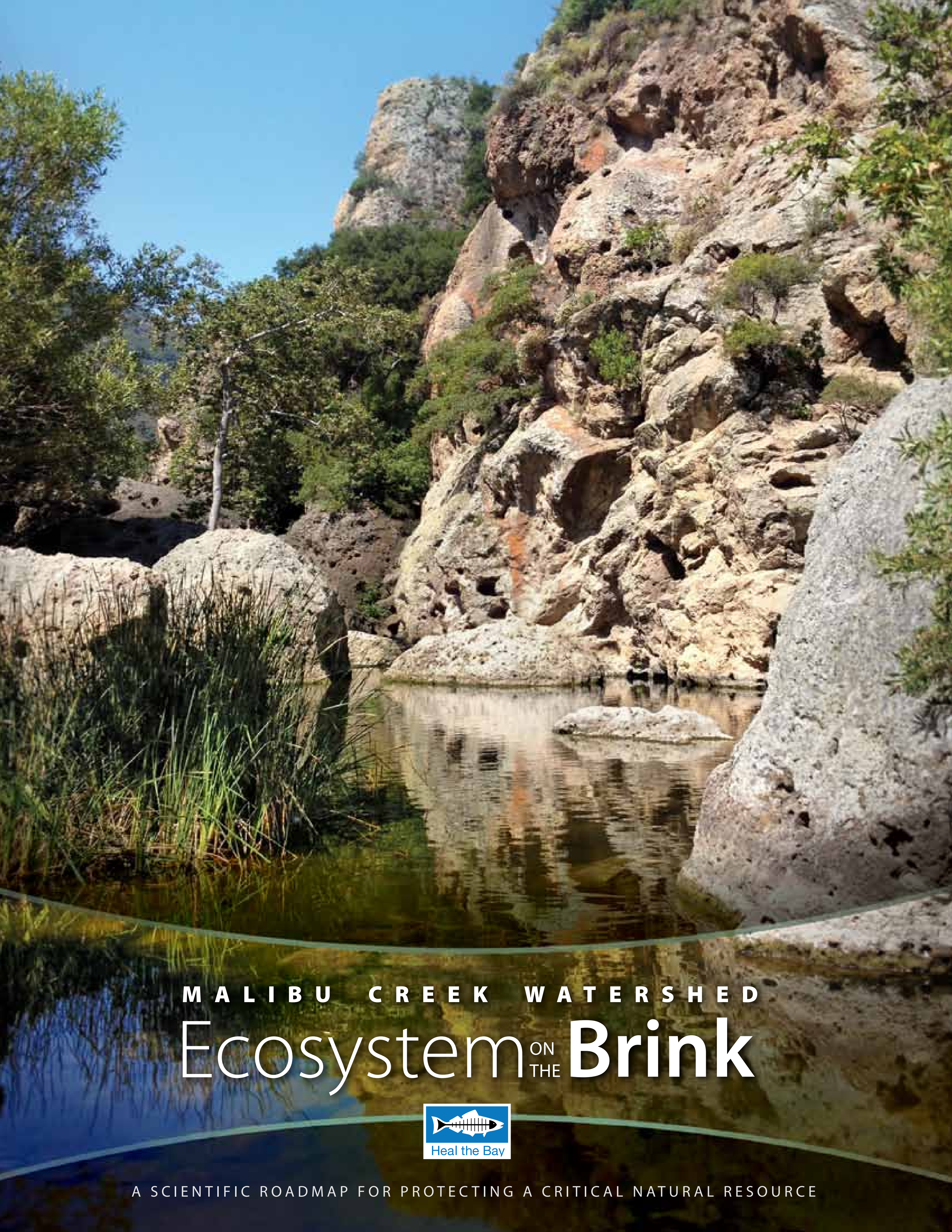

MALIBU CREEK WATERSHED

Ecosystem on the Brink

Heal the Bay

A SCIENTIFIC ROADMAP FOR PROTECTING A CRITICAL NATURAL RESOURCE

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ACRONYMS

BMI	Benthic Macroinvertebrate
BMPs	Best Management Practices
CDFW	California Department of Fish and Wildlife
CSBP	California Stream Bioassessment Procedure
DO	Dissolved Oxygen
ESHA	Environmentally Sensitive Habitat Area
GIS	Geographic Information System
GPS	Global Positioning Satellite System
IBI	Index of Biological Integrity
LCP	Local Coastal Program
LID	Low Impact Development
LIP	Local Implementation Plan
LUP	Land Use Plan
LVMWD	Las Virgenes Municipal Water District
MRT	Mountains Restoration Trust
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NZMS	New Zealand Mudsnails
RCD	Santa Monica Mountains Resources Conservation District
RPB	Rapid Assessment Protocol
SCAG	Southern California Association of Governments
SHI	Stream Health Index
SMBRC	Santa Monica Bay Restoration Commission
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
UCLA	University of California, Los Angeles
US EPA	United States Environmental Protection Agency
WQS	Water Quality Score

Q. What is a watershed?

A watershed is the area of land where all of the water that drains off of it goes into a common outlet.

EXECUTIVE SUMMARY

INTRODUCTION

The Malibu Creek Watershed is the second largest watershed draining to the Santa Monica Bay. Despite its location in one of the largest urban areas in the world, the 110-square mile watershed is dominated by open space. Over 75% of the Malibu Creek Watershed is undeveloped, with several small cities and rural residential communities located within its reaches. The highly visited, world-famous Surfrider Beach is located at the terminus of the watershed. Protecting water quality and biological resources in the Malibu Creek Watershed is paramount for protecting ecological conditions and allowing safe recreational use in the Santa Monica Bay. Targeted monitoring and watershed health assessment is also necessary, as it is one of the last watersheds in the area that has considerable amounts of natural habitat.

The Malibu Creek Watershed contains a wide variety of diverse habitats including coastal strand, oak and riparian woodlands, chaparral, coastal sage scrub, native grasslands, sulfur springs, and brackish water lagoon. The watershed is home to several threatened and endangered plants and animals. Few natural areas globally can rival the extraordinary biological and habitat diversity of the Malibu Creek Watershed and greater Santa Monica Mountains, especially in close proximity to such a dense urban area. Even though the watershed is less populous than the rest of the Los Angeles area, the impacts of urbanization on the local natural resources are prevalent.

Heal the Bay initiated its Stream Team program in 1998 to collect water quality and riparian habitat data, identify water quality and habitat stressors, and assess the health of the Malibu Creek Watershed. The Stream Team program uses field crews comprised of skilled professional staff and trained volunteers to conduct watershed monitoring. Stream Team began by mapping Malibu Creek and its tributaries using GPS technology to pinpoint the location of outfalls, pollution sources, and degraded habitat. Over the past 15 years, monthly water chemistry monitoring has been conducted at numerous sites throughout the watershed measuring parameters including nutrients, bacteria, pH, dissolved oxygen, temperature, and turbidity. Sites are classified as reference (minimal human impact), middle, and outlet sites. Stream Team staff and volunteers have also conducted numerous habitat restoration projects throughout the watershed, including manually removing invasive vegetation,

The Malibu Creek Watershed

planting native plants, and removing structural barriers in streams to enable fish passage and migration. Additionally, Stream Team has conducted annual bioassessment monitoring, sampling benthic macroinvertebrates that live in the creek beds to evaluate the biological health of the ecosystem. These data help identify areas of degraded water quality and stream habitat, and stressors on stream ecosystems in the watershed, as well as inform management measures to improve and protect local natural resources.

The Malibu Creek Watershed has been a focal area for conservation efforts by federal, state, and local government agencies, non-governmental organizations, and scientific researchers. Yet, even with unprecedented land conservation and dedicated restoration and protection efforts, there is significant environmental degradation throughout the watershed. Many of the streams within the watershed are listed for several pollutants on the Clean Water Act section 303(d) List of Impaired Waterbodies for California. This designation indicates that listed waters are polluted and do not meet water quality standards. The watershed also suffers from the incursion of highly invasive species, including New Zealand mudsnails, red swamp crayfish, bullfrogs, giant reed (*Arundo donax*), periwinkle (*Vinca*), and fennel.

Unlike most other watersheds, where development occurs lower in the watershed, the most urbanized areas in the Malibu Creek Watershed are concentrated in the mid-to-upper portion of the watershed. These urban areas have high amounts of impervious paved area (e.g. streets, sidewalks, parking lots), which contribute to polluted runoff by conveying contaminants from urban land-uses directly into nearby waterways rather than allowing natural infiltration into the ground. Several streams in the developed areas of the watershed are channelized, and streambank armoring is present throughout the watershed. Impervious land cover and stream channelization also impact stream hydrology, leading to higher peak flows, which contribute to streambank erosion and disturbs stream ecology. Additionally, several stream barriers (e.g. Arizona and Texas crossings) are present throughout the watershed, and block natural water flow and the migration of aquatic life, including the federally endangered southern steelhead trout (*Oncorhynchus mykiss*).

Agricultural use of the Malibu Creek Watershed and surrounding mountains is growing. Animal boarding facilities, equestrian ranches, and vineyards are some of the most prevalent agricultural uses in the area. Understanding the effects of these land uses is important for designing and implementing effective conservation policy.

This report offers one of the first comprehensive assessments of the state of the Malibu Creek Watershed. It presents the results of Heal the Bay's 12-year investigation of Malibu Creek Watershed health, including Malibu Creek and its major tributaries (Las Virgenes, Medea and Cold Creeks), as well as some of the smaller watersheds in the Santa Monica Mountains. It also includes specific recommendations to protect and improve watershed health. Our ultimate goal is to provide a comprehensive assessment of stressors to inform policy development to protect and improve habitat and water quality as development in the watershed continues.

Why the Malibu Creek Watershed Matters

• The health of the watershed affects the well-being of humans not only in the watershed itself, but also downstream at public beaches. Poor watershed quality can also harm industries, such as tourism which depend on clean beaches and ocean water.

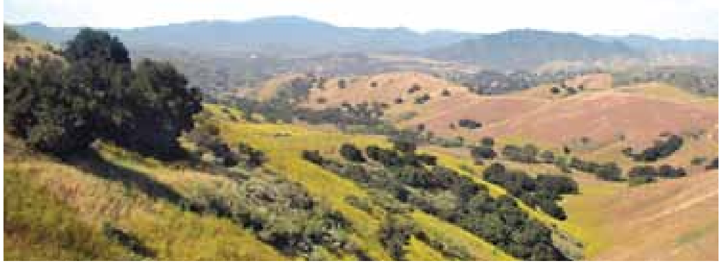
• Preserving and protecting open space and natural resources benefits wildlife, plants, and humans.

• A watershed that is healthy provides humans with recreational opportunities such as hiking, swimming, surfing, and fishing – this is especially important given the proximity of Malibu Creek Watershed to urban Los Angeles.

• A healthy watershed provides ecosystem services to humans such as natural purification of water, food, water availability, and natural flood control.

• Native wildlife and plants have an intrinsic value that many people appreciate.

• Because over 75% of the watershed remains undeveloped and in a mostly natural state, we have an unprecedented opportunity to protect and improve the remaining natural resources.



Malibu Creek. Photo credit: Heal the Bay

KEY FINDINGS

Physical habitat assessments revealed that riparian and stream habitats are heavily disturbed, despite the common perception that the Malibu Creek Watershed is a relatively pristine area.

HABITAT PROTECTION AND RESTORATION IS IMPERATIVE FOR ENHANCING WATERSHED HEALTH

Several streams throughout the watershed are impacted by hardening, erosion, loss of riparian habitat, and sedimentation. This is particularly evident in the high density areas of the mid-to-upper watershed; in many areas there is little or no buffer between waterways and residential and commercial development. In Calabasas, Agoura Hills, and other areas of the watershed, large portions of creeks are channelized or directed underground to stormdrains.

Additionally, these developed communities are largely characterized by impervious surface area, such as roads, parking lots, commercial, and residential buildings, which impede water from infiltrating directly into the ground and lead to higher and faster runoff volumes. Impervious cover affects the hydrology, chem-

The Malibu Creek Watershed contains a wide variety of diverse habitats including coastal strand, riparian woodlands, chaparral, coastal sage scrub, native grasslands, sulfur springs, and brackish water lagoon.

istry, and biological health of aquatic ecosystems. Increased impervious cover and channelized streams degrade channel stability, water quality, and biodiversity. Through biological and habitat assessments, we found that areas with 6.3 percent impervious cover show major signs of biological degradation. This finding is surprising, given that it is a much lower level of impervious cover that causes negative stream health effects than has been shown in previous studies.

Protecting streams and riparian buffers from modification and development, and restoring altered streams are critical actions for protecting the long-term health of the Malibu Creek Watershed. Local governments within the Malibu Creek Watershed should adopt stream health protection ordinances to guard streams and riparian buffers from degradation due to development and human encroachment, with a purpose of creating buffer zones or setbacks for all development next to soft-bottom streams and to restrict streambank modifications. Additionally, restoration activities, including stream barrier removals, must remain priorities in the Malibu Creek Watershed. Removing barriers and illegal structures from local streams will considerably improve habitat and water quality. Implementing bioengineered options to restore and stabilize streambanks, rather than installing riprap or concrete, will improve the natural habitat and water quality, and better protect residences and businesses along the streams where a large percentage of streambank modifications are failing.

Furthermore, Los Angeles County should adopt a Local Coastal Program that protects streams and sensitive habitats in the Santa Monica Mountains. Specific activities of concern include development on steep slopes, encroachment of development on streams and riparian habitat, and increased agricultural use in the watershed. In order to protect the region's valuable natural resources, provisions in the Local Coastal Program must be protective of open space, limit steep slope development to reduce sediment loading, include development setback requirements from streams consistent with adjacent communities, limit further streambank hardening, and protect sensitive resources from potential pollutant-loading and sedimentation associated with agricultural activities. Appropriate installation, monitoring and maintenance of agricultural best management prac-

How the Malibu Creek Watershed Is Broken

Channelization of streams and streambank armoring are common throughout the watershed, causing erosion and negative impacts to stream ecology.

Many streams within the watershed do not meet water quality standards and are designated as impaired.

High nutrient and bacteria levels are found in many locations, which can promote algal growth, lower available oxygen, and impact biological and human health.

Invasive aquatic animals and plants are widespread in the watershed, displacing, outcompeting, and impacting native species.

Degradation of Water Quality in the Watershed

TRASH | BACTERIA | SEDIMENTATION | ALGAE

tices (BMPs) to protect water quality and habitat are needed to protect natural resources in the watershed from further impact associated with agricultural use. Similar policies should also be pursued in local communities within the Malibu Creek Watershed that are outside of the Coastal Zone.

WATER QUALITY IMPROVEMENT EFFORTS SHOULD INCLUDE POLLUTION PREVENTION AND IMPLEMENTATION OF EXISTING REGULATIONS

The ecological health of the Malibu Creek Watershed and safe recreational use of local waters depend upon good water quality. Data collected over the past 12 years by Heal the Bay's Stream Team has helped inform regulation and guide restoration throughout the watershed. These data have been used to list local stream reaches on the Clean Water Act section 303(d) List of Impaired Waterbodies for California, and in the development of nutrient, bacteria, and trash total maximum daily loads (TMDLs) in the Malibu Creek Watershed. Yet, water quality in the Malibu Creek Watershed is still degraded, and nutrient loading, excessive algae, sedimentation, and bacterial pollution are of particular concern.

The Malibu Creek Watershed has several point and non-point sources of nutrient inputs. Generally, nutrient concentrations are lower at reference locations, and increase along the gradient from upper watershed monitoring locations to outlet sites. The Tapia Water Reclamation Facility (Tapia), located just downstream from Malibu Creek State Park, has historically been the most obvious and largest source of nutrients in the watershed. Over the past decade, Tapia has worked to reduce nutrient concentrations in their effluent. During the dry season (April 15 - November 15), Tapia is not permitted to discharge effluent to Malibu Creek. However, Tapia is allowed to discharge to the creek during the wet season (November 16-April 14). Despite efforts to reduce nutrient loading to Malibu Creek, nutrient concentrations are higher at monitoring locations below Tapia's discharge location than above it. High nutrient concentrations throughout the Malibu Creek Watershed, and particularly in the lower watershed, are likely to contribute to the excessive algal growth documented in several areas throughout the watershed. Targeted monitoring along Las Virgenes and Malibu Creeks is needed to identify the sources of nutrients that are not related to Tapia's discharge.

Physical habitat assessments revealed that riparian and stream habitats are heavily disturbed, despite the common perception that the Malibu Creek Watershed is a relatively pristine area.

Major Sources of Effluent in the Watershed			
SEPTIC SYSTEMS	FACILITY DISCHARGE	STORMWATER RUNOFF	AGRICULTURAL
			

Fecal indicator bacteria concentrations are also high throughout the watershed, and generally increase along the gradient from reference through outlet sites. Over the past 10 years, considerable improvements have been made to address bacteria problems in the watershed. Tapia is heavily regulated with tertiary treatment requirements, Title 22 requirements, and dry-weather discharge prohibition during the summer months. Tapia continues to implement programs to reduce nuisance flows from irrigation and to increase water recycling. However, septic systems remain a concern as a source of bacteria and nutrient loading to the watershed. The implementation of a centralized wastewater recycling plant in the Malibu Civic Center will help address this issue in the lower watershed by phasing out many existing septic systems in the area. Further, advanced treatment, including denitrification and disinfection should be required for septic systems in close proximity to streams to reduce bacteria and nutrient pollution.

Pollution associated with stormwater runoff is also of major concern in the Malibu Creek Watershed. The adoption of ordinances by local governments requiring low impact development (LID) measures at new and redevelopment sites that promote the onsite capture and reuse or infiltration of runoff would significantly reduce runoff associated bacteria and nutrient loading in the watershed. Reducing runoff through the implementation of increased LID measures in the watershed will also help protect stream habitat by reducing scour associated with high flow speeds and volumes from impervious areas.

Finally, implementing and enforcing existing water quality regulations is a necessary step towards improving water quality in the area. With over 20 different 303(d) listed impairments in Malibu Creek Watershed, several additional TMDLs need to be developed to improve water quality. Further, implementation of and compliance assurance efforts for the three existing TMDLs is much slower than necessary to restore water quality in the watershed. The Los Angeles Regional Water Quality Control Board must develop implementation plans, with enforceable milestones, for all of the TMDLs in the watershed as soon as possible, especially the Environmental Protection Agency (EPA) TMDLs for nutrients and fecal indicator bacteria. These plans, along with potential incentives for compliance, are necessary to facilitate TMDL implementation and protect beneficial uses in the watershed.

> The ecological health of the Malibu Creek Watershed and safe recreational use of local waters depend upon good water quality... . Yet, water quality in the Malibu Creek Watershed is still degraded, and nutrient loading, excessive algae, sedimentation, and bacterial pollution are of particular concern.

BIOLOGICAL HEALTH IS MOST AFFECTED BY POOR WATER QUALITY AND IMPERVIOUS DEVELOPED AREA

Since 2000, Heal the Bay has been assessing the biological health of the streams by sampling the benthic macroinvertebrate communities, most recently implementing the Surface Water Ambient Monitoring Program (SWAMP) developed by the State Water Resources Control Board. The benthic macroinvertebrate community composition is assessed at each monitoring location and scored according to an Index of Biological Integrity (IBI), an analytical approach recommended by the US EPA to assess human stressors on the biotic condition of waterbodies. Different benthic macroinvertebrate species vary in their ability to withstand stress, therefore the presence or absence of specific species can provide insight to the health of the ecosystem. IBI scores are valuable as they provide a single measure for overall aquatic health. Stream health at sites that have poor to good IBI scores has the potential to improve with efforts to improve habitat condition and water quality.

We found that reference sites have much higher IBI scores than middle and outlet sites. The average IBI score at reference sites is 62, in the "good" range, while average IBI scores at middle and outlet sites fall in the "poor," range with scores of 30 and 24 respectively. Similar to water quality, IBI scores tend to decrease along the gradient from upper watershed to lower in the watershed.

Two major contributing factors to decreased biological integrity in the Malibu Creek Watershed are poor water quality (high nitrate, phosphate, and bacteria concentrations) and high percentage of impervious area. Efforts to improve biological health in streams throughout the watershed should include the implementation of LID measures in developed areas of the Malibu Creek Watershed. The adoption of stream protection ordinances and local plans that include development setbacks from streams and provisions that minimize streambank armoring will also benefit the biological health of streams. Additionally, implementation and enforcement of new and existing water quality regulations would help improve biotic condition. These and other improvements should be seriously considered in order to benefit aquatic life and the overall biological health of the Malibu Creek Watershed.

The spread of aquatic invasive species throughout the Santa Monica Mountains is also a major concern; exotic New Zealand mudsnails, crayfish, bullfrogs, and mosquito fish are already present at several locations in the watershed. Invasive species decrease the biological diversity of native ecosystems through predation, competition, and displacement of native species. Local stream surveys have shown that streams in the more developed areas of the Santa Monica Mountains have high numbers of invasive crayfish and fish, and have fewer native species such as California newts and California treefrogs.

The presence of New Zealand mudsnails (NZMS) was identified in the Malibu Creek Watershed in 2005. Since the invasion began, there have been no clear effects of NZMS other than physical dominance over available substrates in some areas. However, based on known NZMS impacts in other watersheds and their rapid spread throughout the Malibu Creek Watershed, it is critical that careful monitoring for NZMS continue and a clear plan be implemented to curtail the spread. This plan should include the installation of informational signage in both affected and unaffected areas about how to avoid transporting NZMS, strict re-

Native aquatic species have shown population declines due to physical barriers, invasive species, loss of habitat, and degraded conditions. The federally endangered southern steelhead trout (*Oncorhynchus mykiss*) population in the Malibu Creek Watershed is greatly reduced from its historic numbers.

Native vs. Invasive Biota in the Watershed

NATIVE SPECIES (Clockwise from top): Malibu Steelhead Trout, Blue-eyed Grass, Pacific Tree Frog	INVASIVE SPECIES (Clockwise from top left): New Zealand Mudsnail, Mosquito Fish, *Arundo*, Crayfish

Photo credits: Heal the Bay, except Top left, by Steve Williams, RCDSMM

quirements on how to carefully monitor the watershed to control against NZMS spread, and education to stakeholders and user groups in the watershed about how to identify NZMS and their potential impacts on aquatic health.

Further, plans to curb the spread and reduce ecological impacts of crayfish, bullfrogs, mosquito fish, and invasive vegetation should be developed. Trapping efforts have shown to be effective in reducing crayfish from localized areas in the Santa Monica Mountains. Additionally, targeted vegetative restoration has also been successful in some areas. However, when resources are not available for site maintenance, vegetative restoration efforts are often stunted. Although invasive species removal may be effective in localized areas, full eradication of invasive species from the Malibu Creek Watershed would be very difficult. Prevention is the most critical step to control the spread of invasive species throughout the watershed and surrounding areas.

The spread of aquatic invasive species throughout the Santa Monica Mountains is a major concern. Invasive species decrease the biological diversity of native ecosystems through predation, competition, and displacement of native species.

DEVELOPMENT OF A STREAM HEALTH INDEX AS AN INTEGRATED WATERSHED HEALTH ASSESSMENT TOOL

Monitoring ecosystem health is vital to informing conservation and restoration actions. The Malibu Creek Watershed is affected by a variety of stressors, including water pollution associated with urban and agricultural runoff, failing septic systems, and waste-water treatment plant discharges; riparian and stream habitat degradation associated with development, streambank hardening, erosion and sedimentation; illegal dumping; and biotic condition impairments, such as invasive species. However, the effects of multiple stressors on stream and watershed health are not well understood.

Several indices currently exist to measure biological condition, habitat health, and water quality independently, but there is no well-accepted, widely-used metric to measure the combined effects of multiple stressors on watershed health. This report presents a simple Stream Health Index (SHI) using biological, habitat, and water quality data collected by Heal the Bay's Stream Team since 1998. These parameters are analyzed together to provide a single, integrated value, which reflects the health status of individual monitoring locations in the Malibu Creek Watershed. The SHI is based on a 27 point scale, with water quality, biotic condition, and habitat condition each comprising nine of the points. Even in its basic form, this index could be used in the future to evaluate trends in ecosystem health at specific locations or assess ecosystem response to remedial actions taken to protect and improve watershed health.

Highly Degraded vs. Least Impacted Monitored Sites in the Watershed

Medea Creek Outlet is a highly degraded site

Upper Cold Creek is one of the least impacted sites

The SHI scores range from 5 at the Medea Creek outlet, which is a highly degraded site, to 27 at Upper Cold Creek, one of the least impacted reference sites. In general, reference sites receive the highest SHI scores, with sites in the middle and lower watershed receiving much lower scores. The mean SHI score for outlet sites is 9.8, sites in the middle of the watershed have an average SHI score of 10.9, and the mean SHI score for reference sites is 22.7. The decreasing scores from the upper watershed to lower watershed may indicate that considerable degradation is occurring in the mid-watershed, directly below areas impacted by development and high human use.

Several indices currently exist to measure biological condition, habitat health, and water quality independently, but there is no well-accepted, widely-used metric to measure the combined effects of multiple stressors on watershed health.

Malibu Creek. Photo credit: Heal the Bay

RECOMMENDED ACTIONS FOR WATERSHED PROTECTION

Although there have been numerous noteworthy land acquisition successes, riparian restoration efforts, wastewater treatment pollutant load reductions, and runoff pollution reduction ordinances in the Malibu Creek Watershed, these efforts have not been enough to stem the tide of continued watershed degradation. As population continues to grow in the Malibu Creek Watershed, ecological stressors associated with development may intensify.

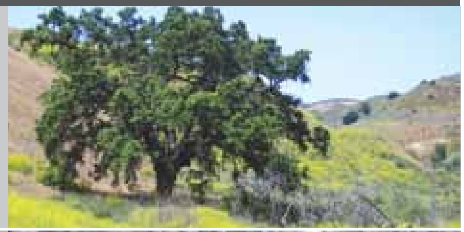
Streams downstream from the more developed areas of the watershed show clear signs of degradation, which indicates a need to protect areas in the watershed that are relatively unaffected by human influence. It is also critical that integrated efforts to protect and improve water and habitat quality are implemented to comprehensively address the many stressors degrading the Malibu Creek Watershed.

Immediate action to reduce watershed stressors, particularly increased impervious area and degraded water quality, are necessary to restore stream health. There are several measures that will help greatly improve habitat, water quality,

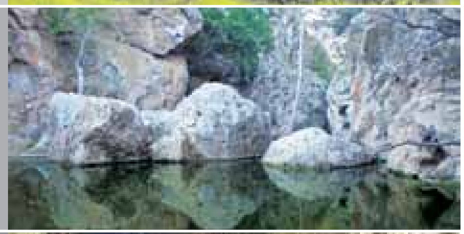
Immediate action to reduce watershed stressors are necessary to restore stream health.

What We Need to Do the Fix the Problems

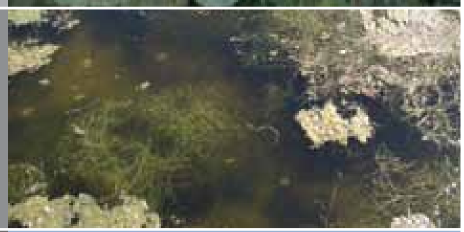
Protect riparian and in-stream habitats



Implement and enforce existing water quality regulations



Reduce nutrients and bacteria to background levels



Improve biological health and diversity

Now is the time to take the next step – bold actions must be taken to protect the Malibu Creek Watershed's valuable natural resources.

We have a critical decision to make: ignore the strong indications that natural resource degradation is rapidly occurring throughout the watershed, or work collectively and urgently towards improving habitat and water quality.

How We Will Fix the Problems

Meet and work with stakeholders in the watershed to implement recommendations

Provide concrete and specific actions that the public can do to improve the watershed

Continue monitoring the watershed and providing our data to stakeholders and the public and biological condition of the Malibu Creek Watershed. This report provides the top five recommended actions to improve watershed health in the categories of protecting riparian and in-stream habitat, implementing and enforcing existing water quality regulations, reducing nutrients and bacteria to background concentrations, and improving biological health and diversity.

These recommendations include, but are not limited to the following actions:

- ✔ The adoption and implementation of strong stream protection policies by local governments that include setback requirements of a minimum of 100 ft. from the outer edge of the riparian habitat;
- ✔ The adoption of Low Impact Development ordinances that require 100% onsite capture and reuse, or infiltration of runoff for all new development and redevelopment;
- ✔ The implementation of existing TMDLs, and development of new TMDLs in the Malibu Creek Watershed for the pollutants that impair its local waterways;
- ✔ The development and implementation of local plans to prevent further spread of invasive species, such as New Zealand mudsnails and crayfish, throughout the watershed; and
- ✔ Removal of Rindge Dam.

Over the past 15 years, government officials, non-governmental organizations, and local citizens have become increasingly aware of the problems facing the Malibu Creek Watershed and adjacent areas. Several projects have been implemented to address these issues; however most have occurred on an individual basis and this region is still faced with a decline in the condition of its natural resources. Significant resources have been spent to educate stakeholders about these problems and plan for integrated solutions, and we have a solid understanding of the contributing factors to water quality and habitat degradation.

Now is the time to take the next step – bold actions must be taken to protect the Malibu Creek Watershed's valuable natural resources. The implementation of creative, integrated solutions addressing both water quality improvement and habitat protection are necessary to help reverse the degradation that is occurring throughout this region. We have a critical decision to make: ignore the strong indications that natural resource degradation is rapidly occurring throughout the watershed, or work collectively and urgently towards improving habitat and water quality. ■

Chapter 1

A WATERSHED ON THE BRINK

AN OVERVIEW OF THE MALIBU CREEK WATERSHED

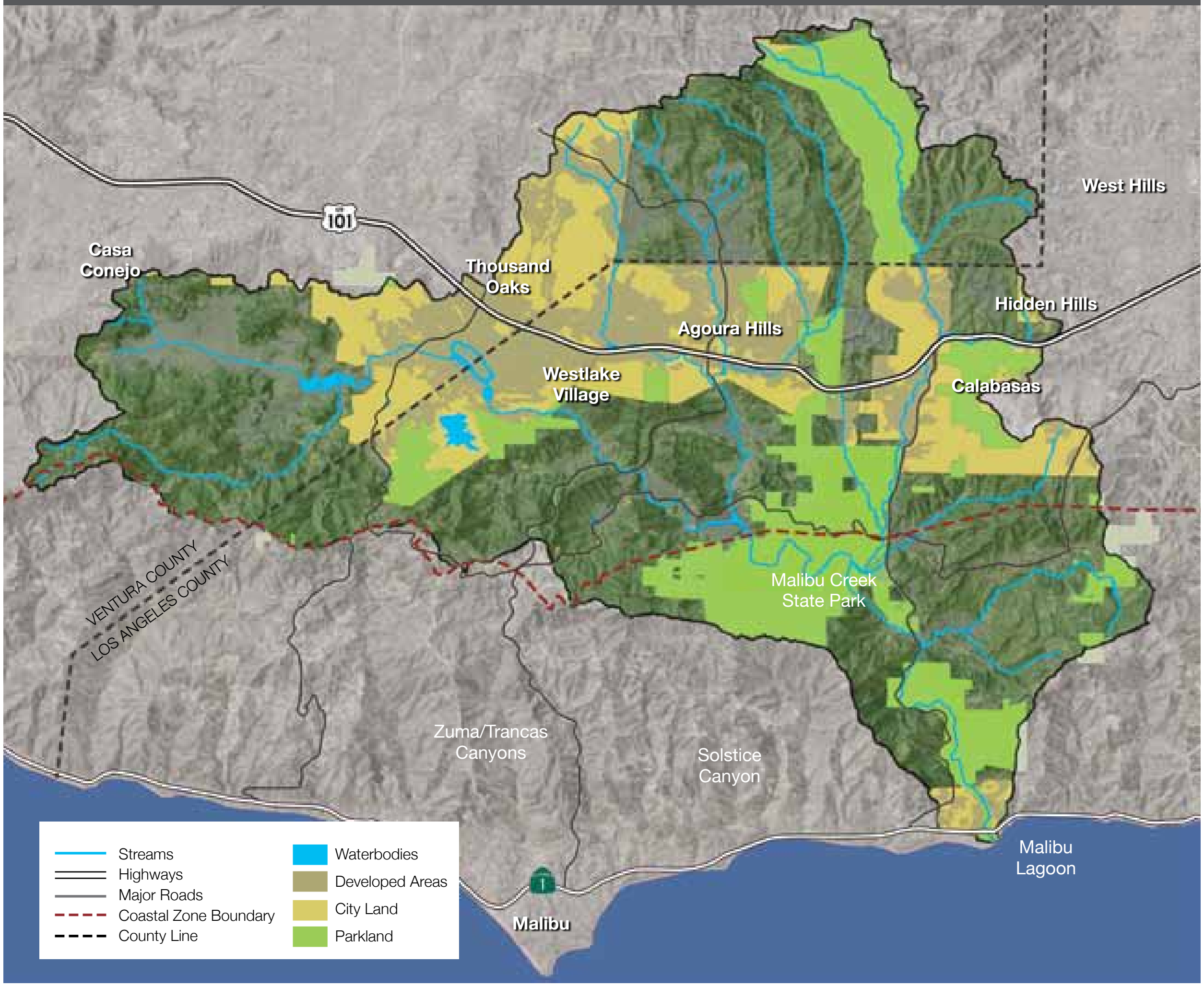
The Malibu Creek Watershed is located on the northern coast of Santa Monica Bay. At 109.9 square miles, it is the second largest watershed draining into the Santa Monica Bay, with the cities of Agoura Hills, Westlake Village, Calabasas, Thousand Oaks, Hidden Hills, and a portion of Malibu and Simi Valley within its boundaries. The Malibu Creek Watershed comprises more than a quarter of the land area that drains into the Santa Monica Bay. Approximately 65% of the watershed is located in Los Angeles County, with the remaining 35% in Ventura County. The largest stream in the watershed, Malibu Creek, drains into Malibu Lagoon, and then flows directly to world-famous Malibu Surfrider Beach, which attracts more than 1 million visitors annually.

SENSITIVE HABITATS AND SPECIES

The Malibu Creek Watershed contains a wide variety of diverse habitats including coastal strand, oak and riparian woodlands, chaparral, coastal sage scrub, native grasslands, sulfur springs, and brackish water lagoon. Some of the best bird watching in the region can be found in Malibu Lagoon State Beach and Malibu Creek State Park. The watershed is home to several threatened and endangered plants and animals including the southern steelhead trout, tidewater goby, California brown pelican, California least tern, red-legged frog, San Fernando Valley spineflower, and many other species. Malibu Creek is also home to the arroyo chub, an endemic minnow adapted to warm, slow flowing waters such as in Malibu Creek and its tributaries during dry months. The arroyo chub is a California species of special concern. Due to the Mediterranean climate in southern California, many streams in the upper watershed are ephemeral and run only during wet weather. Few natural areas globally can rival the watershed's extraordinary biological and habitat diversity, especially in close proximity to such a dense urban area.

Over 75% of the Malibu Creek Watershed is undeveloped, and more than half of the land is owned by local, state, and federal government agencies, which are likely to preserve the land in perpetuity for future generations (Figure 1-1). The watershed contains critical natural protected areas, including Peter Strauss Ranch, Cheeseboro Canyon, Cold Creek Canyon Preserve, Tapia Park, and Malibu Creek and Lagoon State Parks. About 50 square miles of the watershed is parkland or conserved land. Between 2001 and 2010, more than 14.5 square miles of land were acquired by various public agencies. Recently, the state of California, in partnership with other agencies, purchased two ecologically important areas in the watershed: the 1800 acre Ahmanson Ranch at the headwaters of East Las Virgenes Creek in 2003, and the 600 acre King Gillette Ranch on the Soka property close to Malibu Creek in 2005. A parcel containing a private golf practice area, located just west of Malibu Lagoon will be donated to the State in the future.

Figure 1-1: Map of the Malibu Creek Watershed



IMPROVEMENT EFFORTS AND ECOSYSTEM IMPAIRMENTS

Federal, state, and local governments, as well as local non-governmental organizations, have made considerable conservation efforts throughout the watershed. The County of Los Angeles has designated the Malibu Creek Watershed as an Environmentally Significant Area, and much of the lower watershed has been designated as Environmentally Sensitive Habitat Area (ESHA) by the California Coastal Commission and the City of Malibu. ESHA designation provides critical habitat protection against development impacts. From 2005-2008, the National Park Service, in partnership with Heal the Bay, led a major steelhead habitat restoration project in nearby Solstice Creek, which included stream barrier removals to improve fish habitat and riparian habitat enhancement. The Santa Monica Mountains Resource Conservation District also conducts research in the area, including steelhead surveys, habitat assessments, and 24-hour continuous water quality monitoring at select sites in the lower watershed. Additionally, in 2010, the UCLA Institute of the Environment and Sustainability created the La Kretz Center for California Conservation Science for collaborative research and conservation within the region. The La Kretz Center partners with the National Park Service, California State Parks, Mountains Recreation & Conservation Authority, and UCLA Stunt Ranch Santa Monica Mountains Reserve. In the lower Malibu Creek Watershed, the City of Malibu, in partnership with numerous state and local funders, completed construction of Legacy Park in 2010. The facility captures stormwater from the Malibu Civic Center area, which is then pumped to a treatment plant, treated and used for irrigation for landscaping in the park and nearby areas, or returned to Malibu Creek and Lagoon when there is no storage capacity in Legacy Park.

The Santa Monica Bay Restoration Commission (SMBRC), an independent state organization dedicated to protecting and restoring natural resources in the Santa Monica Bay as part of the National Estuary Program, has placed great focus on the Malibu Creek Watershed. Malibu Lagoon restoration and water quality improvement at Surfrider Beach are two of SMBRC's highest priorities. Since 2000, the SMBRC has funded several projects in the watershed, including a risk assessment of septic system impacts on water quality in the lower watershed and the removal of 250 linear feet of concrete in Las Virgenes Creek. In partnership with the Serra Homeowners Association, the SMBRC also funded replacement of an Arizona crossing in lower Malibu Creek with a bridge that does not impede flows, enhancing fish migration and reducing sedimentation.[1]

Heal the Bay also completed numerous habitat restoration projects throughout the watershed over the past decade, including removal of two stream barriers. In 2006, Heal the Bay worked with California State Parks to remove a large Texas crossing in Malibu Creek State Park to improve in-stream habitat. Additionally, over the past decade, Heal the Bay has managed several volunteer-based restoration projects in the mid-watershed, involving the removal of large patches of invasive vegetation and replacement with native plants at sites throughout Malibu Creek State Park.

However, even with the unprecedented land conservation, restoration and protection efforts, there is significant environmental degradation throughout the Malibu Creek Watershed. Numerous reaches within the watershed are designated as impaired for various pollutants on the Clean Water Act section 303(d) list of Impaired Waterbodies for California.[2] This designation indicates that listed waters are polluted and do not meet water quality standards. Waters on the list must be issued a Total Maximum Daily Load (TMDL), an in-depth technical and comprehensive assessment of the problem that also sets pollution limits for all pollution sources that have the potential to cause or contribute to impairments. TMDLs facilitate enforceable actions and water quality improvement. Malibu Creek is listed as impaired for coliform bacteria, nutrients (algae), unnatural scum/foam, sedimentation, trash, benthic-macroinvertebrate bioassessments, and several other pollutants (see Appendix A for complete 303(d) listings in the watershed). Of all the waterbodies evaluated for 303(d) listing within the watershed, upper Cold Creek, which is largely surrounded by natural area, remains the only unimpaired creek segment. However, this area is currently being examined for invasive species impairment. Research and monitoring show numerous pollution-related problems throughout the watershed, such as algal blooms in Malibu Creek and Lagoon, low biodiversity of native aquatic species, and unnatural rates of riparian habitat erosion and sediment deposition.[3] Most of these impairments are more prevalent in the lower watershed, as pollution increases towards Malibu Creek's outlet at Malibu Lagoon and Surfrider Beach.

Federal, state, and local governments, as well as local non-governmental organizations, have made considerable conservation efforts throughout the watershed. [E]ven with the unprecedented land conservation, restoration and protection efforts, there is significant environmental degradation throughout the Malibu Creek Watershed.

[1]Santa Monica Bay Restoration Commission. 2008. The Bay Restoration Plan. Available at: http://www.smbrc.ca.gov/about_us/smbr_plan/docs/smbrplan2008.pdf

[2]California State Water Resources Control Board. California's 2006 Clean Water Act Section 303(d) List of Water Quality Limited Segments. Available at: www.swrcb.ca.gov/water_issues/programs/tmdl/303d_lists2006_epa.shtml

[3]Ambrose, R.F., & Orme, A.R. 2000. *Lower Malibu Creek and Lagoon Resource Enhancement and Management, Final Report to the California State Coastal Conservancy.* Luce, S. & Abramson, M. 2005. Periphyton and Nutrients in Malibu Creek. A Heal the Bay Report: available from Heal the Bay.

From this list, regulators assign a Total Maximum Daily Load (TMDL), which sets pollution limits and a process to restore impaired beneficial uses of the waterway, such as recreational water contact and aquatic life. These TMDLs include numeric limits for the specified pollutant, load allocations for each pollution source, as well as an implementation plan with progress and compliance milestones. Once developed, a TMDL is used in permits issued by the Regional Water Quality Control Board, and as a guide for implementing programs to reduce pollution.

In addition to water quality impairments throughout the Malibu Creek Watershed, there is significant habitat degradation. Urban areas in the watershed contain high amounts of impervious surface, which prevents water from infiltrating into the ground and contributes to polluted runoff. Several streams are channelized, and streambank armoring is present throughout the watershed. High levels of impervious cover and channelization also change stream hydrology, leading to higher peak flows, which affects streambank erosion and stream ecology. Moreover, numerous barriers block natural water flow and migration of various animals, including the federally endangered southern steelhead trout. Rindge Dam, located in the lower stretch of Malibu Creek, is an impassable barrier, blocking nine miles of high-quality steelhead habitat upstream. The Army Corps of Engineers began a feasibility study in 1999 to assess removal options for the Dam, but despite significant community and environmental group support, the study has not been completed due to lack of funding. Habitat impairments in the watershed may cause significant harm to water quality, by conveying pollutants to streams and reducing the natural capacity of creeks to remediate pollution.

CLEAN WATER ACT

The Federal Clean Water Act, section 303(d), requires that each state develop and submit to the United States Environmental Protection Agency (US EPA) a list of polluted waterbodies or portions of streams, rivers, lakes, and ocean waters every two years. In California, each Regional Water Quality Control Board is responsible for compiling this list based on all available data. The impaired bodies are compiled as the List of Impaired Waterbodies, or simply the 303(d) list, and require action to improve water quality.

Stream Team members conducting habitat bioassessment. Photo credit: Heal the Bay

NEED FOR WATERSHED ASSESSMENT

The Malibu Creek Watershed Council was established in the early 1990s as part of an effort to examine and improve habitat and water quality in the watershed. Council partners include diverse stakeholder groups from areas throughout the watershed, including representatives from local, county, state and federal government agencies, environmental non-profit organizations, and members of the public. Despite numerous monitoring and research efforts throughout the watershed, this report presents one of the first comprehensive assessments of the state of the Malibu Creek Watershed. It also makes specific recommendations to protect and improve watershed health.

Heal the Bay initiated its Stream Team monitoring program in 1998 with generous support from the California Coastal Conservancy, Environment Now, and SMBRC. Stream Team conducts a three-pronged approach to watershed assessment: monitoring water chemistry, mapping physical features and impairments such as excess algae and sediment, and assessing biological conditions by monitoring insect larvae, worms, and snails that live on the bottom of the streams, also known as benthic macroinvertebrates (BMI). This comprehensive approach towards watershed assessment provides a detailed overview of watershed health.

The Malibu Creek Watershed, though nearly 80% undeveloped, supports land uses that may negatively affect stream health. Understanding the effects of these land uses is important for designing and implementing effective conservation policy. The growing populations of local communities and an increasing number of horse ranches and vineyards are identified as concerns in the watershed. The goal of this watershed assessment is to provide a comprehensive view of stressors and impacts in order to inform the development of policies to protect and improve habitat and water quality.

Left: Stream Team member measuring water depth. Right: Barrier removal by jackhammer at Solstice Canyon. Photo credit: Heal the Bay

STREAM TEAM SAMPLING METHODS

This report presents the results of Heal the Bay's 12-year investigation (1998-2010) of Malibu Creek Watershed health, including Malibu Creek and its major tributaries (Las Virgenes, Medea, and Cold Creeks), as well as some nearby smaller watersheds in the Santa Monica Mountains. Heal the Bay's database includes 19 sampling locations, which have been monitored on a monthly basis for water chemistry and annually for bioassessment. Heal the Bay staff and volunteers have spent over 40,000 hours collectively surveying the watershed, and have conducted more than 120 water chemistry sampling events over the past 12 years. This report includes integrated data analysis of over 1,300 samples to identify site-specific impairments and large scale influences, discussion of regulatory and restoration approaches to improving water and habitat quality, and recommendations for future actions to address chronic problems, development, and restoration in the watershed.

