Total Maximum Daily Loads for Bacteria
Malibu Creek Watershed

California Regional Water Quality Control Board
Los Angeles

Adopted January 29, 2004

Revised December 13, 2004

ES. EXECUTIVE SUMMARY

This TMDL[1] addresses bacteria water quality impairments in the Malibu Creek Watershed. The TMDL is consistent with the Santa Monica Bay Beaches Bacteria TMDL, which was approved by the United States Environmental Protection Agency (EPA) in June 2003. The Santa Monica Bay Beaches TMDL expressed the Waste Load Allocation for bacteria at Santa Monica Bay Beaches in terms of the number of days that the single sample bacteria water quality objectives in the Basin Plan may be exceeded. The Santa Monica Bay Beaches TMDL applies to Surfrider Beach, which is located at the mouth of the Malibu Creek Watershed. In terms of the number of days that the single sample bacteria limits are exceeded, Surfrider ranks among the most impaired beaches in the Bay. This TMDL addresses the bacteria sources from Malibu Creek and Lagoon, but does not address other coastal sources that may impact the impairment at Surfrider Beach.

The Malibu Creek Watershed Bacteria TMDL was developed using available monitoring data and surface water quality models. The data available for the Creek and Lagoon were not as robust as the data for the Santa Monica Bay Beaches. The county and city health departments monitor the beaches on weekly, or in some cases, daily basis. However, Malibu Creek and Lagoon are monitored only monthly by volunteer monitoring groups and the Las Virgenes Municipal Water District during dry weather. The Los Angeles County Department of Public Works monitors stormwater bacteria counts during wet weather. Due to the lack of monitoring data, this TMDL relied heavily on modeled output data. The models were calibrated against actual in-stream monitoring data, but data were not sufficient to validate the models. In other words, the multiple variables in the models were adjusted to reasonably match historical creek water quality data, however data were not sufficient to confirm that the models would be able to predict the bacteria concentrations in the creek if one or more of the assumed inputs of bacteria are changed. Although, available monitoring data for the Malibu Lagoon were sparse, the model predicted a substantially higher number of exceedances in the Lagoon than for Malibu Creek or it tributaries during dry weather.

The responsible jurisdictions and responsible agencies, primarily the incorporated cities, Los Angeles County and Ventura County, are responsible for meeting the final pollutant allocations. Consistent with the Santa Monica Bay Beaches TMDLs, Waste Load Allocations and Load Allocations are expressed in terms of allowable days of exceedance of the single sample bacteria limits and no exceedance of the 30-day geometric mean limits. In addition, this TMDL provides an estimated reduction in bacteria loading necessary to meet the allocations. Based upon the model output, stormwater from commercial/industrial and high density development generate the highest annual bacteria loading. However, these loads are a result of episodic storm events. Bacteria loads from on-site wastewater treatment systems, especially in the Malibu Civic Center area, are believe to contribute bacteria loading year round and may have a greater impact on impairments during dry weather. Another significant finding is that based on the model output, loading reductions designed to meet the allowable days of exceedance of the single sample limits were not sufficient to meet the 30-day geometric mean. In addition, the model indicates that it may not be possible to achieve the 30-day geometric mean in the Lagoon due to fecal contamination from birds.

This TMDL, provides an implementation schedule allowing the responsible jurisdictions and responsible agencies time to gather additional monitoring data to validate the model and to better quantify the loading from birds in the Lagoon. The Regional Board may reconsider the TMDL in three years from the effective date to consider the impact of birds in the Lagoon and to refine the days of allowable exceedance based on additional studies. At that time, the Regional Board may revise the TMDL to allow for a Natural Source Exclusion, as provided for in the Basin Plan. The Natural Source Exclusion can only be applied after all anthropogenic sources of bacteria have been controlled. The schedule would allow six years from the effective date to meet both summer and winter dry-weather Waste Load and Load allocations. This is a longer schedule than generally provided for in the Santa Monica Bay TMDL for summer dry weather. However, it is warranted due to the disperse nature of the sources and the foreseeable implementation measures. In Santa Monica Bay, the City of Los Angeles and the County of Los Angeles already had

[1] A Total Maximum Daily Load (TMDL) is the sum of pollutant loading from point sources (Waste Load Allocation) and nonpoint sources (Load Allocation), and natural background that can be assimilated by a water body, without exceeding water quality standards.

started construction of the implementation measure, which is dry-weather diversion of major storm drains. Therefore a three year schedule for summer dry weather was feasible. In Malibu, the likely primary implementation for dry weather compliance will be to evaluate and upgrade individual on-site wastewater treatment systems if necessary, or the construction of a centralized wastewater treatment plant in the Civic Center area of the City of Malibu. In addition, strategies for dealing with on-site wastewater treatment systems will be impacted by the upcoming Malibu Creek nutrient TMDL, scheduled for release in 2004. While properly sited and maintained systems are an effective method for treating bacteria, advanced treatment may be required to reduce total nitrogen. Therefore, the responsible jurisdictions and responsible agencies may wish to consider the implications of the nutrient TMDL before finalizing plans to address on-site systems.

It is anticipated that wet-weather allocations will be met primarily through on-site stormwater collection and treatment devices rather than widespread reliance on diversion of major storm drains. This is due to the rural nature of the watershed, which is not served by a major stormwater network. In addition, the diversion of natural creeks and drainages could have adverse impact on aquatic life and wildlife, and should be avoided. This TMDL allows 10 years for compliance with the wet-weather allocations.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

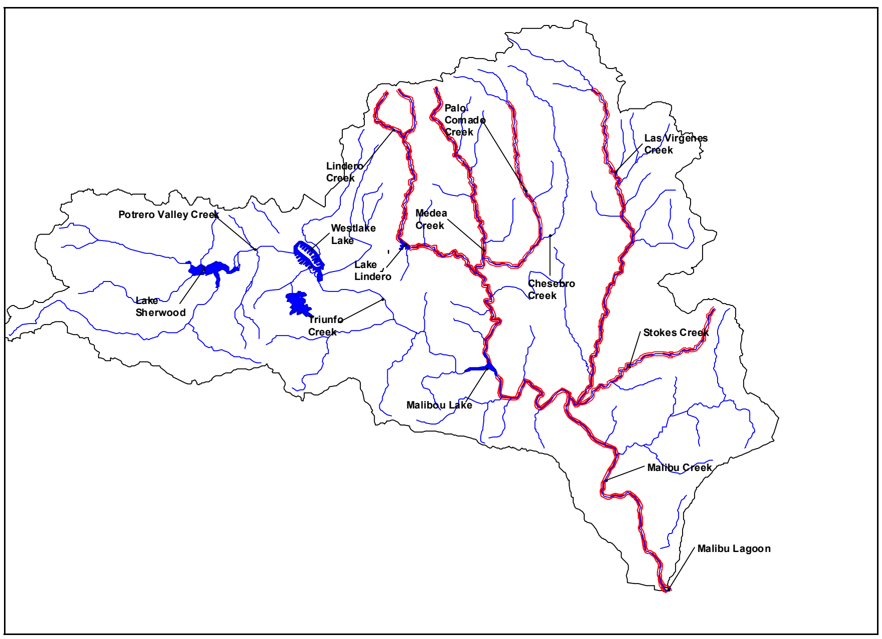
LIST OF APPENDICES

1. INTRODUCTION

This document describes the Total Maximum Daily Load (TMDLs) for bacteria indicators for the Malibu Creek Watershed, which includes Malibu Lagoon, Malibu Creek and its tributaries. The target bacteria indicators addressed in this TMDL are fecal coliform, total coliform, E. coli, and enterococcus. Malibu Creek, five of its tributaries (Stokes Creek, Las Virgenes Creek, Palo Comado Creek, Medea Creek, and Lindero Creek) exceed the water quality objectives (WQOs) for bacterial indicators (RWQCB, 1996 and 1998).

This TMDL complies with 40 CFR 130.2 and 130.7, Section 303(d) of the Clean Water Act and U.S. Environmental Protection Agency (EPA) guidance for developing TMDLs in California (U.S. EPA, 2000). This document summarizes the information used by the EPA and the California Regional Water Quality Control Board, Los Angeles Region (Regional Board) to develop waste load and load allocations for bacterial indicators. The TMDL also includes an Implementation Plan and cost estimates for complying with the TMDL. The water bodies in this TMDL are highlighted in Figure 1 and described in Table 1.

Figure 1 - Malibu Creek Watershed Impaired Creeks



1.1 Regulatory Background

Section 303(d) of the Clean Water Act (CWA) requires that each State "shall identify those waters within its boundaries for which the effluent limitations are not stringent enough to implement any water quality objective applicable to such waters." The CWA also requires states to establish a priority ranking for waters on the 303(d) list of impaired waters and establish TMDLs for such waters. For the purpose of this document, 303(d) listed water bodies and impaired water bodies are synonymous.

The elements of a TMDL are described in 40 CFR 130.2 and 130.7 and Section 303(d) of the CWA, as well as in the U.S. Environmental Protection Agency guidance (U.S. EPA, 2000). A TMDL is defined as the "sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background" (40 CFR 130.2) such that the capacity of the water body to assimilate pollutant loading (the Loading Capacity) is not exceeded. A TMDL is also required to account for seasonal variations and include a margin of safety to address uncertainty in the analysis (USEPA, 2000).

The Environmental Protection Agency has oversight authority for the 303(d) program and is required to review and either approve or disapprove the TMDLs submitted by states. In California, the State Water Resources Control Board (State Board) and the nine Regional Boards are responsible for preparing lists of impaired water bodies under the 303(d) program and for preparing TMDLs, both subject to EPA approval. If EPA does not approve a TMDL submitted by a state, it is required to establish a TMDL for that water body. The Regional Boards hold regulatory authority for many of the instruments used to implement the TMDLs, such as the National Pollutant Discharge Elimination System (NPDES) and state-specified Waste Discharge Requirements (WDRs).

The Regional Board identified over 700 water body-pollutant combinations in the Los Angeles Region where TMDLs would be required (LARWCQB, 1996, 1998). These are referred to as "listed" or "303(d) listed" water bodies . A schedule for development of TMDLs in the Los Angeles Region was established in a consent decree (Heal the Bay Inc., et al. v. Browner C 98-4825 SBA) approved on March 22, 1999. For the purpose of scheduling TMDL development, the consent decree combined the more than 700 water body-pollutant combinations into 92 TMDL analytical units.

This TMDL addresses Analytical Unit 47 of the consent decree, which consists of Malibu Lagoon, segments of the Malibu Creek and tributaries. These listings were included on the 1996 and 1998 303(d) lists and were retained on the 2002 303(d) list. The listed water bodies are identified in Table 1. Malibu Beach and Surfrider Beach are covered under the Santa Monica Bay Beaches (Analytical unit #48). The consent decree schedule requires that this TMDL and the Malibu Creek nutrient TMDL be completed by March 22, 2003. EPA established bacteria and nutrient TMDLs in fulfillment of the consent decree requirement in March 2003.

This TMDL represents an independent analysis of the EPA TMDL and includes an implementation schedule for meeting the allocations. If adopted by the Regional Board and the State Board, and subject to EPA's approval, this TMDL will supercede the EPA TMDL. Regional Board staff are scheduled to release a revised nutrient TMDLs in late 2004, based on additional studies.

Both this TMDL and EPA's TMDL are consistent with the Santa Monica Bay Beaches Bacteria TMDLs, which were adopted by the Regional Board in 2002, and approved by EPA in June 2003. The Santa Monica Bay Beaches Bacteria TMDLs were developed by Regional Board staff in cooperation with a Technical Advisory Committee (TAC), composed of key stakeholders. This was a precedent setting TMDL, which grappled with two difficult aspects of bacteria exceedances:

- The difficulty of controlling high bacteria counts during wet weather and
- The need to balance the needs of human recreational use and wildlife, which can be a significant source of bacteria loading.

The TAC recognized that even relatively undeveloped watersheds exceed bacteria standards on occasion due to natural sources such as birds and other wildlife. The Water Quality Control Plan for the Los Angeles Region (the Basin Plan) contains bacteria limits for single samples and the 30-day geometric mean values. The Santa Monica Bay Beaches Bacteria TMDL limits the number of allowable days that the single sample bacteria standards may be exceeded, but requires compliance with the 30-day geometric mean at all times. The number of days that the single sample limits may be exceeded were based on the historical days of exceedance at Leo Carillo Beach, the beach at the base of the Arroyo Sequit reference watershed.

1.2 TMDL Elements

Guidance from USEPA (2000) identifies seven elements of a TMDL. These elements of the Malibu Creek Bacteria TMDL are described in Sections 2 through 8 of this document. The elements are:

1. Problem Identification. This section reviews the evidence used to add the water body to the 303(d) list, and summarizes existing conditions using that evidence along with any new information acquired since the listing. The problem identification reviews those reaches that fail to support all designated beneficial uses; the beneficial uses that are not supported for each reach; the water quality objectives (WQOs) designed to protect those beneficial uses; and the data and information regarding the decision to list each reach, such as the number and severity of exceedences observed.

2. Numeric Targets. For this TMDL, the numeric targets are based on the numeric water quality objectives for coliform bacteria that apply to the watershed and the allowable number of exceedance days established in the Santa Monica Bay Beaches TMDL.

3. Source Assessment. This is a quantitative estimate of point sources and nonpoint sources of bacteria into the Malibu Creek Watershed. The source assessment considers factors such as seasonality and flow, which may influence the relative magnitude of contributions from various sources.

4. Linkage Analysis. This analysis demonstrates how the sources of coliform bacteria in the water body are linked to the observed conditions in the impaired water body. The linkage analysis includes an assessment of critical conditions, which are periods when the changing pollutant sources and changing assimilative capacity of the water body combine to produce either critical conditions or conditions especially resistant to improvement.

5. Pollutant Allocation and TMDL. The allocations are expressed in terms of allowable days of exceedance of the single sample limit and the rolling 30-day geometric limits. However, for informational purposes, the TMDL estimates the loading that will achieve the allocations. Allocations are designed such that the water body will meet the applicable numeric targets in all reaches. Point sources are given waste load allocations and nonpoint sources are given load allocations. Allocations need to consider the worst-case conditions that are expected to re-occur with some recognized return frequency (e.g., 90^{th} percentile event), so that the pollutant loads may be expected to remove the impairment under critical conditions.

6. Implementation Recommendations. This section describes the plans, regulatory tools, or other mechanisms by which the waste load allocations and load allocations may be achieved and recommends several implementation options

7. Monitoring Recommendations. This TMDL provides for the monitoring plan that will be used to determine compliance with the TMDL and to provide additional assessment of the current impairment.

2. PROBLEM IDENTIFICATION

In this section, we identify the 303(d) listed impairments and describe the environmental setting of the Malibu Creek Watershed. Table 1 includes a listing of the impaired segments of the Creek system and the area or stream miles affected.

The Malibu Creek Watershed is located about 35 miles west of Los Angeles. The 109-square mile watershed extends from the Santa Monica Mountains and adjacent Simi Hills to the Pacific Coast at Santa Monica Bay. Several creeks and lakes are located in the upper portions of the watershed, and these ultimately drain into Malibu Creek at the downstream end of the watershed. Historically, there is little flow in the summer months; much of the natural flow that does occur in the summer in the upper tributaries comes from springs and seepage areas. During rain storms the runoff from the watershed may increase flows in the creeks dramatically. The natural hydrology of the watershed has been modified by the creation of several dams and man-made lakes, the importation of water to the system for human use which provides most of the base flow to the system, and the presence of the Tapia Wastewater Reclamation Facility (WRF), which provides significant dry-weather flow to the system in the winter months. Flows from watershed drain into Malibu Lagoon and ultimately into Santa Monica Bay when the Lagoon is breached.

In terms of land use patterns, about 80% of the land in Malibu Creek Watershed is undeveloped. The developed land is a mixture of residential (13%), commercial/industrial (4%) and agricultural (3%) land uses.

A number of water bodies in the Malibu Creek Watershed are hydrologically connected to the water bodies listed in the 1998 and 2002 Water Quality Assessment (See Table 1). These unimpaired or unassessed water bodies include Hidden Valley Creek, Potrero Canyon Creek, Triunfo Creek, Cheeseboro Creek, and Cold Creek and four lakes (Lake Sherwood, Westlake, Lake Lindero and Malibou Lake). These water bodies have been considered within the analytical framework of this TMDL because they have the potential to contribute significant bacterial indicator loading to the downstream impaired water bodies.

The western part of the watershed drains the areas around Hidden Valley, Portero Creek, Westlake and Triunfo Creek (total area about 25,210 acres). These areas are largely undeveloped. There is some limited agricultural land use, located mostly in the Hidden Valley subwatershed. Most of the residential and commercial/industrial land use is in the area around Westlake Village. Nearly all the runoff from this large watershed area is funneled to Triunfo Creek and ultimately to Malibou Lake. None of the creek reaches in this western-most portion of the watershed have been listed for fecal coliform bacterial impairments. However, it is important to note that the water bodies in these areas were largely unassessed by the Regional Board due to a lack of data. It is highly probable that the runoff from these areas contributes fecal coliform loading to the listed segments downstream of Malibou Lake and need to be considered in TMDL development.

Malibou Lake also receives flows from a number of water bodies that are listed for bacterial impairments, specifically Lindero Creek, Medea Creek and Palo Camodo Creek. These 15,900-acre area drains watersheds associated with these three creeks and the watersheds associated with Cheeseboro Creek which is not listed. The land use in these areas while still largely undeveloped has a higher percentage of residential and commercial land uses especially in the areas around Lindero Creek and Medea Creek watersheds.

Malibou Lake discharges to Malibu Creek, which is listed as impaired for its entire 10-mile length from the Lake to the Lagoon. Malibu Creek also receives flow from Las Virgenes Creek and Stokes Creek, both of which are listed as impaired. Land use at the bottom of the watershed near the lagoon is much more developed with significant residential and commercial development.

Table 1 - Water bodies within the Malibu Creek Watershed that are listed as impaired due to high fecal coliform counts (LARWQCB, 2002a)

Water body	Extent impaired
Lindero Creek Reach 2 (above Lake Lindero)	4.8 miles
Lindero Creek Reach 1 (Medea Creek to Lake Lindero)	2.2 miles
Medea Creek Reach 2 (above confluence with Lindero Creek)	5.4 miles
Medea Creek Reach 1 (from Malibou Lake to confluence with Lindero Creek	3.0 miles
Palo Comado Creek	7.8 miles
Las Virgenes Creek	11.5 miles
Stokes Creek	5.3 miles
Malibu Creek	9.5 miles
Malibu Lagoon	13 acres

3. NUMERIC TARGETS AND CONFIRMATION OF 303(d) LISTINGS

This section provides a review of the data used by the Regional Board to list the water bodies within the Malibu Creek Watershed for fecal coliforms. Where appropriate the data have been updated with more recent information. As the Regional Board's listing decisions are based on impairments to water quality, it is appropriate to begin this section with a discussion of the applicable water quality standards. In addition, the numeric targets for this TMDL are defined and the data are compared with those targets.

3.1 Applicable Water Quality Standards

Water quality standards consist of the following elements: 1) beneficial uses, 2) narrative and/or numeric water quality objectives and 3) an antidegradation policy. In California, beneficial uses are defined by the Regional Water Quality Control Boards (Regional Boards) in the Water Quality Control Plans (Basin Plans). Numeric and narrative water quality objectives are specified in each of the Regional Board's Basin Plans. The water quality objectives are designed to be protective of the beneficial uses in each water body in the region. The Basin Plan for the Los Angeles Regional Board (1994) defines 14 beneficial uses for the Malibu Creek Watershed. All the designated beneficial uses must be protected. However, the two beneficial uses most pertinent to coliform bacteria are REC-1 and REC-2. Table 2 identifies for each of the listed water bodies the uses (existing or intermittent) that are affected by high bacterial indicator levels.

Table 2 - Malibu Creek Watershed Beneficial Uses - Not Supported

Watershed	REC-1	REC-2
Malibu Lagoon	E	E
Malibu Creek	E	E
Las Virgenes Creek	E	E
Stokes Creek	E	E
Upper Medea Creek	I	I
Lower Medea Creek	E	E
Lindero Creek	I	I
Palo Comado Creek	E	E

Recreational uses for body contact (REC-1) and secondary contact (REC-2) apply to all the listed water bodies as either existing, potential or intermittent. These uses apply even if access is prohibited to portions of the water body. Objectives designed to protect human health (e.g., bacterial objectives) are appropriate to protect recreational uses of the creek. The REC-1 standard protects uses where ingestion of water is reasonably possible. The REC-2 standard protects uses, which occur in proximity to water (such as picnicking, sunbathing, hiking, or boating) where ingestion of water is reasonably possible.

The Wildlife use designation (WILD) is for the protection of wildlife. This use applies to all impaired water bodies within the Malibu Creek Watershed. This is pertinent to the coliform TMDL because wildlife can contribute bacterial loading to the watershed. Issues related to the effect of wildlife population on water quality and the potential for competing beneficial uses (REC-1 vs. WILD) are discussed in more detail in Section 3 (Numeric Targets).

Specified reaches of Malibu Creek were determined to be impaired for recreational beneficial uses due to exceedance of bacterial water quality objectives during the 1996, 1998, and 2002 water quality assessment. The applicable bacterial objectives at that time were specified in the Basin Plan as follows:

In waters designated for water contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml (based on a minimum of no less than four samples for any 30-day period), nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

The Regional Board recently updated the bacteria objectives for waters designated as REC-1 to be consistent with EPA criteria guidance which recommends the use of E. coli criteria for freshwater and the enterococcus criteria for marine waters (See Regional Board Resolution R01-018 and State Board Resolution 2002-0142). The updated revisions have subsequently been approved by the Office of Administrative Law and EPA, and became effective on August 19, 2002. The revisions create objectives for these two new indicators and revise the way in which the objectives for fecal and total coliform bacteria are implemented in freshwater and marine waters, respectively. The revised objectives are summarized in Table 3.

Table 3 - Summary of bacteria standard revisions

	Parameter	30-Day Geometric Mean	Single Sample
Streams (freshwater)	Fecal	200	400
	E.coli	126	235
Lagoon (marine water)	Total	1,000	10,000 or 1,000 if FC/TC > 0.1
	Fecal	200	400
	Enterococcus	35	104

The implementation provisions for the water contact recreation bacteria objectives defined in these resolutions are as follows:

The geometric mean values should be calculated based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period).

If any of the single sample limits are exceeded, the Regional Board may require repeat sampling on a daily basis until the sample falls below the single sample limit or for five days, which ever is less, in order to determine the persistence of the exceedance.

When repeat sampling is required because of an exceedance of any one single sample limit, values from all samples collected during that 30-day period will be used to calculate the geometric mean.

In this TMDL we recognize that there are natural sources of coliform bacteria (e.g., birds in lagoon) and that in some instances these sources may contribute bacterial loading sufficient to cause exceedance of the single sample and /or 30-day geometric mean water quality objective. Therefore, a reference system/antidegradation approach is used to establish the acceptable frequency of exceedance of the single sample objectives for the Malibu Creek TMDL.

The reference system/anti-degradation approach ensures that bacteriological water quality is at least as good as that of a reference system and that no degradation of existing bacteriological water quality is permitted where existing bacteriological water quality is better than that of the selected reference system.

The reference watershed approach is used to set a numeric target expressed in terms of allowable exceedance days for the single sample standard. This is consistent with the intent of the Regional Board's prior actions on the Santa Monica Bay TMDLs. The Basin Plan was recently amended to incorporate the following language:

The single sample bacteriological objectives shall be strictly applied except when provided for in a Total Maximum Daily Load (TMDL). In all circumstances, including in the context of a TMDL, the geometric mean objectives shall be strictly applied. In the context of a TMDL, and at the discretion of the Regional Board, implementation of the single sample objectives in fresh and marine waters may be accomplished by using a 'reference system/antidegradation approach' or 'natural sources exclusion approach.' A reference system is defined as an area and associated monitoring point that is not impacted by human activities that potentially affect bacteria densities in the receiving water body.

These approaches recognize that there are natural sources of bacteria, which may cause or contribute to exceedances of the single sample objectives for bacterial indicators. They also acknowledge that it is not the intent of the Regional Board to require treatment or diversion of natural water bodies or to require treatment of natural sources of bacteria from undeveloped areas. Such requirements, if imposed by the Regional Board, could adversely affect valuable aquatic life and wildlife beneficial uses supported by natural water bodies in the Region.

Under the reference system/antidegradation implementation procedure, a certain frequency of exceedance of the single sample objectives above shall be permitted on the basis of the observed exceedance frequency in the selected reference system or the targeted water body, whichever is less. The reference system/anti-degradation approach ensures that bacteriological water quality is at least as good as that of a reference system and that no degradation of existing bacteriological water quality is permitted where existing bacteriological water quality is better than that of the selected reference system.

Under the natural sources exclusion implementation procedure, after all anthropogenic sources of bacteria have been controlled such that they do not cause an exceedance of the single sample objectives, a certain frequency of exceedance of the single sample objectives shall be permitted based on the residual exceedance frequency in the specific water body. The residual exceedance frequency shall define the background level of exceedance due to natural sources. The 'natural sources exclusion' approach may be used if an appropriate reference system cannot be identified due unique characteristics of the target water body. These approaches are consistent with the State Antidegradation Policy (State Board Resolution No. 68-16) and with federal antidegradation requirements (40 CFR 131.12).

The appropriateness of these approaches and the specific exceedance frequencies to be permitted under each will be evaluated within the context of TMDL development for a specific water body, at which time the Regional Board may select one of these approaches, if appropriate.

Arroyo Sequit, located about 10 miles north of Malibu, was chosen as the reference watershed for this TMDL in part for its proximity and similarity to the Malibu Creek Watershed. Arroyo Sequit is the least developed watershed in the area (98% open space), like Malibu Creek it has a freshwater outlet to the beach (Leo Carillo Beach), and there is an existing shoreline monitoring station at the beach. Equally important, Arroyo Sequit is also the reference watershed being used in the Regional Board's Santa Monica Bay Beaches Bacteria TMDLs (LARWQCB, 2002b, 2002c) and the Regional Board has established a procedure for setting the acceptable allowable days of exceedances based on the historic exceedance rate at the mouth of this watershed.[2]

[2] While Arroyo Sequit is similar in many ways to Malibu Creek, it does not have a terminus lagoon and the bird population associated with such a lagoon. Therefore, this TMDL makes provision for further evaluation of the contribution from birds and consideration of a Natural Source Exclusion.

3.2 Numeric Target

The Santa Monica Bay TMDLs allow for 17 exceedance days per year during wet weather, three exceedance days during winter dry weather, and zero exceedance days during summer dry weather.[3] An exceedance day is any day when any of the applicable bacteria single sample limits are exceeded. No exceedances of the 30-day geometric mean are allowed. Wet days are defined as days 0.1 inch or more of rainfall and the following 3 days to account for residual rainfall effects. This applies to all the beaches within Santa Monica Bay including Surfrider Beach, except where historical data indicates better water quality. Pursuant to the antidegradation policy (State Board Resolution 68-16), where existing water quality is better than the allowable exceedances, then the historical exceedance rate will apply. We propose the same allowances for the Malibu Lagoon, Malibu Creek and all the tributaries within the Malibu Creek Watershed.

3.3 Assessment of existing conditions relative to bacteria standards and numeric targets

This section describes conditions in the Malibu Creek Watershed which resulted in the inclusion of water bodies as impaired on the 1998 and 2002 Section 303(d) Lists. In performing the assessment of inland waters, the Regional Board compared the data to the fecal coliform standard in effect at the time of the assessment and the allowable exceedance days as established under the Santa Monica Bay Beaches TMDL. Because the data were too limited to directly assess compliance with 30-day geometric mean standard of 200/100 ml, the evaluation was based on greater than 10% of the samples exceeding the single sample standard of 400 /100 ml and the median using the entire data set. The Malibu Lagoon listing was based on data from Las Virgenes Municipal Water District (Ambrose *et al*., 1995). Although the Regional Board did not include Triunfo Creek and Cold Creek on the 303(d) list, they are included in Table 4 since they were part of the Regional Board's assessment of conditions in the Malibu Creek Watershed. It is also likely that sources discharging in these water bodies contribute fecal coliform loading to the listed segments downstream and therefore need to be considered as part of our source analysis.

Bacterial water quality data from four organizations (see Table 4) were reviewed during the development of this TMDL.Enterococcus dataset were not used during this assessment because the Basin Plan does not specify objectives for enterococcus in fresh waters. Furthermore, Regional Board staff were unable to define a statistically significant correlation between enterococcus and fecal or E.coli counts. Heal the Bay has been collecting monthly E. coli samples from seven locations within the watershed since December 2001 (Table 5). Analysis of this monthly monitoring data is included in Appendix A. Analysis of this data show few exceedances of the E. coli health standards occur during dry weather at these locations.

[3] The allowable exceedance days are based on a daily sampling schedule. If weekly sampling is performed the allowable exceedance days are reduced accordingly.

The Basin Plan does not include enterococcus standards for non-marine water bodies. A summary of the fecal coliform data used in the 1998 listing process is included in Table 5.

Table 4 - Sources of updated water quality monitoring data

Agency	Water bodies	Time Period	Parameters	Comment
Los Angeles County Department of Public Works	Malibu Creek	January 1995 to January 2002	total coliform, fecal coliform	Wet-weather only
City of Calabasas	Las Virgenes Creek, Malibu Creek	November 1999 to September 2002	total coliform, fecal coliform	dry-weather
Las Virgenes Municipal Water District	Malibu Creek, Malibu Lagoon	January 1998 to October 2002	total coliform, fecal coliform, enterococcus	dry-weather
Heal the Bay	Malibu Creek Palo Comado, Malibu, West Carlysle Chesebro Las Virgenes, and Cold Creeks	November 1998 to March 2003 December 2001 to December 2002	enterococcus E. coli	dry-weather dry-weather

Table 5 - Summary of fecal coliform data (counts/100 ml) used in the 1998 listing process (LARWQCB, 1996, 1998, 2002a).

Water Body Name	Number of Samples	Range*
Triunfo Creek	4	ND-2,300
Lindero Creek Reach 1	9	1,700-90,000
Palo Comado	4	220-30,000
Medea Creek Reach 1	8	23-50,000
Medea Creek Reach 2	4	300-90,000
Las Virgenes	10	40-17,000
Stokes Creek	4	80-14,000
Cold Creek	7	ND-90,000
Malibu Creek	83	ND-14,000

* Basin Plan single sample standard is 400 counts/100 ml.

Discussion

Recent (post-1998) bacterial water quality monitoring data were available for the streams listed in Table 4 only. Therefore, the following discussion of results will not include water bodies other than Malibu Creek, Las Virgenes Creek, and Malibu Lagoon. In addition, data were not assessed against the Basin Plan geometric mean standards because the standard requires at least five samples during a 30-day period. To give an indication of whether the dataset might have exceeded the Basin Plan geometric mean, the median of the dataset was assessed against the geometric mean standard[4]. Finally, existing data were compared

[4] For positively skewed data the median is usually quite close to the geometric mean (Hesel and Hirsh, 1999)

with the allowable exceedance days for single sample limits, recognizing that this analysis likely underestimates the actual number of exceedances, since none of the datasets include daily sampling.

Las Virgenes Creek - Dry -Weather Sampling

The City of Calabasas submitted updated bacterial indicator data collected for this watershed. These data were collected as part of their volunteer monitoring program. Monitoring locations are shown in Figure 2. As indicated in Table 5, the data were reviewed for the period of November 1999 to September 2002. The database consisted of dry-weather monitoring data only. The indicators tested were total coliform and fecal coliform. The total coliform data were not assessed because the Basin Plan standard for total coliform is applicable for marine waters only.

A total of 198 fecal samples were assessed for compliance with Basin Plan single sample limit of 400 MPN/100 ml. Approximately 28% of the 198 samples exceeded the Basin Plans standard. The median concentration of the samples was 500 MPN/100 ml, and the range of fecal coliform counts was 0 to 160,000 MPN/100 ml. The data did not appear to indicate a trend when the data were analyzed over time. Based on the review of the most recent data for this watershed, the impairment of the REC-1 and REC-2 beneficial uses for fecal coliform based on the single sample standard is confirmed. Also, the review of the data indicates that the 30-day geometric mean standard (200 MPN/100 ml) may have been exceeded based on the median of the database. A comparison of the data with the allowable exceedance days proposed for this TMDL shows that both summer and winter dry-weather as proposed in this TMDL targets were exceeded (see Table 6).

