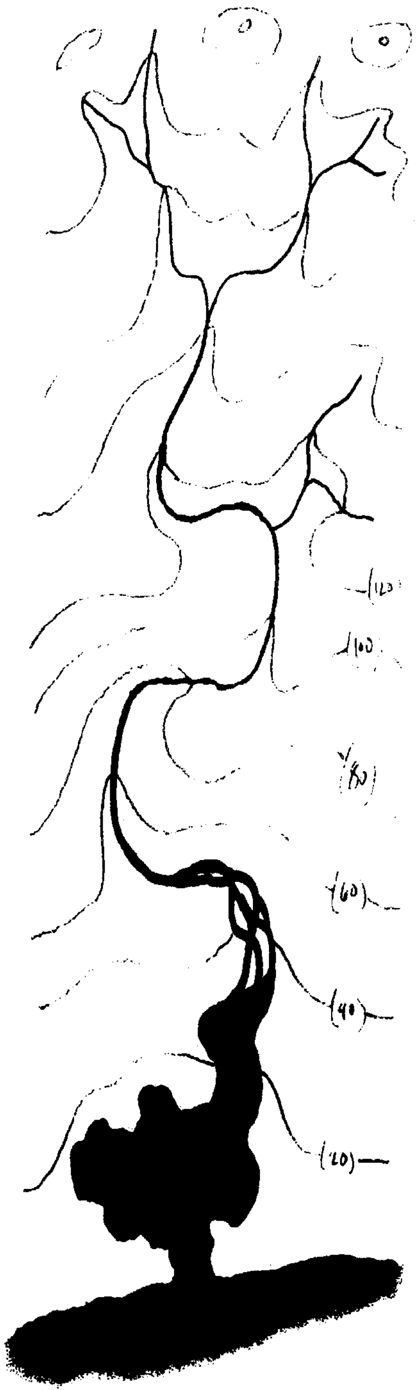

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Finally, we dedicate this project to the memory of Professor John Tillman Lyle who nurtured the 606 Studio since its inception. The success of the 606 Studio over the years is due in large part to his dedication and commitment.

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Section 1

Introduction

Vision for the Watershed

It's late November 2018. The rains have begun and so has the annual steelhead migration from the ocean upstream into the Malibu Creek Watershed. The fish are in search of the perfect gravelly area to spawn. People are sitting on blankets in the dappled sunlight beneath the giant sycamores and alder trees, watching their kids. Children walk along the stream waiting to catch a glimpse of the shiny silver green bodies of steelhead trout as they leap out of the water and announce their presence. The peaceful sound of a rushing stream is periodically interrupted by the excited shouts of children as they follow the steelhead trout upstream.

The streams in the watershed have returned to their natural state, the water is clean and cool, the vegetation is flourishing and the wildlife is abundant. People have also returned to the stream. Swimming holes, on perennial streams, are crowded with kids during the hot dry summers. Bird watchers flock to the lagoon to catch a glimpse of the incredible diversity of migratory birds. Surfers enjoy the excellent surf break and clean water at Surfrider Beach, and people can be seen hiking, picnicking, and enjoying the beauty that is the Malibu Creek Watershed. This is quite a contrast to twenty years earlier when the watershed was a very different place.

In 1998, the health of the watershed, especially water quality, began to improve. Most visible were the teams of volunteers who began to monitor the streams within the Malibu Creek watershed. They walked many miles, surveyed stream reaches, tested water quality and sampled macroinvertebrates. The information was collected and distributed to various local and state agencies, which in turn, led efforts to make changes in policy.

Through the efforts of these volunteers, agencies and local governments have responded to the environmental concerns of citizens in the Malibu Creek Watershed. Zoning and building regulations are far different from what they were twenty years ago. Now, parking lots are smaller, greener, and the paving is porous, allowing storm water to infiltrate into the soil below. Vibrant, tree lined pedestrian-friendly shopping streets have replaced strip malls. The water that drains from parking lots flows into bioswales that filter out pollutants before they can enter the streams. Today, if you look at the Malibu Creek Watershed, there is a sense of community that celebrates the beautiful natural surroundings that attracted residents to this area in the first place.

Purpose

This project is a step towards achieving the above vision for the Malibu Creek Watershed. The purpose of this project is to design a citizen volunteer monitoring program, that over the long term can evaluate the water quality of the entire Malibu Creek Watershed and target areas for future studies, protection, restoration, and enhancement. The ultimate hope for this project is that citizens and agencies will work together to protect the Malibu Creek Watershed, identify problems, and implement measures to correct these problems.

The information collected by citizen volunteer monitors can be used to better understand the unique physical, biological, and recreational resources of the area. This information can hopefully be used to balance the need for human development while maintaining the ecological integrity and unique natural character of the Malibu Creek Watershed. It is the hope of the project team that private sector developers and local planning agencies work together for increased cooperation in implementing the recommendations that improve ecological functioning within the watershed.

This project document is intended for active use by citizens, local, state, and federal agencies and non-profit organizations concerned about the Malibu Creek Watershed. This project document begins with goals and objectives to explain the background of the project. The second section gives an overview of the natural processes and the history of settlement in the Malibu Creek Watershed. Key issues affecting ecological functions within the watershed are then discussed in Section 3. Section 4 details the monitoring element of the project, including the structure, organization and the flow of data. The fifth section describes the in-depth analysis and modeling that was used to select monitoring sites. It also presents a framework for other agencies that wish to monitor in the watershed. The final section, Section 6, considers design recommendations and alternatives that directly address the key issues identified in Section 3.

Background

Heal the Bay, a non-profit organization, and the California State Coastal Conservancy have contracted the 606 Studio, a team of landscape architecture graduate students and faculty members from the Department of Landscape Architecture at California State Polytechnic University, Pomona, to design a volunteer monitoring program. This program is to be used to evaluate the water quality and overall ecological health of the Malibu Creek Watershed. The monitoring program was designed to adjust to changes in volunteer participation and capabilities and be flexible to address new issues as they arise in the future.

To meet this contract, the 606 Studio has prepared two documents: *The Malibu Creek Watershed, Stream Team Field Guide* (a field guide to be used to train volunteer water quality monitors), and this document, *The Malibu Creek Watershed: A Framework for Monitoring, Enhancement and Action.*

The California State Coastal Conservancy and Heal the Bay are actively involved in issues of water quality. The California State Coastal Conservancy is a unique state resource agency that uses innovative techniques to purchase, protect, restore, and enhance coastal resources and to provide access to the shore. They work in partnership with local governments, other public agencies, nonprofit organizations, and private landowners. In funding and support of this project, the California State Coastal Conservancy has formed a partnership with Heal the Bay, a non-profit environmental group dedicated to making the Santa Monica Bay and the Los Angeles County coastal waters safe and healthy for people and marine life. Both organizations have a long history of successful projects throughout the State.

Objectives

Monitoring Program Structure and Process

Research

- Conduct a watershed inventory of the Malibu Creek Watershed. This involves collecting and analyzing past studies of the watershed and identifying the major ecological issues of concern.
- Study existing monitoring programs and the strategies used to collect and distribute information.

Design

- Design a volunteer monitoring program that addresses the specific issues and needs of the Malibu Creek Watershed. This program will provide information needed by private and public agencies to identify opportunities to improve the overall ecological health of the Malibu Creek Watershed.
- Create a field guide volunteers can use in conjunction with hands on training to collect and record pertinent information about the Malibu Creek Watershed.

Planning & Management Framework

- Develop an overall strategy that can be used to coordinate current and future individual monitoring efforts within the watershed, to maximize the quality of information collected and utilize the limited resources of these programs.
- Design a monitoring program framework that can be used by Heal the Bay to organize and train volunteers to collect information about the Malibu Creek Watershed. This framework will be designed so that the monitoring program can adapt to changes in levels of volunteer participation.
- Create a framework that Heal the Bay can use to organize, store, and distribute the information collected by volunteers to the numerous local, state, and federal agencies that are charged with protecting the Malibu Creek Watershed.
- Provide a tool box of design recommendations and references for improving the Malibu Creek Watershed ecosystem. As volunteers identify areas that are degraded or in trouble, decision-makers will be armed with strategies to enhance these areas.

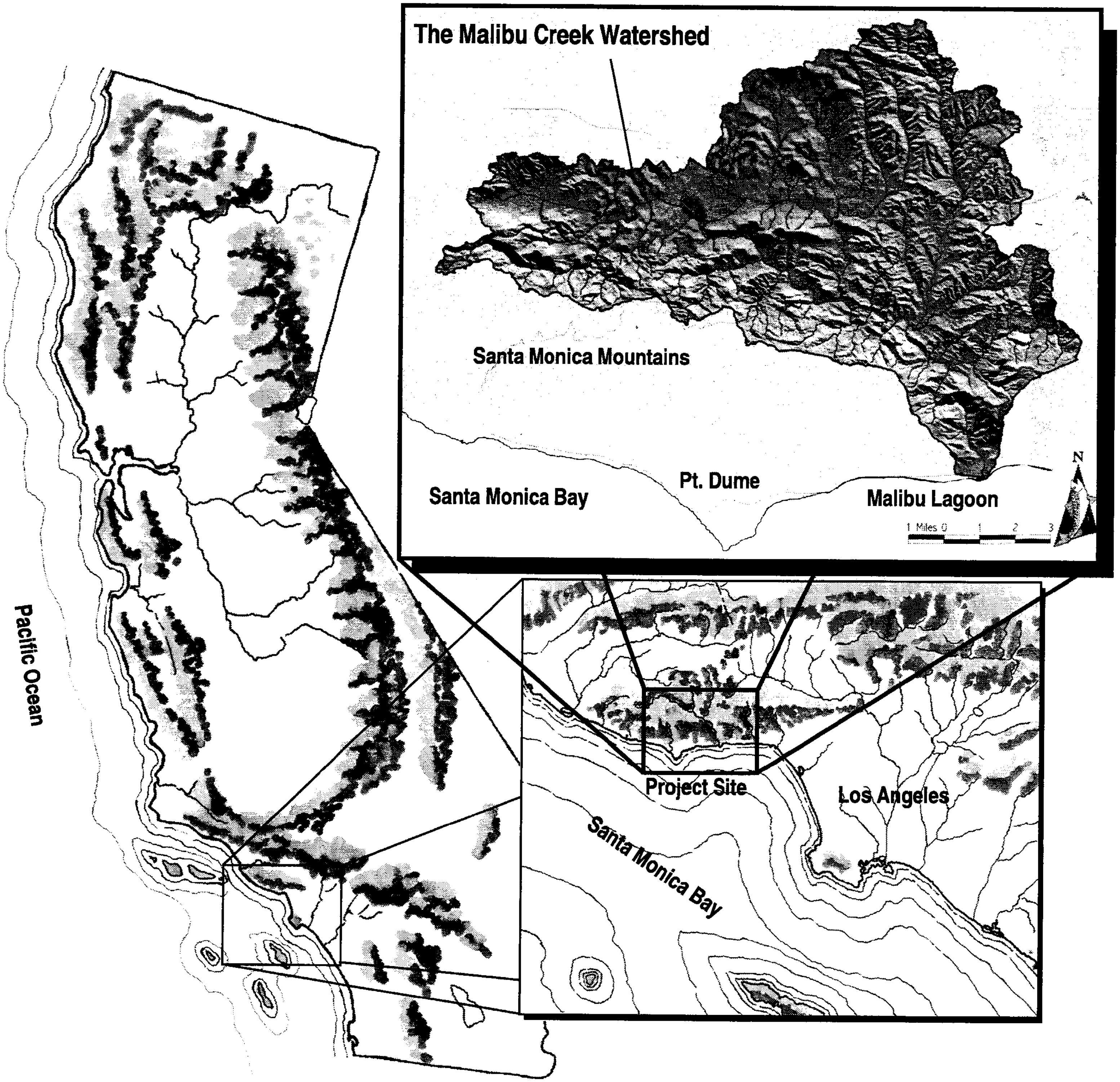


Figure 2-1: Site Context, the Malibu Creek Watershed

Section 2

Natural Processes and the History of Settlement

Context

The Malibu Creek Watershed, at 109.9 sq. miles, is the second largest watershed draining into the Santa Monica Bay (Figure 2-1). Rain falling within its boundaries eventually reaches the Pacific Ocean via the system of surface streams and groundwater. The watershed is located approximately 35 miles to the west of the City of Los Angeles in the Santa Monica Mountains and Simi Hills. Approximately 65% of the watershed is located in Los Angeles County with the remaining 35% in Ventura County. Within its boundaries are the cities of Agoura Hills, Westlake Village, and portions of Malibu, Calabasas, Thousand Oaks, Hidden Hills, and Simi Valley.

The topography varies throughout the watershed. In the uppermost region, the Simi Hills roll gently. In contrast, the steep, rugged Santa Monica Mountains cover the remaining majority of the watershed. The Malibu Creek Watershed can be divided into seven smaller subwatersheds. These are Hidden Valley, Westlake, Agoura, Las Virgenes, Malibou Lake, Malibu Creek, and Cold Creek. A major tributary drains each subwatershed, eventually joining Malibu Creek. The creek flow south into the Malibu Lagoon, one of the few remaining coastal wetlands in southern California. Here the freshwater mixes with the Pacific Ocean at Malibu Surfrider Beach.

Natural Processes

Climate

The climate of the Malibu Creek Watershed is generally characterized as a Mediterranean type with mild wet winters, hot dry summers, and coastal fog occurring in spring and mid summer between the months of May and July. The area is frost-free 275 to 325 days on average. Spring temperatures range from 65 to 85 degrees Fahrenheit during the day and can drop as low as 45 to 65 degrees at night.

The phenomenon known as the "Pacific High" diverts storms away from southern California, causing the warm dry summers. Inland summer daytime temperatures generally remain around 85 degrees and will occasionally exceed 100 degrees with low temperatures dipping into the mid-fifties. Coastal temperatures are generally 15 degrees cooler than those of inland valleys (Jorgen 1995, p. 6).

Fall temperatures range from 65 to 90 degrees inland during the day and can dip down between 20 to 60 degrees at night. Fall is usually associated with the warm, dry Santa Ana winds that blow in from the deserts. Due to these dry summer and fall conditions, fire has become an integral part of the local ecosystem.

Winter is characterized by periodic rainfall, which accounts for nearly all the precipitation in the area. The majority of rainfall occurs between November and April averaging 25 inches over the mountainous regions to the north and along the coast, to rainfall averages of about 13 inches in the inland valleys. Measurable precipitation occurs on average 35 days per year with December and January usually the wettest months (Jorgen 1995, p. 7). Average winter temperatures reach highs in the mid-60s with average lows in the mid-40s. Freezing temperatures sometimes occurs at the higher elevations of the Santa Monica Mountains. Snow falls very rarely but has occurred within the watershed.

Geology

The Santa Monica Mountains and Simi Hills are part of the Transverse Ranges. They were formed through a process of deposition, erosion, volcanic activity, and tectonic forces. 135 million years ago, the ocean covered the area where the Santa Monica Mountains are located. Over millions of years, sediments settled on the ocean bottom, and eventually, through pressure and chemical processes, were transformed into sedimentary rocks–shale and sandstone–that compose most of the area (Jorgen 1995, pp. 7-8).

The greatest volume of rock mass in the Malibu Creek Watershed is composed of young sandstone, shale, and volcanic flows that occurred between 10 to 20 million years ago during the Miocene Epoch (Warshall, et al. 1992, p. 18). The distinctive black-gray and reddish volcanic rocks in the central and upper western portions of the watershed are known as the Conejo Volcanics. It was not until four million years ago that northward pushing tectonic forces caused the Santa Monica Mountains to thrust their way out of the ocean (Warshall, et al. 1992, p. 18). Erosion of the volcanic and sedimentary rocks created sediments which were deposited by flowing water, filling valleys and streambeds with alluvial soil (Figure 2-2). This alluvial layer is 30 feet deep in streambeds and canyon bottoms and tapers off rapidly to less than four feet thick up canyon slopes (USDA NRCS MCWNRP 1995, p. 8).

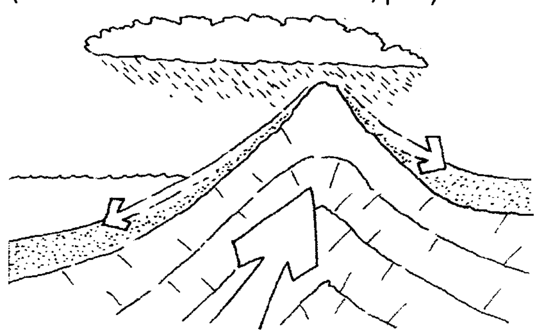


Figure 2-2: Uplift and erosion

Soils

The soils of Malibu Creek Watershed are susceptible to high erosion rates. This is due to a combination of climate, topography, vegetation and soil structure. Mediterranean climates provide the highest sediment yields in the world (Levy, Korkosz 1997, p. II-9).Soils in the area are derived from sandstone, shale, volcanic and igneous rock, and from alluvium composed of a mixture of rock sources that compose the Santa Monica Mountains. Soil types determine the amount of water storage and the ability to absorb and filter runoff within the watershed. The Malibu Creek Watershed contains 40 soil mapping units in the Los Angeles County portion, and 38 soil mapping units in the Ventura County portion of the watershed (USDA NRCS MCWNRP 1995, p.13).

Vegetation

The Malibu Creek Watershed is covered with plants that have evolved to fit the unique soils and climate of the region. Chaparral and Coastal Sage Scrub are two plant communities that dominate the Santa Monica Mountains. These plant communities are adapted to wet winters and dry summers. For example, many of these plants have small, waxy leaves to retain moisture, as well as the ability to drop their leaves in times of drought.

Vegetation plays a critical role in the watershed. It helps control erosion by holding the soil together with its roots and by breaking the force of rainfall with its canopy of leaves and branches (Figure 2-3). This slows the flow of water and allows more water to percolate into the soil. Runoff is minimized and less water flows all at once into streams. It also provides food and shelter for a wide variety of animals.

Vegetation within the Malibu Creek Watershed can be categorized into plant communities based upon similar characteristics. Figure 2-4 shows some of the various dominant plant communities found within the watershed and their approximate locations.

Riparian Zone

The Riparian Zone is the vegetative corridor on either side of a body of water (Figure 2-5) (US EPA 841-B-97-003 1997, p. 203). This area is unique because it is where the land-based (or terrestrial) and aquatic ecosystems interface (Murdoch, Cheo, and O'Laughlin 1996, p. 60). Riparian zones contain an important plant community that helps to maintain

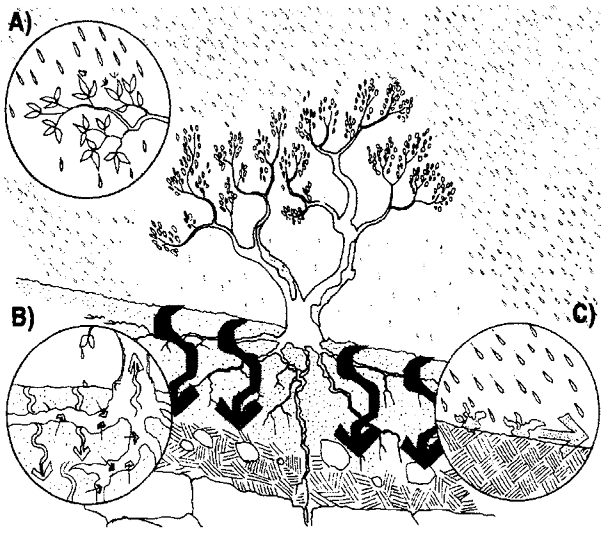


Figure 2-3: Vegetation aids infiltration and prevents erosion by A) intercepting the rain and slowing down water flow, B) roots creating pore spaces for water to infiltrate and C) rain impacting exposed soils, picking up sediments, carrying them into waterways.

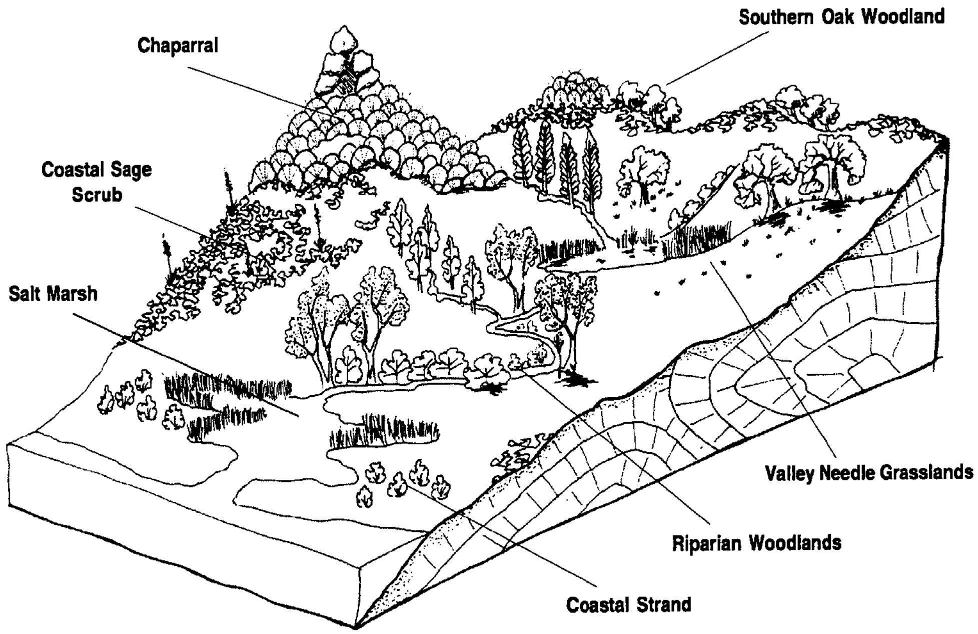


Figure 2-4: Plant communities and their approximate locations within the watershed

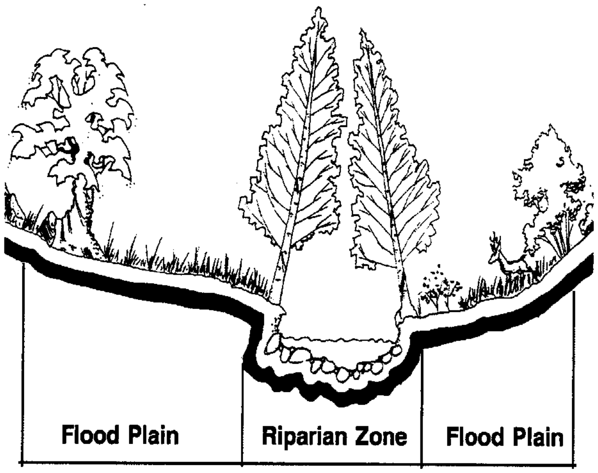


Figure 2-5: The riparian zone

water quality and stream health. Riparian vegetation generally has a higher need for water, thus occurs in drainages or areas with a high water table. The plants of a healthy riparian corridor are diverse and can include trees such as oaks, sycamores or willows, and various shrubs and groundcovers.

A healthy riparian zone supports birds, aquatic life, and additional diverse wildlife. According to the Washington State Department of Wildlife, more than 85% of wildlife inhabit riparian areas at some time during their life cycle to find water, shelter, and food. Trees provide shade for the stream, maintaining cooler water temperatures that are important for certain fish species like the steelhead trout. Shade also minimizes evaporation, providing water for the long, hot summer season. Trees and other vegetation drop leaves, twigs, and branches that provide food for aquatic organisms located at the bottom of the food chain. This debris also accumulates in the streams, providing habitat for fish and other aquatic organisms.

Nutrients

Natural sources of nitrates include soil, animal wastes, and decomposing plants that are washed off the surface of the landscape and eventually into the streams (Figure 2-6). Phosphorous is an essential nutrient for plant growth and for the metabolic reactions in plants and animals (Behar, Dates, and Byrne 1996, p. 130). Phosphates are considered a limiting factor, because they are the least available of all nutrients for plant growth. If phosphate is added to a freshwater system, even in small quantities, the plant growth will usually increase substantially (Behar, Dates, and Byrne 1996, p. 130). Natural sources of phosphates include soil, decomposing plants, rocks that contain phosphate, and animal wastes.

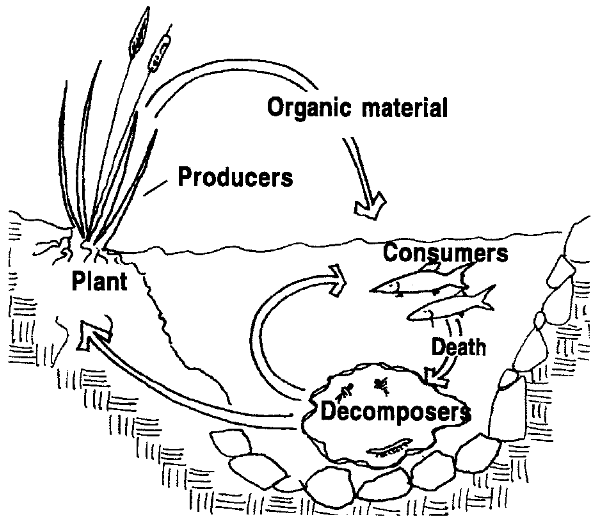


Figure 2-6: Basic aquatic nutrient cycle

Fire

Fire is an essential part of the natural processes in the Malibu Creek Watershed. Chaparral plants such as Toyon and Chamise, and Coastal Sage Scrub plants such as Black Sage and California Sagebrush are fire-adapted and depend on regular burning to remove old growth and rejuvenate the plants. Fires mineralize organic matter into potash, which provides nutrients to the soil and stimulates new plant growth

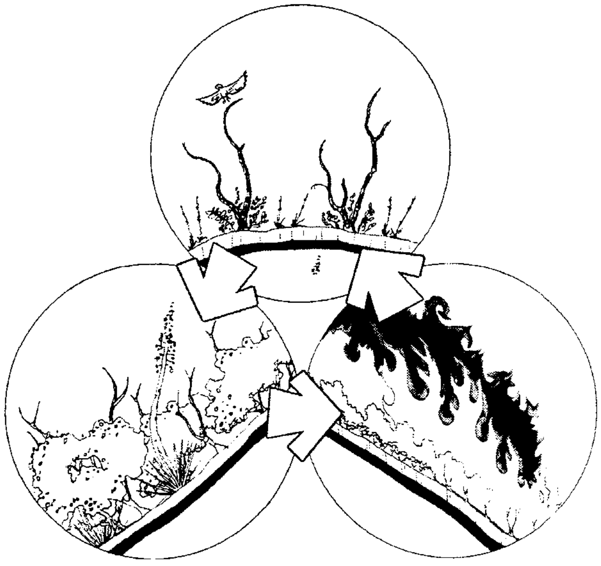


Figure 2-7: Chaparral fire cycle

(Jorgen 1995, p.16). Many of these plants have seeds that need fire to stimulate them to germinate, or have the ability to crown sprout from their roots after a fire (Figure 2-7). Animal populations decrease following a fire because of limited shelter and available food, but these populations soon return when the fire- dependent seeds germinate providing tender young shoots for browsing animals to eat. Fires were believed to have started from lightning strikes in the San Fernando Valley and the San Gabriel Mountains prior to recent human settlement. Santa Ana winds fanned these flames over the hills and into the Santa Monica Mountains (Jorgen 1995, p. 16). The watershed is most susceptible to fires beginning in early May and lasting through October, when annual grasslands dry out and temperatures are higher. Fire within the Santa Monica Mountains occurs at natural intervals between 10 to 50 plus years (Levy, Korkosz 1997, p. II-9).

Wildlife

The Malibu Creek Watershed is home to a diverse range of wildlife. This includes about 50 species of mammals, over 380 bird species, 25 species of reptiles, 11 species of amphibians, 5 species of fish, and a large number of invertebrates (USDI 1993). There are also several listed endangered species within the watershed.

Hydrologic Cycle

The hydrologic cycle is a closed loop system driven by the energy of the sun, which continually transports water between the atmosphere and the earth's surface (Figure 2-8). The three main processes of the hydrologic cycle are precipitation, evaporation, and transpiration. Once precipitation falls onto the land, approximately two-thirds is evaporated back into the atmosphere. The remainder is either absorbed into the ground and soils, or flows over the land as surface water. Transpiration occurs when energy from the sun draws water from the leaves of plants back into the atmosphere in the form of water vapor. The total amount of water on the earth's surface is finite, and in essence, it is the same water cycling over and over again.

The hydrologic cycle process can be explained beginning with surface water. Surface water stored in lakes, streams, lagoons, and oceans, is heated by the sun's energy and turned into vapor through the process of evaporation. Transpiration begins

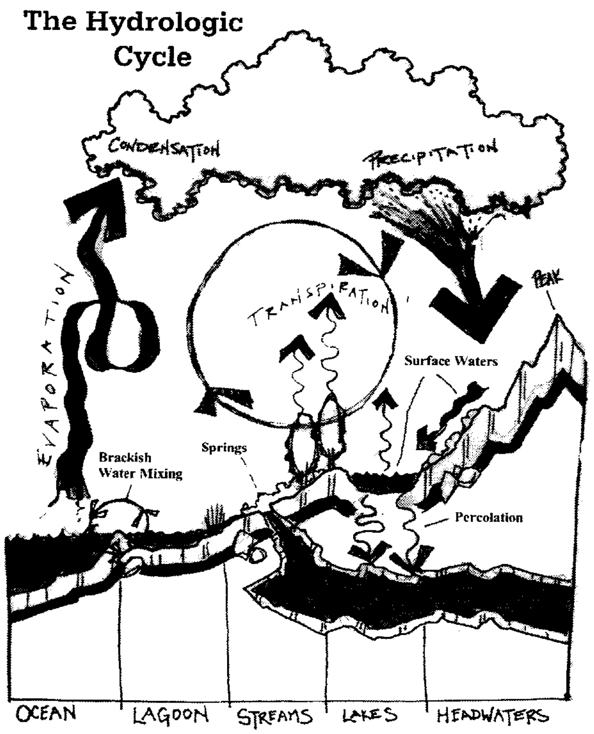


Figure 2-8: The Hydrologic Cycle

when plant roots absorb water stored in the soil. The water migrates up the stem or trunk until it eventually comes out of thousands of tiny holes on the bottom of leaves. A large oak tree transpires approximately 39,578 gallons per year (Leopold 1997, p. 5). The warmer the air temperature, the more water vapor the air can carry. When this air is cooled, the water vapor exceeds the carrying capacity of the air. This vapor turns back into its heavier liquid form, and falls to earth as precipitation. The rain is trapped by the leaves of plants, stored in the soil, or flows over the land and into the streams and eventually into wetlands, lakes, and the ocean.

Infiltration

One important aspect of the hydrologic cycle in terms of watersheds, is the process of infiltration, the rate at which water is absorbed into the ground. Infiltration is influenced by two main factors: the characteristics of the soil material, and the type and density of the vegetation growing or lying on the ground (Leopold 1997, p. 10). Soil is composed of millions of tiny particles that have air spaces, or pores, separating each particle. Precipitation that falls onto the land is absorbed, or infiltrated, through these pores. Soils with bigger pores, like sand, allow precipitation to infiltrate more quickly. Conversely, soils with smaller pores, like clay, infiltrate water more slowly. When rain falls faster than the pores can absorb, or when soil becomes saturated, the excess rain flows onto the surface of the land. This surface runoff flows over the ground and eventually into streams.

Vegetation plays an important role in the infiltration of rain by reducing the velocity of water flow over the landscape, and minimizing rapid sheet flows of water into streams and creeks. The roots of plants and burrowing insects that live near plants loosen compacted soils and create additional pore spaces that help to infiltrate water. Studies conducted on plots of land with varying amounts of vegetation reveal the benefits of vegetation on the infiltration process. On one plot, 37% of the land was covered with grass or other vegetation, and the other plot was bare ground. The land with 37% vegetative cover infiltrated water at six times the rate as bare ground (Leopold 1997, p. 12).

Groundwater

Another important element of the hydrologic cycle is groundwater (Figure 2-9). Once water has infiltrated into the soil, three results can occur: the water can be absorbed by plant roots and transpired back into the atmosphere, move laterally into streams as subsurface storm runoff, or move downward into the groundwater zone (Murdoch, Cheo, and O'Laughlin 1996, p. 5). Water is able to seep lower into the earth through

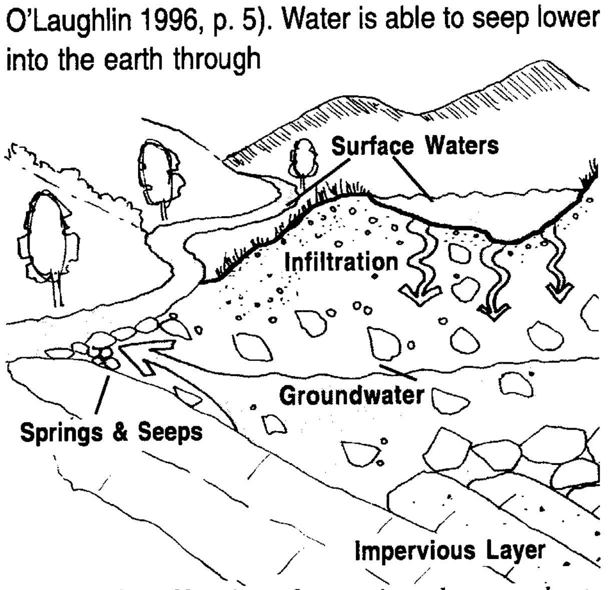


Figure 2-9: Infiltration of water into the groundwater

fractures, cracks, and pore spaces in rocks and soil material that are numerous towards the surface and become less abundant at greater depths (Leopold 1997, p. 18). Natural pore spaces may exist among the rocks. Sandstone and other sedimentary rocks that compose the geology in the Malibu Creek Watershed are excellent examples of porous rock.

Water will eventually find a level where it can sink no farther, and will begin to fill the same voids and pores that allowed it to penetrate into the earth. Eventually, the height of the groundwater zone will reach a level where it re-emerges as surface water through a seep or spring. This area where groundwater resurfaces is called a "discharge area" (Murdoch, Cheo, and O'Laughlin 1996, p. 5). Discharge areas are found in topographically low spots, usually the deepest cut in a stream channel (Leopold 1997, p. 20). The contribution of groundwater to surface water systems is called "baseflow" (Murdoch, Cheo, and O'Laughlin 1996, p. 5). This is one reason that streams continue to flow long after the last rain.

Surface Water

Streams are dynamic forces, both reflecting and changing the character of the surrounding landscape. There are three types of streams in the Malibu Creek Watershed (figure 2-10). The first type of stream is ephemeral, flowing only during

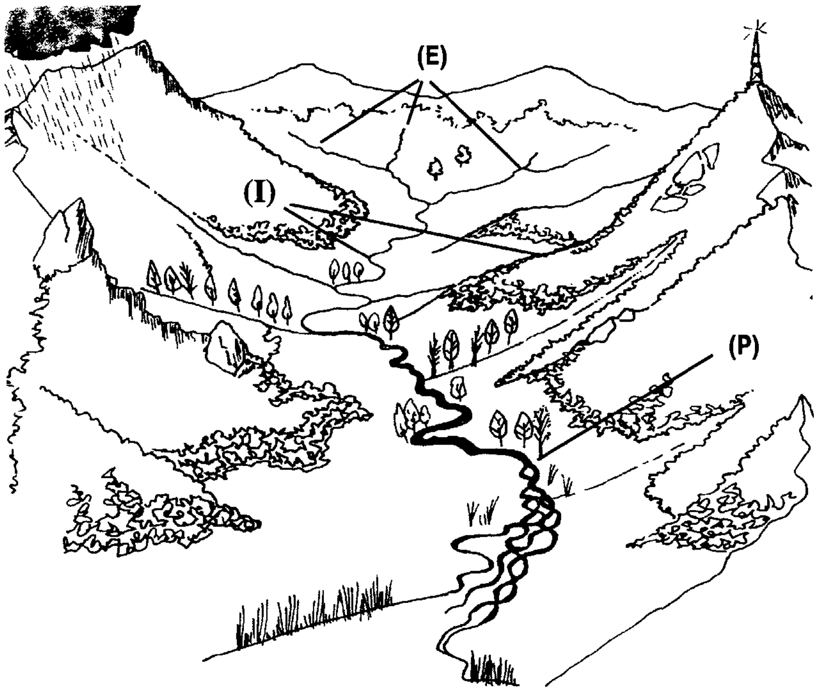


Figure 2-10: The Three types of streams within the watershed: (E) ephemeral, (I) intermittent, (P) perennial.

storms. Many of the streams in the upper watershed are ephemeral. The second is intermittent, a type of stream that has surface flows during the wet season, but still may be flowing subsurface during drier periods. Intermittent streams are the most dominant stream type in the Malibu Creek Watershed. Lower in the watershed, streams converge and the water table remains high enough to maintain the year round flows of the third type of streams, perennial streams. Historically, much of the flow that occurs during the summer season originates from springs, seepage areas, and areas of stored groundwater (Trim 1994, p. 1).

The Stream Continuum

A watershed drainage network continuously attempts to establish a balance between the shape of its stream channels and the amount and force of water running off the hillsides (Murdoch, Cheo, and O'Laughlin 1996, p. 63). Healthy streams have reached a state of equilibrium when the amount of sediments and water that enter the stream are the same amount that leave the stream. This process of equilibrium occurs as sand and gravel is scoured from the outside bend of a curve, and are then deposited on the inside of the curve (Figure 2-12). The meandering pattern of streams forces water to travel over a longer distance and dissipates the erosive power of the water. Unusual natural events or permanent alterations in the stream continuum caused by development can upset the balance of erosion and deposition of stream sediments.

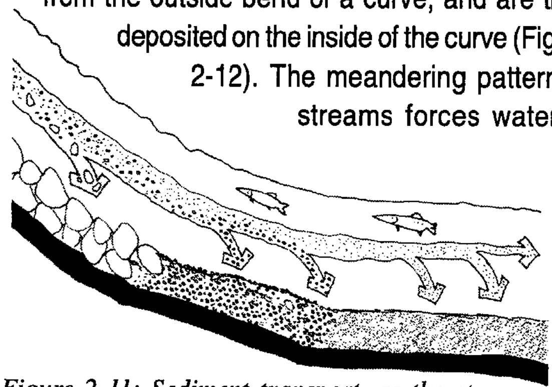


Figure 2-11: Sediment transport, as the stream gradient and velocity decrease, smaller particles are deposited.

Lining each stream are materials such as sand, cobbles, or boulders, making up the substrate of the stream. The type of substrate is a direct result of many factors including elevation, soils, geology, and slope. Substrate material, in general, is larger in size in the upper reaches of a stream. Headwater streams are narrow with stable substrates consisting of large cobble, boulders, or bedrock. In middle stream sections, the substrate will generally be composed of medium-sized cobbles and gravel. Heading downstream, the bottom material becomes finer, and is composed of sand and silt. The insoluble soil particles are carried in the water as suspended solids. Suspended solids remain in the water as long as the flow is significant enough to hold these particles in the water (Figure 2-11). At the base of the watershed,

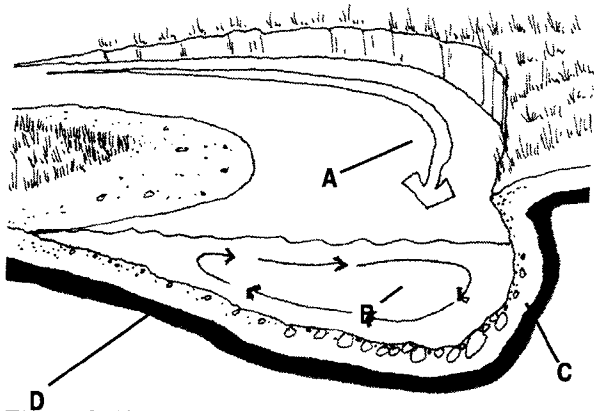


Figure 2-12: Erosion and deposition along stream curves: A) path of current around curve, B) circulatory current in water flowing around curve, C) area of erosion, and D) area of deposition (from figure 28, Leopold. Water, Rivers and Creeks 1997).

the amount of water continues to increase while the gradient flattens out, resulting in slower flowing, wider stream channels. The slower flowing water loses the ability to transport suspended solids, and may deposit them as sediments. These deposits create large sandbars that give the stream a braided appearance. In the natural process, much of the sediment washed into the waterways are deposited during intense storm events. This is why the streams and ocean look muddy after a large storm.

The Lagoon

At the bottom of every watershed is an outlet, either into another watershed, or into a large body of water. The outlet for the Malibu Creek Watershed is the Malibu Lagoon within the Santa Monica Bay. Lagoons act as large natural water filters, with plants and animals absorbing and breaking down nutrients, purifying the water. The maze of channels, the wetland plants, the tidal action, and the aquatic life contribute to the filtering and cleansing of water. The Malibu Lagoon is where freshwater and seawater interface. The Santa Monica Bay Watershed, which contains Malibu Lagoon, is recognized as one of four estuaries in California currently included in the U.S. EPA's National Estuary Program, which is aimed at improving or maintaining coastal water quality (USDA NRCS MCWNRP 1995, p. 7).

Sandbars are a key feature of the lagoon ecosystem. During the summer months, the closed sandbar separates the lagoon from the ocean. This is because less freshwater reaches the lagoon, due to the decreased flow of ephemeral or intermittent streams. As the freshwater flows diminish, sediments build up and close off the lagoon from the ocean.

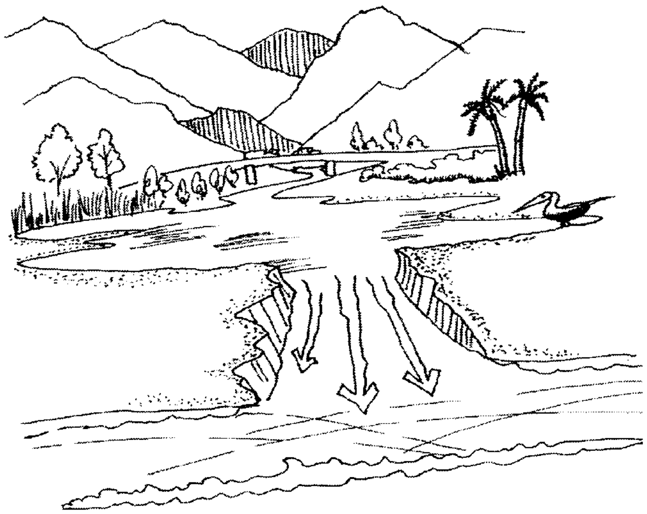


Figure 2-13: Increased flows of water during the winter months cause the lagoon's sandbar to breech.

This creates an important brackish or partially saline wetland condition that supports a large diversity of terrestrial and aquatic life. In the wet winter months, the high quantity of water flowing into the lagoon breaches or breaks open the sandbar (Figure 2-13).

The lagoon is a critical estuarine habitat. Currently it houses a population of the endangered Tidewater Goby that was reintroduced into the lagoon from the Ventura River Estuary (Figure 2-14). Migrating birds use the Malibu Lagoon as a rest stop on their long journey. The lagoon also supplies a critical rearing habitat for the endangered Southern Steelhead Trout. Steelhead use the lagoon to make the transition from salt water to fresh water before they begin their spawning runs up the Malibu Creek. Young steelhead use the brackish waters of the lagoon to adjust to saline conditions as they leave freshwater streams and migrate into the ocean.

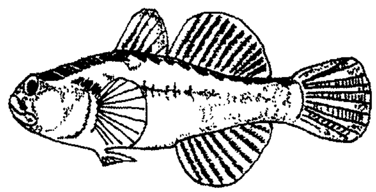


Figure 2-14: Tidewater Goby

History of Settlement

The earliest evidence of human habitation in the Malibu Creek Watershed dates back over 7,500 years ago. These inhabitants were the predecessors of what would eventually develop into the Chumash culture. Malibu Canyon is located along the interface between the Chumash and the Gabrielino (Tongva) peoples. The Chumash inhabited the area from Malibu Canyon west and then north into San Luis Obispo County. Many Chumash archaeological sites have been found in the Santa Monica Mountains. These mountains were a plentiful source of game and plants were used for making shelter and for providing food. An extensive foot trail system was established throughout the mountains to facilitate traveling, trading, and hunting and gathering of food.