VOLUNTEER SCIENCE

Field crews comprised of skilled professional staff from Heal the Bay and trained volunteers conduct the watershed monitoring. Teams complete water chemistry sampling at specific sites within the Malibu Creek Watershed and at adjacent reference watersheds through the Stream Team program. The value of volunteer monitoring is undeniable. Over the past 12 years, Heal the Bay has created an extensive dataset for the watershed at a significantly lower cost than other monitoring programs that do not rely on volunteer science. Data collected through Stream Team follows strict quality assurance and quality control guidelines, thus providing a reputable source of information for better understanding the Malibu Creek Watershed.[4] Volunteer monitoring also increases watershed stewardship and fosters education among residents and recreational users through service.

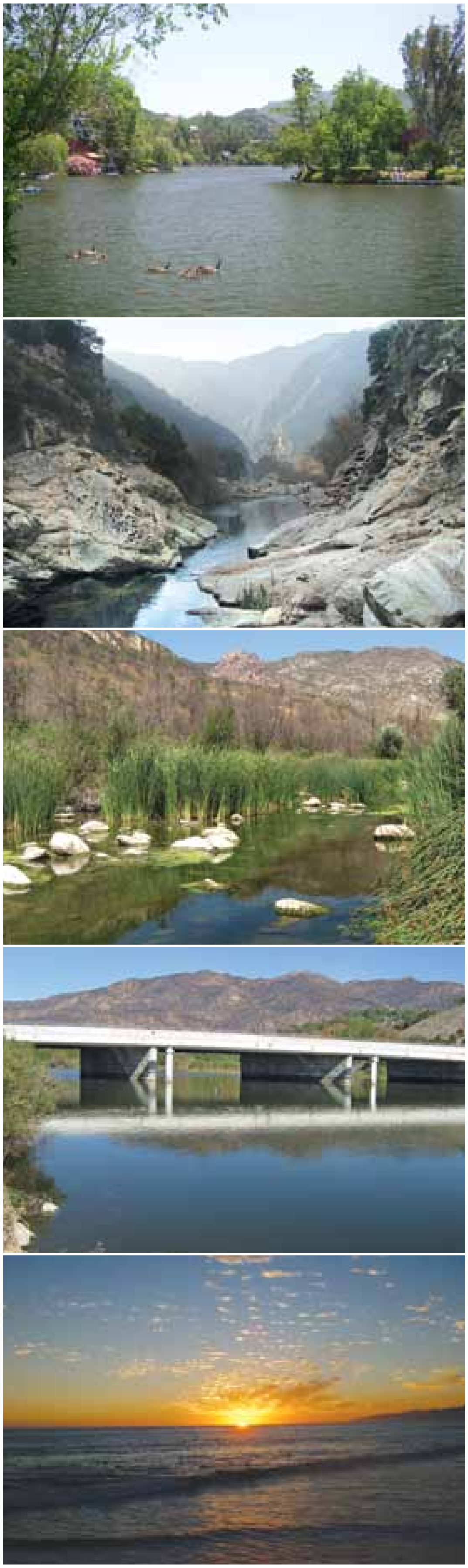
[4]EPA. 2006. *The Volunteer Monitor's Guide to Quality Assurance Project Plans* (EPA841-B-96-003). Retrieved from http://water.epa.gov/type/rsl/monitoring/upload/2002_08_02_monitoring_volunteer_qapp_vol_qapp-2.pdf

SAMPLING SITE SELECTION

Malibu Creek itself is approximately 10 miles long from its beginning at the outlet of Malibou Lake to its terminus at Malibu Lagoon and Surfrider Beach. The major tributaries are Las Virgenes, Medea, Triunfo, Lindero, Potrero, Hidden Valley, and Cold Creeks. Las Virgenes Creek flows from headwater streams on former Ahmanson Ranch (now known as Upper Las Virgenes Canyon Open Space) and the historic grazing lands of Las Virgenes Canyon, through the City of Calabasas and into Malibu Creek State Park, where it joins Malibu Creek. Palo Comado and Cheeseboro Creeks flow through undeveloped canyons above Agoura Hills and into Medea Creek, which flows through the City of Agoura Hills and into Malibu Creek. The shallow man-made lake in the City of Westlake flows into Triunfo Creek and then to Malibou Lake. Carlysle Canyon and Potrero Creeks flow through mainly rural residential areas with some agriculture and into Malibou Lake. All together, these creeks drain about 110 square miles of land (Figure 1-2 on p. 33).

Heal the Bay staff spent considerable time and effort searching for monitoring sites throughout the watershed, including both minimally developed sites to serve as reference points, and outlets of major subwatersheds that drain into Malibu Creek. Site selection was based on land use data, aerial photos, field surveys, and knowledge of the watershed. Sites were specifically chosen to represent relatively homogeneous stream habitat types. This allowed monitoring efforts to focus on upstream impacts on water quality, rather than more localized impairments. However, this also limited our analysis of specific habitat impairments on benthic communities and water quality because the sites were not selected randomly and do not necessarily represent all habitat types or impairments. Heal the Bay began monitoring seven sites in 1998. In 2002, the program expanded to include a total of 19 sites throughout the Malibu Creek Watershed and three in adjacent watersheds; eight of these monitoring locations are considered upstream of developed areas. Heal the Bay discontinued sampling six sites in 2003 and 2004 that were often dry to monitor, and two reference sites that no longer met initial criteria (Table 1-1).

> Malibu Creek is approximately 10 miles long from its beginning at the outlet of Malibou Lake to its terminus at Malibu Lagoon and Surfrider Beach.



Top to Bottom: Malibu Creek as it starts from Malibou Lake and flows through the watershed to the terminus at the Pacific Ocean.

Table 1-1: Monitoring Site Descriptions					
Fig. 1-2 Reference	Site Number	Monitoring Site	Description	Dates Monitored	# of WQ Sampling Events
1	O1	**Outlet of Malibu Creek**	Downstream of commercial, residential, rural residential, septic systems, Tapia Water Reclamation Facility (treated sewage discharge), freeway, major dam	Nov98 – Jun10	115
2	O2	**Outlet of Cold Creek**	Downstream of rural residential, septic systems, moderate equestrian use	Nov98 – Jun10	105
3	R3	**Upper Cold Creek**	Drains a restricted-access nature preserve	Nov98 – Jun10	115
4	O4	**Outlet of Malibou Lake**	Downstream of commercial, high-density residential, rural residential, freeway, a large dam and manmade lake. Heal the Bay did not sample algae or bioassessment at site 4. Sampling at this site stopped when Heal the Bay began monitoring the lake itself.	Nov98 – Oct03	59
5	O5	**Outlet of Las Virgenes Creek**	Downstream of commercial, high-density residential, rural residential, sewage sludge injection field and reclaimed water irrigation, freeway, some grazing	Nov98 – Jun10	116
6	R6	**Upper Cheeseboro Canyon Creek**	Drains National Parks property with hiking and equestrian use	Nov98 – Jul03*	51
7	O7	**Outlet of Medea Creek**	Downstream of commercial, high-density residential, rural residential, freeway, small dams and manmade lakes	Nov98 – May06, May10*	91
8	R8	**Upper Palo Comado Creek**	Drains open space, recreational hiking and equestrian trails	May01 – Aug03	16
9	R9	**Upper Las Virgenes Creek**	Located on State parks property. Drains open space with hiking and historic grazing and orchard uses	May01 – Oct10*	30
10	R10	**Upper Carlysle Creek**	Reference site is upstream of Lake Sherwood. Drains mostly open space	May01 – Aug03	18
11	M11	**Mid-Cold Creek**	Downstream of minimal rural residential development, septic systems and equestrian use	Apr02 – Oct03*	15
12	M12	**Upper Mid-Malibu Creek**	Located in Malibu Creek State Park. Downstream of commercial, high-density residential, rural residential, freeway, small dams and man-made lakes	Apr02 – Jun10	70
13	M13	**Mid-Las Virgenes Creek**	Downstream of freeway, high density commercial and residential	Apr02 – Jun10	69
14	R14	**Outlet of Solstice Creek**	Located on National Parks property. Drains open space with moderate hiking use	Apr02 – Jun10	72
15	M15	**Mid-Malibu Creek at LA County stream gage**	Downstream of the Tapia Water Reclamation Facility (treated sewage discharge), commercial and residential, septic systems and equestrian uses. Heal the Bay only sampled semiannually at site 15, for BMI and associated parameters	Mar08 – Jun10	25
16	O16	**Outlet of Stokes Canyon Creek**	Downstream of rural residential development, septic systems and equestrian uses	Apr02 – Oct03	15
17	O17	**Triunfo Creek**	Downstream of high-density commercial, residential, freeway, man-made lake and dam, vineyards and equestrian use	Apr02 – Jun10	57
18	R18	**Outlet of Lachusa Creek**	Located on National Parks property. Drains open space with minimal human presence	May02 – May06 Jan09 – May10	61
19	R19	**Mid-Arroyo Sequit Creek**	Downstream of septics, highway	Apr02 – Jun10	39

Summary of each monitoring site, the time period it was monitored by Heal the Bay, the number of sampling events at the site, and a brief description of site location.

▒ = Shaded sites are those currently being monitored by Heal the Bay on a monthly basis

* = Indicates sites where Heal the Bay bioassessment monitoring is ongoing

O# = Outlet Site **M#** = Middle Site **R#** = Reference or Minimally Developed (R) site

Figure 1-2: Map of Heal the Bay Monitoring Sites

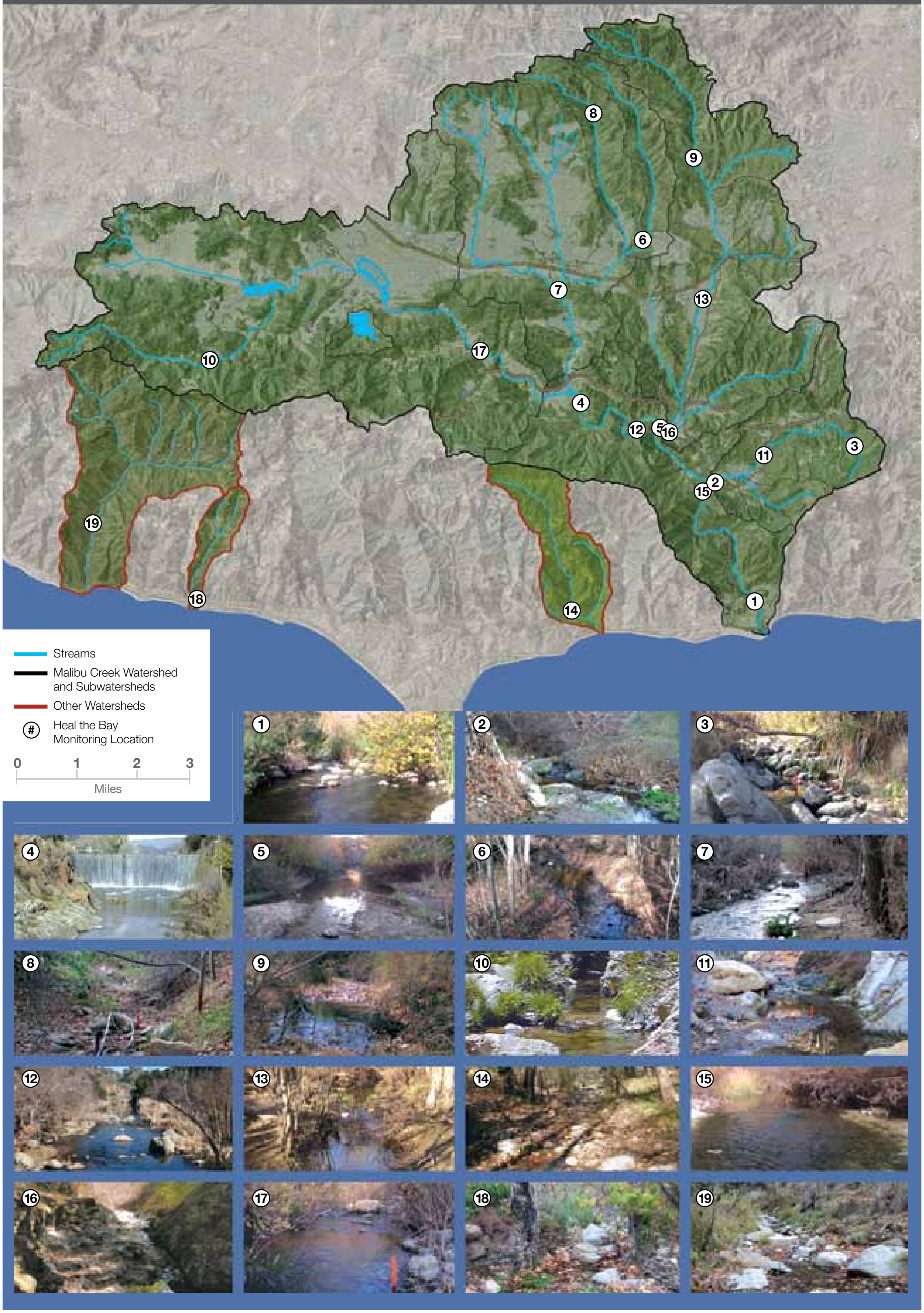


FIGURE 1-2: Heal the Bay monitoring locations in the Malibu Creek Watershed and adjacent reference watersheds.

Reference sites were selected at minimally developed sites that represent some of the least impacted areas in the watershed; waters at these sites are just downstream from protected open space with some hiking uses and minimal paved areas. For example, Upper Cold Creek (R3) is directly below a restricted-access nature preserve. Middle sites are located in the mid-watershed and were selected to detect where stream degradation may occur in each tributary, as well as gradient impacts from the upper to lower stretches of individual streams. For example, Mid-Las Virgenes Creek (M13) is downstream of the City of Calabasas and the 101 freeway, a major transportation corridor, but upstream from the Rancho Las Virgenes Composting Facility. To examine different land use impacts, the Mid-Cold Creek (M11) site was chosen because it drains limited rural residential development, equestrian facilities, and paved roads in its drainage. Seven sites were selected at the outlets of tributaries. Most outlet sites are downstream of residential or commercial development, the 101 freeway, and stream alterations such as culverts and concrete banks (Figure 1-2).

Without enhanced coordinated and collaborative efforts to improve habitat and water quality, natural resources in [the Malibu Creek Watershed] are unlikely to be preserved for future generations.

Malibu Lagoon outlet into the Pacific Ocean. Photo credit: Joy Aoki

Left: Removing Texas crossing stream barrier in Malibu Creek. Right: Volunteers removing trash from Malibu Creek watershed. Photo credit: Heal the Bay

A WATERSHED ON THE BRINK

The Malibu Creek Watershed contains some of southern California's most precious resources, and is unique because it is has substantially more open space than most other watersheds draining into Santa Monica Bay. Significant progress has been made in the watershed to preserve and improve water quality and habitat through land acquisition, regulations, habitat restoration, and education. Many groups are vigorously working to protect the natural resources in this area and have completed several projects, from barrier removals to vegetation restorations, in addition to conducting regular monitoring activities.

Yet, as described in this report, degradation is spreading throughout the watershed in predictable and unfortunate patterns. Without enhanced coordinated and collaborative efforts to improve habitat and water quality, natural resources in this area are unlikely to be preserved for future generations.

Malibu Creek Watershed protection and improvement planning efforts have been underway for more than 15 years. However, comprehensive action has been slow, and most efforts have occurred on an individual project basis. Most recommended actions have not been implemented. Yet, there are opportunities for more comprehensive and collaborative efforts to protect and improve habitat and water quality without restricting access to and enjoyment of the natural resources within the Malibu Creek Watershed. By protecting stream habitats and riparian zones from development, implementing and enforcing existing water quality and habitat protection regulations, implementing low impact development (LID) techniques for onsite reduction of polluted runoff and retrofitting existing developments, ensuring land use and general plans are written to provide adequate habitat protection, and continuing watershed monitoring to gauge progress and assess stream health, we can protect the Malibu Creek Watershed. There is a critical decision to make: ignore the strong indications of natural resource degradation throughout the watershed, or work collectively and aggressively towards improving habitat and water quality. ■

Chapter 2

STATE OF THE HABITAT

STATE OF THE HABITAT

MALIBU CREEK WATERSHED LAND USE

More than 75% of the Malibu Creek Watershed is open space, with several small cities and rural residential communities located throughout the areas. With a growing population of over 90,000 people in the watershed, human impacts are prevalent.[5] The Malibu Creek Watershed is home to Malibu Creek State Park, a popular destination for swimming, rock climbing, hiking, biking, and horseback riding. Because a large amount of land in the watershed is owned by local, state and federal government agencies, access to recreational activities in this area is likely to be preserved for future generations. However, there is also a considerable amount of privately owned open space in the watershed. Guiding development in these areas is important for effective watershed management over the next decade and beyond.

LAND USE AND IMPERVIOUS COVER

Land use greatly influences habitat and water quality within the Malibu Creek Watershed and along the coast. Many of the characteristics associated with developed areas in the watershed threaten aquatic and riparian resources. Developed areas often have larger areas and higher percentages of impervious surface, such as roads, parking lots, and commercial and residential buildings, which impede water from infiltrating directly into the ground. This impervious cover conveys urban runoff into channels and streams, which affects the hydrology, chemistry, and biological health of aquatic ecosystems.

Urban runoff often contains trash and debris, bacteria, sediments, nutrients, metals, toxic chemicals, and other pollutants, which can adversely affect receiving waters, associated biota, and public health. Increased impervious cover degrades channel stability, water quality, and biodiversity.[6] In contrast, pervious grounds help improve water quality by promoting groundwater infiltration, acting as a filter. Vegetation takes up some pollutants, and reduces flow velocities, which can reduce scour.[7]

The degree of imperviousness of an area depends on land use classification. For example, water infiltrates more readily in open space than urban areas. The degree of infiltration can be categorized as percent impervious area, which provides a measure of impervious area, incorporating its ability to infiltrate water.

The Southern California Association of Governments (SCAG) releases the most recent land use data approximately every five years. This information helped Heal the Bay select moni-

[5] Malibu Creek Watershed Council Website, accessed in June 2011: www.malibuwatershed.org

[6] Paul, M.J., & Meyer, J.L. 2001. Streams in the Urban Landscape. *Annual Review of Ecology and Systematics* 32:333-365; Center for Watershed Protection. 2003. Impacts of Impervious Cover on Aquatic Systems. *Watershed Protection Research Monograph* No. 1.

[7] Chau, H. 2009. *Green Infrastructure for Los Angeles: Addressing Urban Runoff and Water Supply through Low Impact Development.* City of Los Angeles. Accessed in November 2011: http://www.lastormwater.org/siteorg/program/Complete-Grn-Infrastruct.pdf

Figure 2-1: Malibu Creek Watershed SCAG Land Use Map (2001)

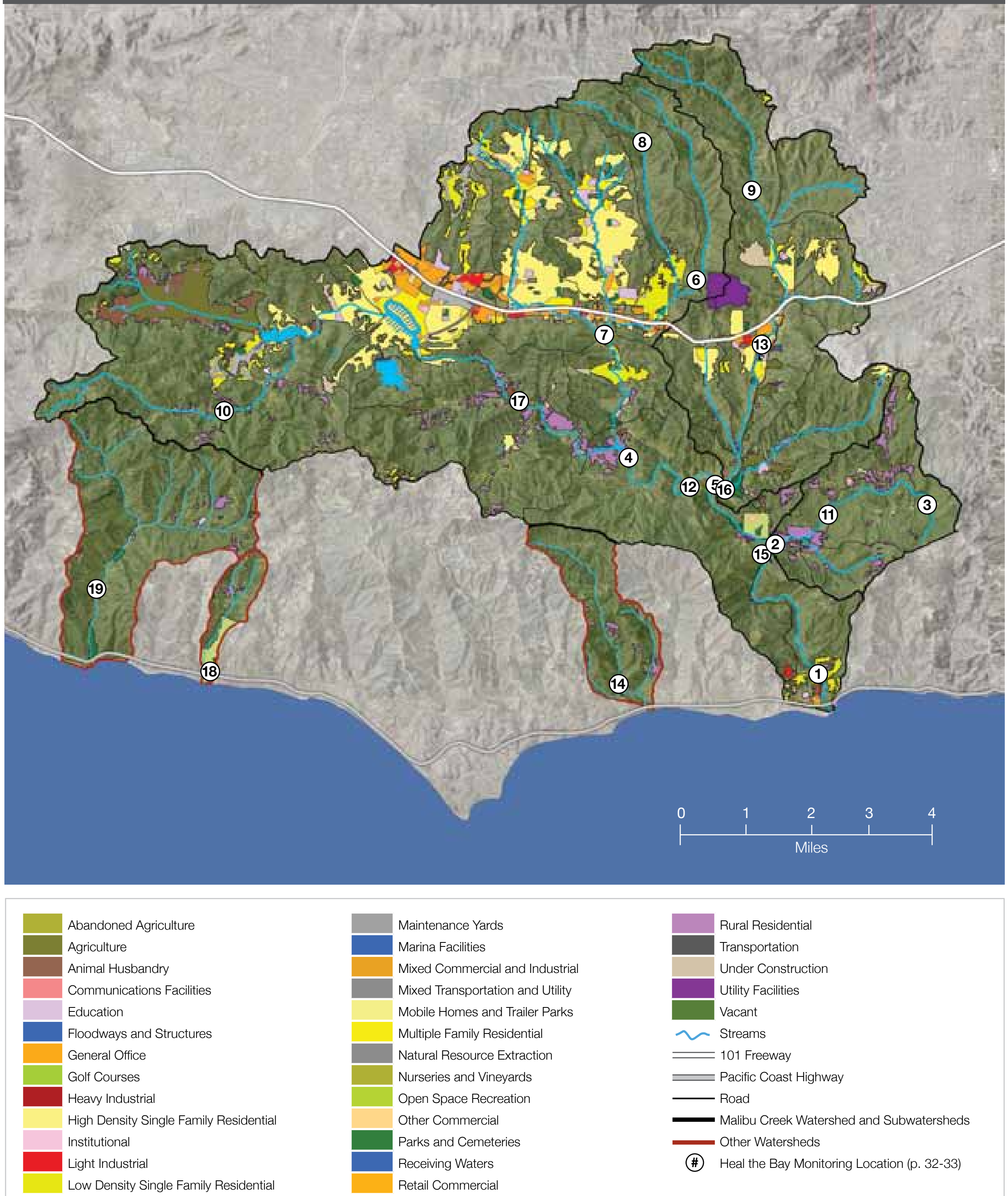


FIGURE 2-1: Land uses in the Malibu Creek Watershed and adjacent watersheds based on SCAG data and aerial photos.

Land use greatly influences habitat and water quality within the Malibu Creek Watershed and along the coast. Many of the characteristics associated with developed areas in the watershed threaten aquatic and riparian resources.

toring site locations in the watershed and identify prospective areas to examine for potential upstream sources of pollution. Figure 2-1 shows the 2001 SCAG land use data for the Malibu Creek Watershed. With the potential for new development at several sites in the watershed, understanding the impacts of land use change is of utmost importance for guiding future development and watershed management.

Top to bottom: Lake Lindero Country Club Golf Course; Vineyard in Triunfo Canyon; Triunfo Creek in residential area; Calabasas landfill.
Photo credit: Heal the Bay

LAND USE CHANGES BETWEEN 2001 AND 2005

Analyses comparing the 2001 and 2005 SCAG land use data indicate that land use designations in the Malibu Creek Watershed changed by less than 1% over this time period. Areas with the most notable land use changes include an increase in low and high density single family residential area in Calabasas from open space, increased agricultural (e.g. equestrian use and viticulture) activities above Malibou Lake and along Cold Creek, and changes in land use above Westlake and Lake Sherwood (Figure 2-2). It will be interesting to compare this analysis to the next updated version of SCAG data when it is available. Heal the Bay staff expect to see an increase in viticulture within the watershed, as well as an increase in equestrian facilities in the middle and lower areas of the watershed based on observations of development and human use in the area. However, we only expect to see a slight increase in impermeable area.

Heal the Bay used the 2001 SCAG land use data to determine the impervious surface area of the Malibu Creek Watershed. Percent impervious area was determined based on the percentage that each land use results in runoff due to its level of impermeability or its allowance for infiltration. For example, the landscaping associated with single family residential areas results in some infiltration, so this land use is not considered completely impervious in this analysis.[8] In addition to

[8] For more information on how we determined percent impervious area, see Appendix B.

Figure 2-2: Land Use Changes 2001-2005

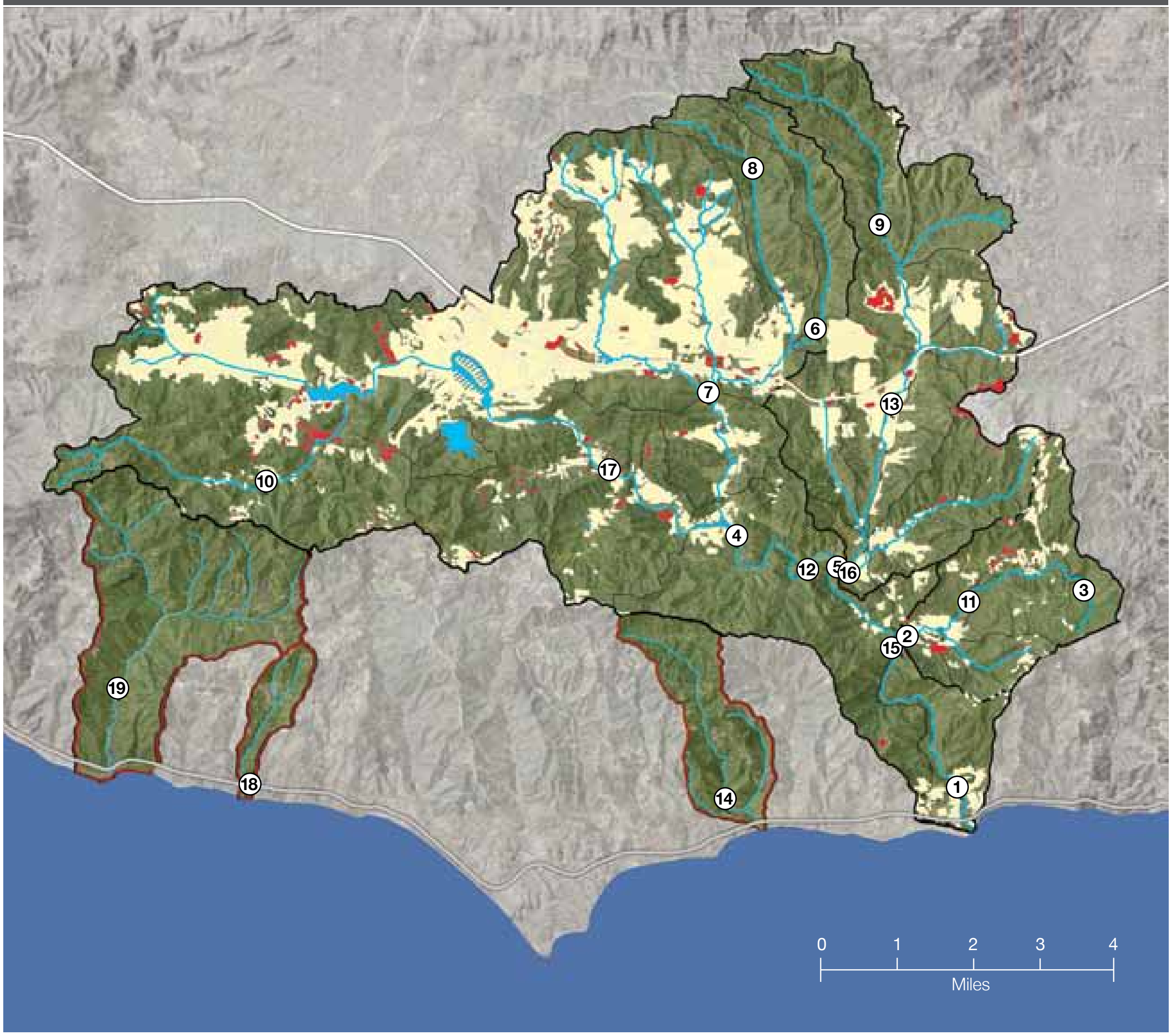


FIGURE 2-2: Land use changes in the Malibu Creek Watershed between 2001 and 2005 based on SCAG land use designations. Total land use change is less than 1% throughout the watershed, but appears greater in areas near preexisting developments.

percent impervious area, we determined the overall development in an area, which is the equivalent of all land uses in a subwatershed excluding vacant land and open space recreation. The proportion of developed area upstream of monitoring sites ranges from 3.2% in the Arroyo Sequit reference watershed to 31% in Medea Creek. The percent imperviousness for the monitoring sites ranges from 2.8% in Arroyo Sequit to 19.6% in Medea Creek (Table 2-1). In some areas of the watershed, the percent impervious area greatly exceeds the 10% threshold that has been shown to cause permanent degradation of receiving waters and riparian habitat.[9] Several areas of the watershed also exceed the 8% area of urbanization that has been found to negatively impact aquatic communities in the Santa Monica Mountains.[10] The overall imperviousness of the Malibu Creek Watershed is nearly 12%, above both the 8% and 10% thresholds.

[9]Schueler, T. 1994. The importance of imperviousness. *Watershed Protection Techniques* 2(4):100-111.

[10]Riley, S.P.D. et al. 2005. Effects of urbanization on the distribution and abundance of amphibians and invasive species in southern California streams. *Conservation Biology* 19(6):1894-1907.

There has been a recent movement towards low impact development (LID) in many parts of the country, including in Los Angeles and Ventura Counties. LID refers to building in a way that infiltrates or captures a majority of rainwater and runoff on site, mostly by maintaining or creating permeable surfaces like gardens, and green space, but also by capturing and using the water to off-set potable water use. The trend in recent LID regulations has been to retain the runoff generated from the 85th percentile storm (3/4 inch) on site. Best management practices (BMPs) that retain, infiltrate and/or treat urban runoff can help mitigate the effects of impervious cover on streams.[11] When water is diverted to a permeable surface, like a rain garden or swale, it percolates through the ground, where it is naturally filtered and cleaned, and ultimately ends up recharging natural groundwater supplies. Malibu City also has numerous LID policies in place throughout its land use documents that govern development and redevelopment. For instance, the Malibu General Plan Land Use Implementation Measures 5 and 6 address stormwater runoff by "limiting impermeable lot coverage to no more than 45% of lot for lots one-quarter acre or smaller, 35% for lots between one-quarter and one-half acre, and 30% for lots greater than one-half acre."[12] The recently-adopted Los Angeles County Municipal Storm Water permit requires LID measures to be implemented for certain new and redevelopment projects. These LID requirements need to be implemented as soon as possible and we encourage municipalities in the Malibu Creek Watershed to go beyond these requirements and reduce the project thresholds for new- and re-development projects that require compliance.

The presence of hardened surfaces, especially adjacent to creeks, increases the volume and rate of flow. This can alter the natural ecology of creeks and streams by increasing erosion and sedimentation.[13] The population in the Malibu Creek Watershed grew roughly 7.5% between 2000 and 2010.[14] Impervious surface area in the watershed has also increased over the last decade. In some areas, including the main stem of Malibu Creek, Triunfo Creek, and Medea Creek, the proportion of impervious surface greatly exceeds the 10% threshold (Table 2-1) that is known to cause permanent degradation of receiving waters and riparian habitat.[15] When compared to Heal the Bay's biological assessments, percent impervious area

Table 2-1: Percent Impervious Surface Area Upstream of Monitoring Sites

Monitoring Site	Site Name	% Impervious Surface Area Upstream of Site
Cheeseboro Creek	R6	2.1%
Upper Las Virgenes Creek	R9	2.4%
Upper Cold Creek	R3	2.5%
Solstice Creek	R14	2.8%
Arroyo Sequit	R19	2.9%
Lachusa	R18	4.1%
Mid-Cold Creek	M11	5.4%
Outlet Cold Creek	O2	6.1%
Mid-Las Virgenes Creek	M13	8.6%
Outlet Las Virgenes Creek	O5	9.2%
Outlet Malibu Creek	O1	11.7%
Mid-Malibu Creek, downstream	M15	12.1%
Triunfo Creek	O17	13.2%
Mid-Malibu Creek, upstream	M12	14.1%
Medea Creek	O7	21.2%
Total Malibu Creek Watershed		**11.9%**

Hardened Triunfo Creek. Photo credit: Heal the Bay

[11] Brabec, E. et al. 2002. Impervious surfaces and water quality: a review of current literature and its implications for watershed planning. *Journal of Planning Literature* 16(4): 499-514.
[12] City of Malibu, Malibu General Plan, available at: http://qcode.us/codes/malibu-general-plan
[13] Wood, P.J. & Armitage, P.D. 1997. Biological effects of fine sediment in the lotic environment. *Environmental Management* 21:203–17; Henley, W.F. et. al. 2000. Effects of sedimentation and turbidity on lotic food webs: a concise review for natural resource managers. *Reviews in Fisheries Science* 8:125–39
[14] US Census Bureau 2000 and 2010 population data, available at http://www.census.gov/prod/cen2000/phc-1-6.pdf and http://2010.census.gov/2010census/data/ (accessed Oct 10, 2011).
[15] Schueler, T. 1994. The importance of imperviousness. *Watershed Protection Techniques* 2(4): 100-111.

STATE OF THE HABITAT

MALIBU VALLEY FARMS

Malibu Valley Farms is an equestrian facility located in the rural area of southern Calabasas along Stokes Creek.

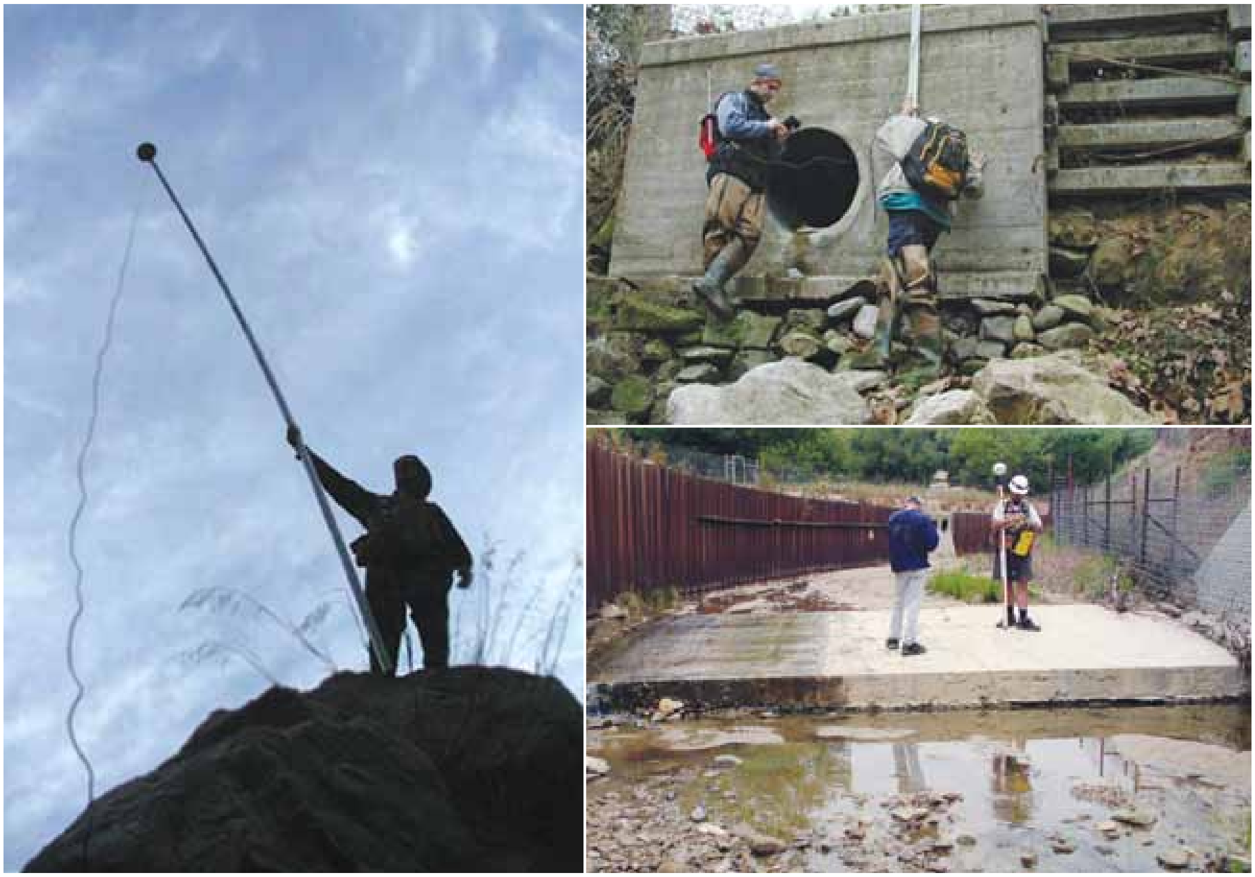
In 2006, Heal the Bay supported a Coastal Commission staff recommendation to deny an application for an after-the-fact request to permit development adjacent to and in Stokes Creek at the facility. The Commission approved the application despite opposition from environmental groups and community members concerned about habitat and water quality degradation from this site, and retroactively approved preexisting unpermitted development in and around the creek.

Monitoring below Malibu Valley Farms indicates that the facility is likely contributing to high bacteria concentrations in the creek, as well as manure, sand, and hay inputs to the stream. Further, erosion next to the corral fencing and associated hardened streambanks on the site is significant and has contributed sediment loading to the creek. Better practices should be put into place at Malibu Valley Farms to reduce their impact on the creek. Equestrian facilities must be built and managed in a way that is protective of the sensitive natural resources in the watershed, including riparian habitat and water quality. At a minimum, they must be sited at an appropriate distance (at least 100 feet from the outer edge of the riparian canopy) from creeks and waterways, and facilities should implement BMPs to eliminate nutrient and fecal indicator bacteria contaminated runoff in order to protect watershed health.

Stream Team staff mapping hardened streambank modification. Photo credit: Heal the Bay.

above 3% correlates strongly with decreasing biological integrity. All streams that are considered "poor" or "very poor" based on their biotic condition had impervious area greater than 6.3% (see Chapter 4). Monitoring and mitigating the increasing development associated with human population growth in the watershed is essential to preserving riparian habitat, biological diversity, and overall water quality.

With the trend towards increased development in areas that already have a relatively high percent impervious area, such as the City of Calabasas (as shown by the 2005 SCAG land use data), we may see a continued decline in biotic quality as these areas reach the threshold for permanent degradation. Examining the next version of SCAG land use data, when it is made available, will help lead to further identification of areas of increasing concern.



Mapping impairments in the watershed through the Stream Walk program (left), such as discharge points (right top) and streambank hardening (right bottom).

MAPPING THE WATERSHED: MALIBU CREEK STREAM WALK

Heal the Bay embarked on its Stream Walk program in 2000 to identify and map major impairments in the Malibu Creek Watershed. This program used teams of trained professional staff and volunteers to map Malibu Creek and its major tributaries. Crews conducted surveys and documented eroding streambanks, streambank modifications, invasive vegetation, instream algae, instream sediment, instream pool habitat, barriers to fish passage, large dump sites, impacting land uses, and discharge points and outfalls. These items were mapped using a global positioning satellite system (GPS) capable of sub-meter accuracy and documented with digital photographs. In addition, field crews documented potential causes of these conditions or impairments. GPS data were then corrected to improve the locational accuracy and imported in a geographic information system (GIS). This four-year mapping effort (2000-2004) resulted in detailed surveys of more than 70 miles of stream in the Malibu Creek Watershed.

STREAMBANK MODIFICATIONS AND STABILITY

Unstable streambanks suffer scour and erosion at rapid rates, and degrade habitat and water quality. Some causes of unstable banks include flow from discharge points and outfalls (e.g. storm drain outlets and dewatering pipes), riparian vegetation removal, grading, streambank hardening, increased runoff flows, upstream bank armoring, and straightening of stream channels. These instabilities negatively impact the watershed by decreasing riparian habitat, increasing fine sediments in the stream, and degrading in-stream habitat and water quality. Impervious surface cover near creeks and on streambanks, stream hardening, and straightening result in greater flow velocity and scouring, contributing to downstream erosion of streambanks. Impervious cover directly contributes to this problem; stream channels begin to widen at 6% impervious cover, and are generally considered unstable when impervious cover reaches 10%.[16]

During Stream Walk, unstable banks were mapped that had been scoured or eroded by stream flows, surface runoff from outflow pipes, and poorly drained roads and trails. Further, measurements were taken of the surface area and height of streambank collapses, the severity of the collapse, whether it was caused by surface runoff or stream flow, and the adjacent land use.[17] Figure 2-3 shows the locations of unstable streambanks mapped throughout the watershed, totaling 19.6 linear miles of the 68 miles mapped.

Three major causes of unstable streambanks and downstream sediment issues were observed during the course of this study: (1) increased impervious surface cover, channel straightening and/or hardening; (2) poorly sited and installed discharge outfalls; and (3) poorly drained roads and trails. Table 2-2 shows the bank modification mapping results for each creek, including linear miles of unstable streambanks, linear miles of modified streambanks, and discharge points.

Clockwise from top: Channelized upper Las Virgenes Creek; Channelized Lindero Creek; Channelized Medea Creek. Bottom: Photo credit: Heal the Bay

UNSTABLE BANKS IN UNDEVELOPED AREAS

Through spatial analysis, significant areas of bank erosion upstream of development were found in Palo Comado, Cheeseboro, and Las Virgenes Creeks in public open space. Since these areas did not appear to be impacted by urbanization, a closer look into the possible causes of instability revealed that numerous unpaved roads and trails were within 300 feet of eroded banks in upper Las Virgenes, Cheeseboro, and Palo Comado Creeks. Also, many of these streambanks have been noted as associated with poor trail drainage in the field data. Further, 27% of mapped unstable banks occurred within 100 feet of unpaved roads and trails, while 60-90% were within 150 feet. This analysis suggests that 100 foot buffer zones from unpaved roads and trails may be inadequate to mitigate streambank erosion caused by trails and roads, and the resulting sedimentation into streams.

[16] Paul, M.J. & Meyer, J.L. 2001. Streams in the urban landscape. *Annual Review of Ecology and Systematics* 32:333-365

[17] For more detailed description of these measurements see the Stream Team Field Guide at: http://www.healthebay.org/sites/default/files/pdf/Stream%20Team%20Field%20Guide_May2012.pdf

Figure 2-3: Streambank Modifications and Unstable Streambanks

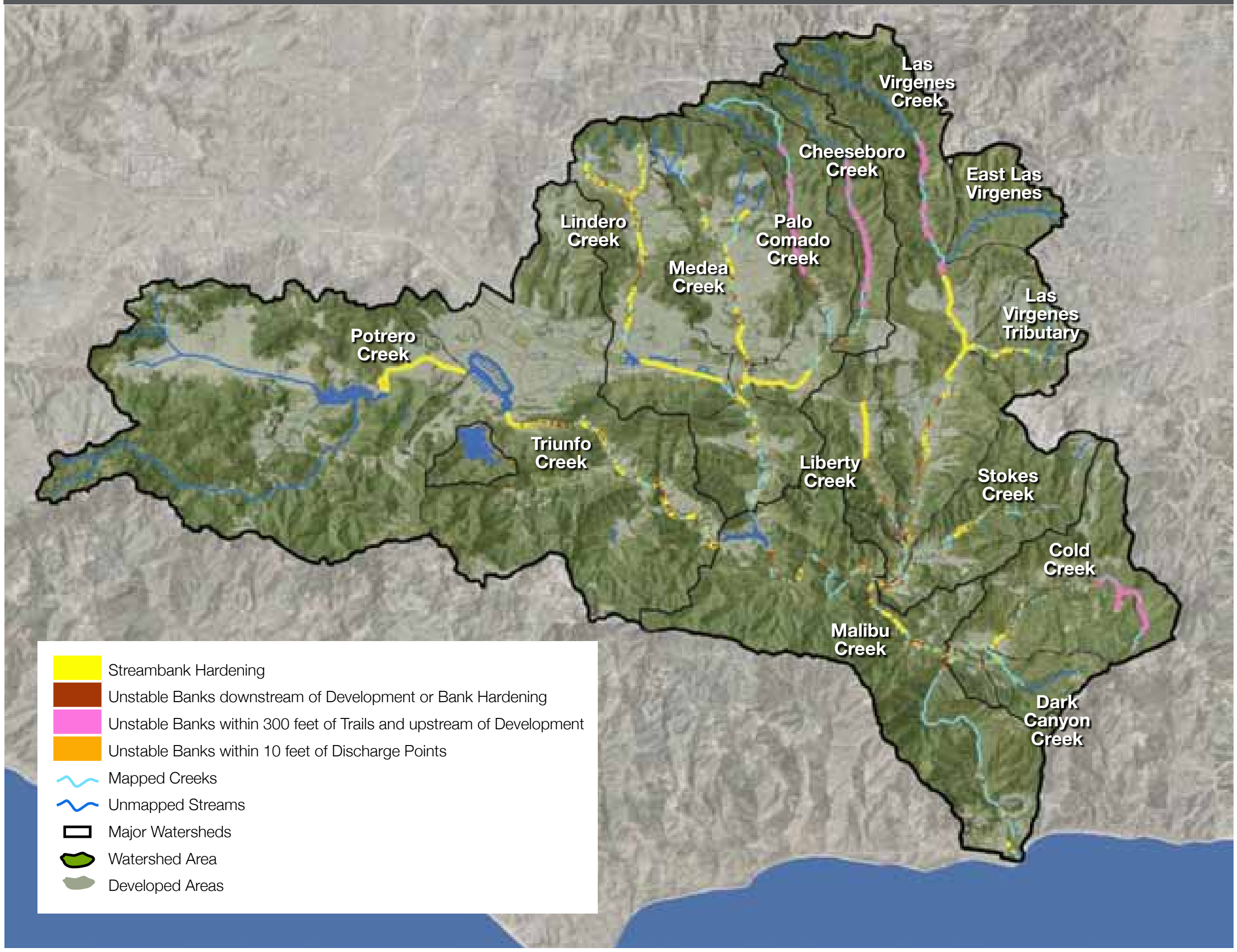


FIGURE 2-3: Streambank modifications and unstable streambanks throughout the Malibu Creek Watershed, mapped through Stream Walk (2000-2004).