Figure 2 - City of Calabasas Las Virgenes Creek Monitoring Stations

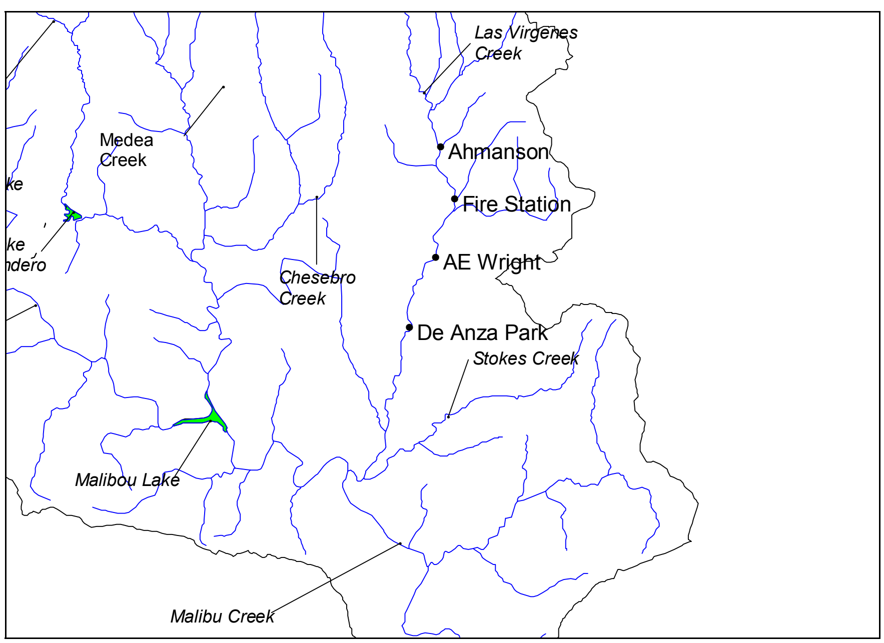


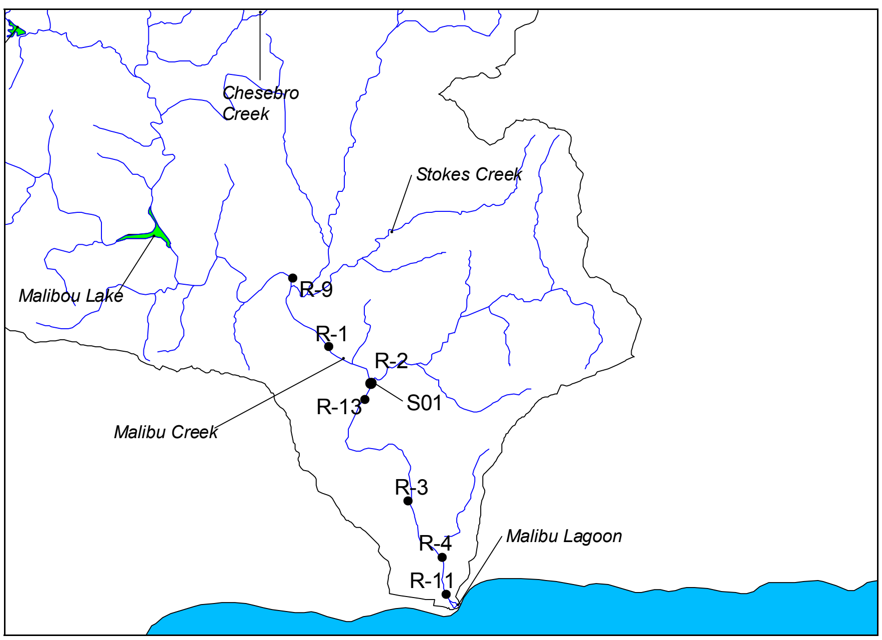
Table 6 - Las Virgenes Creek Comparison with Dry-Weather Target

Season	Dry Season Target	Exceedance Days			
		1999	2000	2001	2002
Summer	0	2	26	16	15
Winter	3	1	14	25	3

Malibu Creek - Dry Weather

The Las Virgenes Municipal Water District submits in-stream water quality data as required by their NPDES discharge monitoring reports. The data for Malibu Creek was collected at stations R-1, R-2, R-3, R-9, and R-13 (see Figure 3). The data were reviewed for the period of January 1998 to October 2002. The database consists of dry-weather monitoring data only for following bacterial indicators: fecal coliform, total coliform, and enterococcus. The total coliform and enterococcus data were not assessed, since there are no applicable fresh water objectives for these parameters.

Figure 3- LVMWD and LACDPW Malibu Creek and Lagoon Monitoring Stations



A total of 340 fecal coliform samples were assessed for compliance with Basin Plan standard of 400 MPN/100 ml, and reference/antidegradation approach. Approximately 8.5% of the 340 samples exceeded the Basin Plan standard. The median concentration of the samples was 70, and the range of the fecal coliform counts was 17 to 5,000 MPN/100 ml. The data demonstrated a decreasing trend when the data were analyzed over time. Review of the data indicates that the 30-day geometric mean standard (200 MPN/100 ml) does not exceed the Basin Plan standard based on the median of the database. A comparison of the data with the proposed allowable exceedance days shows that both summer and winter dry-weather targets were exceeded (see Table 7). Actual exceedance days may have been higher.

Table 7 - Malibu Creek Comparison with Dry-Weather Numeric Target

Season	Dry Season Target	Exceedance Days				
		1998	1999	2000	2001	2002
Summer	0	1	1	2	2	4
Winter	3	3	0	3	12	1

Malibu Creek - Wet Weather

The Los Angeles Department of Public Works submits stormwater monitoring data as required by their NPDES discharge monitoring reports. The data for Malibu Creek was collected at station S01(see Figure 3) located below the confluence of Cold Creek and Middle Malibu Creek. The data were reviewed for the period of January 1995 to January 2002. The database consists of wet-weather monitoring data only for following bacterial indicators: fecal coliform and total coliform. The total coliform data were not assessed.

A total of 52 fecal coliform samples were assessed for compliance with Basin Plan standard of 400 MPN/100 ml. Approximately 86.5% of the 52 samples exceeded the Basin Plan standard. This database was not assessed against the reference/antidegradation target. The median concentration of the samples was 50,000 and the range of the fecal coliform counts was 0 to 1,600,000 MPN/100 ml. The data demonstrated a decreasing trend when the data were analyzed over time. Based on the review of the most recent data for this watershed, the impairment of the REC-1 and REC-2 beneficial uses for fecal coliform based on the single sample standard is confirmed. In addition, review of the data indicates that the 30-day geometric mean standard (200 MPN/100 ml) may have been exceeded based on the median of the database.

Cold Creek - Dry Weather

Heal the Bay collects E.coli data in Cold Creek as part of the Stream Team monitoring program. The data for Cold Creek was collected at station HTB3 (at Stunt Road) and HTB11 (at Piuma Road). The data were reviewed for the period of December 2001 to December 2002. The database consists of dry-weather monitoring data for the following bacterial indicators: E. coli and total coliform. The total coliform data were not assessed.

A total of 33 E. coli samples from HTB3 and HTB11were assessed for compliance with Basin Plan standard of 235 MPN/100 ml. Approximately 3% (1of 33) samples exceeded the Basin Plan standard. The geomean concentration of the samples at HTB3 and HTB11 were 9 and 15 cfu/100, respectively. The range of the E. coli counts at the sites was 5 to 272 cfu/100ml for HTB3, and 5 to 86 cfu/100mL at HTB11. Review of this data indicates that E. coli standard in upper and middle Cold Creek is in compliance with Basin Plan objectives for the single sample and geomean standard during dry weather.

Malibu Lagoon

The Las Virgenes Municipal Water District collected data for the Malibu Lagoon at stations R-4 and R-11 (see Figure 3). The data were reviewed for the period of January 1998 to October 2002. These data were assessed based on the bacterial water quality objectives for marine waters. The database consists of dry-weather monitoring data only for fecal coliform and total coliform.

Above Pacific Coast Highway – Dry Weather

A total of 57 fecal coliform and 63 total coliform samples from monitoring station R-4 were assessed for compliance with Basin Plan fecal coliform standard of 400 MPN/100 ml and total coliform standard of 1,000 MPN/100ml or 10,000 MPN/100ml, which ever applied. Approximately 8.7% of the 57 fecal coliform samples and 30% (20 of 57) of the total coliform samples exceeded the Basin Plan standard. The median concentration of the samples was 80 MPN/100 ml for fecal coliform and 800 MPN/100 ml for total coliform. The range of the fecal coliform counts was 20 to 1,700 MPN/100 ml, while the total coliform range was 70 to 9,000 MPN/100 ml. The data demonstrated an increasing fecal coliform trend and gradual decreasing total coliform trend, when the data were analyzed over time. Based on the review of the most recent data for this watershed, impairment is confirmed of the REC-1 and REC-2 beneficial uses for total coliform based on the single sample standard. On the other hand, review of the data indicates that the 30-day geometric mean standard (200 MPN/100 ml) does not exceed the Basin Plan standard for fecal or total coliforms based on the median of the database.

A comparison of the data with the allowable exceedance days shows that the summer dry-weather target was exceeded, but winter dry-weather target was not (see Table 8.) However, this analysis likely underestimates the actual exceedances since it is based on a very small number of samples.

Table 8 - Malibu Lagoon (R4) Data Comparison with Dry Weather Target

Season	Dry Season Target	Exceedance Days		
		2000	2001	2002
summer	0	0	0	2
winter	3	1	2	0

Below Pacific Coast Highway – Dry Weather

A total of 71 fecal coliform and 77 total coliform samples from monitoring station R-11 were assessed for compliance with Basin Plan fecal coliform standard of 400 MPN/100 ml and total coliform standard of 1,000 MPN or 10,000 MPN, whichever applied. Approximately 28.5% of the 71 fecal coliform samples and 7% (6 of 77) of the total coliform samples exceeded the Basin Plan standards. The median concentration of the samples was 220 MPN/100 ml for fecal coliform and 1,100 MPN/100 ml for total coliform. The range of the fecal coliform counts was 20 to 5,000 MPN/100 ml, while the total coliform range was 20 to 16,000 MPN/100 ml. The data demonstrated a decreasing trend for fecal and total coliform, when the data were analyzed over time. Based on the review of the most recent data for this watershed, the impairment of the REC-1 and REC-2 beneficial uses is confirmed for fecal coliform based on the single sample standard. In addition, review of the data indicates that the 30-day geometric mean standard (200 MPN/100 ml) exceeds the Basin Plan standard for fecal or total coliforms based on the median of the database.

A comparison of the data with the proposed allowable exceedance days shows that the summer and winter dry-weather target were exceeded (see Table 9.) However, this analysis likely underestimates the actual exceedances since it is based on a very small number of samples.

Table 9 - Malibu Lagoon (R-11) Data Comparison with Dry-Weather Numeric Target

Season	Dry Season Target	Exceedance Days		
		2000	2001	2002
summer	0	2	6	3
winter	3	8	3	1

In summary, the most recent monitoring data were reassessed against the newly revised bacteria water quality objectives and the numeric targets proposed for this TMDL and the 303(d) listed impairments were confirmed.

3.4 Fecal to E. Coli Coliform Relationship

The freshwater standards for E. coli and fecal coliform apply to all the creeks in the watershed. The marine standards for total coliform, fecal coliform and enterococcus apply to the lagoon. Recognizing that these multiple standards apply, the modeling for the linkage analysis in this TMDL was based solely on fecal coliform objectives, which are the same for fresh and marine waters. This decision was made in part because the 303(d) listings were based solely on the exceedances on the fecal coliform standard. There is almost no data on E. coli data to assess compliance with the E. coli freshwater standard and very little enterococcus data to assess conditions in the lagoon. While there is a substantial dataset for total coliform, the total coliform standard only applies to the lagoon. We anticipate that actions targeted toward the reduction of fecal coliform in the watershed will also reduce concentrations of total coliform in the lagoon.

Given the limited data for bacteria indicators in the watershed, the TMDL developed and established by USEPA in March 2003 was based solely on fecal coliform as an indicator target. Fecal coliform waste load and load allocations were developed for bacteria sources to ensure attainment with water quality standards. During the public comment period USEPA received comments that questioned whether water quality could be attained in the streams, since allocations were not developed for E. coli. In order to address these comments, the Regional Board staff conducted a data analysis to determine whether a statistical relationship between E. coli and fecal coliform existed based on a linear regression analysis of historical data from the Malibu Creek Watershed. The results of this analysis indicated that the E. coli and fecal coliform concentrations were highly correlated (r-value = 0.994). Linear regression analysis demonstrated that the concentration of E. coli could be predicted from fecal coliform concentrations (coefficients of determination [R^2] =98.7%). Therefore compliance with the fecal coliform geometric mean concentrations of 200 org/100 ml, should ensure compliance with the E. coli single sample standard numeric target of 235 org/ 100 ml, based on the relationship demonstrated in Table 10.

Equation (1) *E. coli = (1.00409 fecal coliform) - 10.6*

Table 10 - Fecal Coliform Relationship

Fecal Coliform	**Fecal/E. coli Relationship**	**Predicted E. coli**
200 org/100 ml	1.00409 (200)-10.6	190.28

Equation 1 was not used to predict the geometric mean concentrations for E. coli, since the fecal coliform data set evaluated did not have a minimum number of samples (5 samples over a 30-day period) to assess a geometric mean relationship.

4. SOURCE ASSESSMENT

Fecal coliform bacteria may be introduced from a variety of sources including onsite wastewater treatment systems, animal wastes, and runoff from both developed and undeveloped areas. An inventory of possible point and nonpoint sources of fecal coliform bacteria to the water body was compiled, and both simple methods and computer modeling were used to estimate bacteria loads for those sources. Source inventories were used in the analysis to identify all potential sources within the Malibu Creek Watershed, modeling was used to identify the potential delivery of pathogens into the creeks and the lagoon.

Fecal coliform loads from the watershed were estimated by using a computer model (Hydrologic Simulation Program – FORTRAN) and supplemental estimates of selected sources (Tetra Tech, 2002). Fecal coliform loading deposited on land surfaces or in the soil, may be attenuated through sunlight, heat, and decay over time. Transport of coliform bacteria is a result of periodic rainfall and groundwater seepage into the creek system. This source assessment chapter discusses the gross loading potential of various identified sources. While gross loading are applicable to direct discharges, adjustments were made for indirect discharges resulting from surface runoff or groundwater discharge. Gross loading was adjusted for indirect discharges and is referred to herein as “net” loading. The gross and adjusted net loading was further refined based upon calibration of the model with actual in-stream monitoring data (calibrated loading). In most cases, the calibrated loading was less than the gross and net loading. It is important to note that multivariate models were used. The multiple sources of bacteria loading (quantity of each variable) in the models were adjusted to reasonably match historical creek water quality data. Since the inputs were indirectly estimated, the data was not sufficient to confirm that the models would be able to predict the bacteria concentrations in the creek or lagoon if one or more assumed inputs of bacteria are changed. For more detailed information on the source assessment, please refer to the modeling report (Tetra Tech, 2002).

Tapia Waste Water Reclamation Facility. The Tapia WWRF has the capacity to treat and discharge up to 16.1 mgd of tertiary- treated sewage. The treated effluent from Tapia has one of two end destinations. The effluent is either reclaimed for irrigation and industrial uses, or is discharged to streams. Effluent is discharged to Malibu Creek or Las Virgenes Creek through discharge points 001, 002, and 004 (Figure 4). The primary outfall into Malibu Creek is Discharge No. 001, which is located about 0.3 mile upstream of the confluence with Cold Creek. Discharge No. 002 flows into lower Las Virgenes Creek, and is used to release surplus effluent from Las Virgenes Reservoir No. 2, which is used for distribution of the reclaimed water system. Discharge No. 004 is the discharge from the percolation ponds. Currently, discharge to Malibu Creek is not allowed from April 15 to November 15 (Regional Board Order No. 97-135). On average during the winter months the plant dischargers between 8 to 10 mgd (LVMWD, 1996-2000).

Tapia’s permit requires that all the wastewater be chlorinated to at least 2.2 MPN/100 ml for fecal coliform. Although fecal coliforms have not been detected in the effluent, an upper bound on the estimated loading can be made by multiplying the reported detection limits for fecal coliforms by the average flows. The fecal coliform loads discharged to Malibu Creek from Tapia were estimated from the monthly flow and concentration measurements collected by the Las Virgenes Municipal Water District for their NPDES monitoring reports (LVMWD, 1993-2000). Based on this analysis the annual fecal coliform loading from the Tapia plant are on the order of 30 to 60 billion counts per year (Table 11).

Figure 4 - Malibu Creek Watershed Compliance Points and Tapia Discharge Points

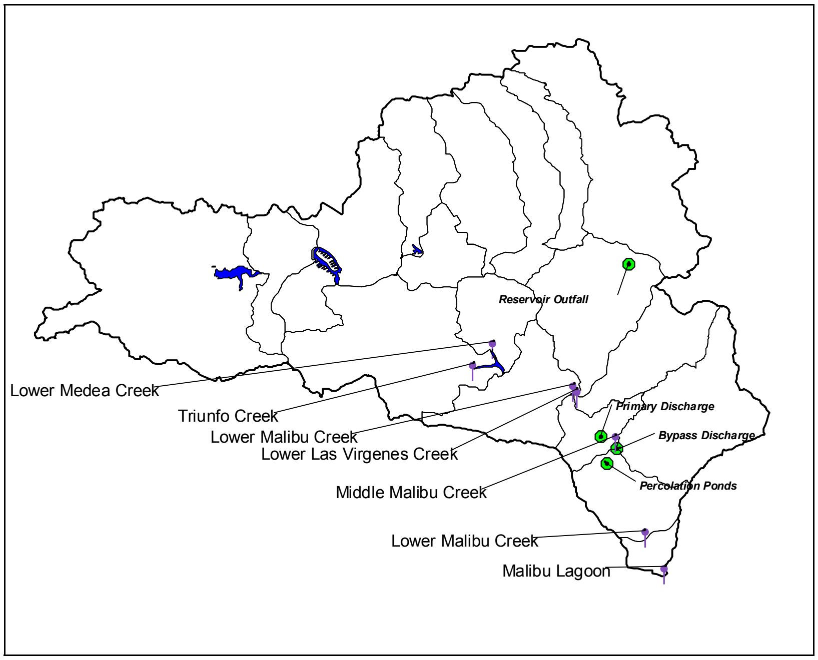


Table 11 - Annual gross fecal loading (billion counts/year) in Tapia effluent (Tetra Tech, 2002)*

	1992	1993	1994	1995	1996	1997	1998	1999
Max	<1	<1	<1	<1	<1.1	<1.1	<1.1	<1.1
Average Flow (cfs)	4.76	5.35	4.02	4.80	3.13	3.00	6.44	3.18
Load	42.2	47.3	35.7	42.8	30.5	29.3	62.9	30.8

* Fecal loads were assumed to the equal to total coliform loads. This is a conservative assumption, and it is expected that the actual fecal loads may be lower.

The Las Virgenes Municipal Water District (LVMWD) sells approximately 4,000 acre-feet per year of reclaimed wastewater from its Tapia facility that is used for irrigating open space and landscaping (Abramson et al., 1998). The use of reclaimed water is regulated under water reclamation requirements contained in Order No. 87-86 and 94-055. Table 12 summarizes the annual loading of total coliform from each effluent irrigation operation, estimated by multiplying flows times the concentration/detection limit. These are gross numbers, and do not reflect loading to receiving water. Indeed, Order No. 87-86 requires that irrigation water shall be retained on the areas of application and not be permitted to escape as surface flows, that reclaimed water shall not be applied at a rate which exceeds vegetative demand, and that special precautions shall be taken to prevent overwatering and to exclude the production of runoff.

Table 12 - Annual gross fecal loads (billion counts/year) associated with effluent irrigation in the Malibu Creek Watershed (Tetra Tech, 2002)*

Source	1992	1993	1994	1995	1996	1997	1998	1999
Triunfo Sanitation District	5.3	3.4	5.3	6.0	18.0	20.8	13.4	19.9
Western Las Virgenes Municipal Water District	30.0	28.1	24.2	27.2	29.1	37.0	27.2	34.0
Calabasas	11.7	14.7	17.1	16.7	21.3	20.0	15.6	20.7
Las Virgenes Valley	1.2	3.3	3.9	2.9	3.8	2.6	1.9	3.4
Rancho Las Virgenes	0.9	1.1	0.7	0.2	0.9	0.9	0.6	1.2
Rancho Las Virgenes Composting	0	0	0	0	0	0	0.05	0.05
Tapia Percolation Beds	11.8	8.3	21.1	27.5	23.2	26.4	0	0
Malibu Creek Park	0	0	0	0	0	0	0	0.02
Tapia Spray Fields and Wastewater Reclamation Facility	0.6	0.3	0.9	0.3	0.3	10.6	0.05	0.05
Tapia Yard	7.0	7.1	7.0	6.2	8.2	0	0	0
TOTAL	**68.5**	**66.3**	**80.2**	**87.0**	**104**	**118.3**	**58.8**	**79.3**

* Fecal loads were assumed to the equal to total coliform loads. This is a conservative assumption, and it is expected that the actual fecal loads may be lower.

Tapia is permitted to compost the solid wastes from its treatment facility into fertilizer at their Rancho Las Virgenes Compost Facility (LVMWD, 1994; LA RWQCB, 1997; Abramson et al., 1998). Another portion of the sludge from Tapia may be digested and pumped to their Rancho Las Virgenes Farm for subsurface injection. This activity is regulated under Waste Discharge Requirements contained in Order No. 79-107. Table 13 summarizes the annual loading from sludge disposal. These have decreased in recent years as composting at Rancho Las Virgenes has come on line, but injection still occurs (approx. 1 dry ton/year) according to a Las Virgenes Municipal Water District official (Colbough, 2003).

Table 13 - Annual gross fecal coliform loading associated with sludge Injection Loads at Rancho Las Virgenes Farm (Tetra Tech, 2002)

Year	Sludge Biosolids Loading (dry ton/yr.)	Fecal Coliform Loading (billion counts/year)
1997	307	53,800
1998	90	16,300
1999	1	NA

The loads from Tapia either from direct discharge or indirectly from use of reclaimed water for effluent irrigation or sludge injection are insignificant (<0.1%) of the total estimated annual loading. Both the direct discharge and reclaimed water are chlorinated so that the effective concentrations of fecal coliforms are less than 1 MPN. Given that concentrations from Tapia are less than 0.5% of the water quality objective for fecal coliform bacteria, flows from Tapia actually provide additional assimilative capacity to the system.

Onsite Wastewater Treatment Systems. Except for the City of Malibu, most of the medium to high-density residential developments in the watershed are on sewer systems. However, onsite wastewater treatment systems are still used in rural residential areas and in the City of Malibu. The term onsite wastewater treatment system is being used in this document instead of the traditional term: septic systems. Onsite wastewater treatment system describes the location and purpose of these systems. The total number of systems in the watershed was estimated at 2,300 in the mid-1990s (NRCS, 1995) and 2,420 in 2001 (Tetra Tech, 2002).

The USEPA (2003) assumed that there were about 20 commercial onsite wastewater treatment systems in shopping centers and commercial areas in the vicinity of Malibu Lagoon which discharge an estimated

70,000 to 80,000 gallons of septic effluent per day (LARWQCB, 2000). Furthermore, this refined number of commercial and multifamily systems is based on the watershed defined by surface topography and drainage along the land surface of the Malibu Lagoon Subwatershed. Since onsite wastewater treatment systems are below grade: the groundwater flow regime controls whether groundwater passing beneath a system ultimately flows into Malibu Creek, Malibu Lagoon or the surfzone. Therefore, at this time we cannot positively identify systems that contribute groundwater flow to the Creek and the Lagoon. Several hundred thousands of gallons per day are estimated to be discharged from private residences in the Malibu area of the lower watershed (LARWQCB, 2000). It is presumed that most of these systems are providing adequate treatment of bacteria. Warshall (1992) estimated that 30 single family residences with onsite systems were "short circuited" and therefore contributing elevated levels of bacteria to the Lagoon. The locations, designs, and depths to groundwater of these systems have not been inventoried to confirm this claim. Table 14 presents the total annual fecal coliform loads generated from onsite wastewater treatment systems in the Malibu Creek Watershed as used in the Tetra Tech modeling (2002).

Table 14 - Estimated gross and net annual fecal coliform loads generated from Onsite Wastewater Treatment systems

Subwatershed	Onsite WastewaterTreatment Systems							
	Total	Normal	Failed	Short-Circuited	Commercial	Effluent flow (gal/day)	Gross Fecal Coliform Load (billion /year)	Net Fecal Coliform Load (billion /year)
Hidden Valley Creek	625	500	125			171,250	1,551,250	124,100
Portereo Canyon Creek								
Westlake	60	48	12			16,440	148,920	11,914
Upper Lindero Creek								
Lower Lindero Creek								
Upper Medea Creek								
Palo Comado Creek								
Cheeseboro Creek								
Lower Medea Creek	110	88	22			30,140	273,020	21,842
Triunfo Creek	820	656	164			224,680	2,036,700	162,819
Upper Malibu Creek	95	76	19			26,030	235,790	18,863
Upper Las Virgenes Creek								
Lower Las Virgenes Creek	50	40	10			13,700	124,100	9,928
Stokes Creek	85	68	17			23,290	210,970	16,878
Middle Malibu Creek	50	40	10			13,700	124,100	9,928
Cold Creek	300	240	60			82,200	744,600	59,568
Lower Malibu Creek	5	4	1			1,370	12,410	993
Malibu Lagoon								
Above Lagoon	170	136	34			46,580	423,400	33,775
Adjacent to Lagoon	30			30		8,220	74,460	74,460
Commercial near lagoon	20				20	75,000	678,900	678,900
Total	2,420	1896	474	30	20	732,600	6,638,620	1,223,968

Source: LARWQCB, 2000; NRCS, 1995; Finney,

When properly sited and operated, it is assumed that onsite wastewater treatment systems remove nearly 100% of the fecal coliform bacteria. However, onsite wastewater treatment systems can be significant sources of bacteria when the systems provide inadequate treatment and discharge directly to groundwater in close proximity to surface waters or discharge directly to surface water via overland flow. Inadequate treatment may be due to insufficient vertical separation to the groundwater, insufficient horizontal separation or surface discharge from a failed disposal field. Onsite wastewater treatment system failure rates have been estimated to be 20 to 30% in the unincorporated parts of Los Angeles County and within the Malibu Creek Watershed. It is presumed that this estimate of system failure apparently includes a wide range of types of failures, many of which may not impact surface water quality. For example, failing systems include systems that have backed up, have surfacing effluent that does not reach a creek, or have poorly functioning leach fields. LARWQCB has historically been concerned about the bacterial loading from the residential onsite wastewater treatment systems in the Malibu Colony and Cross Creek shopping areas adjacent to the Malibu due to their close proximity to the lagoon. This concern is based on limited evidence of high pollutant concentrations measured in the shallow groundwater in this area and the potential for insufficient vertical separation between the bottom of the soil absorption systems and the high groundwater table (LARWQCB, 2000).

In estimating loads from the failing systems, a maximum failure rate of 20 percent was assumed. However to calibrate the model the failure rate was adjusted. This resulted in an average failure rate of about 8 percent for onsite wastewater treatment systems above Malibu Lagoon. Forty percent of the bacteria from these failed systems were assumed to reach surface waters (Tetra Tech 2001). For the short-circuited and commercial onsite wastewater treatment systems adjacent to the lagoon, the calibrated fecal coliform failure rate was assumed to be 20 percent throughout the year, and assuming that 100% of the bacteria from the failed systems reached the lagoon. In order to account for both lower assumed to be failure rates and bacteria die off in route to the receiving water, 20 percent of the gross bacteria loads were assumed to enter the receiving water (Tetra Tech, 2002).

The City of Malibu has undertaken a study of the impact of onsite wastewater treatment systems on groundwater quality in this area. This project, entitled *Risk Assessment of Decentralized Wastewater Management in High Priority Area, Malibu, California*, is being conducted by the City of Malibu, with a California Coastal Conservancy Grant, and is administered by the Santa Monica Bay Restoration Commission. This study is collecting groundwater quality samples in this watershed on a monthly basis for one year. This ongoing study will provide a area-wide characterization of the potential contribution of onsite systems to the Malibu Lagoon Watershed. The results of this study will be incorporated into a three dimensional computer model of groundwater flow and solute transport, and will be available to refine the assumptions of the models used to more accurately allocate the source loading from onsite systems in this subwatershed. For example, the model will enable the determination of travel times for bacteria in groundwater to determine whether adequate die-off of bacteria is likely to occur prior to reaching the lagoon. Unfortunately, data from the study have not yet been released and therefore could not be considered in the development of this TMDL. However, the study results should assist the city in implementing the TMDL.

Both estimated gross and net bacteria loads are provided in Table 14. Calibrated loads for onsite wastewater treatment systems, based on the calibration of the models, are provided in Table 18. Based on these assumptions, we estimated that onsite wastewater treatment systems may account for about 18% of the total annual fecal coliform loading to the Malibu Creek Watershed. Similarly, the onsite wastewater treatment systems in the Malibu Lagoon subwatershed may account for 12% of the total annual loading to the entire Malibu Creek Watershed.

Runoff from Residential and Commercial Areas. Runoff from residential and commercial areas can be important sources of bacteria. Most of the major residential and commercial areas are in the cities of Westlake Village, Thousand Oaks, Agoura Hills, Calabasas, and Malibu. Lower density residential areas are scattered in many areas of the watershed, and include the communities around Lake Sherwood and Malibou Lake, the Hidden Valley area, the Palo Comado Creek area east of Agoura Hills, and the community of Monte Nido. The potential sources include fertilizer used for lawns and landscaping; organic debris from gardens, landscaping, and parks; trash such as food wastes; domestic animal waste; and human waste from areas inhabited by the homeless. These pollutants build up, particularly on impervious surfaces, and are washed into the waterways through storm drains when it rains. These loads are typically highest during the first major storms after extended dry periods, when the pollutants have accumulated. Activities such as the watering of lawns and the washing down of parking lots and driveways can contribute pollutants between storms. The bacterial loading from residential runoff were estimated to be 3,150,000 billion counts per year. The estimated bacterial loading associated with commercial and industrial were on the order of 2,550,000 billion counts per year. During wet weather, urban runoff appears to be the predominate source of bacterial loading.

Horse and Livestock. Manure produced by horses, cattle, sheep, goats, birds and other wildlife in the Malibu Creek Watershed are sources of both nutrients and coliforms. These loads can be introduced directly to the receiving waters in the case of waterfowl or cattle wading in streams, or they may occur as nonpoint sources during storm runoff.

Most of the horses are concentrated in a few areas. These are Hidden Valley, the Palo Comado Creek area east of Agoura Hills, the Triunfo Creek and Lower Medea Creek areas in the vicinity and upstream of Malibou Lake, and the Cold Creek area around the community of Monte Nido. Cattle grazing is confined primarily to the Hidden Valley area in the upper western portion of the watershed. Approximately 250 cattle are estimated to reside in this area (NRCS, 1995). Approximately 200 sheep and goats reside in the pasture area north and east from the Rancho Las Virgenes. In past years, cattle grazing have also occurred on the Rancho Las Virgenes property of the upper Las Virgenes Creek subwatershed (Orton, 2001).

Estimates of fecal loads produced by horse and livestock can be estimated by multiplying the number of animals in the watersheds by a per unit fecal production load (Tables 15 and 16).