Figure 2-15: Malibu Lagoon was thought to be the location of a trading village of the Chumash.

Within the Malibu Creek watershed, Malibu Creek and its tributaries served as a major north-south travel route through the mountains. A major Chumash village was located along the ocean at the base of Malibu Canyon (Figure 2-15). The Chumash are believed to have used the Malibu Lagoon as a launching area for their canoes (Ambrose, Suffet, and Hee 1995, p. 9). Fish and shellfish were some of the abundant resources available to the Chumash at this site. The watershed supported a viable and rich Native American culture.

Spanish explorers traveled through this area starting in the 1500s, but it wasn't until the late 1700s that Spanish settlers and missionaries started coming to the Santa Monica Mountains. This had a profound impact upon the lives of the Chumash people. The community of villages fell apart under the influence of the mission system, the introduction of European diseases, and the assimilation of the Chumash culture into the Spanish, and later on into the Mexican and American, cultures.

During the 1800s, settlement and ranching activities started to take hold throughout southern California, including the Santa Monica Mountains. Under Mexican authority, land grants were made for private ownership of land and large ranchos were established. These privately held ranchos continued after California became part of the United States in 1850. Over time, these have been sold and subdivided until today we see a patchwork of privately and publicly held land with a mixture of land uses and development within the Santa Monica Mountains.

In the early 1800s, cattle grazing started in and around the Malibu Creek Watershed. The Rindge Ranch, a cattle and grain raising operation, occupied much of the area in the latter half of that century (Doyle et al. 1985, p. 39). In 1908, a railroad was built which spanned 15 miles of coast including the Malibu Lagoon. This Rindge line began near Las Flores Canyon and went all the way to Yerba Buena Road in what is now Ventura County. In 1928, the Rindge Dam was constructed in Malibu Creek to store water for irrigation to be used on the ranch (Doyle et al. 1985, p. 39). Construction of the Roosevelt Highway was completed and opened to the public in June of 1929. It was later renamed the "Pacific Coast Highway", and, as with the railroad, crosses over Malibu Lagoon.

Development in and around the watershed continued, and in the late 1950s and early 1960s growth was fueled by the rapid expansion around the Los Angeles area. In 1965, the Tapia Wastewater Treatment Plant (Tapia) was built to accept wastewater from the growing community within the watershed.

Recreational Opportunities

The Malibu Creek Watershed has some of the best recreational opportunities within the Santa Monica Mountains, and perhaps some of the best within southern California. Close to and easily reached from the Los Angeles metropolitan area of over 13 million people, the Santa Monica Mountains is a popular destination for those wanting to find high quality recreational activities.

Creation of parklands within the Santa Monica Mountains began in the 1940s by the State of California. At the national level, the need to preserve and protect the unique resources of the Santa Monica Mountains was recognized by Congress in 1978 when it established the Santa Monica Mountains National Recreation Area under the National Park System. Various governmental agencies and private groups have joined in the effort to preserve land within the Santa Monica Mountains. The result is an evolving system of parklands that not only protect the natural resources of the mountains, but also offer many opportunities to recreational users.

There is a wide range of sites where the public can visit and learn about the unique natural and cultural resources within the Malibu Creek Watershed. These include Tapia Park, Malibu Creek State Park, Rocky Oaks Park, Peter Strauss Ranch, Cheseboro Canyon, and Malibu Lagoon State Park. Adjacent to the lagoon is Malibu Surfrider Beach, one of the most heavily used beaches in southern California. It is world-renowned for its excellent surf break and is used year-round. Throughout the watershed is an extensive trail system. Most trails are limited to hikers, but others are designated for use by mountain bikers and equestrians. Additional activities enjoyed by visitors include, biking, horseback riding, birdwatching, swimming, picnicking, scuba diving, fishing, whale watching, and beach going.

Section 3

Issues and Analysis

Settlement in the area has altered the natural hydrologic regime and ecological functioning within the watershed. This section details issues of concern in the Malibu Creek Watershed due to settlement. Of primary concern are the influences of imported water, the increased acreage of impervious surfaces, accelerated erosion and sedimentation, and increased levels of nutrients flowing into the receiving waters. Further, settlement has altered the natural fire regime, the distribution of vegetation, loss of wildlife habitat, and the size and function of the lagoon within the Malibu Creek Watershed.

Imported Water

In response to the demand of a growing domestic, commercial, and industrial community, water has been imported into the watershed since the 1960s. Approximately 20,000 acre-feet, or 6.6 billion gallons a year, is imported into the watershed primarily from the California State Water Project, which collects and transports water from northern California. Imported water and any pollutants it may carry enter the stream system in three ways: by discharges into Malibu Creek from Tapia, by surface runoff via the storm drain network, and through groundwater. Increased water quantity and decreased water quality have altered chemical, biological, and physical characteristics of the streams and lagoon.

Tapia receives wastewater from households and businesses within and beyond the watershed, and services an estimated population of 90,000 people. By the year 2020, the population serviced by Tapia is predicted to rise to 160,000 (Bauer Environmental Services March 1996, p. 54). Tapia is located along Malibu Creek approximately five miles north of the Malibu Lagoon. Tapia filters and treats the wastewater, reclaiming it to a condition that allows it to be reused safely for irrigation (Figure 3-1). Tapia also composts the solid waste into fertilizer for fodder crops at their Rancho Las Virgenes Compost Facility (Las Virgenes Municipal Water District 1994, p. 36).

Tapia has increased its capacity since it opened in 1965, and now has the capacity to handle 16 million gallons per day (mgd). Current inflows average 7.75 mgd, or 8,680 acre-feet per year. Tapia sells

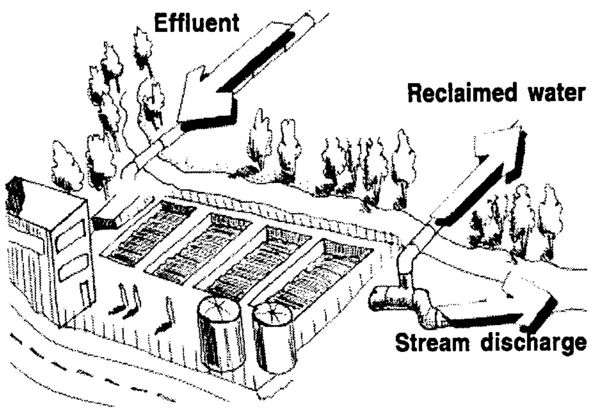


Figure 3-1: The Tapia Wastewater Treatment Facility

approximately 4,000 acre-feet of reclaimed water each year for use in irrigating open space and landscaping. The additional 4,680 or so acre-feet is treated and discharged to Malibu Creek (USDA NRCS MCWNRP 1995, p. 35). Reclaimed water has higher than normal levels of nutrients that can enhance the growth of algae. When these algal blooms die, the decomposition process may rob the water of the oxygen that fish and other aquatic life need to survive. Tapia is the only such facility in the watershed.

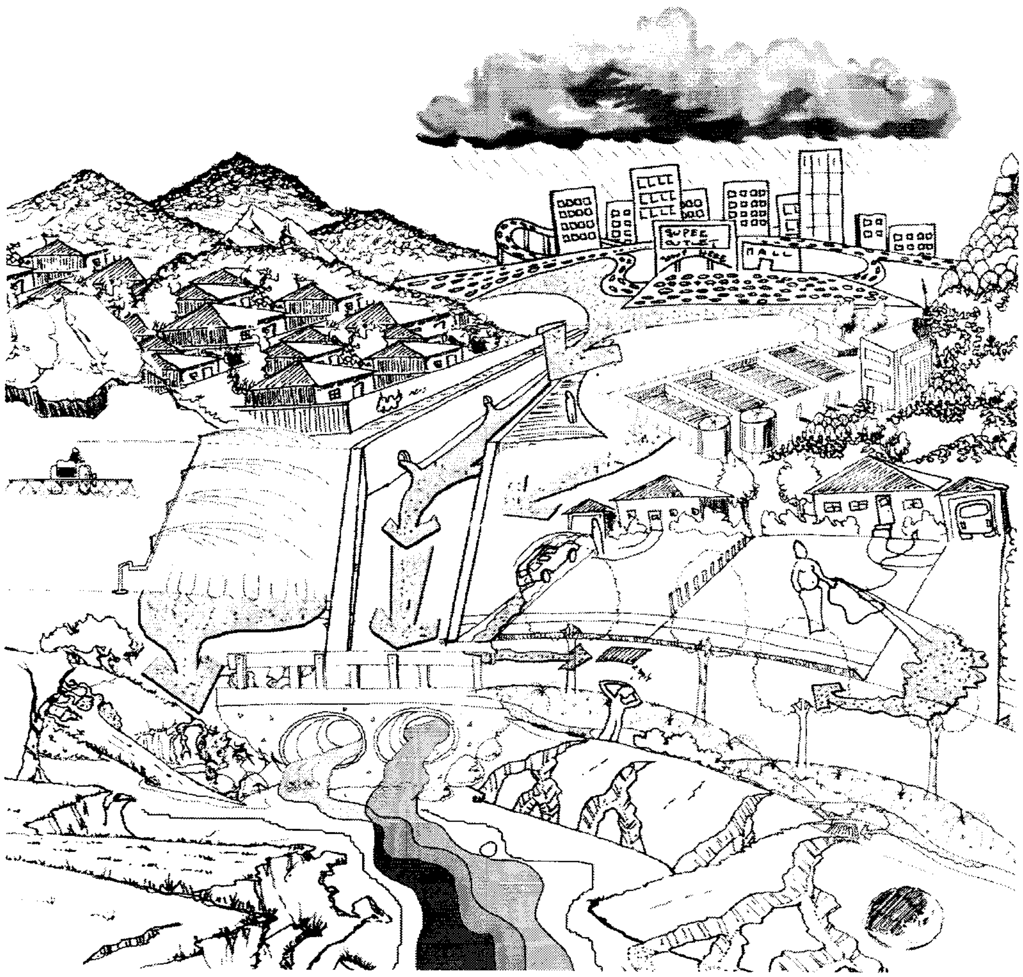


Figure 3-2: Overview of runoff associated with development.

The use of imported water for a variety of purposes outdoors, including landscape and agricultural irrigation, has altered the quantity, quality, and seasonal flow of water within the watershed. Runoff from overwatering or improperly designed and installed irrigation systems can flow onto streets and into the storm water drainage network. In addition, water can enter stormdrains from the hosing down of driveways, sidewalks, and streets as well as from washing cars in areas where water can not be absorbed into the soil. Unlike water that enters the sewage system, this water is conveyed directly into a nearby receiving water body without any form of treatment.

Runoff associated with landscape and agricultural irrigation may carry herbicides and pesticides, and nutrients from fertilizers. Water that is used to wash cars and hose down driveways and streets may wash metals, nutrients, oil, and grease into receiving waters (Figure 3-2).

Imported water can also reach the streams through groundwater. Water that is not absorbed by plants may move laterally into streams as subsurface storm runoff, or move downward into the groundwater zone (Murdoch, Cheo and O'Laughlin 1996, p. 5). Water from landscape irrigation or from septic systems is infiltrated through the soils. This water can carry nutrients from the over fertilization of lawns and agriculture, and improperly functioning septic systems. The watershed has an estimated 2,300 septic tanks (USDA NRCS MCWNRP 1995, p.16).

Impervious Surfaces

Impervious surfaces are constructed surfaces that do not allow water from rainfall or other sources to be effectively absorbed or infiltrated directly into the soil. Examples include rooftops, roads, parking lots, driveways, and sidewalks, usually made out of asphalt, concrete, brick or other types of paving materials, but they may also be areas with compacted soils, such as dirt roads. Such surfaces replace vegetation and soils, thereby affecting the area's ability to clean and infiltrate surface runoff. Storm water rushes off of the impervious surfaces, into the storm drain network, and eventually into a channel or creek (Figure 3-3).

Impervious surfaces collect and accumulate pollutants from a variety of sources, including those from the atmosphere, oil from cars, tossed debris, and fecal matter from animals. These accumulate over time until they are eventually washed away into the watershed's drainage network via the storm drain system. This runoff concentrates in creeks and streams, and eventually flows through the watershed and out into the Santa Monica Bay at

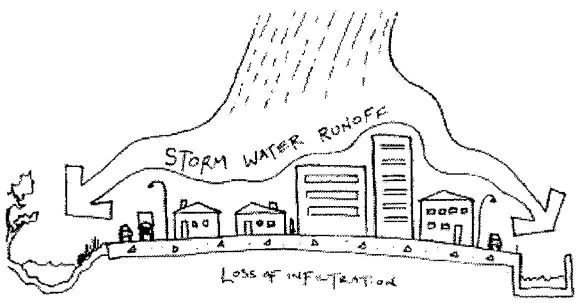


Figure 3-3: Impervious surfaces prevent infiltration, dramatically increasing stormwater volume and peak intensity.

Surfrider Beach. Storm water runoff is normally at its highest level of contamination during the "first flush" which is the first significant storm event of the rainy season after pollution has had a chance to accumulate during the long, dry summer period. A health effect study conducted by the University of Southern California, reported that people swimming within 100 yards of a flowing storm drain reported increased incidents of becoming sick. The amount of pollution washed into the riparian system can be directly related to the amount of impervious surfaces in the watershed (Schueler 1995, p. 24).

The runoff of pollutants into streams and the accelerated rate of soil erosion that impervious surfaces cause can drastically alter the vegetation along streams. Decreased amounts of vegetation that shades the stream can increase water temperature and decrease the available dissolved oxygen needed by aquatic organisms. This, along with a variety of pollutants, can cause a decrease in the health of aquatic animals, including amphibians and fish.

Besides accumulating pollutants, impervious surfaces increase storm water runoff and cause accelerated erosion of soil. Accelerated erosion is due to the greater rate and volume of runoff during storm events. Studies have shown that runoff from a one acre parking lot can be about 16 times the amount of runoff from a one acre undeveloped meadow. The increased volume of storm water runoff into the riparian system also increases the frequency of bankfull conditions in creeks and streams, resulting in streambank erosion and greater degradation of riparian habitats. The threshold for maintaining good quality urban stream habitats is about 10% to 15% impervious surfaces. An increase in the percentage of impervious surfaces above this level results in the decline of predevelopment water quality and stream habitat (Schueler 1995, p. 24).

Dealing with the effects of impervious surfaces is costly. An extensive storm water drainage system is built with pipes, concrete culverts and channels. Construction activity is needed to handle the erosion of slopes and streambanks. It is cheaper and more cost effective to limit the amount of impervious surfaces in the watershed rather than to try later to fix the problems impervious surfaces can cause.

The construction of impervious surfaces and the importation of water have resulted in increased runoff and stream flows in the watershed. The Natural Resource Conservation Service (NRCS) collected data at the stream gauge located below Tapia in Malibu Creek for the years 1931-1994. From this data, they constructed a water budget. Their analysis

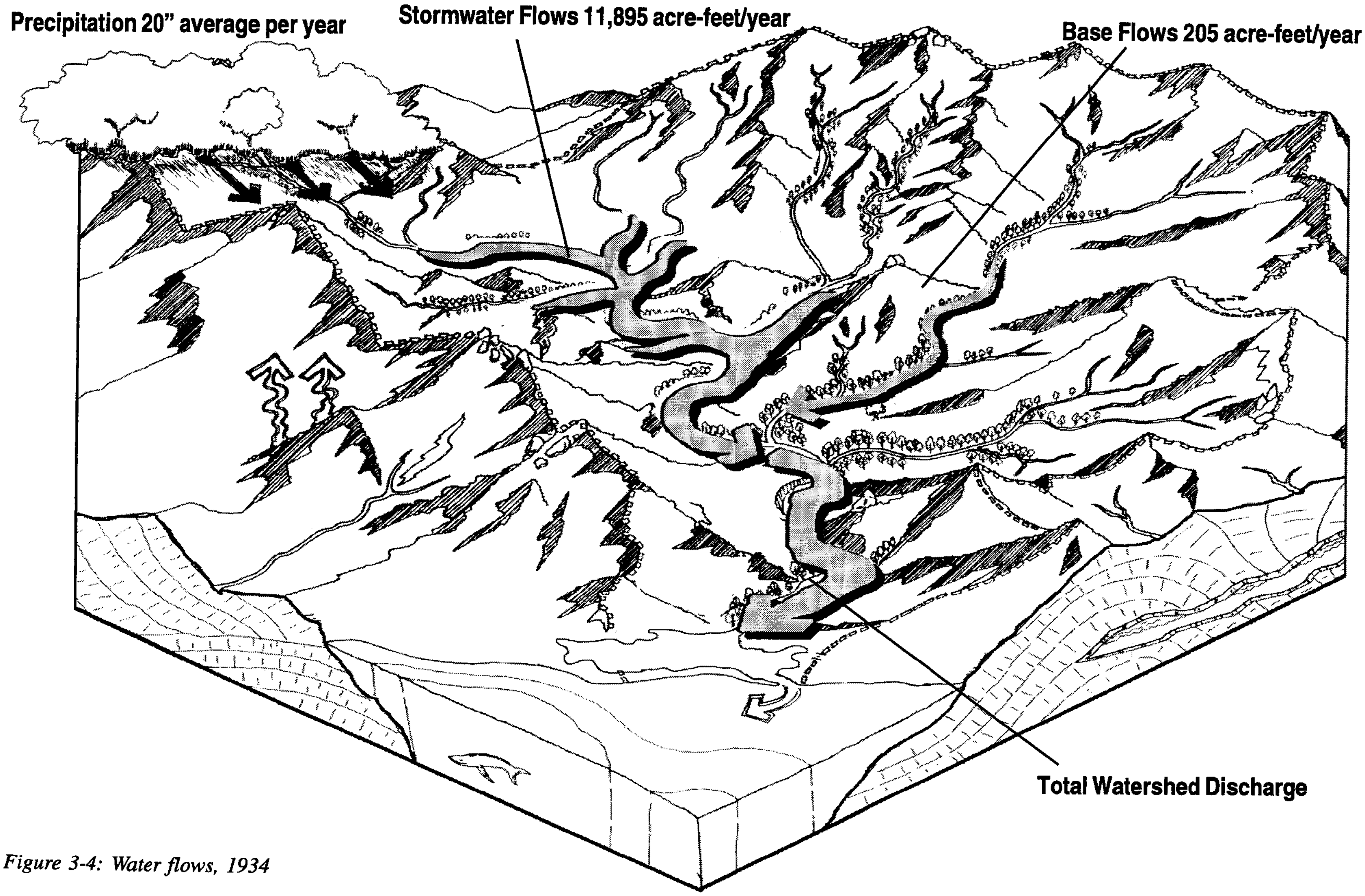


Figure 3-4: Water flows, 1934

demonstrates how stream flows have been altered due to changing land uses within the watershed, the importation of water, and the replacement of vegetation with impervious surfaces. Their analysis also reveals a change in base flows within Malibu Creek from 205 acre-feet in 1934 (Figure 3-4) to 2,050 acre-feet in 1994 (Figure 3-5). Base flow is the water volume measured in the creek and excludes releases of reclaimed water from Tapia. In addition to increases in base flows, stream flow during storm events also increased dramatically, from an annual average of 11,895 acre-feet in 1934 to over 21,000 acre-feet in 1994.

From 1931 to 1965, prior to significant upstream development, imported water, and discharges by Tapia into Malibu Creek, the average annual stream flows recorded at the stream gauge were about 12,000 acre-feet. The average annual flow of water since 1966, after significant upstream development, has averaged 27,000 acre-feet per year (USDA NRCS MCWNRP 1995, p. 36).

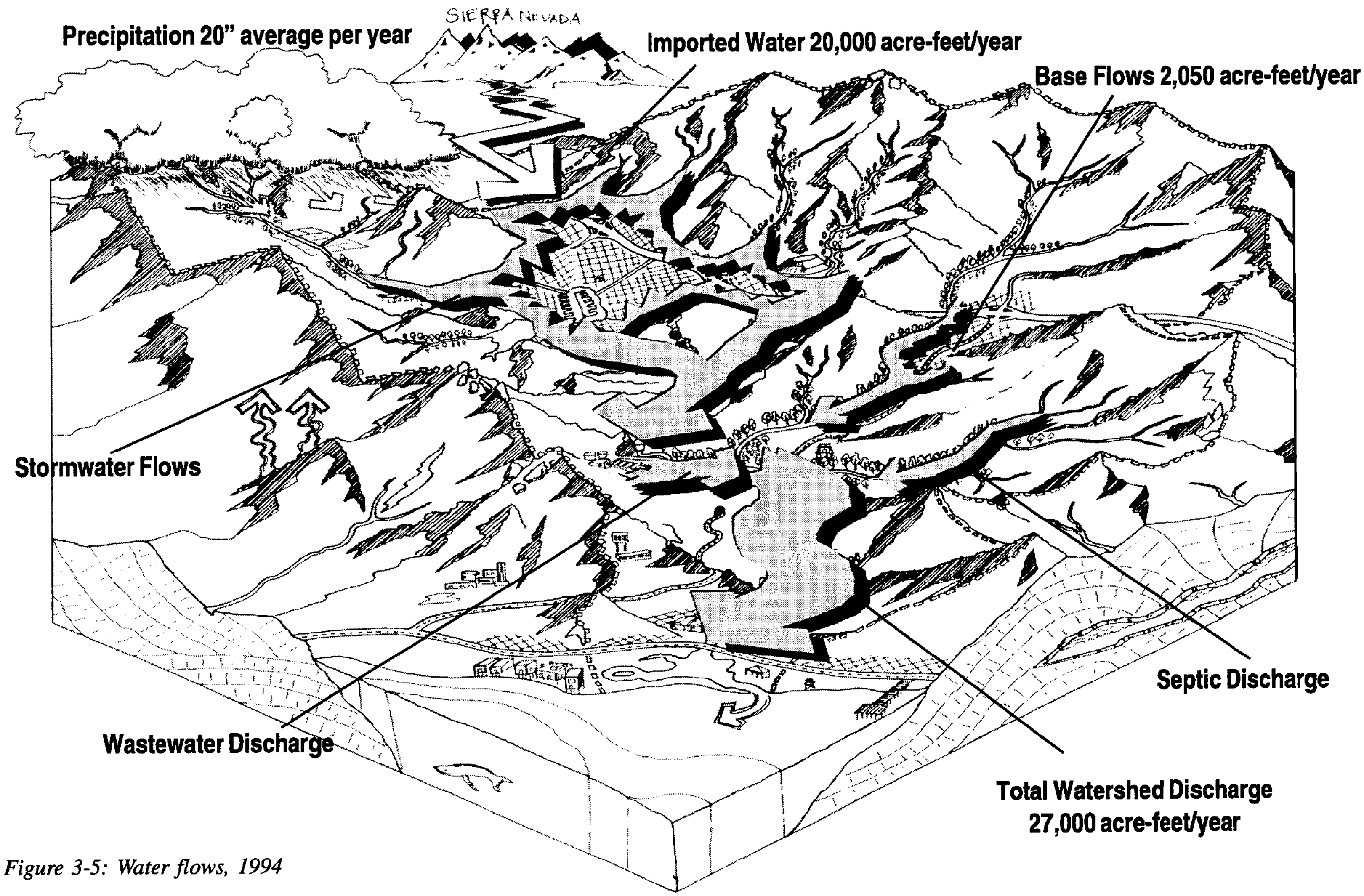


Figure 3-5: Water flows, 1994

The NRCS Malibu Creek Watershed Natural Resources Plan (MCWNRP 1995), estimates the break down of these increased flows as follows:

Discharge from Tapia	4,000 acre-feet
Runoff from home use and landscape irrigation	2,500 - 3,500 acre-feet
Septic tanks seepage	500 acre-feet
Storm runoff	19,000 - 20,000 acre-feet

A model was created to determine the effects of increasing development and impervious surfaces on peak discharges for each of the seven major tributaries. The model compares the natural conditions prior to human influence with the current conditions in the watershed. The model calculates runoff and peak discharges for 2, 5, 10, 25, 50, and 100-year storm events. The results demonstrate the overall increase in peak flows and the volume of runoff that is particularly evident in the more densely developed subwatersheds of Westlake and Agoura. This model does not consider inputs from Tapia. The overall flows entering the lagoon have also more than doubled. The details and the model can be seen in Appendix A.

To avoid flooding caused by the increased volume and intensity of runoff created by impervious surfaces, many streams and creeks are channelized (Figure 3-6). Potrero Creek from Lake Sherwood to Westlake Lake is almost completely channelized. Significant channelization has also occurred throughout the City of Agoura Hills. Channelization affects a watershed's hydrologic functioning. Designed to move water quickly out of the area, channelized streams are artificially lined with concrete for flood control purposes. The result is a waterway that has few, if any plants, and little wildlife habitat value. The channelization of an area diminishes other benefits of riparian corridors, such as water purification, and slowing water flows. Because there are no cobbles, boulders, plants, or streambank irregularities that could slow down rushing water, downstream riparian areas are often overwhelmed by the increase in water velocity.

Erosion and Sedimentation

Erosion and sedimentation are also important issues of concern within the Malibu Creek Watershed. Erosion is the process of surface water cutting into

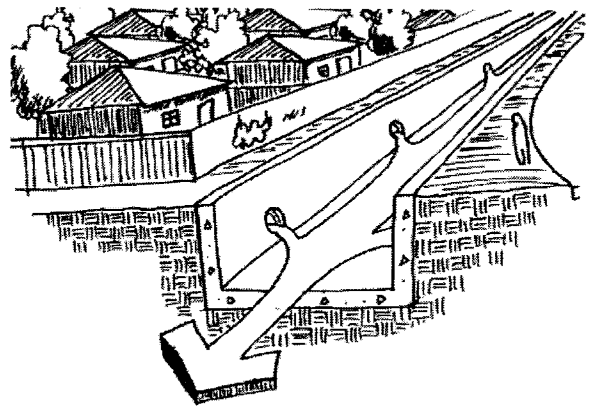


Figure 3-6: Channelization eliminates any benefits provided by riparian corridors.

and carrying soils, organics and rock material into waterways. When they settle, these insoluble particles are called "sediments". The Santa Monica Mountains contains many soil types that are considered highly erodible. An area's erodibility is dependent on the type of soils, slope, vegetative cover, and its exposure to water and rain. Consequently, erosion is a natural process that happens frequently within the watershed, and erosion adds sediments and nutrients to the streams. Erosion is also part of the natural cycle of wildfires; however, in developed areas, fire suppression measures have resulted in older, unburned plants. This in turn increases fuel loads, and therefore the intensity of a potential fire. The resulting erosion from such intense fire events increases sediment loading into streams.

Increased sedimentation of waterways can have a significant effect on instream habitat quality. Several factors have caused an increase in the sedimentation of streams, altering their natural process. Construction sites have exposed soils that erode, increasing sedimentation (Figure 3-7). Typically, 35 to 45 tons of soil per year per acre is washed from construction sites (Center for Watershed Protection n.d., p. 23). As well, agriculture, animal husbandry, and areas of disturbed or non-vegetated land significantly contribute to sediment loading. These sediments can cover stream bottoms, altering the habitat for aquatic life. The local steelhead trout is particularly sensitive, since they need gravelly stream bottoms for reproduction (Figure 3-8).

Dams used to create reservoirs or recreational lakes also play a role in the sedimentation process. They slow water flow to the point that suspended solids are dropped. The dam then becomes a sediment trap that quickly fills in (Figure 3-9). This has happened at Rindge Dam, located two and one-half miles north of the Malibu Lagoon. It creates barriers, preventing the migration of steelhead trout to their historic spawning grounds in the upper parts of Malibu Creek. The dam also traps sediments that may have been carried to the ocean and used for beach replenishment (Ambrose, Suffet, and Hee 1995, p. 10). Many of the reservoirs and constructed lakes within the Malibu Creek Watershed require regular dredging. Dredging is expensive, particularly if these sediments are placed in a landfill. These reservoirs and dams interrupt the natural migration of sediments.

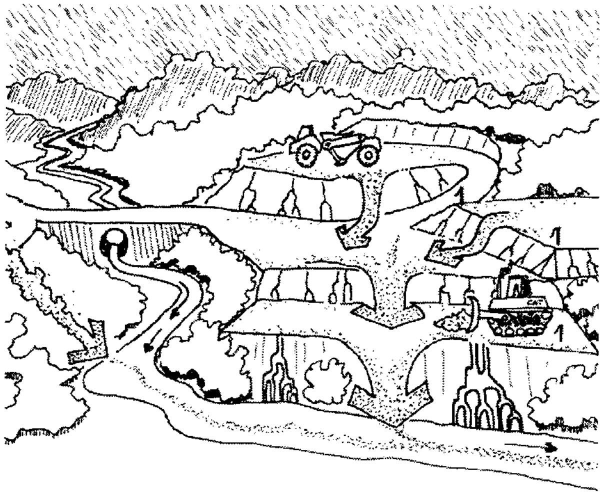


Figure 3-7: Construction sites can be a significant source of sediments.

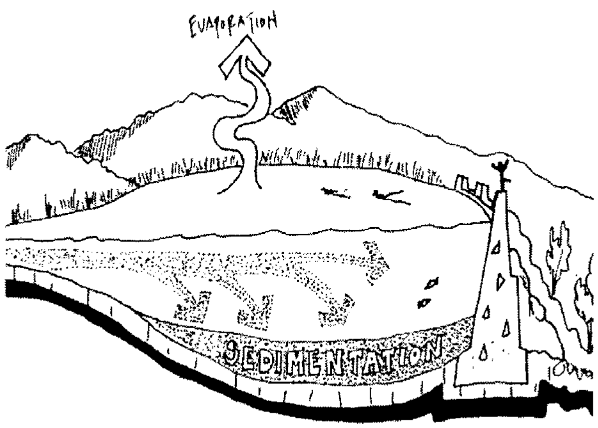


Figure 3-9: Reservoirs slow sediment transport to the point of becoming sediment sinks.

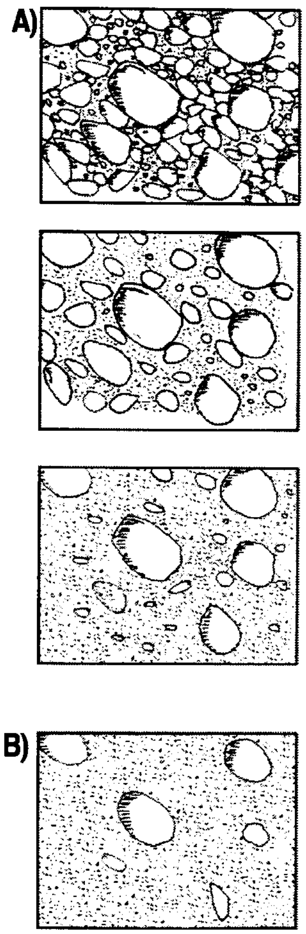


Figure 3-8: How a stream can become embedded in sediments, changing the substrate from gravelly (A) to silty (B), degrading Steelhead Trout breeding areas.

Nutrient Loading

Nutrients are necessary for the growth of plants and animals in natural water systems, and are primarily composed of nitrates and phosphates (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 47). Nutrient loading takes place when there is an overabundance of nutrients. High nitrate levels may cause increased algae production, cloudy water, decreased oxygen levels, and objectionable odors (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 47). Areas of standing water like the various constructed lakes and the Malibu Lagoon may be subject to increased effects of excessive algal growth and low dissolved oxygen levels causing fish kills and odor problems (Figure 3-10). Persistent eutrophication problems can change the composition of plant and animal species and decrease the biological diversity of a particular water body (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 48). To minimize the growth of algae, many of the constructed lakes are treated with copper sulfate, a powerful chemical; this may further contribute to degraded water quality and be a threat to the ecological functioning of the watershed. Prior sampling in the watershed has revealed that nutrient loading is a problem throughout the watershed.

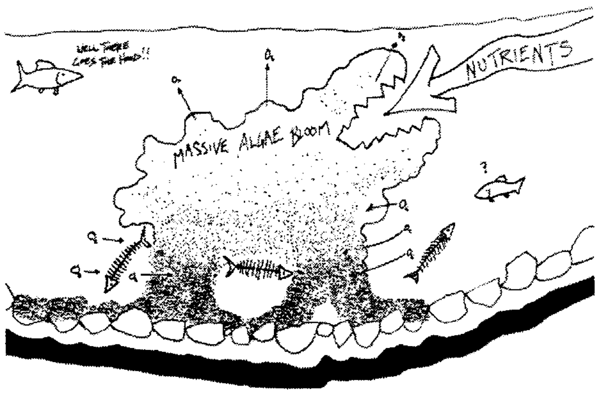


Figure 3-10: Algae blooms sparked by excessive nutrient can result in depleted oxygen level with detrimental effects to aquatic life.

High phosphates levels can also disrupt water quality. Sources include runoff from manure storage areas, feedlots, barnyards, leaking or improperly maintained septic systems, wastewater treatment plants, detergents and commercial cleaning preparations, soil erosion, and phosphate rich fertilizers (Behar, Dates, and Byrne 1996, p. 130). The fire retardant used to fight fires is a significant source of phosphorous and ammonia. A 1989 study found that during the first 24 hours following an aerial application of fire retardant, significant amounts of phosphorous, ammonia, and nitrogen were present in nearby streams (Ambrose, Suffet, and Hee 1995, p. 15).

Fire

Fire suppression near developed areas has allowed the plants to age, increasing woody fuel loads, and decreasing wildlife habitat value. Fire within older chaparral and coastal sage scrub stands has resulted in more intense fires and increased erosion. Fires cause increased runoff and stream flow, increasing sediment transport and nutrient loading to the lagoon (Ambrose, Suffet, and Hee 1995, p.7). The natural fire regime affects both water quality and water quantity within the watershed. Chaparral vegetation exudes oils, fats and other organic residues during combustion, which fall to the ground and create water-repellant soils. Water quantity is increased due to the removal of vegetative cover and the decreased porosity of soils. Increased runoff and less vegetative cover cause soil to be transported into the streams. The increased sediment load raises the turbidity, temperature, and dissolved organic nutrients content in the stream (Levy, Korkosz 1997, p.II-51). Plants that are burned from fire are washed into the streams during rain events causing elevated nutrient levels.

Effects of Settlement on Vegetation & Wildlife

Settlement has altered the native vegetation in the Malibu Creek Watershed. Much of the native vegetation has been eliminated by the addition of housing, roads, and surfaces that do not allow water to be absorbed into the ground, increasing the volume and intensity of storm water run off. Native vegetation is important in the riparian zone because they provide shade, which cools the water temperature, and provide food, habitat and shelter for aquatic animals and fish. Non-native plants brought in by early cattle ranchers and settlers, as well as plants used for landscaping, have been introduced into the watershed, and some of these plants are extremely invasive, displacing large areas of native vegetation. Landscaping practices affect water quality with the use of fertilizers, herbicides, pesticides.

Wildlife is dependent upon vegetation for shelter and food. Though the Santa Monica Mountains provide a large amount of healthy habitat, increased development is taking its toll through loss of habitat and habitat fragmentation.

The Lagoon

Development throughout the watershed has also had a significant effect on the lagoon's ecosystem. Pollutants from urban runoff, sediments, nutrients, and debris collect in the lagoon, creating a sink, or point of deposition. Although lagoons are excellent water purifiers, the additional quantity and lower quality of water reduces the lagoon's capacity to effectively filter the water. Prior to modern development, the lagoon was substantially larger than it's present 13 acres, and had greater species richness and abundance than today's 13 fish species (Ambrose, Suffet, and Hee 1995, p. i). The earliest maps seem to confirm a much larger lagoon that extended eastward around the point and to the west up to the base of the hill where Pepperdine University is now located (Ambrose, Suffet, and Hee 1995, p. 4). In essence, this smaller lagoon is asked to treat more water of lower quality. Excess flows of wastewater discharged into Malibu Creek cause the sandbar to breech during the dry season. This has the potential to suddenly change the lagoon's salinity, disrupting natural processes and affecting wildlife.

Section 4
The Monitoring Program

Many monitoring programs throughout the country utilize a variety of techniques to assess the overall ecological health within a watershed. A comprehensive approach to monitoring, one that takes into account the chemical, biological, and physical aspects of the stream ecosystem, yields the most usable data. This information allows decision-makers to attack the sources of problems from many different angles, not just one. Monitoring techniques include water quality or chemical testing, macroinvertebrate sampling, and stream reach surveying. The methods vary for each monitoring program, and grow out of the program goals and objectives.

The Cal Poly Team has designed a monitoring program that utilizes citizen volunteers to evaluate the overall ecological health of the Malibu Creek Watershed. The monitoring program is designed to address the issues related to imported water, impervious surfaces, erosion and sedimentation, nutrient loading, and pollutants associated with urban runoff. It is hoped that the monitoring program will determine the degree of degraded riparian habitats within each of the subwatersheds and target areas for future enhancement and restoration. Details about the specific monitoring procedures can be found in *The Malibu Creek Watershed, Stream Team Field Guide*, prepared by the Cal Poly Team.

The monitoring program is designed to represent an overall view of the entire watershed. This is a pilot project; therefore, it may not be practical to implement every element in the initial start-up phase. A phased approach allows the program flexibility, and is intended to provide Heal the Bay with options and the flexibility to adjust the program as necessary.

Involvement by citizen volunteers in the monitoring program should allow Heal the Bay and the California State Coastal Conservancy to meet the following long-term objectives:

- To establish baseline information that will ascertain the current overall health of the watershed.
- To determine the potential impacts of impervious surfaces and water quality due to urbanization within the watershed.
- To locate areas of degradation along stream corridors and to identify potential future restoration efforts.
- To assess the effectiveness of planning recommendations or Best Management Practices (BMPs) that are implemented to protect the watershed or mitigate potentially negative impacts.

Design Process

The design of the volunteer monitoring program began with a watershed inventory that involved the collection of studies conducted on the Malibu Creek Watershed. These studies were researched to gain a clear understanding of the natural processes at work in the watershed. A summary of this information can be found in section 2 of this document, Natural Processes. The second step was to analyze the collected information, and consult with concerned groups and local, state, and federal agencies that are active in the watershed. This helped identify key issues and questions that needed answers from the monitoring program. Section 3, Issues and Analysis, summarizes these elements. In addition, monitoring programs and protocols being used around the country were researched. Telephone surveys and questionnaires were distributed to the leaders of these monitoring programs to identify and avoid potential pitfalls. A workshop with a pool of potential volunteers was conducted, wherein volunteers were asked to identify potential monitoring sites and problem areas, to create a name for the program, to evaluate the proposed program for ease of use, and to establish a level of commitment Heal the Bay could expect from volunteers. Monitoring protocols and early drafts of the field guide were tested at two training events. Volunteers were asked to critique the protocols and the field guide. The monitoring program was revised based upon the input and suggestions of volunteers to the current design detailed in this section.

Successful Programs

The following elements were identified as being critical to ensure a successful volunteer monitoring program, as identified in the San Francisco Estuary Institute's *Riparian Station How-To Manual,* and from phone interviews with other monitoring programs around the country.

Motivating Volunteers

- Meet the needs of volunteers. This may be a simple as giving praise for a job well done or providing snacks and water at monitoring events.
- Listen and consider volunteer recommendations and suggestions.
- Acknowledge and reward the efforts of volunteers.
- Explain how the information collected by volunteers is being used to enhance the watershed.
- Involve volunteers in restoration activities and solutions, as well as in identifying problems.

Quality Control

- Provide the necessary equipment to collect good quality information.
- Assure the quality of the data by having frequent quality control checks and ongoing training.
- Ensure the quality of data collected through regularly scheduled training events, and appropriate protocols.

Program Organization and Expansion

- Organize a well structured program.
- Develop additional funding to support and expand the monitoring program as interest grows.

Using the Information

- Ensure the information collected by volunteers is analyzed and made available to interested agencies and groups that work in the watershed, for planning and resource protection.
- Integrate other locally collected data for analysis and dissemination.
- Use the Stream Team Program to educate the public about watershed issues.

MONITORING PROGRAM OVERVIEW

The Stream Team Volunteer Monitoring Program has been designed by the Cal Poly team for use in two phases. The purpose of Phase 1 is to provide useful monitoring information while at the same time providing volunteers with an opportunity for hands-on participation. Phase 1 will involve two types of monitoring activities–Stream Walking, and Water Chemistry Testing. This is a fact-finding phase that will help Heal the Bay to ascertain the existing condition of the watershed. In addition, trouble spots will be identified and located for further investigation and restoration. Phase 1 is the pilot phase of the project. Phase 2 expands on Phase 1 by adding the additional activities of Stream Reach Surveying and Macroinvertebrate Sampling.

All the information collected by the volunteers will be entered into a Geographic Information System (GIS) database (a computer mapping and database program) that will be maintained at Heal the Bay. This GIS program will allow the information to be analyzed by Heal the Bay and distributed to agencies throughout the area. The following is a brief description of the activities that will occur during each phase of the project.

Phase 1

Stream Walking

Stream Walking is the systematic visual observation of physical conditions along streams within the Malibu Creek Watershed. The focus includes locating all types of discharges flowing directly into streams, and areas of disturbance such as erosion and invasive plant species, barriers to fish passage, illegal dumpsites, and human alterations to the streambank (Figure 4-2). This is a method for quickly collecting

Figure 4-2: Stream walker with GPS device noting location of discharge point.

information on elements that are impacting the water quality and ecological functions of the stream. This gathered information should alert Heal the Bay to the locations of suspected impacts within the Malibu Creek Watershed so that these impacts can be targeted for immediate removal or restoration. Stream Walking provides valuable information that should help prioritize the more specific testing that will occur during Phase 2.

Water Chemistry Testing

The Water Chemistry Testing team will use chemical testing to examine the water quality of a number of fixed stream sites throughout the watershed (Figure 4-3). Tests include pH, temperature, dissolved oxygen, turbidity, conductivity, nitrates, ammonia, and phosphates. Once the data is compiled and analyzed, a picture of the existing conditions of the watershed should be revealed. This procedure is designed to determine how much each subwatershed is contributing to downstream flows and water quality. This information will be used to guide the expansion of the Water Chemistry Testing in Phase 2, and will be shared with the Regional Water Quality Control Board so that the sources of pollution can be identified and eliminated.

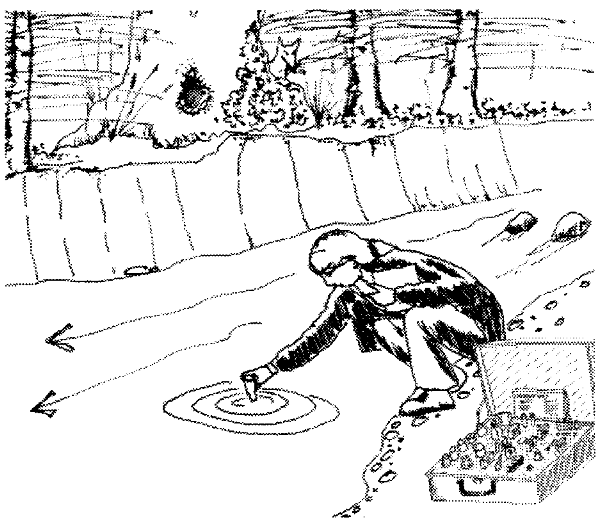


Figure 4-3: Water Chemistry tester taking pH reading.

Phase 2

Macroinvertebrate Sampling

Biological monitoring is an important tool for testing water quality and assessing the health of the watershed. Aquatic macroinvertebrates live most or all of their lives in the water. They react to pollutants, water temperature, and habitat conditions like sedimentation of substrate, and are therefore continuous indicators of water quality. Monitors will collect macroinvertebrates, identify them, and sort them into taxonomic categories. If a monitoring sample shows a great number of pollution-tolerant macroinvertebrates, and very few, if any, of the pollution-sensitive macroinvertebrates, it can indicate that water quality is poor. A healthy stream should demonstrate excellent species diversity for the various types of aquatic macroinvertebrates in the watershed (Figure 4-4).