Table 2-2: Impacted Stream Habitat

Creek	Miles mapped	Discharge points	Modified banks (hardening)		Unstable banks	
			Miles	Percent	Miles	Percent
Malibu Creek main stem	9.8	51	1.3	13%	2.9	30%
Cold Creek	5.7	36	0.8	14%	2.1	37%
Medea Creek	9.0	150	2.8	31%	1.9	21%
Las Virgenes Creek	8.8	99	3.1	35%	2.8	32%
Cheeseboro Canyon Creek	5.5	59	1.3	24%	2.0	36%
Lindero Creek	7.1	83	4.5	63%	1.5	21%
Palo Comado Creek	5.5	16	0.1	2%	1.7	31%
Triunfo Creek	4.9	48	2.6	53%	1.9	39%
Stokes Creek	4.5	22	0.7	16%	1.7	38%
Potrero Creek	2.0	55	1.9	95%	0.0	0%
Liberty Canyon Creek	2.6	15	1.0	38%	0.9	35%
Dark Canyon Creek	1.4	6	0.1	7%	0.0	0%
Las Virgenes tributary	1.0	28	0.7	70%	0.1	10%
Total/Average	**67.8**	**668**	**20.9**	**31%**	**19.5**	**29%**

TABLE 2-2: Impacted Stream Habitat. Discharge points, linear miles of modified streambanks, and linear miles of unstable streambanks along individual streams in the Malibu Creek Watershed, mapped through Stream Walk (2000-2004).

UNSTABLE BANKS DOWNSTREAM OF DEVELOPED AREAS

Creeks adjacent to areas of urban development had a larger proportion of streambanks altered by bank modifications than those surrounded by open space or less developed area. For example, Lindero, Las Virgenes, and Medea Creeks, all adjacent to urban development, have substantially more altered streambanks compared to Malibu Creek, which is surrounded by less development (Table 2-2 and Figure 2-4). Spatial analysis of the data indicates that severe streambank erosion often occurs downstream from large areas of bank hardening.

STREAMBANK MODIFICATIONS

In order to mitigate unstable streambank erosion, protect adjacent private property, and allow for access, streambanks are often modified for reinforcement with concrete, boulders, fencing, planted vegetation or other materials as an attempt to prevent or repair unstable banks. However, many of these artificially engineered solutions become unstable themselves and begin to impair creeks and streambank functions. Hardened streambanks and modifications eliminate riparian and instream pool habitats, prevent the natural uptake of pollutants, decrease the ability of wildlife to migrate, and exacerbate the problem of downstream bank erosion.

During mapping, Stream Team staff and volunteers identified 987 streambank modifications. The data suggest that streambank hardening and development in close proximity to streams negatively affect stream health and water quality, including increasing sediment scour downstream and potentially influencing decisions to place additional armoring as downstream erosion mitigation. The three most channelized creeks also have the greatest number of outfall pipes in the watershed: Lindero, Las Virgenes, and Medea Creek, which have 83, 99, and 150 outfall pipes respectively (Table 2-2). The extent of hardening in Potrero Creek is also notable, with cement channels or significant bank modifications along 1.9 miles of the total 2.02 miles mapped.

Figure 2-4: Unstable Streambanks along Las Virgenes Creek

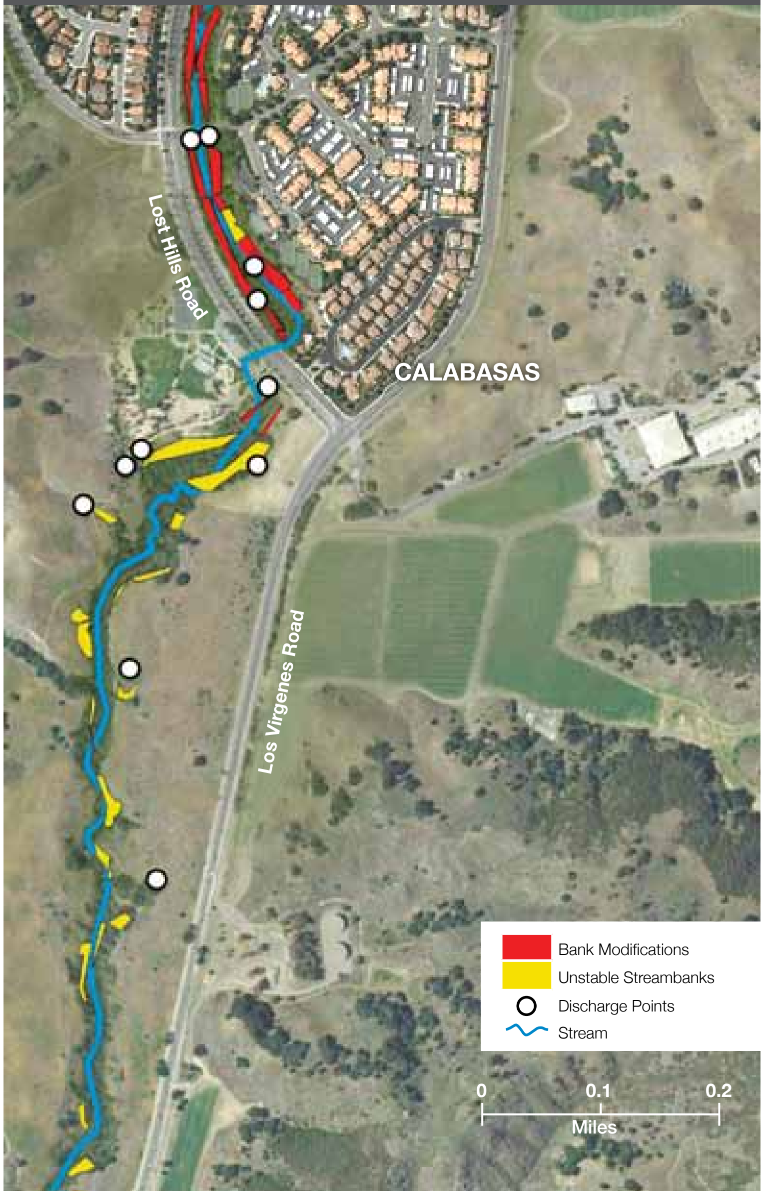


FIGURE 2-4: Unstable streambanks downstream of hardened bank modifications and outfall discharges on Las Virgenes Creek (along Lost Hills Road), mapped through Stream Walk (2000-2004).

Figure 2-5: Types of Streambank Modification Mapped

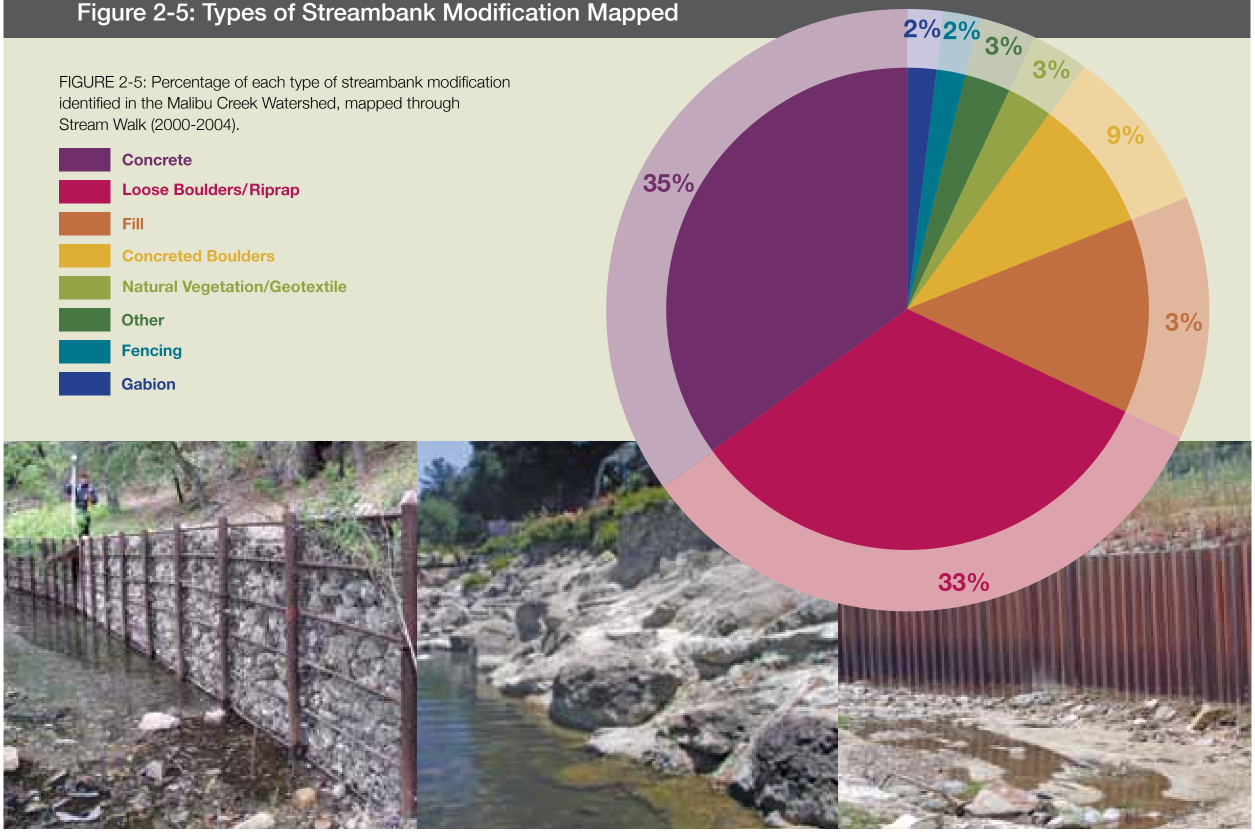


FIGURE 2-5: Percentage of each type of streambank modification identified in the Malibu Creek Watershed, mapped through Stream Walk (2000-2004).

Photos (left to right): Fencing and gabion, concrete boulders, corrugated fencing.

Artificial streambank modifications include hardened structures such as concrete, wood, metal, or rocks used to reinforce the banks of a waterbody. A total of 20.9 linear miles or 31% of all mapped streambanks were engineered with hardened materials. Through Stream Walk, the modifications, the materials used in the modification, as well as the current condition of the modification were documented. Simple concrete reinforcement was the most common modification in the watershed, followed by loose boulders and riprap, dirt fill, concreted boulders, and finally metal fencing and vegetation and/or geotextile coverings (Figure 2-5).

Further analysis indicated that 62% of the 987 individual streambank modifications mapped were either degraded or were failing altogether (Figure 2-6).[18] Over 65% of the modifications made of loose boulders/riprap, concreted boulders, and gabion were unstable or failing. A large portion of modifications made of concrete or metal fencing were also unstable or failing (approximately 40% for each type). Vegetation/geotextile and fill modifications, considered slightly more natural bank modifications, had an instability rate of 21% and a failure rate of 30%.

Figure 2-6: Percentage of Failing Bank Modifications by Type

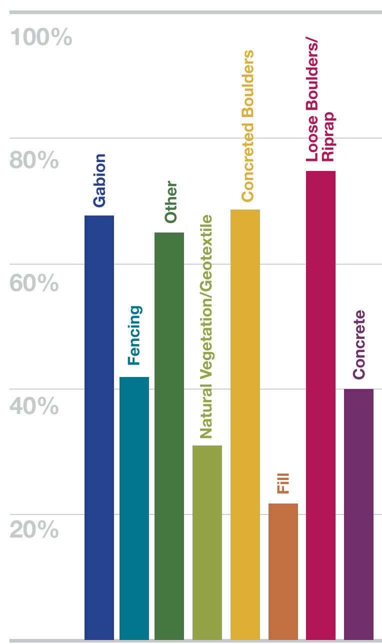


FIGURE 2-6: The percent of degraded or failing streambank modifications by type in the Malibu Creek Watershed, mapped through Stream Walk (2000-2004).

[18] Instability is defined as significant cracking, collapsing, undercutting, or downcutting.

DISCHARGE POINTS

Discharge points, or outfall pipes, are also prevalent throughout the area – 668 discharge points were documented in the Malibu Creek Watershed. There were more discharge points per mile of stream in urbanized areas and channelized creeks than natural areas within the watershed. Many of the discharge points and outfalls were associated with substantial gullying, streambank erosion, and sedimentation in the creeks. An analysis of the mean surface area of each unstable bank within a specific distance of a known discharge point demonstrated that the mean surface area of erosion decreased as distance from the discharge point increased.

Further, the area of unstable streambank increased dramatically with pipe outfalls greater than 12 inches in diameter discharging onto a natural bank (Figure 2-7). The greatest erosive effects were seen closest to the outfall pipe, but impacts associated with discharge points greater than 12 inches in diameter were still frequently seen at 50 feet from the outfall.

Erosion around discharge points and culverts is a significant and continuing problem that has not been well addressed in the watershed. More natural dissipation measures should be employed to decrease the area of unstable streambanks in the watershed. Installing step pools, sloping pipes across streambanks rather than straight down, and decreasing the use of culverts would decrease the effect of these discharges on streambanks.

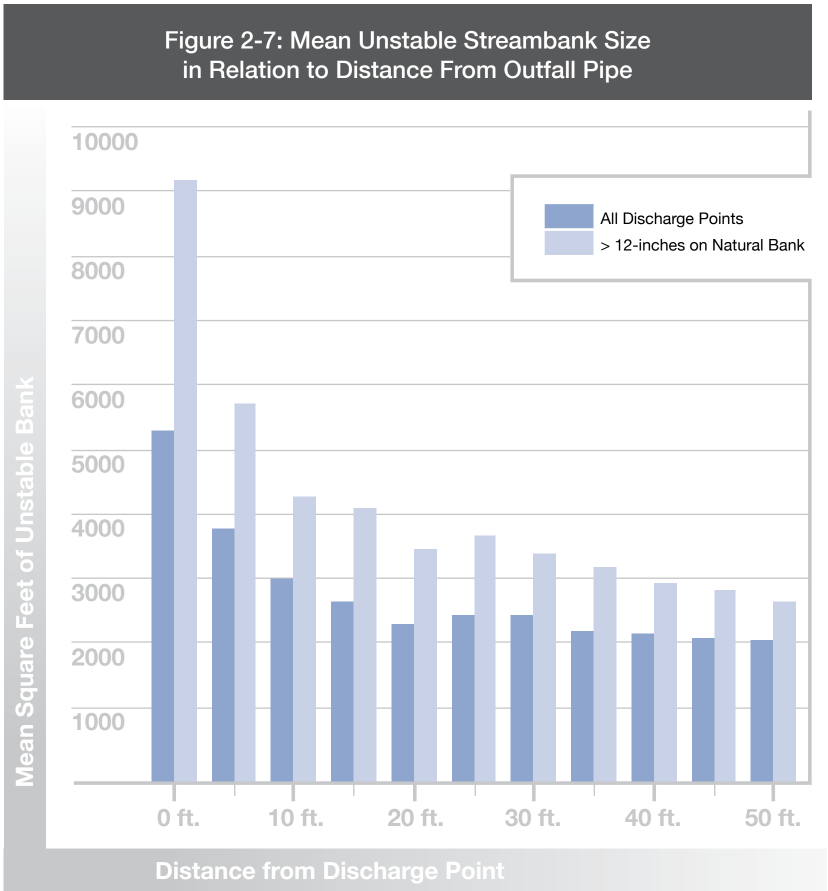


FIGURE 2-7: Unstable streambank area as related to the distance from discharge points, mapped through Stream Walk (2000-2004). Dark blue bars represent an average of all the discharge points in the watershed, and light blue bars represent discharge points of pipes at least 12 inches in diameter and draining onto naturally vegetated slopes.

STATE OF THE HABITAT

CHANGES IN STREAMBANK MODIFICATIONS

In 2010 and early 2011, some of the major mapped sites were revisited to document any changes since the initial mapping effort. Many of the mapped bank modifications have become more degraded or continued to fail since the original mapping effort. The riprap on lower Malibu Creek adjacent to the Mariposa property and its associated unstable streambanks, and the bank hardening and undercut banks in Triunfo Creek, are prime examples of the effects of streambank modifications and unstable banks on riparian habitat. The photos shown in Figures 2-8, 2-9, and 2-10 were taken when these sites were revisited, and are compared to the original mapping from 2000 through 2004.

The riprap in lower Malibu Creek adjacent to the Malibu Creek Shopping Center provides an excellent, but unfortunately not unusual, example of the effects of streambank modification on riparian habitat. Following the 1998 El Nino and flooding events, the Coastal Commission approved a temporary streambank modification including large rocks, known as riprap, to stop the streambank from eroding further into private property. In early 2009, the revetment owners applied to permanently retain the approximately 500 linear feet of riprap. Despite inconsistencies with the City of Malibu's Local Coastal Program, the City and Coastal Commission approved a permit for permanent placement of the riprap in August 2012 with some efforts to add vegetation. However, as shown below, streambank scouring downstream from the riprap is causing erosion and will likely encroach on the commercial property and Malibu Lagoon State Park just below this area.

Figure 2-8: Riprap and Downstream Scour in Lower Malibu Creek

FIGURE 2-8: Digitized figure of riprap and downstream scour from 2000 to 2004 at the Mariposa property in lower Malibu Creek. Photos taken in 2011 to show similar conditions as previously mapped.

Figure 2-9a: Streambank Modifications and Associated Erosion in Triunfo Creek at Kanan Road

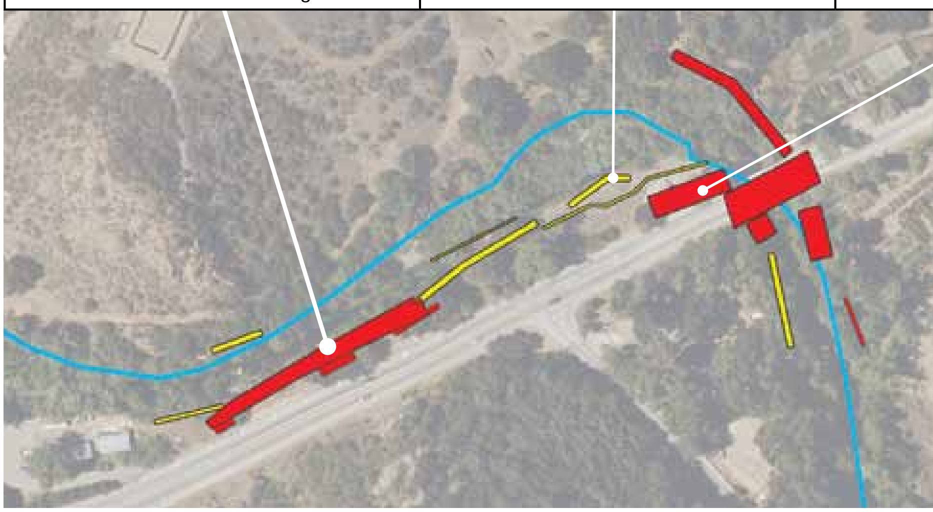


Figure 2-9a: Streambank Modifications and Associated Erosion in Triunfo Creek. Digitized figure of streambank hardening, failing modifications, and downstream erosion in Triunfo Creek near Kanan Road, mapped between 2000 and 2004 (stream flows from left to right). Photos taken in 2011 at the same sites as previously mapped. Triunfo Creek is a tributary to Malibu Creek in the middle of the watershed, well above the Lower Malibu Creek streambank modifications and scour photos shown in Figure 2-8.

Figure 2-9b: Streambank Modifications and Associated Erosion in Triunfo Creek at Mulholland Highway

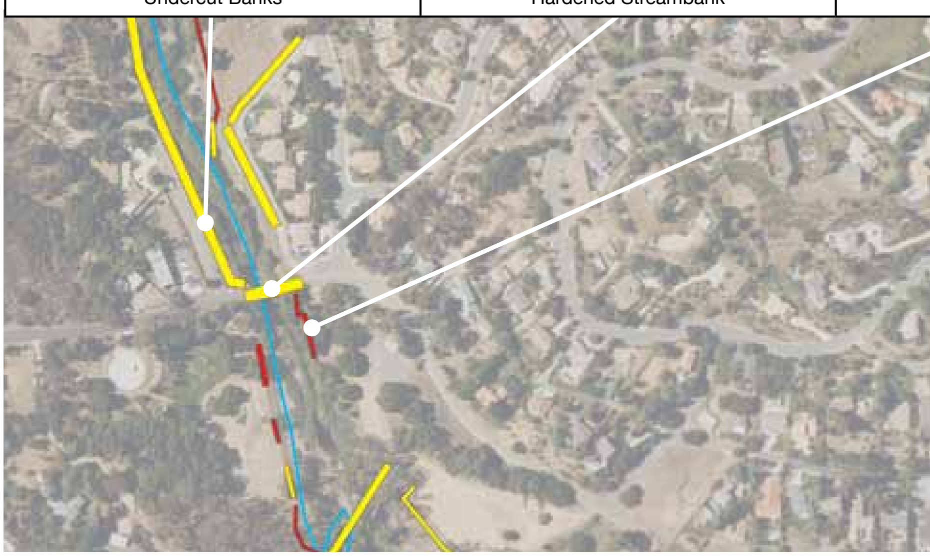


Figure 2-9b: Streambank Modifications and Associated Erosion in Triunfo Creek. Digitized figure of undercut streambank, hardened banks, and downstream erosion mapped between 2000 and 2004. Photos taken in 2011 to show similar conditions as previously mapped. Triunfo Creek is a tributary to Malibu Creek in the middle of the watershed, well above the Lower Malibu Creek streambank modifications and scour photos shown in Figure 2-8.

Clockwise from top: Sites impacted by street litter and streamwashed debris (top) and abandoned vehicles (bottom). Photo credit: Heal the Bay

DUMP SITES

Between 2000 and 2004, 742 dump sites were identified in the Malibu Creek Watershed through Stream Walk, totaling nearly 625,000 square feet. Dump sites included illegal dumping of construction, landscaping, or household waste by haulers or homeowners; street litter and streamwashed debris (trash that has entered the storm drain system and is then transported downstream by creek flows); and abandoned structures and materials from agricultural areas, and/or ranches. The entire area of each dump site was documented, and the type of debris and probable sources were identified. The average dump site size was about 840 square feet.

Figure 2-10 illustrates mapped dump site locations throughout the watershed. The majority of illegal dumping and streamwashed debris occurred in developed areas and near major roads. Much of the mapped debris was household waste, most likely from individuals who used these streams as a dump site. Larger construction and landscaping related waste indicates that waste haulers and contractors contributed significant debris to the watershed. The high number of mapped dump sites in Las Virgenes Creek and Medea Creek are especially concerning, with 173 and 161 dump sites respectively.

Much of the mapped streamwashed debris consisted of food wrappers, single-use plastic bags, food-related foam items, broken pieces of expanded polystyrene, and cigarette butts. Numerous locations where picnickers simply abandoned their trash were also documented. Several abandoned structures were also identified, which usually occurred on public lands.

Based on trash data collected by Heal the Bay and other organizations over the past decade, significant efforts have been taken in the watershed to prevent and reduce trash from getting into the environment. A zero Trash TMDL was established by the Los Angeles Regional Water Quality Control Board in July 2009 for the Malibu Creek Watershed. The creeks listed on the 303(d) List of Impaired Waterways for trash include Medea Creek, Las Virgenes Creek, Malibu Creek, and Lindero Creek.

The Trash TMDL implementation plan requires the implementation of structural and non-structural best management practices (BMPs) to capture all of trash before it reaches these waterways. Examples of these BMPs include catch basin screens and inserts; hydrodynamic separators (flow-through structures inserted into the storm-drain system that allow trash to settle and be separated from the water); and other technologies. If implemented effectively, this regulation will greatly reduce trash in the watershed.

Additionally, some local governments have enacted ordinances addressing commonly littered items. In 2005, the City of Malibu banned polystyrene food containers at restaurants, followed by a plastic carryout bag ban at all retailers within the city in 2008. The City of Calabasas also adopted an expanded polystyrene food container ban in 2008, and an ordinance banning plastic carryout bags and charging for paper bags at grocery and convenience stores in 2011. Los Angeles County also adopted an ordinance in 2010 that bans plastic carryout bags and places a cost on paper bags at grocery and convenience stores in unincorporated areas of the county, which includes areas near Agoura and the Mulholland corridor.

However, despite these improvements, dumping in the creek, particularly construction and landscape waste, remains a serious issue which needs to be addressed. Based on the number of dump sites in the watershed, efforts must be taken to curb illegal dumping, remove trash and litter before it enters waterways, and address abandoned structures and agricultural debris in the watershed.

Figure 2-10: Dump Sites in the Malibu Creek Watershed

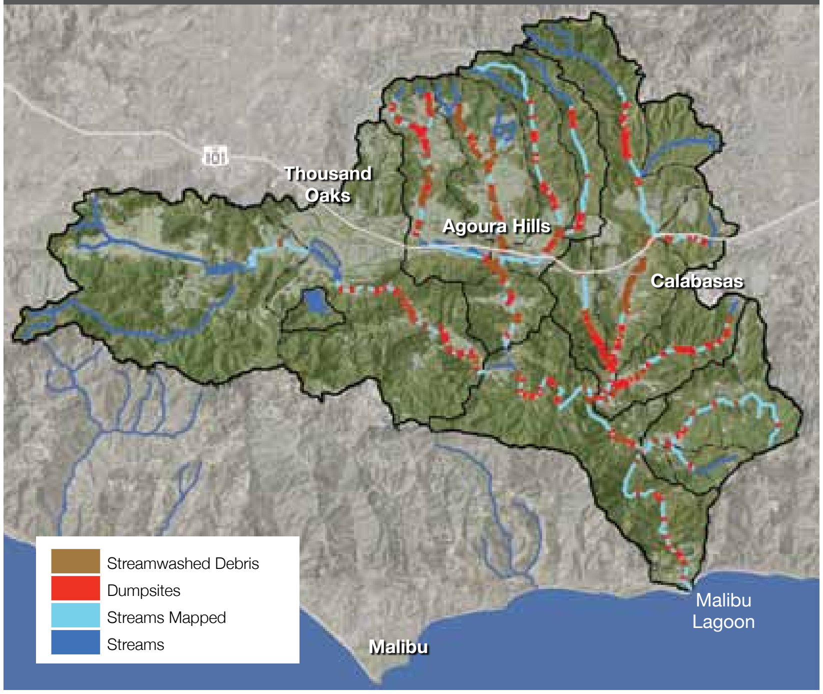


FIGURE 2-10: Map of dump sites located in riparian areas throughout the watershed, mapped through Stream Walk (2000-2004).

Much of the mapped streamwashed debris consisted of food wrappers, single-use plastic bags, food related foam items, broken pieces of expanded polystyrene, and cigarette butts. Numerous locations where picnickers simply abandoned their trash were also documented.

STATE OF THE HABITAT

Abnormally high sediment in Las Virgenes Creek due to construction site (see page 99). Photo credit: Heal the Bay

EXCESS FINE SEDIMENTS

The sediment, sand, gravel, cobble, and boulders that comprise the bottom of a stream channel are collectively referred to as the stream substrate. Substrate type is particularly important for steelhead trout and the benthic macroinvertebrates on which they feed. Substrate embeddedness measures how much of the substrate is buried or surrounded by fine sediments and/or sand. Steelhead prefer spawning in reaches of stream that have gravel substrate with low levels of embeddedness; high levels of fine sediment decrease survival of steelhead eggs and fry.[19]

Heal the Bay mapped streams with substrates dominated by fine sediments and/or sand, and where gravel, cobbles, and boulders were embedded by 50% or more. Embeddedness was determined utilizing the State Water Resources Control Board SWAMP protocol. Embeddedness counts were conducted randomly in multiple locations along stream segments. The percent buried depth of at least 10 individual substrate particles was measured at several locations along the length of the stream segment.[20] The average embeddedness of a stream segment was determined by calculating the mean of the embeddedness values of the individual particles measured within each survey reach. Embeddedness was only measured in riffles and glides. Pools were excluded from this analysis because of their natural tendency to collect fine sediments.

[19] Reiser, D.W. & White, R.G. 1988. Effects of two sediment size-classes on survival of steelhead and Chinook salmon eggs. *North American Journal of Fisheries Management* 8: 432-437.

[20] The crew member visually inspected each sediment particle and estimated the amount of the particle that was buried by fine sediments. For example, if a piece of gravel was buried halfway, it was considered 50% embedded. This method is recommended by Kaufman et al. 1999 (Kaufmann, P.R., Levine, P., Robinson, E.G., Seeliger, C., & Peck, D.V. 1999. Quantifying physical habitat in wadeable streams. EPA/620/R-99/003. U.S. Environmental Protection Agency, Washington, D.C.); Ode, P.R. 2007. Standard operating procedures for collecting macroinvertebrate samples and associated physical and chemical data for ambient bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 001.

The mapping data show that large areas within the watershed are dominated by fine sediments (Figure 2-11). Based on surveys of approximately 70 miles of glides and riffles, 21.29 miles (32%) of all surveyed streams were impaired by excess fine sediments (Table 2-3). Only 0.29 miles of 21 miles (1.4%) of sediment-impacted stream segments occurred upstream of developed areas. Sedimentation in these areas may be due to roads and trails in parklands that are poorly maintained or too close to creeks. Lindero Creek and Stokes Creek were the most impacted creeks by fine sediments, with a respective 65% and 50% of the substrate throughout these streams dominated by fine sediments. Large stretches of Malibu Creek, Cold Creek, Medea Creek, and Triunfo Creek also had substrate dominated by fine sediments. Dark Canyon Creek (a tributary of Cold Creek), and portions of Las Virgenes Creek had some segments that did not have excessive sedimentation.

Steelhead prefer spawning in reaches of stream that have gravel substrate with low levels of embeddedness; high levels of fine sediment decrease survival of steelhead eggs and fry.

There are many sources of excess fine sediment in creeks. Streambank erosion was a major source of sedimentation in Las Virgenes and several other creeks. With focused monitoring, a major sediment source in Las Virgenes Creek was mapped between March 2004 and January 2005. During this period, runoff from several storms transported massive amounts of sediment from a construction site near the creek. The fine sediment was carried from the site onto the floodplains and into the high-flow channel of Las Virgenes Creek. Despite efforts by the site developer to maintain and enhance sediment control practices on the site, the repeated sediment spills were beyond the capacity of the BMPs implemented. Construction-related runoff, and the associated BMPs for control, must be better sized, maintained, and monitored to help understand whether failing or inadequate BMPs are contributing to sediment loading in the watershed. Additionally, the Los Angeles Regional Water Quality Control Board needs to perform more site inspections to understand the construction related issues leading to excessive sedimentation. (See Chapter 3 for more information on turbidity).

Figure 2-11: Streams Impacted by Excess Fine Sediments

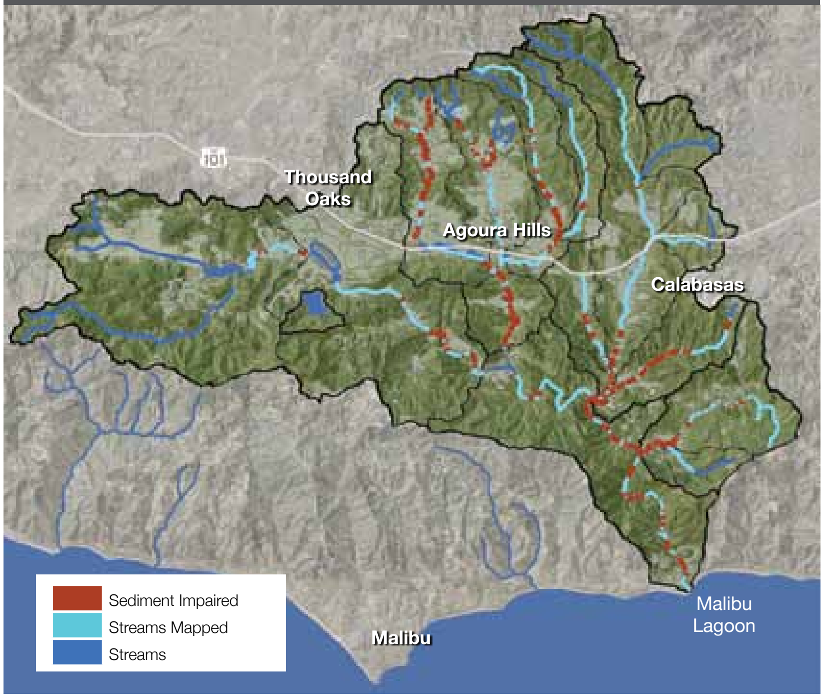


FIGURE 2-11: Streams throughout the Malibu Creek Watershed impacted by excess fine sediments, mapped through Stream Walk (2000-2004).

Malibu Creek, Medea Creek, Las Virgenes Creek, Lindero Creek, and Triunfo Creek are all listed as impaired for sedimentation/siltation on the 303(d) List of Impaired Waterbodies. The TMDL for sedimentation for Malibu Creek is supposed to be completed by March 2013[21]; however, Los Angeles Regional Water Quality Control Board development of the TMDL and more detailed source examination has not yet begun. Development and implementation of this TMDL should greatly reduce sedimentation in parts of the watershed.

Table 2-3: Streams Impacted by Excess Fine Sediments

Creek	Miles mapped	Miles impacted	% of creek impacted
Malibu Creek main stem	9.8	3.8	39%
Cold Creek	5.7	2.0	35%
Medea Creek	9.0	3.7	41%
Las Virgenes Creek	8.8	1.6	18%
Cheeseboro Canyon Creek	5.5	0.6	11%
Lindero Creek	7.1	3.8	54%
Palo Comado Creek	5.5	1.5	27%
Triunfo Creek	4.9	1.2	24%
Stokes Creek	4.5	2.3	51%
Potrero Creek	2.0	0.4	20%
Liberty Canyon Creek	2.6	0.5	19%
Dark Canyon Creek	1.4	0.0	0%
Las Virgenes tributary	1.0	0.0	0%
Total	**67.8**	**21.4**	**32%**

TABLE 2-3: Streams Impacted by Excess Fine Sediments. Extent of siltation in Creeks throughout the Malibu Creek Watershed (reported in miles impacted and percent of total area mapped impacted), mapped through Stream Walk (2000-2004). Creeks in **bold** are listed on the 303(d) list of Impaired Waters for sedimentation/siltation.

In March 2004, Heal the Bay's Stream Team documented severe construction related runoff from the Shea Homes development located along the east slope of Las Virgenes Road in Calabasas. *See page 99 for details.* *Photo credit: Heal the Bay*

[21] US EPA Region 9. Status of LA Consent Decree TMDLs – State Adoption & EPA Establishment. Available at: http://www.epa.gov/region09/water/tmdl/la-lakes/LaConsentDecreeTMDLsRevSched2.pdf

Invasive plant removal at Malibu Creek State Park. Photo credit: Heal the Bay

STREAM TEAM SURVEYS AND RESTORATION ACTIVITIES

Exotic and invasive vegetation is a serious threat to the native species and biological diversity in the Malibu Creek Watershed. Invasive vegetation frequently spreads into natural areas and displaces the native vegetation. Often times the invaders do not provide food or habitat for native wildlife. Invasive plants usually have shallower root structures, which in riparian areas can lead to streambank erosion and increased sediment loading to our streams. Additionally, many of these species are not adapted to the reoccurring fires of southern California, and burn hotter and faster than native plants.

EXOTIC AND INVASIVE VEGETATION

Between 2000 and 2004, Stream Team field crews documented extensive areas of invasive riparian vegetation in the watershed. Twenty-six percent of the total stream miles mapped in the watershed were impacted by invasive vegetation (out of a total area of 91 acres). The five most common species in order of area impacted were periwinkle (*Vinca major*), spurge (*Euphorbia* sp.), fennel (*Foeniculum vulgare*), giant reed (*Arundo donax*), and eucalyptus trees (*Eucalyptus* sp.), which in combination, totaled more than 2,600,000 square feet of invasive vegetation on streambanks (Figure 2-12 and Table 2-4).

In 2004, Stream Team implemented a vegetative restoration program focusing on several sites along Las Virgenes, Stokes, and Malibu Creeks. The program worked closely with California State Parks and focused on sites within Malibu Creek State Park. Stream Team staff and volunteers worked over the course of approximately three years to remove non-native plant species and replant natives by hand from the State Parks greenhouse and other local nurseries.

In some of the restoration areas, species diversity improved; however, the overall results were not substantial. Volunteer-based vegetative restoration only allowed for focus on small patches throughout the State Park, and success was limited without regular maintenance of the site. As a result, many Heal the Bay restoration sites repopulated quickly with non-native and invasive vegetation before native plants had the opportunity to establish. Areas with continued effort, such as the Braille Trail in Malibu Creek State Park, showed improvement with focused and repeated efforts. Further, a lack of financial resources and staffing shortages complicated the joint effort between Heal the Bay and State Parks. In 2009, Heal the Bay chose to refocus its efforts on other watershed health monitoring and improvement projects, as vegetative restoration did not prove to be an effective use of time or resources for habitat improvement. Invasive vegetation has reestablished in some of these areas without the necessary, routine invasive plant management in this area.

Various resources agencies, non-profit organizations, and student groups in the Santa Monica Mountains, including the National Park Service, California State Parks, Mountains Restoration Trust (MRT), and Resource Conservation District of the Santa Monica Mountains, currently dedicate significant time and resources to curb the proliferation of invasive species. These programs are most successful when there is dedicated staff and resources for site and plant management and maintenance. Instead of taking a lead role on vegetative restoration, Heal the Bay has recently partnered with groups like MRT to recruit volunteers for their restoration efforts.

Figure 2-12: Invasive Riparian Vegetation

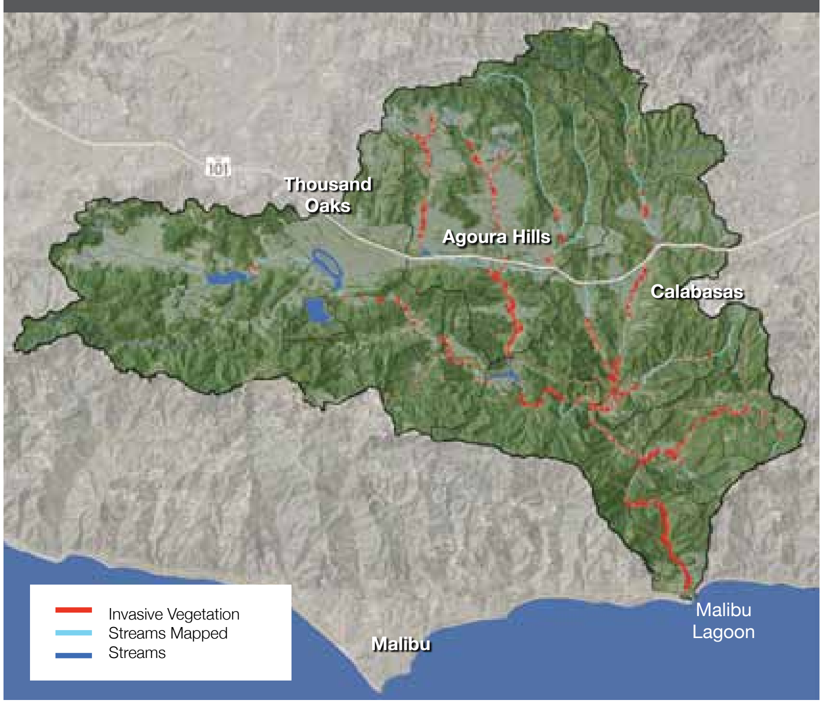


FIGURE 2-12: Map of invasive and exotic vegetation in riparian zones throughout the Malibu Creek Watershed, mapped through Stream Walk (2000-2004).

Invasive plants (clockwise from top left): Ivy, Arundo, Vinca, Pampas Grass, Fennel, Eucalyptus. Photo credit: Heal the Bay

Table 2-4: Extent of Invasive Riparian Vegetation			
Creek	Miles mapped	Miles impacted	% of creek impacted
Malibu Creek main stem	9.8	4.7	48%
Cold Creek	5.7	2.2	39%
Medea Creek	9.0	3.0	33%
Las Virgenes Creek	8.8	2.3	26%
Cheeseboro Canyon Creek	5.5	0.2	4%
Lindero Creek	7.1	1.7	24%
Palo Comado Creek	5.5	0.4	7%
Triunfo Creek	4.9	1.4	29%
Stokes Creek	4.5	0.8	18%
Potrero Creek	2.0	0.1	5%
Liberty Canyon Creek	2.6	0.6	23%
Dark Canyon Creek	1.4	0.3	21%
Las Virgenes tributary	1.0	0.2	20%
Total	**67.8**	**17.9**	**26%**

TABLE 2-4: Extent of Invasive Riparian Vegetation. Extent of invasive vegetation in riparian zones throughout the Malibu Creek Watershed (reported in miles impacted and percent of total area mapped impacted), mapped through Stream Walk (2000-2004).

Rindge Dam. Photo credit: Heal the Bay

CREEK BARRIERS

The Malibu Creek watershed supports numerous native aquatic species, including the threatened California red-legged frog, the arroyo chub (CDFW Species of Special Concern), the endangered southern steelhead trout, and the western pond turtle (CDFW Species of Special Concern).[22] However, much of the aquatic habitat is unavailable to fish and amphibians because of physical barriers, such as dams and crossings that block fish from reaching high-quality habitat upstream. The proliferation of invasive and exotic aquatic species that prey on native species has been a problem as well. Malibu Creek and its tributaries have suffered habitat loss from channelization, sedimentation, and degraded water quality, but a substantial amount of high-quality habitat remains throughout the watershed, especially in the upper areas. Steelhead are anadromous, migrating from the sea to freshwater streams to spawn. They are particularly affected by barriers in the lower watershed, most notably Rindge Dam, which limit access to high quality upstream spawning habitat. Obstructed access to spawning and feeding habitat is a limiting factor in the population size that can be supported within the watershed. The current steelhead population in the Malibu Creek Watershed and throughout southern California is greatly reduced from its historic numbers.

[22] Riley, S.P.D. et al. 2005. Effects of urbanization on the distribution and abundance of amphibians and invasive species in southern California streams. *Conservation Biology* 19(6):1894-1907; Dagit, R. 2003. Western Pond Turtle Study in the Topanga Creek Watershed: First Year Report May 2002-2003. Resource Conservation District of the Santa Monica Mountains, Topanga, CA.