Table 15 - Gross annual fecal loads associated with horse manure

Subwatershed	Number of Horses	Estimated Fecal coliform loads (billion counts/year)
Hidden Valley Creek	920	140,890
Portereo Canyon Creek	40	6,132
Westlake		
Upper Lindero Creek		
Lower Lindero Creek	5	767
Upper Medea Creek	20	3,066
Palo Comado Creek	100	15,330
Cheeseboro Creek		
Lower Medea Creek	140	21,462
Triunfo Creek	160	24,528
Upper Malibu Creek		
Upper Las Virgenes Creek	15	2,300
Lower Las Virgenes Creek	5	767
Stokes Creek	45	6,899
Middle Malibu Creek	30	4,599
Cold Creek	115	17,630
Lower Malibu Creek		
Malibu Lagoon	100	15,330
Total	**1695**	**259,700**

Table 16 - Gross annual fecal coliform loads associated with livestock manure

Subwatershed	Cattle	Sheep/Goats	Estimated Fecal coliform (billion counts/year)
Hidden Valley Creek	250		26,000
Upper Las Virgenes Creek	15		1,560
Upper Las Virgenes Creek		200	2,400
Total	**265**	**200**	**29,960**

The values in Tables 15 and 16 present estimated gross fecal coliform loads from horse and other livestock manure, respectively, in the Malibu Creek Watershed. They do not reflect the estimated net loading to the creeks. In our model, the gross loads from horses were reduced by forty percent for input into the model, due to collection of horse manure from stables, except for the Hidden Valley subwatershed where there are many open pastures. Additionally, loads were reduced by twenty percent for horses and thirty percent for cows and sheep because these percentages were assumed to occur as urine (ASAE, 1998). Since urine is not expected to contain fecal bacteria, the reductions were necessary. Because horse and livestock loads occur as nonpoint sources in the model, there is a buildup of the bacteria during the dry periods and thus reduced contribution of the bacteria to the stream reaches during these periods. Based on these assumptions, our best estimate of net loading to the creeks is 32,100 billion counts per year. This represents about 0.5% of the total loading to the Malibu Creek Watershed.

Wildlife. Wildlife wastes contribute to the bacterial loads from the large undeveloped portions of the watershed, and may be the only source of bacteria from these areas. Over 75 percent of the entire Malibu Creek Watershed is undeveloped wildland consisting primarily of chaparral, scrub, and woodlands, with smaller areas of grasslands and forests. The abundance of wildlife varies among the different habitat and vegetation types. Approximately 50 species of mammals and 380 species of birds occur in the watershed

(NRCS, 1995). The important mammals include mule deer, hares, rabbits, squirrels, foxes, bobcats, badgers, ring-tailed cats, weasels, coyotes, raccoons, skunks, mountain lions, and a variety of small rodents (rats, mice, gophers, voles) (NRCS, 1995). We have no direct estimates of populations or the loading rates associated with these animals. However, the values for bacterial loading associated with runoff from undeveloped land provide an indirect estimate of wildlife contribution. It is estimated that runoff from chaparral/sage scrublands contributes 37,700 billion per year, runoff from grasslands contributes 2,690 billion per year, and runoff from woodlands contributes 809 billion per year. Estimates for each type of vegetation were based on literature and event mean concentrations measured by the Los Angeles County Department of Public Works (Tetra Tech, 2002).

Waterfowl are important components of the Malibu Lagoon ecosystem, and may also contribute nutrients and bacteria to the various lakes in the watershed. Waterfowl were considered as a separate loading source only for Malibu Lagoon, since birds have previously been suggested to be an important source of the elevated coliform levels in the lagoon (Warshall et al., 1992). Table 17 presents the estimated annual bacteria loads produced by waterfowl near Malibu Lagoon. The loads were reduced to 35% of the total load for use after model calibration (see Table 18). This reduction in bird loads can be explained by the fact that the birds do not spend all their time in the lagoon. It should be pointed out that waterfowl loads were not evaluated for the lakes, since bird counts were not available.

Table 17 - Estimated gross annual bacterial loads (billion counts) produced by waterfowl near Malibu

Month	Bird Population	Estimated Fecal coliform (billion counts/year)
January	1000	75,330
February	1500	102,060
March	1630	122,788
April	400	29,160
May	300	22,599
June	320	23,328
July	230	17,326
August	200	15,066
September	400	29,160
October	750	56,498
November	780	56,862
December	1100	82,863
Annual Total	8610	**633,040**

Source: Topanga-Las Virgenes Resource Conservation District; ASAE, 1998.

Golf Courses. Golf courses are a potential source of bacteria since the typical fertilization and watering rates are generally high. Golf courses also attract large numbers of waterfowl. The bacteria may be transported to waterways in storm runoff. Most of the golf courses are adjacent to waterways. Both Lake Sherwood and Lake Lindero have golf courses just upstream of the lakes, and Westlake Lake has a golf course about 0.6 mile northeast of the lake. In addition, two golf courses are located in the upper portions of the Westlake and Upper Lindero Creek watersheds near perennial or intermittent streams. There is also a small private golf course on the west side of Malibu Lagoon in the Malibu Colony area (Tetra Tech, 2002). Based on our analysis, the runoff of fecal coliform bacteria associated with golf courses appears to be negligible (less than 1%).

Tidal Inflow to Lagoon. Tidal inflow loads of bacteria were calculated from estimated tidal inflow rates from the UCLA study (Ambrose et al., 2000) and fecal coliform concentrations in coastal waters measured during the Malibu Technical investigation (LARWQCB, 2000). The average concentration for fecal coliform at beach surf zone stations was 69 counts per 100 ml. From this number, annual loading associated with tidal inflow was estimated to be 16,100 billion counts per year. This is a relatively small percentage (0.2%) of the annual loading to the lagoon.

Dry weather storm drain loads to Malibu Lagoon. Three storm drains discharge to the Malibu Lagoon. These are the Civic Center drain, the Cross Creek Road drain, and the Malibu Colony. It is estimated that the fecal loading from the Malibu Colony storm drain was 48 million per day. These high concentrations from these storm drains may result in localized exceedances of water quality standards. However in terms of annual loading, these drains appears to contribute a very small fraction (<1%) of the loads to the lagoon.

Sanitary Sewer Overflows, Leaking Sewer Pipes

Sanitary Sewer Overflows (SSOs) and exfiltration from sewer systems has been indentified by EPA as a potential cause of pathogens in surface water (USEPA 2000a and 2001). SSOs are primarily addressed through enforcement actions such as Administrative Civil Liabilities (ACL) fines, Cease and Desists Orders (CDOs), and litigation. In addition, USEPA documents indicate that although exfiltration may be possible given certain conditions, "no data or narrative information in the literature demonstrate, or even suggest, that sewer exfiltration has directly contaminated surface waters."(USEPA 2000a). Thus, these potential sources were not included in the source assessment.

Illicit Connections

Sources of elevated bacteria to marine and fresh waters may also include direct illegal discharges from malfunctioning onsite water treatment systems and illicit discharges from private drains. Data were not available at the time of TMDL development to assess the bacterial contribution from illicit connections. Based on local code and/or ordinances, illicit connections are prohibited in the following areas: unincorporated county areas of Ventura and Los Angeles and the cities of Calabasas, Westlake Village, Thousand Oaks, Simi Valley, and Malibu.

4.1 Summary of source assessment.

The values in Tables 11-17 do not by themselves provide enough information to allocate load reductions among the various sources. A model has been developed to relate loading to concentrations in the creek and lagoon system. The model integrates this information on potential loading with assumptions about the timing and delivery of these loading relative to instream flows and instream processes to predict water quality. The calibrated modeled loads to the system are summarized in Table 18.

These values represent our best estimates of potential sources from the watershed to the creeks and lagoon. Surface runoff loads from residential and commercial areas appear most likely to be the largest sources. Most of these loading are associated with storms. However dry-weather urban runoff also contributes anthropogenic loading. Based on preliminary data, inadequate onsite wastewater treatment systems may result in significant fecal contribution, especially to the lagoon. Birds are another significant potential source of fecal coliforms to the lagoon. These are the apparent major contributors to the total watershed on an annual basis. During the dry season, urban runoff appears to be the largest source of fecal coliforms, but the loads associated with birds and failing onsite wastewater treatment systems may be comparable in magnitude.

5. LINKAGE ANALYSIS

Information on sources of pollutants provides one part of the TMDL analysis. To determine whether those pollutants impair a water body, it is also necessary to determine the assimilative capacity of the receiving water under critical conditions. This section describes the use of a hydrodynamic and water quality model to determine the loading of bacteria that are expected to achieve the compliance with the TMDL. In this section, we also describe the approaches for defining the critical conditions and developing an appropriate Margin of Safety (MOS) to ensure that water quality standards will be met.

5.1 Model description

Receiving water quality models were used to predict fecal coliform concentrations in the 303(d) listed creeks and lagoon under various loading scenarios. The models were used to establish potential relationships between pollutant loads from the identified sources within Malibu Creek Watershed and the in-stream water quality targets for the listed reaches (Tetra Tech, 2002).

HSPF was selected since it could be linked directly with the watershed and stream modeling framework. For the purpose of analysis, the Malibu Creek Watershed was divided into 18 subwatersheds. The source loading data from each these subwatersheds were treated as inputs at the appropriate location within the network of tributaries and creeks that were modeled as part of Malibu Creek Watershed (Figure 4). The following stream reaches within the Malibu Creek Watershed were included in the model: Hidden Valley Creek, Portrero Canyon Creek, Upper Lindero Creek, Lower Lindero Creek, Upper Medea Creek, Palo Comado Creek, Cheeseboro Creek, Lower Medea Creek, Triunfo Creek, Upper Malibu Creek, Upper Las Virgenes Creek, Lower Las Virgenes Creek, Stokes Creek, Middle Malibu Creek, Cold Creek, Lower Malibu Creek and Malibu Lagoon. The following lakes were also considered as part of the stream network: Westlake Lake, Lake Sherwood, Lake Lindero and Malibou Lake.

Calibration of the model involved a comparison of historical receiving water data (baseline conditions) with predicted receiving water concentrations (simulated conditions) from the model. The model predictions were compared to actual in-stream concentrations at five locations within the watershed where there were existing data: Upper Malibu Creek (R9), Middle Malibu Creek (R2), Lower Malibu Creek (R3), Malibu Creek at the Lagoon (R4) and Malibu Lagoon (R11). As result of calibration, some pollutant source inputs were adjusted. The final calibrated sources loads are summarized in Table 18. Although the model was calibrated, the model was not validated due to insufficient instream monitoring data at the time of model development. Therefore, we cannot be sure that the model reflects all of the existing and potential bacteria sources. Furthermore, since this model has multiple variables and has not been validated, we cannot be sure that the loads are appropriately allocated among the sources. These source loads should be considered to be estimates. The nature of the calibration process and the parameters adjusted to achieve calibration are detailed in the modeling document (Tetra Tech, 2002).

Table 18 - Summary of Calibrated Source Loading

Potential Sources	Total Annual Loading (billion counts/year)
Tapia Discharge	59
Storm Water Runoff	
Commercial/Industrial	2,550,000
High/Med. Density Residential	2,700,000
Low Density Residential	344,000
Rural Residential	97,500
Agriculture/Livestock	32,100
Onsite Wastewater Treatment Systems	247,000
Effluent Irrigation	12
Dry Weather Runoff	
Entire Watershed (except lagoon)	5,210
Malibu Lagoon	18
Birds	450,000
Tidal Inflow	16,100
Natural Sources Other than Birds	
Vacant	1,950
Chaparral/Sage Scrub	37,700
Grasslands	2,690
Woodlands	809

The model results were evaluated for the critical condition (See Section 5.2) and then used to evaluate the bacterial load reductions that would be required to ensure that water quality standards are met at each of the listed reaches (See Section 5.3).

5.2 Critical Conditions and Seasonality

The linkage analysis revealed the conditions to which the impaired water bodies were most likely to exceed water quality standards: storms and summer dry weather. During summer dry weather when Tapia WWRF is prohibited from discharging to the creek and base flows in the creek system and to the lagoon are fairly low, dilution of bacterial loads is minimal. Under these conditions, small and localized loading (e.g. onsite wastewater treatment systems) can result in exceedances of water quality standards. On the other hand the largest bacterial loads are delivered during winter storm events. The effect of storm runoff is to dramatically increase the in-stream instantaneous concentration and the 30-day geometric mean.

To establish the critical condition for the wet days, we used rain data from 1993. Based on data from the Regional Board's Santa Monica Bay TMDL, this represents the 90th percentile wet-weather year based on rain data from 1947 to 2000. Use of this year provides a conservative estimate of loading from runoff. For the critical year (1993) we identified 69 wet days and 296 dry days.[5] To further evaluate the critical conditions, we modeled a representative dry year. The model was calibrated using meteorological data from 1992 to 1995. Of these years, 1994 had the greatest number of dry-weather days (310). The dry-year scenario was based on 1994, which was the 50th percentile year in terms of dry-weather days for the period of 1947-2000.

Based on the linkage analysis of in-stream response to source loading, we have determined the bacterial concentrations are most likely to exceed the single sample standard of 400 org/100mL and the geometric mean standard of 200 org/100mL during storm events. In addition, the single sample standard is likely to be exceeded during the summer dry weather in a representative dry year. Therefore, this TMDL will be based on two critical periods to ensure compliance of water quality standards.

5.3 Application of the model to link loading to water quality

The model was used to examine the relationship between loading and the numeric targets. Seven critical compliance points were identified at major tributaries and the Malibu Creek mainstem (see Table 19). These compliance points (see Figure 2) were consistent with the listed reaches, modeling output points and/or available monitoring data. Although Triunfo Creek is not listed, a compliance point was identified to address the contributions of fecal coliform loading from the western section of the watershed.

Table 19 - Compliance Points and Major Load Contributions

Compliance Point	Description	Local Watershed Loads	Upstream Creek Loads
Lower Medea Creek	upstream of confluence with Malibou Lake	Storm water Residential Onsite Wastewater Treatment Systems	Upper Lindero Creek Lake Lindero Lake Lindero Creek Lower Lindero Creek Chesebro Creek Palo Comado Creek Upper Medea Creek
Triunfo Creek	upstream of confluence with Malibou Lake	Storm water Residential Onsite Wastewater Treatment Systems	Hidden Valley Creek Lake Sherwood Potrero Creek Westlake Lake
Lower Las Virgenes	upstream of confluence	Storm water	Upper Las Virgenes

[5] The 1993 calendar year is used solely in the modeling scenarios which will lead to the recommended load reductions percentages. For purposes of calculating the allowable days of exceedances, the storm year was used, which is consistent with the Santa Monica Bay Wet-Weather Bacteria TMDL. .

Creek	with Malibu Creek		Creek
Upper Malibu Creek	upstream of confluence with Las Virgenes Creek	Storm water Residential Onsite Wastewater Treatment Systems	Malibou Lake
Middle Malibu Creek	downstream Tapia discharge serial 001	Storm water Residential Onsite Wastewater Treatment Systems	Lower Las Virgenes Creek Stokes Creek
Lower Malibu	downstream of Cold Creek confluence	Storm water Residential Onsite Wastewater Treatment Systems	Cold Canyon
Malibu Lagoon	Cross Creek Road and below Pacific Coast Highway	Storm water Commercial Onsite Wastewater Treatment Systems Birds	Lower Malibu Creek

Baseline Conditions – Comparison with Allowable Exceedance Days

For each of the seven compliance points the relationship between loads and water quality was determined based on examination of the model output results. The daily fecal coliform counts for the critical wet year (1993) predicted by the model were evaluated against the single sample standard of 400 org/100mL.

The model results indicated a significant number of days of exceedance during the critical years (see Appendix 1). Most of the exceedance days are associated with rain days. Indeed, the model suggests that every storm of 0.1 inch or greater has the potential to cause exceedance of the single sample standard. The predicted number of wet-day exceedances far exceeds the 17 days dry weather allowance for wet days. In comparison, there were relatively few dry-day exceedances in the creeks. The dry-day exceedance predicted by the model vary by watershed but range from 3 to 12 days. The higher numbers were associated with the Triunfo Creek and Lower Las Virgenes Creek watersheds. In contrast to the creeks, the number of exceedances dry-days predicted for the lagoon (42 days) far exceeds the 3 day allowance for dry weather days.

Baseline Conditions –Comparison with the 30 day Running Geometric Mean Standard

The 30-day geometric mean fecal coliform counts for the critical wet-year (1993) generated by the model were evaluated against the geometric standard of 200 org/100mL. The model hindcast that the 30-day geometric mean was exceeded at each compliance point more than 100 days during 1993. According to the model output the geometric mean for the estuary was exceeded 365 days for 1993. As noted in Section 2, review of dry weather data for lagoon monitoring station R-11 indicates that the median concentration from 1998-2002 was above 200 MPN/100 ml suggesting that the 30 day-geometric mean will exceeded in dry weather as well. Based on the modeling scenarios, this maybe a result of the year round fecal coliform loading from birds or onsite wastewater treatment systems (see Appendix 2).

Load Reductions

The compliance points were used during the linkage analysis to assess the relationship between water quality and source load reduction. The goal of the assessment was to reduce source loads to achieve the fecal coliform water quality standards at each compliance point. (See Appendix 3 and 4 for linkage graphs).

Various load reduction scenarios were modeled. The initial scenario was designed to meet the allowable exceedance days during the critical wet year (1993) during storm events. However, exceedance of the single sample standards were still occurring according to model output during the dry period (April 1 to October 31) of the critical wet-weather year (1993). This pattern is apparently related to the temporal influence of major loading sources: storm water (during storms) and onsite wastewater treatment systems (low-flow conditions). Compliance was finally achieved with the single sample standard by reducing a combination of dry season and wet season loads. Further reductions were required to meet the numeric targets for the critical dry year (1994).

Additional reductions were required to achieve compliance with the 30-day geometric mean standard (200-org/100 mL). In order to achieve the geometric mean standard, further reductions were required from watersheds upstream of these affected compliance points. As a result, reductions were required in watersheds, which were not listed on the 303(d) list and but were upstream of listed reaches. In the case of Triunfo, reductions were required from Hidden Valley and Westlake subwatersheds, although these watersheds are not listed as impaired. The Medea Creek geometric mean compliance was achieved by further reducing loads in Chesebro, Palo Comado, Upper Lindero, and Lower Lindero until water quality in Medea Creek meet the 30-day geometric mean. The Malibu Lagoon estuary 30-day geometric mean could not be achieved, even after anthropogenic loads within the water body were reduced by 99%. The final overall load reductions for each compliance point is included in Table 20. A map delineating the subwatershed is provided in Figure 5.

Figure 5 - Subwatershed Delineation

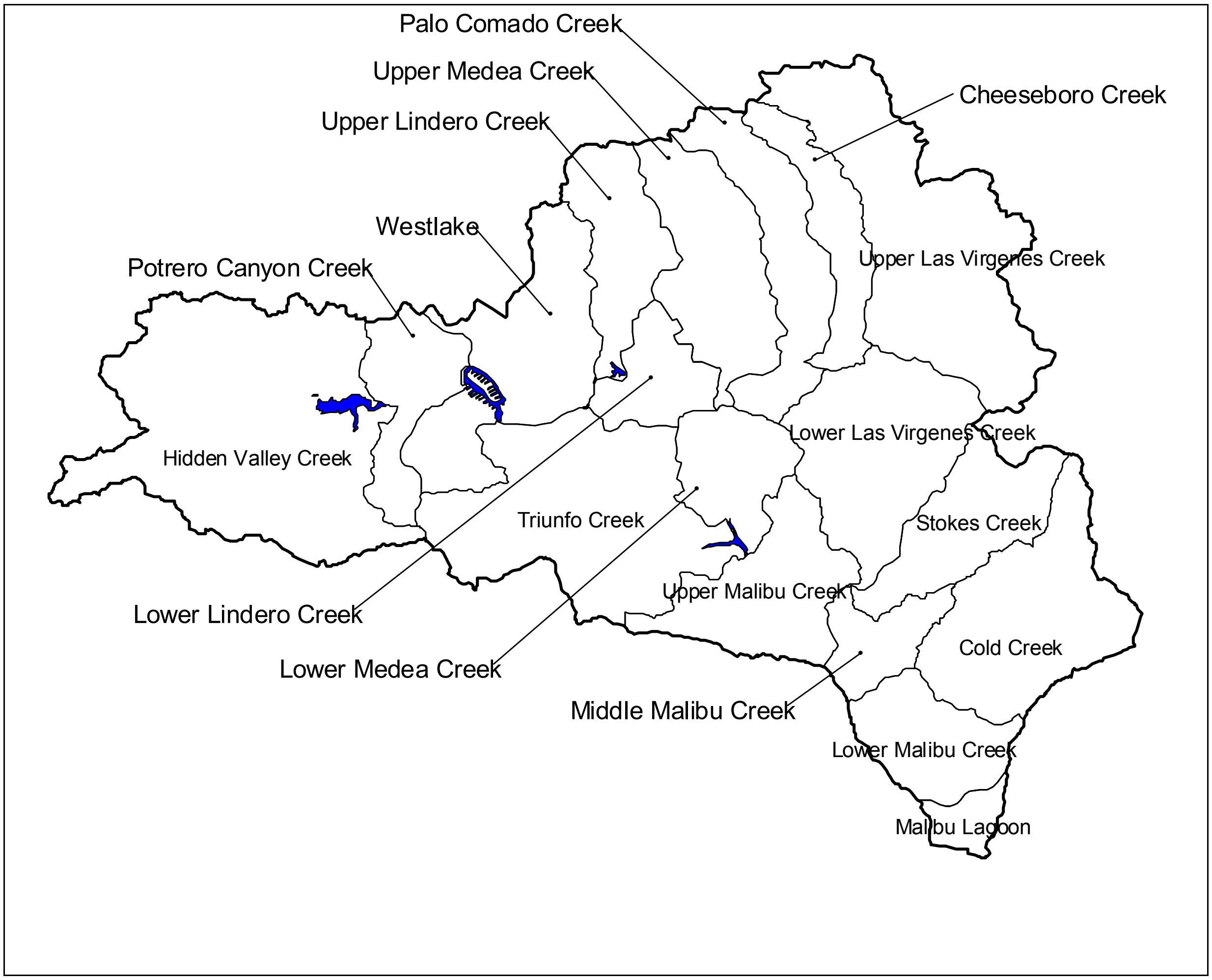


Table 20 - Subwatershed Estimated Source Reductions to Meet TMDL Allocation

Watershed	Estimated Load	Allocation	Estimated Percent Reduction
Triunfo	1.70×10^{14}	3.85×10^{13}	77
Hidden Valley	1.36×10^{14}	5.14×10^{13}	62
Potrero	3.22×10^{14}	2.07×10^{13}	94
Westlake	1.60×10^{15}	9.53×10^{13}	94
Lower Medea	6.47×10^{13}	4.93×10^{12}	92
Upper Medea	9.46×10^{14}	1.32×10^{13}	99
Chesebro	6.40×10^{13}	1.56×10^{12}	98
Palo Comado	2.85×10^{14}	4.86×10^{12}	98
Upper Lindero	4.66×10^{14}	6.99×10^{12}	99
Lower Lindero	5.10×10^{14}	6.97×10^{12}	99
Lower Las Virgenes	7.14×10^{14}	9.07×10^{13}	87
Upper Las Virgenes	2.34×10^{14}	4.74×10^{12}	98
Upper Malibu	1.36×10^{13}	1.14×10^{13}	16
Middle Malibu	2.24×10^{13}	6.14×10^{12}	73
Stokes Creek	6.17×10^{13}	1.25×10^{13}	80
Lower Malibu Creek	4.27×10^{12}	2.60×10^{12}	39
Cold	1.24×10^{14}	2.51×10^{13}	80
Malibu Lagoon (subwatershed)	1.36×10^{14}	9.32×10^{11}	99
Estuary	6.70×10^{14}	4.95×10^{14}	26
Total	$\mathbf{6.54 \times 10^{15}}$	$\mathbf{8.94 \times 10^{14}}$	**86**

The seven compliance points each receive load contributions from within its watershed, from upstream water bodies and/or a tributary. The lakes were not included in Table 20, because the lakes were not identified as a fecal coliform source during the source assessment (Section 4). The existing loads (or baseline) presented in Table 21 are the same loads presented in Table 20. The allocation is the load that meets the in-stream targets, and corresponds to attainment of the numeric targets. Included in the allocation load category are the natural sources of bacteria, such as wildlife. The percent reduction category is the load reduction required from the estimated existing baseline conditions to meet the instream numeric targets.

Prior to allocations of the bacteria loads, natural sources of bacteria must be subtracted from the gross loads. In this TMDL, natural sources of bacteria include birds, as well, as the following land uses: chaparral/sagebrush, grassland, and woodlands. The estimated anthropogenic loads primarily from runoff and onsite wastewater treatment systems available for allocations are presented by watershed in Table 21.

Table 21 - Estimated Watershed Anthropogenic Source Allocation

Watershed	Existing Loads	Natural Source Loads	Existing Anthropogenic Sources	Allocation Anthropogenic Sources	% Reduction Anthropogenic Sources
Triunfo	1.70×10^{14}	5.30×10^{12}	1.65×10^{14}	3.32×10^{13}	80
Hidden Valley	1.36×10^{14}	7.06×10^{12}	1.29×10^{14}	4.44×10^{13}	67
Potrero	3.22×10^{14}	1.84×10^{12}	3.20×10^{14}	1.89×10^{13}	94
Westlake	1.60×10^{15}	1.95×10^{12}	1.60×10^{15}	9.33×10^{13}	94
Lower Medea	6.47×10^{13}	1.51×10^{12}	6.32×10^{13}	3.42×10^{12}	94
Upper Medea	9.46×10^{14}	9.06×10^{11}	9.45×10^{14}	1.23×10^{13}	98
Chesebro	6.40×10^{13}	7.97×10^{11}	6.32×10^{13}	7.66×10^{11}	98
Palo Comado	2.85×10^{14}	1.07×10^{12}	2.84×10^{14}	3.08×10^{12}	98
Upper Lindero	4.66×10^{14}	7.24×10^{11}	4.65×10^{14}	6.72×10^{12}	98
Lower Lindero	5.10×10^{14}	4.90×10^{11}	5.10×10^{14}	6.48×10^{12}	98
Lower Las Virgenes	7.14×10^{14}	2.93×10^{12}	7.11×10^{14}	8.77×10^{13}	87
Upper Las Virgenes	2.34×10^{14}	2.84×10^{12}	2.31×10^{14}	1.90×10^{12}	99
Upper Malibu	1.36×10^{13}	3.45×10^{12}	9.45×10^{12}	7.95×10^{12}	16
Middle Malibu	2.24×10^{13}	1.34×10^{12}	2.11×10^{13}	4.78×10^{12}	77
Stokes	6.17×10^{13}	2.85×10^{12}	5.89×10^{13}	9.65×10^{12}	83
Lower Malibu	4.27×10^{12}	2.28×10^{12}	1.99×10^{12}	3.21×10^{11}	84
Cold	1.24×10^{14}	5.12×10^{12}	1.19×10^{14}	2.00×10^{13}	83
Malibu Lagoon	1.36×10^{14}	1.53×10^{11}	1.34×10^{14}	7.78×10^{11}	99
Estuary	6.70×10^{14}	4.95×10^{14}	1.75×10^{14}	4.07×10^{11}	100
Total	$\mathbf{6.54 \times 10^{15}}$	$\mathbf{5.38 \times 10^{14}}$	$\mathbf{6.00 \times 10^{14}}$	$\mathbf{3.56 \times 10^{14}}$	**94**

6. POLLUTANT ALLOCATIONS AND TMDLs

The Waste Load Allocations and Load Allocations for this TMDL are the same as for the Santa Monica Bay Beaches Bacteria TMDL (See Table 22).

Table 22 - Waste Load and Load Allocations for the Malibu Creek Watershed Bacteria TMDL*

Summer (April 1 to October 31) Dry-Weather Days	Zero (0) exceedance days based on the Single Sample Bacteria Water Quality Objectives Zero (0) exceedance days based on the Rolling 30-Day Geometric Mean Bacteria Water Quality Objectives
Winter (November 1-March 31) Dry-Weather Days	Three (3) exceedance days based on the Single Sample Bacteria Water Quality Objectives Zero (0) exceedance days based on the Rolling 30-Day Geometric Mean Bacteria Water Quality Objectives
Wet-Weather Days (days with 0.1 inch of rain or greater and three days following the rain event)	17 exceedance days based on the Single Sample Bacteria Water Quality Objectives Zero (0) exceedance days based on the Rolling 30-Day Geometric Mean Bacteria Water Quality Objectives

*The allowable exceedance days are based on daily sampling. If weekly sampling is performed, the allowable exceedance days are scaled accordingly.

Responsible jurisdictions, responsible agencies, and responsible entities may employ any reduction strategy they choose to meet these allocations. However, a sample strategy, based on model output is depicted in Table 23. This table is for information purposes only. However, it appears that any successful strategy must achieve major reductions in loading from runoff from urban and suburban areas in the upper watershed and in Malibu, and commercial and multi-family onsite wastewater treatment systems in the Malibu Lagoon subwatershed and estuary. The following subsections describe staff's analysis of suggested loading reductions.

Table 23 - Example Watershed Reduction Strategy by Source Category

Source	Estimated Existing Loading	% of Total Existing	TMDL Allocation	%Reduction
Tapia Discharge	5.92×10^{10}	0.00%	5.92×10^{10}	0%
Effluent Irrigation	1.16×10^{10}	0.00%	1.16×10^{10}	0%
Commercial/ Industrial Stormwater Runoff	2.55×10^{15}	39.03%	7.65×10^{13}	97%
High/Med. Density Res. Stormwater Runoff	2.71×10^{15}	41.33%	8.13×10^{13}	97%
Low Density Residential Stormwater Runoff	3.44×10^{14}	5.27%	6.88×10^{13}	80%
Rural Residential Stormwater Runoff	9.75×10^{13}	1.49%	4.88×10^{13}	50%
Agriculture/ Livestock	3.21×10^{13}	0.49%	1.65×10^{13}	50%
Onsite wastewater treatment Systems	2.47×10^{14}	3.78%	3.71×10^{13}	85%
Dry Weather Urban Runoff	5.21×10^{12}	0.00%	2.84×10^{9}	99%*
Lagoon Drains	1.75×10^{10}	0.00%	1.75×10^{8}	99%
Tidal Inflow	2.44×10^{13}	0.37%	1.83×10^{13}	25%
Total	$\mathbf{6.00 \times 10^{15}}$		$\mathbf{3.47 \times 10^{14}}$	

* It is assumed that measures used to control urban stormwater runoff also will effectively control urban dry-weather runoff. Suggested source load reductions by subwatershed are included in Appendix 5.

6.1 Estimated Load Reductions for Point Sources

Tapia Water Reclamation Facility and Effluent Irrigation

The Tapia WRP effectively disinfects the tertiary treated wastewater, which is either discharged to Malibu Creek or reclaimed and used for irrigation. The fecal loading is small and is not likely to increase fecal coliform concentrations. Indeed the effluent from Tapia actually provides additional dilutive capacity to the creek system. Therefore, no load reduction is warranted for this source.

Stormwater Water Discharges

Most of fecal coliform loads are discharged during storm events. Runoff from developed areas is the major source of contamination, increasing the coliform concentrations in streams by several order of magnitude (Tetra Tech, 2001). The water quality model was run repeatedly with different combinations of load scenarios in order to establish the load reductions that would be needed to meet the TMDL targets. The model analyses demonstrated that coliform loads from storm runoff would have to be reduced by more than 90 percent to meet the geometric mean criterion of 200 MPN/100 mL. These load reductions would also meet the single sample criterion of 400 MPN/100 mL.

6.2 Overview of Estimated Load Reductions for Nonpoint Sources

Septic Systems (Onsite Wastewater Treatment Systems)

Properly sited and functioning onsite wastewater treatment systems are expected to meet the load allocations without further modification. The waste being discharged from the onsite systems is being required to meet the REC-1 water quality standard of 200 CFU per 100 ml. It is anticipated that in the leach field the fecal coliform concentrations will be further reduced by more than 99%; this can be confirmed by groundwater monitoring. It has been estimated that these actions will decrease the annual loading to the watershed from 2.47×10^{14} counts per year to 1.04×10^{13} counts per year.

There is a potential for significant loading impacts from the commercial and multi-family onsite wastewater systems in the Malibu Lagoon subwatershed, and these should be a high priority. In addition, residential onsite wastewater systems upstream of the Malibu Creek Watershed have been given a load allocation..

Dry Weather Urban Runoff, Lagoon Drains and Tidal Inflow

These pollutant sources appear to contribute a relatively small percentage of the annual fecal coliform load when compared to onsite wastewater systems and stormwater. However, because creek flows are lower during dry weather discharges assimilative capacity is also low. Reduction was necessary for the loads to ensure that fecal coliform criteria are not exceeded during the low flow periods in the streams and estuary.

Natural Sources

No load reduction was given to birds since they are a natural part of the system. At the present time, we believe that the allocations described above are sufficient to meet the objectives. However, it may prove that the birds in Malibu Lagoon are sufficient alone to cause an exceedance. If this proves to be the case, the Regional Board staff will recommend that the Regional Board consider re-evaluating the TMDL, or to incorporate a natural source exclusion.