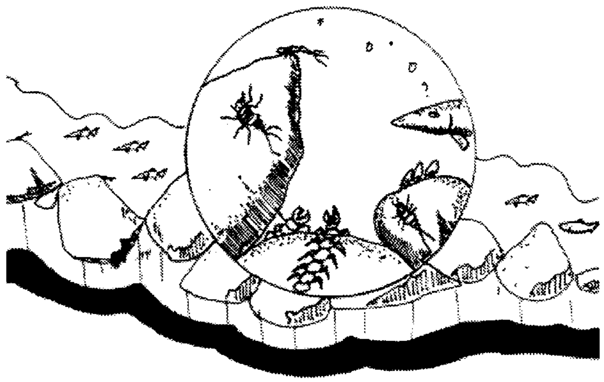


Figure 4-4: View of the macroinvertebrate environment

Stream Reach Survey

Stream Reach Surveying is the detailed measurement and assessment of physical characteristics of randomly selected 100-foot stream segments along the entire length of a stream (Figure 4-5). Further, the Stream Reach Survey involves walking the same tributaries as the Stream Walk procedure, and will be used to monitor the progress made during Phase 1. By examining existing stream characteristics and comparing them against future observations, it may be determined if habitat is being lost or degraded due to upstream development.

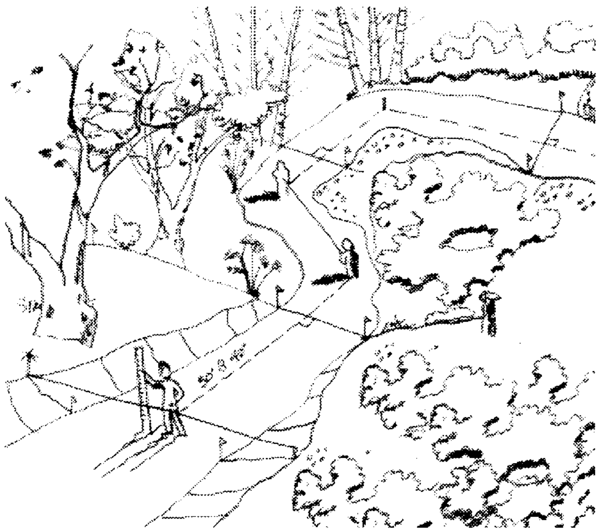


Figure 4-5: Overview of stream reach surveying.

Monitoring relatively undisturbed stream reaches can yield baseline information that can be compared to areas impacted by land use activities, in order to determine if those activities are affecting the conditions of the stream. These same locations can be monitored over time to determine the long term effects of upstream development.

How The Program Works

Volunteers have a choice of taking part in one or more components of the Phase 1 monitoring program. These include Stream Walking or Water Chemistry Testing. Both Stream Walking and Water Chemistry Testing are conducted on a monthly basis, requiring a four-hour commitment on one weekend day per month. Volunteers should be placed on one or more of these teams, based upon their interests, skills, time, and the needs of the volunteer monitoring program.

Each volunteer should attend an initial orientation session, which will provide an overview of the monitoring program and introduce the different components of the program. Following the orientation session, volunteers will be asked to attend two training events. During these events, they will be given the opportunity to learn the basic skills necessary to perform the monitoring tasks. Once they have acquired the necessary skills for monitoring, they can join the Stream Team (Figure 4-6).

Establishing a Core of Volunteers

Volunteers are essential to the Stream Team Program and are an important link between Heal the Bay and the community (Rigney, Fischer, and Sawyer 1996, p. 19). Extensive research on implementing volunteers was conducted through interviewing the program coordinators of other monitoring programs across the country, who were eager to share their experiences and to help others avoid problems they faced. The following suggestions were made:

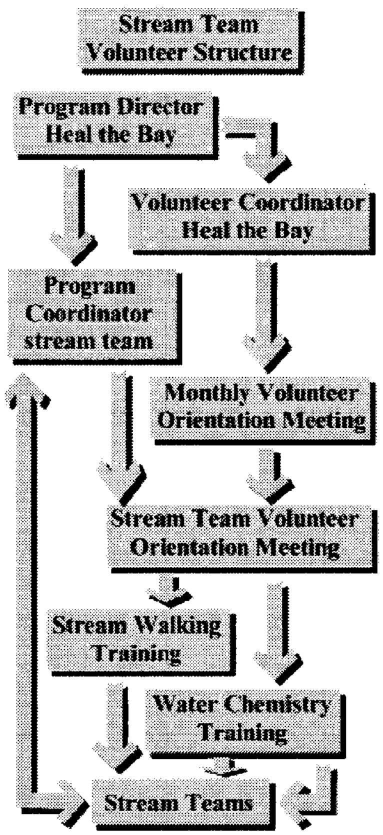


Figure 4-6: Volunteer flow

- Develop a core of volunteers that are very dedicated to the project. This core will assist the program coordinator in many activities involved with the program.
- Create an open channel of two-way communication. Encourage input from volunteers and good suggestions should be incorporated into the program. Volunteers will get discouraged with any program that is not well organized and does not acknowledge their efforts and emphasize what the program is accomplishing.
- Feedback is critical. Any program should be flexible and have the ability to adapt to change. If the manual or procedures are hard to understand, volunteers can provide excellent feedback that can greatly improve the comprehension of the monitoring procedures. A workshop at Heal the Bay revealed that social interaction and meeting people with like interests was an important factor to becoming involved in the Stream Team Program.

Recruiting Volunteers

Heal the Bay is very experienced in recruiting volunteers and can develop and maintain a significant volunteer pool utilizing their existing channels. Several modifications to existing procedures that incorporate the Stream Team Program will ease the workload and save time within the organization. Currently Heal the Bay attends many events where they provide information and literature about the organization as well as opportunities to get involved on a voluntary basis. This literature should include the Stream Team Program and the volunteer opportunities associated with it. It is important that this literature provide some detail about the physical nature of the project as well as the time commitment necessary to participate.

Heal the Bay should include a section about Stream Team activities on their website. A section of their newsletters should be dedicated to activities and accomplishments of the Stream Team and to volunteer opportunities. Newsletters are an excellent way to recruit new volunteers to the Stream Team program and to share accomplishments of the Stream Team program.

Additional potential sources of volunteers:

- Local residents that live in or near the watershed
- Local high schools, colleges, and universities
- Local environmental groups like the California Native Plant Society, Audubon Society, Surfrider Foundation, Cal Trout, Ducks Unlimited, and the Sierra Club
- Local scuba diving clubs, fishing clubs, and equestrian groups

Training Volunteers

The key to collecting high quality data is good training (Rigney, Fischer, and Sawyer 1996, p. 19).
The volunteers need to feel confident in their abilities and the training they receive. A minimum of two hands-on training events is recommended. Volunteers should be accompanied in the field for at least the first two monitoring events by a Stream Team Captain, the Program Coordinator, or the field biologist.

Tips given by existing programs:

- Training events should have clear goals that are attainable. Do not overwhelm the volunteers with too much information during the first event (Rigney, Fischer, and Sawyer 1996, p. 20).
- Volunteers should receive one-on-one attention for all testing procedures. It is not enough to demonstrate the procedures to a large group. Let each volunteer use the equipment and master the procedures.
- Training should occur in the field.
- Volunteers should set their own limits and tell the Stream Team Captain or other person leading the training event if they feel personally uncomfortable or unsafe.
- Tell volunteers how their efforts are important, who is going to use the information they collect, and what they will gain from the Stream Team Program.

A field guide has been developed for the Stream Team Program. The field guide provides educational material about the natural processes of the Malibu Creek Watershed including the changes caused by extensive development in the region. The field guide was created to be inspirational, educational, and easily comprehended by the volunteer. The Stream Team Field Guide is intended to complement hands-on field training.

Keeping Volunteers Interested and Motivated

The Coyote Creek Riparian Station, located in Santa Clara County, invites speakers to address their volunteers from various environmental disciplines. This affords volunteers the opportunity to meet and learn from environmental professionals. Opportunities for volunteers to participate in field activities other than the Stream Team include the California Department of Fish and Game, California Department of Parks and Recreation, National Park Service, and the Resource Conservation District of the Santa Monica Mountains. These groups all have opportunities that could benefit these organizations as well as the volunteers.

Stream Team T-shirts should be designed and distributed to volunteers. Certificates of Training and awards acknowledging outstanding volunteers should be regularly distributed and signed by the Executive Director of Heal the Bay. An annual awards party for the Stream Team which includes a presentation by Heal the Bay's Executive Director about the progress of the program and how it is making a difference in the Malibu Creek Watershed is recommended. An outstanding Stream Team member should be selected every month and their image posted on the website.

Organizational Structure

All persons wishing to volunteer at Heal the Bay are asked to attend a volunteer orientation, run by Heal the Bay's Volunteer Coordinator. During this volunteer orientation, all the volunteer opportunities available at Heal the Bay are presented. Those who are interested and willing to invest the time required, should be referred to the Stream Team Program Coordinator.

The Program Coordinator is the liaison between Heal the Bay and the volunteers. This person is responsible for organizing the training and monitoring events, keeping volunteers informed about activities, and ensuring that volunteer input is heard and incorporated into the program. The volunteers and their commitment are what determine the difference between a program that fails and one that makes a difference. The Program Coordinator must meet the needs of the volunteers including praise, acknowledgment, rewards, parties, and social interactions, as well as letting those people know how important their efforts are and how much they are appreciated by Heal the Bay.

The Program Coordinator will:

- Maintain close contact with the pool of volunteers
- Schedule and over see training events
- Ensure that the information collected is distributed to stakeholders and decision-makers
- Ensure that volunteers are aware of their contribution to the overall monitoring effort and are aware how the information they collect is making a difference in the Malibu Creek Watershed
- Stay abreast of the latest developments, techniques, and methods for collecting and analyzing data, through contact with other monitoring efforts and continuing education.

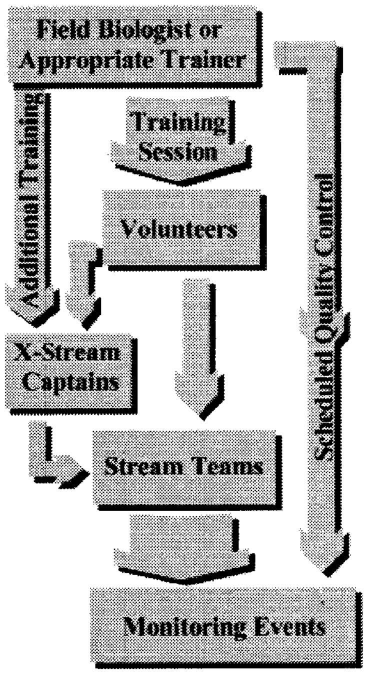


Figure 4-7: Training Flow

The Organization of the Stream Team

A field biologist or other appropriate trainer approved by the science and technical staff at Heal the Bay should train the Program Coordinator and the Stream Team Captains and be present at regularly scheduled quality assurance and quality control events (Figure 4-7). These events are designed to evaluate volunteers on their adherence to monitoring protocols and their familiarity with proper use of the equipment.

The Program Coordinator is ultimately responsible for the safety, training, and day-to-day management of the Stream Team Program. This person should be supported with technical and scientific expertise from within Heal the Bay or from outside consultants. The Program Coordinator should be well versed in all monitoring protocols, procedures, and safety issues, as this person will oversee the training of volunteers. The Program Coordinator must be approachable and accessible for volunteers to express their concerns and provide suggestions regarding the Stream Team.

A core of dedicated volunteers will serve as Stream Team Captains. Stream Team Captains serve as a vital link between the Stream Team volunteers and the Program Coordinator. The Stream Team Captains will be organized into a group known as the X-Stream Team and will be identified as X-Stream Team Captains. This group should attend two training events and be accompanied into the field by the field biologist and Program Coordinator for the first three monitoring events. Captains should receive additional training about safety issues. Captains serve as technical advisors in the field and ensure the consistency of the data collected. Having a Captain on each team will ensure that the program is safer, that monitoring protocols are being followed, and the quality of the data is good. Captains will have the responsibility of making sure the equipment is treated appropriately, and returned to the Program Coordinator following the monitoring event. An X-Stream Team Captain should be assigned to every team. X-Stream Team Captains must ensure that volunteers are not placed into situations that are unsafe and should brief their team before every event about safety issues. Captains must be reliable, approachable, and able to communicate with their team.

Stream Team Volunteers should be accompanied by an X-Stream Team Captain at every monitoring event. X-Stream Team Captains and Stream Team Volunteers should be periodically checked and evaluated on their familiarity with the equipment, and information collection procedures.

How Data Can Be Used

The data collected should be very useful to local government agencies and organizations, including Heal the Bay, the Regional Water Quality Control Board, California Department of Fish and Game, California Department of Parks and Recreation, the National Park Service, the Resource Conservation District of the Santa Monica Mountains, and other stakeholder agencies working to protect the natural environment. These groups are very interested in using the collected data to track trends in water quality, and in assisting local planning agencies to develop future water quality protection goals and land use management strategies. This data will also be uploaded to a Regional Data Base maintained by the Regional Water Quality Control Board.

Heal the Bay will use the information gathered during the Stream Walking in Phase 1 to create a map of potential restoration sites, discharge points and outfalls, sites that need clean up activities, and potential barriers to fish passage. This mapped information can assist local planning agencies and other concerned organizations in developing future watershed protection goals and restoration strategies.

Monitoring Activities

The following is a more detailed account of the various monitoring activities

Stream Walking

Stream Walking is the starting point for monitoring in the Malibu Creek Watershed. Stream Walking is an active task that requires the volunteer to get down into the riparian corridors and explore with an acute attention to visual details. The goal of Stream Walking is to provide an overall impression of the stream reaches within the watershed as well as identify key elements of concern. Stream Walk teams will be comprised of an X-Stream Team Captain and two Stream Team Volunteers.

What to Monitor

The collection of the following information should provide Heal the Bay with an overall view of the Malibu Creek Watershed. Analysis of the data should help Heal the Bay chart a course of action geared at improving the ecological function and water quality within the watershed. Heal the Bay should distribute this information to the many agencies with responsibility over the area so that they can make informed planning decisions and take necessary corrective actions.

Volunteers are asked to record information about each of these physical parameters:

1. Discharge Points and Outfalls
2. Unstable Bank Conditions
3. Artificial Streambank Modifications
4. Impacting Land Uses
5. Large Patches of Exotic and/or Invasive Vegetation
6. Possible Barriers to Fish Passage
7. Dump Sites

1. Discharge Points and Outfalls

Discharge points and outfalls are pipes and culverts that carry storm water runoff into a stream at a single point (Figure 4-8). This may cause water quality and stream morphology to be impacted, especially at the point of discharge into the creek. Not all discharges are legal, and information regarding the current location of all outfalls to the creeks is limited. This information will help Heal the Bay update available mapped information.

Figure 4-8: Storm drain discharge point

2. Unstable Bank Conditions

Unstable bank conditions are a common problem along local streams, particularly ones that are subject to upstream development. Banks that are eroding or collapsing into the stream do not have stable soils for vegetation to establish (Figure 4-9). Eroding banks contribute sediments that can impact the habitat of steelhead trout and macroinvertebrates, and collapsing banks can block stream flows, causing flooding and damage to nearby property.

Figure 4-9: Collapsing streambanks and vegetation.

3. Artificial Streambank Modifications

Artificial streambank modifications often are used in urbanized or developing watersheds to prevent flooding (Figure 4-10). This method of streambank stabilization and flood control eliminates the natural vegetation. Vegetation provides food and habitat for aquatic and land-based birds and wildlife, slows the flow of surface runoff, and balances the nutrient levels of streams. Alteration of streambanks is often necessary when private property backs up to a stream and structures are built close to the stream's edge. While artificial bank modification may solve the problem of one property owner, the results are a funneling of problems further downstream to the next property owner, and beyond.

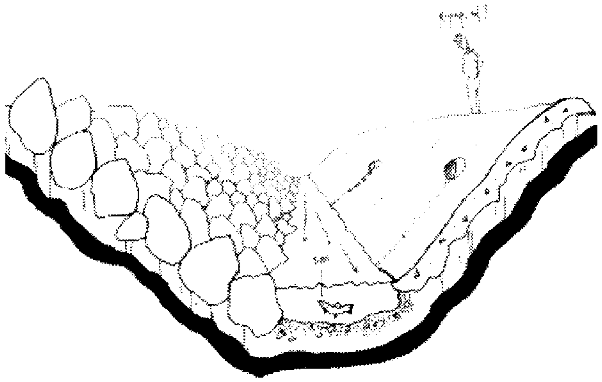


Figure 4-10: Artificially lined streambanks

4. Impacting Land Uses

Impacting land uses that are adjacent to streams can potentially affect the stream environment. The land uses of concern are those that have replaced riparian vegetation. For example, some places in the watershed have horses or other animals that graze right at the edge of the streambank (Figure 4-11). In other locations shopping centers or houses may be located right on the streambank edge. While these land uses may not have a discharge directly to the stream, runoff from these areas could have an effect on stream health.

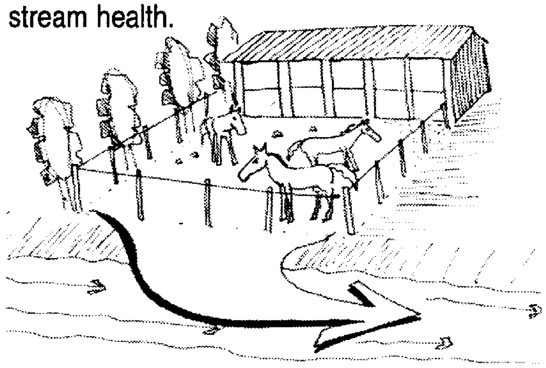


Figure 4-11: Impacting Land Use

5. Large Patches of Exotic and/or Invasive Vegetation

Large patches of exotic and/or invasive vegetation are non-native plants introduced to the Malibu Creek Watershed from other parts of the country or from other regions of the world. Many of these plants are well adapted to local climate and soil conditions; some are aggressive and may out-compete and displace native vegetation (Figure 4-12). Problems arise when these plants do not provide the food and habitat required by the native species of birds and wildlife.

Figure 4-12: Identifying patches of invasive vegetation.

6. Possible Barriers to Fish Passage

Possible barriers to fish passage potentially affect the passage of steelhead trout and other fish to protective spawning ground within the upper watershed (Figure 4-13). Currently, the annual steelhead run is restricted to the lowest 2.5-mile stretch of Malibu Creek, below Rindge Dam. Healthy fish habitat is usually productive habitat for many other aquatic species.

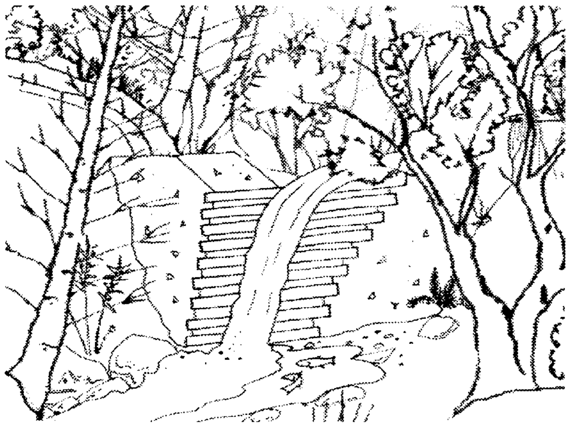


Figure 4-13: Constructed check dams can pose obstacles to fish migration.

7. Illegal Dump Sites

Illegal dumpsites exist partially because dumping is cheaper than legal disposal of waste. Frequently dumped wastes include hazardous chemicals, or large items like appliances (Figure 4-14). The problem is compounded when certain areas become recognized as places to dispose of waste. Areas in and around streams are frequently used as dump sites because they are off the beaten track, lessening the likelihood of the perpetrators being caught in the act.

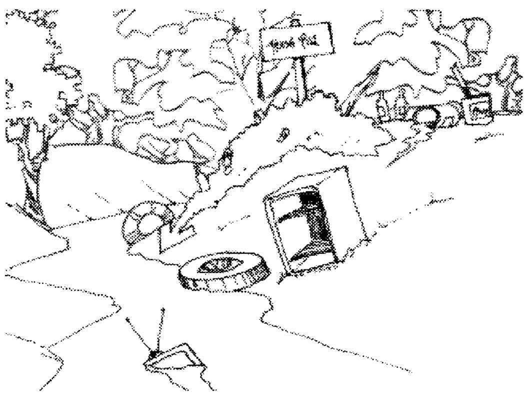


Figure 4-14: Illegal dump sites

When any of the seven listed parameters is identified, a Global Positioning Unit (GPS) will be used to record its precise location. The location will be added to a GIS database that is owned by Heal the Bay. This information will be analyzed by Heal the Bay and suggestions will be made to correct the problems identified during the Stream Walk. Maps that identify the locations of these items along the streams and creeks throughout the watershed should be distributed to interested agencies. By summarizing the information collected during the Stream Walk into a GIS, the data becomes usable by a wide range of groups and agencies.

Quality Control and Quality Assurance

The Program Coordinator and a field biologist should provide training to the X-Stream Team Captains and to Stream Team Volunteers. X-Stream Team Captains should receive two intensive field trainings by the Program Coordinator and a field biologist. Captains should be accompanied in the field on the first three monitoring events. Stream Team Volunteers should also attend two training events with either the Program Coordinator or a field biologist. All teams should have an X-Stream Team Captain plus two volunteers. All volunteers should be able to demonstrate the ability to follow monitoring protocols and proficiency with using the equipment provided in the field kit. Each team should be recertified once every six months on their proficiency with data collection methods and their ability to use the equipment. The field biologist and the Program Coordinator should be present during recertification.

Water Chemistry Testing

If the overall goal of the monitoring program is to improve water quality, then Water Chemistry Testing provides the springboard of data from which further action can be taken. Specifically, the objectives include:

- To establish current baseline conditions within the various subwatersheds of the Malibu Creek Watershed.
- To determine how much each subwatershed contributes to poor downstream water quality.
- To explore the ability of streams to support native plants, and aquatic wildlife such as steelhead trout.

Water quality that is good for aquatic life is often good for humans as well. The overall goal of water chemical testing is to ultimately improve water quality throughout the watershed.

What to Monitor

The specific parameters to be monitored are selected based on issues of concern and the analysis conducted of the Malibu Creek Watershed. Detecting the presence of pollutants and their potential sources should lead to actions that improve the water quality throughout the Malibu Creek Watershed. Each test is to be conducted twice. If the second result does not closely coincide with the first result, a third test must be performed. Double-checking results in this way will ensure higher quality data.

The following parameters will be measured for the Malibu Creek Watershed Stream Team Pilot Project:

Physical Parameters

1. Site Conditions (weather conditions, debris, and stream properties like color and odor)
2. Stream Flow
3. Air Temperature
4. Water Temperature

Chemical Parameters

5. Dissolved Oxygen
6. pH
7. Turbidity
8. Conductivity
9. Phosphorous
10. Nitrate-Nitrogen
11. Ammonia-Nitrogen

For purposes of the program, Site Conditions are visual observations that do not require quantitative measurements, but do require a general agreement on observation conclusions. Items three through eight are either measured chemically or with meters, and require patience and acute attention to detail. Water Chemistry Teams will collect water samples for items nine through eleven, but will not perform the actual tests. Measuring phosphorous, nitrogen, and ammonia involve complicated procedures. To ensure high quality information, these measurements should be performed by Heal the Bay's Program Coordinator or a field biologist.

1. Site Conditions

The site conditions of the monitoring location will aid Heal the Bay in analysis of the data. These parameters are generally brief, but careful observations should be noted on the "Site Conditions" field sheets. Included among these are weather conditions, presence of debris, and properties of the stream, like presence of algae, water color, appearance, and odor. Observations can be noted at any time during the monitoring event.

2. Stream Flow

Stream flow is the volume of water that moves past a fixed point in a specific interval of time. The amount of water (volume) and how fast it is traveling (velocity) determines the flow of a stream (Figure 4-15).

Stream flow is an important indicator of water quality. It affects the available oxygen level in water that fish and other aquatic wildlife depends on to live. Generally, streams with higher flows have more oxygen available for aquatic wildlife. Stream flow also controls the amount of sediment that is transported in a stream. Streams with higher velocities and larger flows transport greater amounts of sediments than streams with lower flows. In addition, stream flow determines how pollution is transported downstream, and influences the ability of a stream to dilute pollution.

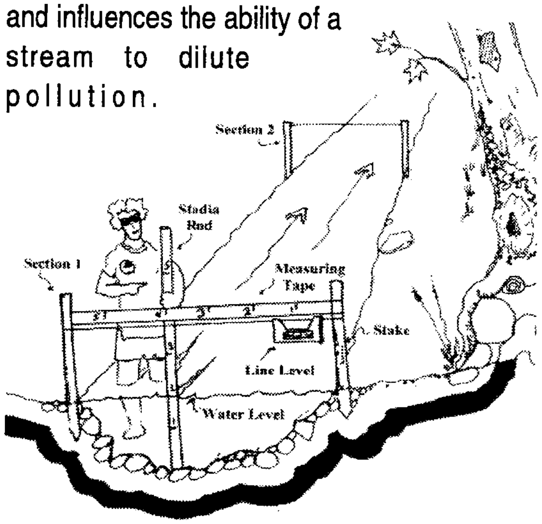


Figure 4-15: Measuring Stream Flow.

Large, swift rivers have a greater ability to dilute and degrade runoff pollutants, unlike smaller streams.

3. Air Temperature

Air temperature can influence water temperature. Air temperature measurement should be taken at the beginning and end of the monitoring event.

4. Water Temperature

Temperature of the water directly affects biological and chemical processes. Some fish species prefer colder waters than other species. Macroinvertebrates will move in the stream in order to find their optimal temperature. Water temperature should be taken twice, once at the beginning of the monitoring event, and once at the end.

5. Dissolved Oxygen (DO)

Aquatic organisms rely on the presence of oxygen in streams. Water temperature and altitude, time of day, and seasons can all affect the amount of dissolved oxygen. Oxygen is both produced and consumed in a stream. Because of constant churning, running water, especially in riffles, dissolves more oxygen

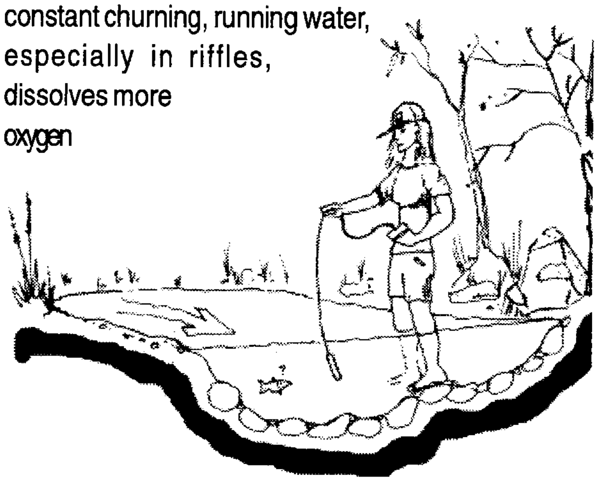


Figure 4-16: Measuring Dissolved Oxygen

than the still water often found in a lake or stream pool (Figure 4-16) (US EPA 841-B-97-003 1997, p. 139). The presence of aquatic plants also affects dissolved oxygen concentrations. Green plants release oxygen underwater during photosynthesis. Maximum amounts of DO are produced with the energy of the late afternoon sun. By early morning, the same plants may have taken up the oxygen, making levels of DO lowest at this time. Because DO is lowest in the morning hours, it is one of the first tests performed at the sampling station.

6. pH

pH is a measure of how acidic or alkaline the water is at the time of testing. The pH of a stream affects the ability of plants and wildlife to function and live. pH is measured on a scale from 1.0 to 14.0. Neutral pH is 7.0. Acidic pH is less than 7.0, and alkaline is greater than 7.0. A wide variety of aquatic animals prefer a range of 6.5-8.0 pH. A pH meter measures the electric potential of water in millivolts or pH units.

7. Turbidity

Turbidity is a measure of water clarity. Insoluble solids or suspended particles such as clay, silt, sand, algae, plankton and other substances affect the clarity of the water. High levels of turbidity affect the ability of steelhead trout and other aquatic organisms to survive. Water temperature is increased when suspended particles absorb more heat. Also, when turbidity is high, photosynthesis is reduced, due to the decrease in the amount of light traveling through the water (Figure 4-17). Sources of turbidity include soil erosion, waste discharge, urban runoff, eroding streambanks, large numbers of bottom feeders that stir up sediments, and excessive algal growth.

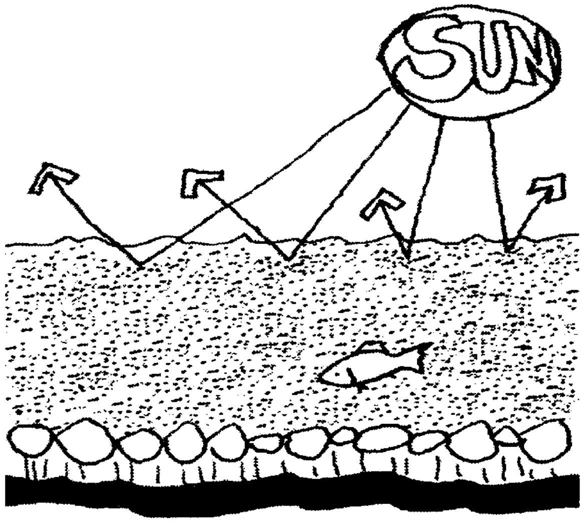


Figure 4-17: Dissolved sediments blocking sunlight

8. Conductivity (Total Dissolved Solids)

Conductivity is a measure of the ability of water to pass an electrical current. The concentration of dissolved solids or the conductivity of streams is directly affected by the substrate or stream bottom material. Conductivity indirectly indicates the presence of inorganically dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, iron, and aluminum (Murdoch, Cheo, and O'Laughin. 1996, p. 181). These substances and seawater enhance the ability of water to conduct electricity. Failing septic tanks, sewage spills, and agricultural runoff containing phosphates and nitrates are indicated by high conductivity measurements. In general, conductivity is higher in areas with clay soils because these soils tend to dissolve in water. Conversely, organic substances like oil, alcohol, and grease are poor conductors of electricity and will yield low conductivity measurements. Excessive amounts of dissolved solids leads to poor tasting drinking water with laxative effects (Murdoch, Cheo, and O'Laughin. 1996, p. 181).

9, 10, & 11. Phosphorus, Nitrate-Nitrogen & Ammonia-Nitrogen

Phosphorus and nitrogen are both nutrients occurring in streams, and are essential for plants and animals in an aquatic ecosystem. These nutrients originate from both naturally occurring sources and from areas of human development. Naturally occurring sources include soils, eroding rocks, and terrestrial animal and plant waste washing into the streams. Problems occur when large amounts of phosphorous and nitrogen is introduced into the stream ecosystem, results in excessive algal growth depleting the available oxygen in the stream that fish and other aquatic organisms depend upon. Sources of nutrients from human development include wastewater treatment plants, runoff from fertilized agricultural lands, lawns, and golf courses, runoff from grazing animals, commercial cleaning activities, and other similar sources.

Phosphorous is a useful indicator of potential problems associated with excessive plant growth. High amounts of dissolved phosphorous may indicate a pollution source such as chemical fertilizers or septic system leachate. Insoluble phosphorous can be due to excessive erosion, animal waste, or sewage (Murdoch, Cheo, and O'Laughin 1996, p. 180). Two field tests are used to measure the nitrogen content in streams: nitrate-nitrogen (N_2 + $N0_3$), and ammonia-nitrogen. Although nitrogen (N_2) is the gas that composes 80% of the air we breathe, most plants cannot use nitrogen in this form. N_2 is converted into nitrates, a form that can be used by plants to build proteins. It is this form of nitrogen that the Stream Team will measure. In streams with low levels of dissolved oxygen and elevated levels of nitrates, nitrogen will be found in the form of ammonia. Ammonia is extremely toxic to aquatic life, as compared to nitrates. Sources of nitrogen include wastewater treatment plants, runoff from animal manure storage areas, runoff from fertilized lawns and croplands, failing or improperly maintained septic systems, and industrial discharges containing corrosion inhibitors.

Water Chemistry Monitoring Locations

The long-term goal of the program is to have monitoring locations in each of the seven subwatersheds within the larger Malibu Creek Watershed. Monitoring sites will be at a minimum of two fixed locations in each subwatershed of concern. These two sites will be upstream and downstream of pre-determined land use impacts. The fixed monitoring location above the pre-determined land use will be in a relatively pristine section of the stream. The second fixed monitoring site will be located at the base of the subwatershed, where a stream leaves that particular subwatershed and enters another one.

Comparing the results from these sampling sites should help Heal the Bay determine the effects of land uses and impermeable area on water quality, and to what extent a given subwatershed is contributing to downstream pollution. Based on the results of the work, Heal the Bay and other agencies should be able to determine which subwatersheds require immediate attention and future action.

Because each subwatershed has its own unique natural features and land uses, the impacts to water quality differ between them. For example, the impacts to water quality may be more obvious in the highly developed Westlake and Agoura Hills subwatersheds than in the largely rural Malibou Lake and Cold Creek subwatersheds.

Water Quality Monitoring will occur once a month at each monitoring station. To accurately sample for trends over time, monitoring must take place at the same location, and at the same time of day. This is because concentrations of the substances being tested for vary according to season, time of day, and temperature. A schedule of Water Chemistry Testing events, including the dates and times will be created.

Quality Control and Quality Assurance

Heal the Bay is part of the Southern California Volunteer Monitoring Quality Assurance Project Plan that details testing methods and accuracy requirements of the Water Chemistry Procedures. This section provides recommendations to Heal the Bay that will improve data quality and the time it takes to conduct test procedures.

1. All water chemistry testing volunteers should attend two training events with each volunteer having the opportunity to conduct the tests and use the equipment.
2. X-Stream Team Captains should be accompanied into the field by the field biologist or the Program Coordinator for the first three monitoring events.
3. All tests should be performed twice and if the data does not agree, a third time.
4. Recertification should occur every six months at which time volunteers must demonstrate their proficiency in using the equipment, following the protocols, and accurately collecting analyzing the water samples.
5. Side by side sampling should occur at the same time to ensure the accuracy of the equipment and reagents in the field kit.
6. A strict schedule for replacing reagents in the field kit should be maintained, and the lower expiration limits on those reagents should be used.
5. One person should be in charge of maintaining equipment and ensuring that the equipment is properly cleaned, calibrated, and maintained.
6. The Program Coordinator should be well versed in calibration procedures and life expectancy of all field equipment. A replacement schedule and funding for new equipment should be in place.

Water Chemistry Recommendations:

The following recommendations regard the field kit.

1. Heal the Bay should purchase the testing modules for the field kit packaged individually and not in the current package case format. By modularizing the purchases it will be easier to customize or modify this kit in the future as better testing procedures and methods become available.
2. By modularizing the field chemistry kit, the kit can be assembled in a backpack unit that will be easier for volunteers to

transport.

3. Specialized cases for sensitive equipment like GPS units, electronic water chemistry equipment, and digital cameras can be integrated into a single Stream Team field kit which will be better protected from unforeseen accidents.
4. Volunteers will be more productive and the data collected will be of more value if the field kits incorporate dissolved oxygen meters and turbidity meters instead of the titration method currently being utilized.
5. The nitrate test, nitrogen as ammonia test and phosphate test may not be accurate enough to make the data collected useful in analysis. Water samples should be collected by volunteers, labeled and put into a full ice chest. The sample should be transported to the central meeting place and analyzed using a colorimeter by the Program Coordinator or field biologist. By using a central meeting place, the samples can be analyzed in a more timely manner and only one colorimeter need be purchased.
6. Training and monitoring events should be scheduled far in advance at regular intervals, e.g. the first Saturday of every month.
7. Volunteers should gather at a central meeting place prior to each event and at the end of each event. This can be used to pass out and collect equipment, to ensure that all volunteers are safe, and to perform the nutrient testing.

Phase 2

Phase 2, if implemented, would provide supplemental data regarding the effects of development and urbanization on stream health. This phase would include macroinvertebrate sampling and stream reach surveying. Biological monitoring could be integrated into the Stream Team Program, or be a supplement program conducted by an outside agency. If an outside group samples for macroinvertebrates, they should choose sites detailed in section 5 of this document. This will enhance the monitoring program and ensure the data collected is most useful.

The Stream Reach Survey should be implemented in Phase 2 and should build on the Stream Walk information. This tiered approach allows Heal the Bay time to develop a volunteer pool and develop a well-organized program based on field experience. This approach should allow Heal the Bay to better evaluate if volunteers are able to accurately collect this more complex data.

Macroinvertebrate Sampling

Biological monitoring is a monitoring tool for testing water quality and assessing the health of the watershed. Biological testing depicts water quality over a longer period of time, since the biological components of a stream live in direct contact with water and are affected by the quality of that water. These organisms are the continuous indicators of water quality. An integrated approach using chemical testing, biological testing, and assessing the physical components of a stream, can result in a more comprehensive evaluation of stream and watershed health.

Why Monitoring for Macroinvertebrates is Important

A common way that volunteers can test the biological health of a stream is by monitoring for aquatic macroinvertebrates. Since riparian macroinvertebrates are largely immobile and spend part or all of their life within water, they are continuous indicators of water quality. Some macroinvertebrates are highly pollution-sensitive while others are more pollution-tolerant. They can react to changes in water temperature, dissolved oxygen levels, chemical and organic pollution, and sedimentation. If a monitoring sample shows a great number of pollution-tolerant macroinvertebrates and very few, if any, of the pollution-sensitive macroinvertebrates, it can be an indication that water quality is poor.

What are Macroinvertebrates?

Macroinvertebrates are organisms that have no backbone and can be seen with the unaided eye. These can be aquatic clams, snails, worms, and insects. Many of the macroinvertebrates live the majority of their life within water. For many this is their aquatic stage. They include organisms such as mayflies, dragonflies, and caddisflies (Figure 4-18). Once they enter the adult stage they develop wings and are able to fly, mate, and deposit eggs for another generation to form and develop. The aquatic stage can last a few weeks or up to a few years, depending upon the organism. Other types of macroinvertebrates, such as aquatic worms and snails, live all of their life within water.

The macroinvertebrates to be monitored are benthic macroinvertebrates. These are macroinvertebrates that live on the bottoms of streams and watercourses. Benthic macroinvertebrates can be divided into functional feeding groups. These groups are collectors, shredders, scrapers, and predators. Collectors feed on tiny pieces of organic material, and can be further divided into collector-filterers and collector-gathers. Shredders feed on coarser pieces of organic material such as leaves, algae, and twigs. Shredders break down these larger pieces which other macroinvertebrates can then feed on. Scrapers feed on algae attached to stones and other surfaces found on the stream bottom. Predators directly feed on other aquatic organisms found within the aquatic environment. Each of these functional feeding groups plays a vital role in breaking up organic material and contributing food and nutrients along the food chain.

Selecting Monitoring Sites

Two types of monitoring sites should be chosen in the watershed. These two sites are reference sites and monitoring sites. A reference site is needed to compare other monitoring sites against. It is a site that is minimally impacted by human use and similar in characteristics to the monitoring site. Since the reference site is minimally impacted, it should show what a healthy stream in the watershed looks like, and the mixture and diversity of macroinvertebrates that can be expected. Monitoring sites are picked because of their strategic location and their ability to indicate what is happening in various parts of the watershed.

Monitoring for macroinvertebrates normally takes place in areas of the stream that have riffles. Riffles are areas where water flows rapidly over rocks in a shallower part of the stream. This is a good area to monitor because macroinvertebrates find this

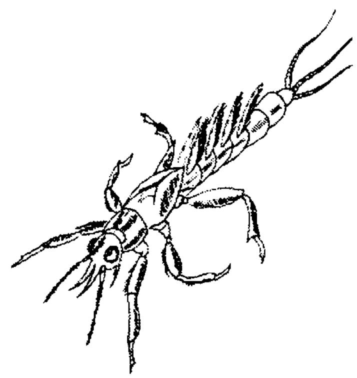


Figure 4-18: Sample macroinvertebrate: a common burrower.

environment a favorable place to live. The fast moving water captures oxygen from the air, increasing the dissolved oxygen content of the water. The large stones and rocks create niches where macroinvertebrates attach their homes or find shelter from predators in the rapidly moving stream. This environment also creates nooks and crannies where organic material and other food can be trapped. The riffle part of a stream is where a great degree of diversity in the types of macroinvertebrates is found.

Most organisms have been categorized into the following six functional feeding groups based on their method of acquiring food; shredders (SH), predators (P), scrapers (SC), filtering collectors (FC), collector gathers (CG) and piercers (PI). The composition of functional feeding groups will change depending on the type and degree of disturbance to the stream. For example, absence of riparian canopy will allow more sunlight to enter the stream producing more periphyton and more scrapers, which eat periphyton. Macroinvertebrate abundance varies with the type of pollution affecting the stream.

Creating a Monitoring Protocol

Currently the California Department of Fish and Game (CDFG) is revising their protocol to be more user-friendly and geared towards volunteer monitoring programs. CDFG will be publishing a key that will be helpful for monitoring for macroinvertebrates in the Malibu Creek Watershed. Heal the Bay should use CDFG's protocols and the macroinvertebrate key for Phase 2 of the Stream Team Program.

Stream Reach Surveying

Stream reach surveying measures the physical forms and characteristics of a particular section of a stream and provides a documented record that can be compared over time. The idea behind the stream reach survey is to take a representative sample of an entire stream or creek, such as 15% of the total length, and apply the findings to the whole stream. The stream reach survey collects specific information about the channel shape, size, the meander pattern, bankfull width and depth as well as measuring average depth of pools, and characterizing the instream habitat, substrate, and overhead cover. This procedure collects detailed information that can be checked year after year to determine if the stream has been changed due to factors upstream. This procedure will allow the monitoring program to sample the effects of sedimentation on the watershed, whereas the other procedures will only provide limited data regarding sediments.

Stream reach survey design should include collecting data as teams move upstream to the next survey site. It is a logical extension of the Stream Walk procedures used in Phase 1 and provides more detailed quantifiable information about the stream. This method is used by the California Department of Fish and Game and the Forest service, making the information collected extremely useful for analysis and planning.

Why Stream Reach Surveying is Important

Using stream reach survey to chart "change over time," would allow Heal the Bay to discern the effects of development upon the physical character of a stream. This procedure further allows various agencies and users of the information collected to accurately characterize the stream using Rosgen's stream classification technique. The Rosgen system is considered very valuable in restoration work.

The objectives include:

- To accurately map the physical properties of a stream
- To establish current baseline conditions within the various subwatersheds of the Malibu Creek Watershed.
- To compare areas upstream and downstream of urbanization to help determine impacts associated with urbanization.

What to Expect When Stream Reach Surveying
Stream Reach Surveying will occur monthly following the completion of the Phase 1, Stream Walk. Teams consist of an X-Stream Team Captain and three volunteers.

The specific protocols for the stream reach survey should fit the information needs of stakeholders in the watershed at the time Phase 2 is ready to begin. A consultation with Fish and Game will determine the information needs and appropriate methods to collect information. Many volunteer programs are using the Stream Reach Survey to collect information. Care must be taken by the volunteers because many of the field procedures are complex and may be difficult.

This Monitoring Program section details the monitoring program and recommended monitoring protocols for the Stream Team. Special emphasis has been placed on identifying and avoiding potential pitfalls, maintaining high levels of volunteer enthusiasm and participation, and ease of procedures. The Stream Team Program will identify problem areas and provide good quality baseline data about the seven subwatersheds within the Malibu Creek Watershed. The information collected will be in a form that is usable by other groups and agencies charged with protecting the environmental resources of the Malibu Creek Watershed. The program has been designed to educate volunteers about the watershed and provide information that will help identify problems and keep decision-makers better informed. The flexibility of the program, and the two-phased approach, should help Heal the Bay to achieve the monitoring goals and in the long-term improve water quality and enhance the ecological functioning of the watershed.