Figure 2-13: Prioritized Stream Barrier Removal

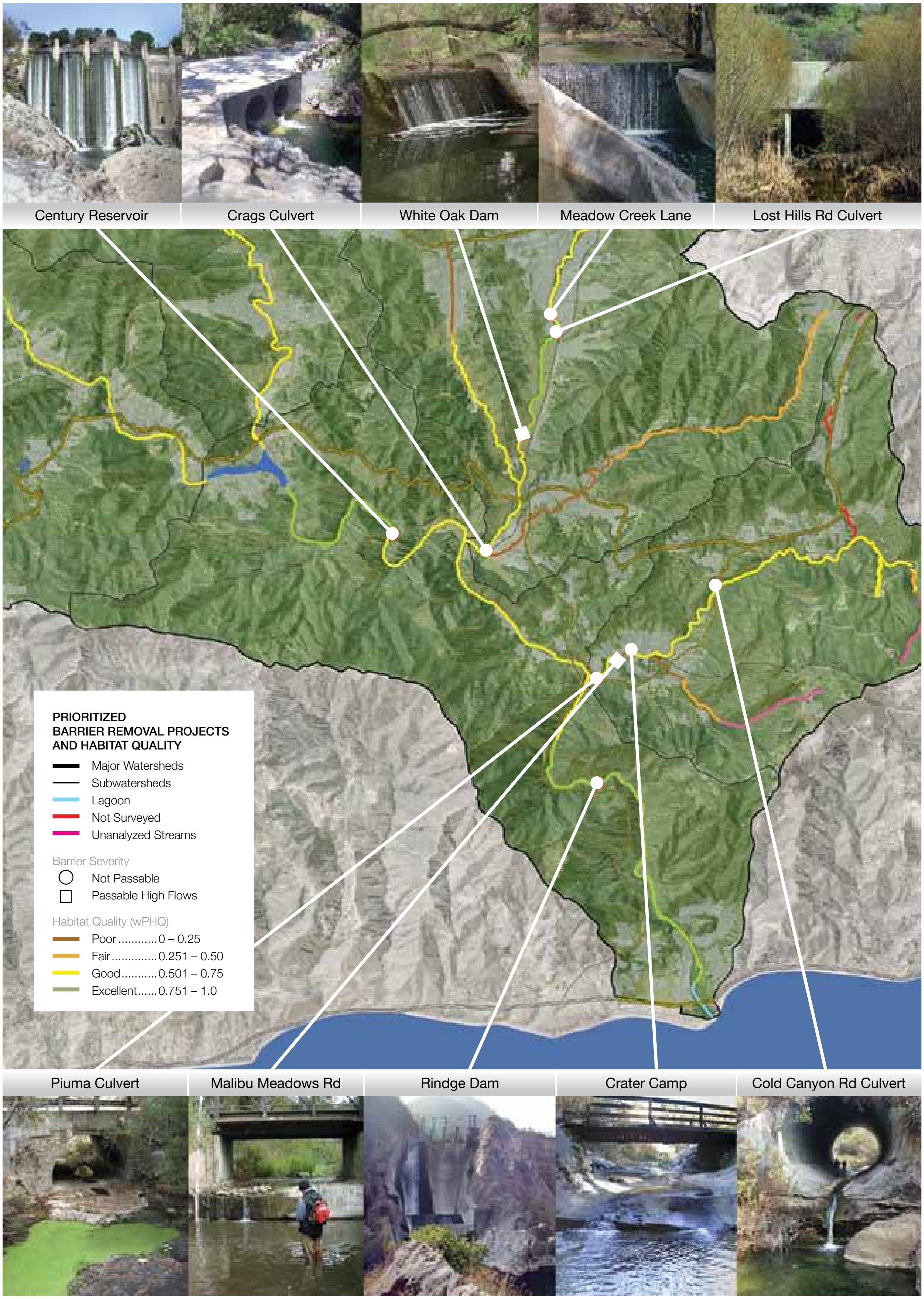


FIGURE 2-13: Ten priority sites for stream barrier removal to improve steelhead and aquatic life access to spawning and feeding habitat.

Top row and bottom left: Texas Crossing barrier in Malibu Creek. Bottom right: Heal the Bay team and State Parks staff remove Texas Crossing barrier in October and November 2006. Photo credit: Heal the Bay

Malibu Creek today after removal of the Texas Crossing barrier. Photo credit:Heal the Bay

In 2005, Heal the Bay's Stream Team surveyed approximately 70 linear miles of streams in the Malibu Creek Watershed and mapped potential fish barriers, in-stream pool habitat, pool substrate types, pool substrate embeddedness, percent pool shelter cover, and exotic predator species. A total of 201 potential barriers were mapped, followed by identification of a list of the top 10 priority barriers that should be targeted for removal as shown in Figure 2-13. Removal of priority barriers will provide aquatic life access to 6.86 miles of additional habitat on Malibu Creek, 4.39 miles on Las Virgenes Creek, and 4.83 miles on Cold Creek. It will also provide access to 0.58 miles of Stokes Creek, 1.78 miles of Liberty Canyon Creek, 0.24 miles of Dark Canyon Creek, and an undetermined amount of habitat on Dry Canyon Creek, a tributary of Cold Creek that was not mapped. The Santa Monica Bay Restoration Commission has an overall goal of increasing steelhead habitat in the Santa Monica Mountains by 20 miles.[23] Removing these barriers would achieve 93% of that goal by providing access to at least 18.68 additional miles of available habitat (a 622% increase).

In October and November 2006, Stream Team and State Parks staff worked to remove a Texas Crossing in the Malibu Creek State Park. This elevated crossing was a barrier to fish and aquatic life passage. Approximately one-third of the 220-by-30 foot crossing was removed by hand use of sledgehammers with feathers and wedges, to protect the stream. The remainder was removed using Bobcats equipped with breaker bars for stream protection. Altogether, more than 350 tons of concrete and 30 tons of steel were removed from the creek, and recycled. The removal of this barrier resulted in access to over a mile of excellent habitat upstream.

RINDGE DAM

Rindge Dam, built in 1926, is a 100-foot dam located in the lower watershed of Malibu Creek about three miles upstream from the Malibu Lagoon. The dam was originally created as a reservoir, but quickly filled with sediment and no longer effectively serves this purpose. Beginning in 1999, the Army Corps of Engineers began a feasibility study to assess removal options for Rindge Dam. Fourteen years later, the study has yet to be completed, despite the already significant amount of financial and public resources devoted to the project. Completing the feasibility study is necessary to fully examine the potential options for dam removal and the benefits of the project, such as improving the quality of and access to fish and amphibian habitat in the Malibu Creek Watershed. The Army Corps of Engineers has recently reconvened the Rindge Dam Technical Advisory Committee and has re-engaged efforts to plan for Rindge Dam removal.

[23] Santa Monica Bay Restoration Commission. 2008. The Bay Restoration Plan. Available at: http://www.smbrc.ca.gov/about_us/smbr_plan/docs/smbrplan2008.pdf

In 2004, Serra Retreat homeowners and the Santa Monica Bay Restoration Commission funded the removal of the Arizona crossing and bridge replacement near Serra Retreat at the bottom of the watershed. This was a critical restoration project, as it resulted in the removal of the furthest downstream barrier to steelhead migration in Malibu Creek.

Despite the presence of Rindge Dam in the lower watershed, removing barriers upstream is still extremely important. Removing Texas and Arizona Crossings, before the removal of Rindge Dam, benefits fish, invertebrates, and other aquatic life that live in the upper watershed by providing more habitat access. These restoration activities also allow natural sediment transport downstream. Barriers restrict the natural flow of sediment downstream, thus causing sediment starved waters to increase streambank erosion below the barriers. Barrier removal projects in the upper watershed are also less expensive to complete because it is not currently an active steelhead area, which would necessitate additional permitting requirements and greater protection of sensitive aquatic species. Removing stream barriers throughout the Malibu Creek Watershed will help restore natural flows, improve habitat quality, and re-establish a more normal sediment regime.

The Malibu Creek watershed supports numerous native aquatic species, including the threatened California red-legged frog, the arroyo chub, the endangered southern steelhead trout, and the western pond turtle.

Clockwise from above: Barrier removal at Solstice Canyon; Red-Legged Frog; Arroyo Chub; Western Pond Turtle; juvenile Steelhead Trout. Photo credit: Heal the Bay

Volunteer group removing invasive Vinca along Stokes Creek. Photo credit: Heal the Bay

RECOMMENDATIONS

Despite the common perception that the Malibu Creek Watershed is a largely open, natural area, physical habitat assessments reveal that riparian habitat is heavily disturbed, including streambank alterations and other human disturbances. Several streams throughout the watershed are impacted by hardening, erosion, loss of riparian habitat, and sedimentation. Protecting our streams and riparian buffers from modification and development is one of the top priorities for Heal the Bay and the Santa Monica Bay Restoration Commission.

Development in the watershed is guided by several different plans and regulations. Areas within the Coastal Zone (see Figure 1-1) are regulated by the California Coastal Act, and related Local Coastal Programs, while areas outside the Coastal Zone, which are not in state or federally owned land, are only regulated by local government plans. Water quality protection in the watershed is primarily managed by the Los Angeles Regional Water Quality Control Board.

The adoption and implementation of ordinances or policies by local governments requiring LID would help to improve water and habitat quality in the watershed. Such policies would require that measures be implemented to reduce stormwater runoff and pollutant loading to streams through retention of runoff during storm events, such as infiltration or capture and reuse for irrigation. A comprehensive LID approach to polluted runoff management in the watershed could possibly result in elevated impervious area on a macro scale; however, impervious area would not increase as drastically as development without LID.

RECOMMENDATIONS FOR DEVELOPMENT WITHIN THE COASTAL ZONE

Under the California Coastal Act, local governments are required to develop a Local Coastal Program (LCP) to aid in planning and to regulate development in coastal area. The LCP contains two documents, the Land Use Plan (LUP) which regulates policy, and the Local Implementation Plan

Streams of the watershed in hardened and natural states. Photo credit: Heal the Bay

(LIP) which outlines how policy will be implemented in the area. If a county or city does not have an LCP, the Coastal Commission regulates development in the otherwise unprotected Coastal Zone.

The City of Malibu LCP was certified by the Coastal Commission in 2002. Environmentally Sensitive Habitat Area (ESHA) is defined by the Coastal Act as: "Any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments."[24] This includes riparian habitat and streams. The Malibu LCP has a relatively strong provision protecting ESHA and requires that applications for proposed development within 200 feet of ESHA must include analyses on biological resources, potential habitat and water quality impacts, alternative projects, and mitigation measures. Further, development is prohibited from within 100 feet of the outer edge of the riparian canopy. While the City still has the right to, and sometimes does allow variances, these variances should be a last resort and impacts must be minimized to adequately protect ESHA and preserve riparian habitat buffers.

After many years, Los Angeles County is finally developing an LCP for the Santa Monica Mountains, including areas within the Malibu Creek Watershed; however initial drafts were not sufficiently protective of water quality and sensitive habitats. The preliminary draft allowed for grading and development on steep slopes, and encroachment of development on stream and riparian habitat. In order to protect the valuable natural resources in the Malibu Creek Watershed and greater Santa Monica Mountains area, provisions in the LCP must be protective of open space, include setback requirements consistent with the City of Malibu LCP of 100 feet from the outer edge of the riparian canopy, and limit further streambank harden-

[24] California Coastal Commission. 2010. California Coastal Act, Section 30107.5. Available at: http://www.coastal.ca.gov/coastact.pdf

ing. Until Los Angeles County has an approved LCP, the Coastal Commission will continue to regulate development in unincorporated areas of the Coastal Zone within the County.

RECOMMENDATIONS FOR DEVELOPMENT OUTSIDE THE COASTAL ZONE

Outside of the Coastal Zone, there are no specific regulations for stream protection. This is particularly evident in the high density areas in the upper watershed. In many areas there is little or no buffer between waterways and residential and commercial development. In Calabasas, Agoura Hills, and other areas of the watershed, large portions of the creek are channelized and/or directed underground to storm drains.

Riparian buffer zones serve as natural boundaries between development and natural waterways. They serve to filter pollutants, sediments, nutrients, and bacteria from run-off. Further, riparian buffer zones provide groundwater recharge, flood control, wildlife migration corridors, streambank stabilization, and stream temperature control benefits. Buffers also allow natural lateral stream movement. The lack of stream protection throughout the watershed is significantly degrading the habitat and water quality.

The SMBRC and Heal the Bay are currently working with the City of Los Angeles to develop a Stream Protection Ordinance to guard streams and riparian buffers from direct degradation from development and other human encroachment.[25] The primary purpose of the ordinance is to create buffer zones or setbacks for all development next to soft-bottom streams and to restrict streambank modifications. Currently, a majority of the active channels in the City of Los Angeles have been heavily modified or are heavily impaired without the riparian buffer. This Stream Protection Ordinance should serve as a model for Los Angeles County to help guide habitat and water quality protection measures within the watershed. Because the Malibu Creek Watershed has not been as heavily modified as most streams in the City of Los Angeles, adopting a stream protection ordinance before more development continues will significantly improve governments ability to prevent stream habitat and water quality degradation.

OTHER RECOMMENDATIONS

Restoration activities, including stream barrier removals, must remain priorities in the Malibu Creek Watershed. Removing barriers and illegal structures from local streams will considerably improve habitat and water quality. Implementing bioengineered options to restore and stabilize streambanks, rather than installing riprap or concrete, will improve the natural habitat and water quality, and better protect residences and businesses along the streams where a large percentage of streambank modifications are failing. ■

TOP 5 Recommendations to Protect Riparian and In-Stream Habitat

(For more information, see p. 132)

- Develop a Local Coastal Program for the Santa Monica Mountains
- Adopt a Stream Protection Ordinance
- Prevent Streambank Hardening
- Monitor and Strengthen Requirements for Construction
- Remove Stream Barriers

[25] Santa Monica Bay Restoration Commission. 2008. The Bay Restoration Plan. Available at: http://www.smbrc.ca.gov/about_us/smbr_plan/docs/smbrplan2008.pdf

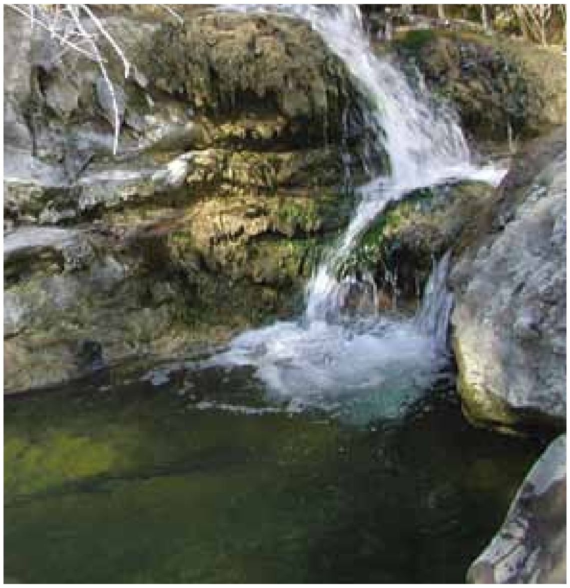
Chapter 3

STATE OF THE WATER QUALITY

INTRODUCTION

Water quality is important to the health of natural ecological communities and people who use streams, lakes, and the coast for recreation. Regular water chemistry sampling provides a relatively simple tool to monitor watershed health. Heal the Bay and several governmental and non-governmental organizations[26] measure a variety of water quality parameters throughout the Malibu Creek Watershed to determine how concentrations differ throughout the watershed and adjacent areas and to gain insight into the causes, impacts of, and possible solutions to current water quality problems. Heal the Bay's water quality monitoring program follows strict quality assurance and quality control protocols detailed in our Stream Team Field Guide.[27]

The data collected throughout the past 15 years by Heal the Bay's Stream Team have helped inform regulation and guide restoration throughout the watershed. Our data have been used to list reaches of streams on the 303(d) list of impaired waters and in the development of nutrient, bacteria, and trash TMDLs in the Malibu Creek Watershed.[28] We are currently providing information to the Los Angeles Regional Water Quality Control Board and the US Environmental Protection Agency to use in the development of additional TMDLs for the watershed, including for sedimentation and benthic community effects. These data also inform land acquisition efforts, environmental organization's review and comments on development projects, and help in the development of Local Coastal Programs.



[26] Monitoring in the Malibu Creek Watershed is conducted by Heal the Bay, Las Virgenes Municipal Water District, Resource Conservation District of the Santa Monica Mountains, National Park Service, Southern California Coastal Water Research Project (SCCWRP), Malibu Creek Watershed Monitoring Program, LADWP, and the EPA. http://www.healthebay.org/sites/default/files/html/MCW_Monitoring_Locations.html

[27] See Heal the Bay's Stream Team Field Guide for full description quality assurance and quality control procedures (http://www.healthebay.org/sites/default/files/pdf/Stream%20Team%20Field%20Guide_May2012.pdf).

[28] US EPA Region 9. Total Maximum Daily Loads for Nutrients, Malibu Creek Watershed. Available at: http://www.epa.gov/region9/water/tmdl/malibu/final_nutrients.pdf and http://www.epa.gov/region9/water/tmdl/malibu/final_bacteria.pdf

Runoff from equestrian facilities can lead to high nutrient concentrations in the watershed. Photo credit: Heal the Bay

NUTRIENTS

Nutrients, including nitrogen and phosphate, are essential for plant growth. Naturally occurring sources include soils, eroding rocks, some plant species, and animal waste. Excess nutrients can originate from point sources, including wastewater treatment plants, municipal storm drains, and septic systems as well as from non-point sources, including runoff from agricultural sites, equestrian or livestock facilities, golf courses, and landscaping. The presence of elevated nutrient concentrations in waterbodies can cause major pollution problems, such as excessive algal and microbial growth, which can negatively impact aquatic life. High nutrient concentrations can cause eutrophication of waterways, severely depleting the dissolved oxygen critical for a healthy aquatic ecosystem.

Malibu Creek Watershed has several point and non-point sources of nutrient inputs. The Tapia Water Reclamation Facility (Tapia), located just downstream from Malibu Creek State Park, has historically been the most obvious and largest source of nutrients in the watershed. Over the past decade, Heal the Bay, regulators, and other organizations have prioritized working with Tapia to get them to reduce nutrient loads in their effluent. Tapia has made improvements to effluent water quality based on increasingly stringent permit requirements and recent efforts to implement denitrification systems. With these improvements, they have achieved strong total nitrogen reductions. Although denitrification efforts have reduced nitrogen concentrations in their effluent, Tapia still discharges nutrient-rich effluent at levels associated with eutrophication directly into Malibu Creek, during the "wet season" between November 16 and April 14, as regulated within their National Pollutant Discharge Elimination System (NPDES)[29] permit which is renewed approximately every five years. Heal the Bay sample-sites directly affected by Tapia's effluent include lower mid-Malibu Creek (M15) and the outlet of Malibu Creek (O1).

[29] National Pollutant Discharge Elimination System (NPDES). Available at: http://63.199.216.6/larwqcb_new/permits/docs/4760_R4-2010-0165_WDR_PKG.pdf

The effects of several large manmade lakes on the watershed and possible atmospheric deposition on nutrient loading are current information gaps. Atmospheric deposition of nutrients is relatively low in the area because of the proximity to the coast and location upwind of pollution sources. Atmospheric deposition contributes an estimated 21.2 grams of nitrogen per hectare daily in the Malibu Creek Watershed.[30] While atmospheric deposition of nitrogen and phosphorus is estimated to account for less than 1% of the total nitrogen and 0.1% of the total phosphorus in watershed creeks, deposition of metals and other pollutants is relatively unknown.[31]

Through our water quality monitoring, Heal the Bay has found elevated nutrients at several sites throughout the watershed, which indicates that additional sources of nutrients, such as residential runoff, agricultural activity, Las Virgenes Municipal Water Districts spray field irrigation site, and historic sludge injection (which ended in 2003), may also be contributing nutrient loading throughout the watershed. US EPA also considered these inputs as nutrient sources in the Malibu Creek nutrient TMDL, and assigned them all waste load allocations.[32] These potential nutrient sources should not be ignored in water quality improvement efforts as all potential sources of upstream nutrient loading should continue to be investigated and reduced to ensure improved water quality.

NITROGEN

The US EPA TMDL for total nitrogen (Nitrate-N + Nitrite-N) has different waste load allocations for the summer (April 15 - November 15) and winter (November 16 -April 14) seasons - 1.0 mg/L and 8.0 mg/L respectively.[33] The 8 mg/L winter limit was selected based on a modification of Basin Plan[34] limits which are related to public health, but not biostimulation or the effects of nutrients on the ecological health of the watershed. Since adoption of the total nitrogen TMDL in 2002, the US EPA and Los Angeles Regional Water Quality Control Board have both stated that the winter limits should be consistent with the summer limits, resulting in a year-round limit of 1.0 mg/L.[35]

Heal the Bay measures nitrogen as nitrate (NO_3-N) and ammonia (NH_3-N). Consistently over the past 12 years, nitrate concentrations increased on a gradient throughout the watershed, with reference sites having low nitrate concentrations as compared to outlet sites (Figure 3-1). Solstice Creek (R14) provides an exception to this trend, which may be explained by a 2005 nutrient loading incident from a failed septic system (see p. 75). Nitrate levels at Solstice Creek (R14) averaged 0.11 mg/L over the duration of Heal the Bay's monitoring (the samples reflecting unusually high levels of nitrate from February-July 2005 were removed to get this average). There is a significant increase in nitrate concentrations as the water moves through the watershed (Figure 3-1), especially above and below Tapia during the wet season (November 16 – April 14) when discharge to Malibu Creek is allowed (Figures 3-5). There are also several equestrian facilities in the middle of the watershed above Stokes Canyon Creek and Medea Creek, which may contribute to elevated nutrient levels in middle and outlet sites.

Though the TMDL limits for total nitrogen (nitrate + nitrite) in the Malibu Creek Watershed differ between wet and dry seasons, sites unaffected by Tapia show very little variation in nitrate concentrations between these seasons. Seasonal variation

[30] Lu, R., Schiff, K.C, & Stolzenbach, K.D. 2007. Nitrogen deposition on coastal watersheds in the Los Angeles region. Available at: ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/AnnualReports/2003_04AnnualReport/ar07-schiff_pg73-81.pdf.

[31, 32, 33] US EPA Region 9. Total Maximum Daily Loads for Nutrients, Malibu Creek Watershed. Available at: http://www.epa.gov/region9/water/tmdl/malibu/final_nutrients.pdf

[34] The Basin Plan was created by the Regional Water Board and designates beneficial uses and water quality standards for all surface water bodies in the region. Available at: http://www.swrcb.ca.gov/rwqcb4/water_issues/programs/basin_plan/basin_plan_documentation.shtml

[35] Becker, M. & Rod Collins, R. 2004. TMDL for Nutrients in Malibu Creek and Lagoon. Presentation, 4 at the LARWQCB.

Figure 3-1: Average Nitrate Concentrations (Dry and Wet Seasons)

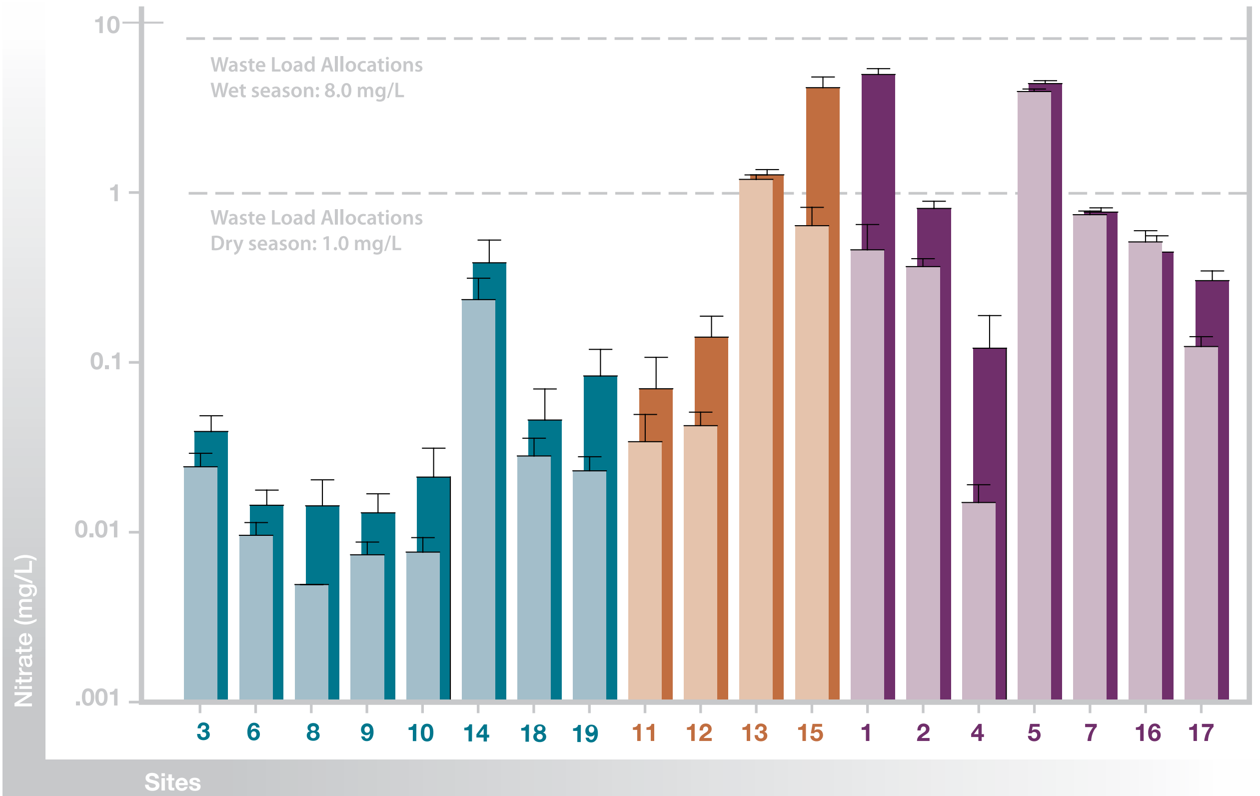


FIGURE 3-1: Average nitrate concentrations during the dry season (April 15 – November 15) (N=623) and wet season (November 16 – April 14) (N=460) with standard error bars. The horizontal lines indicate the waste load allocations in the US EPA total nitrogen TMDL in the Malibu Creek watershed (dry season: 1.0 mg/L, wet season: 8.0 mg/L). In the wet season, nitrate at middle sites along Las Virgenes Creek (M13) and Malibu Creek downstream of Tapia discharge (M15), and outlets of Malibu Creek (O1) and Las Virgenes Creek (O5) are 1.27, 4.15, 4.95, and 4.39 mg/L respectively.

WET SEASON | DRY SEASON = Reference Sites
WET SEASON | DRY SEASON = Middle Sites
WET SEASON | DRY SEASON = Outlet Sites
- - - - - - = Waste Load Allocation

in nitrate in lower mid-Malibu Creek (M15) and the outlet of Malibu Creek (O1) are likely attributable to Tapia's permitted discharge between November 16 and April 14, as these sites are below the facility. Figure 3-5 shows average nitrate concentrations along a transect from Upper Cold Creek (R3) down to the Outlet of Malibu Creek (O1); differences in concentrations are minor until just below Tapia at Lower Mid-Malibu Creek (M15). At site 15, just below the Tapia Reclamation Facility on Malibu Creek, nitrate concentrations averaged 0.62 mg/L in the dry season and 3.65 mg/L in the wet season.

Las Virgenes Creek, another tributary of Malibu Creek, also shows an increase in average nitrate concentration below Tapia's outlet in the wet season (Figure 3-5b). However, we do see higher levels of nitrate in mid-Las Virgenes Creek in both the dry and wet seasons (Figure 3-5b). Site O5, at the outlet of Las Virgenes Creek into Malibu Creek, is particularly high in the dry season (average nitrate of 4.39 mg/L). Sites M13 and O5 are downstream of freeways and high density commercial and residential land use. Site O5 is downstream of additional possible nutrient sources including, rural residential land use, past sewage sludge injection areas, reclaimed water irrigation fields, and some grazing areas. The high nitrate levels at sites M13 and O5 in the wet and dry seasons clearly indicate sources other than direct discharge from Tapia Water Reclamation Facility. Further investigation is needed to determine exact nutrient sources to these sites.

Figure 3-2: Monthly Nitrate levels over time at reference site Upper Cold Creek (R3)

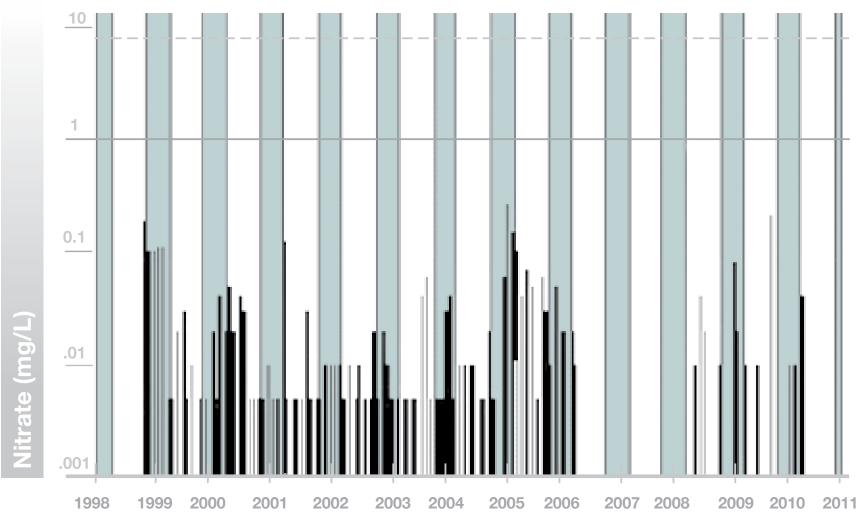


FIGURE 3-2: Shading indicates the wet season (November 16-April 14). The solid horizontal line at 1 mg/L indicates the total nitrogen summer waste load allocation, and the dashed horizontal line at 8 mg/L indicates the winter waste load allocation in the US EPA TMDL for total nitrogen. Site 3 is not influenced by Tapia's discharge (N=101).

Figure 3-3: Monthly Nitrate levels over time at upper mid-Malibu Creek (M12)

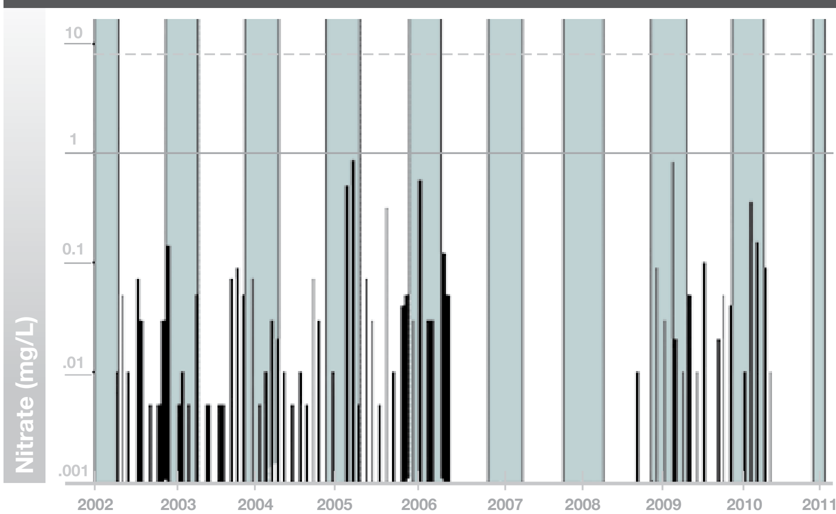


FIGURE 3-3: Shading indicates the wet season (November 16-April 14). The solid horizontal line at 1 mg/L indicates the total nitrogen summer waste load allocation, and the dashed horizontal line at 8 mg/L indicates the winter waste load allocation in the US EPA TMDL for total nitrogen. This site is not influenced by Tapia's seasonal discharge (N=66).

Figure 3-4: Monthly Nitrate levels over time at the outlet of Malibu Creek (O1)

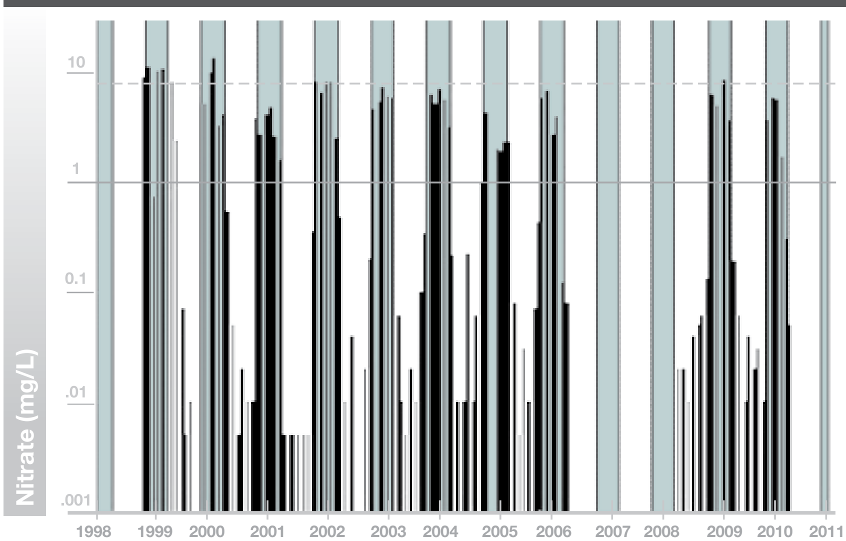


FIGURE 3-4: Shading indicates the wet season (November 16-April 14). The solid horizontal line at 1 mg/L indicates the total nitrogen summer waste load allocation, and the dashed horizontal line at 8 mg/L indicates the winter waste load allocation in the US EPA TMDL for total nitrogen. This site is influenced by Tapia's discharge that occurs during the wet season (N=112).

STATE OF THE WATER QUALITY

Figure 3-5: Average Nitrate Concentrations Along Sites from the Upper to Lower Watershed

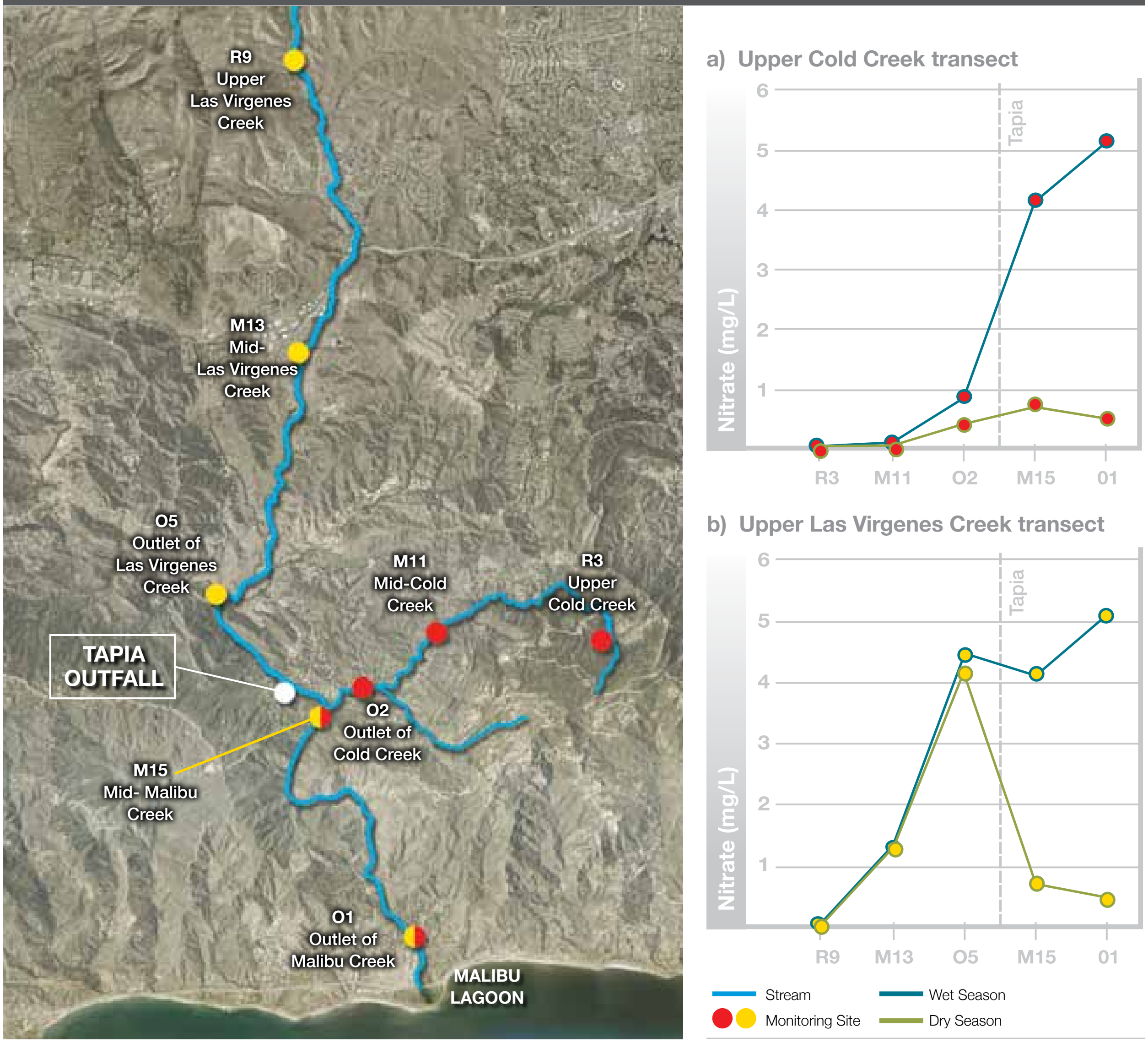


FIGURE 3-5: Average nitrate concentrations along sites from the upper to lower watershed. Average nitrate (mg/L) by site along a transect from (a) Upper Cold Creek (R3) and (b) Upper Las Virgenes Creek (R9) through the outlet of Malibu Creek (O1) during dry and wet seasons. The Cold Creek transect is shown in red, the Las Virgenes transect is shown in yellow, dry season is denoted in green, and wet season is denoted in blue. Direct discharge from Tapia occurs during the wet season below the outlet of Cold Creek (O2) and the outlet of Las Virgenes Creek (O5), but above Lower Mid-Malibu Creek (M15); Tapia's location in the charts is an estimation.

Aerial view (top) and outfall pipe (right) of Tapia Water Reclamation Facility. Photo credit: Google Maps

FAULTY SEPTIC DISCOVERED IN SOLSTICE CANYON

Failing septic systems can contribute to water quality problems. Septic systems need adequate space, proper design, and regular maintenance. A failing septic system may be detected due to contamination of ground or surface water and the resulting spikes in nutrient and bacteria concentrations.

Until January 2005, Heal the Bay's monthly water quality sampling in Solstice Creek (R14) consistently tested low for nitrate concentrations, averaging 0.04 mg/L. On February 13, 2005 nitrate levels were measured at 1.01mg/L, on March 6, 2005 levels were measured at 1.58 mg/L, and by April 3, 2005 nitrate levels had increased to 2.70 mg/L. Due to this substantial increase in nitrate levels at the monthly reference sampling site, Heal the Bay conducted targeted upstream source sampling in an attempt to find a point source of the nitrogen pollution.

In a targeted search, all the seeps and tributaries leading into Solstice Creek from the east bank had higher nitrate levels than the instream samples. Seep and tributary sampling locations 1 and 3 both had significant surface flows and extraordinarily high nitrate concentrations (6.76 mg/L and 5.16 mg/L respectively). With nitrate levels much higher than historic samples in this area, Heal the Bay grew concerned that the adjacent house's septic system may have failed during a recent landslide or that their vineyard had been contributing to the increased nutrient levels.

After Heal the Bay informed the Los Angeles Regional Water Quality Control Board and the property owners of the issues, the owners made repairs to the septic systems. Nitrate returned to levels below 1.0 mg/L in August 2005 and has remained relatively low during subsequent monthly monitoring.

STATE OF THE WATER QUALITY

LAS VIRGENES MUNICIPAL WATER DISTRICT: TAPIA WATER RECLAMATION FACILITY

The Tapia Water Reclamation Facility, located on Malibu Creek upstream from the confluence with Cold Creek, is owned and operated by Las Virgenes Municipal Water District (LVMWD). Tapia treats approximately 10.4 million gallons of wastewater per day (mgd) to tertiary levels from nearby areas, including Calabasas, Agoura Hills, Westlake Village, Hidden Hills, and unincorporated areas of Los Angeles County. Its effluent meets Title 22 public health standards for water recycling. Tapia's current discharge permit (NPDES permit) prohibits discharge during the dry season, from April 15 – November 15 except during the occasional storm. Also, if Malibu Creek flows less than 2 cubic feet per second, then Tapia is required by National Marine Fisheries Service to discharge to augment stream flows enough to meet those flow volumes. According to the annual reports from Tapia, Tapia's dry season effluent release to Malibu Creek ranged from no discharge to 9.2 million gallons from 2006-2009. During the winter months, Tapia's daily discharge into Malibu Creek averages 8 -10 mgd. [36]

HISTORY

Malibu's Surfrider Beach suffers from major bacteria problems; it routinely receives failing grades on Heal the Bay's Beach Report Card®. Malibu Lagoon is naturally a seasonally-breached lagoon; however, unnatural flows can cause it to breach at times it would not naturally do so. During the 1990s, when Tapia was permitted to discharge year-round, the Lagoon breached more frequently because of elevated flows in the creek. This was a major public health concern because, although Tapia's treated effluent does not contain high levels of fecal indicator bacteria, the artificial breaching allowed water from Malibu Lagoon, which has very high bacteria concentrations, to reach the surf zone and pose a health risk to swimmers and surfers. In 1999, under pressure from Heal the Bay, surfers, and other concerned citizens and environmental groups, the Los Angeles Regional Water Quality Control Board modified Tapia's NPDES permit to only allow discharge during the wet season (November 16 – April 14), which has resulted in less frequent breaching of the Lagoon during summer months, when the greatest number of people are in the water at Surfrider Beach. This timing also benefits the tidewater goby, which lives in the lagoon, as its breeding season occurs in late April and May.[37]

Although Tapia's effluent does not contain live bacteria that indicate a risk to swimmers, nutrient loading to Malibu Creek remains a concern. Even with the US EPA TMDL, nitrogen concentrations in the watershed remain high. In 2010, a Biological Nitrogen Removal Reactor denitrification system was installed at Tapia, in an effort to comply with the NPDES discharge limits. Instead of installing a new nitrogen-denitrification facility, which is often used to reduce nutrients, Tapia retrofitted their existing facilities with the nitrogen removal reactor due to space and cost constraints. The Biological Nitrogen Removal Reactor became active in May 2010, resulting in a reduction in total nitrogen concentrations in Tapia's effluent from over 13 mg/L to below 8 mg/L. Tapia is also exploring the feasibility of increasing effluent water reclamation year-round, which would decrease nutrient loads to Malibu Creek. While LVMWD should be commended for decreasing nitrogen concentrations in Tapia's effluent, additional measures like increasing storage or providing recycled water to other agencies should be vigorously pursued until total nitrogen concentrations are consistently below the dry weather limit of 1 mg/L.

[36] US EPA Region 9. Total Maximum Daily Loads for Nutrients, Malibu Creek Watershed. Available at: http://www.epa.gov/region9/water/tmdl/malibu/final_nutrients.pdf

[37] US Fish and Wildlife Service. 2005. Recovery Plan for the Tidewater Goby (Eucyclogobius newberryi). Available at: http://www.fws.gov/arcata/es/fish/Goby/documents/2006%20Final%20Recovery%20Plan%20for%20the%20Tidewater%20Goby.pdf

WATER QUALITY AFFECTED DIRECTLY BY TAPIA

LVMWD conducts water quality monitoring along Malibu Creek, including two sites above the Tapia outfall, one site just below the outfall, and a fourth site slightly further down the creek. However, none of the sites are above the influence of Tapia's composting, irrigation, and previous sludge injection operations. Based on average monthly wet season data reported in the LVMWD annual reports for Tapia (2006 through 2009), average nitrogen increases dramatically downstream of the outfall (Figure 3-6). Above the outfall, Tapia monitoring site 1 has a higher average nitrogen concentration than Tapia site 9, which is further upstream. This may be related to water recycling activities that drain into Las Virgenes Creek in this area. The total nitrogen TMDL estimates that Tapia contributes 30% of the nitrogen loading to the Malibu Creek Watershed annually, despite only five months of discharge.[38]

WATER QUALITY AFFECTED INDIRECTLY BY TAPIA AND WASTEWATER RECYCLING

Nitrate concentrations at the outlet of Las Virgenes Creek (O5) are high throughout the year. This may be due to several sources, including runoff from nearby developed areas and parkland, and year-round waste management activities around Tapia and other facilities in the watershed that are not restricted during the dry season. The Rancho Las Virgenes Compost Facility is a 90-acre compost facility located along Las Virgenes Road, upstream of Tapia's discharge site. This facility receives biosolids from Tapia to create top dressing compost available to the public free of charge for use as fertilizer. Tapia was also previously permitted to inject treated sludge on site, which ceased in 2003. The Los Angeles Regional Water Quality Control Board listed the historic sludge injection activities and irrigation as potential nitrogen sources during the Nutrient TMDL development process.[39] Although sludge injection no longer occurs in the watershed, high nitrogen concentrations near this site may be related to previously injected sludge and contaminated groundwater.[40] Tapia also has spray fields and percolation beds for unused treated effluent that may increase nitrogen loading above the wastewater treatment plant along Las Virgenes Creek.[41] Additional research is needed to better understand the sources of the high nutrient concentrations in lower Las Virgenes Creek.