6.3 Margin of Safety

The Margin of Safety was derived from the use of several conservative assumptions during model analysis. These include:

- The watershed loading was based on the 90th percentile year for rain (1993) based on the number of wet weather days. This should provide conservatively high runoff from different land uses for sources of storm water loads

- The watershed loading was also based on a very dry rain year (1994). This ensures compliance with the numeric target during low flows when onsite wastewater treatment systems and dry urban runoff loads are the major bacterial sources.

.

- The TMDL was based on meeting the fecal 30-day geometric mean target of 200 MPN/ 100 ml, which for these watersheds was estimated to be more stringent level than the allowable exceedance of the single sample standard. This approach also provides assurance that the E. coli single sample standard will not be exceeded.

- The load reductions established in this TMDL were based on reduction required during the two different critical year conditions. A wet year when storm loads are high and a more typical dry year when base flows and assimilative capacity is low. This adds a margin of safety for more typical years.

6.4 Summary of pollutant reductions

The percent reduction is calculated based on estimated existing loads as determined by the model output and is provided for informational purposes only. Although localized load reductions may vary based on subwatershed, these allocations provide a watershed-wide summary of the expected load reduction needs by source type. The loads presented herein were derived from the 4-year average (1992-1995) of the simulation period, for all loads entering the Malibu Creek Watershed system. Future monitoring and assessment may result in refining these estimates.

7. IMPLEMENTATION PLAN

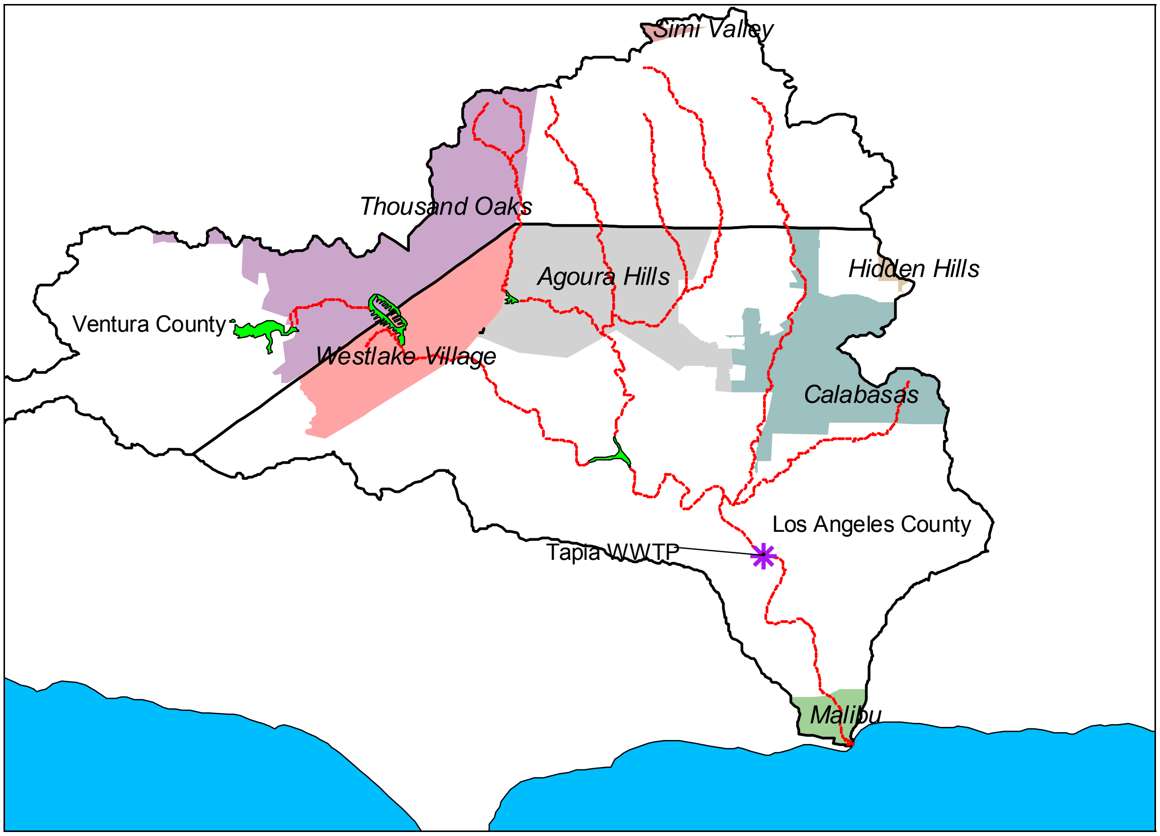
The objective of this section is to develop an implementation plan that will demonstrate a manner to which the waste load and load allocations developed for the Malibu Creek Coliform TMDL can be met. Where possible Regional Board staff considered implementation measure that have been proposed or discussed in publicly available stakeholder developed watershed management plans or Regional Board policies.

The Porter Cologne Water Quality Control Act prohibits the Regional Board from prescribing the method of achieving compliance with water quality standards, and likewise TMDLs. Below staff have identified some potential implementation strategies; however, there is no requirement to follow the particular strategies proposed herein as long as the maximum allowable exceedance days for each time period are not exceeded.

7.1 Responsible Jurisdictions, Agencies and Entities

The cities of Calabasas, Malibu, Westlake Village, Agoura Hills, Hidden Hills, Simi Valley, Thousand Oaks, the Counties of Los Angeles and Ventura, California Department of Parks and Recreation, National Park Service, and Santa Monica Mountains Conservancy, and Caltrans are jointly responsible for meeting the TMDL requirements for urban runoff in the for the Malibu Creek Watershed. Onsite, commercial and multi-family facilities served by on-site wastewater treatment systems are subject to Waste Discharge Requirements are individually responsible for their discharges and are responsible entities. To the extent that single-family on-site wastewater treatment systems continue to be regulated by local agencies, the local agency will be the responsible agency. Should the regulation of single family residential on-site wastewater treatment systems revert to the Regional Board, the owners of those systems will become the responsible entity (see following subsection on single-family systems). The cities and the counties may jointly decide how to achieve the necessary reductions in exceedance days at each compliance point by employing one or more of the implementation strategies discussed below or any other viable strategy. Since, the majority of the Malibu Creek Watershed is located in an unincorporated area of the County of Los Angeles, the County of Los Angeles is the primary jurisdiction. Staff expects that the additional monitoring and source characterization outlined in the monitoring plan in Section 8 will assist municipalities in focusing their implementation efforts on key land uses, critical sources and storm periods.

Figure 6 - Jurisdictions within the Malibu Creek Watershed



7.2 Implementing Strategies for Achieving Allocations

Municipal Stormwater Permits

As required by the federal Clean Water Act, discharges of pollutants to the Malibu Creek Watershed from municipal storm water conveyances are prohibited, unless the discharges are in compliance with a NPDES permit. The Los Angeles County Municipal NPDES Storm Water Permit (Board Order No. 01-182; NPDES No. CAS004001) and the Ventura County Municipal Storm Water Permit (Board Order No. 00-108; NPDES No. CAS004002) will be key implementation tools for this TMDL. Future storm water permits will be modified in order to address implementation and monitoring of this TMDL and to be consistent with the waste load allocations of this TMDL.

A requirement of the Los Angeles County Municipal Storm Water Permit is that a Watershed Management Area Plan (WMAP) must be developed that include actions that address water quality problems and concerns that are unique to the six watershed areas of Los Angeles County. The WMAP for the Malibu Creek Watershed was developed in 2001. A brief description of some proposed implementation measures applicable to this TMDL are cited from the WMAP are presented below:

Permeable Urban Landscapes

Using the soils data on GIS, the Council of Governments will identify opportunities to increase permeability on new urban landscapes, parking lots and street parking lanes. Cities and the County will take the responsibility of implementing the identified opportunities. Technologies have been developed to safely allow storm water infiltration in parking lots and along street corridors, *which provide functions of flow attenuation and water quality improvement. Extensive opportunities exist to install such features in new developments, and to retrofit existing development when upgrading is appropriate.*

Storm Drains

Over-irrigated landscape areas that discharge to the street and enter storm drains during dry weather will be identified and minimized. Surveys could be carried out during routine clearing of catch-pits for water quality maintenance. Where there is a practicable alternative (for example using porous, pollution-filtering drainage galleries to encourage infiltration) discharges from the storm water system to streams will be blocked. To enable this, the outfall's catchments may have to be fitted with discharge control devices as well as replacing pipes with porous drainage galleries.

The strategies described in the Malibu Creek WMAP may be used to meet the Waste Load Allocation for the MS4 permit. However, it is most likely that such strategies would need to be expanded to include both new and existing commercial and high-density residential developments. Retrofitting of existing facilities may best be achieved by providing some combination of financial incentive and local ordinances.

Alternatively, the MS4 co-permittees could pursue a centralized strategy of diverting and treating dry-weather and wet-weather urban runoff from storm drains. The County of Los Angeles and the City of Los Angeles are presently pursuing diversion and treatment strategies in urbanized watersheds of the Santa Monica Bay. However, as stated in the Basin Plan, as amended, it is not the intent of the Regional Board to require treatment or diversion of natural water bodies or to require treatment of natural sources of bacteria from undeveloped areas. Therefore, strategies involving diversion and treatment should be limited to the higher-density developed areas of the Malibu Creek Watershed.

Distributed on-site retention and treatment strategies, such as those described in the Malibu Creek WMAP, offer several advantages to centralized diversion and treatment. These advantages include providing incentives to the individual property owners to reduce dry-weather runoff from irrigation overspray and to encourage architectural designs to maximize non-permeable surfaces. On-site retention systems also reduce wet-weather flows, and the potential for downstream flooding. A distributed onsite structural control strategy is based on the premise that specific land uses, critical sources, or specific periods of a storm event can be targeted to achieve the TMDL waste load allocations. For the Malibu Creek Watershed the target land uses identified are commercial/industrial and high density residential.

Structural controls may include placement of storm water treatment devices specifically designed to reduce bacteria densities or storage and infiltration facilities at critical upstream points in the storm water conveyance system. A treatment system may be further targeted to a specific storm period such as the first 0.5-inch or 1 inch if the bacteria wash-off pattern mimics a 'first-flush' effect. The results from effluent sampling indicate removal rates of 97 percent for fecal coliform bacteria (90 percent for dissolved nitrogen and 90 percent phosphorus). A description of a potential control strategy taken from USEPA Factsheet (USEPA, 1999) on modular treatment system is provided below:

A modular treatment system consists of a series of sedimentation chambers and small constructed wetlands. The wetlands are contained within a modular tank. A storm water treatment system currently on the market can be applied in residential areas, as well as, industrial/commercial developments. A diagram of the such a system in located in Appendix 6. Also, a USEPA fact sheet is located in Appendix 6. The systems are suitable for the diverse settings that exist in the Malibu Creek Watershed: coastal and inland areas. These systems are protective of groundwater by removing pollutants prior to infiltration. Soil types and high water tables surrounding the modular unit will not limit the effectiveness of the system.

Influent is conveyed from a catch basin through piping to sedimentation chambers and subsequently to the soil wetlands portion of the treatment system. The system has a static holding volume of 5,270 liters (1,390 gallons). The basis for the system sizing is the static holding volume *plus associated detention structures. Generally, 1-2 units are required for each acre of impervious surface. The first flush volume is stored in the preliminary storage structures (tanks or underground pipes). The system captures and treats the first half-inch of all the smaller (routine) storms and treats the first flush of the large (less common) storms. A 0.5-inch storm requires 1 tank per acres, and a 1-inch storm requires 2 tanks per acres.*

Dry -Weather Urban Runoff Reduction

In order to achieve the reductions required to meet the load allocation for dry weather urban runoff, a runoff reductions program must be implemented. The Malibu Creek Watershed Urban Runoff Reduction Project is a runoff reduction program developed by the Las Virgenes Municipal Water District and cities of Westlake Village, Calabasas, and Agoura Hills. This program will identify sources of commercial and residential urban runoff by a combination of curbside observations and computer analysis of water use (LVMWD, 2003). The sources of dry weather runoff identified will be offered technical assistance by the LVMWD staff to reduce runoff. An example of a mitigation measure offered LVMWD staff is tuning of irrigation systems to address inefficient irrigation practices. Water use and runoff will be monitored to measure the effectiveness of the program at reducing urban runoff (LVMWD, 2003). Although elimination of dry-weather urban runoff is the preferred strategy, it is likely that measures employed to control wet-weather urban runoff, also will control dry-weather urban runoff.

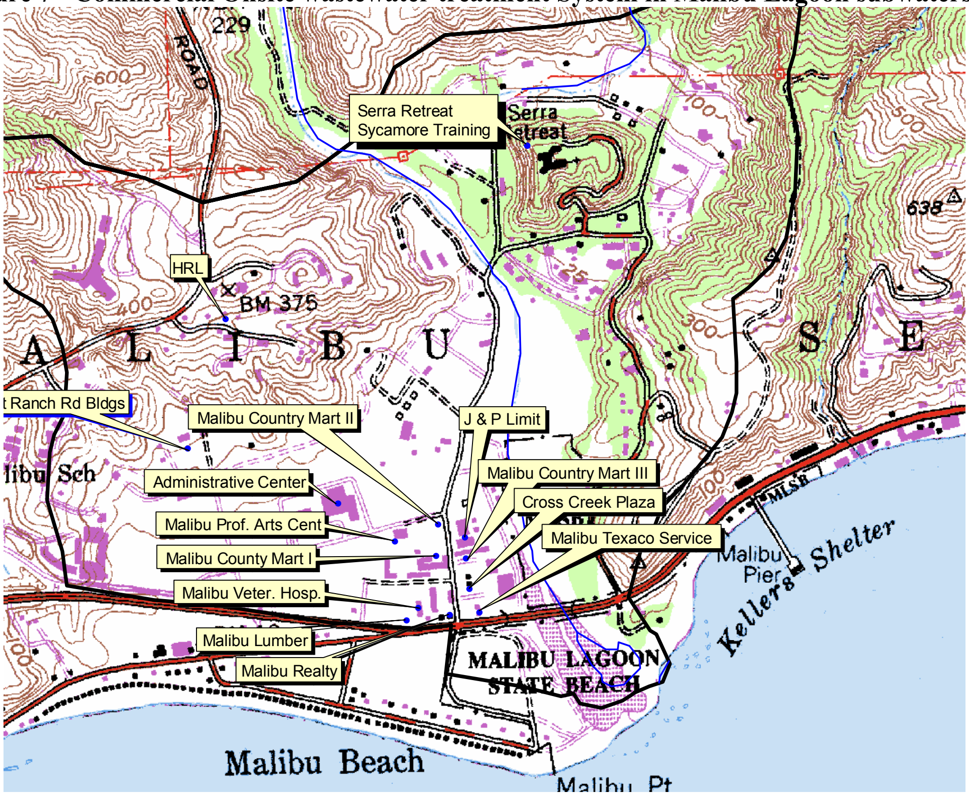
Onsite Wastewater Treatment Systems

On-site treatment systems were identified as a potential major anthropogenic source of dry-weather exceedances of the single sample and 30 day geometric limits. These systems are located within the City of Malibu and the unincorporated rural residential areas. Based on staff's analyses, commercial and multi-family systems represent the highest bacteria loading and are of highest priority. However, private residential systems may also cause exceedances of bacteria standards, especially when systems are not properly sited, designed, or operated. These situations are more likely to result in bacterial contamination of surface waters when inadequate systems, are located in areas of high groundwater tables and in close proximity to the creek or lagoon.

Commercial and Multi-Family Systems

Commercial and multi-family systems are regulated by the Regional Board (Order No. 01-031). These systems are confined to the City of Malibu, and within the Malibu Creek Watershed, are located in the Civic Center area. The commercial/multi-family systems targeted for reduction are located in the Malibu Civic Center area (see Figure 6). Some of these onsite wastewater treatment systems may be located adjacent to the lagoon, in a groundwater table with historic levels that do not allow as least 10 feet between the groundwater and the wastewater distribution system. The specific vertical separation of these systems to groundwater has not yet been determined. Commercial multi-family onsite wastewater treatment systems located within the aforementioned commercial centers were the focus of Los Angeles Regional Board Resolution 98-023. This resolution provided direction to the Executive Officer to require the submittal of Reports of Waste Discharge for all discharges from multi-family and commercial onsite wastewater treatment systems located in the Malibu Creek Watershed.

Figure 7 - Commercial Onsite wastewater treatment System in Malibu Lagoon subwatershed



Waste Discharge Requirements

WDRs will be the mechanism for implementation of the onsite wastewater treatment system Load Allocations (LAs) derived from this TMDL for commercial and multifamily occupancies. The LAs developed for this TMDL will be established as WDR permit limits for the individual onsite wastewater treatment systems. The WDRs have specific prohibitions on onsite wastewater treatment systems within 10 feet of the highest historical groundwater levels.

The *Onsite Wastewater Treatment Systems Manual* (USEPA, 2002) has been released since the General WDR requirements were released in early 2001. This manual states: "Normal operation of septic tank/infiltration systems results in retention and die-off of most, if not all, observed pathogenic bacterial indicators with 2 to 3 feet (60 to 90 centimeters) of the infiltrative surface (USEPA, 2002; page 3-33)." However, the USEPA Manual may not have considered commercial and multi-family systems with higher flow rates that have a greater potential of saturating underlying soils. Also, the study must presume 2 to 3 feet of suitable soil types for infiltration and treatment. Systems overlying fractured bedrock, which occurs within the Malibu Creek watershed, may contaminate groundwater even with 10 feet or more of separation. In short, site specific variables must be taken into account to positively identify systems that are contributing to groundwater or surface water contamination.

Within the Malibu Creek Watershed, the recently renewed WDRs require disinfection for commercial and multifamily occupancies. Three types disinfection technology are available to commercial and multifamily WTS: chlorination, ozonation, and ultraviolet (UV) disinfection. The USEPA onsite manual (USEPA, 2002, page 3-33) also lists the typical pathogen survival time as less than 70 days. Therefore, systems located with greater than a specific residence time (using an appropriate safety factor) in groundwater away from surface waters, should not require disinfection. Although each technology is capable of achieving the reductions required by this TMDL, chlorination is more cost effective, and thus more widely used (USEPA, 1999). The owners of the on-site commercial and multi-family systems are individually responsible for complying the WDRs, which will be written to comply with the load allocations for this TMDL.

Centralized Waste Water Treatment Facility

The City of Malibu has developed a conceptual plan to centralize wastewater treatment, disposal, and reuse in the Civic Center area (City of Malibu, 2003). The plan proposes connecting existing and proposed commercial properties of the Civic Center to wastewater reclamation facility (Questa, 2003). Wastewater will be treated to tertiary standards for wastewater reclamation. The facility will include disinfection and nitrogen removal. The system would provide redistribution of the reclaimed wastewater back to the commercial properties where it was generated, for use as non-potable water and irrigation. Questa Engineering Corporation provided a preliminary assessment of the feasibility of installing a community wastewater reclamation facility.

Single-Family Systems

The Regional Board issued waivers for residential systems in the early 1950's as resolutions Nos. 52-4 and 53-6. The resolutions waived reporting and permitting requirements to the Regional Board for wastewater treatment systems from single-family dwellings. The waivers allowed local agencies to approve and permit this specific group of wastewater treatment systems in accordance with local ordinances. These waivers are conditional and maybe terminated at any time by the Regional Board. Recent legislation amending sections 13269 of the CWC (senate Bill 390) requires that the Regional Board review its wastewater treatment system waivers and either renew or terminate them by June 30, 2004. In addition the legislature adopted Assembly Bill 885 in September 2000, which amended sections 13290 and 13291 of the CWC. The newly amended sections require that the State Board adopt statewide regulations or standards for permitting and operation of wastewater treatment systems by January 1, 2004. Key requirements of Section 13290 and 13291 are presented below:

- minimum operating requirements that may include siting, construction, and performance requirements
- requirements for systems adjacent to impaired waters identified pursuant to subdivision (d) of section 303 of the Clean Water Act (33 U.S.C. Sec 1313(d));
- requirements authorizing a qualified local agency to implement systems/standards/regulations within its jurisdiction, if the local agency request such authorizations;
- requirements for corrective actions when systems fail to meet requirements or standards;
- minimum requirements for monitoring to determine system performance, if applicable;
- exemption criteria to be established by regional boards; and,
- requirements for determining systems are subject to a major repair.

Pursuant to SB 390, the Board must make a finding that the waiver for residential systems does not harm water quality or public health. In order to make such a finding, staff presently are negotiating Memoranda of Understanding (MOUs) with local agencies to ensure adequate regulation of on-site systems. At a minimum, it was thought that the MOU would incorporate the AB 885 regulations. However, it now appears that the AB 885 regulations may not be finalized in time to meet the SB390 deadline. Furthermore, regardless of the status of AB 885 regulations, the Board may consider whether the MOU will ensure compliance with the TMDLs, when granting a waiver. Without an MOU, the Board may not be able to make the requisite findings to continue the waiver. In which case, the regulation of single family systems would revert to the Regional Board.

Regulation of the single family onsite systems will be regulated by local agencies subject to an MOU or in lieu of an MOU, by the Regional Board directly, via a Waste Discharge Requirement. Owners of single family systems subject to Waste Discharge Requirements will become responsible entities under this TMDL. WDRs will be written to comply with the load allocations specified in this TMDL.

Regardless of the oversight mechanism, the requirements for on-site systems should include a demonstration that the systems are meeting the load allocations under the TMDL. Such a demonstration may include a site assessment evaluating depth to groundwater during times when the groundwater table is high, presence of fractured bedrock, and proximity to surface water bodies and/or groundwater monitoring. Absent such a demonstration, or upon finding that the systems are not meeting the TMDL allocations, system upgrades may be required. These may include disinfection or alternative onsite systems. Operation of disinfection systems may be problematic for individual homeowners, who may not have the time or the knowledge to ensure proper operation. In some cases, where systems will require more active maintenance and operation, an operating permit program, such as adopted by the City of Malibu in Ordinance 242, or a benefit assessment district may be required.

Technologies, and design criteria, are currently available for single family residential systems, which could provide the necessary level of bacterial reduction required to meet load allocations. For example, systems that have disposal fields, which do not meet the minimum vertical, and/or horizontal setback requirements from surface/groundwater, may need to incorporate advanced treatment with disinfection, alternative soil absorption fields. For example, a sewage treatment mound is a potential alternative for problem locations. A mound is disposal fields elevated by sand fill to provide adequate separation between the disposal field and saturated soil conditions. Elevation of the disposal field eliminates the "short circuiting" of effluent with groundwater, and allows for bacterial degradation within the mound disposal field. Mounds treatment systems are a standard technology for single-family residences (Solomon et al., 1998). However, mounds have specific land area requirements and may not be appropriate on many existing parcels in Malibu. A mound system is a specific example of an intermittent sand/media filter (USEPA, 2002). Other types of intermittent sand/media filters can provide similar attenuation of pathogenic bacteria (USEPA, 2002).

Lagoon Drains

The City of Malibu is in the process of installing an advanced disinfection system to collect storm water "first flush" and dry weather urban runoff from the three drains (Civic Center, Malibu Colony, and Cross Creek Road) which discharge into Malibu Lagoon estuary. The system is known as the Malibu Storm Drain Treatment Facility. Preliminary testing of the effluent from the system has demonstrated the ability to meet or the REC-1 standards for bacteria indicators.

Tidal Inflow

The sources of fecal bacteria in the surfzone were not assessed during this TMDL. Potential sources of tidal inflow loads maybe foreshore washing of bird feces, subsurface exchange of contaminated lagoon or groundwater, and ebb flow from the lagoon (Grant, 2002). It is anticipated that the upstream implementation measures (e.g., OSWTS and urban runoff) as well as implementation of the Santa Monica Bay TMDL will contribute to the reduction of surfzone fecal bacteria load.

7.3 Implementation Cost Estimates

Stormwater Structural Control Strategy

This cost estimate is based on the modular treatment system described in Section 7.2. Modular treatment systems are prefabricated. The cost for one unit is $4,900 and the installation cost is approximately $1,400. The estimated total cost for purchase and installation is $6,300. Per tank cost decrease as the number of units per site increase. The estimated maintenance cost for one tank is $80 to $120 every three to five years. The impervious area requiring treatment in the Malibu Creek Watershed is approximately 5,440 acres of commercial and residential landuse (Tetra Tech, 2002). Assuming a lot size of 1-acre per discharger, the preliminary cost estimate based on 5,440 units to treat 5,440 acres of impervious surface from the watershed is approximately $34,272,000. The cost were based on the StormTreat Systems Sizing Worksheet.xls located in Appendix 6.

Commercial and Multi-family Onsite Wastewater Treatment Systems

Disinfection systems will likely be required for many commercial and multi-family systems. The cost of disinfection systems is dependent on the manufacturer, the site, the capacity of the plant, and the characteristics of the wastewater to be disinfected. In addition, the annual operation and maintenance costs for disinfection include power consumption, chemicals and supplies, miscellaneous equipment repairs, and personnel costs. The approximate capital cost of systems recently permitted within the Santa Monica Bay watershed are presented in Table 24.

Table 24 - Cost of Recently Permitted Systems

Discharger	Volume	Treatment	Cost
Malibu RV Park	18,000 gpd	FAST (biological)	0.5 million
Malibu Bay Club	59,000 gpd	Zenon (membrane)	1.4 million
Trancas WWTP	288,000 gpd	Secondary (biological) BMR	1.6 million
POTW (other area)	1.5 MGD	tertiary, with UV	4.5 million

Note: With the exception of the Malibu RV Park, the systems in Table 24 are designed to treat nutrients as well.

The conceptual plan estimates for the cost of collection, treatment, and redistribution for the core commercial facilities in the Civic Center area (see Figure 6) is approximately 12 million dollars. The estimated annual operation and maintenance cost are approximately $700,000. (Questa, 2003).

Upgrade of Residential Onsite Wastewater Treatment Systems

Single family onsite wastewater treatment systems that do not meet the requisite vertical or horizontal separation distance from groundwater and/or surface water may be upgraded to a mound type system. Design and installation of a mound system in rural parts of the country is approximately $10,000 (Solomon et al, 1998). On a national basis, the annual operation cost is approximately $150 – 200 (USEPA, 2002) An estimate of 440 failing systems was used for this TMDL (Tetra Tech, 2002). Assuming all failing system installed the mound system, and an average cost of $10, 000 per mound system, the total capital cost for the entire watershed is approximately $4,400,200.

Dry Weather Urban Runoff Reduction

The Malibu Creek Dry Urban Runoff Reduction Project is partly funded by the Proposition 13 Nonpoint Source Pollution Grant Program. The total cost to fund the program through May 2005 is $304,428 (LVMWD, 2003)

Lagoon Drains

Construction cost of the Civic Center Drain Treatment Facility is estimated at $850,000, with annual operating and maintenance cost estimated at $31,000 (City of Malibu, 2002). The cost for the three drains discharging to Malibu Lagoon is $2,500,000.

7.4 Implementation Schedule

The proposed implementation schedule shall consist of a phased approach as discussed below and outlined in Table 25. This TMDL provides an implementation schedule allowing the responsible jurisdictions and responsible agencies time to gather additional monitoring data to validate the model and to better quantify the loading from birds in the Lagoon. The Regional Board may reconsider the TMDL in three years from the effective date to consider the impact of birds in the Lagoon and to revise the allowable days of exceedance based on additional studies. At that time, the Regional Board may revise the TMDL to allow for the Natural Source Exclusion, as provided for in the Basin Plan. The Natural Source Exclusion can only be applied after all anthropogenic sources of bacteria have been controlled. The schedule would allow six years from the effective date to meet both summer and winter dry-weather load and waste load allocations. This is a longer schedule than generally provided for in the Santa Monica Bay TMDL for summer dry weather. However, it is warranted due to the disperse nature of the sources and the foreseeable implementation measures. In Santa Monica Bay, the City of Los Angeles and the County of Los Angeles already had started construction of the implementation measure, which is dry-weather diversion of major storm drains. Therefore a three year schedule for summer dry weather was feasible.

To be consistent with the SMB Beaches TMDLs, the Regional Board intends to revise this TMDL, in conjunction with the revision of the SMB Beaches TMDLs. The SMB Beaches TMDLs are scheduled to be revised in four years: to re-evaluate the allowable winter dry-weather and wet-weather exceedance days based on additional data on bacterial indicator densities in the wave wash; to re-evaluate the reference system selected to set allowable exceedance levels; and to re-evaluate the reference year used in the calculation of allowable exceedance days. This TMDL is scheduled to be re-considered in three years from the effective date which will approximately coincide with the Santa Monica Bay TMDL revision.
Until the TMDL is revised, the allowable number of winter dry-weather and wet-weather exceedance days will remain as presented in Table 22. Revising the TMDL will not create a conflict in the interim, since the TMDL does not require compliance during winter dry-weather or wet-weather until six and ten years, respectively, from the effective date of the TMDL. Therefore, the allowable exceedance days for winter dry-weather and wet-weather will be revised as necessary before the compliance deadlines.

Table 25 - Summary of Implementation Schedule

120 days after the effective date of this TMDL	Responsible jurisdictions and responsible agencies must submit a comprehensive bacteria water quality monitoring plan for the Malibu Creek Watershed to the Executive Officer of the Regional Board. The plan must be approved by the Executive Officer before the monitoring data can be considered during the implementation of the TMDL. The Executive Officer will consider cost in relation to the need for data. Monitoring cost will be considered with the benefits of protecting human health for persons swimming and wading in Malibu Creek and its tributaries, and for swimmers and surfers using downstream beaches that are impacted by the creek and lagoon. The purpose of the plan is to better characterize existing water quality as compared to water quality at the reference watershed,- and ultimately, to serve as a compliance monitoring plan. The plan must provide for analyses of all applicable bacteria indicators for which the Basin Plan has established objectives including E. coli. For fresh water and enterococcus for marine water. The plan must also include sampling locations that arespecified in Table 7-10.2, at least one location in each subwatershed, and areas where frequent REC-1 use is known to occur. However, this is not to imply that a mixing zone has been applied; water quality objectives apply throughout the watershed—not just at the sampling locations.
1 year after effective date of this TMDL	1. Responsible jurisdictions and responsible agencies shall provide a written report to the Regional Board outlining how each intends to cooperatively achieve compliance with the TMDL. The report shall include implementation methods, an implementation schedule, and proposed milestones. Specifically, the plan must include a comprehensive description of all steps to be taken to meet the 3-year summer dry weather compliance schedule, including but not limited to a detailed timeline for all category of bacteria sources under their jurisdictions including but not limited to nuisance flows, urban stormwater, on-site wastewater treatment systems, runoff from homeless encampments, horse facilities, and agricultural runoff. 2. If the responsible jurisdiction or agency is requesting an extension of the summer dry-weather compliance schedule, the plan must include a description of all local ordinances necessary to implement the detailed workplan and assurances that such ordinances have been adopted before the request for an extension is granted. 3. Local agencies regulating on-site wastewater treatment systems shall provide a written report to the Regional Board's Executive Officer detailing the rationale and criteria used to identify high-risk areas where on-site systems have a potential to impact surface waters in the Malibu Creek watershed. Local agencies may use the approaches outlined below in (a) and (b), or an alternative approach as approved by the Executive Officer.

(a) Responsible agencies may screen for high-risk areas by establishing a monitoring program to determine if discharges from OWTS have impacted or are impacting water quality in Malibu Creek and/or its tributaries. A surface water monitoring program demonstration must include monitoring locations upstream and downstream of the discharge, as well as a location at mid-stream (or at the approximate point of discharge to the surface water) of single or clustered OWTS. Surface water sampling frequency will be weekly for bacteria indicators and monthly for nutrients. A successful demonstration will show no statistically significant increase in bacteria levels in the downstream sampling location(s).

(b) Responsible agencies may define the boundaries of high-risk or contributing areas or identify individual OWTS that are contributing to bacteria water quality impairments through groundwater monitoring or through hydrogeologic modeling as described below:

(1) Groundwater monitoring must include monitoring in a well no greater than 50-feet hydraulically downgradient from the furthermost extent of the disposal area, or property line of the discharger, whichever is less. At a minimum, sampling frequency for groundwater monitoring will be quarterly. The number, location and construction details of all monitoring wells are subject to approval of the Executive Officer.

(2) Responsible agencies may use a risk assessment approach, which uses hydrogeologic modeling to define the boundaries of the high-risk and contributing areas. A workplan for the risk assessment study must be approved by the Executive Officer of the Regional Board.