Section 5

ANALYSIS, SITE SELECTION, and MONITORING PROGRAM

Models are used to better understand where and how key issues function within the watershed. The models created for this project analyzed each subwatershed in terms of land uses, surface water features, and water quality issues. To better understand water quality throughout the watershed, the key components are modeled. These maps predict probable source areas of urban runoff associated with impervious surfaces, nutrient loading, and sedimentation. Areas of recreational resources are mapped to predict areas most likely to receive recreational use. Finally, using these predictive models and criteria, the best monitoring sites are located, and recommendations are made concerning existing and future monitoring sites.

Analysis and Modeling

Water quality within the Malibu Creek Watershed is a major contributing factor to the overall ecological functioning of the area and the biggest threat to the health of recreational users. Malibu Creek ranked second on a study listing water bodies contributing contaminants to Santa Monica Bay (Santa Monica Bay Restoration Project 1994, pp. 13-14). In 1992, a survey of 5,800 residents within the watershed was conducted by the City of Malibu's General Plan Task Force. Of 406 respondents, 95% felt that the prevention of pollutants to the creeks, lagoon, and ocean should be of the highest priority (Schmidt 1992, p. A3). Achieving water quality that is capable of sustaining a healthy population of aquatic wildlife that does not pose any human health risks is a highly desired goal.

Subwatersheds

To better understand the watershed, and to consider the potential effects of impervious surfaces on each of the major tributaries that drain the watershed, the watershed has been broken down into seven smaller subwatersheds. These seven subwatersheds are Agoura, Cold Creek, Hidden Valley, Las Virgenes, Malibu Creek, Malibou Lake, and Westlake.

Hidden Valley Subwatershed

The Hidden Valley subwatershed is located at the eastern end of the Malibu Creek Watershed in a large fertile valley. Potrero Creek is the major tributary draining this area. Prior to development, this area likely served as a floodplain for Potrero Creek and therefore has collected large deposits of alluvial materials that make up the fertile soils. Hidden Valley subwatershed is 16.9 square miles and is predominantly rural in nature, with an estimated population of 1,200 people. With the exception of vacant land, agriculture is the dominant land use, comprising 1.87 square miles.

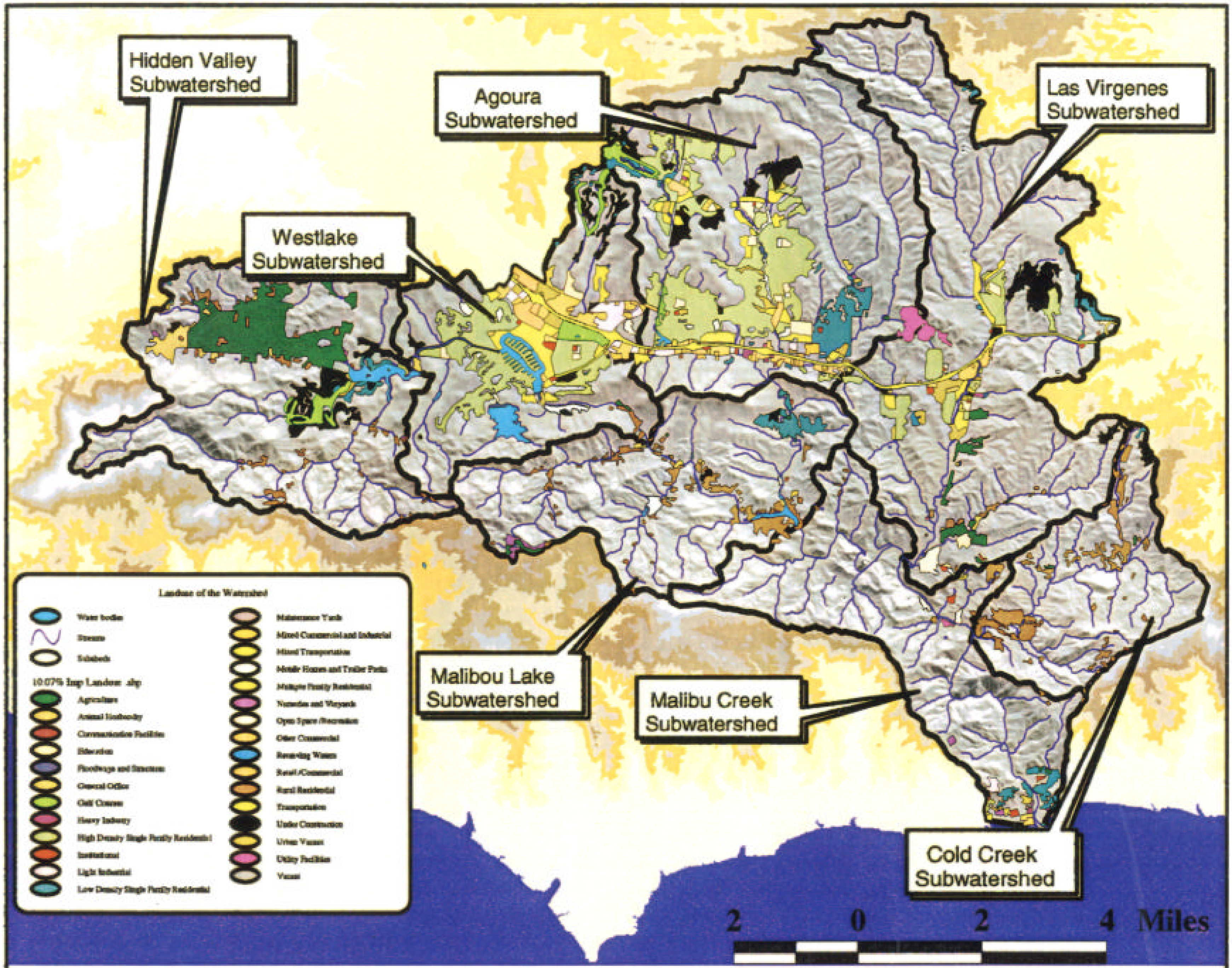
Lake Sherwood is located at the outlet, or base, of this subwatershed and was constructed in 1904 to serve as a source of water for the ranches in the area. The lake can store 2,600 acre-feet of water and has an estimated surface area of 163 acres (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 55). The staff of Lake Sherwood Ranch, which manages the lake, uses copper sulfate to minimize algae growth. Since the mid-1980s, wastewater treatment has occurred through connection to a sewer system, while the potable water supply continues to come from well water (Hidden Valley Municipal Water District 1998). There are numerous ranches in the area with much of the area being used for raising livestock, agriculture, and pastures for horses (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 58). Water samples taken by the NRCS indicate that above acceptable levels of phosphate are present in the receiving waters that drain this subwatershed.

Westlake Subwatershed

Westlake subwatershed is 13.0 square miles in area. Being predominantly urban, the highest land use is high density single family residential, comprising approximately 1.96 square miles. Two constructed lakes and one reservoir are contained within this subwatershed. Westlake Lake is 18 feet deep near the dam, and can store approximately 791 acre-feet of water with a surface area of 95 acres (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 57). Westlake Lake empties into Triunfo Creek and is required to discharge water from May 1 to September 1. Las Virgenes Reservoir (Westlake Reservoir) drains approximately 0.9 square miles with a storage capacity of 10,000 acre-feet or 3.3 billion gallons, and is used by the Las Virgenes Municipal Water District to store imported water (LVMWD 1994, p. 30). Lake Eleanor drains 1.2 square miles and has a surface area of 9 acres that stores approximately 104 acre-feet of water. The channel between Lake Sherwood and Westlake Lake is almost completely altered with either riprap or concrete for flood control purposes (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 57). The population for the city of Westlake Village is estimated at 7,640 residents, which is predicted to grow to 12,200 by the year 2015 (Bauer Environmental Services March 1996, p. 5).

Agoura Subwatershed

Agoura subwatershed contains 180 acres of golf courses and a large single family residential population. Lake Lindero is located within this subwatershed, and drains 5 square miles with the capacity to store 90 acre-feet of water with a surface area of 14 acres (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 59). The total area is 21.6 square miles, with high-density single family residential being the largest land use, totaling 3.4 square miles excepting vacant land. The major tributary is Medea Creek, which is fed by Lindero , Palo Commado, and Cheseboro Canyons. The majority of the 21,000-person population, according to 1993 estimates, resides in the city of Agoura Hills (Bauer Environmental Services March 1996, p. 5). The city of Agoura Hills is expected to increase in population to 27,330 based on SCAG projections for the year 2015. Sampling and modeling conducted in the Agoura subwatershed in 1993 found both high salt levels and high concentrations of coliform. Confined livestock near the Palo Commado area are thought to be a problem regarding water quality.



Sources: Land Use, Watershed Boundary by Los Angeles County Department of Public Works, Streams by National Park Service not for legal use.

Land Use of the Watershed

Universal Transverse Mercator Projection
North American Datum, 1927

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Las Virgenes Subwatershed

Las Virgenes subwatershed is 24.3 square miles in area with the largest land use being high density single family residential (0.8 sq. mi.). 300 of the 3,766 households in Calabasas are on septic systems, the majority of which are in Stokes Canyon towards the base of the subwatershed. This area has had high nitrogen, phosphorous, and fecal coliform concentrations that may indicate malfunctioning septic systems (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 59). Las Virgenes Creek is the major tributary that drains this area. The remainder of the subwatershed is largely rural in character. This subwatershed also has orchards, pastureland, and field crops but predominantly consists of open space. This subwatershed is not yet heavily developed, and may be undergoing development pressures due to the large amount of undeveloped private land. During May and September, sampling events conducted by NRCS, upper Las Virgenes Creek showed high concentrations of phosphates above the acceptable level and were considered high enough to impact downstream water (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 62).

Malibou Lake Subwatershed

Malibou Lake subwatershed is 13.2 square miles. Rural residential comprises 0.677 square miles and is the dominant land use, with some homes located along creeks and surrounding the lake. This subwatershed receives water from the Agoura and Westlake subwatersheds. Malibou Lake is fed by Triunfo Creek to the west and Medea Creek from the north. The lake drains 64 square miles and has a surface area of 55 acres with a storage capacity of 500 acre-feet. This subwatershed has an estimated 2,978 households with 625 on private septic systems (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 63). Previous water chemistry sampling done by the United States Geological Survey (USGS), from 1985-1987, and those done in 1993 by the NRCS demonstrate high levels of phosphorous in Triunfo Creek and high phosphorous levels and fecal coliform at the base of Medea Creek and in Malibou Lake (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 64). Both Triunfo Creek and Malibou Lake were designated as impaired at least some of the time by the 1994 California State Water Quality Assessment. Malibou Lake opens the outlet valves to the dam annually to expel sediments as well as periodically dredging to remove sediments. The lake is also treated with copper sulfate to minimize algae growth (Trim 1994, p. 36).

Cold Creek Subwatershed

Cold Creek subwatershed, at 8.2 square miles, is predominantly open space with the exception of rural residential land uses on private septic systems comprising 0.8 square miles. In addition, this subwatershed has 34 acres of confined animal units concentrated towards the lower part of the subwatershed (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 65). Sampling conducted by the USGS from 1982 to 1988, and one site survey by the NRCS in 1993, demonstrated consistently high levels of phosphorous averaging in excess of 5.6 mg/l which are high enough to impact downstream water quality (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 65).

Malibu Creek Subwatershed

Malibu Creek subwatershed is 12.8 square miles and comprised mostly of mountainous open space. Low density, single family residential comprises 0.2 square miles and is the predominant land use in this subwatershed. Malibu Creek is subject to receiving waters from the other six subwatersheds. Tapia is located in this subwatershed. Treated water has been discharged from this facility into the creek since 1961 and has altered the dynamics of both surface water quality and quantity. Malibu Creek was listed as having intermediate impairments in the 1994 California State Water Quality Assessment (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 66). Areas tested above Tapia were below the 10-mg/l threshold set by the Regional Water Quality Control Board (RWQCB) for concentrations of nitrates. Measurements taken below Tapia have been recorded in excess of 16 mg/l (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 48).

The Century Reservoir is located in the Malibu Creek subwatershed. This reservoir drains 68.1 square miles and has a surface area of seven acres that can store 70 acre-feet of water. Located within this subwatershed is the 102 foot tall Rindge Dam. This dam is completely full from sedimentation, serving as a testament to the highly erodible soils in the area. Where Malibu Creek empties into the lagoon as it passes through the City of Malibu, a small portion of mainly commercial property is evident. The wastewater at the base of the Malibu Creek subwatershed in the City of Malibu is handled by private septic systems. There is strong public opinion that these septic systems are a major contributing factor to the consistently poor water quality in the lagoon and at Surfrider Beach. Currently, UCLA is studying the lagoon with funding from the California Coastal Conservancy.

The RWQCB has established a list of designated beneficial uses for various water bodies in the Malibu Creek Watershed. The RWQCB has set measurable water quality objectives that ensure that these beneficial uses do not become impaired (USDA, NRCS Malibu Creek Watershed Natural Resources Plan 1995, p. 42). These lists can be obtained in the RWQCB's 1994 Basin Plan.

Impervious Surfaces

Mapping areas of impervious surfaces can be used as an effective tool to predict impacts of development within the watershed. There is a strong relationship between the percentage of impervious surface in a watershed and the quality of stream habitat and water quality. Mapping impervious areas can be useful as a planning tool to help assess and manage impacts development will have in the watershed.

Measuring the percent of impervious coverage is best done at the subwatershed level. Impacts associated with impervious surfaces are likely to occur in the tributary that drains these impervious surfaces. Headwater subwatersheds can be organized into three different categories, depending upon the percent of impervious coverage. These categories are sensitive, degrading, and non-supportive subwatersheds. The sensitive subwatershed has about 1% to 10% impervious cover (Schueler 1995, p. 42). Water quality and stream biodiversity is normally good to excellent, and stream channel stability is stable. The resource objective in the sensitive subwatershed is to preserve and protect biodiversity and channel stability. The next category is the degrading subwatershed, with 11% to

25% impervious cover. Water quality and stream biodiversity is fair to good. Stream channel stability is unstable and the resource objective is to maintain or restore the key elements of stream quality. The last category is the non-supporting subwatershed. This subwatershed has 26% to 100% impervious cover. Water quality is fair to poor, and stream biodiversity is poor. Stream channel stability is highly unstable. The resource objective within the non-supportive subwatershed is to minimize pollutant loads to protect downstream waters.

There are two methods of measuring the amount of impervious surfaces. These are mapped impermeability and effective impermeability. Mapped impermeability includes all impervious surfaces within a subwatershed. Effective impermeability includes only impervious surfaces that are directly connected to the storm water drainage system or to streams. Effective impervious surfaces does not include surfaces such as rooftops where runoff may flow onto landscaped areas and infiltrate into the soil (Figure 5-1). These surfaces have less of an impact upon the watershed. A large percentage of storm water runoff from these disconnected impervious areas flow onto landscaped areas and infiltrate into the soil before reaching the storm water drainage system. This is especially true during smaller storm events. Unlike disconnected impervious surfaces, nearly all runoff from directly connected impervious areas, such as roads and parking lots, flows directly into the storm water drainage system.

One method of mapping the effective impermeability of an area is by ground truthing or checking data out in the field. Due to the size of the watershed and the limited time of this study, ground truthing for this project was not feasible. The approach used by the Cal Poly team was to calculate the overall area of individual land uses that are known to have impervious surfaces in each subwatershed. These land use areas were then multiplied by an imperviousness factor to come up with the effective impermeability for that land use. The effective imperviousness factor represents the amount of runoff a particular land use generates. Effective impermeability gives a more accurate account of runoff than does mapped impermeability. Imperviousness factors used are from a study done for the cities of Los Angeles County by Heal the Bay (Urban Runoff: A Pollution Abatement Program 1992). Land use categories used in this analysis are based on the maps provided by Los Angeles County Department of Public Works. These maps were updated in ArcView v 3.0a using a digital orthographic aerial photograph taken in April and October 1997. The land use map was placed on top of and compared to the aerial photograph. Adjustments were made so that land use reflected the most current data.

The Impervious Surfaces map shows the effective impervious surface area for each of the seven subwatersheds in the Malibu Creek Watershed. Westlake subwatershed has the largest percentage of impervious surfaces with just over 23%. Agoura subwatershed is second with 18.4% impervious

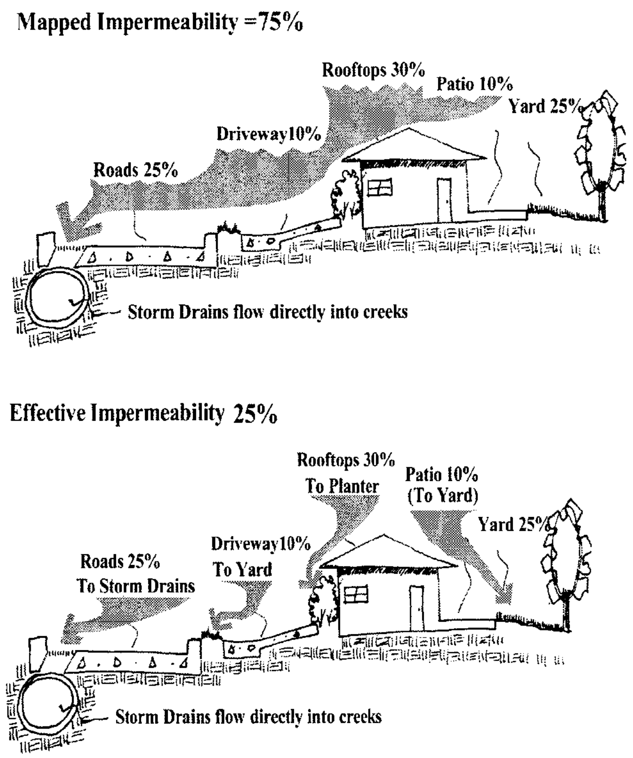
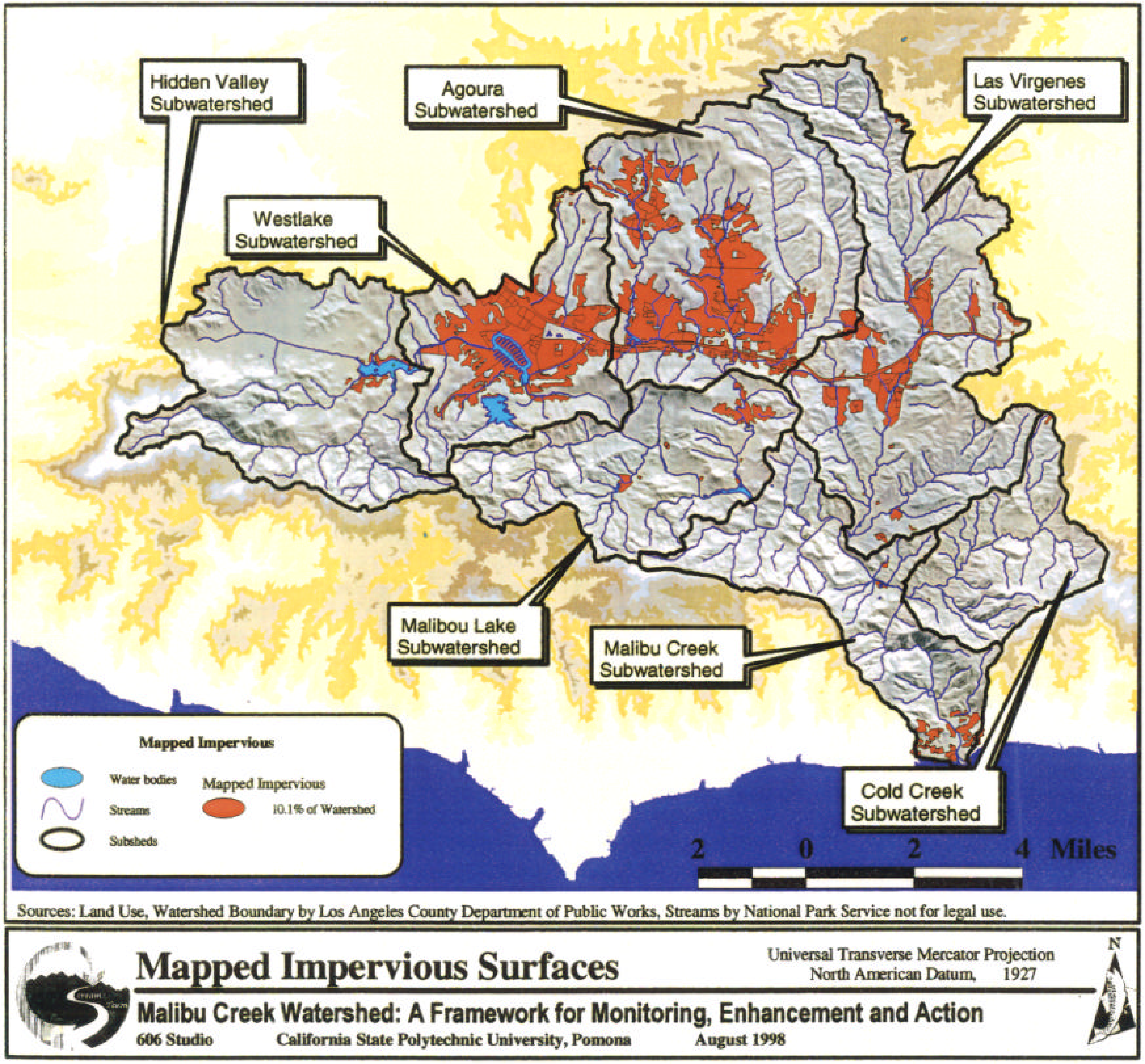


Figure 5-1: Mapped versus Effective Impermeability.


Hidden Valley Subwatershed
Agoura Subwatershed
Las Virgenes Subwatershed
Westlake Subwatershed
Malibou Lake Subwatershed
Malibu Creek Subwatershed
Cold Creek Subwatershed
Mapped Impervious
Water bodies
Streams
Subsheds
Mapped Impervious
10.1% of Watershed
2 0 2 4 Miles
Sources: Land Use, Watershed Boundary by Los Angeles County Department of Public Works, Streams by National Park Service not for legal use.
Mapped Impervious Surfaces
Universal Transverse Mercator Projection
North American Datum, 1927
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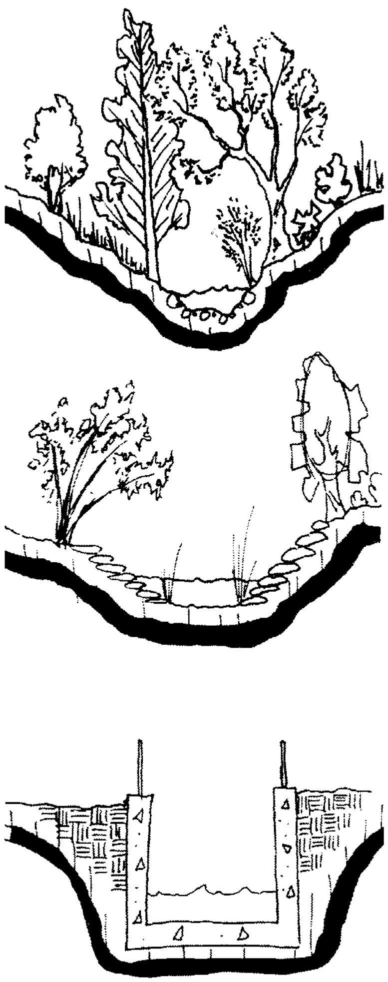


Figure 5-2: The conceptual sketch above shows the condition of riparian corridors in a: A) sensitive, B) degrading, and C) non-supporting, watersheds.

surfaces. These subwatersheds fit into the degrading category, and should have fair to good water quality and stream biodiversity. The objective is to maintain or restore the key elements of stream quality in degrading streams. Within these two subwatersheds, large segments of their tributaries are channelized with concrete or other materials. This suggests that subwatersheds that will potentially reach these percentages of impervious surface area are likely to become channelized and thereby transfer their problems downstream. Westlake subwatershed is dangerously close to reaching a non-supporting level with poor to fair water quality, poor biodiversity, and highly unstable streambanks.

Based upon percent of impervious surfaces, each subwatershed was placed into one of the three categories: sensitive, degrading, and non-supportive (Figure 5-2). The volunteer monitoring program will gather information that will serve as baseline data to further support and identify sensitive, degrading, and non-supportive subwatersheds. Gathering this data will also help to confirm and refine the impervious surface, water quality, and stream habitat relationship.

The Cold Creek, Hidden Valley, and Las Virgenes subwatersheds are all below 9% impervious surfaces. They are considered sensitive subwatersheds, with good to excellent water quality, biodiversity, and stable streambanks. The resource objective in the sensitive subwatershed is to protect and preserve biodiversity and channel stability. The Malibou Lake and Malibu Creek subwatersheds are also within the sensitive subwatershed category. These subwatersheds are not headwater subwatersheds and receive inputs from subwatersheds upstream. Malibou Lake receives water that passes through the Hidden Valley subwatershed into Westlake. The Malibu Creek subwatershed receives water from all of the subwatersheds; therefore the water quality, biodiversity, and stability of their streambanks are subject to upstream levels of impervious surfaces.

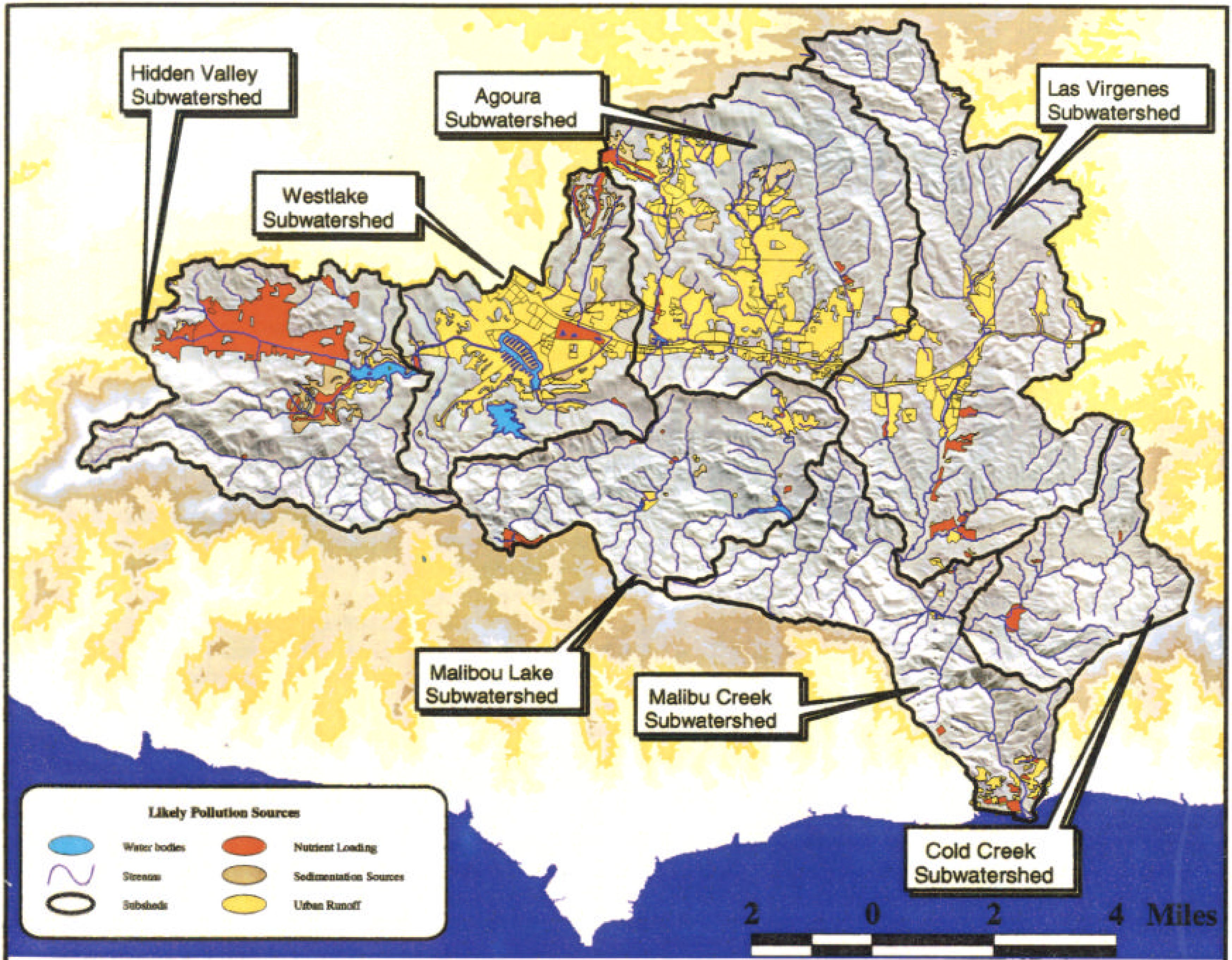
In order to preserve the Malibu Creek Watershed and the biodiversity that makes this watershed special, the ever-increasing amounts of impervious surfaces must be addressed. Continued development and build out of the watershed will cause further channelization of creeks and streams, degraded water quality, less abundant populations of fish and wildlife, and will alter the natural character that attracts millions of visitors and thousands of residents to this area.

Probable Pollution Sources

This model examines three key issues: urban runoff, nutrient loading, and sedimentation, in terms of their water quality pollution potential. Probable pollution sources was derived from the various land uses. Each land use was weighted for its most likely type of pollutant. The map on the next page highlights potential pollution sources.

Urban Runoff Pollution Sources

The urban runoff pollution source model is based on the following land uses that were considered likely to contribute pollutants to receiving waters: Transportation, Retail/Commercial, Other Commercial, Multiple Family Residential, Mixed Transportation, Mixed Commercial and Industrial, Maintenance Yards, Institutional, Heavy Industry, High Density Single Family Residential, and General Office. All urban land uses have a 30% or greater imperviousness factor, and were considered heavily utilized by automobile traffic.



Sources: Land Use, Watershed Boundary by Los Angeles County Department of Public Works, Streams by National Park Service not for legal use.

Areas Likely to Contribute Pollution

Universal Transverse Mercator Projection
North American Datum, 1927

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Nutrient Sources

The following land uses were considered likely sources of nutrient loading: Nurseries and Vineyards, Golf Courses, Animal Husbandry, and Agriculture. Areas of known septic systems that were located within 300 foot from a water body were also included. Areas with high density septic use like Monte Nido, Cross Creek Plaza, the Malibu Civic Center, and Serra Retreat were considered probable sources due to the volume of wastewater treated and the cumulative effect of long-term treatment.

Erosion and Sedimentation Sources

A model was created to reveal probable sources of erosion and sedimentation. The criteria used to create this model are land uses that are considered likely to supply sediments to surface waters. Land uses such as, Under Construction, Nurseries and Vineyards, Animal Husbandry, and Agriculture were all considered for this model. The latest fire to occur in this watershed took place in 1996 and areas affected by this fire were also considered to be likely sources of erosion and sediments. Finally, soil types rated as severe to very severe, and very severe based on their erodibility, were used as probable sources of erosion and sedimentation. Soil types were based on studies done by USDA-SCS and the University of California Agricultural Experiment Station (Soil Survey, Ventura Area, California. April 1970. USDA-SCS and the Topanga-Las Virgenes Resource Conservation District and the Los Angeles County Department of County Engineer. Soils of the Malibu Area, California with Farm and Non-Farm Interpretations, October 1967).

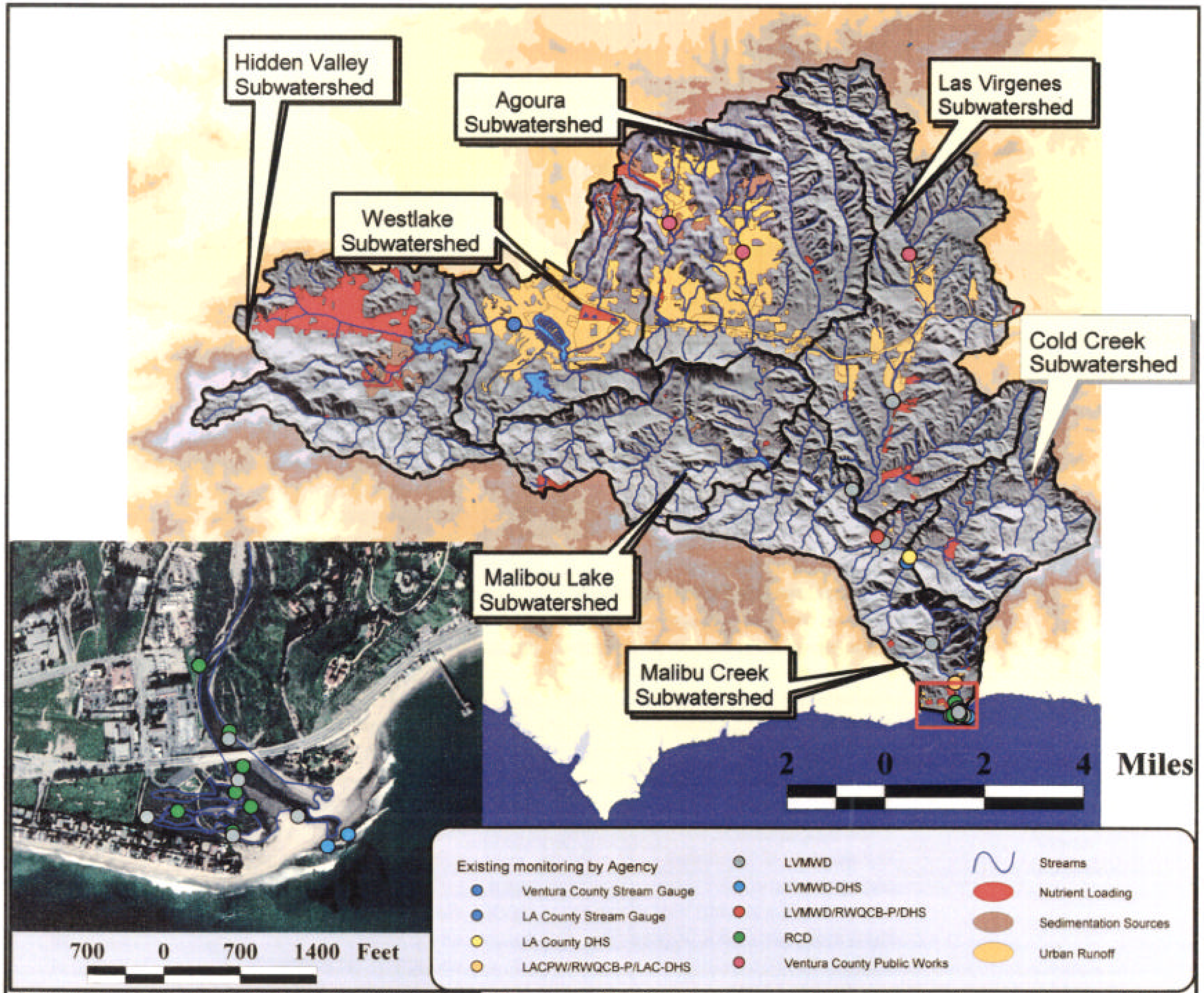
Site Selection Process

It is important that the monitoring program is well organized and steady progress is made in achieving the objectives set by Heal the Bay. This section provides Heal the Bay with two monitoring program options. This flexibility will allow the Stream Team Program to start slowly and progress and expand, as the information base and the experience level of volunteers grows. The two different programs were designed to take advantage of the growing wealth of knowledge about the watershed, the differing skill levels of volunteers, and the growing interest and funding as the program matures.

The site selection process first involves examining existing monitoring efforts within the watershed. Next, streams are classified according to their physical characteristics. Then criteria are established for choosing the different types of monitoring sites. Finally, monitoring sites are selected. A description of the monitoring program follows the monitoring site selection, and the monitoring program options are defined.

Existing Monitoring Sites

The bulk of existing monitoring efforts are at the bottom of the watershed (see map on next page). Very few monitoring stations are located in the upper portion of the watershed, where the probable sources of water quality degradation occur. Currently, four groups are engaged in regular water quality monitoring programs that sample at least once a month. These are the Las Virgenes Municipal Water District, Resource Conservation District of the Santa Monica Mountains, Los Angeles County Department of Health Services, and Los Angeles County Department of Public Works.



Sources:Land Use, Watershed Boundary by Los Angeles County Department of Public Works, Streams by National Park Service, Aerial Photo(April-October 1997) by Aerial Fotobank Inc. Monitoring Sites from Review of Monitoring and Response Protocol for the Malibu Creek Watershed 1994 not for legal use.

Existing Monitoring Locations

Universal Transverse Mercator Projection
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There are redundancies and overlaps between the different agencies with their monitoring efforts. This project recommends coordinating the monitoring efforts and relocating some monitoring sites to collect more comprehensive and useful data. These recommendations can be found in Appendix B–Existing Monitoring Efforts.

Stream Classification

As part of the site selection process, the streams within the Malibu Creek Watershed were classified. The first level stream typing method, based on techniques developed by Dave Rosgen of Wildland Hydrology, was used on all second order and above streams. Each stream fits into one of eight distinct types. Stream classification allows monitoring programs to minimize the number of baseline, or reference, monitoring sites. For example, a "B" type stream in one location should look and behave in the same manner elsewhere in the watershed. Stream classification is also useful for future restoration efforts. This technique allows comparison of a pristine stream of a certain type to a stream of the same type that is influenced by development to determine any differences. Stream classification was done by the Cal Poly Team using 3-D modeling to determine the shape of the landscape, and then calculating the slope and sinuosity of the stream itself using the aerial photograph and USGS 7.5 minute topographic maps. Further details about first level stream typing can be found in Rosgen's book, *Applied River Morphology* 1996.

Overview and Criteria

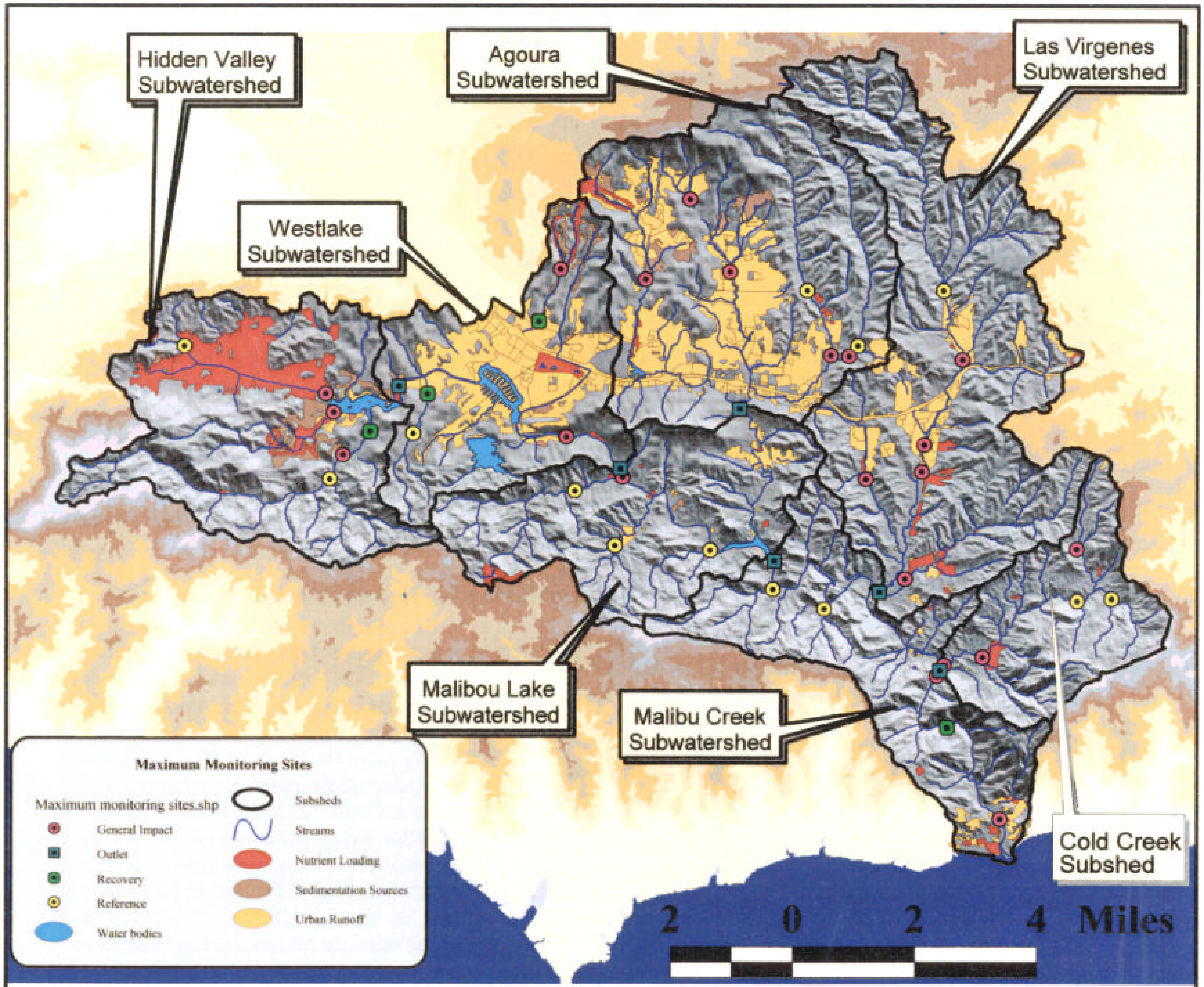
The site selection process for monitoring sites was begun by overlaying the digital aerial photograph, the probable pollution sources model, and land use maps. Using this information, all possible monitoring sites were located, resulting in the Maximum Monitoring Sites Model. These include Reference Sites, General Impact Sites, Recovery and Outlet sites. All streams of less than second order were automatically eliminated from consideration, as it is unlikely that these streams would have adequate water supply to sustain a year round monitoring effort. Using the preliminary first level stream classification discussed earlier, streams of A or AA+ types were eliminated as potential monitoring sites, due to their overall long term stability that, if monitored, would not show changes influenced by development practices. Finally, all monitoring sites chosen had to be located near a road and appear to have access, based on the aerial photo. These sites were also compared against a land ownership map to determine which sites were privately held and those that were public.

Maximum Monitoring Sites Model

Using the above criteria, the maximum number of potential monitoring sites was selected. With all potential sites identified, the monitoring program can expand in the future if changes occur, such as upstream development. When this occurs, this model allows the monitoring program the flexibility of finding new reference locations. The maximum monitoring sites map can be seen on the next page.

Reference Sites are upstream from impacts identified on the Probable Pollution Sources Model and aerial photograph. Reference sites are typically located in relatively undisturbed areas of the watershed (Figure 5-3).

General Impact Sites are located downstream from probable pollution sources. Sites were selected as much as possible to locate and isolate the pollution



Sources: Land Use, Watershed Boundary by Los Angeles County Department of Public Works, Streams by National Park Service not for legal use.

Maximum Monitoring Sites

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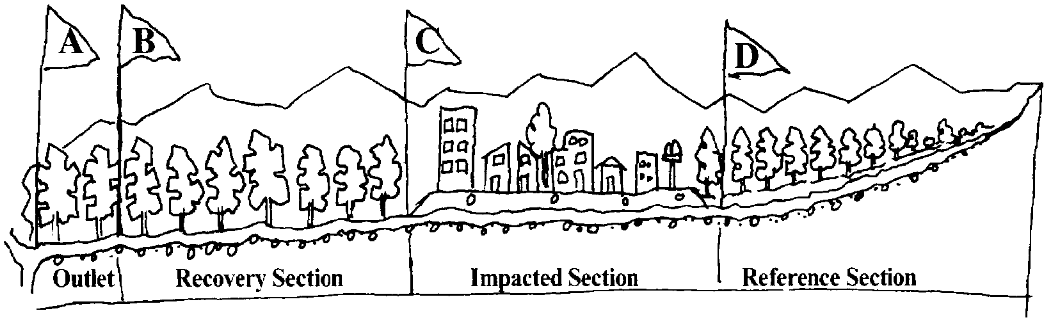


Figure 5-3: This image shows the relative position of the various monitoring sites. They include: A) outlet sites, B) recovery sites, C) impact sites and D) reference sites.

source to a specific tributary. General Impact Sites will help Heal the Bay determine what impacts are being caused by upstream land uses. General Impact Sites were subjected to the same criteria as the reference sites, with the exception that they must be downstream of a suspected impact.