Figure 3-6: Avg. Total Nitrogen Concentrations at Las Virgenes Municipal Water District's Monitoring Locations (above and below Tapia)

FIGURE 3-6: Water chemistry monitoring locations in the Malibu Creek Watershed above and below the Las Virgenes Municipal Water District Tapia Water Reclamation Facility discharge, with average total nitrogen concentrations above and below the Tapia outfall between 2006 and 2009 during wet season discharge months (November 16th – April 14th). Values were obtained from Tapia 2006-2009 NPDES annual reports and were reported monthly; we used data from December to March to calculate wet season averages. Since that time, Tapia has greatly reduced their total nitrogen discharge due to the facility's nitrification/denitrification retrofit.

[38] US EPA Region 9, Total Maximum Daily Loads for Nutrients, Malibu Creek Watershed. http://www.epa.gov/region9/water/tmdl/malibu/final_nutrients.pdf

[39,40] Becker, M. & Rod Collins, R. 2004. TMDL for Nutrients in Malibu Creek and Lagoon. Presentation, 4 at the LARWQCB.

[41] US EPA Region 9, Total Maximum Daily Loads for Nutrients, Malibu Creek Watershed. http://www.epa.gov/region9/water/tmdl/malibu/final_nutrients.pdf. Estimates for the annual loading of Nitrogen from effluent irrigation and sludge injection is 9% of the total loading in the watershed.

PHOSPHATE

The US EPA Malibu Creek Watershed Nutrient TMDL waste load allocation for phosphate is 0.1 mg/L in the dry season, with no waste load allocation for the wet season. However, Malibu Creek samples often exceed the 0.1 mg/L criteria, and in some areas have been recorded over 4 mg/L.

Phosphate levels increase from reference to outlet sites throughout the watershed. Phosphate concentrations average approximately 0.17 mg/L annually at reference sites. However, phosphate concentrations are higher at upper Cheeseboro Canyon Creek (R6) and upper Las Virgenes Creek (R9) than other reference sites (Figure 3-7). Site R6, upper Cheeseboro Canyon Creek, is directly below the Calabasas Landfill. We discontinued sampling at R6 in 2003 because it is frequently dry and it should not be considered a reference site with the landfill upstream. Site R9 in upper Las Virgenes Creek has historic nursery and grazing operations and may be influenced by the Monterey Formation, a geological attribute in the upper Malibu Creek Watershed that may contribute to phosphate loading in the upper watershed. It is difficult to separate the natural contributions to phosphate concentrations from anthropogenic influences in the upper watershed based on Heal the Bay's monitoring locations. Without the inclusion of sites R6 and R9, the average phosphate concentration for reference sites is just above 0.1 mg/L. Without influence from the Monterey Formation, this appears to be an appropriate value. However, even with the potential increased phosphate loading from geologic activity in the upper watershed, concentrations do not exceed 1.0 mg/L until directly below the Tapia outfall.

Phosphate levels at several outlet sites, including Cold Creek (O2), Medea Creek (O7), and Stokes Canyon Creek (O16), are potentially influenced by fertilizers at equestrian facilities, septic systems, and/or commercial discharges. While these sites do not have the highest phosphate concentrations in the watershed, the average phosphate concentrations at all three of these sites is greater than 0.24 mg/L on a year-round basis. Additionally, numerous golf courses, vineyards, landscaped areas, and equestrian facilities are present in the Westlake area, and are thought to contribute to phosphorus loading associated with fertilizers, which could explain the relatively high phosphate levels at Triunfo Creek (O17). Further, rural residential areas, septic systems, equestrian facilities, and construction-related activities are growing above site 2 along Cold Creek near the confluence with Malibu Creek. Monitoring increasing residential development and agricultural activities, especially equestrian facilities and viticulture, is of utmost importance to better understand and reduce phosphate loading in the watershed.

Lower mid-Malibu Creek (M15) is impacted by Tapia's effluent discharge, and the average phosphate concentration is 2.79 mg/L during the discharge period compared to 0.59 mg/L during the dry season. The outlet of Malibu Creek (O1) is also affected by Tapia's discharge, with an average concentration of 1.19 mg/L in the

FURTHER INVESTIGATION OF HIGH NUTRIENT LEVELS

In 2008 Heal the Bay began monitoring a new site in mid-Las Virgenes Creek, M30, in between sites M13 and O5. This site is to the west of Las Virgenes Road and north of Mulholland Highway, near White Oaks Farm. Site M30 is downstream of high density commercial and residential development, the 101 Ventura Freeway, rural residential land use, past sewage sludge injection areas, reclaimed water irrigation fields, and some areas of grazing. M30 has an average nitrate concentration of about 6mg/L in both the wet and dry seasons, well above averages for all other site types. Nitrate concentrations at site M30 exceeded the standard of 1mg/L in 100% of samples during the dry season, and exceeded the wet season standard of 8mg/L in 15% of the samples. Further investigation is needed to determine the source or sources of these unusually high levels of nitrate at site M30.

	Avg. Dry Season Nitrate (mg/L)	Avg. Wet Season Nitrate (mg/L)
Reference	0.06	0.09
Middle	0.61	1.13
Outlet	1.21	2.29
Site 30	6.05	6.00

Figure 3-7: Average Phosphate Concentrations (Dry and Wet Seasons)

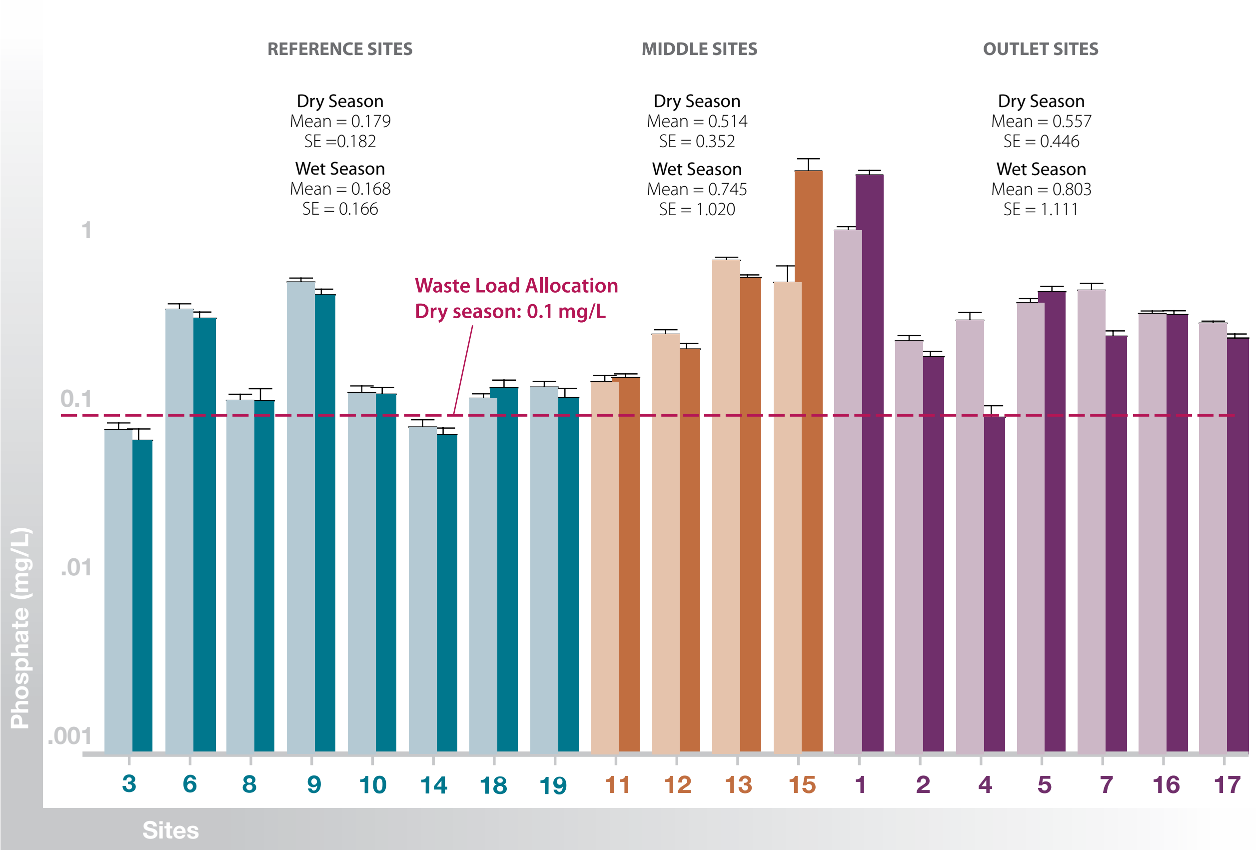


FIGURE 3-7: Average phosphate concentrations during the dry season (N=648) and wet season (N=474) with error bars. The horizontal line indicates the numeric limit of 0.1mg/L for phosphate in the Malibu Creek Watershed.

dry season and 2.64 mg/L in the discharge period. The discrepancy between wet and dry seasons is uncharacteristic, as shown by phosphate concentrations at sites upstream from Tapia only differing by a maximum of 0.05 mg/L between dry and wet seasons (Figure 3-8).This demonstrates that Tapia is likely contributing significant amounts of phosphate to the watershed. Based on US EPA estimates used to develop the nutrients TMDL in 2002, Tapia contributes approximately 48% of the phosphorus loading in the watershed annually despite the fact that the discharge is only permitted five months out of the year.[42] Implementation of the nutrients TMDL through the inclusion of the 0.1 mg/L phosphate limit in the NDPES permit should lead to a decrease in phosphate concentrations in the lower watershed. However, a significant reduction in phosphate loading throughout much of the watershed is necessary to meet these limits.

Phosphate sources other than from Tapia are also of concern, Figure 3-7 indicates high phosphate concentrations at the Outlet of Malibu Creek (O1) in the dry season, when Tapia does not discharge to Malibu Creek. It is not surprising however, that site O1 has a high average phosphate concentration since it is our lowest site in the watershed and may be receiving nutrient inputs from runoff from residential areas, agricultural facilities, and golf courses.

The Las Virgenes Municipal Water District identifies the Monterey Formation, a

[42] EPA Nutrient TMDL for Malibu Creek Watershed, Source and Load Allocations, 2002 http://www.epa.gov/region9/water/tmdl/malibu/final_nutrients.pdf

Figure 3-8: Average Phosphate Concentrations Along Sites from the Upper to Lower Watershed

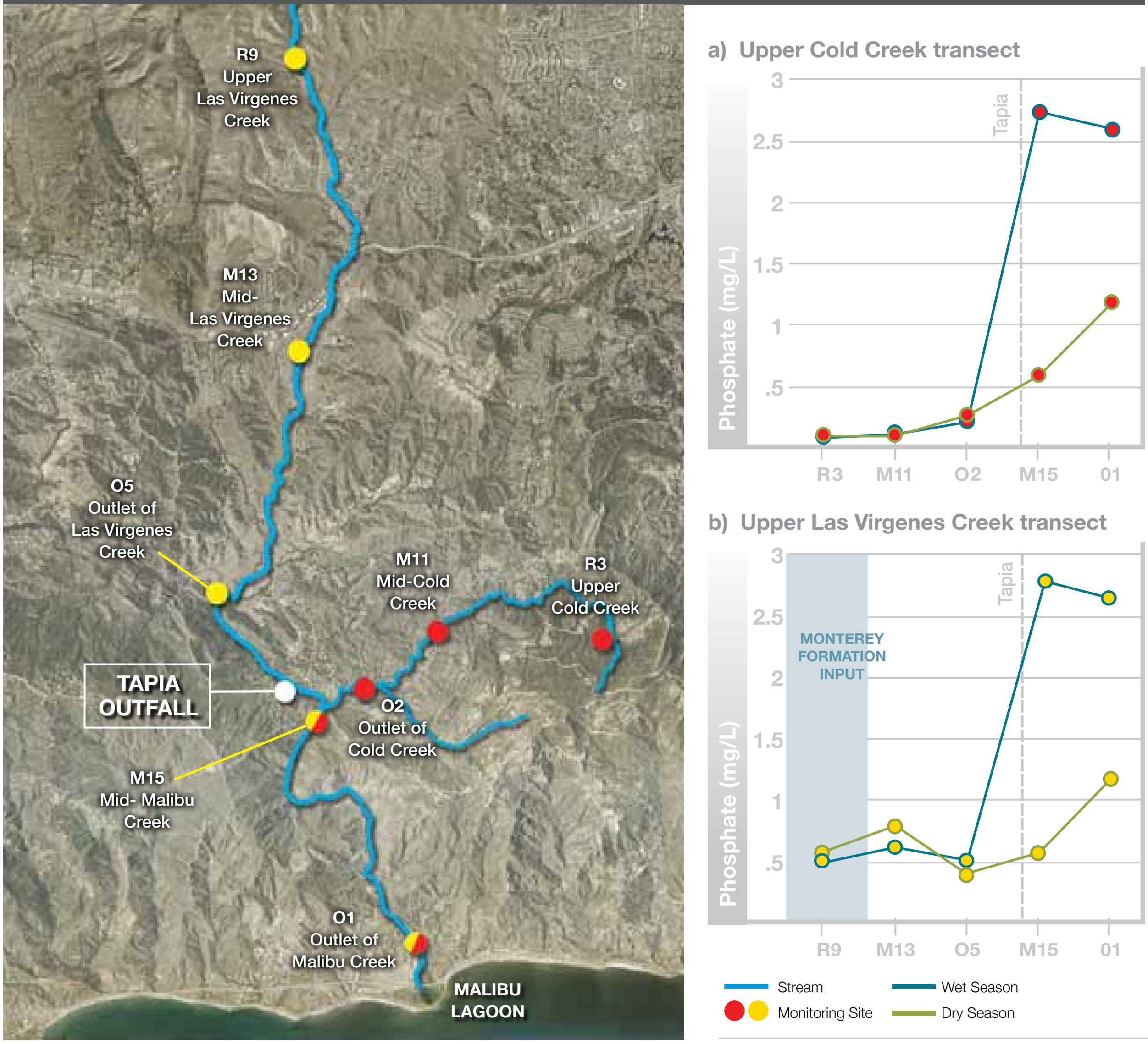


FIGURE 3-8: Average phosphate concentrations along sites from the upper to lower watershed. Average phosphate (mg/L) by site along a transect from (a) Upper Cold Creek (R3) and (b) Upper Las Virgenes Creek (R9) through the outlet of Malibu Creek (O1) during dry and wet seasons. The Cold Creek transect is shown in red, the Las Virgenes transect is shown in yellow, dry season is denoted in green, and wet season is denoted in blue. Direct discharge from Tapia occurs during the wet season below the outlet of Cold Creek (O2) and below the outlet of Las Virgenes Creek (O5), but above Lower Mid-Malibu Creek (M15); Tapia's location in the figure is an estimation.

Numerous golf courses, vineyards, landscaped areas, and equestrian facilities are present in the Westlake area, and are thought to contribute to phosphorus loading associated with fertilizers, which could explain the relatively high phosphate levels at Triunfo Creek.

geological formation in the upper Malibu Creek Watershed, as a primary contributing factor to the increased concentrations of phosphate in the area, especially in Las Virgenes Creek.[43] Although the Monterey Formation may cause increased phosphate levels in the watershed, water quality data collected by Heal the Bay, Las Virgenes Municipal Water District, Los Angeles County, and other agencies seem to indicate that it is contributing up to 0.5 mg/L of phosphate to the areas it influences.[44] Further, the upstream impacts of historic nursery, cattle grazing, and oil extraction operations are difficult to decouple from these potential geological impacts. However, even with the potential elevated phosphate loading from geologic formations in the upper watershed, phosphate concentrations do not exceed 1.0 mg/L upstream of Tapia's outfall location, but frequently exceed 1.0 mg/L (at times up to 3.9 mg/L) at the two sites located downstream of Tapia's outfall during the November-April discharge period (Figures 3-8 and 3-9).

The average phosphate concentration at reference sites of 0.14 mg/L (not including the discontinued reference site R6 in upper Cheeseboro Creek) suggests that the slight elevations in phosphate levels throughout portions of the watershed may be associated with natural sources, particularly in sites known to be in the Monterey Formation. Upper Cold Creek does not occur in the Monterey Formation and does have a low average concentration of phosphate (0.08 mg/L), but we still see increases in concentration lower in Cold Creek and in the watershed (Figure 3-8). Further, the five-fold increase in wet season concentrations that occurs only at sites downstream of Tapia's discharge is not likely attributable to natural sources, but instead is likely the result of the high phosphate concentrations in Tapia's discharge (Figures 3-8 and 3-9).

Figure 3-9: Average Phosphate Concentrations at Las Virgenes Municipal Water District's Monitoring Sites (above and below Tapia)

FIGURE 3-9: Average phosphate (mg/L) concentrations above and below the Tapia outfall between 2006 and 2009 during the permitted discharge period (November 16-April 14). Values were obtained from Tapia 2006-2009 NPDES annual reports and were reported monthly; we used data from December to March to calculate wet season averages. LVMWD monitoring locations are those shown in the Tapia 2009 NPDES Permit. The reported total phosphorus was converted to phosphate by multiplying by 3.[45]

[43,44] Las Virgenes Municipal Water Districts. 2011. Water Quality in the Malibu Creek Watershed, 1971-2010: Existing Conditions, historical trends, and data inter-relationships, Report #2475.00. Submitted by the Joint Powers Authority of the Las Virgenes Municipal Water District and the Triunfo Sanitation District to the Los Angeles Regional Water Quality Control Board in compliance with Order No. R4-2010-0165.

[45] http://water.epa.gov/type/rsl/monitoring/vms56.cfm

Algae in Malibu Lagoon. Photo credit: Heal the Bay.

ALGAE

The Los Angeles Region Basin Plan contains a water quality objective for algae, which is referenced in the US EPA Nutrients TMDL due to the excessive algal growth throughout the watershed. It requires that "waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growth causes nuisance or adversely affects beneficial uses." It also requires that affected waters be free of floating material, including foams and scum "in concentrations that cause nuisance or adversely affect beneficial uses."[46]

In the Malibu Creek Watershed nutrients TMDL, it is stated that the Los Angeles Regional Water Quality Control Board (Regional Board) considers algae to be at a nuisance level when algae reaches 30% surface cover during more than 10% of monitoring events. The US EPA set the nuisance level to be 30% algal cover for floating algae and 60% algal cover for bottom algae, expressed as seasonal means.[47] Algae cover in the Malibu Creek Watershed exceeds 30% cover at almost all of Heal the Bay's monitoring sites. The nuisance algae thresholds have been debated in the scientific and regulatory communities. Therefore, this analysis also used a conservative threshold of >50% algal cover to characterize the severe extent of algal growth and impacts in the watershed. This high level of algal cover constitutes a major water quality and ecological impairment, leaving little room for debate.

Heal the Bay staff and volunteers surveyed and mapped algae along 70 miles of stream in the watershed between 2000 and 2004. The streams listed in Table 3-1 were surveyed once during this time period, along with follow up seasonal surveys along the Malibu Creek main stem. Field crews mapped floating and benthic algae and measured percent algal cover. The length of each algal mat was also measured with a GPS

[46] Basin Plan, Regional Water Quality Control Board, Region 4. Water Quality Objectives. Available at: http://www.swrcb.ca.gov/rwqcb4/water_issues/programs/basin_plan/electronics_documents/bp3_water_quality_objectives.pdf

[47] http://www.epa.gov/region9/water/tmdl/malibu/final_nutrients.pdf

Figure 3-10: Streams in the Malibu Creek Watershed Significantly Impacted by Algal Growth

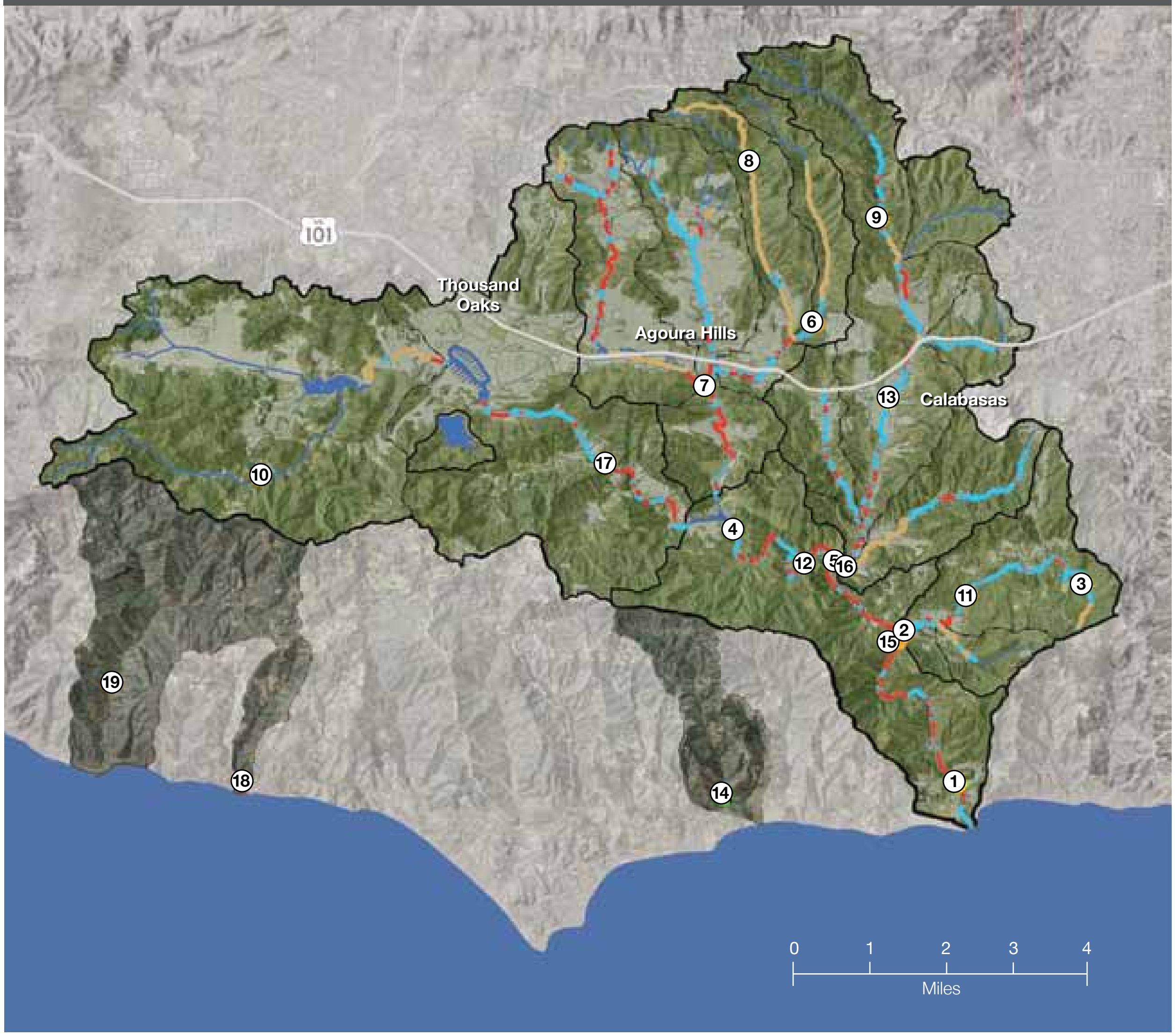


FIGURE 3-10: Streams with greater than 50% algal cover are indicated in red, as documented through Stream Walk (2000-2004).

at all areas where algal cover exceeded 50% of the wetted width of the stream channel.[48] Stream Team field crews also documented the substrate type supporting algal growth and the percent overhead canopy cover at each algae patch. These monitoring efforts, which are recognized to be snapshots in time, were used to map the overall length and percent of stream impacted by algae at levels of over 50% in the Malibu Creek Watershed (Figure 3-10 and Table 3-1). All the streams surveyed contained segments with over 50% algal cover except the Dark Canyon tributary to upper Cold Creek (R3) and upper Palo Comado Creek (R8) (Table 3-1). The surveys were not all performed at the same time of the year and there may be some seasonal variability that is unaccounted for.

In addition to algae data from Stream Walk, the Stream Team collects monthly algae data at our monitoring sites. We estimate percent cover of benthic and floating or mat algae for the general area where we sample. While somewhat subjective, this method provides an estimate of algal cover over time and seasons. These data were

[48] 30% cut off based on EPA TMDL for Malibu Creek nutrients and algae stating that a creek is impaired by algae if algal cover equals 30% of the creek at least 10% of the time.

used to determine the percent algal coverage at surveyed segments at the Regional Board suggested threshold (30% cover over 10% of the time) and our additional conservative threshold (>50% algal cover at ≥50% of the monitoring events) (Figure 3-11). Benthic algal cover (algae and/or diatom mats attached to the stream bed) was lowest at reference sites and highest at outlet sites. Two of four middle sites and five of seven outlet sites are severely impacted by algal growth at the conservative 50% threshold level. Based on the 30% threshold, most streams in the watershed, including reference sites, are negatively impacted by algae.

Spatial examination of the data shows that excess algal cover is a pervasive problem throughout the Malibu Creek Watershed. Of the approximately 70 miles of streams surveyed, 21.5 miles (32%) had greater than 50% algal cover (Table 3-1). The vast majority of these impairments occurred downstream of development and in creeks impacted by runoff from impervious surfaces. In Malibu, Medea, Lindero, Las Virgenes, and Triunfo Creeks, very high levels of algal growth occurred over more than 30% of their respective stream lengths. Only 0.36 miles of the 21.5 miles of stream documented with greater than 50% algae cover occurred above developed areas. Within the undeveloped drainages and at monitoring sites where nitrate and phosphate concentrations were consistently below 0.10 mg/L, algae cover did not exceed the standard of 30% cover during 10% of monitoring events.

In Cold Creek, the percent algal cover increased dramatically from upper Cold Creek (R3) through the more developed areas of mid-Cold Creek (M11) and the outlet of Cold Creek (O2). Heal the Bay also identified algal species during monthly water chemistry monitoring at its regular sites from 2001-2003.[49] Over the two-year period, mid-Cold Creek (M11) exceeded 50% algal cover during 23% of the monitoring events. The outlet of Cold Creek (O2) exceeded 50% cover in 41% of the samples. This pattern of increasing algal growth from upstream to downstream is also evident on upper Las Virgenes, Palo Comado, and Cheeseboro Creeks. However, it should be noted that these three streams had higher average phosphate concentrations, and even the reference sites in their upstream reaches (sites R6, R8, and R9) experienced limited sections of excessive algal growth. Algal cover at upper Las Virgenes (R9), mid-Cold Creek (M11), and Arroyo Sequit (R19) was often dominated by the genus *Chara*, which is indicative of clean water and/or hard water. In upper Las Virgenes (R9), the high conductivity could contribute to *Chara* growth. Areas downstream of development were dominated by species of algae that are associated with excess nutrients and/or other types of pollutants, such as thick diatoms, *Enteromorpha*, and *Cladophera*.[50]

Figure 3-11: Percent Algal Cover at Heal the Bay Monitoring Locations

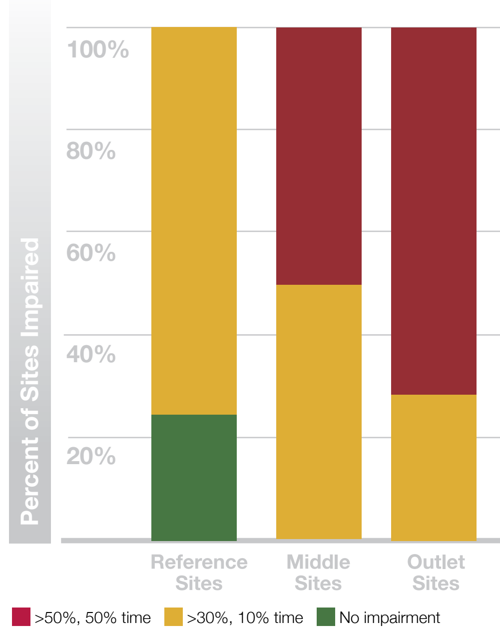


FIGURE 3-11: Percent of total samples with green representing no impairment, yellow representing EPA nuisance level impairment (30% cover, 10% of samples), and red representing >50% cover during ≥50% of the monitoring events by site type between 2001-03. Middle and outlet sites were all considered impaired by one of the standards, with the red representing the most extensive algal growth.

Table 3-1: Creeks Impacted by >50% Algal Cover in the Malibu Creek Watershed

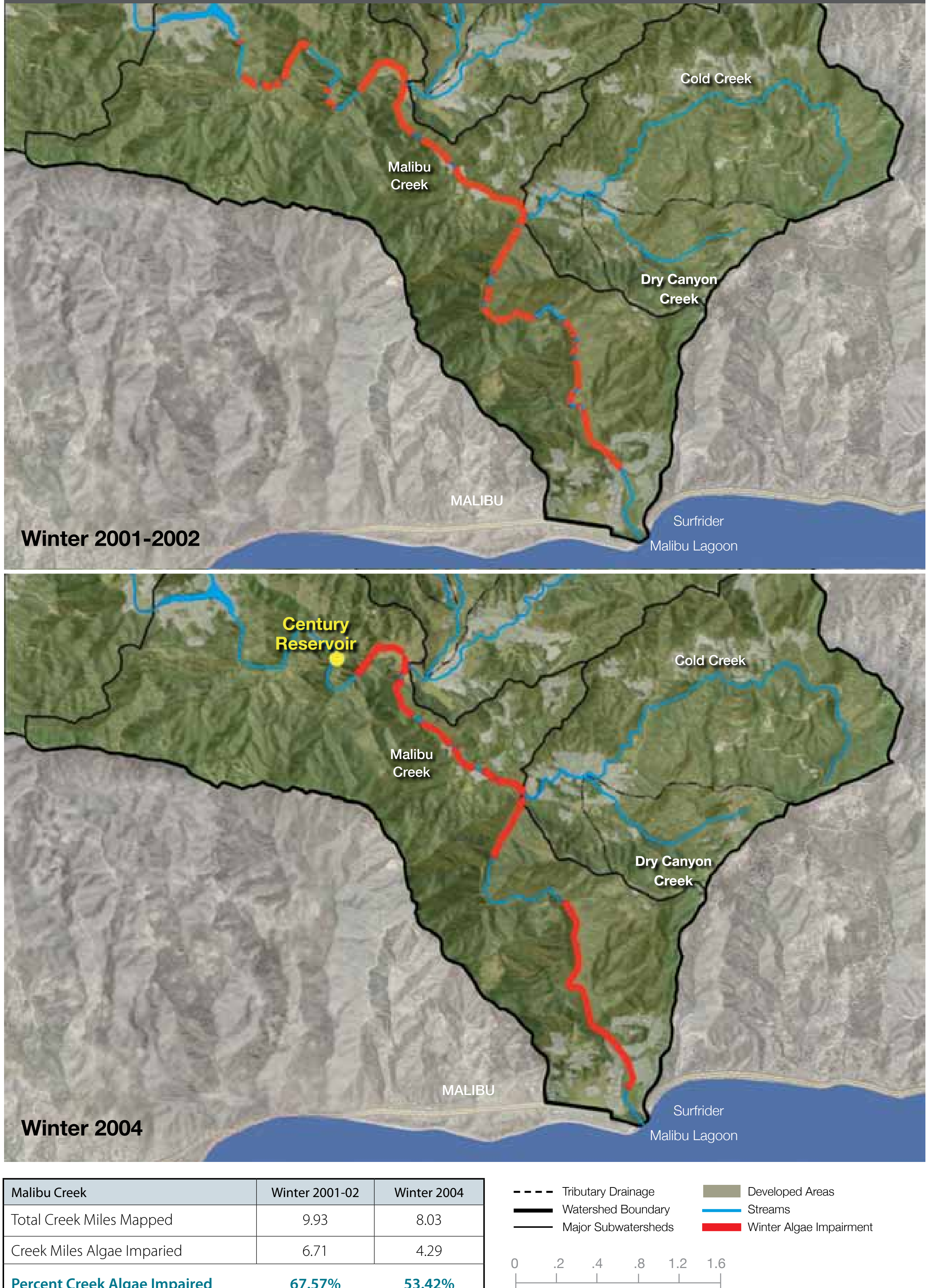
Creek	Miles Mapped	Miles impacted >50%	% of Creek impacted >50%
Malibu Creek	9.8	6.7	69%
Lindero Creek	7.2	3.6	51%
Triunfo Creek	4.9	2.1	43%
Medea Creek	9.0	3.3	36%
Las Virgenes Creek/ Tributary	10.2	2.8	27%
Liberty Canyon Creek	2.6	0.6	21%
Cold Creek	5.8	1.1	19%
Cheeseboro Creek	5.5	0.8	14%
Potrero Creek	2.0	0.2	12%
Stokes Creek	4.5	0.3	7%
Palo Comado Creek	5.5	0.0	0%
Dark Canyon Creek	1.0	0.0	0%
Total	**68.0**	**21.5**	**32%**

TABLE 3-1: Creeks impacted by >50% algal cover in the watershed (as miles and percent impacted). A total of 21.5 miles of mapped creek were impacted by >50% algal cover.

[49] See Heal the Bay's Stream Team Field Guide for full description of algal survey methods: http://www.healthebay.org/sites/default/files/pdf/Stream%20Team%20Field%20Guide_May2012.pdf

[50] Pers. comm. Julie Simpson, UC Santa Barbara, 2001

Figure 3-12: Winter Season Algal Growth on Malibu Creek



Malibu Creek	Winter 2001-02	Winter 2004
Total Creek Miles Mapped	9.93	8.03
Creek Miles Algae Imparied	6.71	4.29
Percent Creek Algae Impaired	**67.57%**	**53.42%**

FIGURE 3-12: Heal the Bay's winter mapping in 2001 and 2004 documented >50% algal cover on the main stem of Malibu Creek.

SEASONAL CHANGES IN ALGAE COVER

The Nutrient TMDL for phosphate does not include a wet-season limit because excess algal growth is considered a bigger nuisance during summer months. Heal the Bay conducted winter algae surveys in the watershed between November 16 and April 14 in 2001 and 2004. Previous studies have shown that severe algal growth along Malibu Creek occurred only during the summer months.[51] It was believed that algal impacts were less problematic during winter months, due to high winter creek flows scouring benthic algae from streambeds.[52] However, field crews documented substantial algal growth during winter months and at times of high creek flow. These efforts demonstrated year-round algal impacts on the main stem of Malibu Creek, with 67% algal cover occurring during the winter of 2001 and 53% during the winter of 2004 (Figure 3-12). These results also demonstrate the need for more algal monitoring during the winter months.

ALGAE AND NUTRIENTS

These mapping efforts, paired with monthly water chemistry monitoring, revealed a clear trend of greater algal cover at sites with higher nutrient concentrations. At monitoring sites where nutrients did not exceed background levels, algal cover was consistently low. Algal growth was substantially higher (often above 50% surface cover) at sites where total nitrogen and/or phosphorous were above background levels.

Light availability and flow velocity can affect algal growth, but further analyses show that these factors do not account for the differences between algal cover at reference and outlet sites.[53] In 2005, a Heal the Bay study found that nutrients are the strongest controlling factor of algal cover in the watershed.[54] Heal the Bay's Stream Team data (1998-2004) show that algal cover in Malibu Creek exceeded 30% when total nitrogen concentrations were greater than 0.1 mg/L and phosphate concentrations exceeded 0.15 mg/L. These concentrations should be considered thresholds for nitrogen and phosphate, above which algal impairments occur. Further, increases in phosphate concentrations directly correlated with increases in percent macroalgal cover.

Heal the Bay finds that algal growth in the Malibu Creek Watershed is much more extensive than what the Regional Board considers to be nuisance levels. The >30% cover for more than 10% of the samples guideline is not well-founded, and should be reexamined based on the severity of algal growth impacts in the Malibu Creek Watershed. However, with 32% of the creeks exceeding 50% cover during Stream Walk surveys, and six of seven outlet sites exceeding 50% cover during 50% of the monitoring events, there is no question that large segments of the watershed are severely impaired by nuisance algae.

Top to bottom: Malibu Creek; Malibu Lagoon Back Channel; Triunfo Creek. Photo credit: Heal the Bay

[51, 52] CH2MHill. 2000. Evaluation of nutrient standards for Malibu Creek and Lagoon. Prepared for Las Virgenes Municipal Water District and Triunfo Sanitation District.
[53, 54] Luce, S. & Abramson, M. 2005. Periphyton and Nutrients in Malibu Creek, a Heal the Bay Report. Available from Heal the Bay.

Malibu Lagoon suffers low Dissolved Oxygen (DO). Photo credit: Joy Aoki

DISSOLVED OXYGEN (DO)

Dissolved oxygen (DO) is important for diverse and thriving aquatic communities. Some organisms, such as steelhead trout, require relatively high concentrations of DO (i.e. greater than 5 mg/L), while others, such as some types of midge fly larvae (Chironomid), are adapted to low DO concentrations.

Monthly monitoring conducted by Heal the Bay's Stream Team indicates that dissolved oxygen in the Malibu Creek Watershed was fairly high in daytime single samples. Average DO concentrations at all monitoring locations were greater than 5mg/L, the Basin Plan's water quality objective for aquatic health in warm waters.[55] Since DO is particularly sensitive to time of day and temperature, the monthly DO measurements taken by Heal the Bay cannot be used to assess DO concentrations throughout the watershed.

However, 24-hour samples taken by the Santa Monica Mountains Resource Conservation District (RCD) at three sites within the watershed show that some areas experience significantly decreased dissolved oxygen concentrations during the early morning hours. Continuous monitoring provides a better assessment of actual DO levels since time of day is taken into account for each location. DO at some of the RCD sites was highly variable throughout the day, dropping far below the 7 mg/L standard for waters designated as COLD (the Basin Plan designated beneficial use signifying water quality needed to protect aquatic species that live in cold water, like steelhead

[55] Basin Plan, Regional Water Quality Control Board, Region 4. Water Quality Objectives. Available at: http://www.swrcb.ca.gov/rwqcb4/water_issues/programs/basin_plan/electronics_documents/bp3_water_quality_objectives.pdf

trout) and SPAWN (the Basin Plan designated beneficial use signifying water quality needed to protect reproduction and early development of fish) in Malibu Creek, and below the 5mg/L standard for waters designated as WARM (the Basin Plan designated beneficial use signifying water quality to protect aquatic life living in warm water habitat) in the remaining tributaries of 5 mg/L (Figure 3-13). Malibu Creek has both COLD and WARM beneficial use designations in the Basin Plan.[56]

Figure 3-13: Dissolved Oxygen Continuous Monitoring Profiles for Lower Malibu Creek

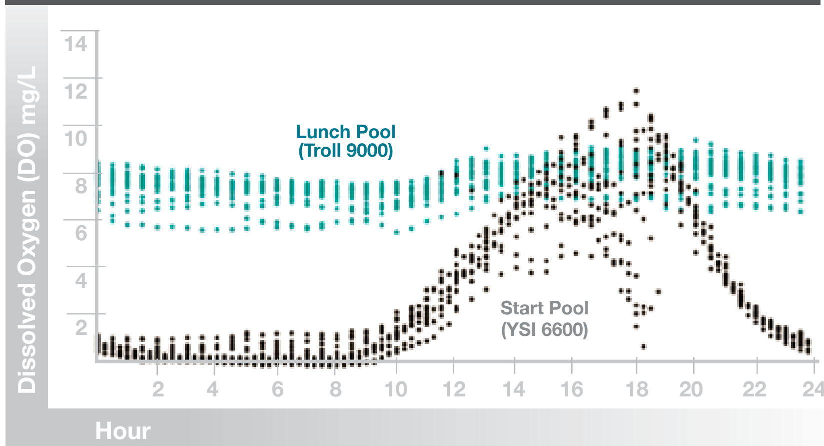


FIGURE 3-13: Continuous monitoring DO profiles for the Lunch and Start Pools in lower Malibu Creek, 2010 Water Quality Monitoring Final Progress Report, Resource Conservation District of the Santa Monica Mountains. Data graphed were collected between August 11, 2009 and September 1, 2009. Start Pool is approximately 250m upstream of Site 1 (outlet of Malibu Creek) and Lunch Pool is approximately 720m upstream of Start Pool.

Wildlife in Malibu Lagoon. Photo credit: Heal the Bay

Restoration of the Malibu Lagoon (see right for details). Photo credit: Heal the Bay

[56] Basin Plan, Regional Water Quality Control Board, Region 4. Water Quality Objectives. Available at: http://www.swrcb.ca.gov/rwqcb4/water_issues/programs/basin_plan/electronics_documents/bp3_water_quality_objectives.pdf

MALIBU LAGOON

The Malibu Lagoon suffers low Dissolved Oxygen (DO) levels, a condition that threatens aquatic life. In a 2005 study, pre-dawn dissolved oxygen concentrations averaged 1.15 ± 0.12 mg/L SE, significantly below Basin Plan thresholds.[57] Concentrations below 5 mg/L threaten aquatic life survival, and periods of low dissolved oxygen and low species diversity have been recorded in the lagoon since the early 1990s.[58] For this reason, along with extensive sedimentation and eutrophication, a comprehensive planning effort was initiated in the late 1990s and early 2000s to restore the Malibu Lagoon, with the primary objectives of improving water quality through increased circulation and enhancing lagoon habitat for birds, fish, and invertebrates. The goals and design of the restoration plan grew out of a long-term multi-stakeholder process that included a diverse group of local residents, agencies, wetland restoration scientists, and environmental groups, including California State Parks and Recreation, the California State Coastal Conservancy, Santa Monica Bay Restoration Commission, and Heal the Bay.

The stakeholders determined that restoring wetland habitat in Malibu Lagoon was their highest priority short-term project. The restoration design was led by a panel of renowned wetland experts. Heal the Bay participated in the development of the final Malibu Lagoon Restoration and Enhancement Plan, which was peer-reviewed and completed in June 2005. Phase I, completed in 2008 by State Parks, Santa Monica Baykeeper, and the State Coastal Conservancy included implementation of a permeable parking lot with bioswales to capture, infiltrate, and treat stormwater from up to a 3.2-inch in 24 hours rainfall event without discharging to the lagoon. Phase I also included planting native plant species surrounding the parking area.

Phase II, led by State Parks, the State Coastal Conservancy, and the Santa Monica Bay Restoration Commission, will improve circulation by recontouring the substrate in the Western Lagoon to a more natural slope. This project is a necessary step towards improving the almost stagnant western fingers of the Lagoon. It includes educational signage on new paths, a bird blind for wildlife viewing, interactive tide gauge, and an amphitheater.

The restoration plan has received approvals from the Coastal Commission, California Department of Fish and Wildlife, National Marine Fisheries Service, Army Corps of Engineers, US Fish and Wildlife Service, and the Los Angeles Regional Water Quality Control Board. Yet, the debate over how to best restore Malibu Lagoon became contentious among some local residents and advocates. Heal the Bay, along with State Parks, the Coastal Conservancy, SMBRC, and numerous environmental and surfing groups strongly support the approved Malibu Lagoon restoration and enhancement plan, as it will greatly improve aquatic habitat in the Malibu Lagoon. Phase II of the restoration was scheduled to begin in June of 2011, but unfortunately, due to litigation and a subsequent stay granted by a state district circuit judge, the start date was postponed. In October 2011, a San Francisco Superior Court Judge found that the California Coastal Commission had considered all reasonable project alternatives, and ruled that the project could move forward. State Parks began the restoration in the summer of 2012, and it will be completed in early 2013.

[57] Briscoe, E. et. al. 2002. Pre-dawn Dissolved Oxygen Levels in the Malibu Creek Watershed. Prepared for the Los Angeles Regional Water Quality Control Board by the Southern California Coastal Water Research Project and Heal the Bay.

[58] Ambrose, R.F., Suffet, I.H., & Que Hee, S.S. 1995. Enhanced environmental monitoring program at Malibu Lagoon and Malibu Creek. Report to: Las Virgenes Municipal Water District, Calabasas, CA. 131 pp.

Stream Team staff measuring conductivity. Photo credit: Heal the Bay

CONDUCTIVITY

Conductivity is the ability of water to transmit electric current. Conductivity indirectly measures dissolved inorganic solids in the water, which form the ions that transmit current (e.g. chloride, nitrate, phosphate, sulfate, and a variety of metal ions). It is a strong indicator of salinity, and can also be an indicator of urban runoff impacted waters.[59]

High conductivity can have negative impacts on benthic macroinvertebrate communities.[60] In the Malibu Creek Watershed, particularly along Las Virgenes Creek, there are several sulfur springs that may be the cause of increased conductivity at upper Cheeseboro Creek (R6), and the upper, mid, and outlet sites of Las Virgenes Creek (sites R9, M13, and O5) (Figure 3-14). Conductivity appears to correlate strongly with geology; however, it is difficult to determine specific anthropogenic influences due to Stream Team's fixed monitoring site locations. Heal the Bay has not conducted any source identification studies on conductivity, as the data do not show a clear indication that conductivity increased from upstream to downstream in the watershed.