4. OWTS located in high-risk areas are subject to system upgrades as necessary to demonstrate compliance with applicable effluent limits and/or receiving water objectives~~4.~~

5. If a responsible jurisdiction or agency is requesting an extension to the wet-weather compliance schedule, the plan must include a description of the integrated water resources (IRP) approach to be implemented, identification of potential markets for water re-use, an estimate of the percentage of collected stormwater that can be re-used, identification of new local ordinances that will be required, a description of new infrastructure required, a list of potential adverse environmental impacts that may result from the IRP, and a workplan and schedule with significant milestones identified. Compliance with the wet-weather allocations shall be as soon as possible but under no circumstances shall it exceed 10 years for non-integrated approaches or extend

	beyond July 15, 2021 for an integrated approach. The Regional Board staff will bring to the Regional Board the aforementioned plans for consideration of extension of the wet-weather compliance date as soon as possible.
2 years after the effective date of this TMDL	The California Department of Parks and Recreation shall provide the Regional Board Executive Officer, a report quantifying the bacteria loading from birds to the Malibu Lagoon. The Regional Board's Executive Officer shall require the responsible jurisdictions and responsible agencies to provide the Regional Board with a reference watershed study. The study shall be designed to collect sufficient information to establish a defensible reference condition for the Malibu Creek and Lagoon watershed.
3 years after effective date of this TMDL** ** May be extended to up to 6 years from the effective date of this TMDL	Achieve compliance with the applicable Load Allocations and Waste Load Allocations, as expressed in terms of allowable days of exceedances of the single sample bacteria limits and the 30-day geometric mean limit during summer dry-weather (April 1 to October 31). In response to a written request from a responsible jurisdiction or responsible agency, the Executive Officer of the Regional Board may extend the compliance date for the summer dry-weather allocations from 3 years to up to 6 years from the effective date of this TMDL. The Executive Officer's decision to extend the summer dry-weather compliance date must be based on supporting documentation to justify the extension, including a detailed work plan, budget and contractual or other commitments by the responsible jurisdiction or responsible agency.
3 years after effective date of this TMDL	The Regional Board shall reconsider this TMDL to: (1) Consider a natural source exclusion for bacteria loading from birds in the Malibu Lagoon if all anthropogenic sources to the Lagoon have been controlled. (2) Reassess the allowable winter dry-weather and wet-weather exceedances days based on additional data on bacterial indicator densities, and an evaluation of site-specific variability in exceedance levels to determine whether existing water quality is better than water quality at the reference watershed, (3) Reassess the allowable winter dry-weather and wet-weather exceedance days based on a re-evaluation of the selected reference watershed and consideration of other reference watersheds that may better represent reaches of the Malibu Creek and Lagoon.

	(4) Consider whether the allowable winter dry-weather and wet-weather exceedance days should be adjusted annually dependent on the rainfall conditions and an evaluation of natural variability in exceedance levels in the reference system(s), (5) Re-evaluate the reference year used in the calculation of allowable exceedance days, and (6) Re-evaluate whether there is a need for further clarification or revision of the geometric mean implementation provision.
6 years after the effective date of this TMDL	Achieve compliance with the applicable Load Allocations and Waste Load Allocations, expressed as allowable exceedance days during winter dry weather (November 1-March 31) single sample limits and the rolling 30-day geometric mean limit.
10 years after the effective date of this TMDL ** May be extended up to July 15, 2021.	Achieve compliance with the wet-weather Load Allocations and Waste Load Allocations (expressed as allowable exceedance days for wet weather and compliance with the rolling 30-day geometric mean limit.) The Regional Board may extend the wet-weather compliance date up to July 15, 2021 at the Regional Board's discretion, by adopting a subsequent Basin Plan amendment that complies with applicable law.

8. AMBIENT BACTERIA WATER QUALITY AND COMPLIANCE MONITORING PLAN

Responsible jurisdictions and responsible agencies are jointly responsible for developing and implementing a comprehensive monitoring plan to better characterize existing water quality based on applicable bacteria water quality objectives and to assess compliance with the waste load allocations and load allocations in the TMDL. The monitoring plan must include all applicable bacteria water quality objectives and sampling frequency must be adequate to assess compliance with the 30 day geometric mean limits (i.e., at least 5 samples per 30 days). Ongoing monitoring programs developed by the Malibu Creek Watershed Management Committee as described below may fulfill the need for ambient monitoring data. However, the responsible jurisdictions and responsible agencies are ultimately accountable for ensuring that the monitoring requirements specified in this TMDL are met.

8.1 Malibu Creek Watershed Monitoring Plan

The Watershed Management Committee (composed of the cities of Calabasas, Agoura Hills, Westlake Village, and Malibu, and the County of Los Angeles) and the Las Virgenes Municipal Water District has been awarded a Coastal Nonpoint Source Control Program grant for $500,000 to implement the Malibu Creek Watershed Monitoring Program. The monitoring program was developed by members from the LARWQCB, State Department of Parks and Recreation, City of Calabasas, Las Virgenes Municipal Water District, Heal the Bay, City of Malibu, and UCS California Sea Grant staff. Monitoring data from this program may be used to fulfill a portion of the monitoring requirements under this TMDL. This may include fecal coliform and E. coli in the creeks, and total coliform, fecal coliform and enterococcus in the lagoon. The program is currently funded through March 2006.

8.2 Compliance Monitoring

For purposes of compliance monitoring, responsible jurisdictions and agencies shall jointly submit a compliance monitoring plan that specifies agreed upon sampling stations that will serve as compliance points. At a minimum, at least one sampling station will be located in each subwatershed. The sampling plan must also list the sampling parameters, methods of measuring flow, and sampling frequency. Responsible jurisdictions and/or agencies shall conduct daily or systematic weekly sampling at each compliance point. If weekly sampling is performed, then the days of allowable exceedance for single sample limits will be scaled accordingly.[6] Also if weekly sampling is conducted, the weekly sampling results will be assigned to the remaining days of the week in order to calculate the daily rolling 30-day geometric mean.

If the number of exceedance days is greater than the allowable number of exceedance days or the 30-day geometric mean is exceeded, then the responsible jurisdictions and agencies within the contributing subwatershed shall be considered out-of-compliance with the TMDL. Responsible jurisdictions or agencies shall not be deemed out of compliance with the TMDL if the investigation described in the paragraph below demonstrates that bacterial sources originating within the jurisdiction of the responsible agency have not caused or contributed to the exceedance.

If a single sample shows the discharge or contributing area to be out of compliance, the Regional Board may require, through permit requirements or the authority contained in Water Code section 13267, daily sampling at the downstream compliance point or at the existing downstream monitoring location (if it is not already) until all single sample events meet bacteria water quality objectives. Furthermore, if a creek location is out-of-compliance as determined in the previous paragraph, the Regional Board shall require responsible agencies to initiate an investigation, which at a minimum shall include daily sampling in the target receiving water body reach or at the existing monitoring location until all single sample events meet bacteria water quality objectives.

The estimated annual cost for the monitoring plan is $200,000. This is based on the cost of monitoring 24 sites on a weekly basis (one site in each of the 18 subwatersheds plus six additional sites where frequent REC-1 use is known to occur) for total coliform, fecal coliform, enterococcus, and E. coli bacteria. Monitoring cost will be considered with the benefits of protecting human health for persons swimming downstream and wading in Malibu Creek and its tributaries, and for swimmers and surfers using downstream beaches that are impacted by the Creek.

---

[6] The number of allowable exceedance days was scaled for weekly sampling by calculating the number of exceedances that would have been identified under a weekly sampling program at the reference beach during the critical year. The number of winter dry weather days that would have been sampled in 1993 under a weekly sampling regime was determined by solving for X in the following equation, where 80 days equals the number of winter dry-weather days during the critical year 1993.

$$\frac{\textbf{80 days}}{\textbf{365 days}} = \frac{\textbf{X}}{\textbf{52 weeks}}$$

Solving for the variable X yields 11.4, which was multiplied by 0.03, the historical exceedance frequency for winter dry-weather at the Leo Carrillo Beach, the reference beach in the Arroyo Sequit watershed (LARWQCB,2003). The adjusted allowable days of winter dry-weather exceedance days under a weekly sampling scenario is 1 day. Likewise, the adjusted allowable exceedance days during wet weather is 3 days when compliance points are sampled weekly. This is based on 75 wet-weather days in 1993, and a historical exceedance rate at the reference beach during wet-weather days of 0.22.

9. REFERENCES

Abramson, M.,. Padick. E.T. Schueman, G.O. Taylor, J. Olson, J. Safford, K. Starman, and J. Woodward. 1998. The Malibu Creek Watershed: A Framework for Monitoring, Enhancement and Action. Prepared for Heal the Bay and The California State Coastal Conservancy. The 606 Studio Graduate Department of Landscape Architecture, California State Polytechnic University, Pomona

Ambrose, R.F.., I.H. Suffet, and S.S. Que Hee. 1995. Enhanced environmental monitoring program at Malibu Lagoon and Malibu Creek. Prepared for the Las Virgenes Municipal Water District by the Environmental Science and Engineering Program at the University of California, Los Angeles.

Ambrose, R.F. and A. R. Orme. 2000. Lower Malibu Creek and Lagoon resource enhancement and management. Final report to the California State Coastal Conservancy. University of California, Los Angeles May 2000.

ASAE, 1998. ASAE Standards. Manure Production Characteristics. ASAE D384.1 DEC93

City of Malibu.2000. Proposition 13 Grant Application--Civic Center Stormdrain Treatment Facility

Colbough, Jim. 2003. Personal communication.

Consent Decree (Heal the Bay Inc., et al. v. Browner) C 98-4825 SBA

Entrix, 1999. Minimum Flow Recommendations for Malibu Creek. Prepared for the Las Virgenes Municipal Water District by ENTRIX, Inc, Walnut CA.

Flowers 1972. Measurement and management Aspects of Water Toxicology: The Malibu Creek Watershed, A mixed residential and Wilderness Areas

Haith, D.A., R. Mandel, and R.S. Wu. 1992. GWLF, Generalized loading functions, Version 2.0 Users Manual. Department of Agricultural and Biological Engineering, Cornell University, Ithaca, New York.

LARWQCB. 1994. Water Quality Control Plan for the Los Angeles Region. California Regional Water Quality Control Board, Los Angeles Region.

LARWQCB. 1996. 1996 Water Quality Assessment and Documentation. California Regional Water Quality Control Board, Los Angeles Region.

Los Angeles Regional Water Quality Control Board.1997. Fact Sheet: Order No. 97-135, Waste Discharge Requirements for Las Virgenes Municipal Water District (Tapia Water Reclamation Facility).

LARWQCB. 1998. Proposed 1998 list of impaired surface waters (the 303(d) List). March 24, 1998. California Regional Water Quality Control Board, Los Angeles Region.

LARWQCB, 2000. Malibu Technical Investigation. California Regional Water Quality Control Board, Los Angeles Region.

LARWQCB. 2002a. Draft 303(d) list. California Regional Water Quality Control Board, Los Angeles Region.

LARWQCB. 2002b. Total maximum daily load to reduce bacterial indicator densities at Santa Monica Bay Beaches during dry weather. California Regional Water Quality Control Board, Los Angeles Region. January 14, 2002.

LARWQCB. 2002c. Draft. Total Maximum Daily Load to Reduce Bacterial Indicator Densities at Santa Monica Bay Beaches during Wet Weather. California Regional Water Quality Control Board, Los Angeles Region. November 7, 2002.

LVMWD. 2002. Proposition 13 Grant Application--Nonpoint Pollution Program.

Lund, L.J., M.A. Anderson, and C. Amrhein. 1994. Evaluation of Water Quality for Selected Lakes in the Los Angeles Hydrological Basin. Prepared for the Los Angeles Regional Water Quality Control Board by the Department of Soil Science, University of California, Riverside, CA.

Manion, B.S. and J.H. Dillingham.1989. Malibu Lagoon: A Baseline Ecological Survey. Prepared for Los Angeles County Department of Beaches and Harbors and California State Department of Parks and Recreation. Topanga-Las Virgenes Resources Conservation District.

Orton, Randall. 2001. Personal Communications.

Tetra Tech. 2002. Nutrient and Coliform Modeling for the Malibu Creek Watershed TMDL Studies. Prepared for US Environmental Protection Agency Region 9 and the Los Angeles Regional Water Quality Control Board by Tetra Tech, Inc. Lafayette CA.

USEPA 2000. Guidance for Developing TMDLs in California

USEPA 2000a. Exfiltration in Sewer Systems, December, 2000. EPA 600-R-01-034

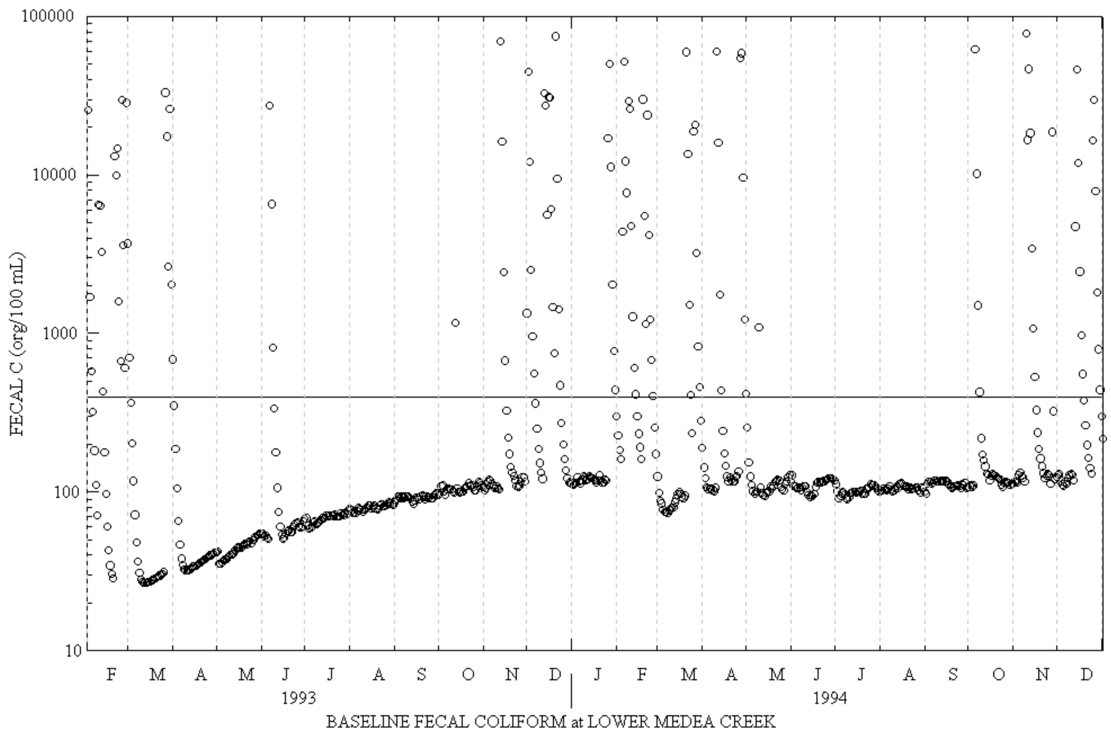
USEPA 2001. Protocol for Developing Pathogen TMDLs: First Edition Jan. 2001, EPA 841-R-00-0002

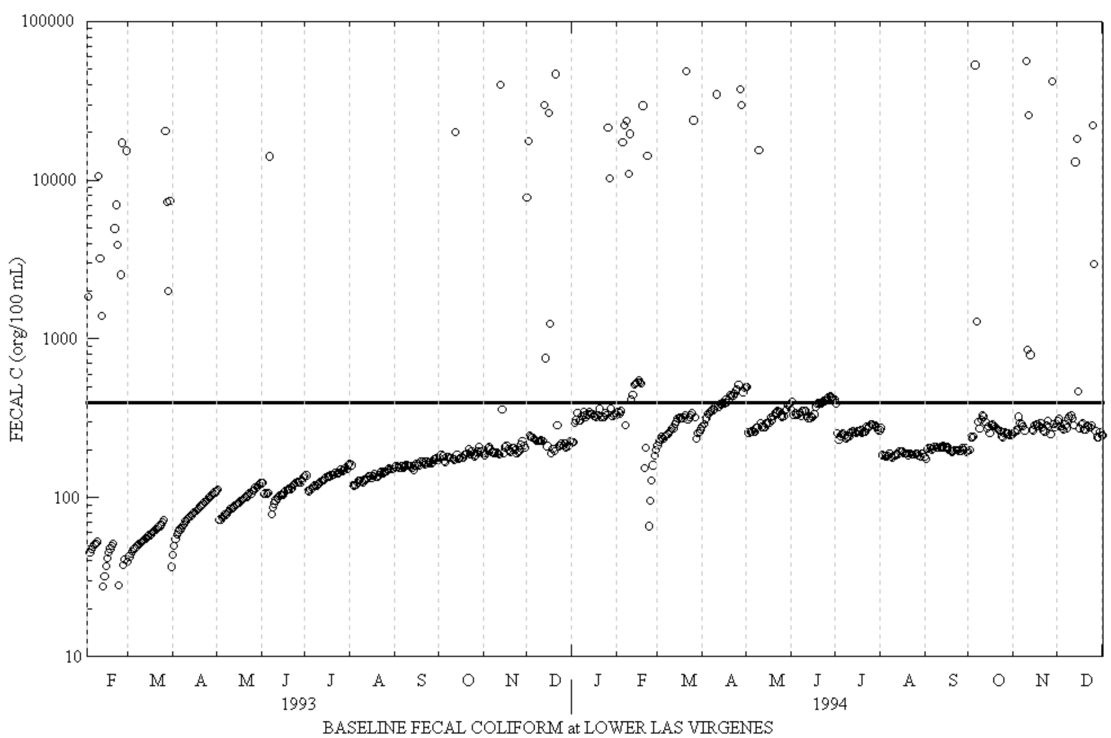
USEPA 2002. Onsite Wastewater Treatment Systems Manual. February, 2002, EPA 625-R-00-0002

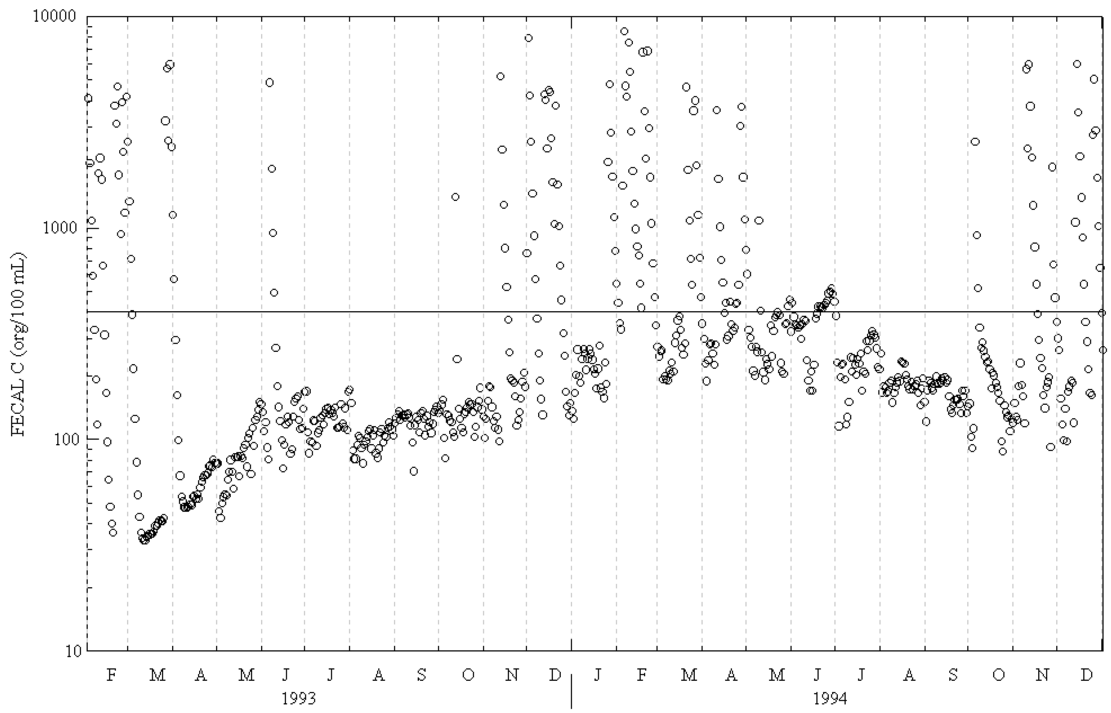
USEPA 2003. Total Maximum Daily Loads for Bacteria in the Malibu Creek Watershed. March 19, 2003

Warshall, P. and P. Williams. 1992. Malibu Wastewater Management Study: A Human Ecology of the New City. Prepared for the City of Malibu. Peter Warshall & Associates and Philip Williams & Associates, Ltd.

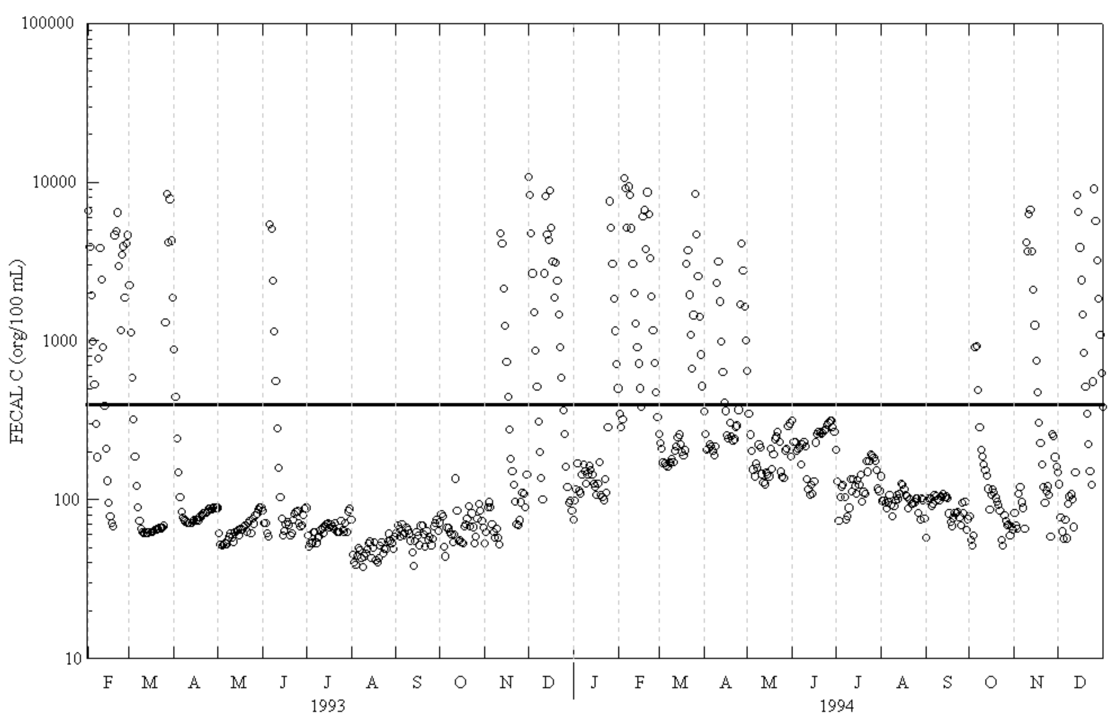
Appendix 1- Baseline Single Sample Model Output


100000
10000
1000
100
10
FECAL C (org/100 mL)
F M A M J J A S O N D J F M A M J J A S O N D
1993
1994
BASELINE FECAL COLIFORM at LOWER MEDEA CREEK

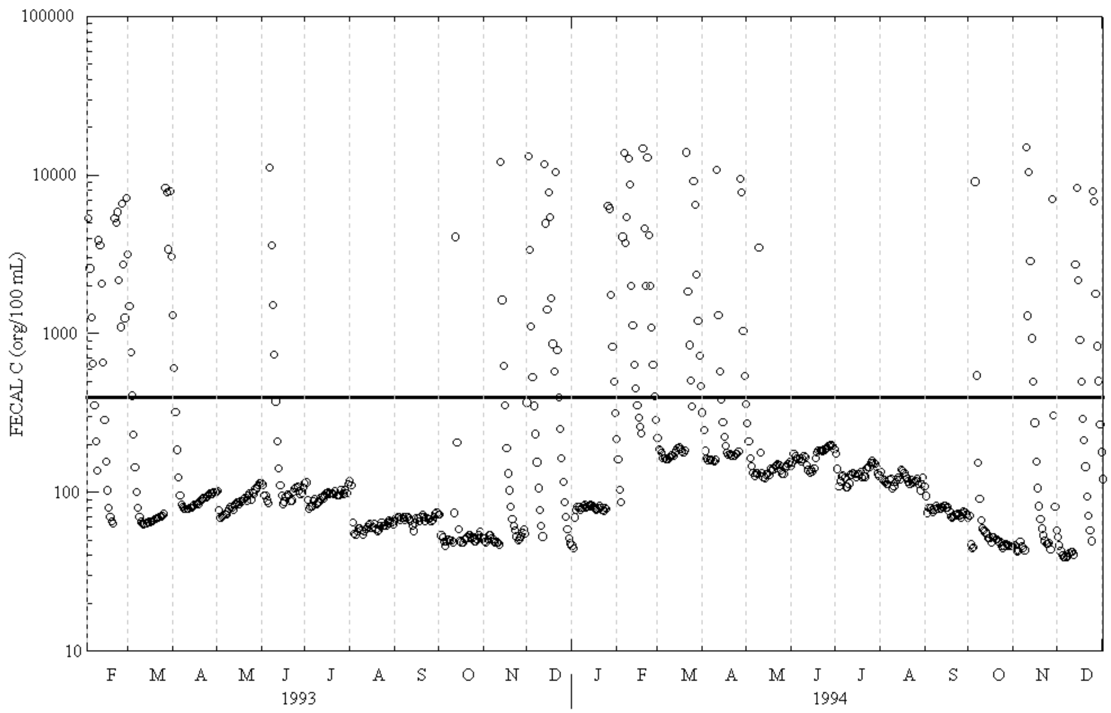

100000
10000
1000
100
10
FECAL C (org/100 mL)
F M A M J J A S O N D J F M A M J J A S O N D
1993
1994
BASELINE FECAL COLIFORM at LOWER LAS VIRGENES



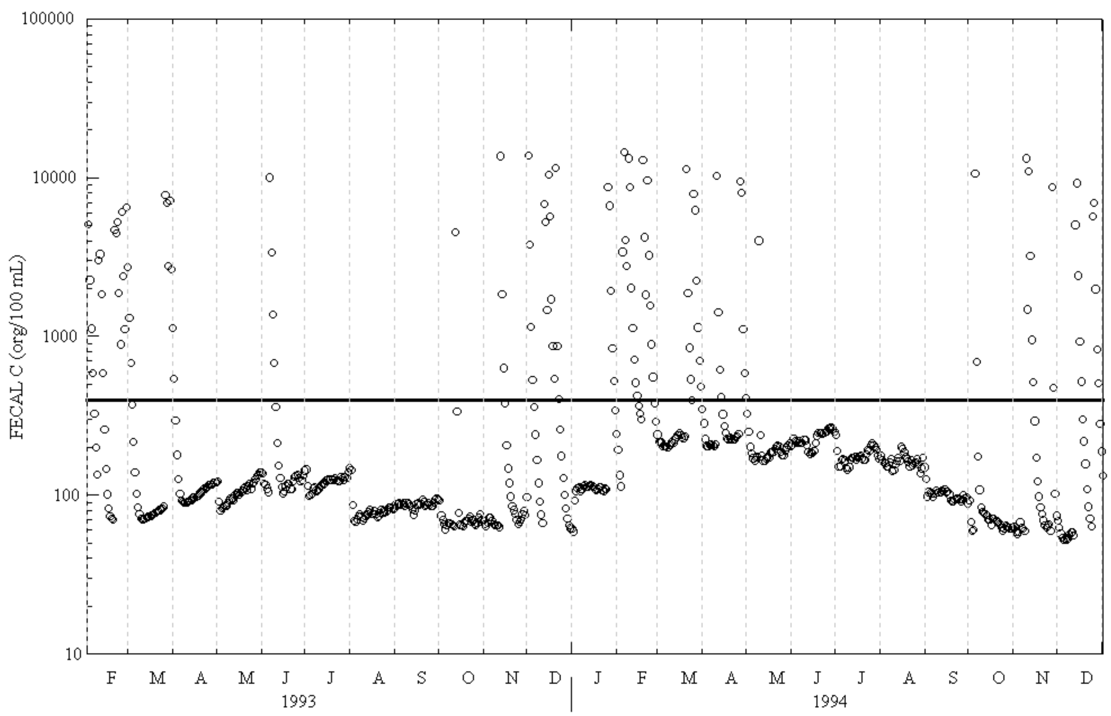
BASELINE FECAL COLIFORM at TRIUNFO CREEK



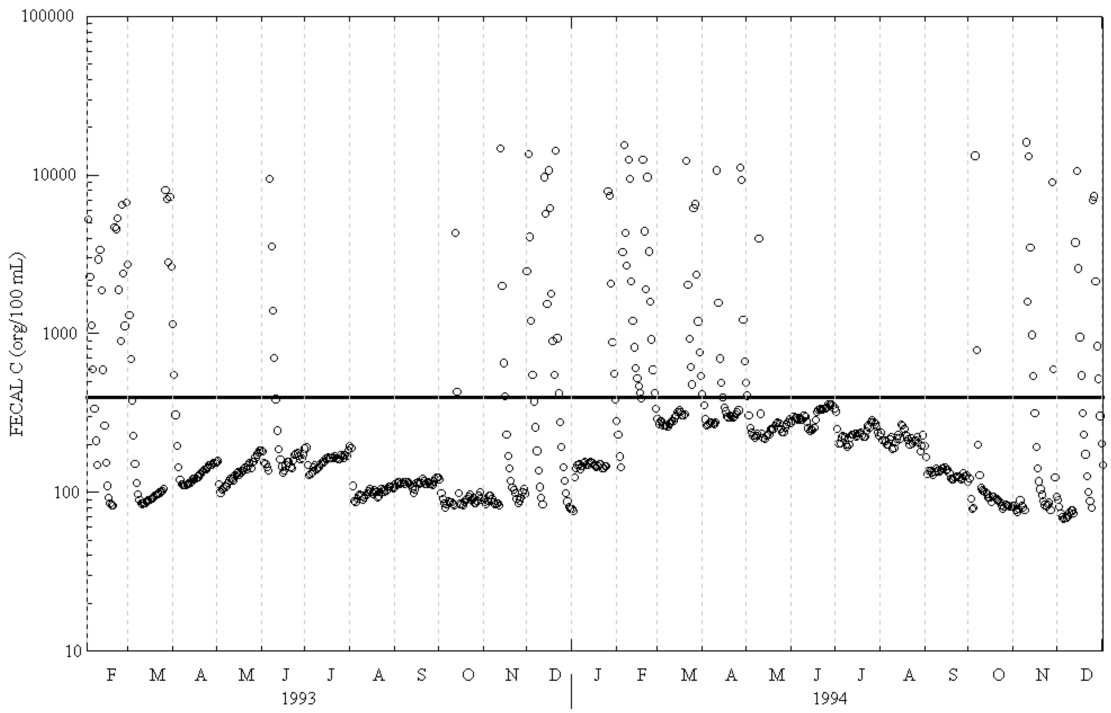
BASELINE FECAL COLIFORM at UPPER MALIBU CREEK