Recovery Sites are located at least 500 yards downstream from General Impact Sites. The goal is to determine how long it takes water quality to recover from probable pollution sources. Recovery Sites were subjected to the same criteria as the previous two types of monitoring sites.

Outlet Sites were chosen for each of the seven subwatersheds. Outlet sites are located where the tributary exits a subwatershed just prior to entering the adjoining downstream subwatershed. Outlet Sites will allow Heal the Bay to determine the contribution of each subwatershed to water quality and quantity.

Type of Monitoring Site	Monitoring Program Option	Criteria Used for Site Selection	Information Sources
1) Reference 2) General impact 3) Recovery 4) Outlet	Maximum # of Monitoring Sites	1) Above suspected pollution sources and impacts 2) Below probable pollution sources or impacted areas 3) downstream of an unaltered reach, downstream of an impact site 4) Base of a Subwatershed	1-4) probable pollution source model, land use map, aerial photo, streams map, subsheds map
1) Reference 2) Outlet	Overview Monitoring Program	1) Above suspected pollution sources and impacts on largest subshed tributary 2) Base of Subwatershed	1-2) Maximum number of monitoring sites model, subsheds map and stream map
1) Reference 2) General impact 3) Outlet	General Impacts, Minimal Monitoring Program	1) Directly above suspected pollution sources and impacts 2) Downstream of dominant pollution source 3) Base of Subwatershed	1-3) Maximum number of monitoring sites model, subsheds map and stream map

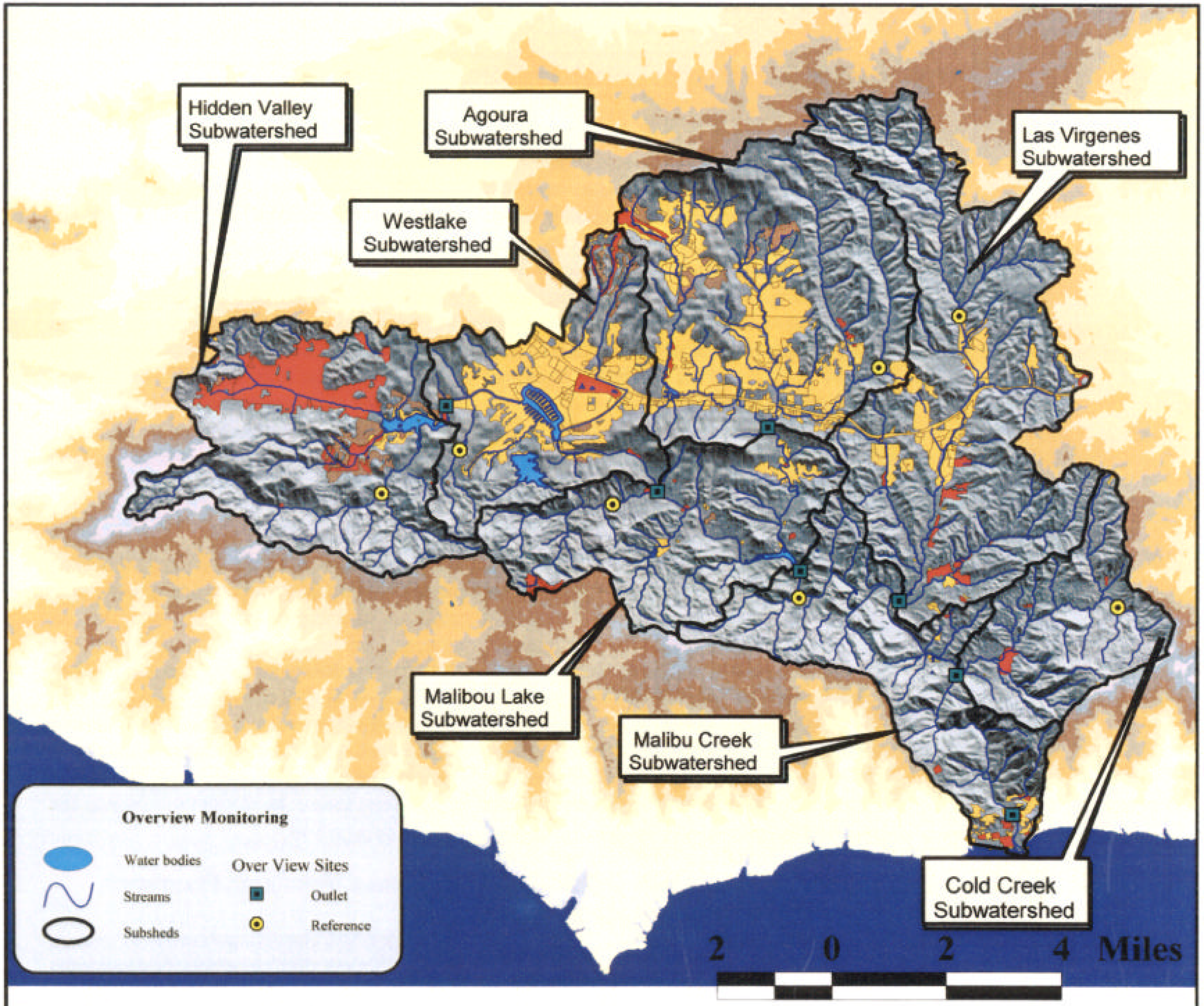
Table 5-1: Monitoring Sites Selection Criteria table

Monitoring Program Options

From the Maximum Monitoring Sites Model, two potential programs were created, the Overview Program, and the General Impacts Program. The criteria used for each monitoring program alternative are summarized in the Monitoring Sites Selection Criteria chart (Table 5-1). These criteria are to be used by the program coordinator to assist in determining where to set up monitoring stations. The goal for each program differs, depending on what type of information is desired by Heal the Bay.

Overview Monitoring Program

This is a program designed to test the general water quality of each of the seven subwatersheds within the Malibu Creek Watershed (see map on next page). This program measures the contribution that each subwatershed has on the overall water quality and quantity within the watershed. Each subwatershed contains two sampling stations, one at the base where the waters leave that particular subwatershed, an Outlet Site, and another Reference Site, upstream of all impacts. Sites selected were located on the tributary in each subwatershed that drained the largest land area. By monitoring these two points in each subwatershed, the results can be compared to each other to determine if land uses are affecting the water quality at the outlet. The Overview Program consists of a total of fourteen sites, two per each subwatershed.



Sources: Land Use, Watershed Boundary by Los Angeles County Department of Public Works, Streams by National Park Service not for legal use.

Overview Monitoring Program

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The Overview approach is recommended for Phase 1 of this pilot program. The Overview Monitoring Program will allow Heal the Bay to determine how each of the seven subwatersheds is contributing to flow and/or degraded water quality within the overall watershed. The weakness of this approach is that it only isolates problems to the subwatershed level. It is a useful approach for Phase 1 and will allow Heal the Bay to determine which subwatersheds are having problems. In Phase 2, Heal the Bay can focus their efforts to target specific areas.

General Impacts Monitoring Program

There are two options within the General Impacts Monitoring Program, Optimal and Minimal. With this program, the maximum numbers of sampling stations are selected based on their ability to isolate the general impacts. These impacts are based on the Probable Pollution model, which highlights areas that are likely contributors of pollution for each of the key issues of sedimentation, nutrient loading, and urban runoff. Additional reference sites were chosen if they were situated immediately upstream of the general impact and were minimally influenced by upstream factors. This was done to help isolate the suspected impact. All sites selected were located near a road on a second order or higher stream, and appeared accessible from aerial photography. As always, A and AA+ stream types were eliminated from consideration. Using these criteria, the program can grow in the future and adapt to unforeseen change.

General Impacts–Optimal

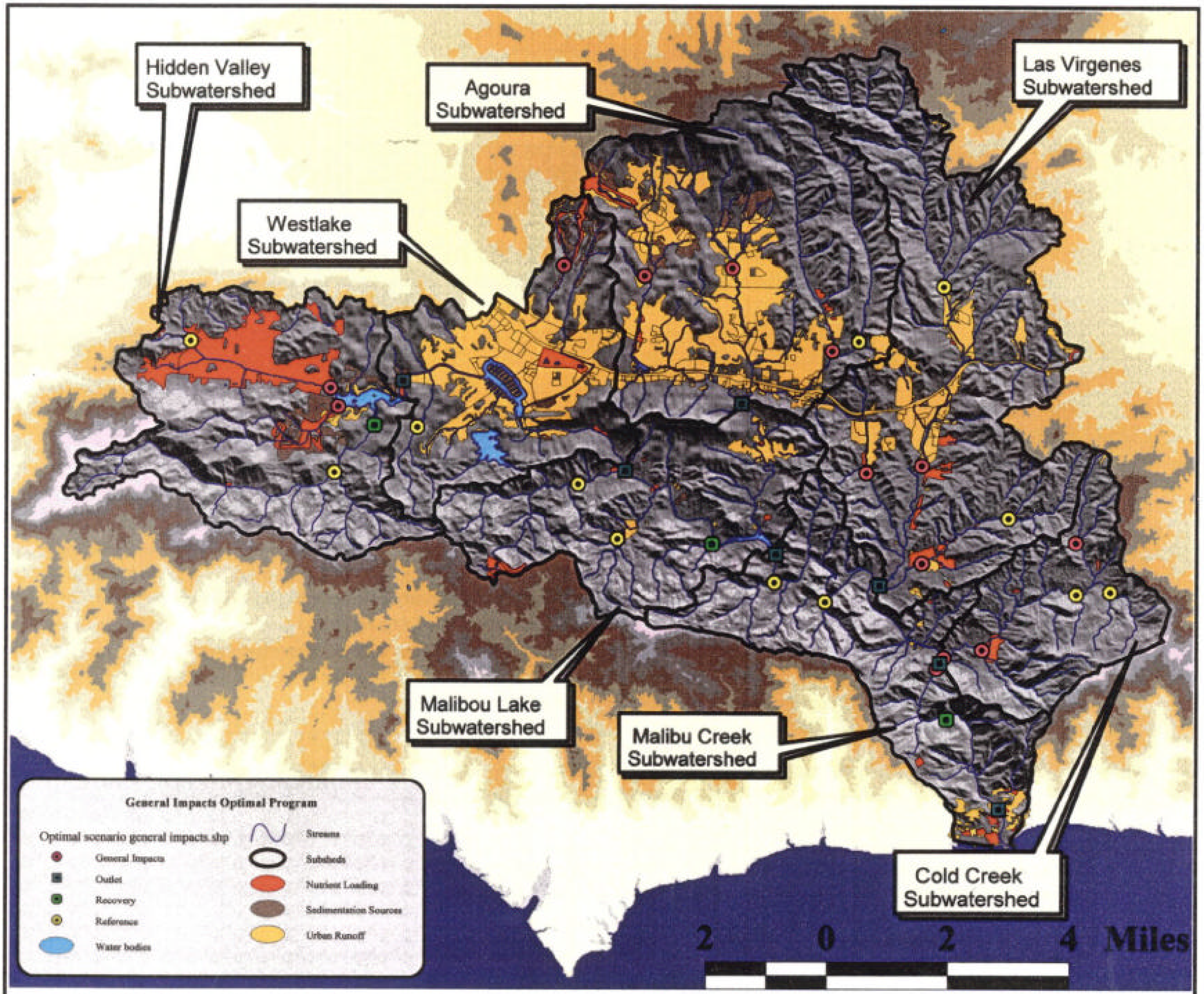
The Optimal option chooses land uses that can be isolated and are potentially impacting major tributaries within each subwatershed. This would allow the monitoring program to generally locate the source of the problem based on the three key issues. Where possible, reference sites were located directly upstream of the suspected impact. When this was not possible, a reference site with the same stream classification was used. Recovery Sites were selected downstream of a location of a likely impact to determine if the stream and water quality has recovered at this lower point and to what extent. This scenario also locates Outlet Sites at the base of each subwatershed to determine the overall contribution to water quality and quantity of each subwatershed. The General Impacts Optimal map can be seen on the next page.

General Impacts–Minimal

The minimal scenario is the fewest number of stations that would determine the effects of pollution on water quality directly above and below an area. This option chooses a Reference Site and a General Impact Site below the suspected dominant pollution source in each subwatershed. An Outlet Site is selected as well. This scenario will isolate pollution sources to a general area and compare the difference between water quality upstream and downstream of the impact. The General Impact Sites, Minimal Monitoring Program map can be seen on page 5-19.

Watershed Monitoring Framework

The Watershed Monitoring Framework section contains three important components of this monitoring program. Prioritizing Subwatersheds provides a framework from which to build a monitoring program. The Recommendations for Future Monitoring contains suggestions on ways to organize the sampling options



Sources: Land Use, Watershed Boundary by Los Angeles County Department of Public Works, Streams by National Park Service not for legal use.

General Impact Optimal Program

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outlined above. Recommendations for Existing Monitoring Efforts details ways in which current monitoring efforts could potentially be more effective.

Prioritize Subwatersheds

The subwatersheds have been prioritized for each monitoring procedure based on how critical the extent of probable impacts are to the streams. Prioritizing provides flexibility for the implementation of the monitoring procedures. This is due to the unpredictability of volunteer participation and the resources available to create field kits for Stream Walking and Water Quality Teams. Each subwatershed is assigned a number, one through seven, one being most critical, seven being the least critical. Subwatersheds were prioritized with regard to Stream Walking and Water Quality Monitoring. Stream Walking was prioritized using the following criteria: which subwatershed is the most critical to locate barriers to fish passage, which subwatershed should have the most unstable streambanks and outfalls into the streams, and which subwatershed should suffer from the greatest impacts from development (Table 5-2). Water Quality was evaluated in terms of most susceptible to pollutants from urban runoff, sediment loading, and nutrient loading (Table 5-3). The ranking and priority for each category can be seen in the tables below.

Recommendations for Future Monitoring

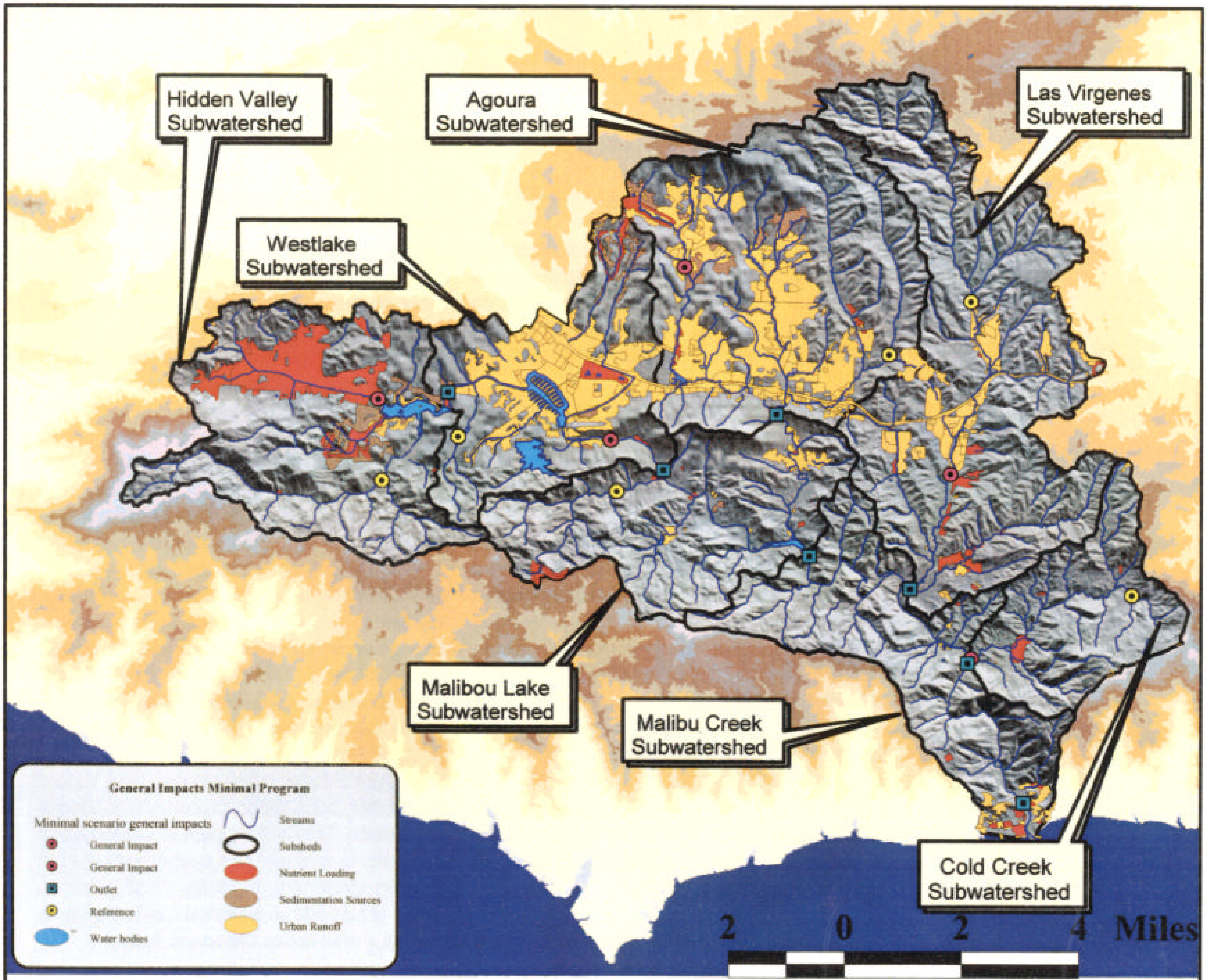
The models created for the General Impacts Monitoring Program should be used to incorporate any future monitoring efforts within the watershed. If a high school or other organization wants to conduct monitoring, water quality sites should be added in accordance with these models. It is recommended that the General Impacts Minimal option be used prior to using the General Impacts Optimal option. By following this plan, the data collection in this watershed will be maximized and redundancy will be minimized. These models should also be used to implement any biological monitoring procedures. By doing so, this data can enhance the overall knowledge about the watershed.

Criteria / Subwatersheds	Fish Migration Potential	Degraded Habitat (based on impermeability)	Greatest Threat from Future Development	Priority of Subwatershed (lowest number equals highest priority)
Malibu Creek	1	6	7	14
Cold Creek	2	7	6	15
Las Virgenes	3	3	1	7
Malibou Lake	4	5	5	14
Agoura	6	2	3	11
Westlake	7	1	4	12
Hidden Valley	8	4	2	14

Table 5-2: Priority chart for Stream Walking

Criteria / Subwatersheds	Likely Pollution from Urban Runoff	Likely Pollution from Nutrients	Likely Pollution from Sediments	Priority of Subwatershed (lower number equals higher priority)
Malibu Creek	4	1	6	11
Cold Creek	7	6	7	20
Las Virgenes	3	4	3	10
Malibou Lake	5	7	5	17
Agoura	2	5	2	9
Westlake	1	3	4	8
Hidden Valley	6	2	1	9

Table 5-3: Priority chart for Water Quality Testing



Sources: Land Use, Watershed Boundary by Los Angeles County Department of Public Works, Streams by National Park Service not for legal use.

General Impacts Minimal Program

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Recommendations for Existing Monitoring Efforts

Current monitoring efforts could potentially be more effective with a few modifications. There is an overlap of monitoring sites by different agencies. Monitoring efforts, including the efforts of the Malibu Creek Watershed Stream Team volunteers, must be coordinated to maximize resources and enhance the quality of data gathered in the watershed.

Monitoring should be done at the same time or at least on the same day at sampling stations that have overlaps. On Malibu Creek at Cross Creek Road, the Department of Health Services (DHS) is testing bacteria, and Las Virgenes Municipal Water District (LVMWD) and LA County Department of Public Works (DPW) are testing conventional, nutrients, bacteria, organic chemicals and making visual observations on a monthly basis (Trim 1994, pp. 12-15). It is recommended that the DHS should consider discontinuing monitoring at the Cross Creek Station. Instead, resources should be re-allocated to include conventional testing, nutrient testing, and bacteria testing at the Salvation Army station on Malibu Creek, so that DHS can quality check LVMWD's data. Currently, DHS is only monitoring bacteria at the Salvation Army Camp station while LVMWD monitors for conventional nutrients, bacteria, organic chemicals, and makes visual observations.

Two ocean sites, 50 yards east and west of the mouth of Malibu Lagoon, are also being monitored by DHS and LVMWD. A schedule should be established to encourage monitoring at the same time that would serve as a quality assurance check. These sites should be monitored ideally in the morning on the first Friday of every month. This schedule will more closely correlate with volunteer monitoring efforts and make the data collected more comparable. Ideally, monitoring would begin at the Salvation Army Site, proceed downstream to Cross Creek, and then end at the two ocean sites. Resource Conservation District (RCD) should work on this same schedule at the lagoon. Further, the RCD should add a monitoring station at Cross Creek Road that is monitored at the same time as LVMWD and DPW. This would be an effective way to verify the accuracy of their data.

The RWQCB Planning Division monitors four surface water sites within the watershed, but does so on an annual basis (Trim 1994, pp. 12-14). This data is of limited use at such an infrequent level of monitoring. The RWQCB Planning Division should discontinue their current monitoring sites and re-allocate those resources to supplying quality control and quality assurance to the volunteer monitoring program. The RWQCB could join the monitoring teams on three Saturdays and three Sundays and take side by side samples to provide quality assurance checks. Further, they could test those samples for bacteria. The Ventura County Department of Public Works monitors three stations on a quarterly basis, testing for conventional nutrients and bacteria. The Cal Poly team recommends that these sites be monitored on a monthly basis–the first Saturday (preferred), or Friday. Finally, Ventura County should add an additional monitoring site to serve as a reference on Cheseboro Road.

Section 6

Beyond Monitoring

The most effective way to improve ecological functioning within the watershed is to take action at the sources of the problems. New construction and renovation provides an opportunity for developers, architects, landscape architects, engineers, planners, and others to integrate designs that combine function, form, and ecological sensitivity. The following section is a catalog of planning and development recommendations, and design alternatives or Best Management Practices (BMPs) for consideration and action.

The monitoring program will advance the understanding of water quality issues, track trends, and identify source areas of pollutants. As long as urban runoff flows untreated and unfiltered directly into streams, water quality will not significantly improve at Malibu Lagoon and Surfrider Beach. By implementing the following action items, the health of stream corridors and ultimately water quality, can improve, fulfilling the vision of the watershed presented at the beginning of this document.

The following recommendations are divided into sections by key issues related to water quality. These are impervious surfaces, nutrient loading and sedimentation, water quantity, riparian habitat conservation, and development. Overall goals describe the conditions for optimal ecological functioning without sacrificing human needs. Objectives contribute towards the improvement of an issue if action items are implemented.

Planning & Development Recommendations could be turned into planning and zoning ordinances for local cities, counties, or regional agencies to implement and enforce. Design Alternatives are land-based actions that an individual or developer could implement on their property or in their community. Reference sections provide specific sources of information relating to a particular objective.

Impervious Surfaces

Reducing the effective level of impervious surfaces can improve water quality. This will increase infiltration, and ultimately reduce not only the volume and intensity of surface flows, but also the pollutants associated with urban runoff within the watershed. Reducing impervious surfaces would diminish future impacts to stream ecosystems. At the site scale, the goal for reducing the effects of impervious surfaces is slightly different than that for the whole watershed. The goal would be to achieve a "no net increase" in the amount of storm water runoff that leaves a given site. This means that the amount of storm water flow off of a site is the same as its pre-development, naturally vegetated state.

Planning and Development Recommendations

Limiting construction of impervious surfaces and promoting the use of permeable surfaces for all current and future projects can help restrict the amount of urban runoff in the watershed. Use of different products and technologies that allow the infiltration of water must be considered for all new developments, whether they are small-scale improvements such as a drainage swale, or a newly planned commercial and residential developments. By enhancing infiltration, the impacts to streams and water quality can be reduced.

One way to lessen the impact of impervious surfaces is to concentrate development in higher density clustered housing (25% to 100% impervious surfaces) in some of the subwatersheds, in order to limit development in other subwatersheds to 10% impervious surfaces (Schueler 1995, p. 38). Clustered development lessens road length and reduces the amount of other impervious surfaces required to support a development. Reductions of impervious surfaces between 10% to 50% from traditional layouts can be accomplished depending upon the configuration of the clustered development (Schueler 1995, p. 61). Substantial savings in infrastructure costs are a direct benefit to the developer.

Land use zoning and other regulations can be used to limit the amount of impervious surfaces. Positive incentives and flexible codes encourage creative strategies for reducing the amount of impervious surfaces. This zoning should be done at the subwatershed scale and should be based upon the subwatershed classification: sensitive, degrading, and non-supporting. The sensitive subwatershed should have an upper limit of 10% impervious surfaces, degrading a 25% limit, and non-supporting no upper limit on impervious surfaces. Non-supporting subwatersheds have poor water quality and highly unstable streambanks. Future development and growth should be designated to occur in non-supporting subwatersheds in order to protect the sensitive and degrading subwatersheds.

Recommendations regarding specific subwatersheds in the Malibu Creek Watershed include:

- Focus development in the Westlake and Agoura subwatersheds and limit this to no more than 25% mapped impermeable surfaces.
- Change the zoning regulations to ensure that Las Virgenes, Malibou Lake, Malibu Creek, and Hidden Hills subwatersheds never exceed the 10% threshold for impervious surfaces.
- Reduce the level of effective impermeability in the Westlake and Agoura subwatersheds. This can be done through ordinances, building codes, and implementing new technologies to handle development.

Studies, such as Schueler's, have shown that it is more effective to reduce the amount of impervious surfaces related to the transport system (roads, parking lots, etc.), since these tend to have higher concentrations of pollutants than do rooftops or other impervious surfaces. These include reducing driveway length, width of streets and amount of impervious parking area.

Design Alternatives–Impervious Surfaces

The keys to mitigating the amount of storm water runoff are to slow down, capture, store, filter, and release storm water runoff. The most effective strategy, of course, is to limit or reduce the amount of impervious surfaces in the watershed. In addition to limiting or reducing impervious surfaces, it is recommended that design alternatives or Best Management Practices (BMPs) be implemented to reduce the amount and filter pollutants out of urban runoff.

The BMPs strategy will depend upon the subwatershed classification. Sensitive subwatershed BMPs should try and maintain pre-development hydrology and reduce sediment loading. BMPs such as biofilters, swales, and sand filters should be located away from streams to protect the hydrology of streams. BMPs for degrading subwatersheds should be implemented to remove pollutants and to reduce the frequency of bankfull and sub-bankfull floods. Pond or wetland designs can be implemented to achieve these goals. Non-supporting subwatershed BMPs objectives are to reduce pollution loads and prevent pollution.

The amount of impervious surfaces can vary greatly depending upon the development strategies and requirements for an area. The width of streets, the density of buildings, parking lot requirements, and the materials specified for such surfaces all contribute to the amount of impervious surfaces within a development. The amount of actual impervious surfaces can vary from 25% to 60% for medium density, single-family homes (Schueler 1995, p. 21). This all depends upon layout of streets, parking lots, and the overall layout and design of the site.

Recommendations

The following are specific actions that can be used to diminish the amount and effects of impervious surfaces.

Overall Recommendations

- Minimize the pollutants, and volume, and intensity of stream flows by restoring channelized portions of the creek throughout the Westlake and Agoura subwatersheds. Efforts to recapture the natural creek should start at the top and work down.
- Implement Best Management Practices throughout the entire watershed.
- Create a system of freshwater wetlands that biologically cleanses the water and regulate the volume and intensity of stream flows into downstream subwatersheds.

Streets, Driveways & Sidewalks

- Narrow width of streets.
- Use bioswales (vegetated depressions) that collect storm water and create visual separation, instead of creating elevated median strips to separate the traffic on two-way streets.
- Create streets and driveways that combine vegetative materials like grass, and ground covers with porous concrete, cobblestones or other materials that allow for the infiltration of water.
- Reduce the size of driveways for single family homes by sharing driveway

entrances. Create permeable extra parking spaces for visitors.

- Install French drain filter strips at the bottom of driveways or parking lots that collect and filter onsite runoff, then disperse water into planted collection areas.
- Use driveway strips with vegetation in the center to absorb leaks from automobiles and increase infiltration.
- Use permeable surface materials, such as cobbles, bricks or concrete paving blocks laid in a sand bed with mortarless joints, decomposed granite, and gravel.
- Design residential streets that receive little traffic with porous pavement to accommodate one way traffic, and use grass pavement for times when two-way traffic is needed.

Parking Lots

- Maximize how parking lots are used by using permeable surface materials on overflow areas or outer edges that are only used during busy holiday seasons.
- Use bioswales to collect runoff from parking, with plants and soil to filter pollutants associated with cars, before entering into the stream system.
- Support and use public transportation; ride bicycles for shorter trips.
- Create pedestrian-friendly malls that encourage strolling, not driving, between stores.
- Require underground parking beneath large structures, such as commercial buildings or apartment complexes.

Rooftops

Rooftop drainage is often sent directly to driveways and streets to rapidly flow into the storm drain system. Collecting, dispersing and filtering rooftop runoff before it reaches the storm drain system is a simple way of reducing negative effects of runoff.

- Drain roof runoff onto permeable areas such as planter beds. Use gravel to disperse gutter flows and to prevent erosion, or trench drains of gravel.
- Collect rooftop runoff from gutters into underground cisterns for future irrigation use.

Drainage Structures

- Retrofit existing storm water channels with pervious surfaces, where safe, to slow velocity of runoff.
- Create soft-bottom channels in place of concrete or pipes.
- Widen channels where possible.
- Establish retention/detention ponds, filters and infiltration systems.
- Create alternate routes for heavier flows through unused corridors or lots.
- Retrofit areas of high runoff due to impervious surfaces.
- Construct wetlands, where hydrology permits, for the enjoyment of residents.

Nutrient-Loading

Mitigation measures can decrease the impacts of pollutants to water quality. The key to preventing excess nutrients from reaching the water is to mitigate them at their source. The intent of this section is to recommend ways to reduce effects of polluted runoff into streams. New developments represent a good opportunity to implement some of these measures.

The following are specific actions that can be used to diminish the amount and effects of nutrient loading:

Recommendations

- Treat runoff onsite in bio-retention ponds or wetlands, before being released into public storm drain system.
- Collect runoff in parking lots into bio-retention ponds such as tree planters, median strips, or bioswales.
- Line streets and parking lots with bioswales to collect and filter runoff.
- Educate the public on ways they can lessen pollution runoff and impacts to the watershed.
- Maintain a water quality monitoring program to give feedback to the public and to agencies responsible for maintaining water quality.
- Lessen the amount of inputs into managed landscapes, such as pesticides, fertilizers and herbicides.
- Restore riparian vegetation.
- Minimize inputs to the wastewater treatment facility by promoting the use of gray water.
- Minimize the use of detergents containing phosphates that are hard to filter.
- Tapia should utilize wetlands that cool, store, and polish wastewater to be delivered during the summer when demand for reclaimed water exceeds supply.
- Begin a regional horse ownership educational program to encourage composting manure, pasture rotation, and proper planting techniques for grazing areas. Encourage the use of bioswales and filter strips to capture runoff leaving areas where horses are kept.
- Establish ordinances requiring a minimum 200-foot riparian buffer zone between areas where horses are kept and the stream.
- Permit no animal grazing within 200-foot of the riparian zone.
- Properly maintain septic systems; require inspections every two years. Require systems that do not pass inspection to be retrofitted with new septic systems that treat and reuse water for landscape irrigation.
- Pass ordinances that require new construction to meet these same requirements. Utilize computer-type systems to monitor the effectiveness of leach fields.

Recommendations for Steelhead Trout Enhancement (see Appendix E for more details)

- Remove the Rindge Dam to enable steelhead trout to migrate further upstream.
- Designate and protect critical habitat for steelhead trout.
- Require Tapia to cool, store, and polish wastewater using wetlands prior to any creek discharge.

- Implement construction BMPs on all projects requiring grading.
- Establish a no-build riparian buffer zone of at least 200-foot from the stream throughout the entire watershed.
- Reduce the effective impermeability of upstream cities through new zoning ordinances, building codes, and implementing structural BMPs.

Sedimentation

With the soils of the watershed being highly erodible, the goal regarding erosion and sediment loading is to minimize its occurrence. The following are specific actions that can be used to diminish the amount and effects of sedimentation:

Recommendations

- Reduce erosion and sedimentation at all construction sites with erosion and sedimentation control measures.
- Require Storm Water Pollution Prevention Plans (SWPPP) at all construction sites. These SWPPPs should be checked along with all sedimentation control measures during the construction process.
- Enforce compliance for all construction sites that do not display a SWPPP or have not implemented the erosion control measures.
- Limit clearing of native vegetation on construction sites.
- Require new construction projects of all sizes to implement sediment and erosion control devices at the construction site (such as silt fences, straw bales, etc.).
- Install terraces, temporary dams, sediment traps, or wetlands, that capture, store, and slowly release sediments over time.
- Protect soil from erosion during construction activities. Soil is highly vulnerable to erosion when vegetation has been removed during construction.

Water Quantity

The ultimate goal regarding water quantity is reducing the amount of imported water to be used, while accommodating population growth and development. With the continued consumption of imported water, the quantity of treated water being stored and released into Malibu Creek will continue to increase.

The following are specific actions that can be used to diminish the amount and effects of water quantity:

Recommendations

- Reduce imported water consumption through more efficient irrigation practices and low flow devices.
- Educate residents on the effects of imported water and provide incentives for reduced consumption.
- Increase the re-use of reclaimed water by allowing the distribution of reclaimed water to more customers, including residential users.
- Encourage the use of gray water systems through better landscape ordinances and rebates to supplement the initial costs.

- Encourage the use of drought tolerant and native vegetation.
- Create a series of wetlands throughout the watershed that would increase groundwater recharge, and decrease the intensity and volume of flows associated with impervious surfaces. Enhance water quality through biological filtration, and increase the available habitat for birds and other wildlife.

Riparian Habitat Conservation

Healthy stream habitats can help to reduce and mitigate problems associated with impervious surfaces, sediment loading, and nutrient loading.

The following are specific actions that can be used to enhance and protect riparian habitats.

Recommendations

- Protect existing riparian habitats.
- Preserve existing riparian corridor habitat.
- Preserve remaining native vegetation patches adjacent to riparian corridors.
- Protect sensitive areas from being developed. These include areas near streams, steep slopes, land on highly erodible soil, and areas with well established native vegetation.
- Protect existing vegetation that is covering the soil and holding the soil together.
- Protect soil from erosion by planting disturbed sites with native vegetation.
- Establish buffer zones between developed areas and streams. Reducing the amount of impervious surfaces near streams will help the vegetated buffer zone absorb and filter storm water runoff. The best strategy is to create a vegetated buffer zone by protecting existing native vegetation.
- Protect existing wildlife habitat corridors.
- Designate additional open spaces that link existing private and public open space.
- Re-establish the natural fire cycle to minimize the intensity, and associated sediment loading, from large intense wildfires.

This section contains recommendations and design ideas that if implemented, could aid in the restoration and enhancement of the ecological functions of the watershed. It is up to concerned citizens and stewards of the watershed to take action and help restore this diverse and spectacular watershed. These ideas are only a smattering of the various opportunities that can help solve the water quality problems of the watershed. Stewardship and design are a strong combination that, together, can result in positive change.

Section 7
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Appendix A

Recommendations and Project Limitations

Recommendations

Any efforts to correct existing digital storm drain data that currently is in a form that is unusable, should consider the Malibu Creek Watershed a high priority. Many groups and agencies currently monitor in the area and can immediately utilize this information to isolate the sources of pollution. An opportunity exists to use the volunteer monitoring program as a way to collect locations of storm drain outfalls by using global positioning systems. This alternative would enable the county to accurately locate storm drain outfalls for a fraction of the cost and time it would take for county employees to accomplish this task. While this would require funding for equipment and training, this is a viable alternative that would mutually benefit both groups.

An important element to any monitoring program is the ability to isolate the sources of pollution problems. Isolating sources of pollution would be more effective if storm drain locations were mapped. The Los Angeles County Department of Public Works, and Ventura County Department of Public Works, should create a single comprehensive digital storm drain map for the Malibu Creek Watershed. This storm drain map must identify storm drain outfalls and the areas drained by each outfall, and identify who is responsible for maintaining each storm drain. In addition, to ensure that digital data is readily available, and to increase the effectiveness of management of this complex system, this information must be compatible with the GIS employed by these counties. Without this type of information, locating the sources of water pollution problems will be impossible.

Existing information exists regarding monitoring throughout the watershed. This data should be synthesized and kept in one location that is accessible by the public and agencies in the watershed. This data can be helpful in making decisions concerning the watershed.

At the current time, Heal the Bay has the facilities to ensure the timely dissemination of the information collected by the Stream Team. As a non-profit agency, they can distribute this information at little to no cost. As the data base grows, Heal the Bay will be forced to upgrade their computer hardware to accommodate the increased volume of stored data. Beyond the time frame of the pilot project, it is recommended that funding to upgrade the computer hardware and software be acquired. Further, Heal the Bay should purchase a new orthographic digital aerial photograph every three years. Funding should be secured to accommodate additional Stream Walk Teams during the course of Phase 1. If Heal the Bay decides to expand the program into Phase 2, the person running the program should receive specific training for Macroinvertebrate Sampling and Stream Reach Surveying.

Flow data at the two stream gages in the watershed does not provide a picture of the contribution from each subwatershed. It is felt that many of the streams that were once intermittent are now perennial from artificial inputs into the streams. Installation of stream gages and rain gages at the base of each subwatershed, that accurately measure low flows would be beneficial to the area.

Project Limitations

Data from this study is based on the most current available information. The soils map received in digital form is considered obsolete and unreliable for this area. The Natural Resource Conservation Service is currently conducting a detailed soil survey for the area, and they have already discovered eight new soil types (Koeneker 1998, p. 5). When this new study is ready, the model should be updated. Land Use data has been revised by the project team from a digitally rectified orthographic aerial photo to reveal the newest information. The aerial photo is a blend of photos taken in April and October of 1997. Sites chosen for the monitoring, and stream classifications are based on observations from the aerial photo, USGS Topographic Maps, and street maps. These sites have not been field checked. The data provided in the digital data set should not be used for building, precise modeling, or any activity that needs data at higher accuracy than 30 meters.

Appendix B

Runoff Analysis for the Malibu Creek Watershed

by Bradley B. Owens

INTRODUCTION

The software used for modeling the watershed is called Watershed Modeling System (WMS) created by Environmental Computer Graphics Laboratory (ECGL) of Brigham Young University. With this model, runoff was estimated utilizing data supplied by Los Angeles County Department of Public Works and digital elevation data from DEMs. The watershed was modeled for two conditions– pre-development and current development. Results show a dramatic increase in runoff from pre-developed conditions to the current developed condition.

WMS provides a graphical interface for standard computer models such as HEC-1 and TR-20; HEC was developed by the United States Army Corps of Engineers, and TR-20 was developed by the Soil Conservation Service (SCS, now the Natural Resource Conservation Service or NRCS). When using this software program, the model can be updated and refined as new information becomes available, thus adding to the effectiveness of analyzing and predicting changes in the watershed.

Peak Runoff Explanation

A hydrograph is a graphical representation of a volume surface flow at a common point, such as a stream gage, in a given time period (cubic feet per second). For this model, a 24-hour storm was used as the time period. After the initial infiltration of rain into the topsoil, overland flow, or runoff, will occur and a peak will also occur at some point when the flows are greatest due to factors such as subwatershed geometry (area, slope), soil types, cover (land use, vegetation), and storm pattern.

The WMS software requires that certain data sets are available, depending on the model type and accuracy desired. Data was collected from a variety of different sources listed in table 1.

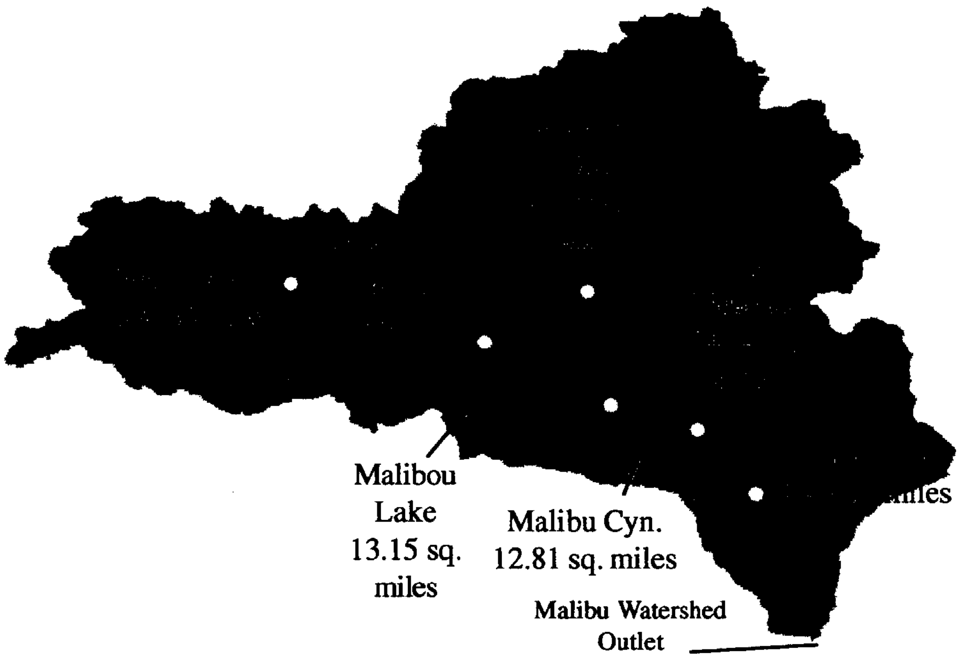

Figure B-1: Malibu Creek Watershed, Boundaries, and Area

Model Inputs and Methods

HEC-1 was chosen as the hydrograph method within WMS due to its ability to utilize the land use and soils data, thus providing more precision than other models such as TR-20. Within HEC-1, the NRCS curve number method was chosen to compute losses (runoff) for the same reason. The curve number method was developed by the NRCS as a way to index various surface runoff conditions based on land use conditions and soil characteristics.

The model was run for intervals of 2, 5, 20, 25, 50, and 100 year storms, based on rain data available from the National Oceanic Atmospheric Agency (NOAA) and applied to two conditions. Current developed conditions and predevelopment conditions were based on a vegetation survey done from 1930 to 1934 by A. E. Wieslander of the United States Forest Service. For predevelopment land use conditions, the Wieslander survey was used to visually estimate the percentages of different vegetation type. These were averaged together to generate predevelopment curve numbers.

Dams

There are at least six dams/reservoirs in the watershed; of these, four were used in the model due to their size and/or location within the watershed. The dams used (with the DWR number) for this model are Lake Sherwood (765-000) in Hidden Valley, Westlake Lake (786-000) in Westlake, Lindero Lake (785-000) in Agoura Hills, and Malibou Lake (771-000) in the Malibou Lake subwatershed. Information about the dams is available on the World Wide Web (see references).

Assumptions, Limitations

This model is dependent on the available primary data; it is assumed that this is the best available at this time. It is known that the soil survey on which the

Primary Data	Source	Notes
Rainfall	NOAA	24hr, 2-5-10-25-50-100 year storms.
Soils	National Park Service	Modified by Suzanne Dallman, UCLA to reflect new information.
Land Use	Los Angeles Co. Department of Public Works	Modified by Cal Poly Pomona 606 Team using digital aerial photography and 3-d analysis.
Watershed, Subshed Boundaries	Los Angeles Co. Department of Public Works.	Modified by Cal Poly Pomona 606 Team using digital aerial photography and 3-D analysis.
Vegetation (current)	National Park Service	
Vegetation (pre-development)	USFS	Survey by A.E. Wieslander.
Elevation DEMs	Cal St. Northridge	Digital Elevation Model (DEM).