Specific conductance above 2000 µS/cm can be harmful to some freshwater organisms.[61] Apart from the sites directly influenced by the sulfur springs, the outlet of Medea Creek (O7), Malibou Lake (O4), and Upper-mid Malibu Creek (M12) also exhibited average conductivity levels above 2000 µS/cm,

[59] Paul, M.J. & Meyer, J.L. 2001. Streams in the urban landscape. *Annual Review of Ecology and Systematic*s 32: 333-365.

[60] Pond, G.J. et al. 2008. Downstream effects of mountaintop coal mining: comparing biological conditions using family- and genus-level macroinvertebrate bioassessment tools. *Journal of North American Benthological Society* 27: 717-737.

[61] McKee, J.E., & Wolf, H.W. 1971. *Water quality criteria.* Sacramento: State Water Quality Board; Goodfellow, W.L. et al. 2000. Major ion toxicity in effluents: a review with permitting recommendations. *Environmental Toxicology and Chemistry* 19: 175-182.

with an increase downstream of Malibou Lake into upper-mid Malibu Creek (Table 3-2). These sites are outside of areas where increased conductivity is expected based on research conducted by the Las Virgenes Municipal Water District.[62] More sampling and a greater understanding of potential anthropogenic and geologic influences is necessary to understand the high levels of conductivity in the watershed, and the potential impacts on local aquatic life.

> In the Malibu Creek Watershed, particularly along Las Virgenes Creek, there are several sulfur springs that may be the cause of increased conductivity.

Table 3-2: Sites with Specific Conductance Averaging Greater than 2000 µS/cm

Heal the Bay Monitoring Site	Site Name	Conductivity (µS/cm)
Mid-Las Virgenes Creek	M13	3518
Cheeseboro Creek	R6	3380
Upper Las Virgenes Creek	R9	3361
Outlet Las Virgenes Creek	O5	3336
Outlet Medea Creek	O7	2877
Outlet Malibou Lake	O4	2321
Upper-Mid Malibu Creek	M12	2275
Lower Mid-Malibu Creek	M15	2141

Figure 3-14: Average Conductivity (Dry and Wet Seasons)

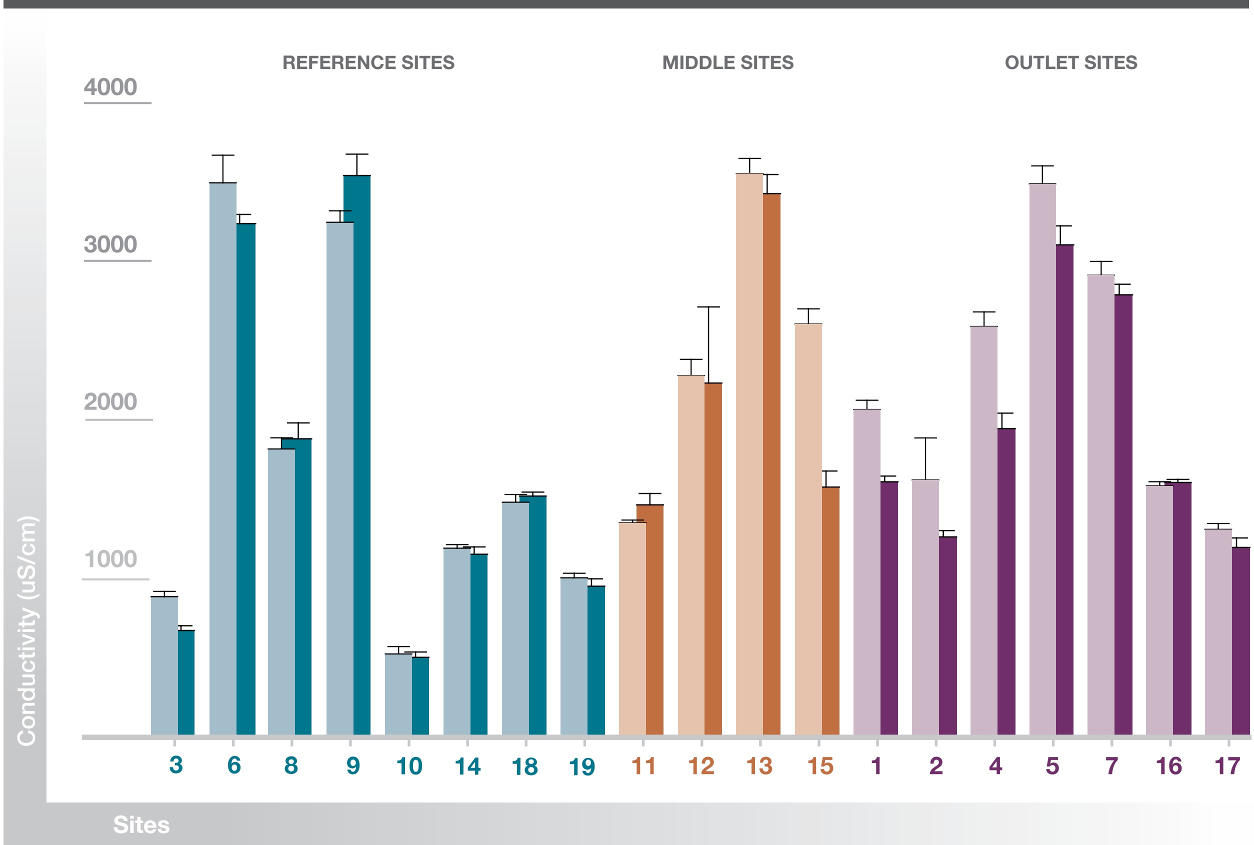


FIGURE 3-14: Average conductivity by site during the wet (November 16-April 14) (N=479) and dry (April 16 – November 15) (N=645) seasons. Sites are ordered by type (reference, middle, outlet). The greatest conductivity measures occur in the upper eastern watershed. Sites 9, 13, and 5 are located along Las Virgenes Creek, site 6 is located on Cheeseboro Creek, and site 7 is the outlet of Medea Creek.

[62] Orton and Dougall. The Monterey Formation: Influence on Water Quality and Aquatic Life in Malibu Creek, California. Las Virgenes Municipal Water District.

Stream Team staff and volunteers conduct laboratory testing for fecal indicator bacteria (top); a positive test for presence of fecal indicator bacteria (right).

BACTERIA

Bacteria play important roles in aquatic systems, including, converting ammonia to nitrate for plant uptake and breaking down dead plant and animal tissue, aiding in nutrient recycling. However, some bacteria are associated with pathogens that pose a health risk to people. These bacteria are generally found in untreated sewage and animal waste, and are not normally found in high concentrations in oceans, rivers, or creeks.[63]

Monthly monitoring conducted by Heal the Bay tests for three types of fecal indicator bacteria, *E. coli*, *Enterococcus* bacteria, and total coliform bacteria. Indicator bacteria generally do not cause illness, but are frequently associated with bacteria that cause illness, so when they exceed certain concentrations in waters used for recreation, exposed individuals have a greater chance of getting sick. *E. coli* and *Enterococcus* originate from warm blooded animals. Illnesses associated with swimming in water contaminated with these bacteria include gastrointestinal illness, ear infection, upper respiratory infection, and skin rash.[64][65] Health standards are set to protect people from getting sick due to contact with water contaminated by human pathogens. The federal EPA fecal indicator bacteria criteria are based on the likelihood of illness when swimming in water contaminated by *E. coli* or *Enterococcus* bacteria.[66]

A bacteria TMDL was established for the Malibu Creek Watershed by the Los Angeles Regional Water Quality Control Board in December 2004 for fresh waters designated for water contact recreation. *E. coli* densities must be below 235/100ml for a single sample, and fecal coliform concentrations must remain below 400/100ml for a single sample. *Enterococcus* concentrations must remain below 61/100ml for a single sample in a fresh waterbody designated for recreation based on US EPA standards.[67]

Fecal indicator bacteria concentrations are high throughout the watershed and generally increase along the gradient from reference through outlet sites (Table 3-3). Dry and wet season exceedances for *E. coli* and *Enterococcus* at outlet sites occur more than twice as frequently than at reference sites, with outlet sites averaging greater than 50% exceedances throughout

[63] See the US EPA website, www.epa.gov/owow/estuaries/monitor/chptr17.html
[64] Dwight, R.H. et al. 2004. Health Effects Associated with Recreational Coastal Water Use: Urban Versus Rural California. *American Journal of Public Health* 94:4(565-567).
[65] Haile, R.W. et al. 1999. The health effects of swimming in ocean water contaminated by storm drain runoff. *Epidemiology* 10: 355–363.
[66] US EPA. 1986. Ambient Water Quality for Bacteria. Available at: http://water.epa.gov/scitech/swguidance/standards/upload/2001_10_12_criteria_ambientwqc_bacteria1986.pdf; US EPA Region 9, Total Maximum Daily Loads for Bacteria, Malibu Creek Watershed. Available at: http://www.epa.gov/region9/water/tmdl/malibu/final_bacteria.pdf
[67] US EPA. 1986. Ambient Water Quality for Bacteria. Available at: http://water.epa.gov/scitech/swguidance/standards/upload/2001_10_12_criteria_ambientwqc_bacteria1986.pdf

the year. Middle site and outlet site percent exceedances are very similar, and all occur downstream of development, regardless of where the sample site is located. It is interesting that wet weather *E. coli* exceeds standards more often than dry weather, while wet weather *Enterococcus* exceeds standards less than dry weather samples (Table 3-3).

Some of the highest concentrations of bacteria occur in and below high-density residential areas. The mid-Las Virgenes (M13) monitoring site located just downstream of the City of Calabasas, south east of U.S. Route 101 (Ventura Freeway) and Las Virgenes Road intersection, exceeded *Enterococcus* standards in 64 of 68 samples and 28 of 69 *E. coli* samples (Figures 3-15 and 3-16). This site represents the highest and second highest percentage of exceedances for *Enterococcus* and *E. coli* throughout the watershed, respectively. The outlet

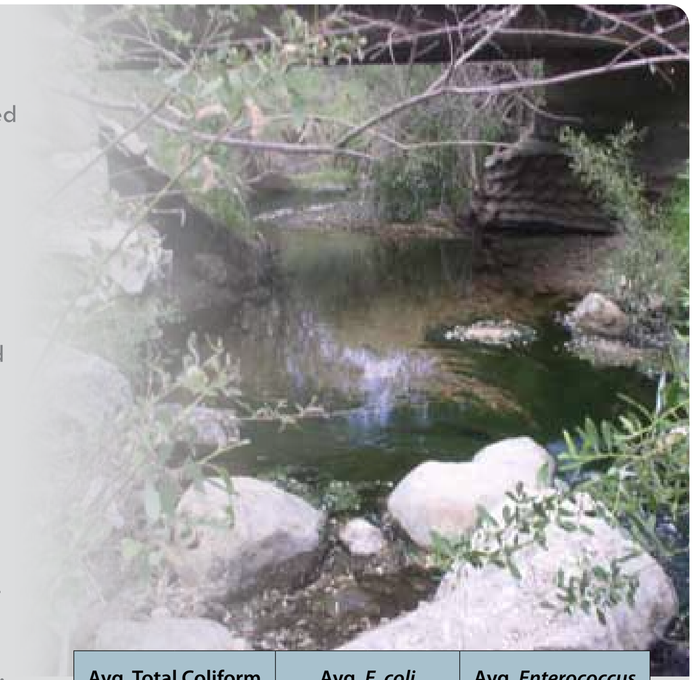
Table 3-3: Frequency of Fecal Indicator Bacteria Exceedances by Site Type

	***E. coli* Exceedances (>235/100ml)**		***Enterococcus* Exceedances (>61/100ml)**	
	% Exceeding (Wet Season)	% Exceeding (Dry Season)	% Exceeding (Wet Season)	% Exceeding (Dry Season)
REFERENCE SITES	9%	5%	17%	40%
MIDDLE SITES	39%	22%	48%	54%
OUTLET SITES	46%	24%	45%	62%

TABLE 3-3: Frequency of Fecal Indicator Bacteria exceedances (*E. coli* and *Enterococcus*) at Heal the Bay monitoring sites by site type (reference middle and outlet sites). Sampling includes rain events.

FURTHER INVESTIGATION OF HIGH BACTERIA LEVELS

Site M30, a new location that has been monitored since 2008, shows high levels of fecal indicator bacteria. M30 is downstream from M13 and upstream from O5. Averages at M30 for total coliform and *Enterococcus* were far above averages at all other types of sites in the watershed. *Enterococcus* levels at M30 exceeded standards 93% of the time in the dry season and 80% of the time in the wet season. Similar to M13, site M30 is downstream of the City of Calabasas, the 101 Ventura Freeway, past sewage sludge injection fields, reclaimed water spray fields, and some areas of grazing. It is not clear what the exact sources are to explain the high bacterial levels at sites M15, M30, and O5. However, we hope to conduct future bacterial source assessments to better understand trends at these sites and how we can work to lower the concentrations of fecal indicator bacteria.



	Avg. Total Coliform concentration (MPN/100ml)		**Avg. *E. coli* concentration (MPN/100ml)**		**Avg. *Enterococcus* concentration (MPN/100ml)**	
	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
REFERENCE SITES	2167	1076	77	33	112	48
MIDDLE SITES	11572	4093	315	178	268	371
OUTLET SITES	9381	5111	391	392	220	364
SITE 30	17469	7525	203	161	329	1276

Figure 3-15 Exceedances in *E. coli* Bacteria Concentrations

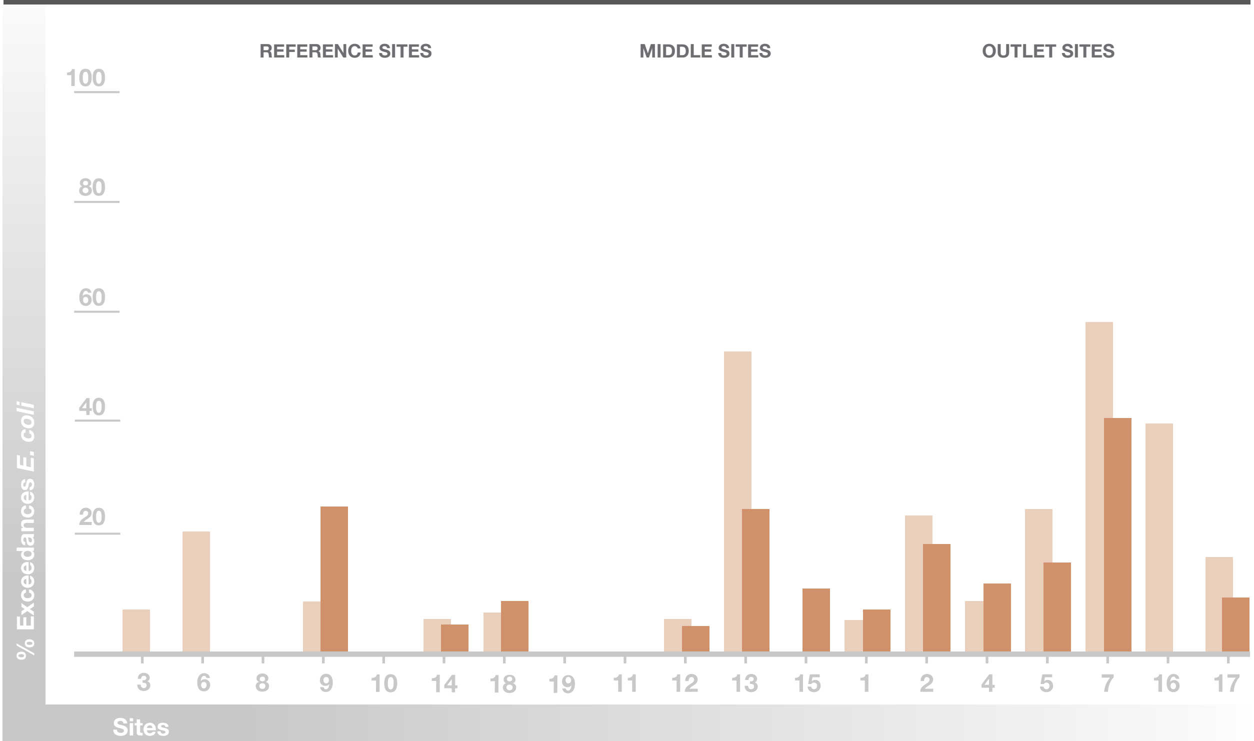


FIGURE 3-15: Percent of sampling events that were over the single sample regulatory limit of 235 MPN/100ml in the dry season (April 15 – November 15) and the wet season (November 16 – April 14). Sampling occurred from Jan 2002 to June 2010. Number of samples varied by site, ranging from 2 to 46 per season. Sites are arranged in order from upper to lower watershed. Sites 3-19 are Minimally Impacted/Reference sites, sites 11-15 are Middle Watershed sites, and sites 1-17 are Outlet sites.

= Wet Season
= Dry Season

Figure 3-16: Exceedances in *Enterococcus* Bacteria Concentrations

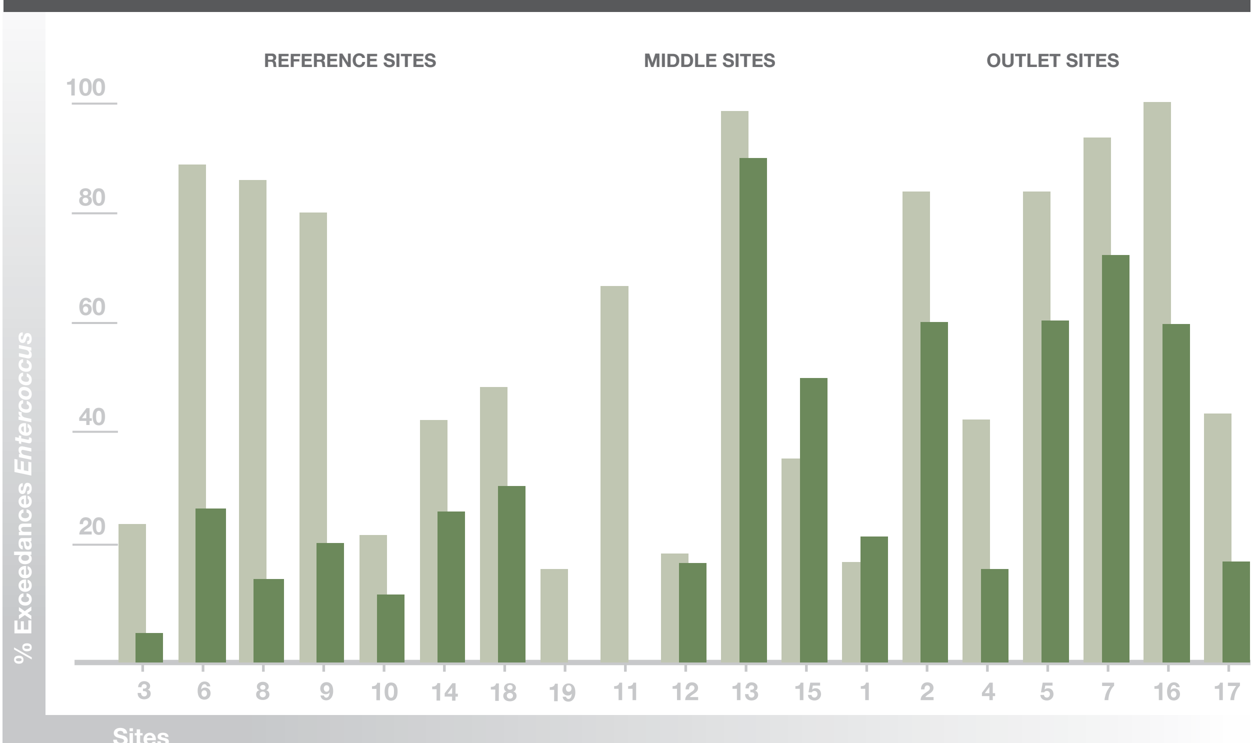


FIGURE 3-16: Percent of sampling events that were over the single sample regulatory limit of 61 MPN/100ml in the dry season (April 15 – November 15) and the wet season (November 16 – April 14). Sampling occurred from Jan 2000 to June 2010. Number of samples varied by site, ranging from 5 to 59 per season. Sites are arranged in order from upper to lower watershed. Sites 3-19 are Minimally Impacted/Reference sites, sites 11-15 are Middle Watershed sites, and sites 1-17 are Outlet sites.

= Wet Season
= Dry Season

Figure 3-17: Average Seasonal *E. coli* Concentrations

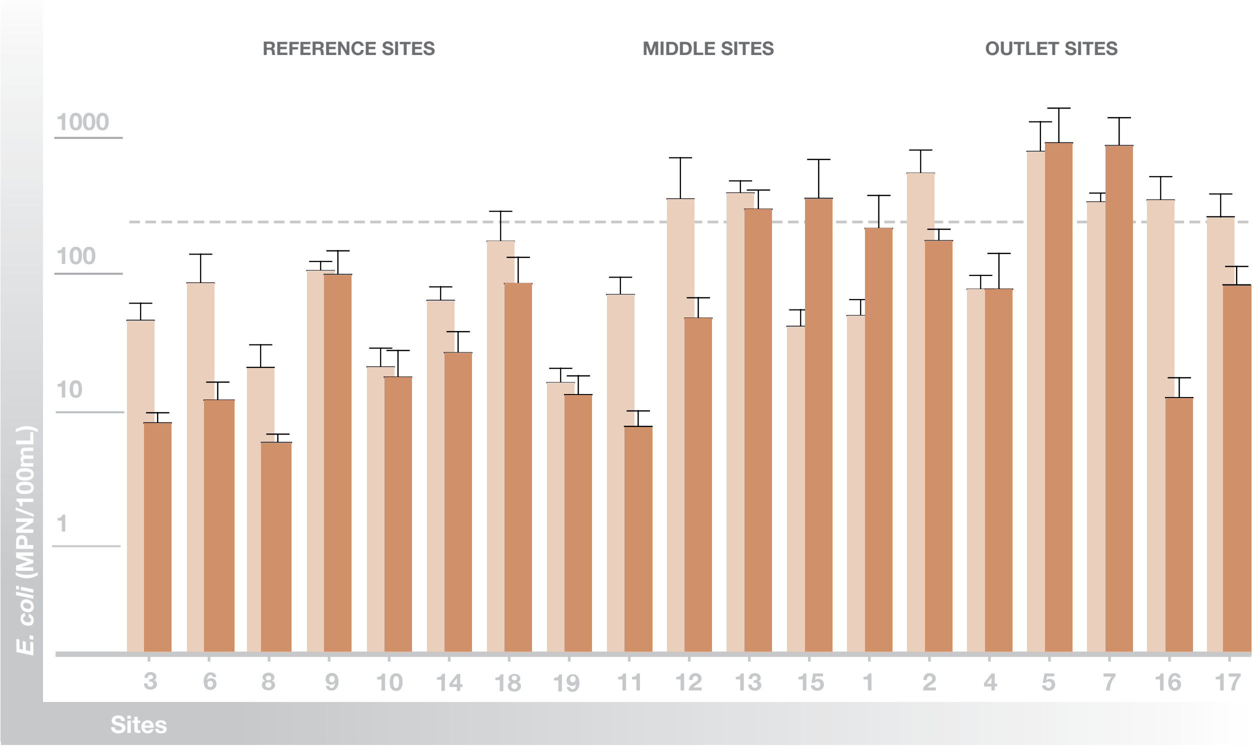


FIGURE 3-17: Mean *E. coli* concentrations by site during the dry and wet seasons. The horizontal line represents US EPA's single sample regulatory limit for *E. coli* in freshwater of 235 MPN/100ml. Sites are grouped by type (reference, middle, outlet) (N=488).

= Wet Season
= Dry Season

Figure 3-18: Average Seasonal *Enterococcus* Concentrations

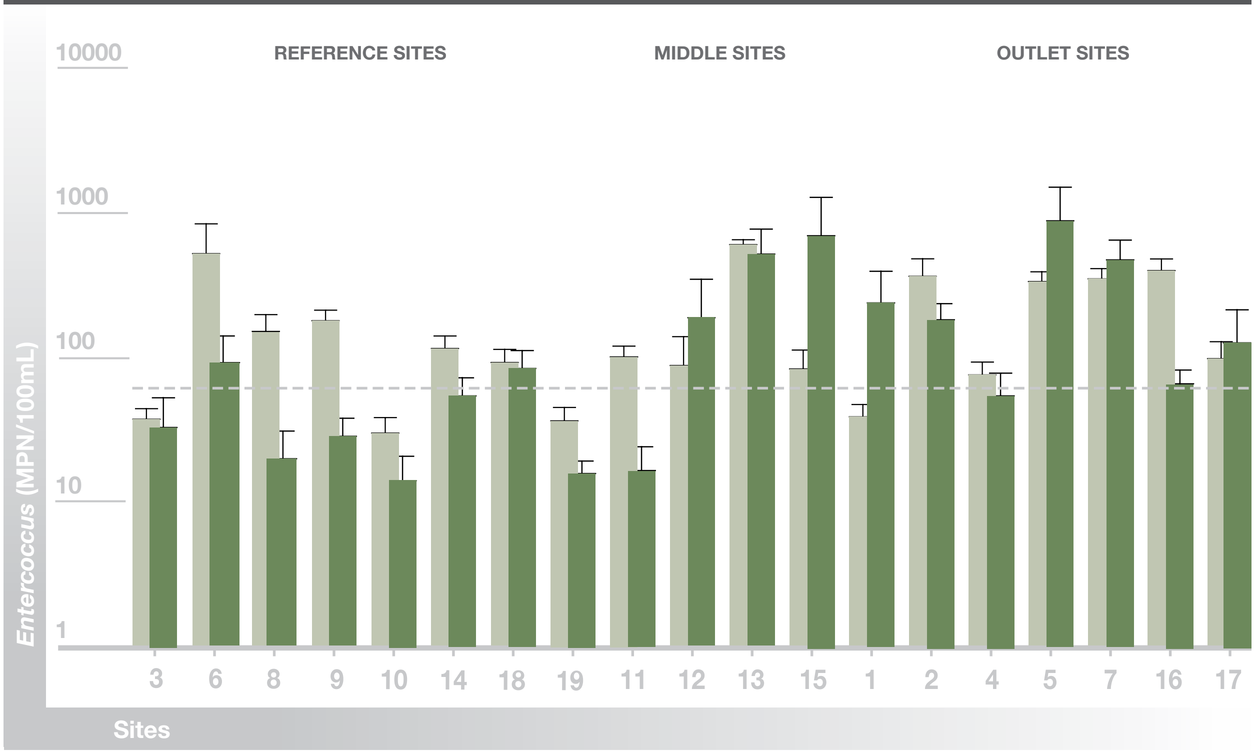


FIGURE 3-18: Mean *Enterococcus* concentrations by site during the dry and wet seasons. The horizontal line represents US EPA's single sample regulatory limit for *Enterococcus* in freshwater of 61 MPN/100ml. Sites are grouped by type (reference, middle, outlet) (N=488).

= Wet Season
= Dry Season

of Medea Creek (O7), located just below Agoura Hills, exceeded *Enterococcus* standrads 84% of the time, and 51% of time for *E. coli* standards (Figures 3-15 and 3-16). Both of these sites are typical of areas downstream from high density residential areas with little or no setback from the creek.

Between wet and dry season, *E. coli* and *Enterococcus* increased at the outlets of Las Virgenes Creek (O5) and Medea Creek (O7), which are located directly below more populous residential areas relative to the rest of the watershed (Figures 3-15, 3-16, 3-17 3-18). These elevated bacteria concentrations may be associated with urban runoff from nearby developed areas. Further, these sites are popular for swimming. Las Virgenes Creek, for instance, is one of the State Parks most popular swimming areas. Heal the Bay staff have encouraged Los Angeles County to put up warning signs about the high bacterial concentrations, but have been unsuccessful in convincing State Parks and the County to install signage.

Increased fecal indicator bacteria in lower Lachusa Creek (R18) during both wet and dry seasons may be explained by prevalent equestrian use upstream near Lachusa Creek outside the National Park Service property (Figures 3-15, 3-16, 3-17, 3-18).

Over the past 10 years, considerable improvements have been made to address bacteria problems in the watershed. Tapia is heavily regulated, with its tertiary treatment and Title 22 requirements and dry-weather discharge prohibition during the summer months. In contrast to nutrients, we do not see any differences in fecal indicator bacteria concentrations directly above and below where Tapia discharges into Malibu Creek in the wet season, indicating other sources for the bacterial problems that we see in the watershed. Tapia continues to implement programs to reduce nuisance flows from irrigation and to increase water recycling. State legislation regulating on-site wastewater treatment systems, AB 885, was signed into law in 2000, listing 2004 as the deadline for the implementation of statewide septic system regulations. However, only recently has the State Water Resources Control Board fulfilled its obligations to develop these regulations.

On June 19, 2012, the State Water Resources Control Board adopted the long overdue septics policy and regulations entitled, "Water Quality Control Policy for Siting, Design, Operations, and Maintenance of Onsite Wastewater Treatment Systems". This policy requires the Los Angeles Regional Water Quality Control Board to develop an implementation plan for the Malibu Creek nutrient TMDL by 2016. In 2009, with subsequent State Board approval, the Los Angeles Regional Water Quality Control Board placed a ban on new septic systems in the greater Civic Center area within the City of Malibu in direct response to the major nutrient and bacteria problems in the lower watershed. The Regional Board has a memorandum of understanding with the City of Malibu to create a centralized wastewater treatment plant for the Civic Center by 2015. Further, a wastewater disposal ban will go into effect in the commercial areas by 2015 and in residential areas by 2019 in the Malibu Civic Center area. These policy changes are critical for reducing bacterial and nutrient pollution in the lower watershed. Yet, parallel efforts are also needed in the upper watershed to comprehensively address bacteria and nutrient pollution through low impact development, riparian and in-stream habitat protection, and implementation of TMDLs.

Between wet and dry season, *E. coli* and *Enterococcus* increased at the outlets of Las Virgenes Creek and Medea Creek, which are located directly below more populous residential areas relative to the rest of the watershed. These elevated bacteria concentrations may be associated with urban runoff from nearby developed areas. Further, these sites are popular for swimming.
Las Virgenes Creek, for instance, is one of the State Park's most popular swimming areas.

HEAL THE BAY'S BEACH REPORT CARD

Heal the Bay's Beach Report Card grades more than 500 beach locations weekly along the West Coast based on the presence of fecal indicator bacteria. Surfrider Beach is a world-class surf break and attracts over one million visitors each year, yet it is also one of California's most polluted beaches. Since Heal the Bay initiated the Beach Report Card more than 20 years ago, Surfrider Beach has been one of Santa Monica Bay's three most polluted beaches for bacteria. Surfrider Beach is the recipient of natural creek flows, polluted runoff, effluent from some onsite wastewater treatment systems (mostly septic systems), agricultural runoff, and disinfected wet-weather discharges from the Tapia Water Reclamation Facility. It is nearly always on Heal the Bay's annual list of Beach Report Card Beach Bummers, which lists the 10 most polluted ocean beaches in the entire state of California. At the breach location of Malibu Lagoon, Surfrider Beach received an "F" in dry weather grading 12 out of 13 years from 2000 to 2012, and 13 of 13 in wet weather years during the same time.

The TMDL for dry and wet weather beach bacteria was established for Santa Monica Bay beaches in 2002. Compliance requirements for the time period between April 1 and October 31 began July 15, 2006. During this time period, zero fecal indicator bacteria exceedances are allowed at Santa Monica Bay beaches.[68] By Heal the Bay's calculations, Surfrider Beach has had 360 Santa Monica Bay Beach Bacteria TMDL violations through October 31, 2012. With an average of more than the 50 violations per year since 2006, Surfrider Beach has the third most Beach Bacteria TMDL violations in the Santa Monica Bay, following Dockweiler Beach at the outlet of Ballona Creek, and the Santa Monica Municipal Pier. Compliance deadlines for winter dry weather (November to March) TMDL requirements began in 2009.

[68] The TMDL for bacteria for single samples, fecal coliform density cannot exceed 400/100 ml and *Enterococcus* density cannot exceed 104/100ml.

High turbidity caused by upstream construction. Photo credit: Heal the Bay

TURBIDITY

Turbidity is a measure of water clarity or ability of light to penetrate the water, which is decreased by suspended particles such as silt, clay, and algae. High turbidity affects photosynthesis by restricting light penetration in the water column and can inhibit respiration of fish and invertebrates. Turbidity is most often increased by sedimentation from erosion.

In the Malibu Creek Watershed, turbidity was lowest at reference sites (average 0.49 NTU during the dry season, 1.0 NTU during the wet season) and highest at outlet sites (average 1.59 NTU dry, 3.96 wet). Turbidity is not a significant issue in the watershed during dry weather. However, since monitoring was conducted on a monthly basis, sampling during storm events was very infrequent.

Monitoring during storm events is important to understanding human impacts on turbidity during rainy weather, and to assess the effectiveness of BMPs installed to control sediment loading from construction sites and for stormwater pollution reduction. The Santa Monica Mountains Resource Conservation District conducted 24 hour monitoring at four sites in the Malibu Creek Watershed between April and October 2010, including two rain events (1" rainfall and 1.5" rainfall). During these rain events, turbidity increased dramatically, but did not exceed 200 NTU during either event.[69]

California's general construction stormwater permit does not currently contain a limit for turbidity. Limits were previously set at 500 NTU for any "high-risk" construction-related discharge but this was more recently dropped from the permit. Based on turbidity data from throughout the watershed, 500

[69] Resource Conservation District, 2010. Water Quality Monitoring Final Progress Report. Resource Conservation District of the Santa Monica Mountains, Topanga, CA.

Culvert at Las Virgenes Creek showing high (left) and low (right) turbidity. Photo credit: Heal the Bay

NTU is an extremely high standard. Only two percent of turbidity samples taken by Heal the Bay throughout the watershed, typically in dry weather, exceed 10 NTU. Based on research from Dr. Richard Horner, a nationally renowned stormwater engineering expert, implementing BMPs including mulch and blanket materials achieves effluent with a maximum turbidity of 73 NTU. This research was submitted to the State Water Resources Control Board by Dr. Horner in May 2007.[71] However, despite this information and a large number of studies supporting lower effluent limits, the most recent general construction stormwater permit approved by the State Water Resources Control Board does not even have a turbidity limit. The permit needs to set a numeric effluent limit for turbidity that is strong and protective of water quality and riparian habitat.

Site specific studies must be conducted to understand the impact of increased runoff and turbidity from construction sites during wet weather. Construction-related stormwater runoff could have serious consequences for nearby waterways due to sedimentation and erosion degrading critical riparian habitat. Further, effective implementation, monitoring, and management of BMPs at construction sites would significantly reduce turbidity.

SHEA HOMES

In March 2004, Heal the Bay's Stream Team documented severe construction related runoff from the Shea Homes development located along the east slope of Las Virgenes Road in Calabasas. In October 2004, following a storm event, Heal the Bay performed a site evaluation and found approximately 800 cubic feet of mud on the flood plain of Las Virgenes Creek, with an average depth of 0.2 feet (photos below). A report was sent to the Los Angeles Regional Water Quality Control Board and Department of Fish and Wildlife, and Shea Homes was fined for failure to comply with its construction stormwater permit and ecological degradation. Shea Homes settled the complaint, which included a clean-up of Las Virgenes Creek and monetary payments of $650,000 to the State of California.[70]

[70] http://www.cityofcalabasas.com/pdf/Shea.pdf
[71] 24 June 2009, Draft NPDES General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities dated April 22, 2009.

Stream Team Volunteer sampling turbidity. Photo credit: Heal the Bay

WATER QUALITY DISCUSSION AND ANALYSIS

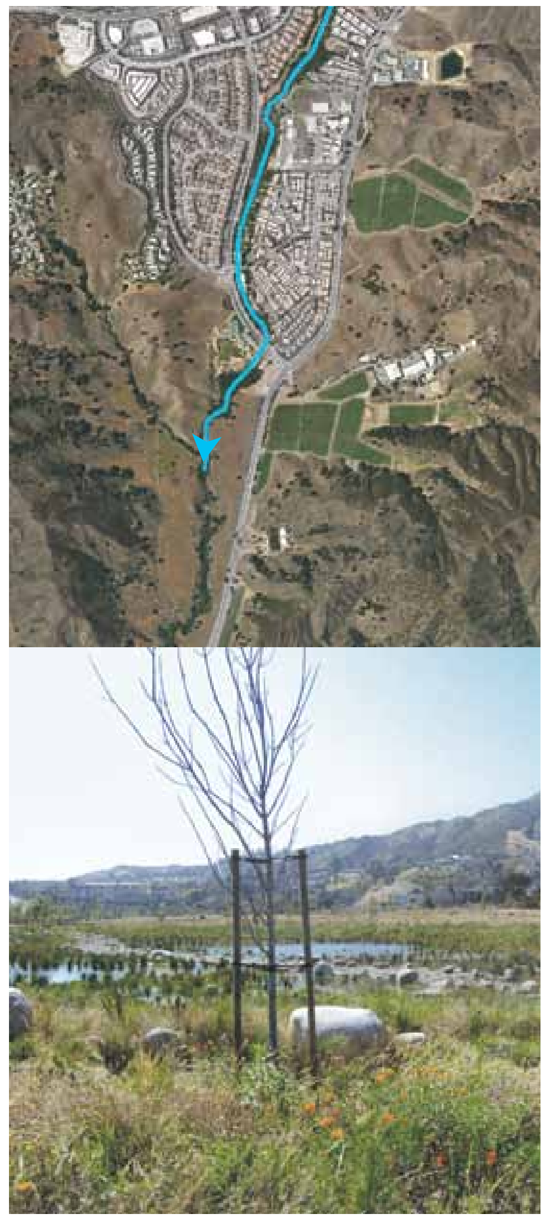
Despite the extent of undeveloped land in the Malibu Creek Watershed, there are severe water quality problems, most notably for nutrients and bacteria. The influence of Tapia Water Reclamation Facility on nutrient levels in Malibu Creek is undeniable, with elevated nitrate and phosphate concentrations just below Tapia during Tapia's discharge period. Further, all sampling sites that are not affected by discharge from Tapia, average total nitrogen concentrations below 1.0 mg/L throughout the year.

However, Tapia is not the only contributor to the significant nutrient impairments in the watershed. Las Virgenes, Triunfo and Medea Creeks, and Malibu Lagoon, also regularly exceed nitrogen limits. Several of these sites are downstream of agricultural development, septic systems, and recreational facilities such as golf courses and equestrian facilities. The impacts of vineyards still need to be assessed. While phosphate concentrations in the upper watershed may be affected by geologic factors, Heal the Bay data clearly show increased phosphate due to Tapia's discharge. The number of listings on the US EPA and State Water Resources Control Board 303(d) List for Impaired Waters alone testifies to the poor water quality in the watershed.

Water quality degradation also strongly correlates with developed area and percentages of impervious area in the watershed. The gradient from undeveloped reference areas through developed commercial or residential areas is particularly evident for nutrients and bacteria in Cold Creek and Las Virgenes Creek. Upper Cold Creek (R3) is one of the cleanest sites for nutrients, bacteria, and algae. The water quality degrades for these pollutants as the creek flows through the more densely developed neighborhood of Monte Nido where homes are located close to the creek. The Monte Nido area also has several equestrian facilities and properties in this area that treat their wastewater through the use of septic systems and leach fields. The combination of stream side vegetation removal to accommodate homes near the creek, drainage from horse facilities, and the use of traditional septic systems near the creek has likely contributed to the degraded water quality in this area. Direct drainage through pipes discharging to the creek and streambank armoring also contribute fine sediments to these waters. The results of the data analyses clearly document that the Monte Nido neighborhood is degrading water quality and contributing to the algae and bacteria impairments in Cold Creek and in the watershed.

Las Virgenes Creek suffers a similar fate. Water quality degrades from the Upper Las Virgenes Canyon Open Space Preserve, better known as the Ahmanson Ranch property, at the creek's headwaters, through the dense development within the City of Calabasas. Las Virgenes Creek receives drainage from the 101 freeway, the Las Virgenes Municipal Water Districts spray field irrigation site, nearby parkland, and the dense urban and suburban uses of the City of Calabasas shopping centers, commercial complexes and residential neighborhoods. Las Virgenes Creek represents some of the most polluted sites for bacteria and nutrients, including a 94% exceedance rate for *Enterococcus* just below the City of Calabasas, and averaging more than 4 times the TMDL limit for total nitrogen (1 mg/L) at the outlet of Las Virgenes Creek (O5) during the dry season.

Efforts to improve water quality at the base of the watershed include the construction of Legacy Park in the City of Malibu. The City of Malibu completed this project with financial support from the state, City of Malibu, and several public and private groups. Legacy Park features a stormwater retention and reclamation facility to remove bacteria from stormwater before it gets used for irrigation or enters the Malibu Creek Lagoon.[72] After runoff is captured at Legacy Park, it is pumped to a treatment facility for filtration and disinfection and then used as recycled water in the Civic Center area. Although Legacy Park is not a comprehensive wastewater and stormwater pollution reduction facility, it greatly helps reduce stormwater pollution in the Civic Center area. Though this facility addresses water quality impairment in the watershed by treating Civic Center runoff, it will not effectively solve the major bacteria and nutrient issues facing the watershed.



Top: Las Virgenes Creek as it travels through the City of Calabasas. Bottom: Legacy Park. Photo credit: Heal the Bay, Google Maps

Water quality degrades from the Upper Las Virgenes Canyon Open Space Preserve through the dense development within the City of Calabasas.

[72] http://malibulegacy.org

Algae growth in Triunfo Creek. Photo credit: Heal the Bay

RECOMMENDATIONS

Wastewater in the Malibu Creek Watershed is a significant issue which can be managed through several different methods. Although Tapia has significantly reduced total nitrogen loading in the watershed, they are currently meeting discharge limits that are likely to contribute to serious algal bloom impairments in the lower watershed. By increasing year-round water storage capacity within the treatment plant's user area, and increasing water recycling throughout the watershed, nutrient loading to Malibu Creek will be reduced. Targeted monitoring along Las Virgenes Creek and Malibu Creek is needed to identify the sources of nutrients that are not related to Tapia's direct discharge, including the fate of irrigation water in groundwater or nearby creeks and tributaries, and the possible effects of past biosolid injection.

There are also several ways that commercial and residential wastewater impacts can be reduced. The prohibition on new septic systems and phasing out of existing systems in much of the Malibu Civic Center area will help address this issue in the lower watershed. Further, advanced treatment for septic systems within 600 feet of watershed receiving waters, including denitrification and disinfection, should be required. The implementation of a centralized state of the art wastewater recycling plant in the Malibu Civic Center area is necessary to reduce bacteria and nutrient pollution in the lower watershed, provide a sustainable local water supply, and comply with the short-term ban on new septic systems and long-term ban on wastewater land disposal. Because Legacy Park does not receive or treat wastewater, there must be a more concerted effort in the lower watershed to reduce nutrients in other ways. Pollution associated with stormwater runoff is also of major concern in the Malibu Creek Watershed. Adopting protective Low Impact Development (LID) ordinances or policies in cities throughout the watershed that require onsite capture, and reuse or infiltration of runoff will also significantly reduce bacteria and nutrient loading in the watershed. The City of Los Angeles LID ordinance, adopted in September 2011, and the City of Santa Monica LID ordinance, adopted in March 2011, can work as excellent guides for implementing water quality improvements through the addition of LID BMPs throughout the watershed.[73] The upper watershed

[73] City of Los Angeles: http://san.lacity.org/wpd/Siteorg/program/LID/LID_Ordinance_09-1554_RPT_ATTY_08-05-11.pdf ; City of Santa Monica: http://www01.smgov.net/cityclerk/council/agendas/2010/20100713/s2010071307-B.htm

within Ventura County is covered under LID requirements through the Ventura County municipal stormwater permit adopted in 2010. The Los Angeles County municipal stormwater permit, approved in November 2012, includes strict LID provisions for new and re-development. Additionally, the adoption of stream protection ordinances by municipalities in the Malibu Creek Watershed will help improve water quality. These ordinances should include provisions requiring buffer zones (at a minimum of 100 feet setback from the creek) that will intercept and infiltrate stormwater before it reaches receiving waters. Further, discharges directly to the stream should be moved out of the streams and also given a buffer zone to allow for infiltration.