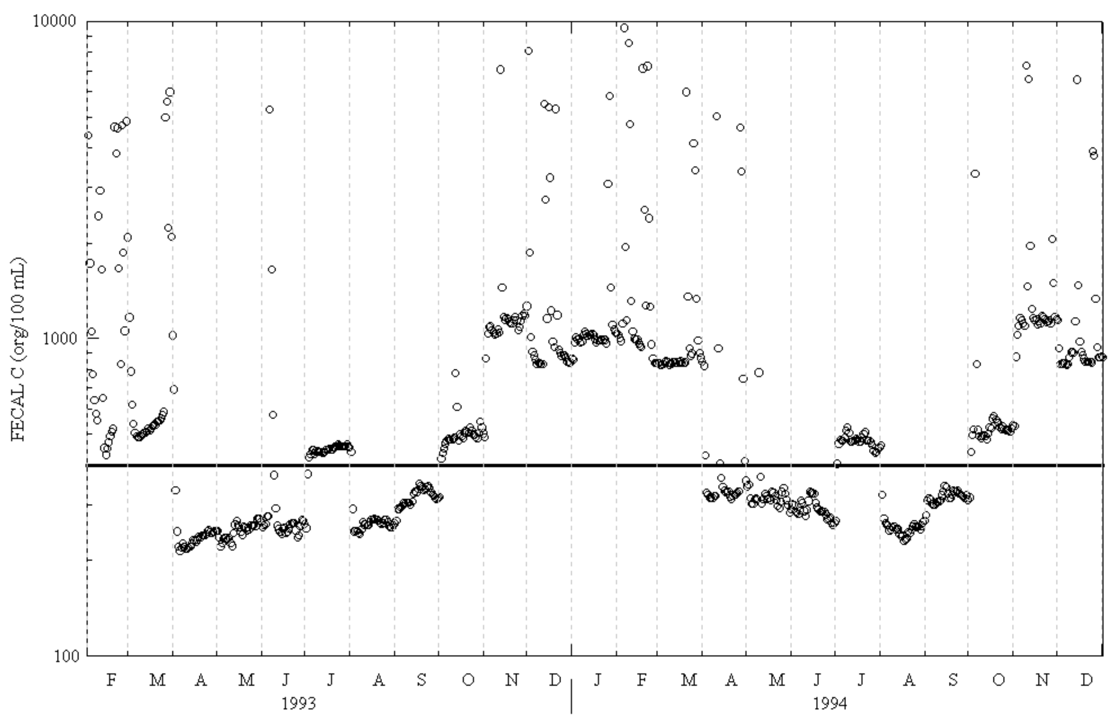
BASELINE FECAL COLIFORM at MIDDLE MALIBU CREEK



BASELINE FECAL COLIFORM at LOWER MALIBU CREEK

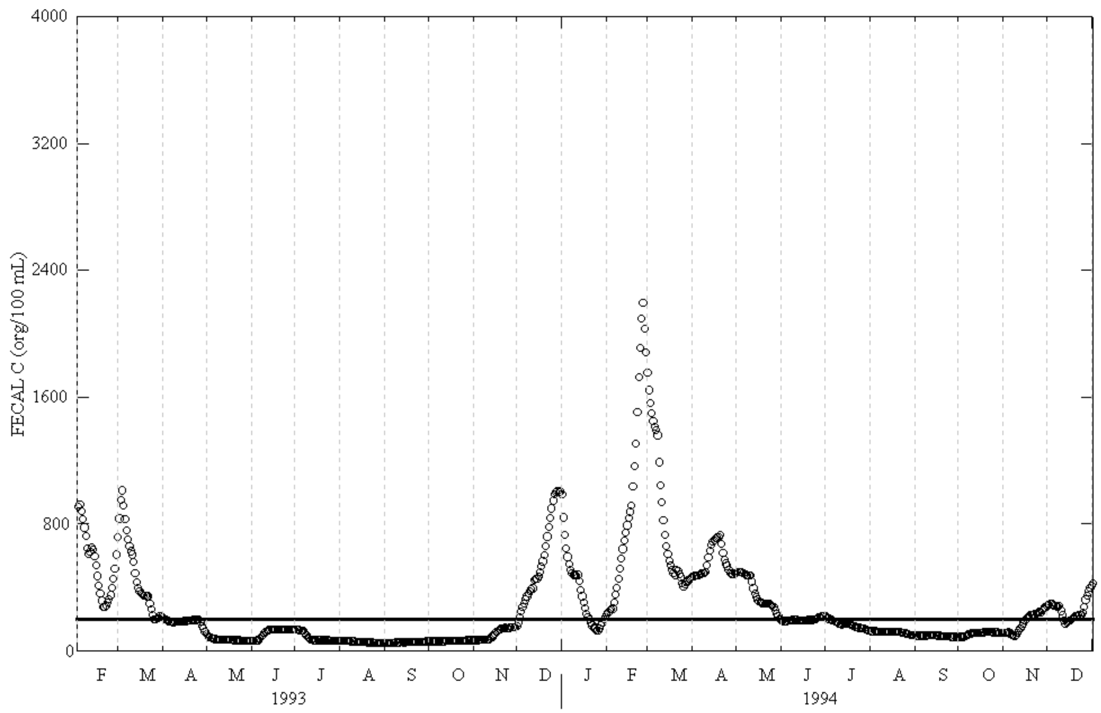


BASELINE FECAL COLIFORM at MALIBU LAGOON SUBWATERSHED

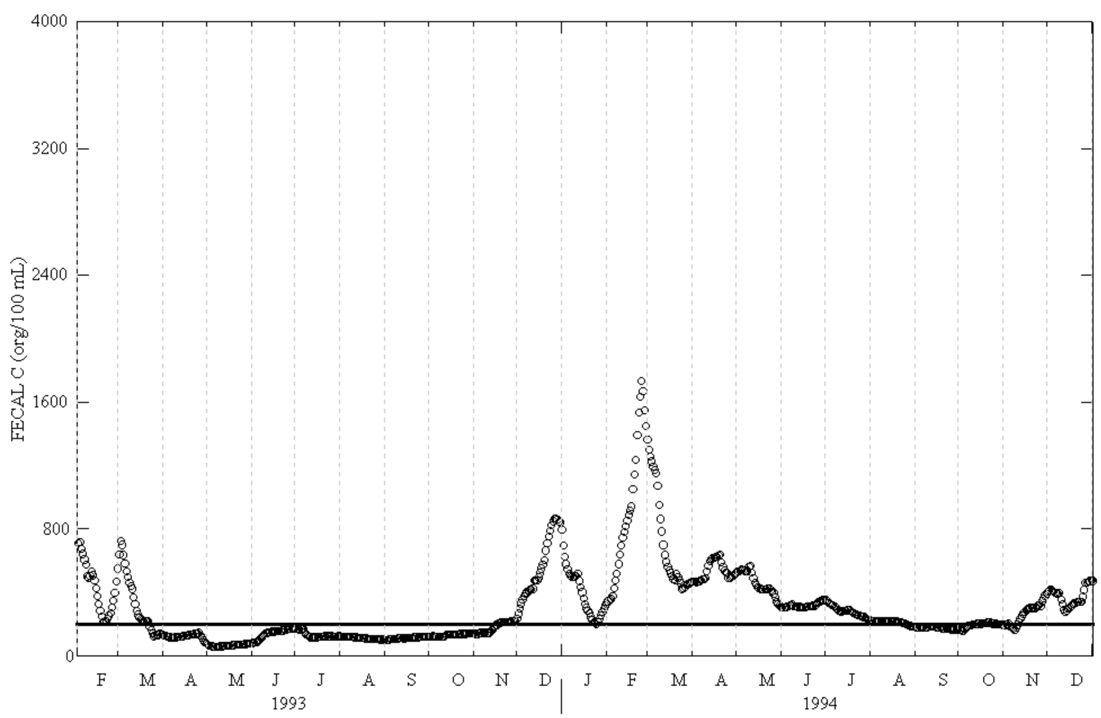


BASELINE FECAL COLIFORM at MALIBU LAGOON ESTUARY

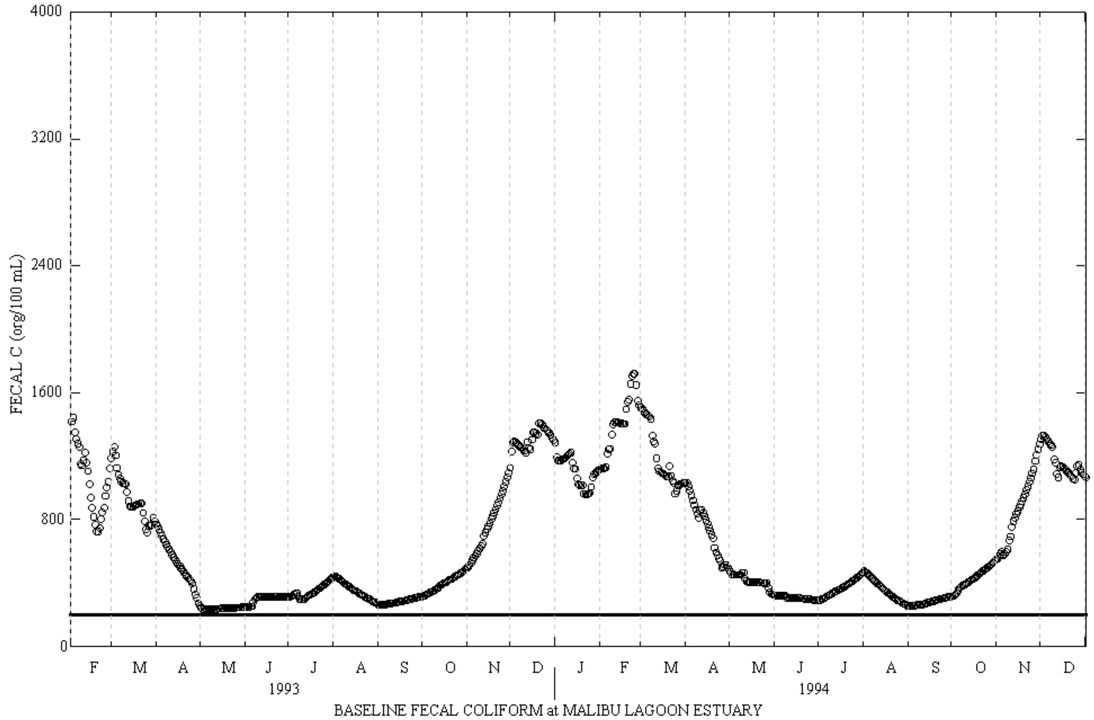
Appendix 2 - Baseline 30-Day Running Geometric Mean Model Output

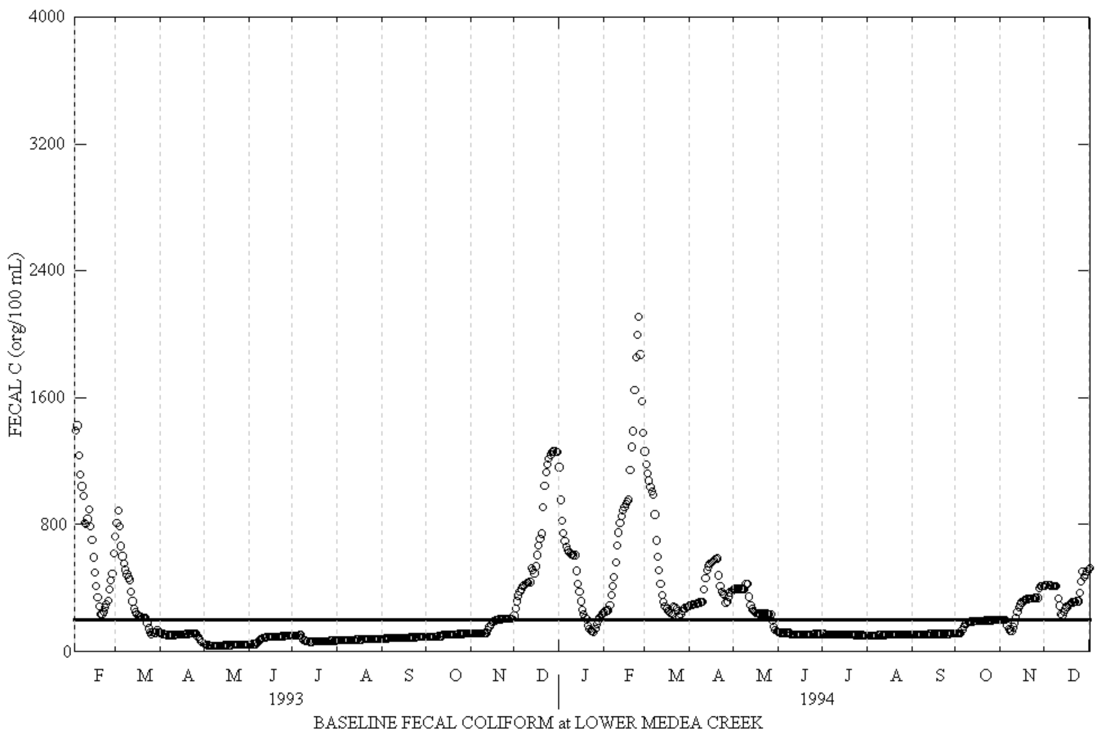


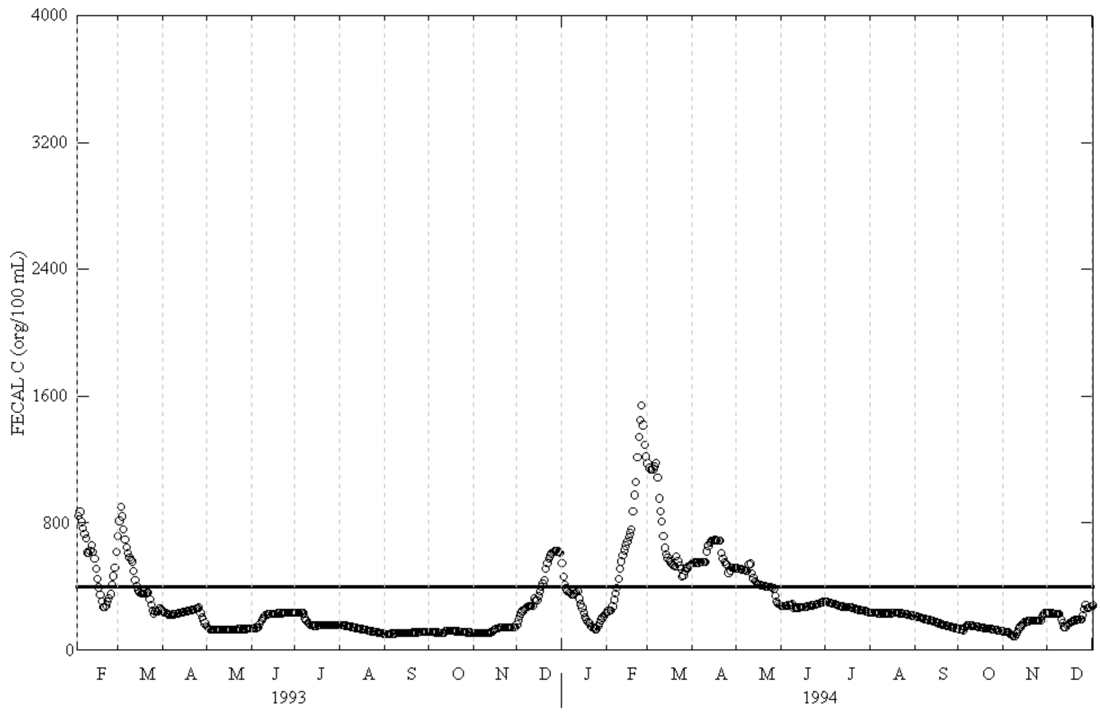
BASELINE FECAL COLIFORM at UPPER MALIBU CREEK



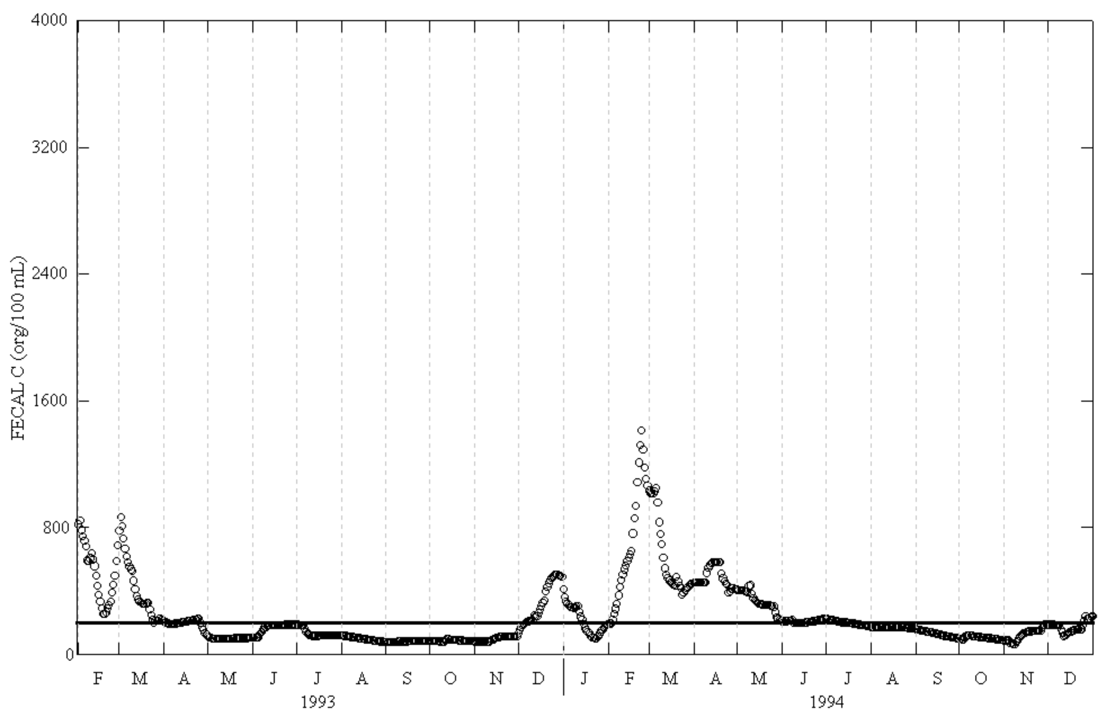
BASELINE FECAL C (Unknown) at TRIUNFO CREEK


4000
3200
2400
1600
800
0
FECAL C (org/100 mL)
F M A M J J A S O N D J F M A M J J A S O N D
1993
1994
BASELINE FECAL COLIFORM at MALIBU LAGOON ESTUARY

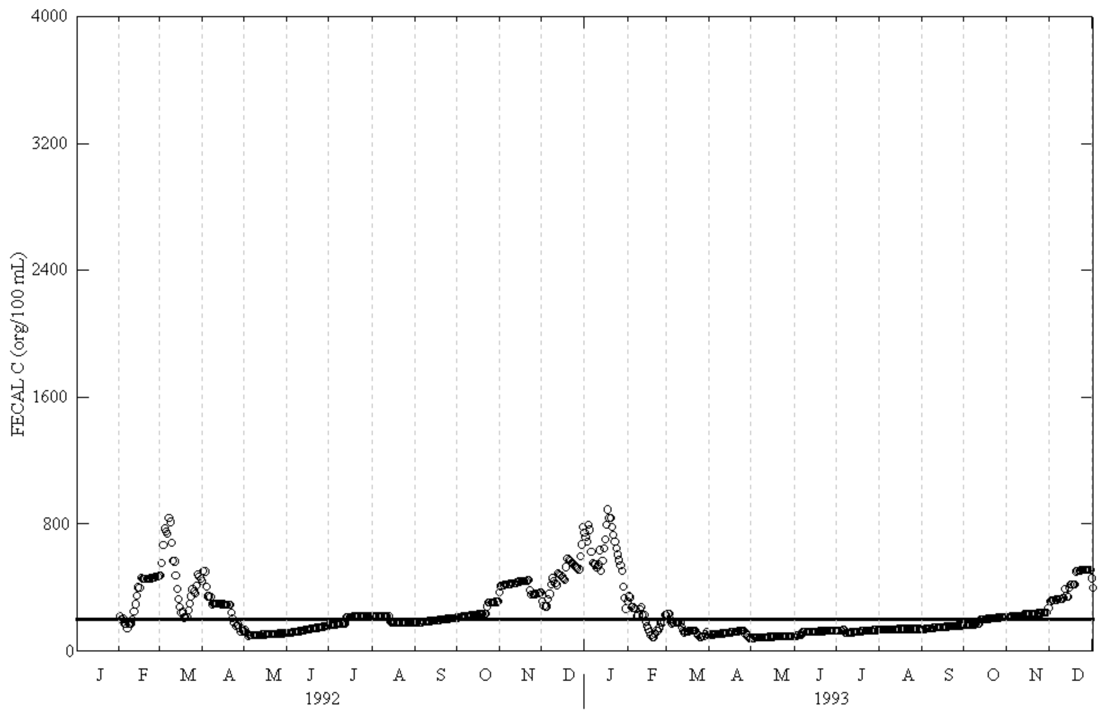

4000
3200
2400
1600
800
0
FECAL C (org/100 mL)
F M A M J J A S O N D J F M A M J J A S O N D
1993
1994
BASELINE FECAL COLIFORM at LOWER MEDEA CREEK



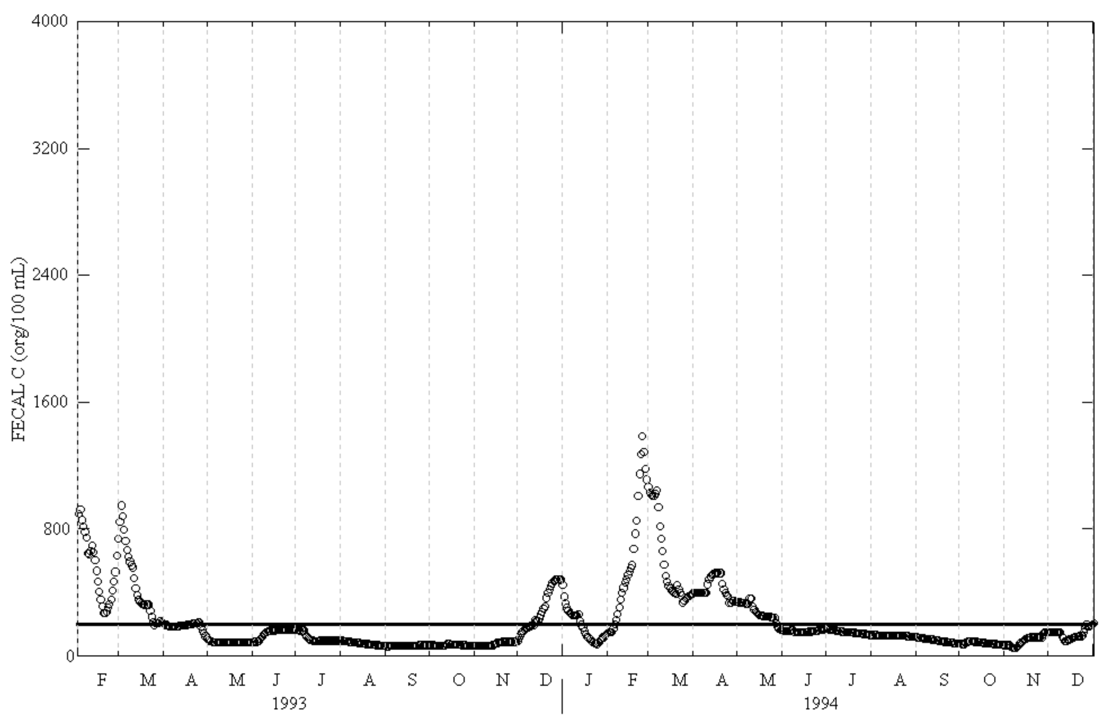
BASELINE FECAL COLIFORM at MALIBU LAGOON SUBWATERSHED



BASELINE FECAL COLIFORM at LOWER MALIBU CREEK

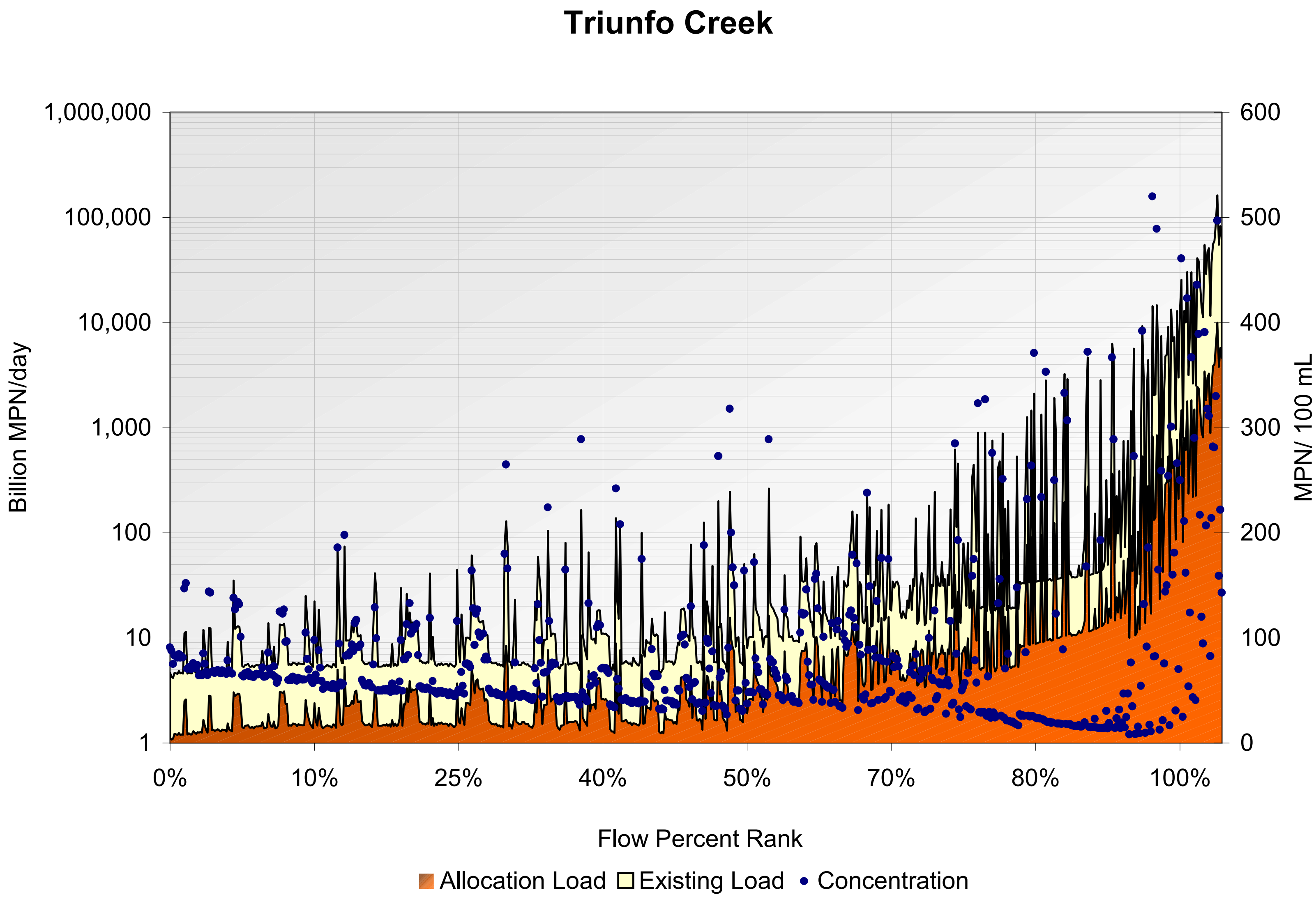


BASELINE FECAL COLIFORM at MALIBU LAGOON ESTUARY

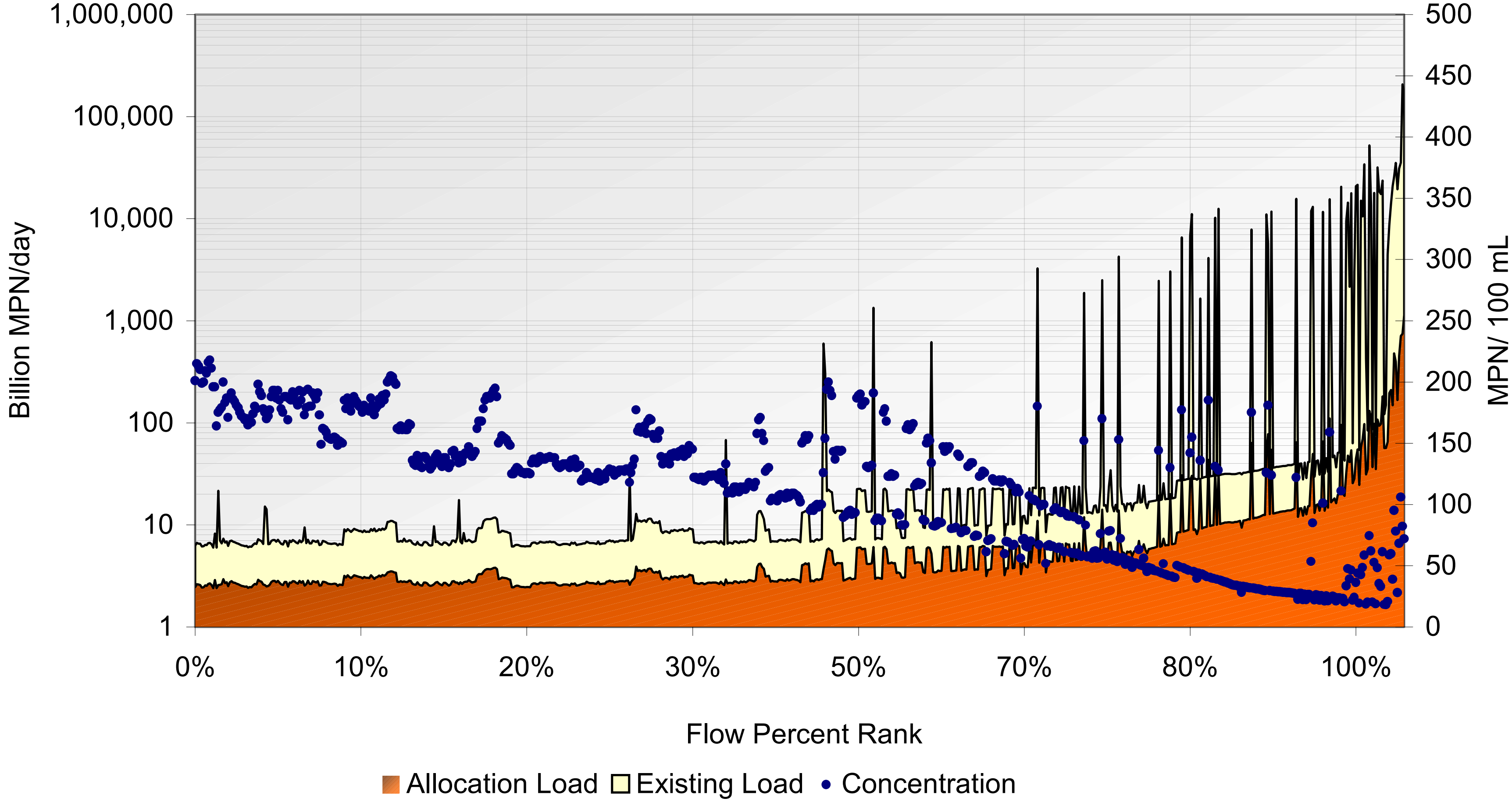


BASELINE FECAL COLIFORM at MIDDLE MALIBU CREEK

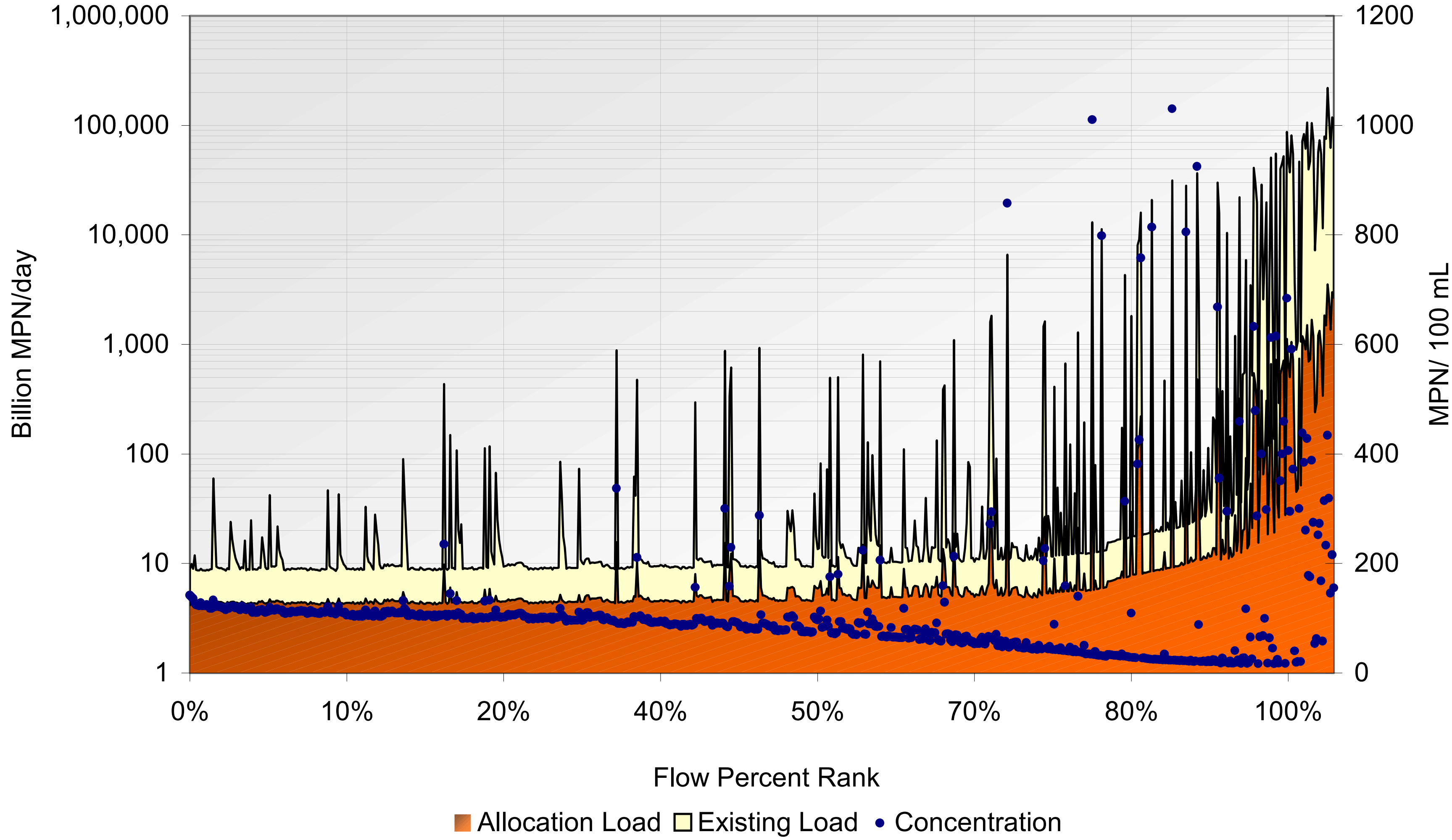
Appendix 3 - Allocations and Predicted Single Sample Compliance