Table B-1

GIS shapefile was based is an interim survey by the NRCS and is currently being updated for official release due in year 2001 (personal communication, Al Wasner, NRCS). In addition, the land use categories supplied did not have direct correlation to the SCS curve number table and this was manually interpolated.

As stated previously, this model has many inputs so modification and refinement over a long period of time will return the best results. Additional information useful would be channel geometry, reservoir geometry and conditions, and more exact soils data. Hydrologic modeling is both art and science, so the results are assumed to be estimates, and will differ from actual conditions.

Results

The runoff analysis resulted in two primary results, predevelopment and current developed conditions with modeled estimates of peak runoff (cubic feet per second) for each subwatershed and a total at the ocean outlet for each storm interval. The data is presented on the following pages in tabular form with a hydrograph for the outlet. Figure 1 represents predevelopment conditions and Figure 2 represents current conditions.

Conclusion

The modeling has shown that the watershed is yielding a large increase in runoff since predevelopment conditions have changed. Increases greater than 100% are seen in every subwatershed, most approaching 200% for a two year storm, and the Westlake subwatershed showing an over 700% increase. Figure 3 shows the relationship between the increase in mapped impervious surfaces and the increase in the amount of runoff is highly correlated.

Table 2 shows that the increase in impervious surface area in each subwatershed has increased the runoff into Malibu Creek (with the assumption being that the predeveloped condition had zero impervious surface). The clearest example is in the Westlake subwatershed where a 22.89% increase in impervious surface has led to a 722.01% increase in runoff. The linear graph also shows that the increase is a logarithmic relationship; small incremental increases of impervious surface leads to greater and greater amounts of runoff (Figure 4).

Although typical (and costly) structural devices such as dams and weirs can be used to control runoff, it is clear that this watershed will yield extreme amounts of runoff as impervious surfaces increase, and due to the erosive nature of the soils, will render these devices largely ineffective in relatively short periods of time as seen with Rindge Dam which has completely filled with sediment.

Malibu Creek Watershed Outflow, Pre-Development Conditions [cfs]

Storm Interval	**Malibu Creek Outlet**	Malibu Cyn	Cold Creek	Las Virgenes	Malibou Lake	Agoura Hills	Westlake	Hidden Valley
2yr/24hr	**1,601**	229	97	260	248	278	159	340
5yr/24hr	**5,247**	635	483	522	1,702	856	901	1,175
10yr/24hr	**8,663**	964	681	841	2,762	1,856	1,001	1,768
25yr/24hr	**13,130**	1,829	1,177	1,285	4,064	2,109	1,308	2,965
50yr/24hr	**15,427**	2,393	1,289	1,533	4,581	2,652	1,761	3,284
100yr/24hr	**23,056**	3,398	1,908	2,545	6,463	4,175	2,498	4,631

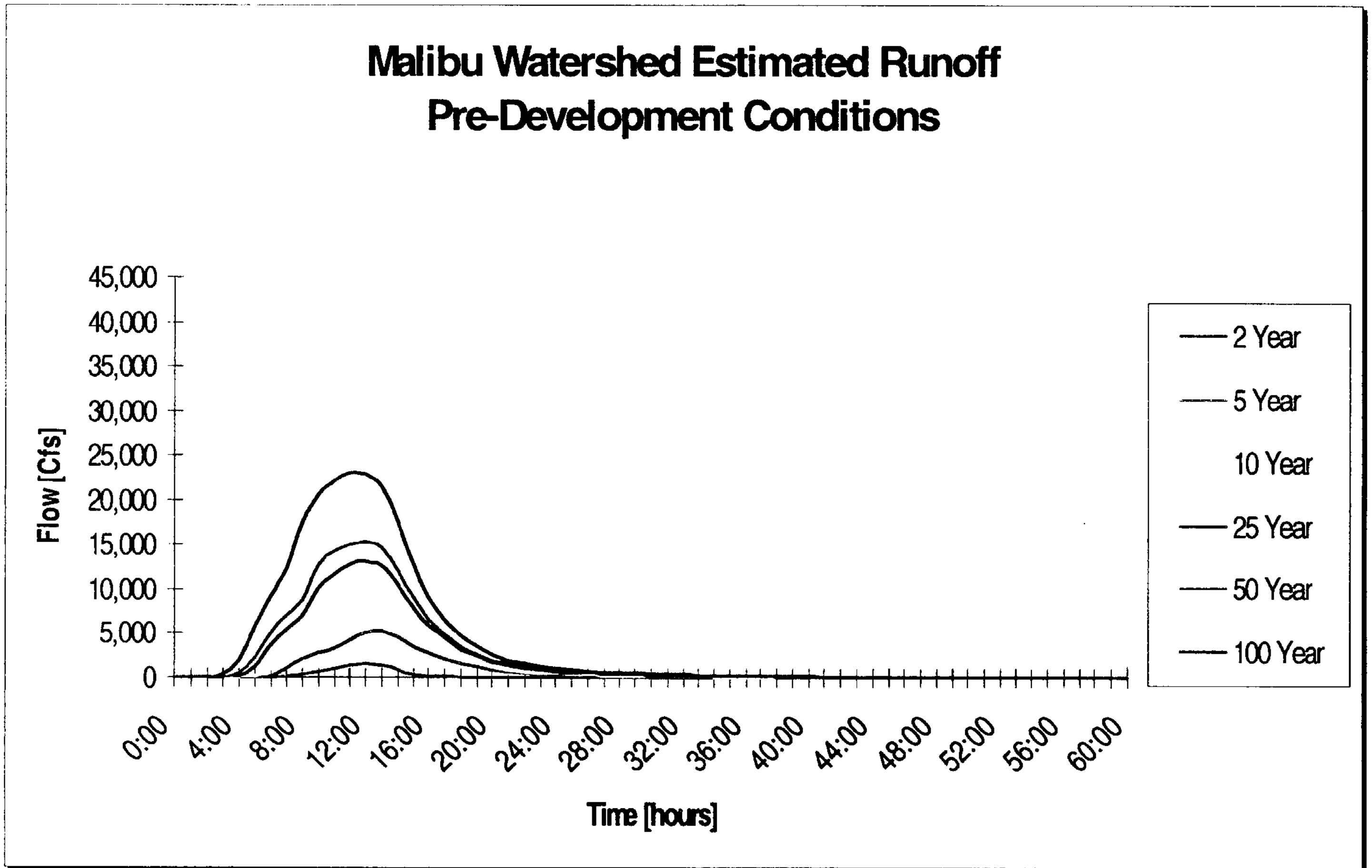

Figure 1

Malibu Creek Watershed Outflow, 1998 Conditions [cfs]

Storm Interval	**Malibu Creek Outlet**	Malibu Cyn	Cold Creek	Las Virgenes	Malibou Lake	Agoura Hills	Westlake	Hidden Valley
2yr/24hr	**3,766**	573	270	702	693	921	1,307	939
5yr/24hr	**13,255**	1,365	1,074	1,265	3,646	2,311	3,162	2,668
10yr/24hr	**19,821**	1,950	1,432	1,888	5,454	4,305	3,907	3,738
25yr/24hr	**26,616**	3,342	2,249	2,682	7,469	4,784	3,982	5,708
50yr/24hr	**30,161**	3,735	2,433	3,109	8,762	5,751	4,814	6,189
100yr/24hr	**42,090**	5,596	3,356	4,699	10,948	8,221	6,559	8,146

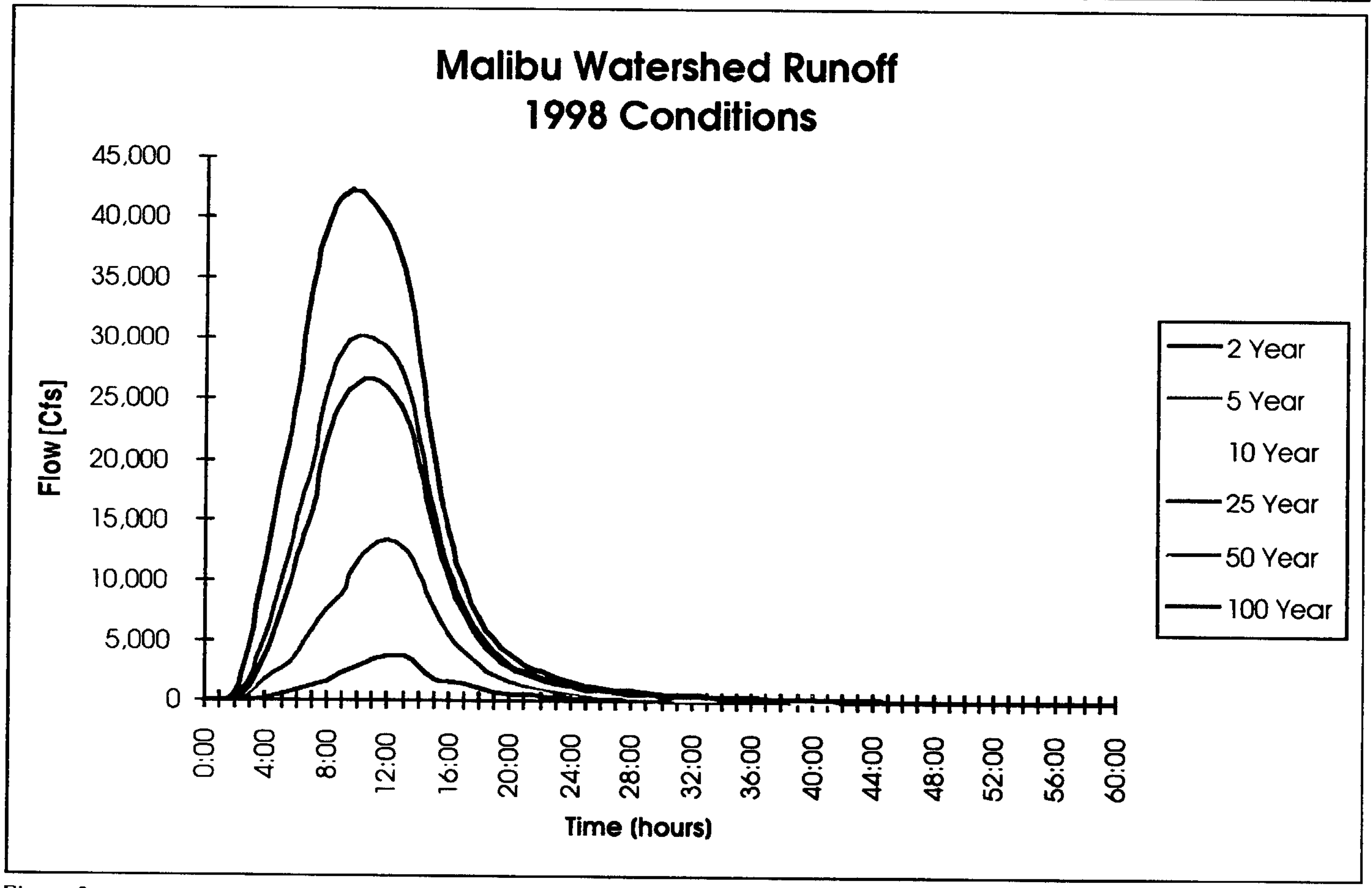

Figure 2

Malibu Watershed Area, Development/ Runoff Relationship

	Malibu Cyn	Cold Creek	Las Virgenes	Malibou Lake	Agoura Hills	Westlake	Hidden Valley
Total Area [mi^2]	12.81	8.16	24.34	13.15	21.62	12.99	16.86
Mapped Impervious (current) [mi2]	0.48	0.16	1.73	0.44	3.98	2.97	0.94
Percent Impervious (PreDev)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Increased (Current)	3.71	2.01	7.11	3.38	18.39	22.89	5.56
PreDev. Runoff (2yr) [cfs]	229	97	260	248	278	159	340
Current Dev. Runoff (2yr) [cfs]	573	270	702	693	921	1,307	939
Percent Increased Runoff	150.2	178.4	170.0	179.4	231.3	722.0	176.2

	Malibu Cyn	Cold Creek	Las Virgenes	Malibou Lake	Agoura Hills	Westlake	Hidden Valley
Percent Increased (Current)	3.71	2.01	7.11	3.38	18.39	22.89	5.56
Percent Increased Runoff	150.22	178.35	170.00	179.44	231.29	722.01	176.18

Table 2

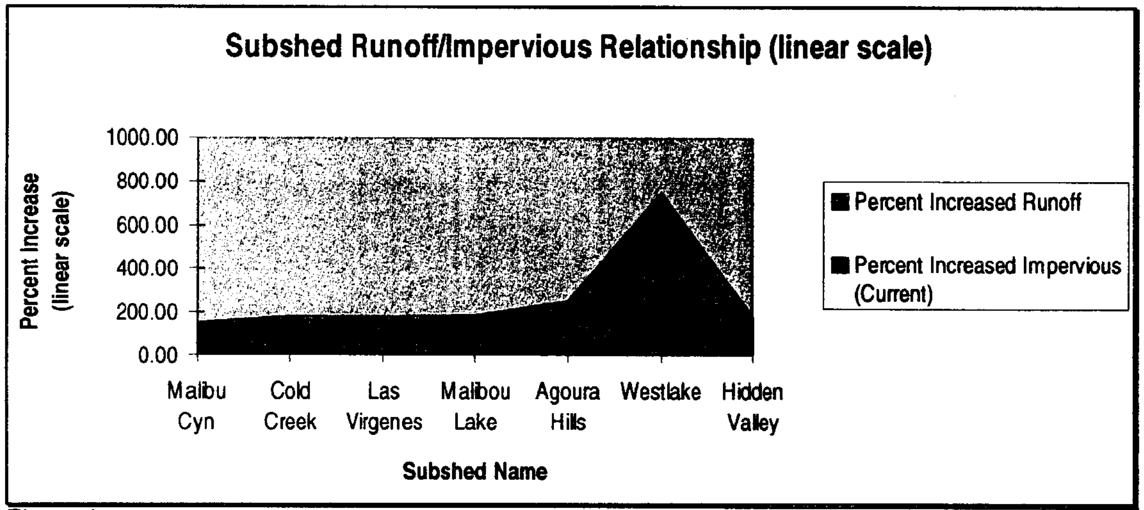

Figure 4

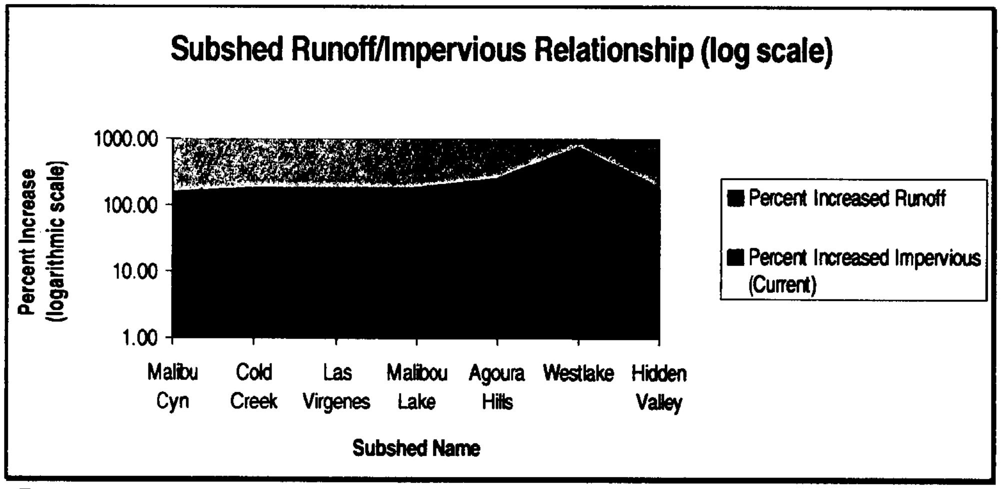

Figure 3

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Appendix C

Within Every Healthy Watershed Dwell Citizen Stewards

by Eileen Takata Schueman

INTRODUCTION

Human beings have altered natural systems by dredging wetlands, channeling streams, damming rivers, and by increasing impervious surfaces by paving over porous soils. Over time, the accumulated effects have altered the natural hydrologic cycle, degraded habitat for native plant and animal species, and strained precious water resources. Government agencies alone can not bring changes to the current situation. Banded together, however, private citizens are capable of improving conditions of these altered streams, rivers, lakes, wetlands, and estuaries in and around their neighborhoods, towns, cities, and counties. Citizen stewards, who participate in monitoring the current health of these ecosystems, contribute to the future health of their natural resources.

OVERVIEW OF EXISTING MONITORING PROGRAMS

It is not clear how many volunteer monitoring programs exist or how many participants are active in this country. The U.S. Environmental Protection Agency reports that over 24,000 volunteers involved with state-supported programs monitor more than 985 streams and rivers, nearly 2800 ponds, lakes, and wetlands, and four major estuaries. Throughout Pennsylvania, 60 groups and over 6,000 volunteers sample surface and groundwater. California's Directory of Volunteer Monitoring Organizations (1997) list over 50 groups around the state. What is clear is that the numbers are rising. Internationally, Australia and the United Kingdom support many stream-monitoring programs, and a joint program exists between Mexico and the U.S.

In the past, coastal lagoons and wetlands had been the focus of citizen monitoring efforts. Isolated streams and rivers have also been monitored extensively. More recently, watershed management has become the impetus behind new grassroots organizations and projects. This holistic approach addresses multiple issues affecting the complex system of streams, wetlands, and creeks. Watershed-wide monitoring addresses problems at their source, and can be effective in integrating multiple solutions to the complex problems.

WHO Is Monitoring?

Volunteers are either local concerned citizens of all ages, elementary through college students. They share a sense of wanting to contribute to "the environment." Monitoring groups call themselves Stream Team, X-Stream Team, Stream Keepers, Stream Watch, Watershed Watch, Texas Watch, Friends of the Estuary, and Riparian Station. Naming ensures a "team spirit" and contributes to the motivation factor, which will be discussed later.

Statewide programs such as Kentucky Water Watch and Hoosier Riverwatch in Indiana are run through their respective Department of Natural Resources. Auburn University's Alabama Water Watch is an example of a collaborative effort between Federal, State, and local agencies. Non-profit organizations coordinate local, regional, or statewide monitoring efforts. In Virginia, the Izaak Walton League's Save Our Stream Program (SOS) supplies its data to the Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation. The Bay Area Regional Watershed Network promotes watershed stewardship by acting as a facilitator and regional funding base for different groups in the San Francisco Bay Area. students at Sequoia Elementary School in Pleasant Hill, California monitor Murderer's Creek.

WHAT Is Being Monitored?

Every project is unique in terms of what is being monitored, and depends largely on the goals and objectives of that particular program. The name Stream Team implies stream quality monitoring, but could easily include wetlands, lakes, vegetation and habitat restoration or watershed surveying. Friends of the Santa Margarita River in southern California are concerned about the health of the entire watershed. In northern California, the Lindsay Museum Watershed Watchers monitor Walnut and Pine Creeks.

Each program samples one or a combination of several stream and watershed parameters. A large number of programs train for chemical sampling of water quality. Physical stream characteristics and biological sampling of benthic macroinvertebrates are also common. Other parameters include bacterial, habitat assessment, illegal dumping, discharges, vegetation, stream/beach cleanup, erosion, or sedimentation. More and more groups are realizing the importance of setting goals for a holistic monitoring program. This ensures that the overall health of a watershed is being measured, not just one particular stream or river.

WHY Monitor?

Volunteers monitor in their community to contribute to society, to do something "good for the environment", and to gain something back. School children gain hands-on educational experience in the natural sciences. Adults gain satisfaction knowing their monitoring results will be used to make improvements to the health of surrounding ecosystems. Many organizations offer training workshops and informational lectures for their volunteers. In this way, volunteers learn new skills and techniques that are essential for high quality data collection.

Programs originate because of one or a combination of three general categories. The U.S. Environmental Protection Agency, Non-Point Discharge Elimination Survey (NPDES) compliance is a primary impetus for starting a program. Many programs have begun due to citizens organizing for a specific reason, such as to take action against a known point-source polluter, or to save an endangered species, or to combat invasive exotic vegetation which has taken over a stream bank. Lastly, effects of degradation and human-induced alterations of riparian ecosystems or watersheds prompt citizens and professionals to organize and develop a comprehensive monitoring program.

Key Issues in Monitoring Programs

In order to gain first hand insight into key issues in monitoring and program planning, I developed a questionnaire which guided telephone interviews. A sample copy is included and follows the bibliography. There are eighteen questions, relating to four general categories: The Program Goals & Objectives, Program Organization and Change, Data Collection and Dissemination, and Volunteers. Talking to actual monitors and program coordinators has unveiled some interesting insights, especially on the importance of volunteers, and reinforced existing knowledge.

Seven organizations have been contacted. Interviews were conducted with Hoosier Riverwatch in Indianapolis, IN, River Watch Network in Montpelier, VT, Kentucky Water Watch in Frankfort, KY, Sonoma Ecology Center in Sonoma, CA, Coyote Creek Riparian Station in Alviso, CA, Bay Area Action out of Palo Alto, CA, and the Mill Valley Watershed Organization out of Fairfax, CA. The contacted persons are program coordinators, office managers, or technical advisors to the project. These contact persons represent either state-sponsored programs, or regional and local non-profit agency-sponsored programs. The one exception is River Watch Network, a non-profit organization that assists in the development of new monitoring programs around the country.

Program Goals and Objectives

Goals for existing monitoring programs surveyed to date serve two primary purposes. The first goal serves the needs of humans, namely the volunteers and the public at large. Monitoring provides educational opportunities for teachers and students of all ages, and provides opportunities for citizen stewardship. Hoosier Riverwatch aims to increase public awareness. The second goal addresses ecological concerns. The need to improve water quality ranks high among these groups. Physical degradation of stream banks, habitat and or species loss, native vegetation concerns, and overall watershed health are other examples of goals stemming from ecological concerns.

What a group monitors depends largely on these goals and objectives. Bay Area Action is concerned with bird and wildlife habitat quality, and the control of invasive plants, as well as the restoration of native vegetation. The Mill Valley Watershed Organization surveys habitat, vegetation, sedimentation, and stream substrate. Watershed survey data is also an important component of data collection. Hoosier Riverwatch sends students out to collect chemical and biological data for school projects.

Program Organization and Change

The individuals that were interviewed have one of four roles within their organization. They are either a Volunteer/Program Coordinator, technical advisor, student intern, or volunteer. Being a program coordinator is a full-time paid position at Kentucky Water Watch and Hoosier Riverwatch, which are also state-funded programs. As for the non-profit organizations, it is not clear if program coordinators are paid or volunteer positions. The Sonoma Ecology Center utilizes a volunteer technical advising committee. Bay Area Action employs a few staff members, engages six student interns for specific projects, coordinates with five to six key managers, and oversees about twenty to thirty citizen volunteers on a typical work day.

Collaboration among agencies on goals and program elements are important to the Sonoma Ecology Center, Coyote Creek Riparian Station/Watershed Initiative Pilot Program, and Bay Area Action. These three groups work with agency partners and local community organizations to plan current projects and future directions. Bay Area Action is involved with the Coordinated Resource Management Process (C.R.M.P.) project, a group of stakeholders interested in an integrated approach to solving watershed-wide problems. Issues range from biodiversity, flood control, and pollution, to the homeless living in creek corridors.

Program objectives change over time for some organizations. Hoosier Riverwatch began as a trash clean-up and awareness program, and has since expanded to include biological and chemical testing. Another group, the Coyote Creek Riparian Station is undergoing a transition because their goals and resource needs have changed. Originally they monitored riparian habitats of several creeks. However, focus has recently shifted towards watershed monitoring, recognizing the need to understand the entire ecosystem, rather than single creek riparian systems. From this reassessment of program goals, the interagency Watershed Initiative Pilot Program was born. This program is collaborative, potentially allowing more access to funding and technical resources through its partner organizations.

Data Collection and Dissemination

A volunteer will record his or her data onsite. The forms that they use vary with each program. Once sampling is complete, forms are turned in to the monitoring organization for data entry and analysis. In the case of Kentucky Water Watch, their World Wide Web site contains an electronic submittal form similar to the paper one, which approximately 20% of volunteers use. The only problem seems to be duplicate submissions; users frequently hit the "submit" button more than once, sending duplicate sets of data to be analyzed. More and more groups are giving volunteers the opportunity to submit data electronically.

Volunteers like to know that their hard work will result in some positive action. Understanding how data will be used is an important part of program planning. Many programs make their data readily available on the internet. The Hoosier Riverwatch program does not know whether or not their Internet database is used. Their goal is to make the information readily available for interested persons, rather than to target specific users. Quality Assurance/Quality Control (QA/QC) methods are employed by various organizations to ensure high quality data. Data collected by school children tend not to be accurate, so it is not released to the general public. Trained adults collect data that is more trusted, therefore, more likely to be used in studies and management decisions. In addition to data quality, Environmental Protection Agency and state agencies will consider funding programs that have a QA/QC plan in place.

The World Wide Web provides opportunities for sharing information across long distances. Information networks are designed for local, regional, or global use. Hoosier Riverwatch plugs their data into the RiverBank database maintained by Global Rivers Environmental Education Network or GREEN. RiverBank is a database that allows volunteers and schools to record and store data. The Coyote Creek Riparian Station/Watershed Initiative Pilot Program will be adding data to the Bay Area EcoAtlas database. EcoAtlas is a Geographic Information Systems (GIS) database available online used to support local and regional environmental planning and management.

During the Fifth National Volunteer Monitoring Conference in August 1996, a special discussion planning session focused on the topic of "Turning data into action" (Proceedings, 1996). The discussion outlined "burning issues" such as making the data available and finding better ways to put the data to use, and improving volunteers' ability to follow up on monitoring results themselves for increased citizen action. Key recommendations involved empowering the citizen monitors by involving them in the decision-making process of how the data will be used by various stakeholders.

Volunteers–The Human Component

The most important information gathered during the interviews relates to the human component of monitoring programs - finding, keeping, and motivating volunteers. Each person interviewed had advice to give on some aspect of the issue of human involvement in the program. Clearly, monitoring programs would not be successful without meeting the needs of volunteers. Background education on why they are monitoring, what they are monitoring for, when they are expected to participate, and where the monitoring will take place is important to convey to volunteers. In turn, they are more motivated, better prepared, and capable of contributing to the best of their abilities. The relationship between volunteers and monitoring agencies or organizations is symbiotic; each is concurrently teaching or learning from the other.

Finding volunteers required some work for one non-profit organization. Once the monitoring creeks were selected, homeowners on or near the creeks were contacted. Information packets were mailed containing monitoring information, meeting or training session information, phone numbers to call in case of illegal dumping, etc. The purpose of these packets is to promote a sense of ownership and to arm creek-side homeowners with basic tools to become active stewards. In addition to adjacent landowners, recreationists are another potential pool of volunteers.

Motivating volunteers through education and training ensures a well-informed, committed volunteer base. A successful program will attempt to explain the "interconnectedness" between the volunteer and their everyday life, as one program coordinator suggested. Keeping volunteers can also mean simply taking care of them by bringing food and drinks to work days and training sessions. In the case of Kentucky's Water Watch program, keeping volunteers means addressing issues of "safety and access first." According the program coordinator Ken Cooke, the following list contained his words of serious advice (Cooke, 1998): (1) Safe parking place; (2) Clear path to river or creek; (3) Comfortable place to stand/sit during testing; (4) Will anyone shoot me while I'm monitoring? If yes, select different site; (5) THEN review hydrologic schematic of watershed to see if location is significant.

River Watch Network, an agency experienced in setting up volunteer programs stressed the need for a committed sponsoring group to take the responsibility for a successful program. Within that group, a "star" person is needed to take the lead. Alabama Water Watch calls this person the Volunteer Monitor Coordinator. River Watch Network recommends that volunteers be given the opportunity to assist in shaping the goals and objectives of the program. Also, they should be encouraged to give their insight into land uses, preferably on a land use map. This way, the citizen who is aware of the "important swimming hole" is contributing to the overall success of the monitoring project.

TOWARDS WATERSHED HEALTH

According to the Streamkeeper's Field Guide, "A stream is only as healthy as its surrounding watershed." This delightful book, subtitled *Watershed Inventory and Stream Monitoring Methods,* covers overall understanding of watersheds and their investigation in the first two chapters. Many other programs are beginning to see the importance of planning and taking action at the scale of the watershed, versus at a single creek, river, lake, wetland or estuary. Every single person lives in a watershed. Citizens who monitor their local creek ensure the future health of their surrounding watershed.

Existing Water Quality Monitoring Programs QUESTIONNAIRE

Date:
Project Name/Location:
Contact Name/Title:
Phone Number:

The Program Goals & Objectives

1. WHO is monitoring WHAT?
2. WHY are they monitoring?
3. WHAT were the original goals and motivating factors of the program?
4. HOW have the goals been met, exceeded, or fallen short?

Data Collection and Dissemination

5. WHAT agency or organization serves as the clearinghouse for the data? Is this the originating organization?
6. HOW are they monitoring and submitting their data?
7. (If online) HOW successful is online data submission?
8. WHAT percentage of volunteers submit online?
9. WHAT are the pitfalls/perks to collecting data online? Paper?
10. WHO is using the information and HOW?

Program Organization & Change

11. WHICH, if any, existing programs did they look to for a model on HOW to set up a monitoring program? WHY?
12. . WHAT aspects of existing programs are successful now?

13. WHAT changes in the current program are taking, need to, or will take place?

14. WHERE do existing/future sources of funding come from?

Volunteers

15. HOW were the Volunteers organized?

16. WHAT motivates the Volunteers to stick to a schedule, sample accurately, etc.?

17. WHAT are the challenges/rewards in working with Volunteers as opposed to hired employees?

18. WHAT are some words of advice to a fledgling monitoring program?

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Appendix D

Ecological Engineering Planning Process for Designing Constructed Wetland Storm Water Systems

by Chris Padick

In undeveloped areas, storm water runoff is managed through the natural hydrological cycle, effectively accommodating even severe storm events. As in the Malibu Creek Watershed, land-use changes associated with urbanization alter the natural hydrology by changing peak flow characteristics, total runoff, and water quality. With a traditional storm water management regime being one of getting the water off site as quickly as possible, the resulting condition is a degraded watershed, poor water quality, erosion and flooding.

Within the Malibu Creek Watershed, the rapid expansion of urban development is having a tremendous impact on the Malibu Creek ecosystem. As levels of impermeability rise, the resulting increase in urban storm water has a direct impact on the water quality of the watershed, primarily in the form of non-point pollution, sedimentation and increased peak water flows. As the watershed continues to be developed, these problems will only continue to increase. The result of these problems is a degraded creek ecosystem. Once the impermeability of a watershed reaches 10-15 % of the total watershed area, we begin to see degradation on the creek ecosystems, primarily in the form of degraded water quality and the erosion of stream beds and banks due to dramatically higher intensity peak flows (Schueler). Though only about 12% of the total Malibu Creek Watershed is developed, development tends to be highly concentrated along many of the upper reaches of the Malibu Creek ecosystem, including some subwatersheds reaching 45% total developed area. The result is a stream system impact that has an effect throughout the watershed.

To deal with these development issues, ecological engineered solutions are proving to be both very effective and environmentally sensitive. Ecological engineering is the design of human environment within the natural environment for the benefit of both (Mitcsh 1989, p.4). Defined, it is engineering that involves the design of natural environments using quantitative approaches and basing approaches on basic science (Mitcsh 1989, p.4).

As the understanding of ecosystem functions and structure drives ecological engineering, ecology is the basic science driving design. Well defined by Odum in 1962 as "environmental manipulation by man using small amounts of supplementary energy to control systems in which the main energy drives are still coming from natural sources", ecological engineering is the design of ecosystems that, once created, rely on the self designing properties of natural ecosystems with a minimum of maintenance. Key to the process is that ecologically engineered designs need to be solar-based, requiring little intervention, thus based on natural ecosystems that are self-sustaining systems running on solar energy (Mitcsh 1989, p.7).

Ecological engineering, with its roots in ecology, is quickly proving to be a significant alternate solution to some of the pressing problems associated with the impacts of human development on the environment. The goal of this appendix will be to introduce the field of ecological engineering as a guiding force for design opportunities concerning constructed wetland applications within the Malibu Creek Watershed for the treatment of non-point pollution sources associated with urban runoff.

When making design decisions for alternative storm water treatment applications, it is important to first understand the key principles driving an ecologically engineered design. The following are in essence, guidelines for a design process.

1. Ecosystem structure and function are determined by the forcing functions, such as temperature, nutrient imports, and water flows, of the system. Alteration of the forcing function causes the most dramatic changes on an ecosystem. Structure of an ecosystem is ultimately controlled by forcing functions. As the driving forces behind an ecosystems function, an in-depth understanding is critical for a successful design (Mitcsh 1989, p.22).

2. Ecosystems are self-designing systems. The more one works with the self-designing ability of nature, the lower the cost of energy to maintain that system. An ecosystem's regulation and feedback mechanisms give it the ability to adapt and self-design to the environment and minimize changes in the function of the ecosystem. It is here that ecosystems and ecological processes are used, not replaced as a primary guiding force in ecological engineering (Mitcsh 1989, p.24)

3. Elements are recycled in ecosystems. Matching humanity and ecosystems in recycling pathways will ultimately reduce the effects of pollution. Elements cycle in all ecosystems, an example of this would be the nutrient cycle. Of primary importance in an ecologically engineered application is understanding the individual cycles of the ecosystem and their rates (Mitcsh 1989, p.25).

4. The processes in ecosystems have characteristic time scales that may vary over several orders of magnitude. For optimal performance, manipulation of ecosystems must be adapted to the ecosystem's natural dynamics (Mitcsh 1989, p.29).

5. Ecosystem components have characteristic space scales. Manipulation of ecosystems should take into account the appropriate size necessary to achieve the desired results (Mitcsh 1989, p.30).

6. Chemical and biological diversity contributes to the buffering capacity of ecosystems. When designing ecosystems, one should introduce a wide variety of parts for the ecosystem's self designing ability to choose from. The more possibilities an ecosystem has, the higher its buffering capacity. This is especially true for the buffering capacities related to the function of the system. A system with a high diversity may change

species composition radically and therefore be considered unstable yet still have a high buffering capacity related to its function. The higher the diversity, the more capable an ecosystem is in handling fluctuations of its force flows (Mitcsh 1989, p.33).

7. Ecosystems are most vulnerable at their geographical edges. Ecological management should take advantage of ecosystems and their biota in their optimal geographical ranges. As ecosystems have defined ranges in which they are tuned to the climatological and geological features of the landscape, these should be primary considerations in the design process. As ecological engineering involves manipulation of ecosystems, the stability of the system will be enhanced if the species are in the middle of their environmental tolerances (Mitcsh 1989, p.33).

8. Ecotones are formed at the transition zones between ecosystems. The interface between human settlement and nature should be designed as gradual transitions, not as sharp boundaries. Nature has developed transition zones, between ecosystems, to make soft transitions. Ecotones may also be considered buffer zones between ecosystems that are able to absorb undesirable changes imposed on an ecosystem from neighboring ecosystems. (Mitcsh 1989, p.34)

9. Ecosystems are coupled with other ecosystems. This coupling should be maintained wherever possible and ecosystems should not be isolated from their surroundings. Ecosystems are open systems, and as such, exchange mass and energy with their environment. Thus it is important in ecological engineering to take this into consideration. If a component is removed from one system, the problem is not solved if the component then harms another system (Mitcsh 1989, p.35).

10. Ecosystems with pulsing patterns are often highly productive. The importance of pulsing subsidies should be recognized and taken advantage of wherever possible. Ecosystems with pulsing patterns often have greater biological activities and chemical cycling than systems with relatively constant patterns. But careful understanding is required to ensure proper frequency and duration to allow a system to operate at optimal levels (Mitcsh 1989, p.36).

11. Everything is linked to everything else in the ecosystem. It is impossible to manage one component of an ecosystem without affecting other parts. As all components of an ecosystem are linked in one way or another, it is particularly important to understand these connections in ecological engineered designed solutions (Mitcsh 1989, p.36).

12. Ecosystems have feedback mechanisms, resilience and buffer capacities in accordance with their proceeding evolution. And understanding of these characteristics will ensure greater success (Mitcsh 1989, p.36).

With these principles guiding the design process, there is a greater chance of understanding the ecosystems involved. With this better understanding, adopting an appropriate design will blend the needs of humanity with the needs of the ecosystem for the benefit of both.

With this in mind, we can now address one of the major issues concerning water quality with in the Malibu Creek Watershed. Non-point pollution sources (NPS), especially those associated with urban runoff, are considered among the nations leading source of surface water and ground water quality impairment (www.epa.gov). Urban storm water runoff, as well as being a major NPS, also contributes to water quality problems through increased peak flows that degrade streams and erode stream banks. The first step in designing the solution is understanding the problem.

In the Non-point pollution associated with urban storm water runoff, the following are the pollutants of concern.

- Biological Oxygen Demand (BOD): Organic molecules and other substances that require large amounts of oxygen to be broken down constitute BODs. Because of this high O2 demand, when released into the environment, those organics can have a detrimental effect on fish and wildlife by robbing them of the available dissolved oxygen.
- Nutrients: When high level of nutrients accumulate in waterways, it creates algae blooms that depletes oxygen needed by fish and other wildlife.
- Suspended Solids (SS) Suspended solids are insoluble materials, sediment particles that cloud water when suspended preventing light and oxygen from reaching aquatic life. Increased sediment settling can also degrade wildlife habitat, especially that of the steelhead trout that needs gravelly bottoms for breeding success.

Along with NPS pollutants, the other major problem associated with urban storm water runoff is the increase in peak water flows during storm events. The result is an overloading of the stream system to the point of downstream flooding and accelerated stream bank erosion.

Here is where ecological engineered solutions can play a vital role in the mitigation of these problems. Showing itself as being a very effective solution is the use of a variety of constructed wetlands. Basically, constructed wetlands are created ecosystems, modeled after natural systems and designed to mimic the natural processes of these ecosystems. Evidence is showing that these artificially created ecosystems, depending on type, are very efficient at filtering out most solid BOD as it passes through sand, soil, crushed rock or brick elements of the wetland substrate, while dissolved BOD is eaten by microbes. Microbes colonize on the surface of plant roots where oxygen is made available as plants photosynthesize and transport oxygen from their leaves to their roots. Constructed wetlands filter these nutrients by using them for vegetative growth. Sediments are also trapped within the wetland systems, primarily from settlement due to slow water flows through the system.

There are several basic types of constructed wetlands to be considered. Some resemble traditional wetlands in character while others are more marshlike. The basic types of constructed wetlands that are being used for storm water treatment consist of Free Water Surface Wetlands (FWSW) and Subsurface Flow Wetlands (SFW).

Free Water Surface Wetlands consist of basins or channels with suitable mediums to support the growth of emergent vegetation, with open areas and with water flowing at relatively shallow depths. The key feature is the presence of free water surfaces. These can include a variety of substrate and are designed as ground water recharging or non-recharging systems. Very similar to natural wetlands, these types often provide wildlife habitat as well.

Subsurface Flow Wetland (SFW), also known as rock reed systems or root zone systems and sometimes interchangeable with the term bio-filter, involve shallow basins or channels planted with suitable vegetation growing in a variety of media designed so that the runoff water flows horizontally through the media with no above surface flow or open surface flow. In SFW systems, runoff is applied to flow horizontally through basins or channels filled with rock or sand. In SFW systems, specific surface area and the porosity of the medium are important variables (Etnier 1996, p.29).

Within both of these systems, vegetation plays a critical role. Wetland vegetation is a function of climate, hydrology and nutrient availability. In a constructed wetland, climate, hydrology and pollutant response influence the selection of plant species. Wetland plants have specific tolerances to the levels and types of pollutants, which could be altered by varying storm water quality. This in turn could alter the plant community. Since new dominants reflect more efficient use of nutrients or more tolerance to pollutants, these plant changes should benefit overall pollutant removal (Hammer 1989, p.258). When referring to the considerations of an ecologically engineered design approach, an understanding of the plant palette is critical. In determining which plants are appropriate for the type of constructed wetland design, it is crucial to look at known efficiency of a plant type in pollutant removal and more importantly, appropriateness of a plant type for survival in local conditions.

As well as vegetative considerations, relationships between the hydrology and wetland characteristics must be included in the design to ensure long term effectiveness. The source of water, volume, renewal rate and frequency of inundation influences the chemical and physical properties of the wetland substrate, which in turn influences species diversity and abundance, primary productivity, organic deposition and flux and nutrient cycling. Hydrology also influences sedimentation, aeration, biology transformation and soil absorption processes. Critical factors that must be evaluated include velocity and flow rate, water depths and fluctuations, detention time, circulation and distribution patterns, seasonal and climatic influence, groundwater conditions and soil permeability. This also includes establishing wetland hydro-period to determine form, nature and function of the wetland. Hydro-period is the depth and duration of inundation measured over the annual wet or dry cycle. Acceptable high and low water elevations will determine the storm water treatment volume capacity of the wetland. Water depth and inundation period can change the plant community, with beneficial or detrimental effects on the wetland or storm water pollutant removal (Hammer 1989, p.225).

It is a solid understanding of both the structure and function of the wetland processes as well as an understanding of the local environmental conditions

Appendix E

Malibu Creek Steelhead

by Mark J. Abramson

It's early morning. The sky is gloomy and threatening as I stand in the shallow waters of a stream in the Santa Cruz mountains. The air on my face is brisk and invigorating. Suddenly, as if attacked by a shark, my rod tip is nearly touching the water. The fight is on and my heart and mind begin to race. I see the shimmering silver-blue green of the majestic steelhead trout and imagine the perilous journey this fish has gone through. Emerging as a tiny fry in this very stream it must survive threats from both native and exotic aquatic species to reach a size and maturity where it can eventually migrate to the ocean. The fish must survive fishing and other threats from marine species to return to its native stream to spawn and continue the life cycle. At times this migration route can be blocked by drought for years at a time, not allowing smolt to leave or adults to return and spawn. The ability of a fish to survive in both fresh and salt water is extraordinary. As I release this fish and admire the pristine natural beauty of the surrounding stream, a feeling of deep respect for this worthy fish floods over me.

A century of water diversions, pollution, dam building, urbanization, and degradation of creeks, streams and rivers have hit California steelhead populations hard. Steelhead trout (Oncorhynchus mykiss), the anadromous form of rainbow trout, were once abundant up and down coastal streams draining mountains throughout the state including the Santa Monica Mountains. "California steelhead populations have dropped by more than 90 percent statewide and estimates of the adult steelhead population is only 250,000, less than half of estimates from 30 years ago."[1] "Historically over one hundred and twenty-two streams south of San Francisco Bay are known to have once contained steelhead populations; 33 percent no longer have any, and all the remaining streams are in decline, some of them in population nosedives."[2] These startling statistics have instigated the National Marine Fisheries Service (NMFS) to list the southern coast populations, those found from the Santa Maria River to Malibu Creek, as endangered.

Life History:

Steelhead is the anadromous form of rainbow trout. They are born in fresh water, then immigrate to the ocean where a majority of their growth occurs. When a storm event provides sufficient flow to breach the sandbars that close the mouths of coastal streams, mature steelhead return to their native streams to spawn. Unlike the salmon, steelhead do not necessarily die after spawning and may make numerous round trips or may spawn and then remain in the stream.