Heal the Bay and the SMBRC are also concerned about increasing agricultural land use in the watershed, especially the recent boom in viticulture and growth of equestrian facilities in the area. Appropriate installation, monitoring, and maintenance of agricultural BMPs to protect water quality and habitat are needed to protect natural resources in the watershed from further impact associated with agricultural use. Currently, there is no comprehensive monitoring program for viticulture, stables, or golf courses in the watershed. Stream buffer zones that prevent direct physical impacts to creeks and provide some natural treatment of runoff are also essential for protecting stream health from the impacts of agricultural land use. Examining land use changes in the watershed when the new SCAG data become available will provide insight to the potentially rapid increase in agriculture in otherwise open space areas. Furthermore, the Santa Monica Mountains Local Coastal Program should be developed to include provisions regarding agricultural use in the watershed that requires implementation, monitoring, and maintenance of BMPs that capture, treat, and infiltrate runoff from equestrian facilities, livestock areas, vineyards, and golf courses to address both nutrients and bacterial pollution. The LCP should prohibit any agriculture or livestock use on properties with slopes that are steeper than 3 to 1. Similar policies should be pursued at local governments outside of the Coastal Zone. Efforts to identify sources of nutrients and runoff must be accelerated to guide site-specific water quality improvements at hot spots contributing to water quality pollution in the watershed.

Finally, implementing and enforcing existing water quality regulations is a necessary step towards improving water quality in the area. With 21 different 303(d) listed impairments in Malibu Creek Watershed, several TMDLs need to be developed to improve water quality. Further, the implementation of and compliance assurance efforts for the three existing TMDLs is much slower than necessary to restore water quality in the watershed. For example, there is currently no implementation plan for the nutrient TMDL; US EPA established TMDLs do not include an implementation plan and the Los Angeles Regional Water Quality Control Board has not developed or issued an implementation plan with actions to meet the pollution limits for nutrients. Moreover, based on Los Angeles Regional Water Quality Control Board recommendations, and the results of this and other monitoring efforts, monthly nitrogen monitoring and Heal the Bay's algae assessments, the total nitrogen TMDL wet-weather limit of 8 mg/L should be revised and made consistent with the dry weather limit of 1 mg/L to reduce nutrient loading and excessive algal growth in the watershed. The Los Angeles Regional Water Quality Control Board must also develop implementation plans, with enforceable milestones, for all of the TMDLs in the watershed as soon as possible. These plans, along with potential incentives for compliance, are necessary to facilitate implementation and protect beneficial uses in the watershed. ■

TOP 5 **Recommendations to Implement and Enforce Existing Water Quality Regulation** (see p. 134)

- Implement and **Enforce Adopted TMDLs** for the Malibu Creek Watershed
- Implement and **Adopt New TMDLs** for Additional Impairments
- Lower Wet Season Total Nitrogen Limit to **Reduce Algal Growth**
- Establish Wet Season **Limit for Phosphate**
- Implement Septic System Policy to **Reduce Pollution**

TOP 5 **Recommendations to Reduce Nutrient and Bacteria to Background Concentrations** (see p. 136)

- Adopt **Low Impact Development** Ordinances or Policies
- Minimize Bacterial and Nutrient Pollution Caused by **Septic Systems**
- **Regulate Agricultural Use** in the Watershed Through Local Coastal Program
- Increase of **Water Storage Capacity** at Tapia Facility
- Source Identification and Remediation of **Pollution Sources**

Chapter 4

STATE OF THE BIOTA

INTRODUCTION

As throughout the world, California rivers and associated riparian habitats have routinely been modified or completely altered in an attempt to control hydrology and drain watersheds for human uses. Streambed modifications to accommodate urbanization, agriculture, and contaminant discharges are often harmful to aquatic life such as fish, amphibians, insects, and snails.[74] In recent years the State Water Resources Control Board has promoted the use of ecological indicators to more effectively measure the effects of streambed modifications and water pollution, and to track ecological changes resulting from implementing BMPs designed to control pollution and restore habitat.[75]

In 2000, Heal the Bay initiated a biological and physical habitat assessment program with guidance from the Sustainable Land Stewardship Institute. Between 2000 and 2010, nearly 175 bioassessment monitoring samples were collected at 14 of Heal the Bay's regular monitoring sites and an additional 15 special study sites. These data have contributed to several reports on the effects of sediment and nutrients on biotic communities within Santa Monica Mountain streams.[76] These data also provide baseline information on benthic macroinvertebrate assemblages and help determine the biotic condition for bioassessment sites within the Malibu Creek Watershed and the three nearby reference watersheds.

Direct measurements of biological communities such as plants, invertebrates, fish, and microbial life are well accepted as effective indicators of stream health.[77] Combined with measurements of watershed characteristics, land use practices, in-stream habitat, and water chemistry, biological assessment (bioassessment) can be a cost-effective tool for long-term trend monitoring of watershed condition.[78]

Benthic macroinvertebrate (BMI) monitoring is a popular and widely-used method of bioassessment. BMIs are critical to the health of stream systems as they are a significant food source for aquatic and terrestrial animals. They are ubiquitous, relatively stationary, and their high species diversity provides a

[74] Jones, R.C., & Clark, C.C. 1987. Impact of watershed urbanization on stream insect communities. *Water Resources Bulletin* 23(6): 447-455; Lenat, D.R., & Crawford, J.K. 1994. Effects of land use on water quality and aquatic biota of three North Carolina piedmont streams. *Hydrobiologia* 294(3): 185-199; Weaver, L.A., & Garman, G.C. 1994. Urbanization of a watershed and historical changes in a stream fish assemblage. *Transactions of the American Fisheries Society* 123(2): 162-172; Karr, J.R. 1998. Rivers As Sentinels: Using the Biology of Rivers to Guide Landscape Management. In *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion*, ed. R.J. Naiman and R.E. Bilby, 502-528. New York: Springer-Verlag.; Miltner, R.J. et al. 2004. The biotic integrity of streams in urban and suburbanizing landscapes. *Landscape and Urban Planning* 69(1): 87-100.

[75] Ode, P.R. 2007. Standard operating procedures for collecting macroinvertebrate samples and associated physical and chemical data for ambient bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 001.

[76] Luce, S.L.M. 2003. *Urbanization and aquatic ecosystem health in Malibu Creek, California: impacts on periphyton, benthic macroinvertebrates, and environmental policy.* (Doctoral dissertation). University of California, Los Angeles; Luce, S., & Abramson, M. 2005. Periphyton and nutrients in Malibu Creek, a Heal the Bay Report. Available from Heal the Bay.

[77] Harrington, J., & Born, M. 2000. Measuring the health of California streams and rivers: A methods manual for water resource professionals, citizen monitors and natural resources students, 2nd Edition. Sustainable Land Stewardship Institute, Box 161585, Sacramento CA 95816.

[78] Davis, W.S., & Simon, T.P. 1995. Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making, Lewis Publishers, Boca Raton, FL.; Karr, J.R. 1998. Rivers As Sentinels: Using the Biology of Rivers to Guide Landscape Management. In *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion*, ed. R.J. Naiman and R.E. Bilby, 502-528. New York: Springer-Verlag; Karr, J.R., & Chu, E.W.. 1999. Restoring Life in Running Waters: Better Biological Monitoring. Island Press, Washing DC 20009, 207 pp.; Karr, J.R., & Yoder C.O. 2004. Biological assessment and criteria improve total maximum daily load decision making. *Journal of Environmental Engineering* 130(6): 594-604.

spectrum of responses to environmental stresses.[79] Individual BMI species reside in the ecosystem for months to several years, and vary in sensitivity to environmental stressors. These stressors can include low dissolved oxygen, diversion in temperature from natural background levels, sedimentation, scouring, invasive species, nutrient loading, and chemical pollution.[80]

Regular bioassessment monitoring provides water resource managers with a unique way of understanding and interpreting water quality data because the indicators reflect changes over an extended period of time, show sensitivity to multiple aspects of water pollution and habitat degradation, and provide the public with more familiar expressions of ecological health.[81] Furthermore, when integrated with physical and chemical assessments, bioassessment can help better characterize the effects of pollutants and point sources, and provide a means for evaluating biological impacts associated with sedimentation and habitat destruction.

Above: Adult Dragonfly. Photo credit: Matthew Fields, Wiki Commons

Top row: Pollution Tolerant BMI (left to right); Scud, Midge, Snail, Leech. Bottom row: Sensitive BMI larvae (left to right); Dragonfly, Mayfly, Caddisfly, Stonefly. Photo credit: California Department for Fish and Game, Aquatic Bioassessment Laboratory

[79] Rosenberg, D.M., & Resh, V.H. 1993. *Freshwater Biomonitoring and Benthic Macroinvertebrates*. Chapman & Hall, London; Merritt, R.W., & Cummins, K.W. 1996. *An Introduction to the Aquatic Insects of North America,* Third Edition. Kendall/Hunt, Dubuque IA. 862 pp.

[80] Resh, V.H., & Jackson, J.K. 1993. Rapid assessment approaches to biomonitoring using benthic macroinvertebrates. In: Rosenberg, D.M., Resh, V.H. (Eds.), *Freshwater Biomonitoring and Benthic Macroinvertebrates.* Chapman & Hall, London, pp. 195-223.

[81] Gibson, G. R., Barbour, M.T, Stribling, J.B., Gerritsen, J., & Karr, J.R. 1996. Biological criteria: Technical guidance for streams and small rivers (revised edition). EPA 822-B-96-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC, 162 pp.

Steelhead Survey at Malibu Creek. Photo credit: Heal the Bay

BENTHIC MACROINVERTEBRATES (BMI) AND THE INDEX OF BIOLOGICAL INTEGRITY (IBI) BACKGROUND

Evaluation of bioassessment monitoring is based on well-accepted ecological principles, such as biodiversity as an indicator of ecological health, and some general observations of the ecology of BMIs.[82] Along with species diversity, BMI assemblages can also represent a diversity of feeding guilds. This contributes to a balanced food web, which is also an indicator of biological health.[83]

Different benthic macroinvertebrate species vary in their ability to withstand stress, therefore the presence or absence of specific BMI can provide insight to the health of the ecosystem. A broad diversity of BMI species indicates a healthy assemblage; however certain species are more sensitive to pollution than others, which is also accounted for in biological health indices. Sensitive species include caddisflies, stoneflies, mayflies, dragonflies, and damselflies, while scuds, snails, leeches, and midges are considered pollution tolerant species.[84] Populations of sensitive species decrease in response to stress, and in return pollutant tolerant BMI populations grow.

The BMI assemblage composition at each site is assessed and scored according to an Index of Biological Integrity (IBI), an analytical approach recommended by the US EPA to assess human stressors on the biotic condition of waterbodies.[85] IBIs also exist for fish, plants, and other taxa; however, the IBI used in this report is based on BMI assemblage composition. An overall site score ranging from 0 to 100 is determined through a multimetric, multivariate technique based on the correlation

[82] Harrington, J., & Born, M. 2000. Measuring the health of California streams and rivers: A methods manual for water resource professionals, citizen monitors and natural resources students, 2nd Edition.

[83] Vannote, R.L. et al. 1980. The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences* 37: 130-137.

[84] Harrington, J. Bioassessment Monitoring (presentation), WPCL Bioassessment Laboratory. 19 August 2004; Harrington, J. & Born, M. 2000. Measuring the health of California streams and rivers: A methods manual for water resource professionals, citizen monitors and natural resources students, 2nd Edition. Sustainable Land Stewardship Institute, Box 161585, Sacramento CA 95816.

[85] Davis, W.S., & Simon, T.P. 1995. Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making, Lewis Publishers, Boca Raton, FL; Barbour, M.T., Gerritsen, J., Snyder, B.D. & Stribling, J.B. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

between human impact and changes in BMI assemblages. Sites are then ranked according to their scores and classified into five groups from "excellent" to "very poor" biotic condition. Geographic regions, including southern California, have unique IBIs because biological conditions change with geography (for more detail on the Southern California IBI development, see Appendix D). The IBI also accounts for stream order to allow for comparison of streams in various parts of a watershed.

Within the southern California IBI, scores are divided into five categories to assess biotic condition: "excellent" (81-100), "good" (61-80), "fair" (41-60), "poor" (21-40) and "very poor" (0-20) (Table 4-1). These categories are considered more relevant to understanding biological health than the raw IBI score. Values of 39 or lower depict a biologically impaired waterbody with poor or very poor biotic condition.[86] The State Water Resources Control Board uses this score to designate waterbodies as impaired for macroinvertebrate communities in the 303(d) List of Impaired Waters.

Table 4-1: IBI Scores Ranges for Southern California

Excellent	Good	Fair	Poor	Very Poor
81-100	61-80	41-60	21-40	0-20

Western Toad. Photo credit: Heal the Bay

Different benthic macroinvertebrate species vary in their ability to withstand stress, therefore the presence or absence of specific BMI can provide insight to the health of the ecosystem.

[86] Ode, P.R. et al. 2005. A quantitative tool for assessing the integrity of southern coastal California streams. *Environmental Management* 35(4): 493-504.

Figure 4-1: Average IBI Score at Reference, Middle, and Outlet Sites

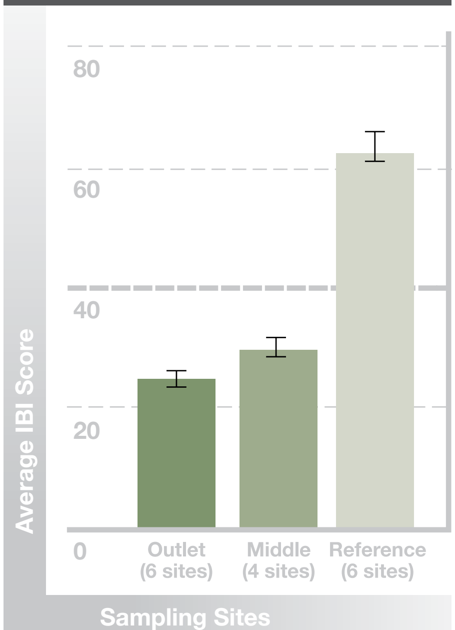


FIGURE 4-1: Average IBI scores at middle and outlet sites are below the State Water Resources Control Board threshold 39 of for biological impairment of macroinvertebrate communities, as indicated by the black dashed line.

Table 4-2: Average IBI Score at Monitoring Sites in the Santa Monica Mountains

Sample Sites	Site No.	Average IBI Score	Average Category	Number of Samples
Upper Cold Creek	R3	77	Good	13
Cheeseboro Creek	R6	51	Fair	7
Upper Las Virgenes Creek	R9	40	Poor	7
Solstice Creek	R14	67	Good	10
Lachusa	R18	56	Fair	9
Arroyo Sequit	R19	66	Good	10
Mid-Cold Creek	M11	49	Fair	9
Mid-Malibu Creek, upstream	M12	23	Poor	12
Mid-Las Virgenes Creek	M13	19	Very Poor	8
Mid-Malibu Creek, downstream	M15	25	Poor	11
Outlet Malibu Creek	O1	23	Poor	12
Outlet Cold Creek	O2	41	Fair	9
Outlet Las Virgenes Creek	O5	26	Poor	12
Medea Creek	O7	19	Very Poor	11
Triunfo Creek	O17	13	Very Poor	8

IBI TRENDS IN THE MALIBU CREEK WATERSHED

As an indicator of biotic health at a particular site, IBI scores can be used to help identify degraded sites and inform further research on potential stressors, such as physical habitat and/or water quality degradation.

Heal the Bay conducted BMI monitoring at 15 sites in the watershed and three reference watersheds between 2000 and 2010. When Heal the Bay began BMI monitoring in 2000, bi-annual samples were collected during spring and fall; in 2006, samples were only taken in spring. Beginning in 2007, samples were collected using the State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) protocol.[87]

Generally, reference sites have much higher IBI scores than middle and outlet sites (Table 4-2 and Figure 4-1). The average IBI score at reference sites is 62, in the "good" range, while average IBI scores at middle and outlet sites fall in the "poor" range with scores of 30 and 24 respectively (Table 4-2 and Figure 4-1). Annual IBI scores at regularly monitored sites range from 0 to 92. Solstice Creek (R14) and Lachusa Creek (R18) experienced the highest variability in scores, varying by greater than 35 points over the 10-year monitoring period. Solstice Creek (R14) declined by 38 points from 2001 to 2010 and Lachusa Creek (R18) has varied from a high of 73 in 2001 to a low of 11 in 2006 and most recent score of 47 in 2010.

Upper Cold Creek (R3) consistently had one of the highest IBI scores in the watershed, which is consistent with its generally excellent water quality as discussed in the previous section. Moving downstream from Upper Cold Creek (R3) through the bottom of the watershed at the outlet of Malibu

[87] Ode, P.R. 2007. Standard operating procedures for collecting macroinvertebrate samples and associated physical and chemical data for ambient bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 001. Available at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/phab_sopr6.pdf

Creek (O1), there is an obvious decrease in IBI scores, as shown in Figure 4-2. This trend is consistent with decreasing water quality at middle and lower sites throughout the watershed, and is most notable below mid-Cold Creek (M11), where IBI scores drop more consistently below 40 in the later monitoring years.

Very few of the sites show decreasing IBI scores over the 10-year monitoring period, as shown in Figure 4-2 and Table 4-3. However, Solstice Creek (R14) is of special concern because as a reference site, it is trending toward lower IBI scores (Figure 4-3 and Table 4-3). In 2002 it was in the upper-good IBI score category, but its scores have been decreasing since then. It is currently in fair condition, and still above the impairment threshold value for southern California streams (IBI score of 39 or below), but has been decreasing since Heal the Bay began monitoring at the site. Invasive New Zealand mudsnails have been found in Solstice Creek but not yet at our specific site (R14). Further, Solstice Creek (R14) does not have evident habitat impairments that would likely affect the IBI score. However, we are concerned that increased agricultural activity, especially vineyards, in Solstice Canyon may be influencing water quality and biotic integrity at this site. Examining the land use changes and increasing stressors in the upper watershed is important to help better understand this trend.

Figure 4-2: Average IBI Scores at Regularly Monitored Sites from Upper to Lower Malibu Creek Watershed

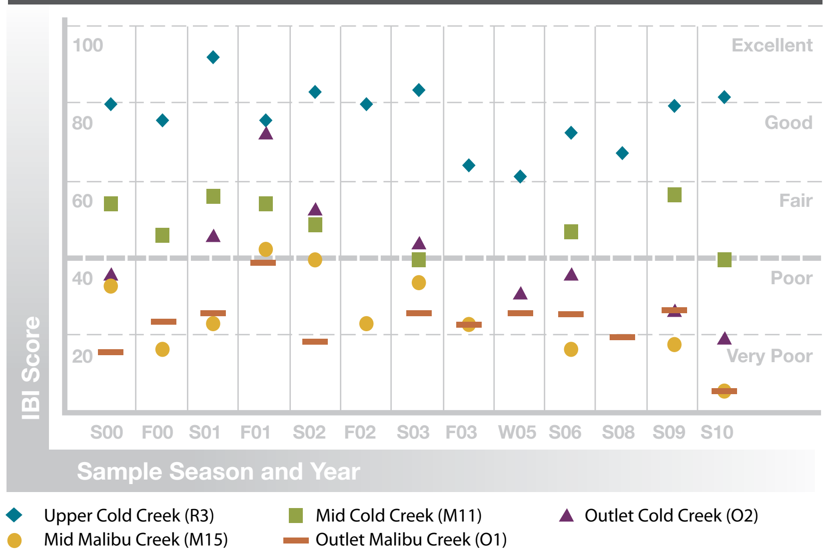


FIGURE 4-2: Average IBI Scores at Regularly Monitored Sites from Upper to Lower Malibu Creek Watershed. Average IBI scores for regularly monitored sites in a transect from upper Cold Creek (R3) to the outlet of Malibu Creek (O1) by season and year (S=Spring, F=Fall, W=Winter).

STRESSOR IDENTIFICATION FOR BIOLOGICAL INTEGRITY

It is important to examine the potential stressors on BMI communities to help understand the trends in biological integrity. In the Malibu Creek Watershed, these stressors include physical habitat quality, invasive species, percent impervious area, and water quality.

PHYSICAL HABITAT QUALITY

Assessing physical habitat quality is a valuable part of characterizing monitoring sites for potential impacts on biological condition. Over the 10 years of monitoring, Heal the Bay used several different methods to determine physical habitat quality at its monitoring sites, all of which employed California state standard procedures developed by the Department of Fish and Wildlife and accepted by the State Water Resources Control Board.

The first physical habitat assessment method used by Heal the Bay was the Rapid Bioassessment Protocol (RBP), developed as part of the California Stream Bioassessment Procedure (CSBP).[88] In 2005, the CSBP was calibrated to a national protocol used by the US EPA for wadeable stream assessment.[89] The Department of

Figure 4-3: IBI Scores for Solstice Creek (R14) from 2001-2010

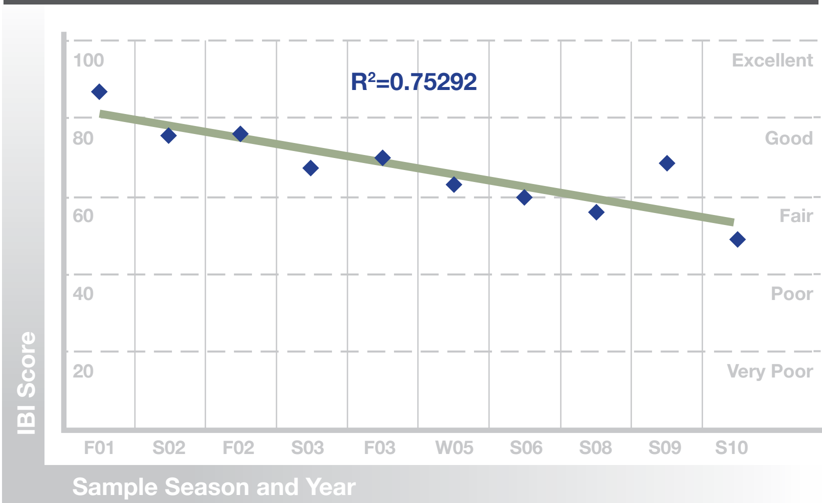


FIGURE 4-3: IBI scores for Solstice Creek have been regularly decreasing over time. X-axis indicates sample season shown by season and year. A linear regression shows that 75% of the variation in IBI score is explained by time.

Table 4-3: IBI Scores for Heal the Bay Bioassessment Sites (2000-2010)

		2000		2001		2002		2003		2005	2006	2008	2009	2010
Location/Site		Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Winter	Spring	Spring	Spring	Spring
Reference Sites														
Cold Creek	R3	80	76	92	76	83	80	84	64	61	73	67	79.5	82
Cheeseboro Creek	R6			59	57	64		49		54	43			34
Las Virgenes Creek	R9					59	26	46		34	34		42	39
Solstice Creek	R14				87	76	76	67	70	63	60	56	69	49
Lachusa Creek	R18				73	72	76	54	61	54	11		57	47
Arroyo Sequit Creek	R19				70	72	66	72	70	64	57	50	70	70
Middle Sites														
Cold Creek	M11	54	46	56	54	49		40			47		57	39.5
Malibu Creek	M12		23	20	37	33	27	21	31	20	17	29/9%	17/65%	3/1%
Las Virgenes Creek	M13					26	24	21	27	11	18		8/15%	13/12%
Malibu Creek	M15	33	17	24	43	40	24	34	23		17/4%		18/29%	6/13%
Outlet Sites														
Malibu Creek	O1	16	24	26	39	19		26	23	26	26/3%	20/78%	27/81%	6/<1%
Cold Creek	O2	36		46	73	53		44		31.5	36.5*		27	20
Las Virgenes Creek	O5	29	34	33	33	39	26	20	29	18	16/24%		26/50%	10/16%
Medea Creek	O7	23	26	19	34	23		9	9	10/59%	20/45%		19/95%	14/57%
Triunfo Creek	O17	20		19		19		4		0	20		18	3
Special Study Sites														
Solstice Creek	SS22										64		53/33%	45/23%

TABLE 4-3: IBI scores for the Heal the Bay bioassessment sites in the Santa Monica Mountains from 2000-2010 (O = outlet, M = middle, R = Reference, SS = Special Study). The presence and percent sample composition of New Zealand mudsnail is indicated in red. IBI values for sites with duplicate scores collected as a quality assurance and control practice samples were averaged, "*" indicates duplicate samples which were not within 10 points of each other.

Fish and Wildlife chose to employ this nationally standardized procedure because it allowed for quantitative comparison to habitats throughout the state and country. The Department of Fish and Wildlife slightly modified this procedure for approval by the State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP), which adopted it in 2008 for the habitat assessment.[90] Heal the Bay adopted this procedure in hopes of being able to use bioassessment data collected by the Stream Team for comparison with state standards. SWAMP procedures are significantly more involved and time consuming than the RBP, and Heal the Bay found that the benefits of the additional time and effort were minimal.

As discussed in the water quality section of this report, Heal the Bay's monitoring sites were pre-assessed for physical habitat integrity before monitoring began in 1998, in order to help facilitate a more focused assessment of water quality and upstream impacts to aquatic integrity. All of the monitoring sites selected have natural substrate, and are not channelized or hardened. Therefore, physical habitat assessments at these monitoring locations are not indicative of habitat quality in the watershed as a whole, but rather provide a "best case scenario" perspective of habitat health in the watershed.

Bioassessment sampling by Heal the Bay staff. Photo credit: Heal the Bay

88 http://www.dfg.ca.gov/abl/Field/professionals.PDF

89 Barbour, M.T., Gerritsen, J., Snyder, B.D., & Stribling, J.B.. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C; USEPA. 2006. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-06-002. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.

90 Ode, P.R. 2007. Standard operating procedures for collecting macroinvertebrate samples and associated physical and chemical data for ambient bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 001.Available at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/phab_sopr6.pdf

HABITAT ASSESSMENT PROTOCOL I: RAPID BIOASSESSMENT PROTOCOL (RBP)

Heal the Bay conducted physical habitat assessment using the RBP methods from 2000-2006. The RBP was also used in 2008 as an initial comparative study with the new SWAMP procedures. Ten individual parameters were used to determine physical habitat quality at each site using the data collected through the RBP. Each parameter was assigned a value indicating its physical habitat quality on a 0-20 scale (0-5 designating poor condition, 6-10 designating marginal condition, 11-15 designating sub-optimal condition, and 16-20 designating optimal condition). Adding the value (0-20) for each parameter results in a total site score ranging from 0-200 (0-50 designating poor condition, 51-100 designating marginal condition, 101-150 designating sub-optimal condition, and 151-200 representing optimal condition) (for more information on the CSBP Physical Habitat Metrics, see Appendix E). Table 4-4 shows that physical habitat quality at all Heal the Bay monitoring sites is in optimal or suboptimal condition. While on average, outlet sites had slightly lower habitat quality, RBP values indicate that physical habitat may not be a significant stressor at these sites. These results are not unexpected because monitoring sites were pre-selected for physical habitat integrity.

It is important to examine the potential stressors on BMI communities to help understand the trends in biological integrity. In the Malibu Creek Watershed, these stressors include physical habitat quality, invasive species, percent impervious area, and water quality.

The upper Las Virgenes (R9) and Cheeseboro Creek (R6) reference sites both had relatively low average RBP values when compared to the rest of the monitoring sites. The reference site at Upper Las Virgenes Creek (R9) had the lowest average RBP value monitored. Similarly, the reference site at Cheeseboro Creek (R6) was not considered a reference site because of its low RPB value and very low flows. Heal the Bay discontinued sampling at Cheeseboro Creek (R6) in 2003 because it was consistently dry during the summer season. Average RBP for reference sites was also calculated without these sites because of these physical habitat and water quality issues.

Table 4-4: Average Physical Habitat Scores by Site between 2000-2008 (Assessed using Rapid Bioassessment Protocol)

Location	Site	Type	Average RBP	Average by Type
Upper Cold Creek	R3	R	173	**Reference Average: 149** *Average (-R6, -R9): 159*
Cheeseboro Creek	R6	R	136*	
Upper Las Virgenes	R9	R	123*	
Solstice Creek	R14	R	155	
Lachusa Creek	R18	R	163	
Arroyo Sequit Creek	R19	R	145	
Mid-Cold Creek	M11	M	162	**Middle Average: 153**
Upper-mid Malibu Creek	M12	M	167	
Mid-Las Virgenes Creek	M13	M	139	
Lower-mid Malibu Creek	M15	M	142	
Outlet Malibu Creek	O1	O	142	**Outlet Average: 133**
Outlet Cold Creek	O2	O	141	
Outlet Las Virgenes Creek	O5	O	128	
Outlet Medea Creek	O7	O	127	
Outlet Triunfo Creek	O17	O	128	

Optimal RBP values

Sub-optimal RBP values

* *Sites with low physical habitat scores and relatively poor water quality, making them less useful as reference locations.*

TABLE 4-4: Heal the Bay discontinued sampling at Cheeseboro Creek (R6) in 2003 because it was consistently dry during the summer season and because of the presence of the Calabasas Landfill upstream. Without sites R6 and R9, the reference site RBP average increases to 159, representing optimal condition.

HABITAT ASSESSMENT PROTOCOL II: SWAMP BIOASSESSMENT PROCEDURE

Starting in 2008, the Heal the Bay Bioassessment Program adopted the SWAMP bioassessment procedures exclusively and began measuring physical habitat condition using only this method. Through this procedure, 11 transects are established every 15 meters along a 150-meter reach. Various physical habitat metrics are measured along these transects, including substrate type, streambank integrity, canopy cover, and riparian habitat integrity.[91] These metrics are used to determine stream morphological description, stream substrate composition, stream flow habitats (e.g. pools, riffles, glides, and runs), and stream habitat characteristics, including in-stream habitat complexity, riparian growth, bank stability, and human disturbance (for more information on the SWAMP Bioassessment results, see Appendix F).

During the establishment of the southern California IBI, 72 regional reference sites and 166 non-reference sites were examined for metrics to quantify human disturbance and physical habitat. These metrics do not yield a single value for comparison across sites like the RBP. However, the physical habitat factors examined may provide potential insight into stressors impacting aquatic health at each monitoring location. While there is not yet a metric for examining these habitat factors, comparing physical habitat metrics from our sites to the regional values may provide some insight to the physical habitat quality of our sampling sites.

As a preliminary analysis, physical habitat quality at Heal the Bay monitoring sites was classified into poor, marginal, suboptimal, and optimal categories based on comparison to the physical habitat assessment conducted while establishing the southern California IBI. The initial results indicate the Heal the Bay monitoring sites generally score in suboptimal and optimal range for habitat quality, with marginal scores at a few sites in the middle and lower watershed (more information in Appendix F).

This preliminary analysis shows that habitat quality is similar across Heal the Bay's monitoring sites, with no strong differences for each metric between outlet, middle, and reference sites. This is consistent with the findings from the RBP analysis, which showed that all of our sampling sites were optimal or suboptimal for physical habitat condition.

The initial results [of the preliminary analysis] indicate the Heal the Bay monitoring sites generally score in suboptimal and optimal range for habitat quality, with marginal scores at a few sites in the middle and lower watershed.

Comparing the RBP and the SWAMP protocols will be a next step for Heal the Bay as we continue to use the SWAMP physical habitat assessment protocol. The RBP method takes significantly less time per site to complete than the SWAMP method. In order to balance the added strain on volunteer resources and staff time, the SWAMP protocol must provide a more accurate and useful evaluation component. Otherwise, the considerable time spent in the field for data collection may not be well-justified, especially at regular sites that have been pre-selected for decent physical habitat.

California Newt. Photo credit: Justin Johnsen, Wiki Commons

[94] Ode, P.R. 2007. Standard operating procedures for collecting macroinvertebrate samples and associated physical and chemical data for ambient bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 001.Available at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/phab_sopr6.pdf

New Zealand mudsnails in the Malbu Creek Watershed. Photo credit: Heal the Bay.

STRESSOR IDENTIFICATION OF BIOLOGICAL CONDITION

New Zealand mudsnails (Potamopyrgus antipodarum) are a highly invasive small snail, approximately 1/8 of an inch in length, which reproduce asexually. New Zealand mudsnails (NZMS) were introduced to the United States in the 1980s. They were first observed in Idaho's Snake River and now occur in all the western states except New Mexico. The first infestation found in California was in the Owens River in 2000. Since then, several streams throughout California have been invaded by NZMS. In some conditions, a single NZMS can colonize an entire streambed with densities up to 500,000 individuals per square yard. When an invasive aquatic species displaces the native population, it can dramatically decrease biodiversity, and in some cases may result in the collapse of the ecosystem.

Several streams in the Santa Monica Mountains currently host NZMS populations, with their first recorded presence in 2005 in samples collected by the City of Calabasas. Heal the Bay began finding NZMS in bioassessment samples in 2006. Surveys conducted in 2009 indicated that eight streams within the Santa Monica Mountains were infested with NZMS (Malibu, Medea, Las Virgenes, Lindero, Cold, Triunfo, Solstice, and Ramirez Creeks), which was an increase from only two streams in 2005, and three streams in 2006.[92]

Most NZMS surveys are qualitative involving simple observations of the streambed or estimating densities along transects in a specific length of streambed. Heal the Bay's bioassessment monitoring provides a more precise, quantitative means to estimate NZMS densities at regularly monitored sites. These surveys will also help demonstrate changes in NZMS density over time and provide the opportunity to examine how NZMS presence affects the BMI community and IBI scores.

[92] Abramson, M. 2009. Tracking the Invasion of the New Zealand mudsnail, Potamopyrgus antipodarum, in the Santa Monica Mountains. *Urban Coast* 1(1).

Figure 4-4: Map of New Zealand Mudsnail Colonization of the Malibu Creek Watershed and Surrounding Areas

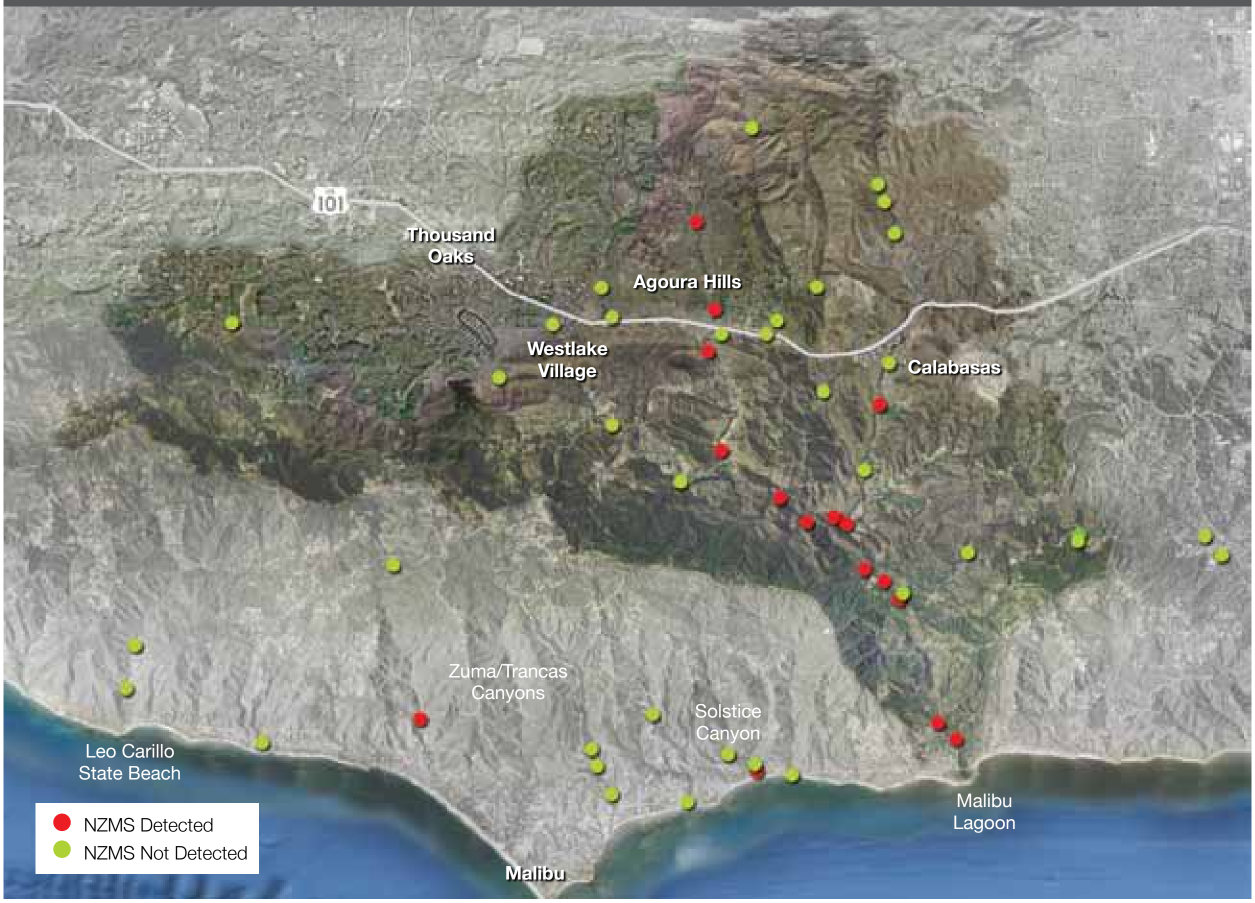


FIGURE 4-4: New Zealand mudsnails (NZMS) were detected at red locations, and were not detected at green locations (surveys through 2008). Monitoring was conducted by Heal the Bay, SMBRC, and UCLA.

The invasion of NZMS is considered a serious threat to the health of the Malibu Creek Watershed by natural resource managers and local environmental organizations. Protocols have been developed by the Department of Fish and Wildlife to prevent the spread of NZMS, including specific practices for those who recreate and conduct monitoring in the watershed.[93] Heal the Bay and the Santa Monica Bay Restoration Commission also developed and utilize precautious protocols to prevent further NZMS spread during stream monitoring and habitat assessment efforts.[94]

EFFECT OF NZMS ON BIOTIC CONDITION IN MALIBU CREEK WATERSHED

NZMS were first documented in the Malibu Creek Watershed in 2005 at two monitoring sites, the outlets of Las Virgenes and Medea Creeks (O5 and O7). In 2006, their presence spread to the outlet and lower-mid Malibu Creek sites (O1 and M15), followed by the upper-mid Malibu Creek (M12) in 2008, and mid-Las Virgenes Creek in 2009. NZMS are currently present at six of Heal the Bay's regularly monitored bioassessment sites including the outlet, lower-mid, and upper-mid portions of Malibu Creek (O1, M15, and M12), the outlet and mid-Las Virgenes Creek sites (O5

[93] State of California, Department of Fish and Game. 2005. Controlling the spread of New Zealand mud snails on wading gear. Available at: http://www.dfg.ca.gov/invasives/mudsnail/
[94] Heal the Bay and Santa Monica Bay Restoration Commission. 2008. Hazard Analysis & Critical Control Points (HACCP) Plan to Prevent the Spread of New Zealand Mudsnails.

and M13), and the outlet of Medea Creek (O7). They have also been documented at several additional locations in the Las Virgenes sub-watershed and in Solstice Creek Watershed (Figure 4-4). Malibu, Medea, Las Virgenes, Lindero, and Solstice Creeks are currently listed on the 303(d) List for Impaired Waterbodies for invasive species impairment. Each of these creeks has been identified with at least moderate NZMS densities since their invasion in 2005.

At the mid-Las Virgenes (M13) and Medea Creek (O7) monitoring sites, the percentage of NZMS within the BMI samples was highly variable across sample events, and ranged from 12% to 95%. Mid-Las Virgenes Creek site (M13) was the least infested by NZMS, and Medea Creek (O7) had the highest NZMS abundance (Table 4-3). Both of these sites had poor water quality and low IBI scores before the NZMS invasion, and colonization by the snail had no apparent consequence on the biotic integrity when measured by the IBI score. However, high densities of NZMS in BMI samples may hinder the ability to understand impacts to biotic integrity when upstream water quality and habitat improvements are made.

A special study was conducted in lower Solstice Creek from 2006-2010. NZMS first colonized Solstice Creek in 2009 with densities of 23%-33% of the BMI sample. From 2009-2010, mean IBI values in Solstice Creek dropped from 61 to 47. This may indicate that sites with generally good biotic condition before NZMS colonization are more negatively affected by invasion. However, upstream in Solstice Creek (R14), there was a noticeable decline in IBI score over the last decade without NZMS invasion, which may indicate a larger problem in the subwatershed.

IBI AND INVASIVE SPECIES

Although IBI is a useful metric, the IBI score may not adequately reflect the effects of NZMS invasion on biotic condition (Table 4-3). NZMS density has increased since colonization at the Malibu Creek sites; however in 2010, NZMS density dropped dramatically in Malibu Creek, which may be due to increased flow (2010 had higher than average rains). High flow may have removed snails by scouring the streambed or flushing fine sediments from the watershed, providing access to habitat for other BMI species. The decrease in NZMS likely affected the IBI scores at some sites, most notably the outlet of and mid-Malibu Creek (O1 and M12) where the scores decreased to 6 and 3 respectively in 2010. The decreased density of NZMS allowed for the colonization of these sites by a single BMI species of mayfly, leading to an overall decrease in the IBI scores. This is of particular interest because mayflies are a sensitive species; they are a source of food for steelhead and indicate increased habitat or water quality. Yet, their dominance led to a low IBI score. However, when NZMS dominate a site, it does not necessarily result in dramatically low IBI scores. The presence of NZMS or any non-native species does not effectually cause an IBI score to decrease, and it can even increase a score. This is counterintuitive as the IBI score is an indicator for stream health, which invasive species may nega-

Adult and juvenile New Zealand mudsnails (Potamopyrgus antipodarum) compared to a dime. Photo courtesy of U.S. Geological Survey tively impact. It may suggest a significant problem with using the current southern California IBI to examine the impacts of invasive species on waterbodies.

The southern California IBI was designed using seven metrics: EPT taxa richness (mayfly, stonefly, and caddisfly), beetle richness, predator richness, percent of individuals in specific feeding groups (collector-filterers + collector-gatherers), percent pollution intolerant taxa, percent non-insect taxa, and percent pollution tolerant taxa.[95] Aquatic invasive species are not specifically considered when determining the IBI score based on the BMI assemblage. New Zealand mudsnails fall into the categories of non-insect taxa and tolerant taxa. Therefore, NZMS at a site add points to these two categories. While species density and diversity of native BMI are decreased by the presence of NZMS, the southern California IBI does not directly incorporate the potential impacts of NZMS or other invasive BMI. This represents a flaw in the southern California IBI, and consideration should be given to redesigning the index based on the presence of aquatic invasive species. Additionally, the impacts of NZMS on stream health must also be researched independently from the IBI to better understand its effects throughout the watershed. We also suggest further investigation into how IBI score is influenced by the presence, absence, and abundances of certain species through simulations.

PERCENT IMPERVIOUS AREA

The developed area of a watershed has a tremendous impact on the overall health of its streams. Developed areas often have significant impervious surface area, such as roads, parking lots, commercial and residential buildings, which impede water from infiltrating directly into the ground and lead to higher and faster runoff volumes.

This impervious cover affects the hydrology, chemistry, and biological health of aquatic ecosystems. Increased impervious cover degrades channel stability, water quality, and biodiversity.[96] Each land use classification has a different degree of imperviousness, which affects the ability of water to infiltrate in that area. As discussed in the habitat section of this report (Chapter 2), the percent of impervious area is measured by the area of development and by the ability of that area to allow water to permeate into the ground. For example, parks have higher permeability than commercial and residential land uses. Details on how percent impervious area is calculated for the Malibu Creek Watershed in this report are available in Appendix C.

Mean IBI scores at Heal the Bay monitoring sites decreased dramatically as the percent impervious area in the area above each site increased (Figure 4-5). The best fit logarithmic trendline crosses the IBI score of 39 (impairment) at 6.3% impervious area. Therefore, there appears to be a threshold of imperviousness above which the benthic community becomes seriously impaired. At 6.3% impervious area and above, all mean IBI scores are 39 or below (39 is the threshold for impairment used by the SWRCB). No sites with greater than 3% impervious area have average IBI scores above 60, in the good range.[97] This is particularly disturbing, as previous studies have identified ecological impacts at higher thresholds of impermeability - habitat degradation in areas with 10% or more impervious cover,[98] and biological impacts to aquatic vertebrate communities in areas of 8% or greater urbanization in the Santa Monica Mountains.[99]

[95] Ode, P.R. et al. 2005. A quantitative tool for assessing the integrity of southern coastal California streams. *Environmental Management* 35(4): 493-504.
[96] Paul, M.J., & Meyer, J.L. 2001. Streams in the Urban Landscape. Annual Review of Ecology and Systematics 32:333-365; Center for Watershed Protection. 2003. Impacts of Impervious Cover on Aquatic Systems. *Watershed Protection Research Monograph* No. 1.
[97] For more information on percent impervious area and development in the watershed, see Chapter 2: State of the Habitat.
[98] Schueler, T. 1994. The importance of imperviousness. *Watershed Protection Techniques* 2(4):100-111.
[99] Riley, S.P.D. et al. 2005. Effects of urbanization on the distribution and abundance of amphibians and invasive species in southern California streams. *Conservation Biology* 19(6):1894-1907.