Triunfo Creek
1,000,000
100,000
10,000
1,000
100
10
1
Billion MPN/day
600
500
400
300
200
100
0
MPN/ 100 mL
0%
10%
25%
40%
50%
70%
80%
100%
Flow Percent Rank
Allocation Load
Existing Load
Concentration

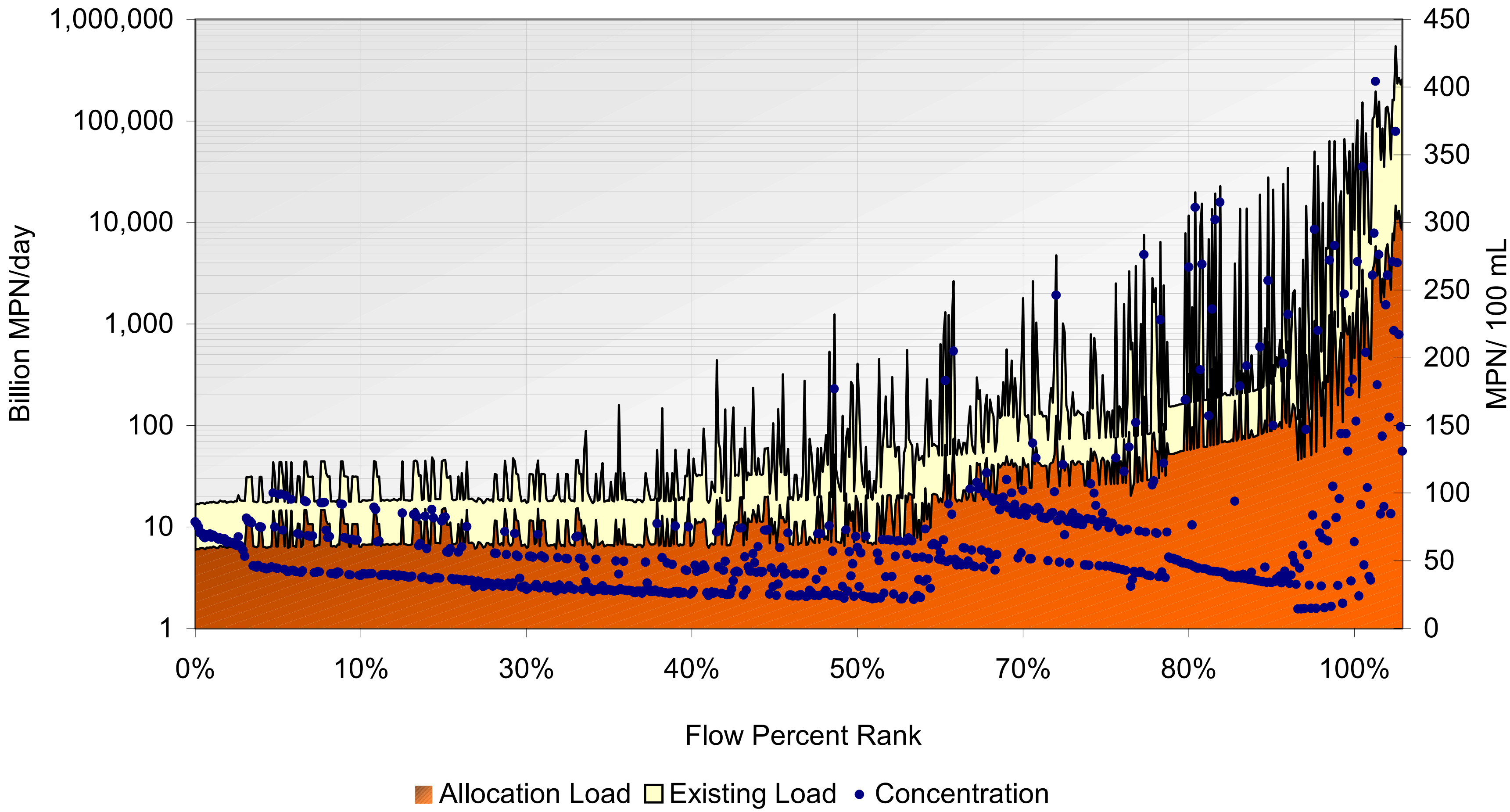
Lower Las Virgenes Creek



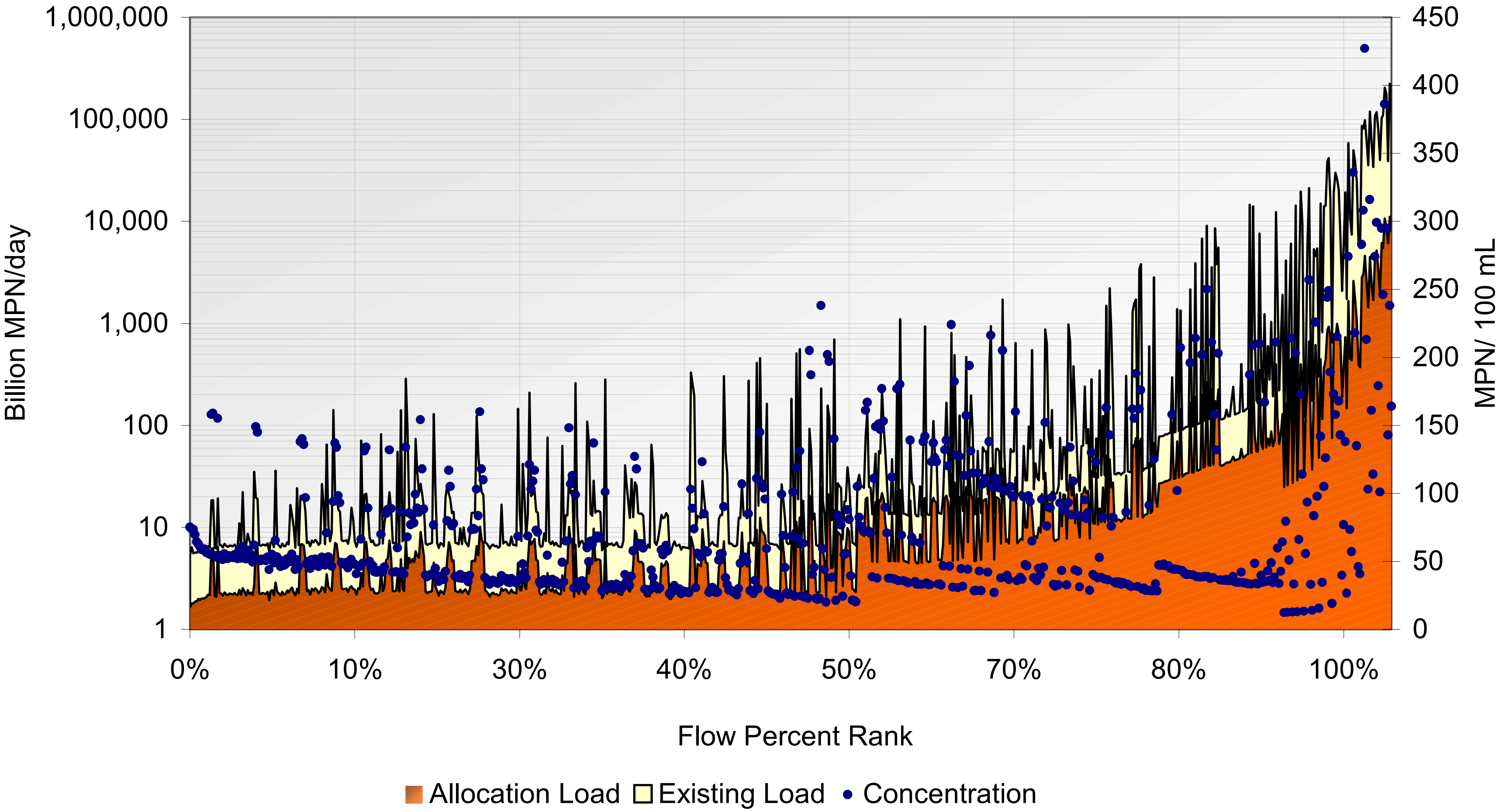
Lower Medea Creek

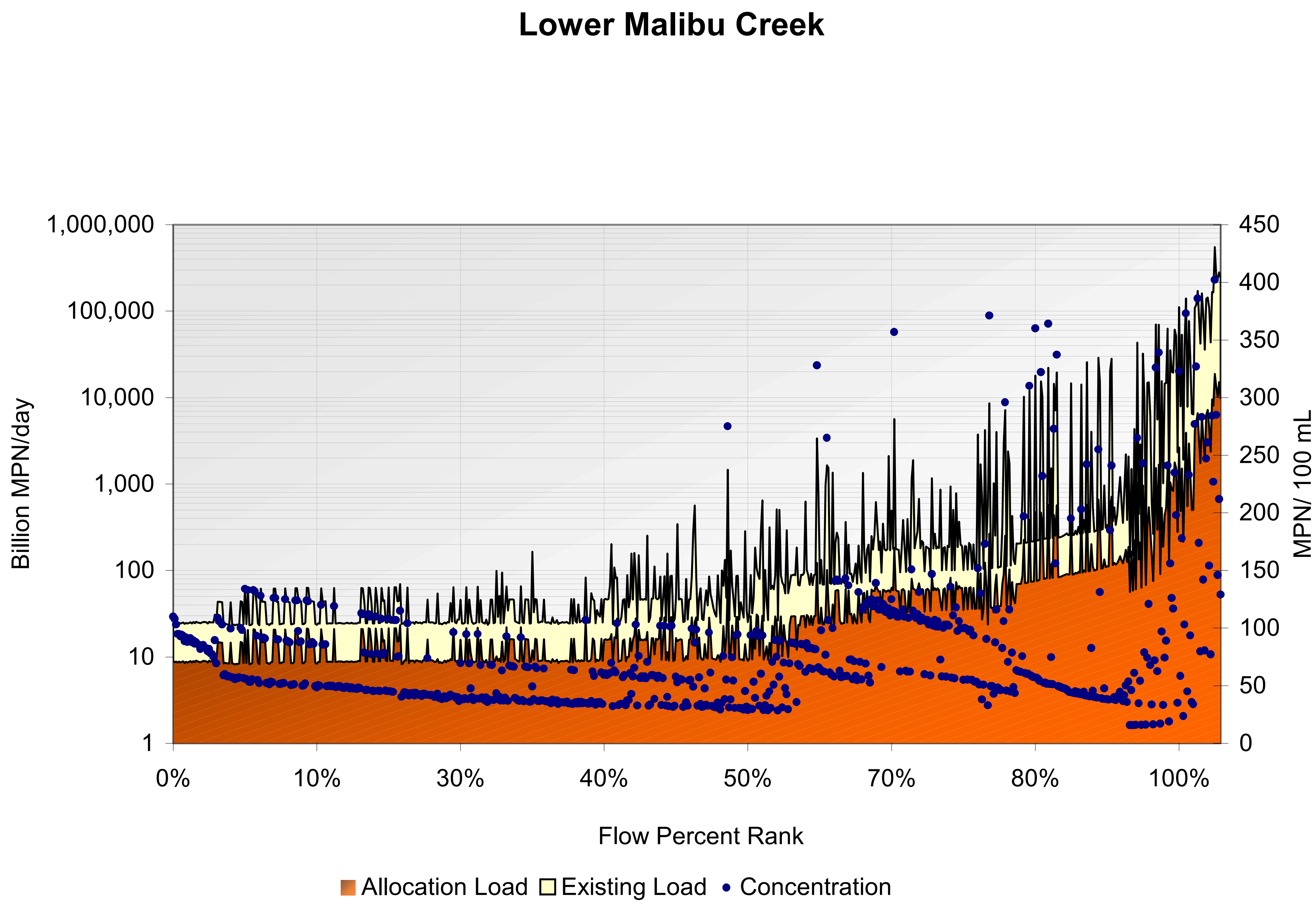


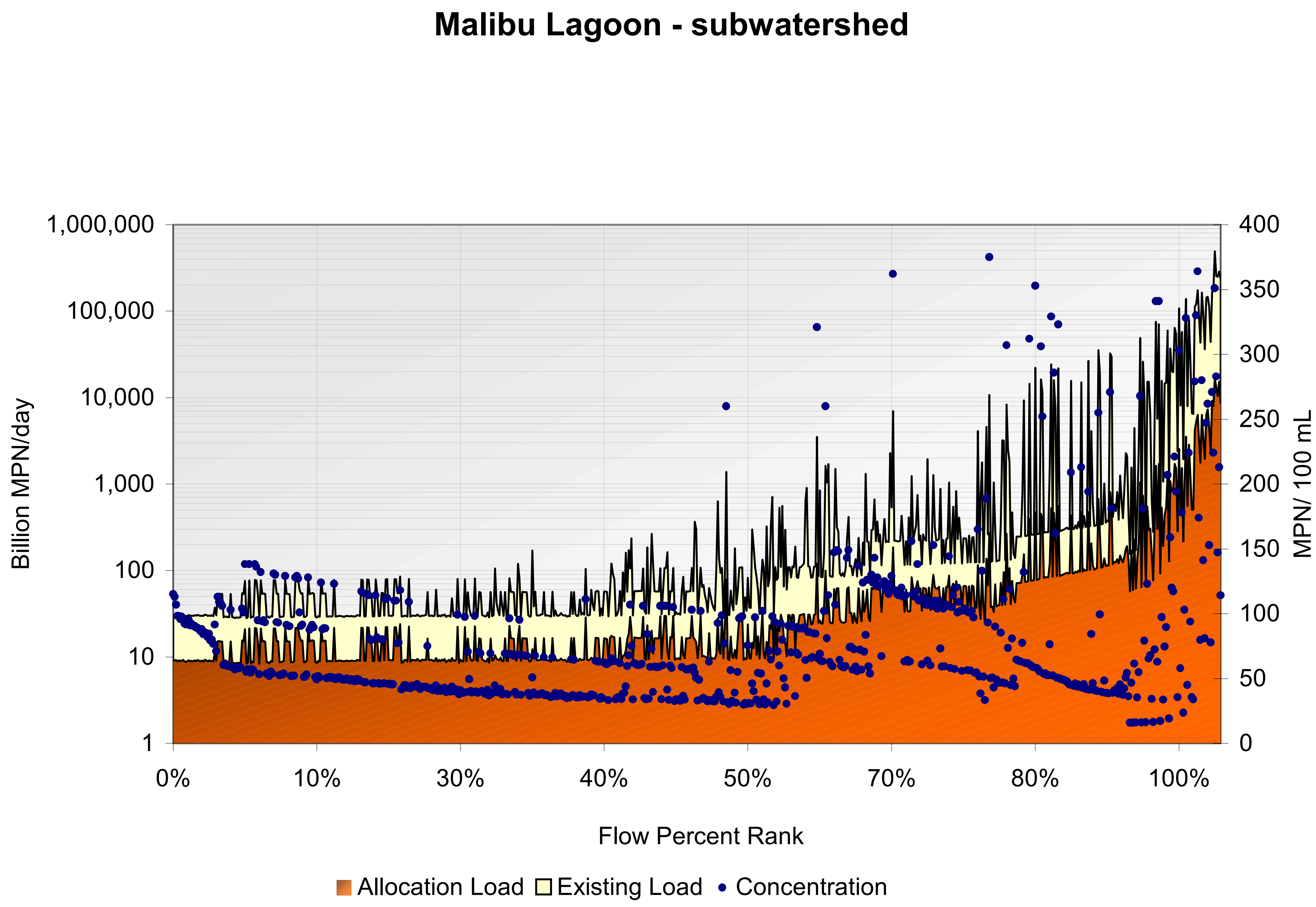
Middle Malibu Creek



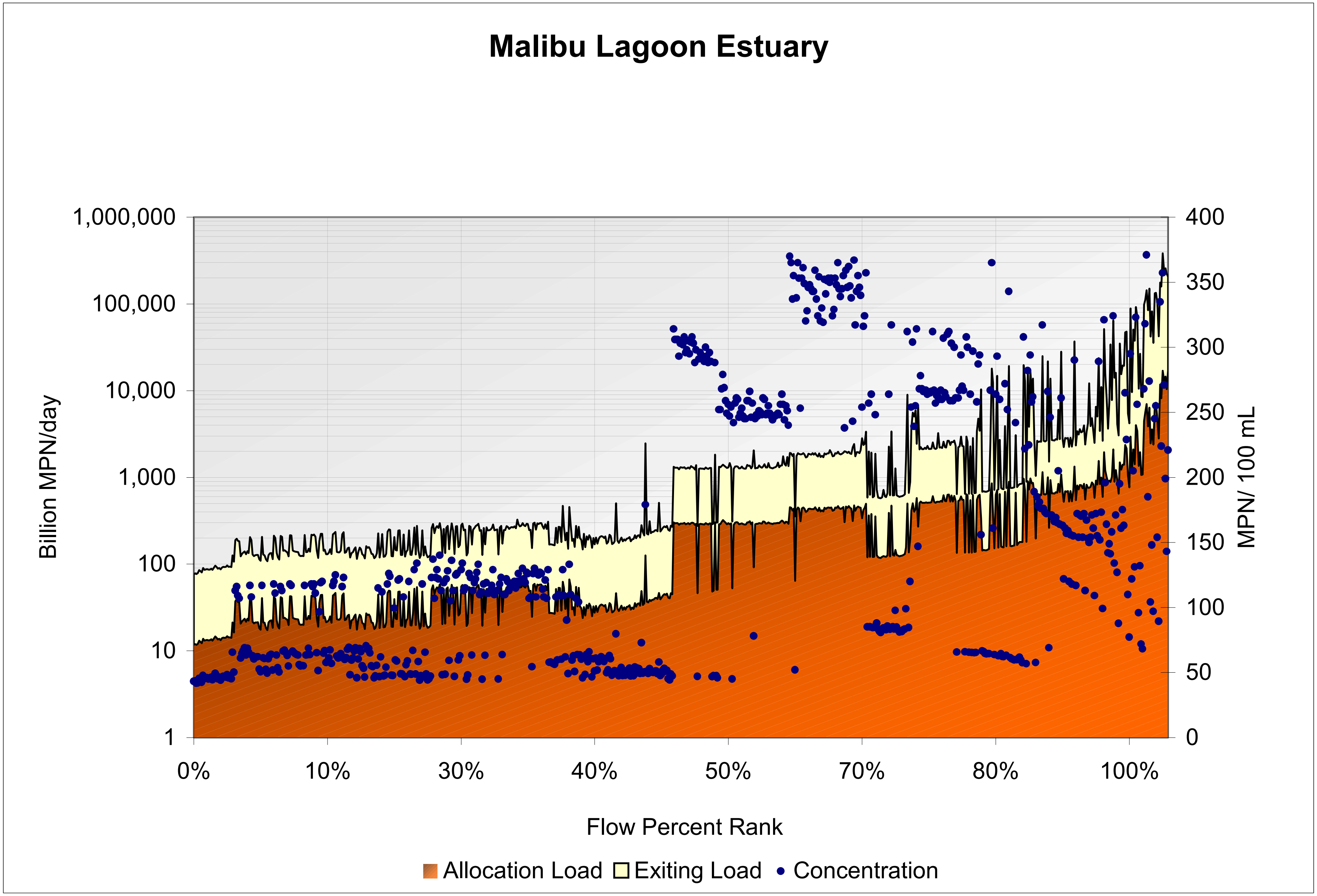
Upper Malibu Creek



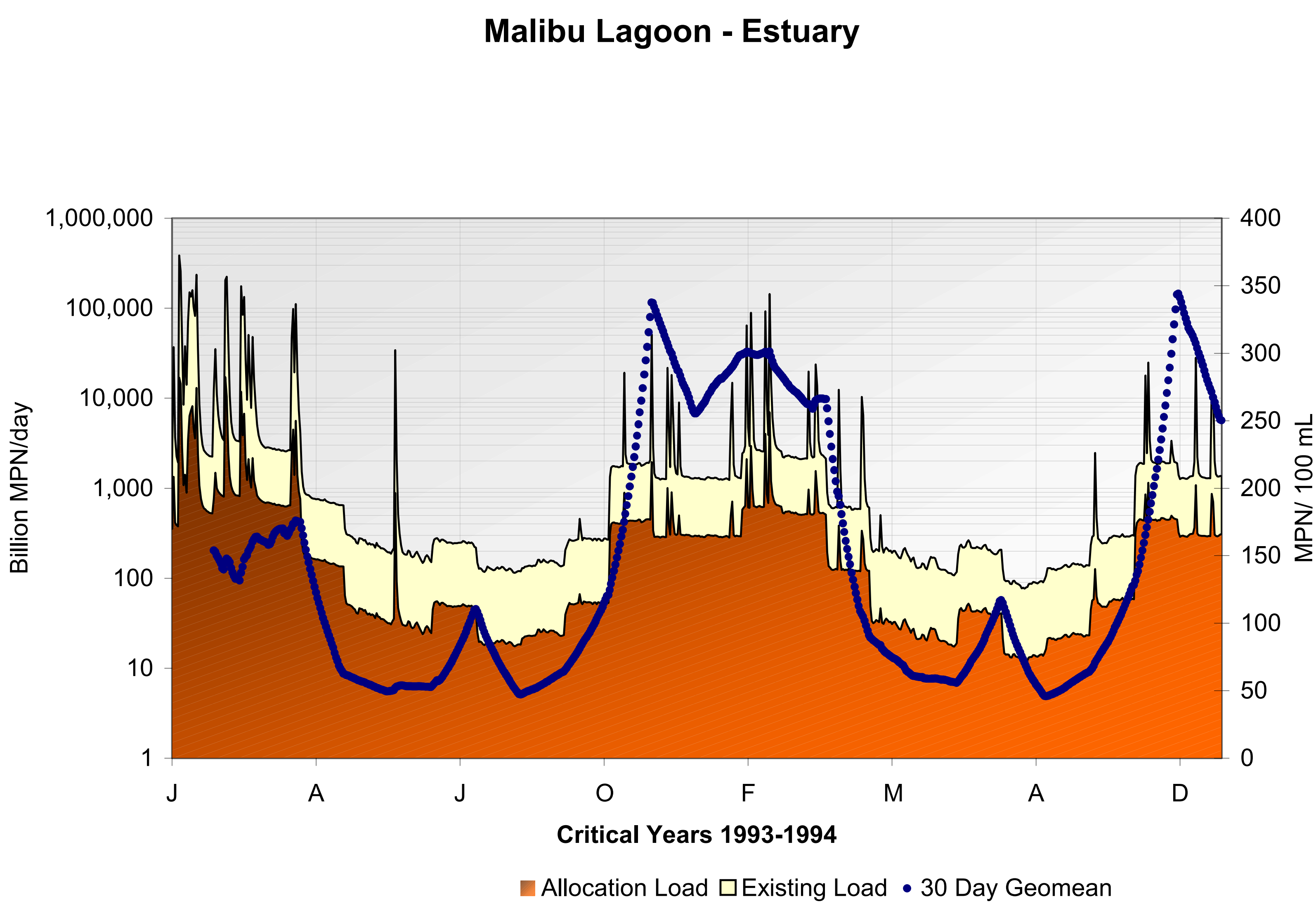

Lower Malibu Creek
Billion MPN/day
1,000,000
100,000
10,000
1,000
100
10
1
450
400
350
300
250
200
150
100
50
0
MPN/ 100 mL
0%
10%
30%
40%
50%
70%
80%
100%
Flow Percent Rank
Allocation Load
Existing Load
Concentration



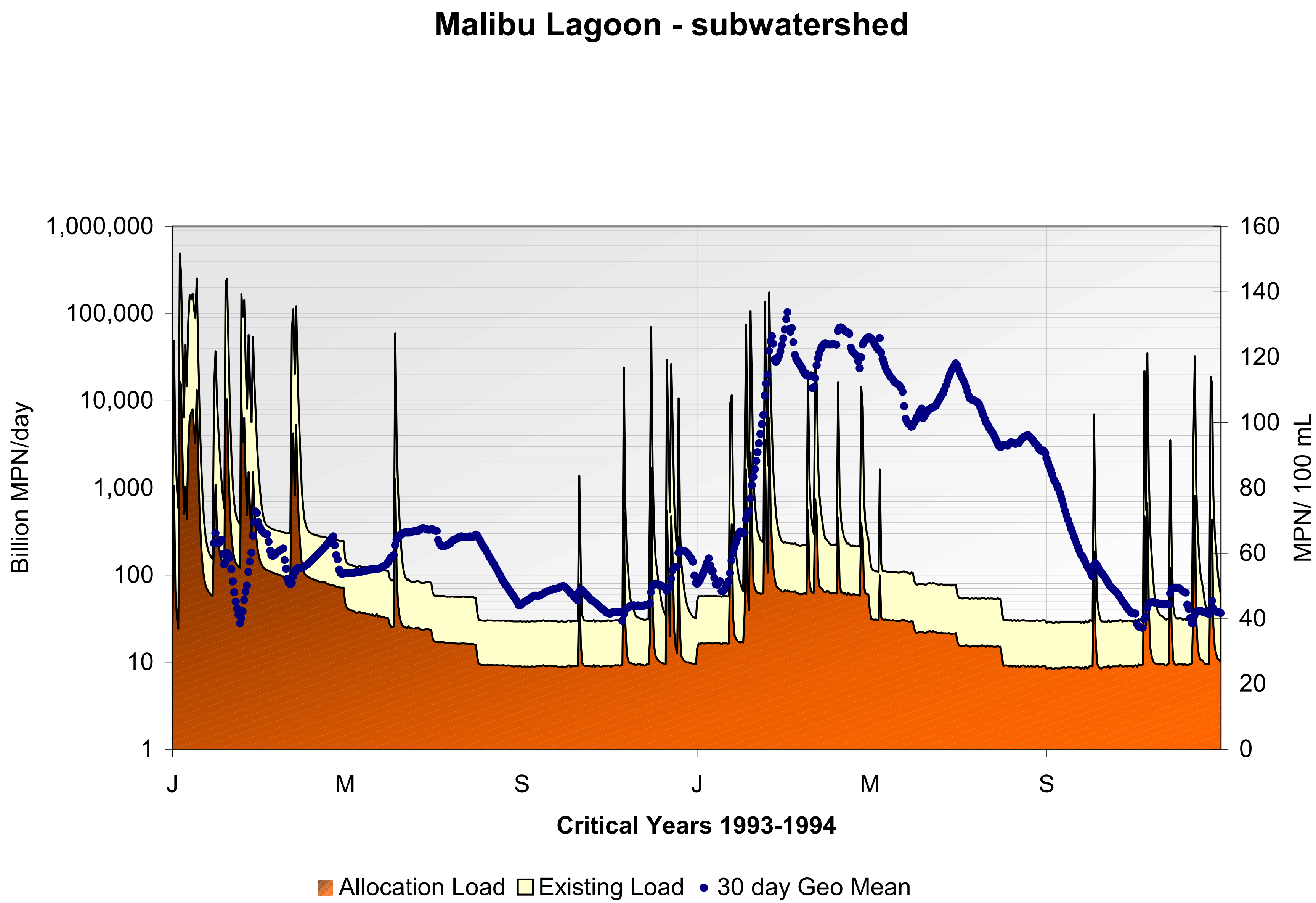
Malibu Lagoon - subwatershed
1,000,000
100,000
10,000
1,000
100
10
1
Billion MPN/day
400
350
300
250
200
150
100
50
0
MPN/ 100 mL
0%
10%
30%
40%
50%
70%
80%
100%
Flow Percent Rank
Allocation Load
Existing Load
Concentration


Malibu Lagoon Estuary
1,000,000
100,000
10,000
1,000
100
10
1
Billion MPN/day
400
350
300
250
200
150
100
50
0
MPN/ 100 mL
0%
10%
30%
40%
50%
70%
80%
100%
Flow Percent Rank
Allocation Load
Exiting Load
Concentration

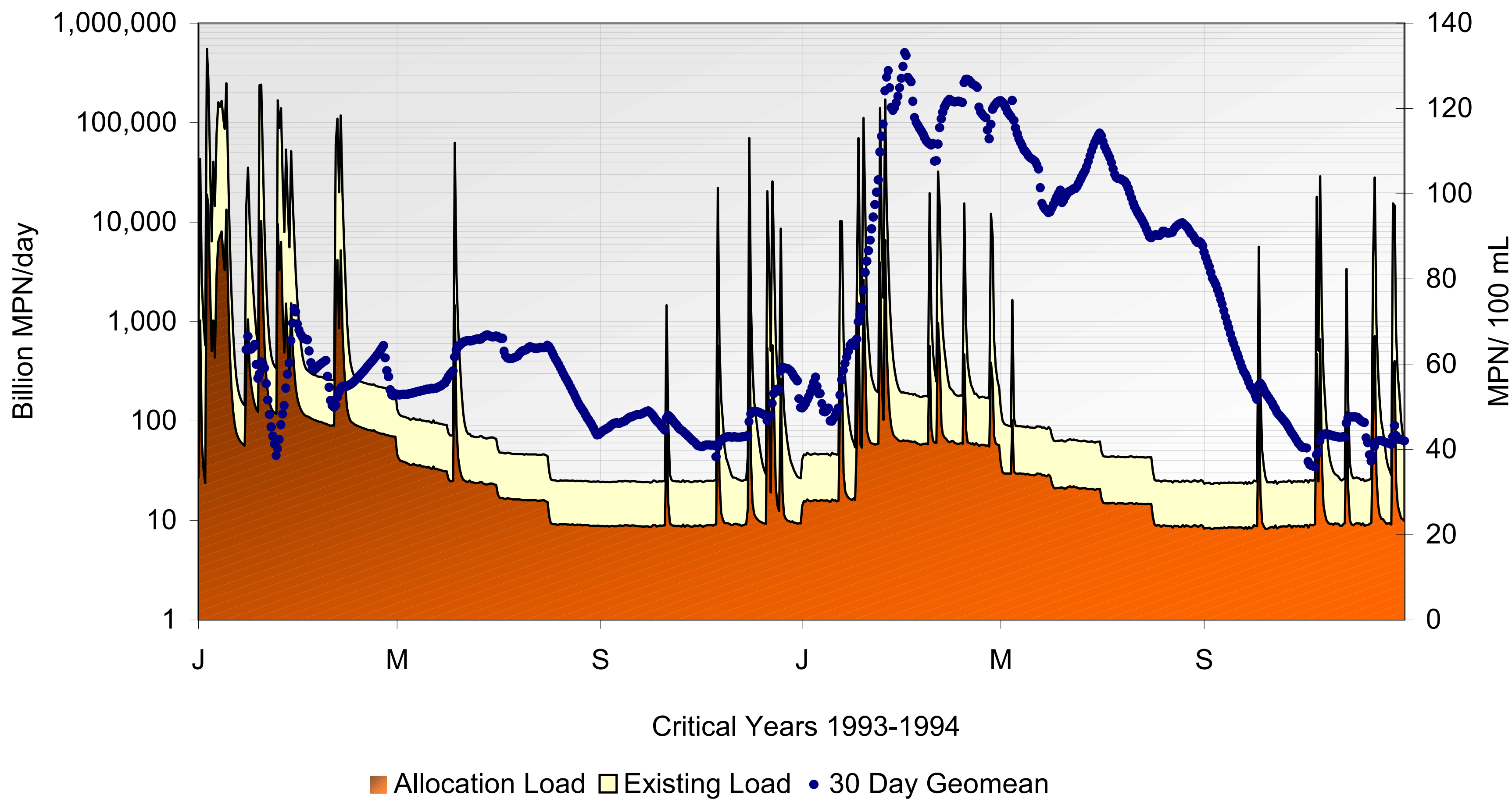
Appendix 4 - Allocations and Predicted 30-Day Running Geometric Mean Compliance