The female selects a site having good intergravel flow, to ensure that oxygen is available for eggs and small hatchlings, and then digs a redd (nest) to deposit eggs. After being fertilized by the male, the eggs are then covered with gravel and the female swims upstream to repeat the process. Hatching time is dependent mostly on water temperature. Studies conducted by Leitritz and Lewis in 1980 record eggs hatching in about 30 days in water temperatures of 51 degrees F. The young hatchlings live in the protective gravel for approximately 4-6 weeks after hatching, depending on the depth of the redd, gravel size, siltation, and temperature, before the emerge as fry.[3] Newly emerged fry move to shallow, protected areas associated with stream margin.[4] Fry soon will find feeding locations in areas of the stream. Juveniles will inhabit riffles but larger ones often inhabit deeper runs or pools.[5] South coast steelhead like those of Malibu Creek, are ocean maturing (winter steelhead). South coast steelhead typically begin their spawning migration in fall through winter and spawn January through March, within a few weeks to a few months of entering fresh water.

Non-anadromous or resident forms of rainbow trout (O.m. irideus) are now believed to be a critical component of the adaptability of steelhead and integral to any type of management plan. It was once believed that they were two distinct subspecies but genetically there are little to no differences between resident and anadromous forms. It is not uncommon for anadromous forms for males to mature as parr then assume a resident life style.[6] Mature male parr rainbow trout have been observed spawning with female steelhead in Waddell Creek.[7] Steelhead are dependent on a variety of conditions in order to successfully migrate to the ocean. Malibu Creek is subject to extreme variations in rainfall and droughts that may last years. These variations may force steelhead to remain in streams for several years at a time. Sufficient stream flow is required to breach sandbars and allow access to stream headwaters or the ocean. During a storm event with sufficient flow, only a brief window allows steelhead to transfer between the ocean and freshwater environments. This flexibility in life history, which allows steelhead to survive and spawn until a time when a migration route is opened, is critical, particularly in the harsh southern geographic limit.

Steelhead must be adaptable in order to exploit resources in rivers, streams, and the ocean as few species do. Southern populations are the most adaptable of all steelhead. Studies of the Malibu fish show them to be the most genetically diverse of any known trout population. For this reason the southern steelhead is considered critical for the survival of the entire species due to their unique ability to adapt to marginal conditions such as high temperatures, and unpredictable water flows.

Instream Habitat

Following are the types of instream habitat preferred by the steelhead trout:

Depth: Steelhead prefer to spawn in depths between 6-24 inches. Fry will utilize water between 2-14 inches deep, while parr utilize water depths between 10-20 inches. In a 1972 study, Thompson reports that seven inches of water is the minimum depth required for successful migration of adult steelhead.

Velocity: Velocities in excess of 10 –13 feet per second hinder the swimming ability of adult steelhead and may slow migration (Reiser and Bjorn 1979).[8] The larger the fish the higher the velocity of water that can be utilized for spawning. Steelhead will spawn with water velocities ranging from 1- 3 cubic feet per second (Barnhardt 1986).[9]

Substrate: Adult steelhead have been reported to spawn in substrates between .2- 4 inches in diameter. The Unified Soil Classification System classifies sand as particles with diameters from .003- .19 inches, gravel as .19- 3 inches, and cobble as 3- 11.8 inches. Gravel must be highly permeable to keep incubating eggs well oxygenated and contain less than 5 percent sand and silt. Fry and juvenile steelhead prefer slightly larger gravel and cobble than spawning adults.

Temperature: While temperature preferences are well documented for northern streams less is known about southern streams. Egg mortality begins to occur at 56 degrees F and steelhead have difficulty getting adequate oxygen from water with temperatures above 70 degrees F.

The type of habitat required by juvenile steelhead varies with lifestage. Younger smaller fish prefer slower shallower water than larger fish.

Malibu Creek Steelhead

Malibu Creek has been listed as the southern most geographic area to support a self-propagating run of steelhead trout. "This run has adapted to drastic changes in flow, water quality and population expansion occurring within the Los Angeles basin."[10] There is a concerted effort by local citizens, and local, state and federal responsible agencies to prevent this run from becoming extinct. The Malibu Creek Watershed does have certain benefits that may help protect steelhead trout and other wildlife in the future. Large partitions of land are owned by California Department of Parks and Recreation as well as the National Park Service, which will ensure that these areas are not developed.

The native fish community include steelhead trout, Arroyo Chub (Gila orcutti), and Pacific Lamprey (Lampetra tridentatta) another native anadromous species. Introduced species include bluegill (Lepomis macrochirus), green sunfish (Lepomis cyanellus), largemouth bass (Micropterus salmoides), brown bullhead (Ictalurus nebulosus), and channel catfish (Ictalurus punctatus).[11]

The water regime within Malibu Creek has been drastically altered as a result of dependence on imported water. The coastal Mediterranean climate results in approximately 16 inches or 41cm of rainfall annually, with nearly all precipitation occurring from November through April. Stream flows typically range from summer lows of 6-10 cubic feet per second (cfs) to storm flow peaks above 600 cfs. Extreme flows include historic no-flow conditions, prior to discharge of treated effluent by Tapia in the late 1960s, and peak flows of 33,800 cubic feet per second were recorded in January 1969.[12]

Accessible Steelhead Habitat

Currently, useable steelhead habitat occurs on an approximately 2.6 mile stretch below Rindge Dam. This stretch of Malibu Creek is characterized as a steep gradient gorge nearest the dam that gradually flattens out into a valley section and eventually flows to the Malibu Lagoon. Steep canyons walls provide topographic shading in the gorge nearest the dam, which serves to regulate water temperature. The gorge has a pool riffle ratio of 1:1 with pools as deep as 5 feet and with more frequent and longer riffles than in the valley section. Dominant substrates in the gorge section range from small cobbles to large boulders, which serve to cool water and provide shelter from predators.[13] As the gradient flattens out, sediments in the slower moving water have the opportunity to settle and particle size decreases to smaller gravel and sand. A >6:1 pool riffle ratio occurs in the low gradient valley section, which has many long pools from 1-3 feet in depth.[14]

Good quality adult and juvenile steelhead habitat is found in the steep canyon for about the first two kilometers heading to the ocean from the dam. Excellent gravels, appropriate channel morphology and abundant cover in the form of boulders, deep water, and surface turbulence, provide good habitat for spawning fish in this section. Good rearing habitat occurs in pockets most abundantly in the gorge where deep pools and larger substrates provide cover, food-producing riffles are more abundant, and canyon walls provide shade and maintain cooler water temperatures of 12.2 degrees Celsius, 100 meters below Rindge Dam.[15]

Largemouth bass thrive on warmer water temperatures and are believed to be a predator of juvenile steelhead trout. Largemouth bass abundance increases with distance downstream, the opposite of steelhead distribution and accounts for 80 percent of the total fish community in the valley section. This section is characterized by low gradients with long pools and runs separated by short riffle sections and increased settlement of sediments. This section had only 3.5 fish per 100m of pool/run habitat due to poor marginal rearing habitat associated with that section. Rearing steelhead seem to prefer pool habitat to run habitat showing 50 percent more utilization of pools than runs.[16]

Several issues are contributing to the severely decreased steelhead run on Malibu Creek. These issues are exotic invasive predator fish species, loss of suitable spawning and rearing habitat, and water quality. The California Department of Fish and Game identifies freshwater habitat loss and degradation resulting from inadequate stream flow, blocked access to historic spawning and rearing areas, and human activities that discharge sediment and debris into water courses as the main factors contributing to the decline of steelhead trout populations.

The Malibu Creek steelhead population is currently relegated to approximately 2.5 miles (4.2 kilometers) representing approximately 35 percent of total available stream habitat below the Rindge Dam. The Rindge Dam is considered the primary obstacle or barrier to steelhead in Malibu Creek. Rindge Dam was originally constructed to provide agriculture irrigation and domestic water supply for the Rindge Ranch. Rindge Dam was built between 1924 and 1926 with private funds from the Rindge family, and was authorized for use on January 31,1933. The original storage capacity was 574-acre feet of water. As a result of the highly erodable soils and fire frequency throughout the watershed, the reservoir was completely filled with sediments and decommissioned by the State of California in 1967. The reservoir is estimated to contain approximately 1.6 million cubic yards of sediment. In 1984, 960 acres of Malibu Canyon, including Rindge Dam were sold to the State of California to become part of Malibu Creek State Park. California Department of Parks and Recreation, manages Malibu Creek State Park and the Rindge Dam, and one mission of that organization is to increase the native biological diversity of the lands they own and manage.

Potential Steelhead Habitat

Entrix investigated the potential of steelhead habitat above Rindge Dam in an effort to determine if removal of the dam would increase available habitat, and likely increase the steelhead population. From Rindge Dam to the Los Angeles County stream gauge, good quality steelhead habitat for both spawning and rearing were found. The entire stream reach is well confined by the steep sided canyon, which provides topographic shading to the stream except for in the lower .4 mile stretch of the stream, which meanders through the sand and gravel deposited behind the dam.[17] In the flatter lower third of the stream reach nearest the dam, substrate is composed of sands and small gravels with a pool/riffle ratio of 4:1. This section has abundant overhanging tree cover and shading. This area has outstanding spawning sites.[18] The remaining section of this stream reach is steeper and has larger substrates of gravels, cobbles and boulders that provide excellent opportunities for escape and instream cover. This section of the stream reach provides good quality rearing habitat. Directly adjacent to the tunnel on Malibu Canyon Rd., is a natural fall of approximately 18-feet that creates a barrier to upstream passage. To provide fish passage around this barrier using a concrete flume, was estimated at a cost of $120,000 in 1989.[19]

The stream reach that starts at the stream gauge and ends at Las Virgenes Creek is characterized by a wide flat valley section moving upstream from the confluence at Cold Creek followed by a more narrow valley section that widens out as Las Virgenes Creek and Malibu Creek converge. Topographic shading is less in this stream section, which has a pool to riffle ratio averaging 5:1. Substrates are filled with fine sediments estimated at 40 percent embeddedness throughout this stream section. Evidence of pools being filled and high degrees of embeddedness suggest that sediments are being transported down Las Virgenes Creek and into Malibu Creek which are impacting potential steelhead habitat. "In the section of stream below Tapia foam appeared on the water beneath each riffle and there was a total lack of attached algae on the stream bottom, algae was present at all the other sites surveyed. The water had an acrid odor and kick samples produced almost no macroinvertebrates."[20] Along this stream reach are two small sections between Cold Creek and Tapia, and adjacent to Tapia Park that exhibit suitable steelhead habitat. These sections have a steeper gradient and therefore have larger substrates with 25 percent embeddedness, and a pool to riffle ratio of 1:1. This area has deeper pools, greater water velocities, and greater amount of cover overhead and instream.[21] The researchers who conducted this survey evaluate the overall habitat quality along this stream reach as ranging from poor to fair.

The stream reach that runs from Las Virgenes Creek to Century Dam flows in a wide valley between gentle hillslopes heading upstream from the confluence of Malibu Creek and Las Virgenes Creek. Triunfo Canyon, in the upper third of the reach, is confined by a deep narrow gorge heading towards Century Reservoir.[22] The bottom section of the reach has a pool to riffle ratio of 8:1, no topographic shading or substantial riparian cover, and small substrates. It is suspected that water temperatures in the lower .5 mile of this reach may exceed the levels tolerable for steelhead. [23] The best steelhead habitat occurs in the upper third of this reach in Triunfo Canyon. This section has large deep pools and excellent topographic shading. Field investigations reveal the substrates in the canyon section range from boulders to bedrock with low percentages of embeddedness.

The stream reach from the mouth of Cold Creek to Stunt Ranch Road is confined by a narrow valley which widens out in short stretches near the mouth and below Stunt Ranch. The canyon is well shaded from a combination of topographic shading and riparian cover. Average pool depths were about 6 inches with the deepest pool measuring 3.6 feet. Pool to riffle ratios ranged from 4:1 in flatter sections to 1:1 in steep sections.[24] Substrates were smaller towards the mouth of the creek with bedrock and boulders in the steepest portions of the reach. The lower third of the creek had 35 percent embeddedness in contrast to the steeper upper reaches that had less than 10 percent.[25] Flows were a limiting factor for upstream migration. Cold Creek has a substantial amount of useable habitat for steelhead during their first most vulnerable year, beyond that age class, only a few deep pools in steeper parts of the reach provide adequate habitat.[26] Three barriers are located on Cold Creek that would prevent upstream migration.

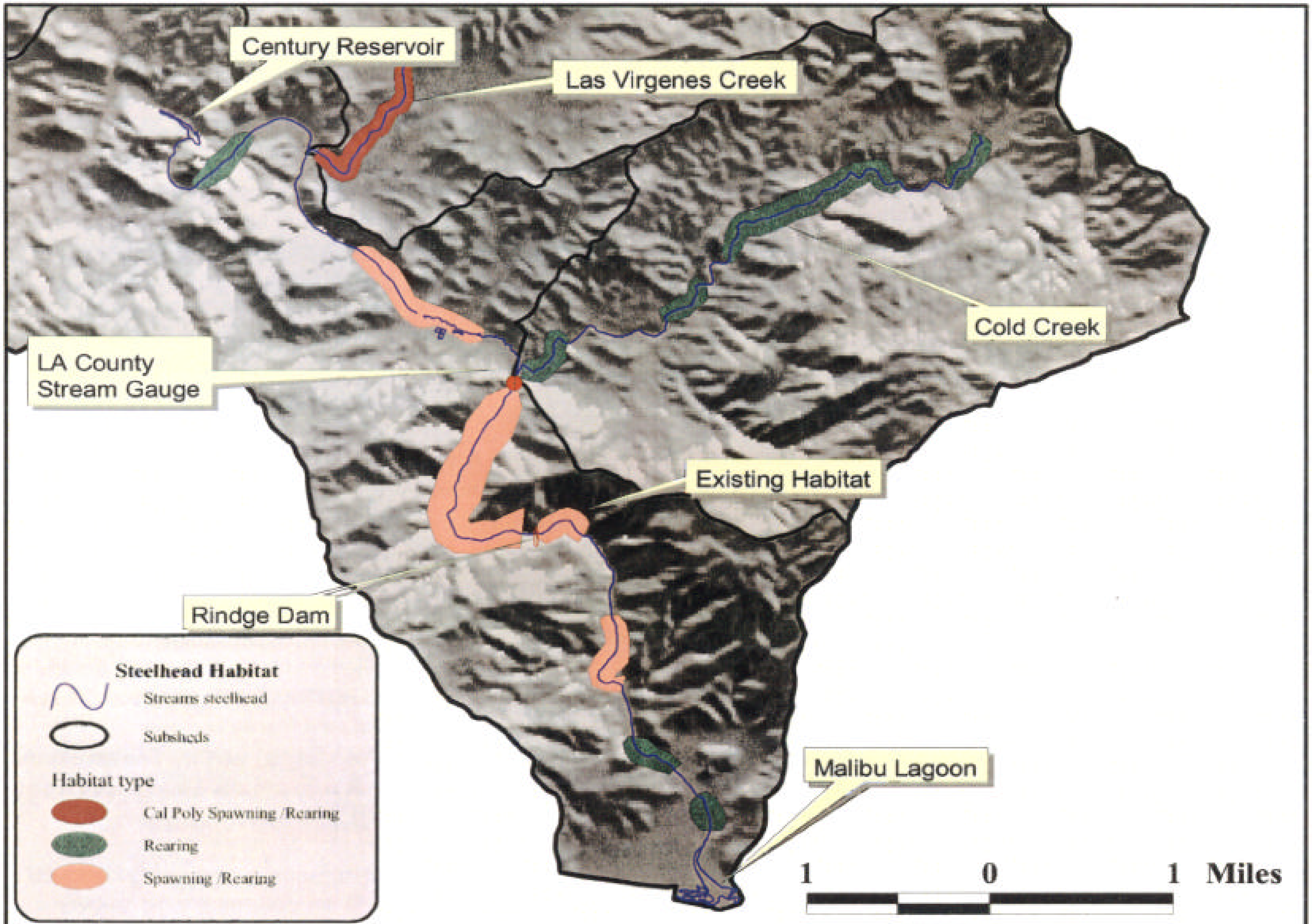
Extensive site investigations were conducted for this project by the research team from Cal Poly, Pomona. The 1998 El Nino year yielded above average rainfall. Site visits in the later months of 1997 confirm the Entrix findings along Cold Creek, and on Malibu Creek from the stream gauge to Las Virgenes Creek. Subsequent visits in March-May of 1998, following several large storm events, revealed lower percentages of embeddedness along both of these stream reaches and pools that were much deeper. Embeddedness on the lower portions of Cold Creek were estimated at 15-25 percent and 20-30 percent from the stream gauge to Malibu Creek. This suggests that sediment deposits had been scoured out during high creek flows. The investigators estimate the average depth of flow beteween 10-18 inches along Cold Creek and average pool depths between 12-18 inches.

The Cal Poly team also investigated the last mile of Las Virgenes Creek where it converges with Malibu Creek. The numerous site investigations reveal that prior to the substantial creek flows in the winter of 1998, the average water depth on this section of Las Virgenes Creek was between 8-12 inches and embeddedness was estimated at 35-40 percent. Following the El Nino winter, average water depth increased to greater than 12 inches and embeddedness decreased to between 20 and 25 percent. Further, the team identified habitat that would be useable for both spawning and rearing.

Currently 65 percent of usable rearing habitat and 86 percent of the spawning habitat in Malibu Creek are inccessible.[27] Four fish barriers have been identified that significantly reduce access to prime steelhead habitat within the Malibu Creek Watershed:

1) Rindge Dam.
2) Tunnel Falls, a natural falls near the tunnel on Malibu Canyon Road.
3) A concrete apron at the county-operated stream gauge below the mouth at Cold Creek.
4) A concrete road crossing in Century Ranch State Park.

According to the 1989 Entrix Steelhead Habitat assessment, by allowing fish passage at these four barriers, the watershed will realize a 590 percent increase in spawning habitat and a 180 percent increase in rearing habitat for steelhead trout or about 4.8 miles of new habitat. "A healthy population of 145



Sources: Watershed Boundary by Los Angeles County Department of Public Works, Streams by National Park Service, Steelhead Habitat from Entrix (1989) not for legal use.

Potential Steelhead Habitat

Universal Transverse Mercator Projection
North American Datum, 1927

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Malibu Creek Watershed: A Framework for Monitoring, Enhancement and Action

606 Studio **California State Polytechnic University, Pomona** **August 1998**

juveniles of three year classes of steelhead utilize Malibu Creek downstream from Rindge Dam, which is particularly significant because the study was conducted in August during the third year of drought conditions."[28] This study suggests that the steelhead population declines as you move further downstream closer to the ocean as a result of declining habitat quality in the lower reaches of Malibu Creek and increased numbers of largemouth bass, a predator to juvenile steelhead. The Steelhead investigations, conducted by Entrix Incorporated, suggest that the steelhead population in Malibu Creek can expect at least a three-fold increase if full habitat is utilized both above and below Rindge Dam.

The best available spawning habitat on Malibu Creek occurs 2 kilometers below Rindge Dam stretching above the dam to the confluence at Cold Creek. These locations were selected because they have adequate water depths and velocities, accessible cover, excellent grain size distribution of substrate materials, low degrees of embeddedness.[29]

The best available rearing habitat was focused in narrower canyon stretches having deeper, swifter flowing water and provided better cover than was found in valley sections. These areas also exhibited more abundant and diverse populations of aquatic macroinvertebrates, and shorter pool lengths ensuring adequate transport of food downstream.[30]

Further, several studies have been conducted regarding fish passage over the Rindge Dam. The Army Corps of Engineers recently completed a reconnaissance study to determine the plausibility of providing access to steelhead above Rindge Dam. If they receive approval and $ 750,000 of funding from Congress the following alternatives will be researched:

1. Complete removal of the dam with the sediments being disposed of in a landfill. The cost of this alternative is estimated at 40 million dollars. If sediments can be used to replenish beach sands or create shallow water habitat nearby, the cost estimate drops to 25 million dollars.
2. Installing a conduit or pipe through the dam which will provide passage. The estimated cost is 10 million dollars.
3. Constructing a hydraulic lift to allow access is estimated to cost 1 million dollars.[31]

Alternatives that have been previously considered include:

1. Notching the dam in intervals and allowing the sediments to flow downstream in a semi-regulated manner.
2. Reestablishing the reservoir for use as fire suppression water storage.
3. Drilling into the top 10 feet of sediments and installing pipes to utilize the dam as a giant sand filter for treatment of surface water during dry weather. This last alternative is proposed until a time when the dam could be removed.

The current consensus among knowledgeable stakeholders is the dam needs to be removed and that lifts to provide passage over the dam will be too unreliable, and, due to poor road access, impossible to maintain. Opposition by Ron Rindge, a descendent of the Rindge family, to keep the dam and get it registered, as a historic structure is ongoing.

Restoration of California's anadromous fish populations is mandated by The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 (SB 2261). This act establishes State policy to increase significantly the natural production of salmon and steelhead and directs the California Department of Fish and Game to develop a program that strives to double the naturally spawning anadromous fish populations by the year 2000. Governor Wilson, in his April 1992 Water Policy Statement, specifically states the urgent need to provide safe reliable water supplies to restore fish and wildlife resources among other things.

Recommendations to Increase and Enhance Steelhead Habitat

This section makes recommendations, that if implemented, will increase and enhance steelhead habitat throughout the Malibu Creek Watershed. Section 6 details recommendations that address the issues identified during the course of this project. Implementing these alternatives will improve water quality and decrease the concentration of pollutants that reach receiving waters. These issues need to be addressed over the entire watershed.

The different alternatives on how to address Rindge Dam have been researched with the following conclusion. The dam is a significant feature of Malibu but serves no useful function at present time. It is not practical and would likely be costly to revitalize the structure to be used for fire protection or irrigation. To maintain the dam would require frequent dredging of sediments due to the highly erodable soils and frequent fires in the area. Removal of the dam is the preferred option. Leaving the spillways and creating an overlook site on Malibu Canyon Road that provides information about the dam is recommended. Ideally, a use for the sediments contained by the dam would be found. This project should also include habitat restoration in the flat area immediately preceding the dam and the riparian zone directly above and below the dam. Further, the restoration and any feasibility study should include passage over tunnel falls.

Quickly designate Malibu Creek, Las Virgenes Creek, Cold Creek, Triunfo Creek and their tributaries as critical habitat areas. This should include at minimum a 200-foot buffer zone on each side of the creek.

Cold Creek has been identified as suitable rearing habitat for juvenile steelhead in their first year when they are most vulnerable. Following winters with significant rainfall, migration corridors are more than deep enough to accomodate steelhead trout. The diversity of macroinvertebrates was greater on Cold Creek as compared to Malibu Creek. The barriers to fish passage are relatively small and could be overcome with small inexpensive projects. Cold Creek offers a perennial source of cool clean water that must be protected to enhance the ability of species survival.

Triunfo Creek has the best diversity and abundance of macroinvertebrates of all areas studied. While Century Dam currently poses an obstacle to the best habitat along this reach, it is owned and operated by California Department of Parks and Recreation. Fish passage can be easily and inexpensively accomplished through removal of the dam or using a fish ladder.

Small pockets of useable spawning and rearing habitat were identified on lower Las Virgenes Creek. This section of the creek has excellent riparian overhead canopy, significant amounts of large woody debris and instream habitat. The majority of this reach is owned by California Department of Parks and Recreation and will never be developed.

The findings recorded by the Cal Poly team suggest that periodically sediments are flushed from the substrate, and pools are scoured creating better and more useable habitat. Although Triunfo Creek, Las Virgenes Creek, and Cold Creek have limited useable habitat, they empty into the best available spawning and rearing habitat along Malibu Creek. Sediments being transported by Las Virgenes Creek are already causing pools to fill and substrate embeddedness of 40 percent where it converges with Malibu Creek. Critical habitat designation will ensure that future construction projects are sensitive to steelhead trout and the habitat they depend upon.

Implement Best Management Practices to reduce the impacts of upstream development, nutrient loading, and sediment loading to the watershed (See Beyond Monitoring, Section 6).

Zoning Ordinances must be changed to prevent the Agoura and Westlake subwatersheds from exceeding 25 percent impervious surfaces. Hidden Valley, Malibou Lake, Cold Creek, Las Virgenes, and Malibu Creek subwatersheds should be maintained at less than 10 percent impervious surfaces. If sensitive building practices are adopted throughout the watershed and these levels of impervious surfaces are maintained water quality and channel stability will be good.

Require all future building to address the needs of fish passage like properly designed culverts. This should be required in the Malibou Lake, Las Virgenes, Agoura, Malibu Creek, and Cold Creek subwatersheds. This will ensure that costly projects to provide fish passage are not necessary when passage above Rindge Dam is realized.

Do not channelize any more of the streams or creeks in the watershed. This increases the velocity of stream flows and can cause downstream erosion of streambanks.

Tapia should be required to further polish and cool reclaimed water before releasing it into Malibu Creek. Reclaimed water has higher than normal levels of nutrients, which can be removed, through biological treatment using a wetland. If properly designed this wetland would also cool water before it is released. This should benefit Tapia by allowing them to store water during the rainy season when the demand for reclaimed irrigation water is low, to be sold when demand increases. Dry season releases to the creek should only be permitted during sustained periods of drought to sustain a creek flow of 1 cfs. LVMWD is currently funding a research project to determine which substrate materials most effectively infiltrate and filter water.

Potential Funding Sources

The following are potential funding sources that could be used to pursue steelhead habitat monitoring and assessment programs. These funds may also be available to organizations that have identified problems that are affecting steelhead or critical steelhead habitat that wish to undertake restoration projects.

Wildlife Conservation Board Funding is authorized to make grants to public organizations and private nonprofit groups for fish and wildlife habitat restoration. This Board has the legal responsibility for disbursement of the following funds:

- California Riparian Habitat Conservation Program, are funds to protect and restore riparian habitat throughout the State through acquisition of interests and rights in land and waters.
- California Wildlife Protection Act of 1990. The Board is responsible for administering annual appropriations to the Habitat Conservation Fund of up to 11.5 million dollars. Funds may be used for acquisition, restoration, or enhancement of aquatic habitat for spawning and rearing of anadromous trout resources.
- Cal Trans Environmental Enhancement and Mitigation Program.
  Funds are available to local, state and federal agencies and nonprofit entities to mitigate impacts of modified or new public transportation facilities. Grants for individual projects are generally limited to $500,000 each but may be larger if certain criteria are met. Eligible projects include the acquisition, restoration or enhancement of resource lands (natural areas, wetlands, forests, woodlands, meadows, streams or other areas containing fish or wildlife habitat) to mitigate the loss or detriment to, resource lands within or near the right-of-way acquired for proposed transportation improvements.

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Appendix F

Common Riparian Plants of the Malibu Creek Watershed

by Gerald O. Taylor, Jr.

Purpose

The purpose of this appendix is to help volunteers involved in the Stream Team monitoring program identify plant species that are found near riparian areas in the Malibu Creek Watershed. This will be especially useful in distinguishing non-native plant species from native plant species. The long term goal is to identify and map significant patches of exotic and/or invasive vegetation and areas that are degraded which may contribute excess sediments into the receiving waters throughout the Malibu Creek Watershed. The information collected will be stored on a GIS system at Heal the Bay and made available to all agencies that work in this watershed. Ideally, maps that accurately locate degraded habitat and large patches of exotic and/or invasive vegetation can be used by local agencies and organizations to develop restoration strategies and to improve water quality throughout the watershed.

The Riparian Zone within the Malibu Creek Watershed

Within the Malibu Creek Watershed there are many areas that can be described as riparian. Riparian areas are commonly found adjacent to intermittent or perennial sources of water, such as creeks, streams, ponds, lakes, springs, or seeps. This field guide covers plants found in riparian habitats and includes plants found along streams, lakes, ponds, and freshwater marshes.

Specific types of plants have evolved within riparian and wetland environments. These plants need access to the additional soil moisture that is available in these areas for their survival. Within the riparian zone, plants have varying water needs. Some plants may be located in soil that is saturated with water (cattails) or on soil that is seasonally saturated with water (alders, sycamores). Others will be located where the soil does not stay saturated (oaks, walnuts). A profile of a stream in the Malibu Creek Watershed may show willows and alders closest to the stream, sycamores a little further away, and oaks on the bank away from the stream. Intermixed among these trees may be a variety of shrubs, perennials, or annuals, each having special needs for location. The arrangement of plants along the riparian profile is never exact and there can be much variation depending upon soils, moisture, aspect, slope, geology, and other factors.

Riparian Vegetation and Stream Ecosystems

Riparian vegetation plays a vital role in the health of a watershed. The canopies of plants help to decrease the direct impact of raindrops onto the soil. Roots bind and hold the soil together. Plants aid in the improvement of water quality by slowing runoff, allowing deeper infiltration and filtering of water. With deeper infiltation and a slower release of water, the watershed is sustained with moisture over a longer period of time.

Vegetation also influences sedimentation flow. Along stream banks, the roots of plants help hold and stabilize the soil. Streamside vegetation and debris helps moderate the flow of water, creating diverse habitats where water flow is varied and aquatic life can find protected places. Organic matter from vegetation that falls into the water also provides nourishment for a wide variety of insects and aquatic wildlife. Foliage canopies of larger trees or shrubs help to shade creeks or ponds, thus keeping the water cool, increasing dissolved oxygen, and making the water more hospitable to the plants and animals that live in this environment.

The Malibu Creek riparian ecosystem has evolved over time to create beneficial relationships between plants and animals and has adapted to the geology and other natural forces of the Santa Monica Mountains. Today, great changes are taking place with human development of the watershed. Changes in the natural, seasonal flow of streams and creeks takes place because of the year-round use and runoff of water into the watershed by humans. Plants not native to the area have been introduced, and many of these, for example Giant Reed and Algerian Ivy, are out-competing and displacing native plants. Riparian areas are especially vulnerable to the invasive character of some non-native plant species, because these species choke up streams, transpire great amounts of water, change water temperature by not providing adequate shading, and develop monocultures and damaged habitats for animals. These changes affect the delicate balance and beneficial aspects of the native plant/animal relationship that has evolved over time.

Illustrations and Descriptive Information

The following plant images and descriptions represent some of the plants Stream Walk volunteers may encounter as they perform their monitoring duties. These plants are commonly found near creeks, seeps, ponds or other riparian areas and include both native and non-native plant species. The illustrations and descriptions are meant to help volunteers identify plant species during the monitoring process.

The plants are arranged alphabetically by their botanical name (genus and species). Common names for plants are also included. It is important for volunteers to list a plant by its botanical name on the monitoring form. A plant will have only one botanical name (synonyms or old names are in parentheses), but may have numerous common names that have arisen over time. Knowing the botanical name is also helpful for finding additional information on these plants, since most reference books list plants by their botanical name.

Each plant in the illustrated compendium has a scanned image and a physical description. The scanned images were created by digitally scanning leaves, flowers, or fruit into a computer desktop program. A ruler is added to show relative scale between the different images.

A listing of key species and non-native riparian and related plant species found in the Malibu Creek Watershed follows the illustrated compendium.

Exotic and/or Invasive Plants

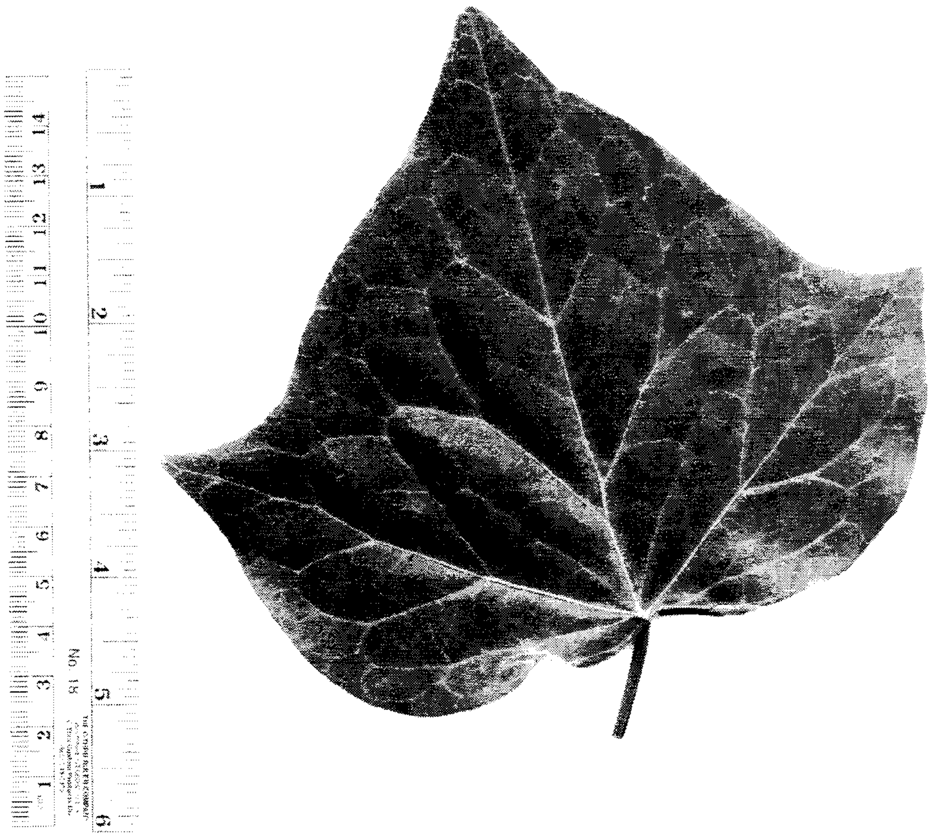
The following are images and descriptions of seven non-native plants found in the Malibu Creek Watershed. Most of these are aggressive plants that can out-compete and displace native plants.

Giant Reed

Arundo donax

Family: Grass Family (Poaceae)
Type: An invasive, non-native, tall perennial grass.
Height: 6' to 20'
Leaves: Large, flat leaves can get up to 2' long, 1 1/2" wide.
Trunk: Thick, bamboo-like woody stems.
Flowers: Flowers occur on large flowering stalks, blooming from spring into late fall.
Fruit: Seeds
Other information:
Giant Reed is an aggressive, non-native plant that has become extremely invasive throughout the watershed. It likes moist soil and is commonly found along riparian areas, often out-competing and displacing native plants. It can uptake and transpire large quantities of water. The dried leaves can create a fire hazard. It can spread vegetatively, often becoming established when pieces of the plant break off and float downstream. Removal of this plant in upstream locations is essential for the complete eradication of this species.

Giant Reed



Algerian Ivy

Algerian Ivy

Hedera canariensis

Family: Ginseng Family (Araliaceae)
Type: An invasive, non-native, evergreen woody vine
Height: 1' to 2'
Spread: 10' to 15'+
Leaves: 5" to 8" wide, leaves are dark green with lighter veins. Usually has 3 to 5 lobes.
Flowers: Small, greenish flowers during spring.
Fruit: A small, black berry. Berries and leaves are toxic if eaten.
Other information:
Algerian Ivy can be found in shady areas near streams or other moist places. It spreads by rooting along stems. It is aggressive often spreading and climbing over other plants.

Tree Tobacco

Nicotiana glauca

Family: Nightshade Family (Solanaceae)

Type: An invasive, non-native, evergreen shrub to small tree

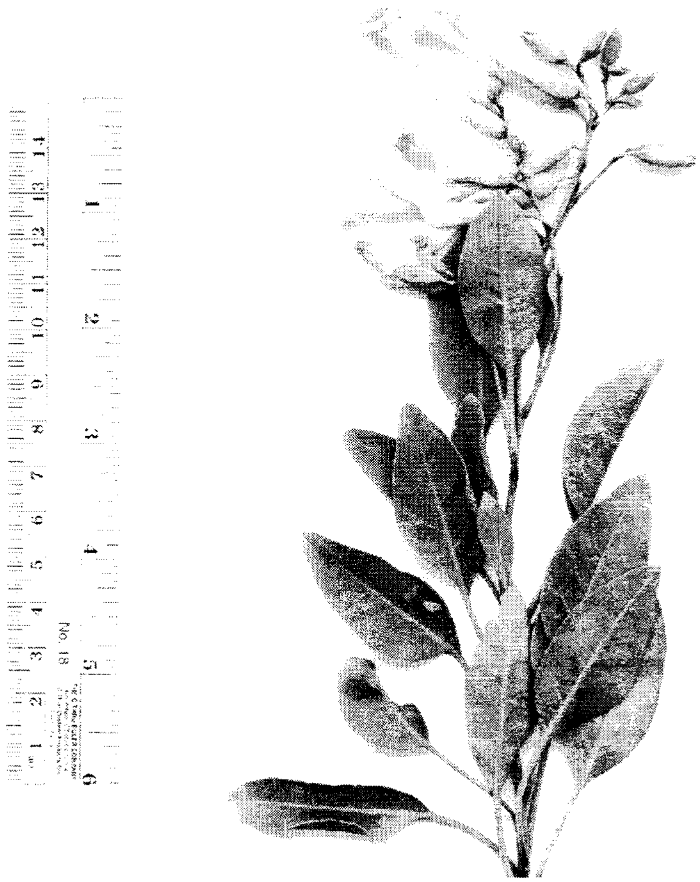
Height: Upright to 8' to 16'

Leaves: Alternate, 1" to 3" long leaves are ovate and bluish green.

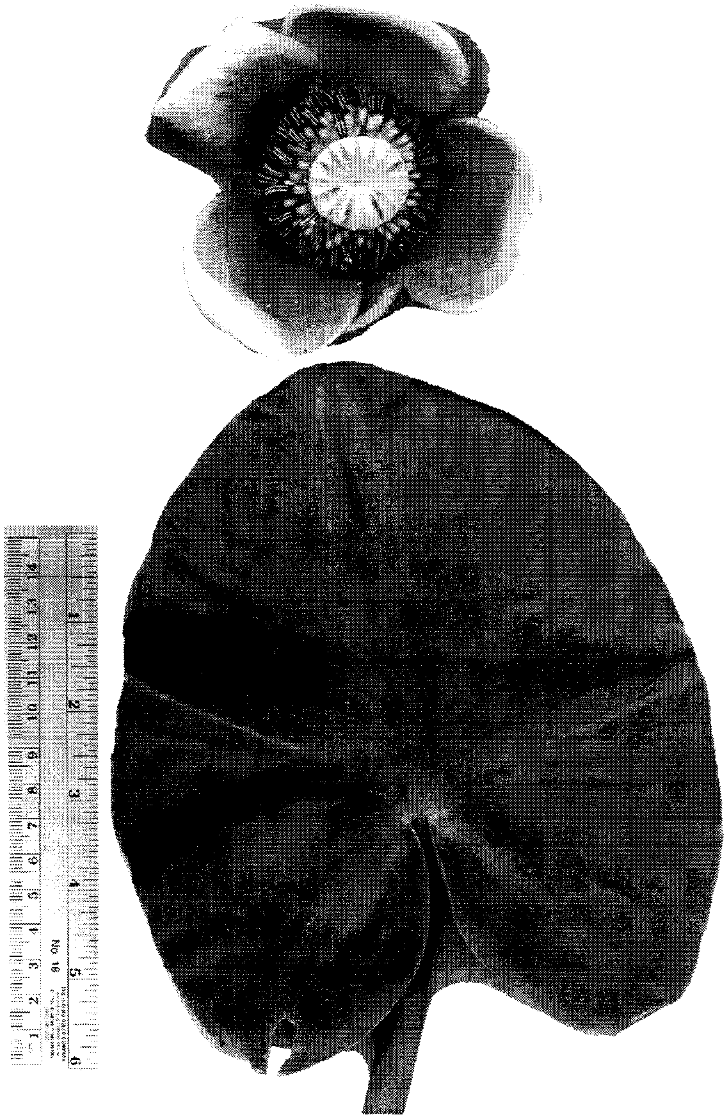
Flowers: Yellow-green flowers are tubular shaped with a narrow flare at the tip. Can flower throughout the whole year but most prolifically during spring into summer.

Other information:

Tree Tobacco is a rapid growing, aggressive plant that is commonly found in disturbed areas but can occur along sandy streams. Tree Tobacco is native to South America.



Tree Tobacco



Yellow Pond Lily

Yellow Pond Lily

Nuphar luteum

Family: Water Lily Family (Nymphaeaceae)

Type: A non-native, aquatic, herbaceous perennial

Height: Floating on surface of water or held up to 1' above water.

Leaves: Large, 12" wide, round, green leaves with long stems.

Flowers: Yellow, 4" to 6" wide flowers occur individually on long stems held above surface of water. Flowers spring through summer.

Other information:

Yellow Pond Lily occurs in shallow areas of freshwater ponds and in slow moving streams. It can be seen in Malibu Lake and in Century Lake in the Malibu Creek watershed.

Castor Bean
Ricinus communis

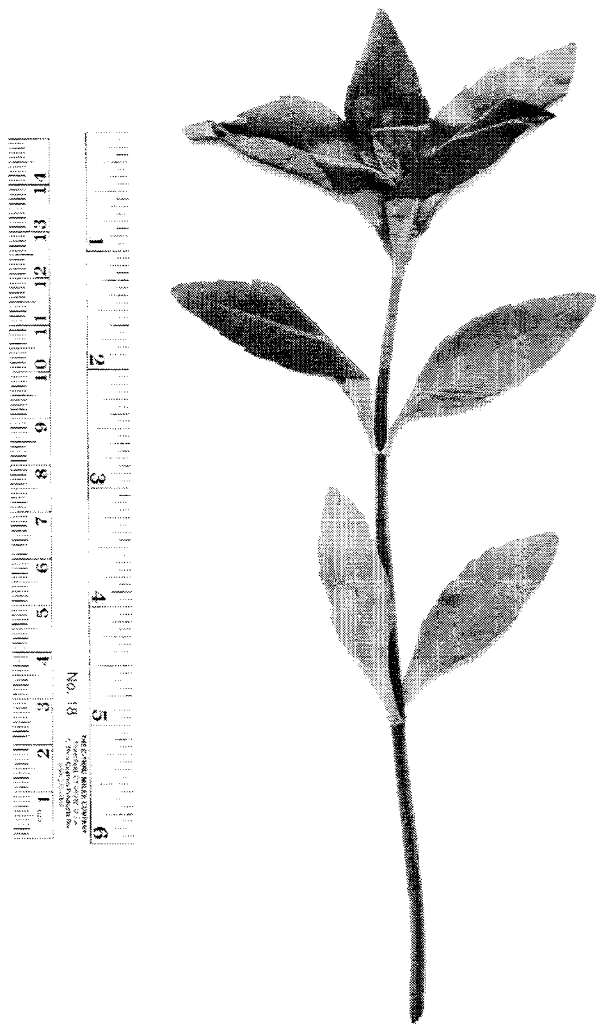
Family: Spurge Family (Euphorbiaceae)
Type: An invasive, non-native, evergreen shrub.
Height: 5' to 15'
Spread: 5' to 15'
Leaves: Large, 1/2' to 3' wide, palmately lobed leaves on reddish stems.
Flowers: Small, greenish white flowers in clusters can occur throughout the year.
Fruit: Extremely poisonous seeds. One seed can be fatal.
Other information:
Castor Bean is an aggressive plant growing mostly in disturbed areas. It can be found in ravines or near riparian areas. Besides the seeds being extremely poisonous (one seed can be fatal), the foliage and seeds can cause allergic reactions in some people if touched.

Castor Bean

Watercress

Rorippa naturtium-aquaticum

Family: Mustard Family (Brassicaceae)
Type: Non-native, aquatic, herbaceous perennial
Height: Prostrate stems can get 2' long.
Leaves: 2" to 4" long, alternate leaves are compound with 3 to 11 ovate leaflets. Stems are free rooting at leaf nodes.
Flowers: Small white flowers occur in clusters at ends of stems, spring to fall.
Fruit: Linear capsule with many seeds.
Other information:
Watercress is found on wet banks, in lakes, ponds and in slow-moving creeks. It is a native of Europe and northern Africa that has naturalized and become established throughout the Malibu Creek watershed. Its leaves are edible and are cultivated for use as edible greens. Watercress is also eaten by wildlife.