Figure 4-5: Percent Imperviousness Impact on Mean IBI Score

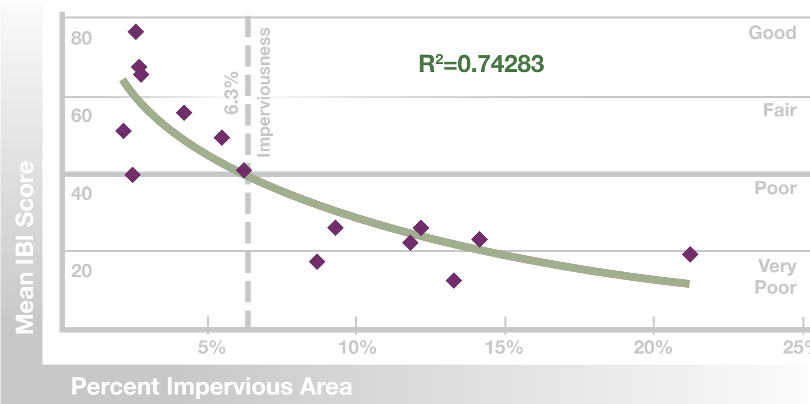


FIGURE 4-5: The mean IBI score appears to be heavily influenced by the percent impervious area above each monitoring site. All sites with percent impervious area at or above 6.3% have average IBI scores in the poor or very poor range, below 39, which is the SWRCB threshold for biological impairment.

In order to better understand how percent impervious area impacts the benthic macroinvertebrate community, we suggest conducting more site-specific research to examine density of impermeable area in specific places and its impact on IBI scores.

Percent impervious area accounts for nearly 74% of the variation in IBI scores (R^2=0.74). Consequently, it is critical that the amount of impervious cover throughout the watershed be reduced and moderated to improve the biotic condition of streams. Though the watershed is nearly 80% open space, the density of impermeable area throughout the watershed has a profound effect on biological integrity. As previously discussed, Low Impact Development (LID) is a means to decrease runoff and increase permeability in developed areas. Local municipalities in the watershed should incorporate LID measures into new development and redevelopment to reduce impervious cover in their planning.

Developed areas often have significant impervious surface area, such as roads, parking lots, commercial and residential buildings, which impede water from infiltrating directly into the ground and lead to higher and faster runoff volumes.

Imperviousness. Photo credit: Heal the Bay

Pacific Tree Frog. Photo credit: Heal the Bay

RECOMMENDATIONS

Biotic condition, water quality, and habitat are an indication of overall health at a particular site. For biotic condition analyses by individual creek, refer to Appendix F. IBI scores act as a single measure for overall aquatic health. Stream health at sites that have suboptimal or optimal IBI scores has the potential to improve with efforts to improve habitat condition and water quality. Widespread implementation of LID systems in developed areas of the Malibu Creek Watershed would help reduce impervious area and improve habitat and water quality throughout the watershed. Additionally, implementation and enforcement of new and existing water quality regulations would help improve biotic condition. These and other improvements should be seriously considered to benefit aquatic life and the overall biological health of the Malibu Creek Watershed.

A major discovery made through our BMI monitoring program was the infestation of benthic communities in the Malibu Creek Watershed with invasive New Zealand mudsnails. Invasive species can have a profound effect on the environment, but the impact of NZMS in the watershed is not yet fully understood. Since the invasion began in 2005, there are no clear effects of NZMS other than physical dominance over available substrates. However, based on known NZMS impacts in other watersheds and their rapid spread throughout the Malibu Creek Watershed, it is critical that careful monitoring for NZMS continue, and a clear plan be implemented to curtail the spread, especially until the ecosystem impacts of NZMS are better understood. The plan should include the installation of informational signage in both affected and unaffected areas, strict requirements on how to carefully monitor the watershed, and education on public lands about how to identify NZMS and their potential impacts on aquatic health. Further, plans to reduce the impacts of other aquatic invasive species, such as crayfish, and invasive plants must be developed and implemented. Another finding was that the presence of NZMS had a trivial effect on IBI scores, especially in already degraded areas. IBI calculation methods should be reexamined and updated to account for the presence and density of invasive species.

Although Heal the Bay and SMBRC have focused heavily on NZMS colonization of the Malibu Creek Watershed and surrounding areas, several other aquatic invasive species are also of concern throughout the Santa Monica Mountains, including crayfish, bullfrogs, and mosquito fish. These species decrease the biological diversity of native ecosystems through predation, competition, or displacement of native species. From 2000-2002, the National Park Service conducted stream surveys throughout the Santa Monica Mountains, and found that streams in the more developed areas often had high numbers of invasive crayfish and fish, and had fewer native species such as California newts and California treefrogs (development was characterized by the percentage of area within each watershed occupied by urban land uses).[100] Yet, studies also show that when invasive crayfish were removed from areas within the Santa Monica Mountains, native species return.[101] Although removal may reduce crayfish in some areas, full eradication of crayfish and other aquatic invasive species from the Malibu Creek Watershed would be very difficult.[102] Prevention is the most critical step to control the spread of invasive species, including NZMS and crayfish, throughout the watershed and surrounding areas. ■

TOP 5 **Recommendations to Improve Biological Health and Diversity**

(For more information, see p. 138)

- Outreach and **EDUCATION** of the Public Regarding Invasive Species
- Implement Measures for **PREVENTION** of the Spread of Aquatic Invasive Animals
- Implement Measures for **PREVENTION** of the Spread of Invasive Vegetation
- Further **RESEARCH** on New Zealand Mudsnails
- Complete Malibu Lagoon **RESTORATION** and Enhancement Project

[100] Riley, S.P.D. et al. 2005. Effects of urbanization on the distribution and abundance of amphibians and invasive species in southern California streams. *Conservation Biology* 19(6):1894-1907.

[101] Kats, L.B. & Brewer, J. Understanding the Invasion Ecology of Exotic Crayfish in California, Sea Grant California. Available at: http://nsgl.gso.uri.edu/casg/casgg07012.pdf (accessed 27 November 2011).

[102] Gherardi, F. et al. 2011. Managing Invasive Crayfish: Is There Hope? *Aquatic Sciences* 73: 185-200.

Chapter 5

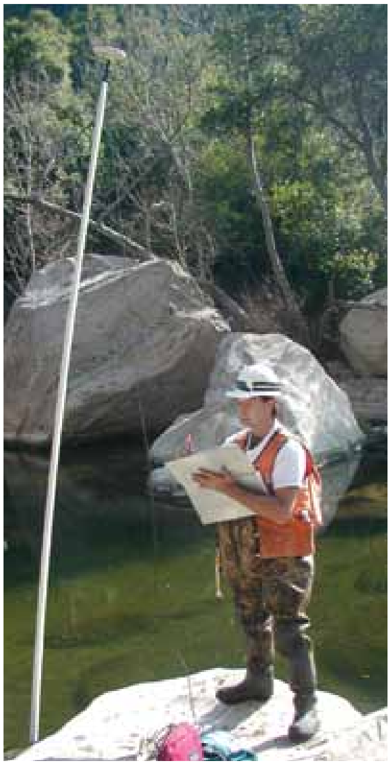
A PROPOSED STREAM HEALTH INDEX

BACKGROUND

Monitoring ecosystem health is vital to informing conservation and restoration actions. The Malibu Creek Watershed is affected by a variety of stressors, including water pollution associated with urban and agricultural runoff, failing septic systems, and wastewater treatment plant discharges; riparian and stream habitat degradation associated with development, streambank hardening, erosion, and sedimentation; illegal dumping; and biotic condition impairments, such as invasive species. However, the effects of multiple stressors on stream and watershed health are not well understood.

Several indices currently exist to measure biological condition, habitat health, and water quality independently, but there is no well-accepted, widely-used metric to measure the combined effects of multiple stressors on watershed health. There has been some effort to develop a more comprehensive index[103], but there is currently no established, common index for evaluating the collective impacts of multiple stressors on watershed health.

A simple Stream Health Index (SHI) was developed using data collected by Heal the Bay's Stream Team over the past decade to provide a comprehensive watershed health assessment. Using indicators for water pollution, habitat quality, and biological integrity, the SHI presents a metric to measure the current health status of Malibu Creek Watershed. It could also be used in the future to measure trends or assess ecosystem response to remediation actions taken to protect and improve watershed health. The SHI is a first attempt at creating an integrative index to assess overall stream health and numerous assumptions were made in its development. We relied on best professional judgment and data availability to determine the factors that we included as well as determine the scoring system. This SHI could benefit from index refinement and sensitivity analysis, which Heal the Bay hopes to work on in the future.



[103] Federico, F. et al. 2007. A multi-metric index for evaluating the condition of riparian ecosystems. *Water Environment Federation Technical Conference*, San Diego, CA.

Stream Team staff member conducting bioassessment monitoring. Photo credit: Heal the Bay

METHODS

The SHI is comprised of a 27 point grading scale - 0 points signifying the poorest condition and 27 points indicating the best condition. Heal the Bay monitoring sites were assigned an individual SHI score based on three metrics (water quality, physical habitat, and biological condition), equally weighted and comprised of 9 points each. Sites that were not regularly monitored were not included in the analysis. The inclusion of additional metrics based on attributes, such as conductivity, plant community, and riparian buffer, would improve the stream health assessment; however data to support the inclusion of all these attributes were not available for the development of this SHI.

WATER QUALITY METRIC

Water quality is of great concern throughout the watershed. Nutrient and bacteria concentrations are relatively high at several monitoring locations, with some sites consistently exceeding standards. Elevated nutrient concentrations can present major pollution problems in stream systems, such as excessive algal growth and depleted dissolved oxygen concentrations. Fecal indicator bacteria (FIB) are frequently a marker of human-impacted waterways, and may be an indicator for other human associated pollutants. Fecal indicator bacteria can also be naturally occurring but we find that their concentrations generally increase along the gradient from reference through outlet sites and the highest concentrations occur in and below high-density residential areas, indicating that FIB detected are likely not primarily due to natural sources .

In an effort to provide an overall picture of water quality health at monitoring locations, each Heal the Bay site was assigned a Water Quality Score (WQS) aggregating the ma-

Table 5-1: Rubric for the Water Quality Score

Water Quality Constituent	Point Allocation			
NITRATE SCORE Nitrate Total = 0 - 3 points	**Average Nitrate Concentration (mg/L) [a]**			
	0 points	1 point	2 points	3 points
	> 3 mg/L	2 mg/L - 3 mg/L	1 - 2 mg/L	< 1 mg/L
PHOSPHATE SCORE Phosphate Total = 0 - 3 points	**Average Phosphate Concentration (mg/L) [b]**			
	0 points	1 point	2 points	3 points
	> 1 mg/L	0.5mg/L - 1mg/L	0.1mg/L - 0.5 mg/L	< 0.1 mg/L
BACTERIA SCORE Bacteria Total = 0 - 3 points (Total is sum of averages of *Enterococcus* and *E. coli* concentrations)	**Average *Enterococcus* concentration [c]**		**Average *E. coli* concentration [d]**	
	0 points	1.5 point	0 points	1.5 point
	> 61 MPN/100ml	≤ 61 MPN/100ml	> 235 MPN/100ml	≤ 235 MPN/100ml
WATER QUALITY SCORE **0 - 9**	*a The regulatory limit for nitrogen is 1mg/L in the dry season. Further, there is a correlation between a nitrogen concentration of 1 mg/L and high algal densities. b The regulatory limit for phosphate is 0.1 mg/L. c The regulatory limit for Enterococcus is 61 MPN/100ml. d The regulatory limit for E. coli is 235 MPN/100ml.*			

TABLE 5-1: All scores are based on an average for each constituent across dry and wet season monitoring. The sum of the nitrate, phosphate, and bacteria scores determines the overall Water Quality Score.

Figure 5-1: Water Quality Score Influence on Mean IBI Score

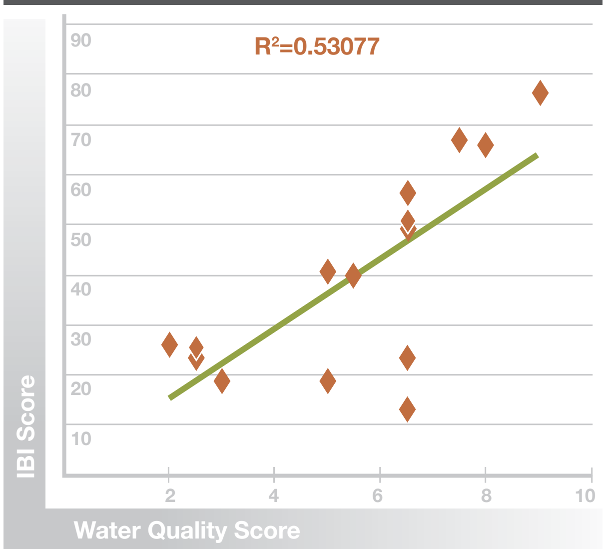


FIGURE 5-1: There is a moderate correlation between mean IBI score and WQS, revealing a trend where improved water quality leads to higher IBI scores ($R^2 = 0.5308$).

Figure 5-2: Water Quality Score Influence on Mean IBI Score (at Sites Without High Impervious Area)

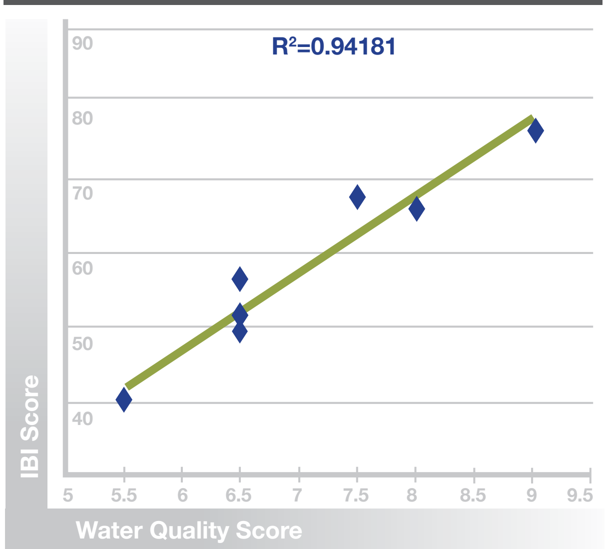


FIGURE 5-2: There is a strong positive correlation between the mean IBI score and WQS at sites with impervious area < 6% ($R^2 = 0.9418$)

jor parameters sampled (nitrate, phosphate, and fecal indicator bacteria). The total WQS is comprised of 9 points, with 3 points each for nitrate, phosphate, and bacteria, using the following rubric described in Table 5-1. Thresholds to determine points were primarily based on regulatory limit concentrations, with sites achieving an average pollutant concentration below the regulatory limit receiving the maximum of 3 points. Concentrations above the regulatory limits received 0-2 points, depending on the metric. We set the ranges for the nutrient concentrations to encompass the general range of our measured values. For nutrients, the cut points were evenly divided among the range we selected. Nutrients were selected as two of the three metrics comprising the WQS because of their direct impact on stream health. Fecal indicator bacteria were selected as the third WQS metric due to its use as a sign for human influence on aquatic systems. The sum of the nitrate, phosphate, and bacteria scores was calculated to determine the WQS.

The WQS for our monitoring sites ranged from 2 to 9 points (see Table 5-4). The lowest WQS of 2 points occurred at the outlet of Las Virgenes Creek (O5). Cold Creek (R3) scored the highest with 9 points. The WQS was compared to the IBI scores for sites monitored for BMI (Figure 5-1). The average IBI scores improved with higher WQS, indicating a trend between good water quality and biotic health ($R^2 > 0.5$).

There is greater variation in WQS at low IBI scores. Because percent impervious area also appears to have an impact on IBI score (Figure 4-5), we decided to examine whether WQS had a stronger impact on IBI score for sites that have low impervious area (under 6%) and are not impaired for BMI (have a score of over 39). We found a very strong correlation between water quality and IBI when we removed sites with high percent impervious area ($R^2 = 0.94$) as shown in Figure 5-2. When highly stressed sites with impervious area over 6% are removed, it appears that water quality is more directly related to biological integrity.

BIOTIC CONDITION METRIC

The biotic condition metric is comprised of two parameters: IBI score and colonization by invasive species (Table 5-2). IBI score for each site makes up the first six points of the metric and is based on the benthic macroinvertebrate community, as described in Chapter 4. The other three points are based on whether or not the site is colonized by invasive species, using New Zealand mudsnails as the metric. We decided to weight the IBI score more heavily than colonization by invasive species because IBI score encompasses a greater breadth of species with a focus on their ecological roles. Ideally, the invasive species metric would be based on all of the aquatic invasive species present in the watershed; however comprehensive data were not available at Heal the Bay's monitoring sites for crayfish, mosquito fish, and bullfrogs. In the future, we hope to refine the SHI by including additional aquatic invasive species. We also would have liked to include a metric addressing algae since it is problematic in the watershed; however, we did not have a comprehensive enough dataset for this version of the SHI. We plan to continue algae monitoring and may revise the SHI in the future to include it.

Stream Team staff mapping Malibu Creek

Table 5-2: Rubric for the Biotic Condition Metric				
Biotic Condition Parameters	Point Allocation			
IBI SCORE Total = 0 - 6 points	**Average IBI Score Category [a]**			
	0 points	2 points	4 points	6 points
	Very Poor	Poor	Fair	Good or Excellent
INVASIVE SPECIES SCORE Total = 0 - 3 points (Based on New Zealand Mudsnail density)	**New Zealand Mudsnail Density [b]**			
	0 points	1 point	2 points	3 points
	High Density (≥50%)	Medium Density (10%-50%)	Low Density (≤10%)	None
BIOTIC CONDITION SCORE **0 - 9**	***a*** *Average IBI Score and Category is reported in Table 4-2 for all sites.* ***b*** *New Zealand mudsnail density indicates the percent sample composition of NZMS of total macroinvertebrates over time from the IBI sampling. Percentages are shown in Table 4-3. We calculated the average percent of NZMS for each site for the years when NZMS was present only. The percent of NZMS varied widely among sites and years, ranging from <1% to 95%. The distribution of values for all sites and years was fairly evenly distributed across this range; however, the average values for each site were more clumped in the 10-50% range.*			

TABLE 5-2: All scores are based on the IBI Score and New Zealand mudsnail density at each site. The sum of these two parameters determines the overall Biotic Condition score.

PHYSICAL HABITAT & WATERSHED CHARACTERISTIC METRIC

The physical habitat metric is comprised of three parameters (Table 5-3). Percent impervious area accounts for up to six points. Although impervious area is not a measure of habitat at each monitoring site, it reflects the upstream habitat characteristics associated with each site. The cut points for scoring imperviousness categories are based on Heal the Bay's findings, as well as on previous studies.

The remaining three physical habitat points are based on quantity of discharge pipes, area of streambank modification, and area of associated unstable banks mapped through the Stream Walk program. Discharge pipes were selected as a parameter because they are frequently associated with streambank erosion and sedimentation. Monitoring sites with more than 78 discharge points upstream were assigned a score of zero, and sites with less than 78 discharge points upstream received one point (see Table 5-3 for details). The area of streambank modifications and unstable banks upstream of sites make up the other two points. Sites with over 1 million ft^2 of streambank modifications and unstable banks upstream were assigned 0 points, sites with upstream streambank modification and unstable banks ranging from 100,000 ft^2 to 1 million ft^2 were assigned 1 point, while sites with less than 100,000 ft^2 of modifications and unstable banks were assigned 2 points. These two parameters may bias towards lower scores in sites lower in the watershed because a site near the end of a stream or watershed has a greater likelihood of having more discharge points, areas of modification, and areas of unstable banks upstream due to its location in the watershed. In the future, we hope to refine the SHI by expressing these parameters as percentage of stream miles impacted or percentage of area impacted upstream of the site. Stream Walk was not conducted in the reference watersheds, so data for discharge points, unstable streambanks, and bank modifications were unavailable for Solstice Creek (R14), Lachusa Creek (R18), and Arroyo Sequit Creek (R19). These sites were assigned zero points (most impacted) for these physical habitat parameters, which results in a conservative estimate of physical habitat quality.

Table 5-3: Rubric for the Physical Habitat Metric				
Biotic Condition Parameters	**Point Allocation**			
IMPERVIOUSNESS SCORE Total = 0 - 6 points	Percent Impervious Area Above Each Monitoring Location [a]			
	0 points	2 points	4 points	6 points
	Impervious Area > 10%	Impervious Area 8 - 10%	Impervious Area 6.3 - 8%	Impervious Area < 6.3%
DISCHARGE PIPE SCORE Total = 0 - 1 point	Number of Discharge Pipes Above Each Monitoring Location [b]			
	0 points	1 point		
	≥ 78 discharge pipes	< 78 discharge pipes		
STREAMBANK MODIFICATION SCORE Total = 0 - 2 points (area of streambank modifications and unstable banks above each monitoring site)	Area of Streambank Modification and Unstable Banks Upstream From Each Monitoring Location [c]			
	0 points	1 point	2 points	
	> 1 million ft^2	100,000 ft^2 – 1 million ft^2	< 100,000 ft^2	
PHYSICAL HABITAT SCORE 0 - 9				

***a** Percent impervious area categories for scoring were based on studies showing that impervious area or urbanization levels of 6.3% (this report), 8%[104], and 10%[105] have biological impacts. **b** The threshold for number of discharge pipes was set at the median value of the discharge points for all our sites. Number of discharge points ranged from 0 to 712. **c** The thresholds for streambank modification were determined by examining the range of values (35,600 ft^2 to 5,167,048 ft^2) and looking for natural breaks. Each category contained an approximate equal number of sites (3, 4, and 5 respectively).*

TABLE 5-3: All scores are based on the percent impervious area, number of discharge points, and area of streambank modifications and unstable banks above each monitoring location. The sum of these three parameters determines the overall Physical Habitat score.

Table 5-4: Stream Health Index for Malibu Creek and Reference Watersheds						
Monitoring Site	Site	Water Quality Score (See Table 5-1, score out of 9)	Biotic Condition Score (See Table 5-2, score out of 9)	Physical Habitat Score (See Table 5-3, score out of 9)	TOTAL SCORE (out of 27)	MEAN TOTAL SCORE by Site Type
Outlet Malibu Creek	O1	2.5	3	0	**5.5**	**9.8**
Outlet Cold Creek	O2	5	7	8	**20**	
Outlet Las Virgenes Creek	O5	2	3	2	**7**	
Medea Creek	O7	5	0	0	**5**	
Triunfo Creek	O17	6.5	3	2	**11.5**	
Mid-Cold Creek	M11	6.5	7	8	**21.5**	**10.9**
Mid-Malibu Creek, upstream of Tapia outfall	M12	6.5	3	0	**9.5**	
Mid-Las Virgenes Creek	M13	3	1	3	**7**	
Mid-Malibu Creek, downstream of Tapia outfall	M15	2.5	3	0	**5.5**	
Upper Cold Creek	R3	9	9	9	**27**	**22.7**
Upper Cheeseboro Creek	R6	6.5	7	9	**22.5**	
Upper Las Virgenes Creek	R9	5.5	5	9	**19.5**	
Solstice Creek	R14	7.5	9	6*	**22.5**	
Lachusa	R18	6.5	9	6*	**21.5**	
Arroyo Sequit	R19	8	9	6*	**23**	

TABLE 5-4: The Stream Health Index (SHI) is a 27-point index comprised of water quality, biotic condition and physical habitat metrics, each comprising 9 points.
* Data for discharge points, unstable stream banks, and bank modifications unavailable. These sites were assigned 0 points as a conservative estimate of physical habitat quality.

[104] Schueler T. 1994. The importance of imperviousness. *Watershed Protection Techniques* 2(4):100-111.

[105] Riley S.P.D. et al. 2005. Effects of urbanization on the distribution and abundance of amphibians and invasive species in southern California streams. *Conservation Biology* 19(6):1894-1907.

Stream Team staff member mapping Malibu Creek. Photo credit: Heal the Bay.

RESULTS AND DISCUSSION

The Stream Health Index (SHI) provides a comprehensive understanding of the health of the watershed. In the future we hope to refine this index by including additional variables, such as algae, conductivity, and other invasive species as well as looking at trends over time. In addition, we plan to perform sensitivity analyses to assess the robustness of the cut points and thresholds we selected for the parameters in the index.

The SHI scores for Heal the Bay monitoring sites ranged from 5 (Medea Creek O7) to 27 (Upper Cold Creek R3) (Table 5-4). Reference sites received the highest SHI scores, with sites in the middle and lower watershed receiving much lower scores generally. The mean SHI score for outlet sites was 9.8, sites in the middle of the watershed had an average SHI score of 10.9, and the mean SHI score for reference sites was 22.7. The decreasing scores from the upper watershed to lower watershed may indicate that considerable degradation is occurring in the mid-watershed, directly below areas impacted by development and high human use. Two major contributing factors to decreased stream health in the watershed are water quality (nitrate, phosphate, and bacteria concentrations) (Figures 5-1 and 5-2) and area of impervious surface cover (Figure 4-5). These issues must be addressed in order to better protect the watershed.

Although some sites are doing well in the watershed, all but two middle and outlet sites (both in Cold Creek) were severely impacted by poor water and habitat quality, and impaired biotic condition. The only sites with a SHI score of 20 or above occur at reference locations or in watersheds that are not highly developed or impacted by human use. All of the sites along the Malibu Creek main stem have SHI scores of 10 or below, which is of particular concern, as this is the receiving water for tributaries throughout the watershed, and leads directly to the Malibu Lagoon and Santa Monica Bay. Medea Creek (O7) and lower Las Virgenes Creek (O5), which are located downstream of urban areas or areas of high human use, also received SHI scores below 10.

As population continues to grow in cities along the 101 freeway, watershed stressors associated with development may intensify. This indicates a need to protect areas in the watershed that are relatively unaffected by human influence. It is also critical that integrated approaches to protect and improve water and habitat quality, such as a widespread LID approach that applies to new and existing development, are implemented to comprehensively address the many stressors degrading the Malibu Creek Watershed. ■

Chapter 6

CONCLUSIONS & RECOMMENDATIONS

RECOMMENDATIONS FOR THE FUTURE

Based on the results of the Stream Health Index (SHI) analysis, the Malibu Creek Watershed is clearly on the brink of severe ecological degradation. Despite the common perception that the Malibu Creek Watershed is a largely open, natural area, evidence of degradation is widespread. Although there have been numerous noteworthy land acquisition successes, riparian restoration efforts, wastewater treatment pollutant load reductions, and runoff pollution reduction ordinances in the watershed, the efforts have not been adequate to stem the tide of continuing watershed degradation. Immediate action to reduce watershed stressors, particularly abating impervious area impacts and improving water quality, are necessary to restore stream health.

There are several measures that will help greatly improve habitat, water quality, and biological condition of the Malibu Creek Watershed. This section categorizes them by riparian and stream habitat protection, implementation and enforcement of existing water quality regulations, reduction of nutrient and bacterial pollution, and improvement of biological health and biodiversity. The top five recommendations for each category are presented in no particular order.

Volunteers planting native bunch grass (left) and removing invasive plants (right). Photo credit: Heal the Bay

Before and after removal of a barrier in Malibu Creek.

RIPARIAN AND IN-STREAM HABITAT PROTECTION

Several streams throughout the Malibu Creek Watershed are impacted by hardening, erosion, loss of riparian habitat, and sedimentation. The following actions are critical for protecting stream and riparian habitat and improving overall watershed health.

1. Develop Local Coastal Program (LCP) for Santa Monica Mountains

Los Angeles County is developing a Local Coastal Program (LCP) for the Santa Monica Mountains. This plan should include riparian habitat setback requirements for development consistent with the City of Malibu LCP (a minimum buffer of 100 ft. from the outer edge of the riparian canopy). It should also include a prohibition of grading during the rainy season on slopes of 3:1 or greater. Additionally, it should prioritize bioengineered solutions over concrete or riprap for streambank stabilization. Culverts and stream crossings should also be designed in a way that maintains the natural streambank and floor. Further, the Local Coastal Program should call for the proper installation of drainage pipes to reduce sediment loading to streams, such as installing flow dissipation devices that reflect the natural geomorphology of the area, such as step pools to dissipate scouring energy from flow. This LCP has been in development for several years, and is seriously needed; a resource protective LCP for the Santa Monica Mountains should be developed by the end of 2014.

2. Adopt a Stream Protection Ordinance

Los Angeles County should adopt a Stream Protection Ordinance for the Santa Monica Mountains consistent with the draft ordinance that has stalled in the City of Los Angeles.[106] The Los Angeles County ordinance should prohibit new streambank armoring and implement setback requirements of a minimum of 100 ft. from the outer edge of the riparian canopy.

[106] Draft NPDES General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities, Permit No. CAR000002, dated April 22, 2009. Available at: http://www.waterboards.ca.gov/water_issues/programs/stormwater/docs/constpermits/draft/draftconst_permit_031808.pdf

3. Prevent Streambank Hardening

The Coastal Commission should adopt a policy prioritizing bioengineered solutions to streambank stabilization over solutions that involve streambank armoring or placement of riprap. Streambank hardening should only be used as a last resort when bioengineered solutions are not technically feasible. We encourage the Commission to move forward with an ordinance by the end of 2014.

4. Require Stronger Monitoring for Construction Projects

The State Water Resources Control Board should require stronger monitoring requirements for construction projects that are permitted through the General Construction Permit to assure that proper BMPs are being implemented and maintained to reduce sediment runoff. The General Construction Permit will not be reviewed for at least another five years but we encourage stronger requirements be added in the next permit cycle. Improved Los Angeles Regional Water Quality Control Board enforcement is also needed for non-compliant construction sites, which will also promote compliance with existing regulations. There is currently no numeric turbidity limit in the permit; we recommend that the next permit have a strong turbidity numeric limit, no greater than 73 NTUs to reduce sediment-loading to creeks and waterways associated with construction. This recommendation is consistent with renowned stormwater engineer, Dr. Richard Horner's recommendation to the State Water Resources Control Board regarding construction BMP performance for turbidity.

Los Angeles County should adopt an ordinance that implements setback requirements of a minimum of 100 ft. from the outer edge of the riparian canopy.

Streambank hardening should only be used as a last resort when bioengineered solutions are not technically feasible.

The State Water Resources Control Board should require stronger monitoring requirements for construction projects.

5. Remove Stream Barriers

Pursue barrier removals with local resource agencies and potential funders based upon the Heal the Bay 2005 prioritization study, including Rindge Dam removal.[107] The top five priorities include:

- ✓ Removal of Rindge Dam;
- ✓ Replacement of double culvert at Las Virgenes Creek and Crags Road with a bridge;
- ✓ Partial removal of dam at White Oaks Farms;
- ✓ Culvert replacement at Piuma and Cold Creek Roads; and
- ✓ Reconfiguration of the bridge at Malibu Meadows Road on Cold Creek.

Furthermore, illegally placed hardened structures in streams and streambanks and abandoned structures on public land (e.g. pipes, riprap, water tanks, fences, and concrete crossings) throughout the watershed should be removed, followed by habitat restoration at these sites. A concerted enforcement and restoration effort by state and local agencies is needed to achieve success.

[107] Abramson, M. & Grimmer, M. 2005. Fish Migration Barrier Severity and Steelhead Habitat Quality in the Malibu Creek Watershed. Produced for California State Coastal Conservancy and California Department of Parks and Recreation.

Pollution threatens the public health of recreational users at streams and beaches throughout the watershed, such as Surfrider Beach. Photo credit:Joy Aoki

IMPLEMENTATION AND ENFORCEMENT OF EXISTING WATER QUALITY REGULATIONS

Bacteria and nutrients associated with wastewater and stormwater runoff are the primary pollutants of concern in the Malibu Creek Watershed. Microbial pathogen pollution threatens the public health of recreational users at streams throughout the watershed and at world-famous Surfrider Beach. High nutrient concentrations at monitoring locations throughout the watershed lead to excessive algal growth, which negatively impacts in-stream habitat, leads to decreased dissolved oxygen levels, and threatens aquatic life. Implementation and enforcement of existing water quality regulations will greatly help reduce bacteria and nutrient pollution throughout the watershed.

Trash is also a significant pollution problem as demonstrated by the state's listing of most of the waterbodies in the Malibu Creek Watershed as impaired for trash on the 303(d) list of Impaired Waterways. However, the Los Angeles Regional Water Quality Control Board has approved a trash total maximum daily load (TMDL) and cities like Malibu, Los Angeles County, Los Angeles City, and Calabasas have passed plastic bag and foam food container bans to help prevent trash from reaching these waterways. These efforts, if adopted throughout the watershed, should go a long way towards elimination of the trash problem, especially if more attention is concurrently given to litter law enforcement.

1. Implement and Enforce Adopted TMDLs for the Malibu Creek Watershed

Over the past decade, the Los Angeles Regional Water Quality Control Board or US EPA have adopted TMDLs for nutrients, bacteria, and trash for the Malibu Creek Watershed. However, none of these TMDLs have been fully implemented, and implementation plans, milestones, and schedules have not been developed for the nutrient TMDLs. It is critical that these water quality regulations are implemented and enforced as soon as possible. The development of incentives for compliance may also assist with implementation.

2. Adopt and Implement New TMDLs for Additional Impairments

Much of the Malibu Creek Watershed is listed on the 303(d) List of Impaired Waterways for several additional constituents including eutrophic conditions, benthic macroinvertebrate community, invasive species, sedimentation, and other stressors and pollutants. The development and implementation of TMDLs for these impairments is important for establishing an enforceable plan to clean-up streams throughout the watershed. The TMDL for benthic macroinvertebrates is currently in development with a scheduled release date of March 2013 as dictated by the consent decree between US EPA and Heal the Bay and Santa Monica Baykeeper.

3. Lower Wet Season Total Nitrogen Limit to Reduce Algal Growth

The total nitrogen limit for wet weather in the US EPA Malibu Creek Watershed Nutrient TMDL is currently set at 8 mg/L, which was based on a modification of the Basin Plan limits related to public health, but not related to biostimulation or the effects of nutrients on the ecological health of the watershed. We recommend that this limit be reduced to 1 mg/L to better control nutrient pollution in the watershed and reduce algal growth. Revision of this standard would result in more control of nutrient-loading to waters throughout the watershed, thereby improving water quality considerably.

4. Establish Wet Season Limit for Phosphate

The phosphate limit for dry weather in the US EPA Malibu Creek Watershed Nutrient TMDL is currently set at 0.1 mg/L. However, there is no current phosphate limit for wet weather. We recommend that a year-round phosphate limit of 0.1 mg/L or at the background level be established for the watershed, consistent with the dry weather limit. The establishment of a year-round limit would greatly reduce nutrient-loading to the watershed.

5. Implement Septic System Policy to Reduce Pollution

Failing and outdated septic systems are a major cause of bacterial pollution in the watershed. The State Water Resources Control Board adopted the long overdue septics policy AB 885 in June 2012. This policy still needs to be implemented through Local Agency Management Programs (LAMPs), which include TMDLs and Advanced Protection Management Programs that target septics within 600 feet of impaired waters. The LAMP shall require all existing and new onsite wastewater treatment systems within 600 feet of impaired waters to meet advanced treatment requirements for nitrogen removal and disinfection. LAMPs should also include a plan to detect failing septics, for instance, through sanitary sewer surveys. LAMPs need to be developed, implemented, and enforced to begin to address bacterial pollution in the Malibu Creek watershed. AB 885 also includes a 2016 deadline by which the Regional Board must draft an implementation plan for the Malibu Creek Nutrient TMDL, which will also aid in addressing the nutrient impairments to the Creek.

Bacteria and nutrients associated with runoff are the primary pollutants of concern in the Malibu Creek Watershed. Trash is also a significant pollution problem.

Runoff from equestrian facilities, livestock areas, vineyards, and golf courses that affect nutrient and bacterial pollution must be addressed.

REDUCE NUTRIENT AND BACTERIA TO BACKGROUND CONCENTRATIONS

In addition to implementing and enforcing existing water quality regulations, additional measures are needed to control the nutrient and bacteria pollution entering streams and waterways in the Santa Monica Mountains. The following measures will complement existing regulations to provide comprehensive water quality protection throughout the watershed.

1. Adopt Low Impact Development (LID) Ordinances or Policies

Local governments throughout the watershed should adopt Low Impact Development (LID) ordinances or policies for all new development and re-development that require onsite capture and reuse, or infiltration of 100% of the runoff generated from the 85th percentile storm. In fact, this is required under the recently-adopted MS4 permit. Additionally, since percent impervious area has a strong influence on degraded water quality, a comprehensive LID retrofit program needs to be developed watershed-wide that targets the biggest potential sources of impairing pollutants (nutrients and bacteria). For retrofits and future ordinances, we suggest reducing percent impervious area to 6.3% or less through LID implementation.

2. Continue to Work Towards Minimizing Bacterial and Nutrient Pollution Caused by Septic Systems

In order to improve water quality in the lower watershed, we need to ensure implementation of the Memorandum of Understanding between the City of Malibu and Regional Water Quality Control Board, Los Angeles Region and State Water Resources Control Board Regarding Phased Implementation of Basin Plan Amendment Prohibiting On-site Wastewater Disposal Systems in the Malibu Civic Center Area. We also recommend that septic systems are appropriately sited and maintained throughout watershed, for instance identifying and repairing failing systems, and upgrading those systems with advanced treatment for nutrients and bacteria that are within close proximity (i.e. 600 feet per the requirements of AB 885) of waterbodies in the Malibu Creek Watershed that are impacted by these pollutants.

3. Regulate Agricultural Use in the Watershed Through Local Coastal Program (LCP)

The Santa Monica Mountains LCP that is currently in development should include provisions regarding agricultural use in the watershed that require the implementation and maintenance of BMPs to capture, treat, and infiltrate or reuse runoff from equestrian facilities, livestock areas, vineyards, and golf courses to address nutrient and bacterial pollution. Similar policies should be pursued at local governments within the watershed that are outside of the Coastal Zone.

4. Increase of Water Storage Capacity at Tapia Facility

The Las Virgenes Municipal Water District should increase water storage capacity at the Tapia Water Reclamation Facility to increase water recycling in the watershed with an overarching long-term goal of no discharge to the Malibu Creek.

5. Source Identification and Remediation of Pollution Sources

Further research examining source identification and remediation of pollution hot spots should be conducted throughout the Malibu Creek Watershed to identify locations and activities contributing to high nutrient and bacteria levels. Since vineyards, equestrian facilities, golf courses, and residential runoff are potential significant nutrient sources in the watershed, these land uses should be carefully monitored, and LID and source reduction BMPs should be implemented if their discharge contains nutrients and fecal bacteria.

Local governments should adopt Low Impact Development (LID) ordinances that require onsite capture and reuse, or infiltration of 100% of the runoff generated from the 85th percentile storm. Pictured: Elmer Ave. Sun Valley LID demonstration house.

The Malibu Lagoon Restoration and Enhancement Project currently underway will greatly help improve circulation and aquatic habitat conditions. Photo: Heal the Bay

IMPROVE BIOLOGICAL HEALTH AND DIVERSITY

Biotic condition and biological diversity are strong indicators of overall ecosystem health. The two largest contributing factors to decreased biological integrity in the watershed are poor water quality and areas of impervious surface cover. Additionally, the spread of invasive species is a major concern in the watershed. The following measures, combined with those specifically targeted to improve water quality and reduce impervious area, will help protect the biological health of the Malibu Creek Watershed.

1. Complete Malibu Lagoon Restoration and Enhancement Project

The Malibu Lagoon Restoration and Enhancement Project currently underway for Malibu Lagoon will greatly help improve circulation and aquatic habitat condition in this critical wetland. Completion and proper management of this project is critical to restoring the overall biological condition of the lower watershed.

2. Further Research on New Zealand Mudsnails

Although research has been conducted to examine the spread of invasive New Zealand mudsnails (NZMS) throughout the Malibu Creek Watershed, their ecological impact is not well understood. Further research is needed to investigate the impact of NZMS on stream health and biological diversity. Heal the Bay's Stream Team bioassessment program has long-term data, including before and after data, for sites infested by NZMS. This information should be critical to helping understand the effects of NZMS colonization on stream ecology. Additionally, we found the presence of NZMS had a minimal impact on IBI scores, especially in already degraded areas. IBI calculation methods should be reexamined and updated to account for the presence and density of invasive species.

3. Outreach and Education of the Public Regarding Invasive Species

With the known NZMS infestation in parts of the Santa Monica Mountains, efforts should be made to prevent further spread of this highly invasive species. Efforts should include public outreach and installation of signs on public lands at high use locations throughout the watershed in 2013, providing information to visitors on the problems associated with NZMS and how to prevent their spread. Signs should be especially targeted to be installed near riparian areas where hiking and equestrian trails and fire road cross streams.

4. Implement Measures to Prevent the Spread of Aquatic Invasive Animals

Crayfish, bullfrogs, and mosquitofish are aquatic invasive species that are also widely present throughout the Santa Monica Mountains. Measures to prevent the spread of these species should be implemented to protect natural diversity in stream systems throughout the watershed and associated areas. Crayfish are problematic because they prey on native aquatic life, like newts, frogs, fish, and small turtles. Prohibiting the sale and use of crayfish as bait in the watershed will help reduce the spread of this stream pest. Effective crayfish trapping and removal efforts have been implemented in some areas of the mountains, such as in Malibu Creek by Mountains Restoration Trust, Trancas Creek by Pepperdine University, and in Topanga Creek by RCD. These efforts should be augmented and extended to other areas in an effort to eradicate this nuisance species. Further, there are efforts by the Santa Monica Bay Restoration Commission (SMBRC) to list red swamp crayfish as an invasive species, allowing for stream segments with crayfish to be placed on the 303(d) list of impaired waters. Mosquitofish also have detrimental impacts on native species, such as amphibians and fish, through direct predation. Mosquitofish are used by local governments to control mosquitoes but they show little specificity in their diet towards mosquito larvae.[108] We urge local governments to consider alternative methods for mosquito control as well as to restrict the availability of the public to obtain mosquitofish. Currently, the Greater Los Angeles County Vector Control District provides free mosquitofish to all district residents as well as free home delivery; the fish are not to be placed beyond a resident's property but they undoubtedly get into natural areas through flooding, intentional release, and carelessness.[109]

5. Implement Measures to Prevent the Spread of Invasive Vegetation

Invasive vegetation is also a persistent problem throughout the Santa Monica Mountains. Although volunteer and targeted vegetative restoration efforts have helped address this problem, most of these projects are limited to relatively small areas throughout the mountains, and they have had mixed levels of success. Addressing invasive vegetation at its source will also help prevent further spread of problem plants. The sale of highly invasive plants (e.g. *Arundo donax, Vinca*, pampas grass, and Algerian ivy) should be prohibited at local nurseries to help control this widespread problem.

Invasive species (top to bottom): New Zealand mudsnail; red swamp crayfish; Vinca major and Arundo donax.
Photo credits: Heal the Bay and WikiCommons

[108] Goodsell, J.A., & Kats, L.B. 1999. Effect of introduced mosquitofish on Pacific treefrogs and the role of alternative prey. *Conservation Biology* 13: 921-924.
[109] Greater Los Angeles County Vector Control District. 2012. Retrieved from: http://www.glacvcd.org/Contents/Vector-Services-Info/Mosquitofish.aspx

Over the past 15 years, government officials, non-governmental organizations, and local citizens have become increasingly aware of the problems facing the Malibu Creek Watershed and adjacent areas. Several projects have been implemented to address these issues; however most have occurred on a discrete basis and this region is still faced with a decline in the condition of its natural resources. Significant resources have been spent to educate stakeholders about these problems and plan for integrated solutions, and we have a solid understanding of the contributing factors to water quality and habitat degradation.

Now is the time to take the next step – bold actions must be taken to protect the Malibu Creek Watershed's valuable natural resources. The implementation of creative, integrated solutions addressing both water quality improvement and habitat protection are necessary to help reverse the degradation that is occurring throughout this region. We have a critical decision to make: ignore the strong indications that natural resources are degrading rapidly throughout the watershed, or work collectively and urgently towards improving habitat and water quality. ■

Bold actions must be taken to protect the Malibu Creek Watershed's valuable natural resources.

APPENDICES

All appendices are available online at: http://www.healthebay.org

APPENDIX A: Impaired Waters in the Malibu Creek Watershed

303(d) listing of impaired waters, impairing pollutants, and sources for the Malibu Creek Watershed.

APPENDIX B: Studies Examining Impacts of Impervious Surfaces on Stream Health

Summary of literature on the effects of impervious surfaces on stream health.

APPENDIX C: Percent Impervious Area Analysis Methods

Description of methods used to determine percent impervious area in the Malibu Creek Watershed.

APPENDIX D: Background & Detailed Information about the IBI

Background on the IBI, the southern California IBI, and the metrics that determine IBI scores.

APPENDIX E: Rapid Bioassessment Physical Habitat Metrics

Description of the ten physical habitat parameters used in the California Stream Bioassessment Procedure.

APPENDIX F: Assessing the Biotic and Physical/Habitat Condition of Selected Stream Sites in the Malibu Creek Watershed – Summary of Data Collected from 2000-2010

A report by Sustainable Land Stewardship Institute International, James Harrington.

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