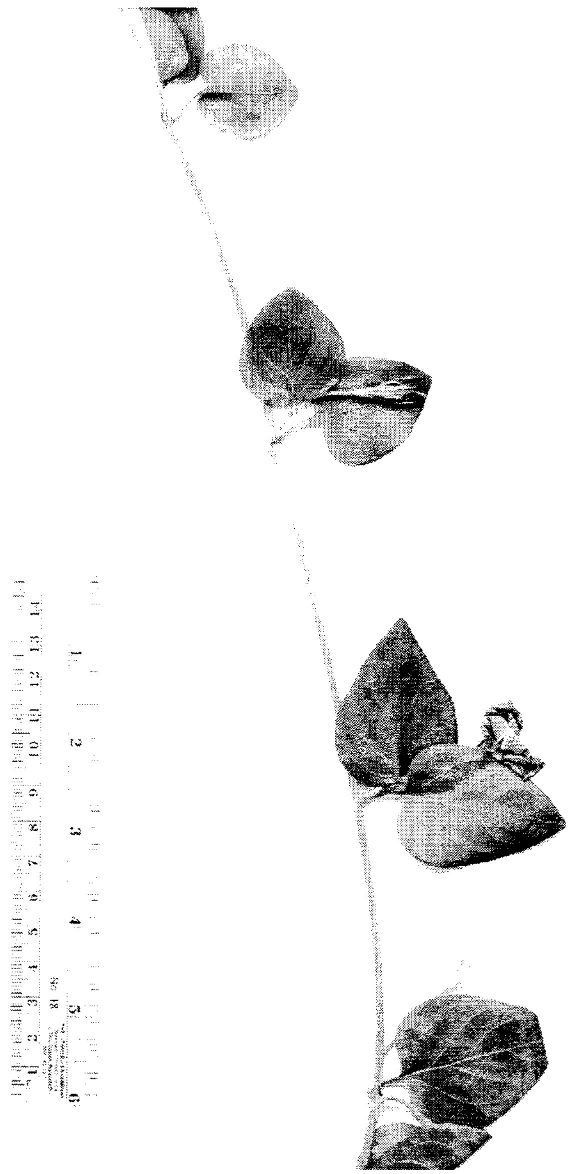


Watercress

Periwinkle

Vinca major

Family: Dogbane Family (Apocynaceae)
Type: An invasive, non-native, evergreen perennial with a vine-like habit.
Height: 1' to 2'
Spread: 10' – 15'+
Leaves: 1" to 3", dark green, oval leaves.
Flowers: Attractive, 1" to 2" wide, lavender blue flowers occur during spring and summer.
Other information:
Long, trailing stems root as they spread. Periwinkle can become extremely invasive in shady, moist areas often displacing other plants. Can often be found growing near streams.



Periwinkle

Native Riparian Plants of the Malibu Creek Watershed

The following pages contain images and descriptions of some of the native riparian plants you may come across during your stream walk. These plants can be good indicators of a healthy riparian zone.

White Alder

White Alder

Alnus rhombifolia

Family: Birch Family (Betulaceae)

Type: Winter deciduous tree

Height: 20' - 50'

Spread: 20' - 35'

Leaves: 2" - 4" long ovate leaves with fine or coarsely toothed margins. Dark green above, light yellowish green beneath with prominent veins.

Trunk: Single-trunk with usually smooth, whitish bark when young. Develops a brownish, fissured trunk with age.

Flowers: Female catkins and pendulous male catkins occur in early spring.

Fruit: 1" long, small woody cones develop from female flowers. These persist on tree through winter.

Other information:

A distinctive characteristic of White Alder is the "eyes" that develop along the trunk. These occur when branches fall off and leave markings that look like "eyes". Native Americans used the inner bark to make a red dye for baskets and for tanning buckskins. A tea made from the plant was used as a blood purifier, to relieve diarrhea, to ease stomachache, and to facilitate childbirth. White Alder can be found along permanent streams and creeks, close to the water's edge usually occurring in masses and groves. It has a rapid growth rate and can grow 30' in 5 - 6 years.

Mule Fat, Seep Willow

Baccharis salicifolia
(B. glutinosa)

Family: Sunflower Family (Asteraceae)
Type: Evergreen, erect woody shrub
Height: 6' to 12'
Spread: 6' to 10'
Leaves: Alternate 2" to 6" long, lance-shaped leaves have saw-toothed margins and are 3-veined.
Flowers: Small, whitish flowers occur in clusters at ends of stems spring into fall. Male and female flowers occur on separate plants.
Fruit: Small seeds develop on female plants.
Other information:
Mule Fat is found along lakes and perennial and intermittent streams throughout the Malibu Creek watershed. Its leaves are willow-like and are sometimes mistaken for a willow at first glance. It used to be listed as *Baccharis glutinosa* and now is known as *Baccharis salicifolia*.

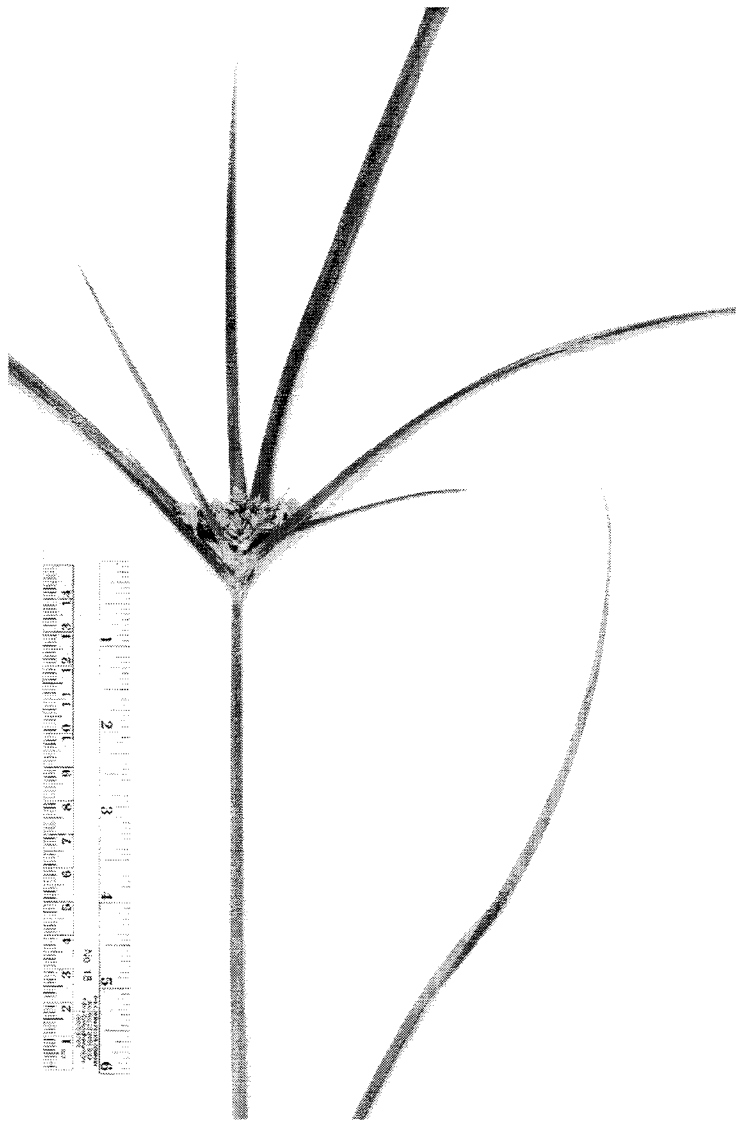
Mule Fat, Seep Willow

Umbrella Sedge

Cyperus species

Family: Sedge Family (Cyperaceae)
Type: Annual or perennial grass-like herb
Height: to 5' tall
Leaves: On solid, 3-sided stems.
Flowers: Mostly spring into fall.
Other information:

Umbrella Sedge is found in wet and marshy places. Most of the *Cyperus* species found in the watershed are perennial, except for *Cyperus odoratus* , which is an annual plant. Umbrella Plant (*Cyperus involucratus*) is a non-native, clumping perennial, which can become invasive.



Umbrella Sedge

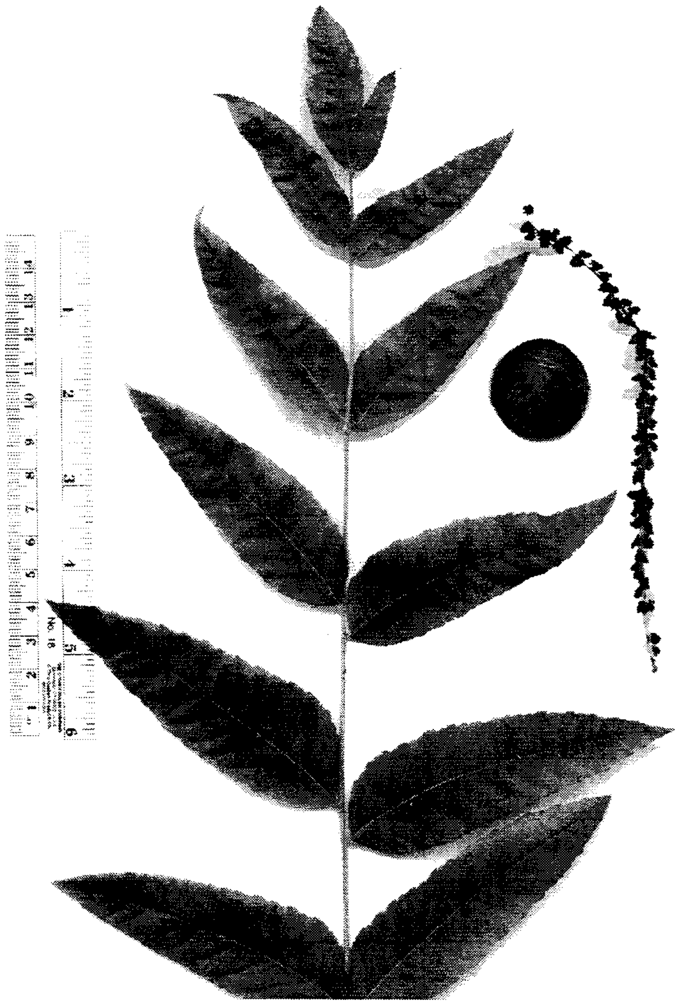
Great Horsetail, Giant Horsetail

Equisetum telmateia

Family: Horsetail Family (Equisetaceae)
Type: Rush-like perennial
Height: Stems to 8' tall
Leaves: This plant has no leaves. The hollow, green stems with grooves take on the role of photosynthesis. Green, infertile stems branch at nodes. Brown, fertile branches do not branch.
Flowers: On 1 1/2', unbranched, fertile brownish stems, flowers occur at top on 2" to 3" long spikes during spring. Small, green infertile flowers occur on stems that branch. Fertile flowers occur on brownish stems that do not branch.
Other information:

Another plant in the genus *Equisetum* located within the Malibu Creek watershed is Smooth Scouring Rush (*Equisetum laevigatum*). Smooth Scouring Rush reaches a height of about 3' tall. Both Great Horsetail and Smooth Scouring Rush can be found in swampy places and along streams.

Great Horsetail, Giant Horsetail



Southern California Black Walnut

Southern California Black Walnut

Juglans californica

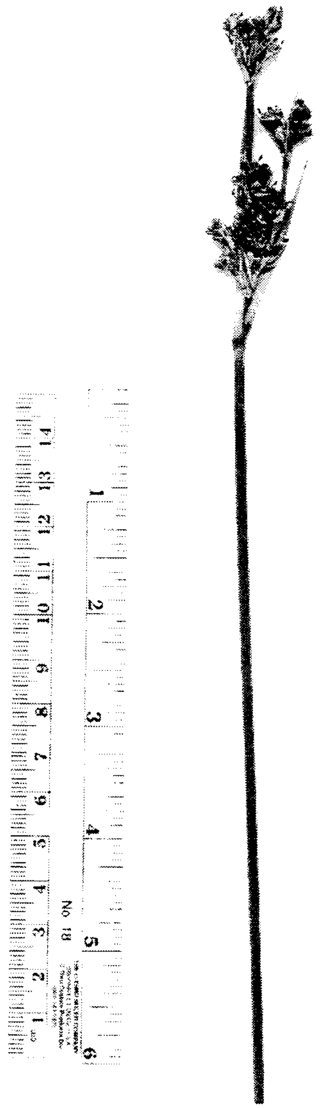
Family: Walnut Family (Juglandaceae)
Type: Winter deciduous tree
Height: 15' to 30'
Spread: 15' to 30'
Leaves: Leaves are compound with 11 to 15 leaflets. Leaflets are 2 1/2" long with smooth to finely toothed margins.
Trunk: Can have single or multiple trunks. Trunk is rough and heavily furrowed.
Flowers: Male flower is a drooping 2" to 3" long catkin. Female flowers occur on shorter flower spikes. Flowers during spring.
Fruit: Fruit is a round, 3/4" to 1" diameter nut. The walnuts are edible but have thick shells that are difficult to crack.
Other information:
The Southern California Black Walnut occurs on north-facing slopes or along streambeds throughout the watershed.

Rush, Wire Grass

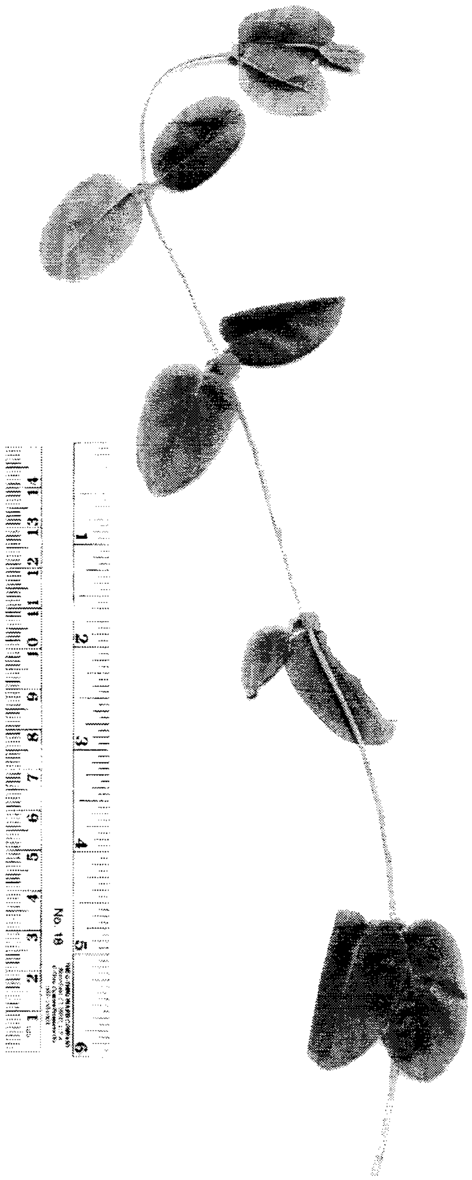
Juncus species

Family: Rush Family (Juncaceae)
Type: Grass-like herbaceous perennial
Height: Varies, to 4'
Leaves: Long, round or flat narrow leaves occur from base of plant.
Flowers: Small green flowers grow in clusters, spring to summer.
Other information:

Rush is commonly found near streams, ponds, canyons or other moist areas. Baltic Rush (*Juncus balticus*) is 1' to 3' tall and can be found along Lake Sherwood. *Juncus macrophyllus* grow's up to 4' tall and can be found along streams at lower elevations within the Malibu Creek watershed.



Rush, Wire Grass



California Honeysuckle

California Honeysuckle

Lonicera hispidula var. vacillans

Family: Honeysuckle Family (Caprifoliaceae)

Type: Climbing vine

Height: Can climb 6' to 18'

Leaves: Opposite, roundish, 1" to 3" long leaves. Leaves are green above and whitish and hairy beneath. Leaves near ends of stems tend to fuse together around stem.

Flowers: Large pink or purplish flowers in whorls at ends of stems occur late spring to early summer. Hummingbirds are attracted to flowers.

Fruit: Fruit is a round red berry that is edible but has a bitter taste.

Other information:

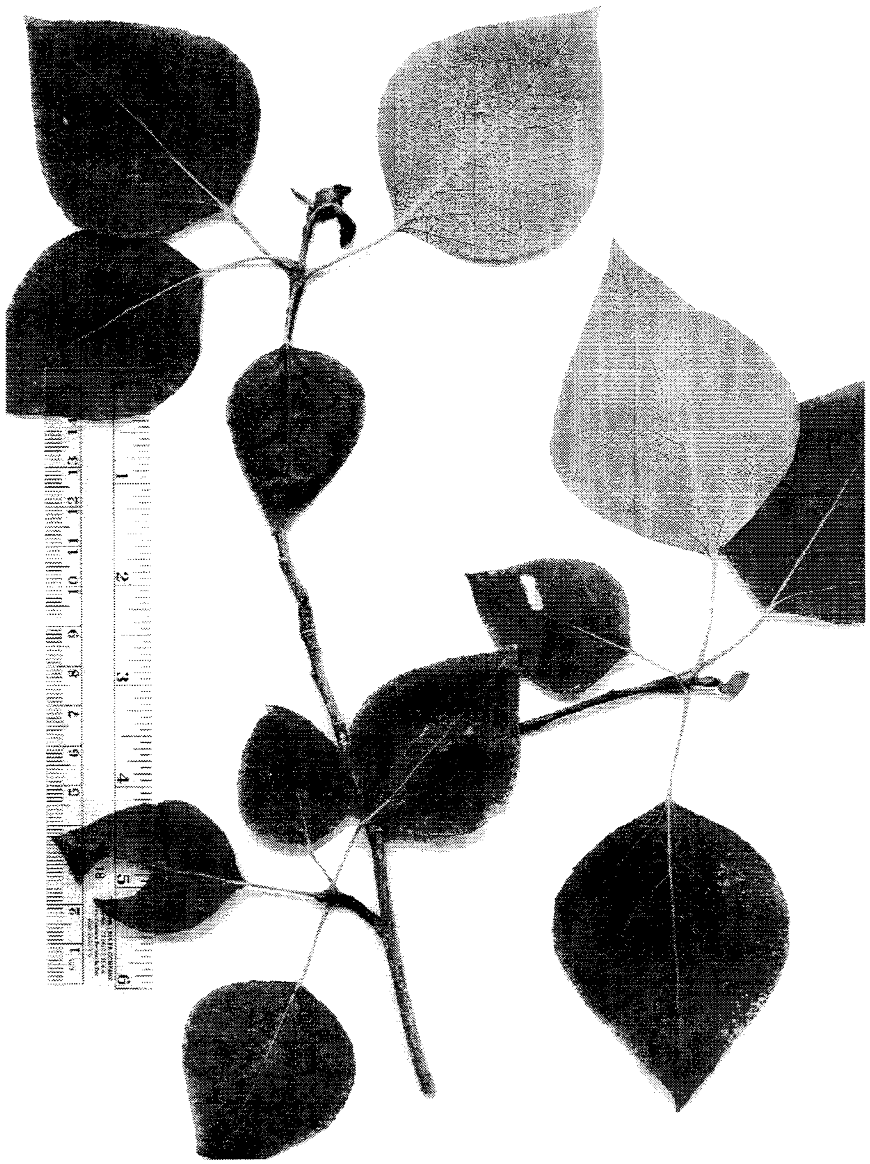
California Honeysuckle occurs near creeks and in deep canyons. Examples can be found south of Tapia Park within the Malibu Creek watershed.

Western Sycamore

Platanus racemosa

Family: Sycamore Family (Platanaceae)
Type: A large, winter-deciduous tree
Height: 30' to 90'
Spread: 30' to 70'
Leaves: Large, broad, 10" - 12" wide, palmate leaves with 3 to 5 deep lobes. Leaves are woolly when young.
Trunk: Can have single or multiple trunks that often grow at angles to the ground. Trunk has distinctive bark that flakes leaving a smooth, whitish trunk with an attractive, mottled appearance.
Flowers: Small flowers occur in ball-like clusters in spring.
Fruit: 3/4" diameter fruit occurs in ball-like clusters of 2 to 7 per stalk and persist into fall after leaves drop.
Other information:
Western Sycamore can usually be found along perennial and intermittent streams in the Santa Monica Mountains, often occurring in large groves. Good examples can be found at Rock Pool and along Malibu Creek near the visitor's center in Malibu Creek State Park.

Western Sycamore



Black Cottonwood

Black Cottonwood

Populus balsamifera spp. trichocarpa (P. trichocarpa)

Family: Willow Family (Salicaceae)

Type: Tall, winter-deciduous tree with a very rapid growth rate of up to 6' per year.

Height: To 90'

Leaves: Alternate leaves are ovate and have finely toothed margins. They are dark green above and a contrasting whitish green beneath. Leaves occur on round stems.

Trunk: Grayish bark that becomes furrowed on older trees and can get 2' to 3' in diameter.

Flowers: Small, inconspicuous flower catkins. Male and female flowers occur on separate plants.

Fruit: On female trees, white, cotton-like seeds develop during spring.

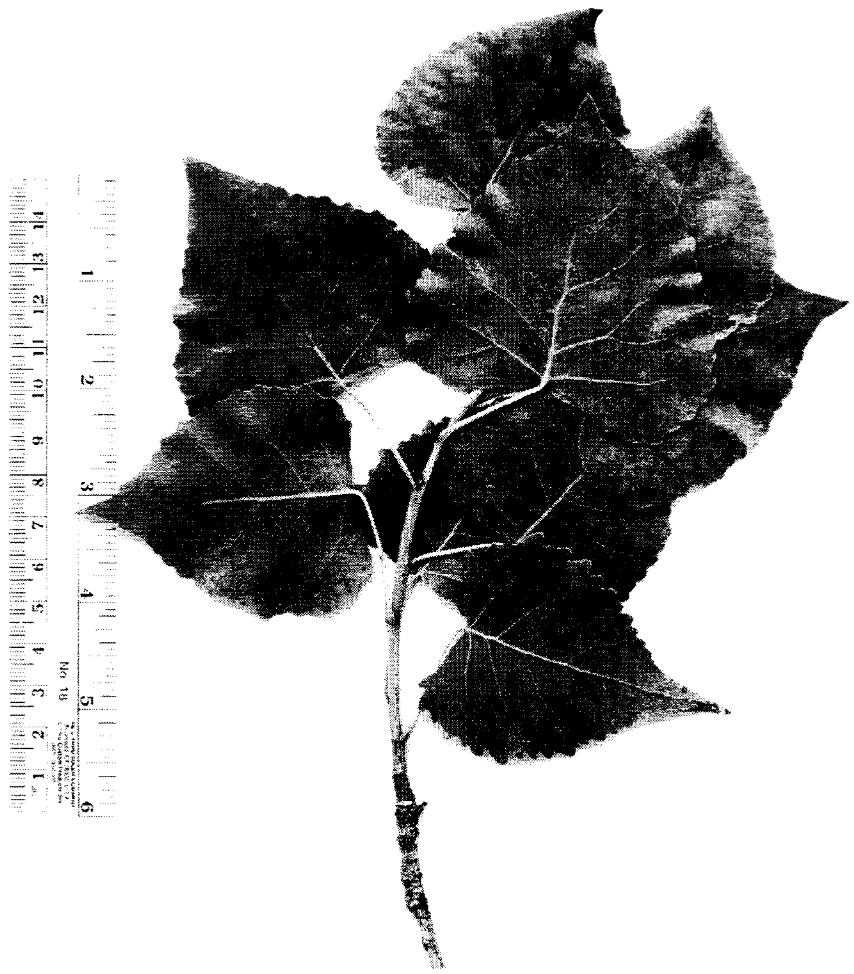
Other information:

Black Cottonwood occurs along permanent streams in sandy soil. Examples can be found at lower elevations within Malibu Canyon.

Fremont Cottonwood, Western Cottonwood

Populus fremontii

Family: Willow Family (Salicaceae)
Type: Large, winter-deciduous tree with a very rapid growth rate of over 5' per year.
Height: 40' to 60'
Spread: 40' to 60'
Leaves: Alternate, 2" to 4" long leaves are bright green to yellowish green on both sides. Leaves are triangular shaped and occur on flattened stems. Leaves are shiny with coarsely toothed margins and turn a bright yellow color during fall before they drop.
Trunk: Trunks can develop whitish, roughly cracked bark.
Flowers: Small, inconspicuous yellowish green flowers occur during spring. Male and female flowers occur on separate plants.
Fruit: On female trees, white, cotton-like seeds develop during spring.
Other information:
Cotton-like seeds on female trees can become quite prolific and when wind-borne can cover large areas. These cottony seeds have been used for stuffed animals and for pillows. Leaves tend to flutter in the wind due to flattened leaf stems. Fremont Cottonwood can be found along permanent streams and in other moist places.



Fremont Cottonwood, Western Cottonwood

Western Bracken Fern

Pteridium aquilinum var. pubescens

Family: Bracken Fern Family (Dennstaedtiaceae)

Type: Winter deciduous fern.

Height: 1' to 4'

Leaves: Large fern fronds arising upright or reclining from a spreading rhizome at base of plant. Leaves are slightly hairy beneath.

Sori: Spores occur late summer into fall.

Other information:

Western Bracken Fern is found in moist shady canyon areas at lower elevations on the coastal side of the mountains. They often occur in large masses.

Western Bracken Fern

Coast Live Oak

Quercus agrifolia

Family: Oak/Beech Family (Fagaceae)
Type: Large, evergreen tree.
Height: 30' to 70'
Spread: 40' to 80'+
Leaves: 1" to 3" long, oval leaves with spiny margins ("agrifolia" means "with spiny leaves"). Leaves are dark green above and lighter green beneath. The underside of leaf has minute brownish hairs where the lateral veins intersect with the midvein. Leaves at the outer surface of the tree canopy tend to be thick, hard and convex. Leaves in shadier interior canopy are larger, thinner and flatter.
Trunk: With age, trunks can become quite massive, up to 8' to 12' in diameter with heavily fissured bark.
Flowers: Small, reddish brown flowers occur in 1" to 2 1/2" long clusters during spring. Male and female flowers are separate but occur on same plant.
Fruit: 1" to 1 3/4" long, slender and pointed acorns with thin caps covering upper 1/3 of acorn.
Other information:
These oaks provide habitat for a wide variety of animals. Native Americans have harvested the acorns from these trees, leaching and cooking them into a mush. Early pioneers used oaks for firewood, tools, and wagons and in the production of charcoal for limekilns. They are commonly found throughout the watershed on north facing slopes, canyons, and near streams.

Coast Live Oak

Narrow-Leaved Willow

Narrow-Leaved Willow

Salix exigua (S. hindsiana)

Family: Willow Family (Salicaceae)
Type: Winter deciduous erect shrub or small tree.
Height: 6' to 20'
Spread: 6' to 15'
Leaves: Narrow, linear to lanceolate leaves are 1 1/2" to 3" long and less than 1/3" wide and have short stems. Grayish hairs giving the leaf a grayish or bluish appearance cover the leaves on both sides. Leaf margins are smooth to finely toothed. Leaf twigs are brownish.
Trunk: Multiple, grayish trunks with furrowed bark.
Flowers: Flower clusters occur at the same time or after leaves appear during winter to early spring. Male and female flowers occur on separate plants. Male flowers have two stamens.
Fruit: Seeds on female plants.
Other information:
There are three willows native to the Malibu Creek watershed: Narrow-Leaved Willow (*Salix exigua*), Black Willow (*Salix laevigata*), and Arroyo Willow (*Salix lasiolepis*). Of these three, the Narrow-Leaved Willow is the easiest to identify because of its narrow leaves. It can be found in sandy riverbeds nearest to the water's edge, often occurring on sandbars at lower elevations in the watershed.

Arroyo Willow

Salix lasiolepis

Family: Willow Family (Salicaceae)
Type: Winter deciduous shrub to small tree.
Height: 10' to 20'
Spread: 10' to 20'
Leaves: Lanceolate leaves are variable in structure and appearance. They can be up to 4" long and about 3/4" wide. Some leaves may be wider above the leaf middle. Leaf margins tend to be irregular. They are dark green above and a paler whitish color beneath. Upper leaf surface may not be smooth. Leaves usually occur on yellowish twigs, but twigs may also have a reddish color.
Trunk: Usually with multiple trunks. Bark is smooth on younger plants, becoming more furrowed with age.
Flowers: Flower catkins are almost a black color and occur during late winter to early spring before leaves appear. Male flowers have two stamens. Male and female flowers occur on separate plants.
Fruit: Seeds on female plants.
Other information:
Black Willow (*Salix laevigata*) is similar in appearance to the Arroyo Willow (*Salix lasiolepis*), but can reach heights of up to 45'. Leaves throughout the tree tend to be of similar shapes, and male flowers have 4 to 5 stamens. Both can be found along permanent or intermittent streams throughout the Malibu Creek watershed.

Arroyo Willow

Blue Elderberry,
Mexican Elderberry

Blue Elderberry, Mexican Elderberry

Sambucus mexicana

Family: Honeysuckle Family (Caprifoliaceae)

Type: Winter deciduous to drought deciduous large shrub or small tree.

Height: 15' - 30'

Spread: 15' - 30'

Leaves: Compound leaves are divided into 3 to 5 leaflets. Each leaflet is 1" to 6" long with finely toothed margins. The terminal leaflet tends to be larger than the other leaflets.

Flowers: Small, 1/4" wide, creamy white flowers occur in flat-topped clusters that are 2" to 8" across, during spring into summer.

Fruit: 1/4" round, dark purplish black berries during summer. Berries have a whitish coating and are edible.

Other information:

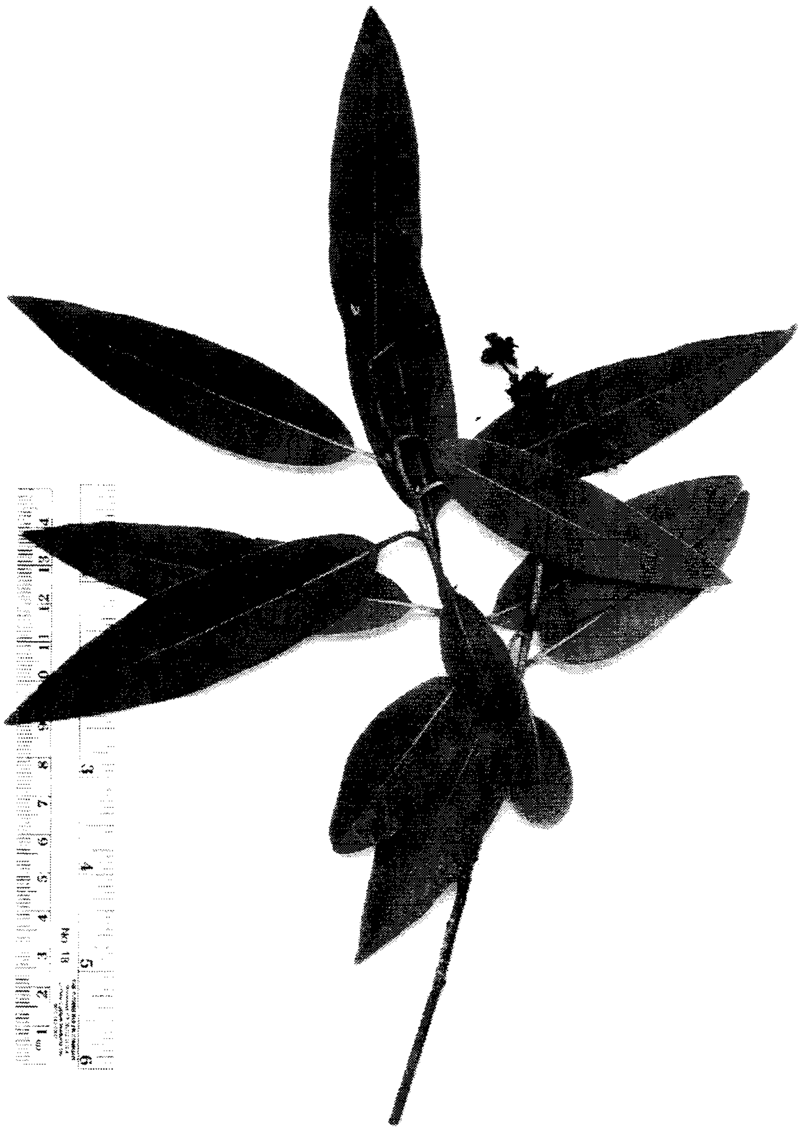
Blue Elderberry is a distinct plant that is very noticeable especially when it is in flower. The edible berries can be eaten fresh or used to make jam, pies, or elderberry wine. Native Americans, in addition to eating the berries, used the berries for making a purple dye and the stems to make a yellow-orange dye. Blue Elderberry can be found throughout the watershed on slopes or in open riparian washes.

Poison Oak

Toxicodendron diversilobum

Family: Sumac Family (Anacardiaceae)
Type: A winter deciduous shrub that sometimes becomes vine-like in shady areas.
Height: 4' to 8'
Spread: Can spread 15' to 20' as a vine.
Leaves: Shiny, alternate, green leaves have three, 2" long, ovate leaflets. Leaflets usually have lobed margins but can be toothed. New growth during the spring is a shiny bronze color and during fall the leaves often turn red before they drop.
Flowers: Small, white to greenish white flowers appear during spring.
Fruit: 1/4" white berry develops during summer.
Other information:
Poison Oak is found throughout the watershed and is often found near riparian areas or other moist, shady areas. Poison Oak is a plant that everyone should learn to recognize. It secretes a juice that can cause severe blistering and itching of the skin. Look for the distinctive leaflets. Remember: "Leaves of three, let it be!" Also, be careful of contact with this plant during the winter as irritation may occur even when there are no leaves. In spite of this, Poison Oak is nevertheless a plant that deserves much respect for its ability to stabilize the soil, and create wildlife habitat for a wide variety of animals.

Poison Oak



California Bay Laurel

California Bay Laurel
Umbellularia californica

Family: Laurel Family (Lauraceae)
Type: Evergreen large shrub to medium size tree.
Height: 20' to 40'
Spread: 20' to 40'
Leaves: 3" to 5" long, aromatic, dark green leaves.
Flowers: Small, yellowish green clusters of flowers appear winter to early spring.
Fruit: Fruit resembles a small, yellow-green, 1" diameter olive that ripens to a dark purple.
Other information:
The California Bay Laurel is a plant that is easy to identify by tearing off a piece of the dark green leaves and smelling the strong aromatic fragrance. California Bay Tree has a long history of many uses. Besides using the leaves for seasoning (use about 1/3 as much as regular bay leaves), Native Americans used the leaves to make a tea for stomach problems, and to repel fleas from their homes. It is often found in canyons and along streams and on shadier slopes throughout the watershed.

Riparian Plant Species List

As a supplement to the illustrated section of this handbook, the following is a comprehensive listing of plants found in riparian areas or nearby zones of the Malibu Creek Watershed. Plants with an asterisk (*) are not native and have been introduced to the Malibu Creek Watershed.

Botanical name	Common Name
Acer macrophyllum	Big Leaf Maple
Acer negundo	Box Elder
Adiantum capillus-veneris	Venus Hair Fern
*Agrostis viridis	Water Bent
Alnus rhombifolia	White Alder
Anemopsis californica	Lizardtail
*Apium graveolens	Celery
Apocynum cannabinum	Indian Hemp
*Artemisia biennis	Biennial Sagewort
Artemisia douglasiana	Mugwort
*Arundo donax	Giant Reed
Aster subulatus var. ligulatus	Slim Aster
Azolla filiculoides	Duckweed Fern
Baccharis douglasii	Douglas Baccharis
Baccharis salicifolia	Mule Fat
Barbarea othoceras	Winter-Cress
Berula erecta	Water Parsnip
Bidens laevis	Bur-Marigold
Carex species	Sedge
Castilleja stenantha	Stream Paint Brush
*Chenopodium ambrosioides	Mexican Tea
Chenopodium macrospermum	Coast Goosefoot
Clematis ligusticifolia	Western Virgin's Bower
Cornus glabrata	Brown Stem Dogwood
*Cotula coronopifolia	Brass Buttons
Cuscuta campestris	Field Dodder
Cyperus species	Umbrella Sedge
*Cyperus involucratus	Umbrella Plant
Datisca glomerata	Durango Root
*Delaireia odorata	Cape Ivy
*Echinochloa crusgalli	Barnyard Grass
Echinodorus berteroi	Bur Head
Elatine californica	California Waterwort
Eleocharis species	Spike Rush
Epipactis gigantea	Stream Orchid
Equisetum laevigatum	Smooth Scouring Rush
Equistetum telmateia	Giant Horsetail
Euphorbia serpyllifolia	Thyme-Leaf Spruge
*Festuca arundinacea	Tall Fescue
*Festuca pratensis	Meadow Fescue
*Ficus carica	Edible Fig
Fraxinus velutina var. coriacea	Arizona Ash, Velvet Ash
Glycyrrhiza lepidota	Wild Liquorice
Gnaphalium palustre	Lowland Cudweed
*Hedera canariensis	Algerian Ivy
Helenium puberulum	Sneezeweed
*Ipomoea purpurea	Common Morning Glory
Juglans californica	S. California Black Walnut
Juncus species	Rush, Wire Grass
Lemna species	Duckweed
Lepidaspartum squamatum	Scale Broom
*Lepidium latifolium	Perennial Pepper Grass
Leptochloa uninervia	Sprangle Top
Lilium humboldtii var. ocellatum	Humboldt Lily
Lonicera hispidula var. vacillans	California Honeysuckle
*Lotus corniculatus	Bird's Foot Lotus
Ludwigia peploides	Yellow Water-Weed
Madia elegans	Common Madia
*Melilotus albus	White Sweet Clover
*Mentha pulegium	Pennyroyal
*Mentha spicata	Spearmint
Mimulus cardinalis	Scarlet Monkey Flower
Mimulus guttatus	Creek Monkey Flower
*Nicotiana glauca	Tree Tobacco
*Nuphar luteum	Yellow Pond Lily
Paspalum distichum	Knot Grass
Petunia parviflora	Wild Petunia
Phacelia ramosissima	Branching Phacelia
Phyla lanceolata	Mat Grass
Phyla nodiflora	Mat Grass
*Plantago major	Common Plantain
Platanus racemosa	Western Sycamore
*Polypogon monspeliensis	Rabbit's Foot
Polypodium californicum	California Polypody
Populus balsamifera ssp. trichocarpa	Black Cottonwood

Botanical name	Common Name
Populus fremontii	Fremont Cottonwood
*Potamogeton crispus	Curled-Leaf Pondweed
Potamogeton pectinatus	Fennel-Leaf Pondweed
Psilocarphus tenellus	Woolly-Heads
Psoralea macrostachya	Leather Root
Pteridium aquilinum var. pubescens	Western Bracken Fern
Quercus agrifolia	Coast Live Oak
*Ricinus communis	Castor Bean
Rorippa curvisiliqua	Yellow Cress
*Rorippa naturtium-aquaticum	Water Cress
Rosa californica	California Wild Rose
Rubus ursinus	California Blackberry
Rumex salicifolius	Willow Dock
Salix species	Willow
Salix exigua	Narrow-Leaved Willow
Salix laevigata	Red Willow
Salix lasiolepis	Arroyo Willow
Sambucus mexicana	Blue Elderberry
Scirpus species	Bulrush, Tule
Scirpus americanus	Three Square
Scirpus californicus	California Bulrush
Scirpus maritimus	Maritime Club-Rush
*Senecio mikanioides	(see Delaireia odorata)
Solidago occidentalis	Western Goldenrod
*Sonchus asper	Prickly Sow Thistle
Stachys albens	White Hedge Nettle
Stachys rigida	Rigid Hedge Nettle
Symphoricarpos mollis	Dwarf Snowberry
Toxicodendron diversilobum	Poison Oak
Trifolium obtusiflorum	Clammy Clover
Trifolim variegatum	White Tip Clover
Typha species	Cat-Tail
Typha domingensis	Slender Cat-Tail
Typha latifolia	Cat-Tail
Umbellularia californica	California Bay Laurel
Urtica dioica ssp. holosericea	Stinging Nettle
*Veronica anagallis-aquatica	Great Water Speedwell
*Vinca major	Periwinkle
Woodwardia fimbriata	Giant Chain Fern

Glossary

Alternate: arrangement of leaves on stems of plant; singularly on one side and then the other; not opposite or whorled.

Catkin: a pendulous, spiked cluster of small, unisexual flowers.

Compound leaf: a leaf that is divided into different segments of two or more leaflets.

Deciduous: leaves falling off at end of a growing season, usually during fall to winter.

Drought deciduous: leaves falling off in response to drought conditions.

Evergreen: leaves remaining on plant throughout the year.

Flower: the assemblage of reproductive structures..

Herb: a plant without a woody stem.

Herbaceous: not woody; like an herb.

Lanceolate: leaves shaped like a lance.

Leaflet: a division of a compound leaf; does not have an axillary bud.

Linear: leaves long and narrow.

Lobe: a rounded division of a leaf or leaflet.

Opposite: arrangement of leaves on stems of plant; in pairs on opposite sides of stem; not alternate or whorled.

Palmate: leaf having lobes or segments radiating from a single point; finger-like.

Perennial: plant living for several years.

Pinnate: leaflets arranged on both sides of a main stem; feather-like.

Shrub: a woody plant smaller than a tree with many stems; usually under 9 feet high at maturity.

Sori: spores on the surface of a fern leaf.

Toothed: leaf margin with small, rounded or pointed lobes.

Tree: a woody plant larger than a shrub usually with a single trunk; usually 9 or more feet in height at maturity.

Winter deciduous: leaves falling off at end of growing season, usually during fall-winter.

Whorled: arrangement of leaves on stems of plant; 3 or more leaves arranged around a stem usually in a circle.

Vine: a plant without a self-supporting stem; usually trailing on ground or climbing on other plants or structures for support.

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About the 606 Studio

The 606 Studio is a consortium group of faculty and third-year Master's students in Landscape Architecture at California State Polytechnic University in Pomona. The Studio is interested in the application of advanced methods of analysis and design with particular emphasis on the preservation and restoration of sensitive natural systems. Projects address serious and important ecological, social and aesthetic issues related to urban, suburban, rural or natural landscapes. They generally result in:

- Conceptual or Specific Plans
- Schematic Site Designs
- Land Use Policies
- Land Management Strategies

Approach

Projects are carried out by teams of third-year graduate students and members of the graduate faculty. Working with the direction and continuous participation of the faculty group, graduate students perform the tasks of research, analysis, planning and presentation. Design approaches vary considerably depending on the scope and character of the project. In every case, the approach fits within the framework of Ecosystematic Design as developed by the Cal Poly graduate program. This approach stresses sensitive understanding of principles of ecology, particularly the systematic behavior of material and energy flows, in relation to human uses.

Project Selection

The academic studio environment offers a unique opportunity for graduate students to explore issues and possibilities. Because it functions within an educational institution, the 606 Studio bears the responsibility to maintain academic integrity, advance the state of the art, and contribute to the public well-being. The real nature of these projects and the clients' needs demand that projects have a strong practical base, as well as display technical and professional expertise. Projects undertaken by the Studio are expected to satisfy the following criteria:

- They must address significant issues concerning resources and the physical environment, with broad implications beyond the boundaries of the project site, and sometimes beyond the immediate concerns of the client.

- They must promise to result in significant benefits to the general public.

- They should be complex, requiring the application of advanced methods beyond those routinely used in the field.

- Sufficient time and support must be available to explore all promising approaches, to do a thorough job, and to communicate the results clearly and completely.

- The results must become public information.

Project Team Description

The design team for this project consisted of four members: Mark J. Abramson, Christopher D. Padick, Eileen Takata Schueman, and Gerald O. Taylor.

Gerald Taylor received his B.S. in Landscape Architecture from California State Polytechnic University at Pomona. He is actively involved in issues related to ecological restoration, native plant habitats, and the healing and restorative properties of landscapes.

Chris Padick received his B.A. in Psychology from the University of California Santa Barbara. He is committed to promoting the concepts of sustainable agriculture and ecosystematic design.

Eileen Takata Schueman received her Bachelors of Landscape Architecture from Virginia Polytechnic Institute and State University. She is involved in advancing the profession of Landscape Architecture by applying the principles of ecosystematic design and planning.

Mark Abramson received his B.S. in Accounting from Pepperdine University. He is dedicated to improving water quality and the ecological function of watersheds by promoting biological treatment processes and the reuse of water.