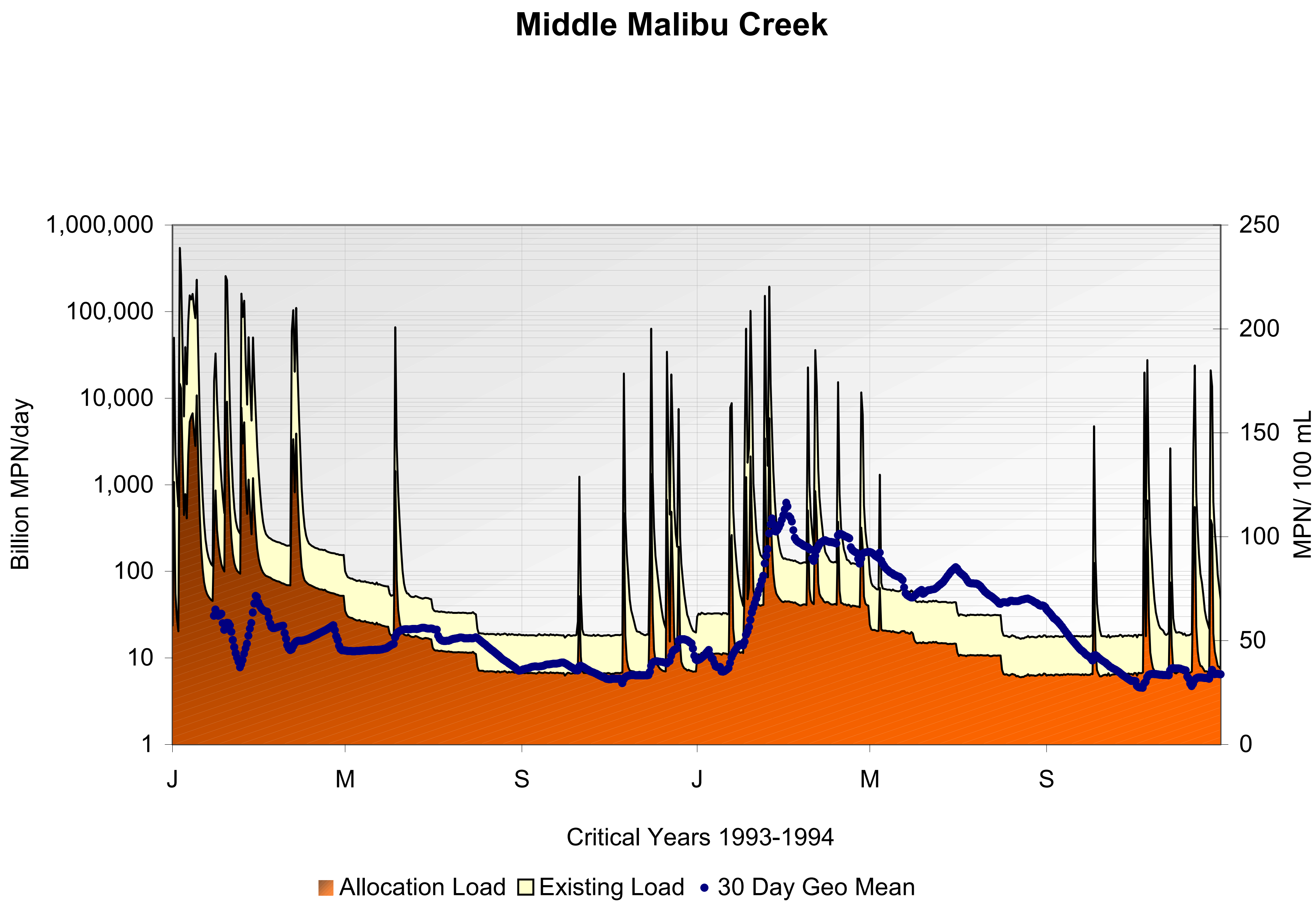


Malibu Lagoon - Estuary
1,000,000
100,000
10,000
1,000
100
10
1
Billion MPN/day
400
350
300
250
200
150
100
50
0
MPN/ 100 mL
J
A
J
O
F
M
A
D
Critical Years 1993-1994
Allocation Load
Existing Load
30 Day Geomean


Malibu Lagoon - subwatershed
1,000,000
100,000
10,000
1,000
100
10
1
Billion MPN/day
160
140
120
100
80
60
40
20
0
MPN/ 100 mL
J
M
S
J
M
S
Critical Years 1993-1994
Allocation Load
Existing Load
30 day Geo Mean

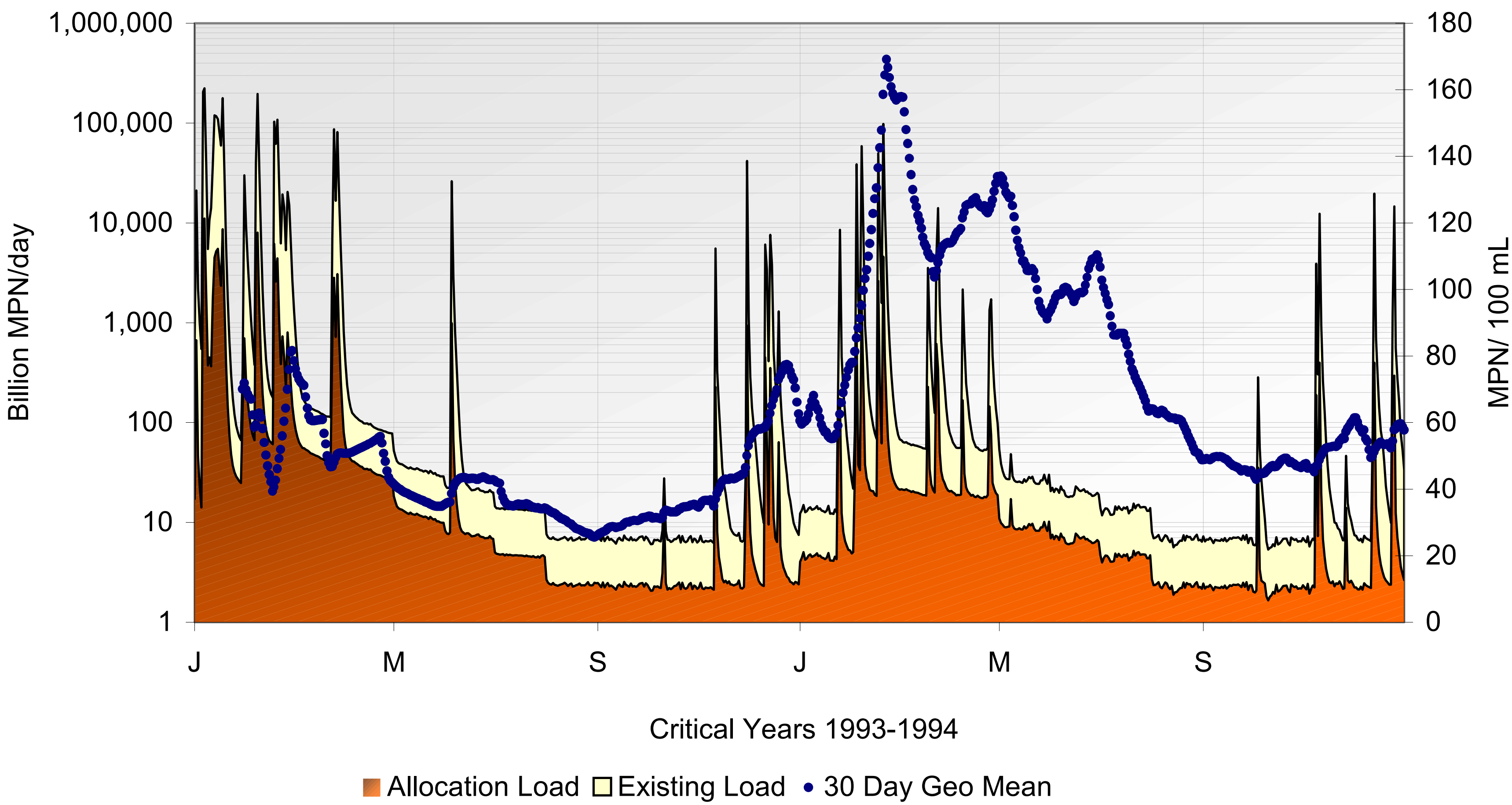
Lower Malibu Creek



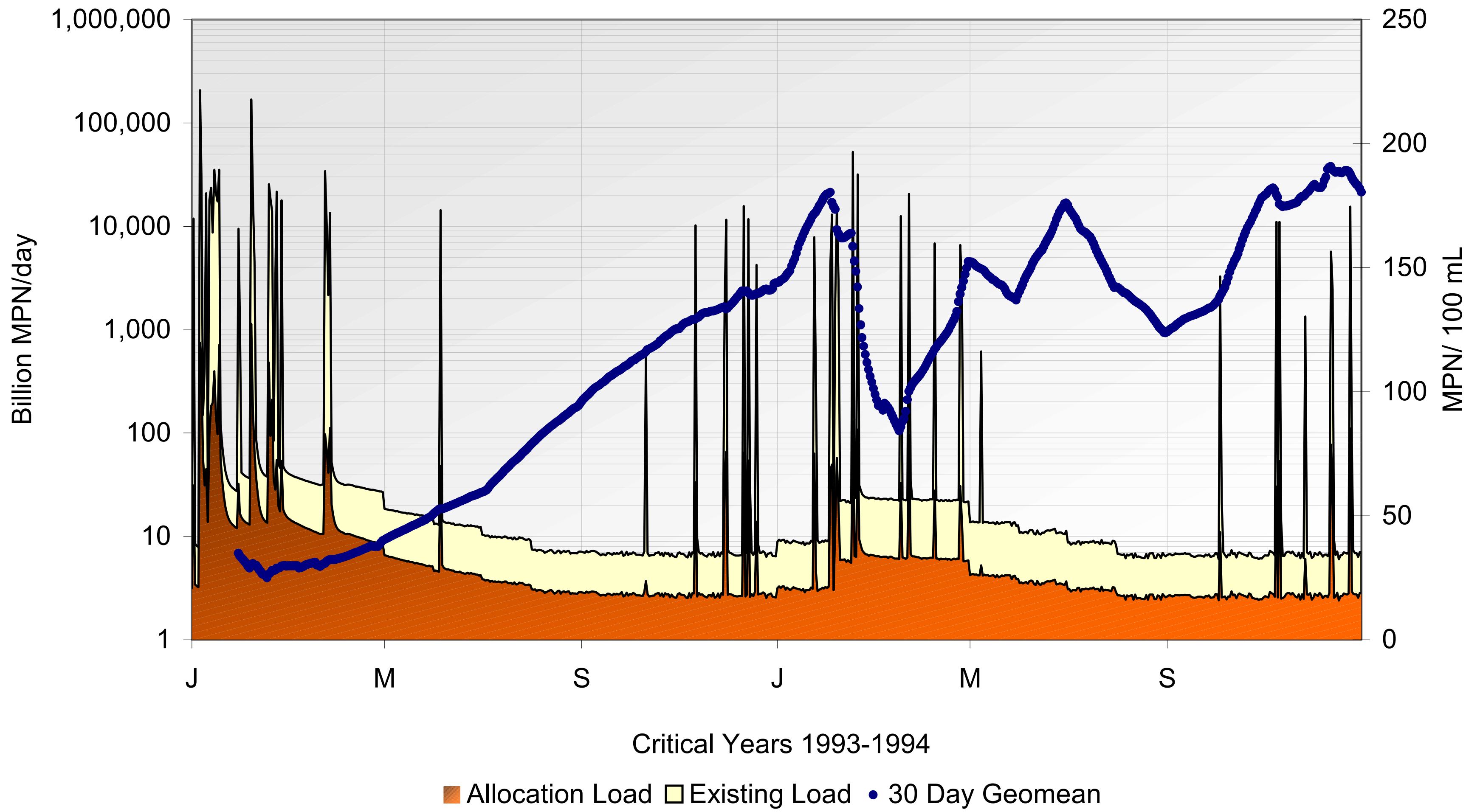


Middle Malibu Creek
1,000,000
100,000
10,000
1,000
100
10
1
Billion MPN/day
250
200
150
100
50
0
MPN/ 100 mL
J
M
S
J
M
S
Critical Years 1993-1994
Allocation Load
Existing Load
30 Day Geo Mean

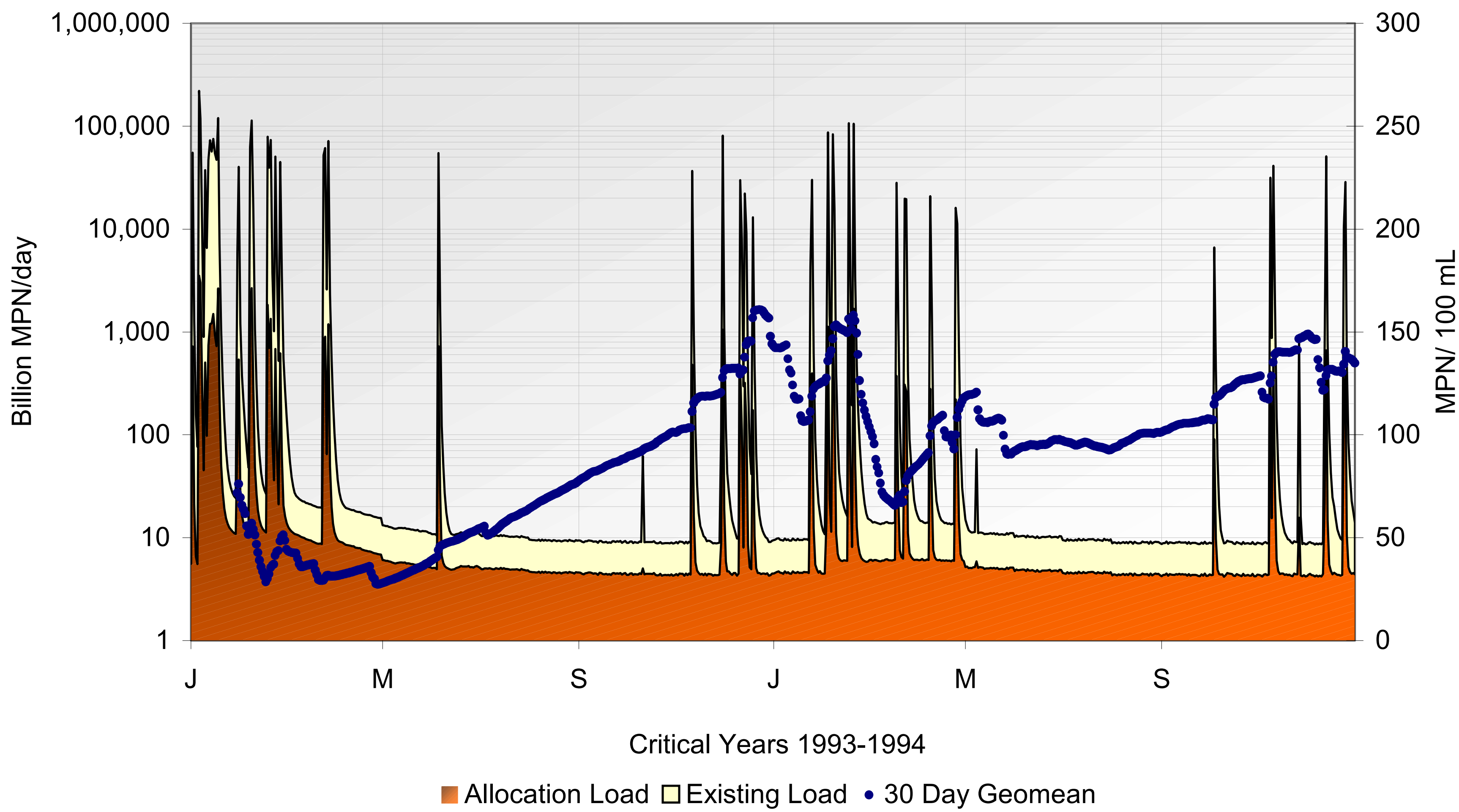
Upper Malibu Creek



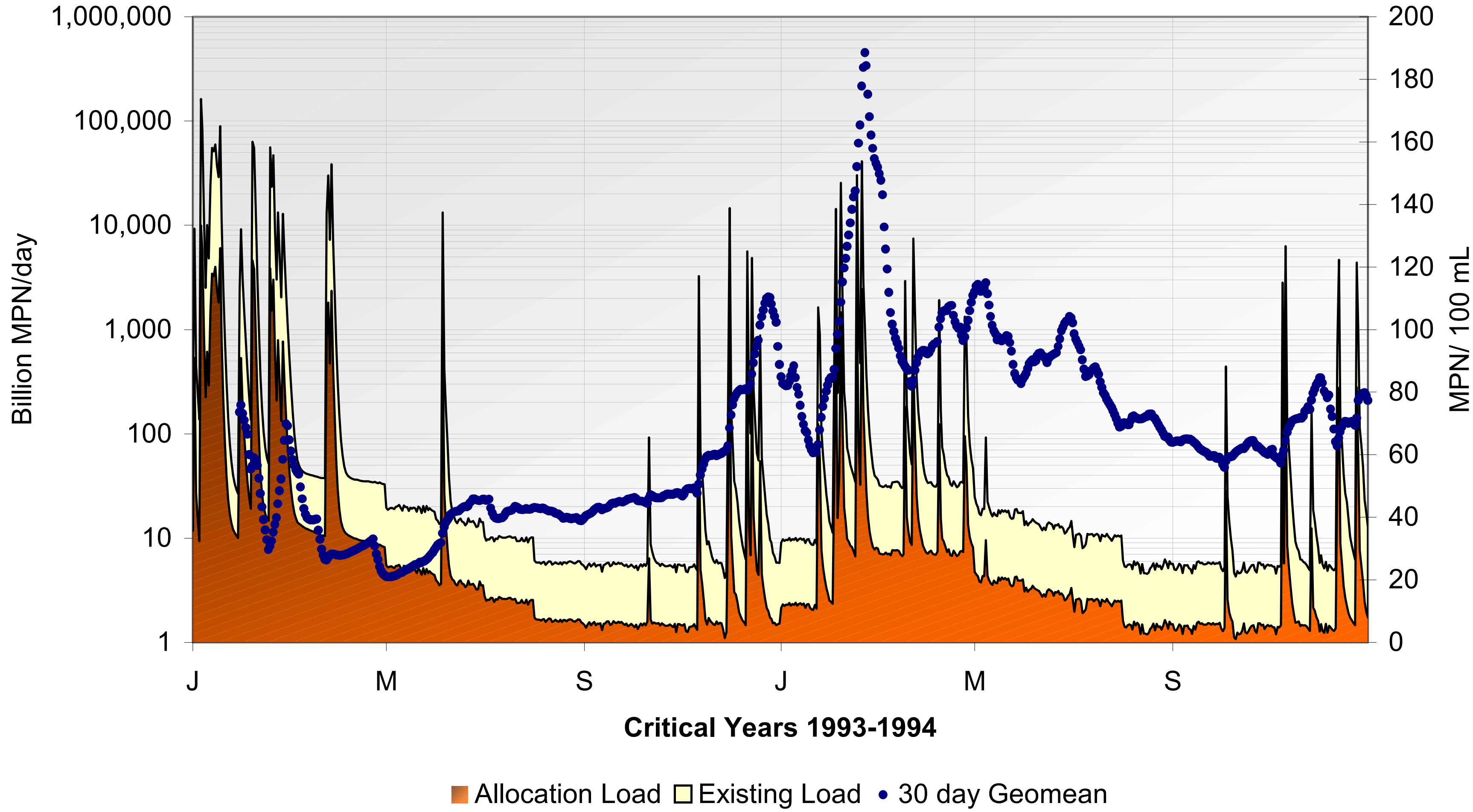
Lower Las Virgenes Creek



Lower Medea Creek



Triunfo Creek



Appendix 5 - Allocation Loads by Subwatershed

Potrero Canyon Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	1.94E+13	1.08E+12
High/Med. Density Residential	2.98E+14	1.68E+13
Low Density Residential	2.12E+12	1.22E+11
Rural Residential	3.32E+11	1.94E+10
Agriculture/Livestock	9.50E+10	9.46E+10
Vacant	5.12E+11	5.06E+11
Chapparral/Sage Scrub	1.24E+12	1.23E+12
Grasslands	1.06E+11	1.04E+11
Woodlands	1.85E+09	1.52E+09
Imported Water	7.37E+11	7.37E+11
Total	**3.22E+14**	**2.07E+13**

Hidden Valley Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	1.70E+13	9.44E+11
High/Med. Density Residential	4.66E+12	2.64E+11
Low Density Residential	3.73E+13	2.14E+12
Rural Residential	1.58E+13	9.22E+11
Agriculture/Livestock	2.87E+13	2.87E+13
Vacant	5.16E+11	5.11E+11
Chapparral/Sage Scrub	6.29E+12	6.22E+12
Grasslands	1.93E+11	1.89E+11
Woodlands	1.37E+11	1.13E+11
Septic Systems	2.54E+13	1.14E+13
Total	**1.36E+14**	**5.14E+13**

Upper Lindero Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	9.97E+13	1.21E+12
High/Med. Density Residential	3.54E+14	4.34E+12
Low Density Residential	1.10E+13	1.37E+11
Vacant	1.52E+11	1.50E+11
Chapparral/Sage Scrub	4.65E+11	4.58E+11
Grasslands	1.18E+11	1.15E+11
Woodlands	1.81E+09	1.29E+09
Imported Water	5.80E+11	5.80E+11
Total	**4.66E+14**	**6.99E+12**

Fecal Coliform in the Westlake Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	9.47E+14	5.26E+13
High/Med. Density Residential	6.45E+14	3.65E+13
Low Density Residential	5.69E+12	3.28E+11
Vacant	3.86E+11	3.82E+11
Chapparral/Sage Scrub	1.27E+12	1.26E+12
Grasslands	3.03E+11	2.98E+11
Woodlands	1.35E+10	1.12E+10
Septic Systems	2.44E+12	2.44E+12
Imported Water	1.50E+12	1.50E+12
Total	**1.60E+15**	**9.53E+13**

Upper Medea Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	2.30E+14	2.79E+12
High/Med. Density Residential	7.04E+14	8.63E+12
Low Density Residential	1.01E+13	1.25E+11
Vacant	3.33E+10	3.29E+10
Chapparral/Sage Scrub	7.98E+11	7.86E+11
Grasslands	6.01E+10	5.86E+10
Woodlands	1.39E+10	9.84E+09
Effluent Irrigation	9.94E+08	9.94E+08
Imported Water	7.59E+11	7.59E+11
Total	**9.46E+14**	**1.32E+13**

Lower Lindero Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	2.50E+14	3.02E+12
High/Med. Density Residential	2.57E+14	3.15E+12
Low Density Residential	1.83E+12	2.27E+10
Rural Residential	1.19E+11	1.51E+09
Vacant	2.77E+09	2.73E+09
Chapparral/Sage Scrub	4.38E+11	4.33E+11
Grasslands	4.58E+10	4.48E+10
Woodlands	9.55E+09	7.27E+09
Imported Water	2.90E+11	2.90E+11
Total	**5.10E+14**	**6.97E+12**

Lower Medea Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	7.26E+12	8.74E+10
Low Density Residential	4.79E+13	5.96E+11
Rural Residential	3.05E+12	0.00E+00
Agriculture/Livestock	3.34E+11	3.33E+11
Vacant	1.31E+10	1.29E+10
Chapparral/Sage Scrub	1.39E+12	1.37E+12
Grasslands	1.23E+11	1.21E+11
Woodlands	7.94E+09	6.52E+09
Septic Systems	4.48E+12	2.24E+12
Effluent Irrigation	5.48E+09	5.48E+09
Imported Water	1.56E+11	1.56E+11
Total	**6.47E+13**	**4.93E+12**

Cheeseboro Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	6.32E+13	7.65E+11
Agriculture/Livestock	4.32E+08	3.95E+08
Chapparral/Sage Scrub	6.55E+11	6.45E+11
Grasslands	1.33E+11	1.29E+11
Woodlands	2.34E+10	1.68E+10
Total	**6.40E+13**	**1.56E+12**

Palo Comado Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	2.06E+14	2.50E+12
High/Med. Density Residential	2.13E+13	2.61E+11
Low Density Residential	5.67E+13	7.03E+11
Agriculture/Livestock	8.99E+10	8.94E+10
Chapparral/Sage Scrub	9.40E+11	9.26E+11
Grasslands	1.22E+11	1.19E+11
Woodlands	2.39E+10	1.71E+10
Imported Water	2.46E+11	2.46E+11
Total	**2.85E+14**	**4.86E+12**

Upper Las Virgenes Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	7.43E+13	6.92E+10
High/Med. Density Residential	1.45E+14	1.37E+11
Low Density Residential	1.02E+13	9.70E+09
Agriculture/Livestock	1.31E+12	1.31E+12
Vacant	1.97E+11	1.95E+11
Chapparral/Sage Scrub	2.07E+12	2.04E+12
Grasslands	5.62E+11	5.48E+11
Woodlands	5.84E+10	4.21E+10
Imported Water	3.80E+11	3.80E+11
Total	**2.34E+14**	**4.72E+12**

Upper Malibu Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Low Density Residential	2.69E+12	2.59E+12
Rural Residential	3.52E+12	3.42E+12
Chapparral/Sage Scrub	3.28E+12	3.24E+12
Grasslands	8.75E+10	8.61E+10
Woodlands	1.22E+11	1.05E+11
Septic Systems	3.87E+12	1.93E+12
Total	**1.36E+13**	**1.14E+13**

Triunfo Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	1.70E+13	9.45E+11
High/Med. Density Residential	3.77E+13	2.13E+12
Low Density Residential	4.73E+13	2.72E+12
Rural Residential	2.88E+13	1.67E+12
Agriculture/Livestock	5.05E+11	5.03E+11
Vacant	3.27E+10	3.23E+10
Chapparral/Sage Scrub	5.20E+12	5.14E+12
Grasslands	3.15E+10	3.10E+10
Woodlands	1.00E+11	8.32E+10
Septic Systems	3.34E+13	8.34E+12
Imported Water	1.56E+11	1.56E+11
Total	**1.70E+14**	**2.18E+13**

Stokes Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	4.13E+13	5.72E+12
Low Density Residential	1.12E+13	1.62E+12
Rural Residential	2.66E+12	3.88E+11
Agriculture/Livestock	2.02E+11	2.00E+11
Vacant	5.08E+10	5.04E+10
Chapparral/Sage Scrub	2.62E+12	2.60E+12
Grasslands	1.60E+11	1.57E+11
Woodlands	4.94E+10	4.22E+10
Septic Systems	4.94E+10	1.73E+12
Total	**5.83E+13**	**1.25E+13**

Lower Las Virgenes Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	4.67E+14	5.62E+13
High/Med. Density Residential	2.34E+14	2.86E+13
Low Density Residential	6.54E+12	8.15E+11
Rural Residential	1.30E+12	1.64E+11
Agriculture/Livestock	2.69E+10	2.53E+10
Vacant	1.60E+10	1.59E+10
Chapparral/Sage Scrub	2.30E+12	2.28E+12
Grasslands	6.07E+11	5.96E+11
Woodlands	5.12E+10	4.25E+10
Septic Systems	2.04E+12	5.09E+11
Effluent Irrigation	3.73E+09	3.73E+09
Imported Water	4.02E+11	4.02E+11
Total	**7.14E+14**	**8.97E+13**

Cold Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	3.80E+12	4.56E+11
Low Density Residential	6.42E+13	8.01E+12
Rural Residential	3.80E+13	4.81E+12
Agriculture/Livestock	6.21E+11	6.20E+11
Vacant	3.32E+10	3.29E+10
Chapparral/Sage Scrub	5.09E+12	5.04E+12
Grasslands	1.87E+08	1.84E+08
Woodlands	4.98E+10	4.35E+10
Septic Systems	1.22E+13	6.11E+12
Imported Water	1.25E+10	1.25E+10
Total	**1.24E+14**	**2.51E+13**

Middle Malibu Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	1.01E+13	1.87E+12
Low Density Residential	4.97E+12	9.54E+11
Rural Residential	3.64E+12	7.08E+11
Agriculture/Livestock	1.70E+11	1.70E+11
Chapparral/Sage Scrub	1.25E+12	1.24E+12
Grasslands	3.28E+09	3.23E+09
Woodlands	1.14E+11	9.95E+10
Septic Systems	2.04E+12	1.02E+12
Effluent Irrigation	1.47E+09	1.47E+09
Tapia Discharge	5.92E+10	5.92E+10
Total	**2.24E+13**	**6.12E+12**

Lower Malibu Creek Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	1.23E+12	1.48E+11
Low Density Residential	2.55E+11	3.20E+10
Rural Residential	2.74E+11	3.45E+10
Agriculture/Livestock	4.27E+09	4.07E+09
Chapparral/Sage Scrub	2.25E+12	2.23E+12
Grasslands	2.71E+10	2.66E+10
Woodlands	2.48E+10	2.12E+10
Septic Systems	2.04E+11	1.02E+11
Total	**4.27E+12**	**2.60E+12**

Malibu Lagoon Watershed

Source Category	Existing Fecal Coliform Loads (no/yr)	Fecal Coliform Allocation (no./yr)
Commercial/Industrial	9.70E+13	4.51E+11
High/Med. Density Residential	7.15E+12	3.34E+10
Low Density Residential	2.45E+13	1.15E+11
Agriculture/Livestock	1.10E+11	1.09E+11
Vacant	4.59E+09	4.22E+09
Chapparral/Sage Scrub	1.48E+11	1.46E+11
Grasslands	1.19E+09	1.10E+09
Woodlands	2.29E+09	1.59E+09
Septic Systems	1.58E+14	1.56E+14
Lagoon Drains	1.75E+10	8.76E+08
Birds	4.95E+14	4.95E+14
Tidal Inflow	2.44E+13	2.44E+13
Total	**8.06E+14**	**6.76E+14**

Appendix 6 - Modular Treatment Systems Cost

Storm Treat Systems Sizing Worksheet

Note: Enter data in the bolded rows only (marked "Enter"); all other parameters are calculated.

Project Engineer:		
Project Location:		
Enter Impervious Area to be Treated:	**1.00**	**acres**
Enter Design or Local Mean Storm Event:	**1.00**	**inches**
Enter Design or Mean Storm Duration:	**12**	**hours**
Water Volume Requiring Treatment: (Calculated)	27225	gallons
Treated Discharge Rate (Recommended Average): (Given)*	1.00	gal/min
Water Residence Time in STS Unit: (Calculated)	0.97	days
Volume Treated During Storm per Unit: (Calculated)	720	gallons
Static Volume of Each STS Unit: (Given)	1390	gallons
Volume Entering Unit During Storm (calculated)	2110	gallons
Number of Storm Treat Units Required: (Calculated)	4	units
Volume of Detention Required: (Calculated)	18785	gallons
Volume of Detention Required: (Calculated)	2505	cuft
Water Residence Time in Detention: (Calculated)	3.26	days
Total Water Residence Time in Treatment System: (Calculated)	4.73	days
If Detention Volume is Known:		
Enter Preliminary Detention Storage Volume Available:**	**30000**	**gallons**
Volume of Detention Required: (Calculated)	4000	cuft
Number of Storm Treat Tanks Required (w/detention): (Calculated)	1	units
Water Residence Time in Detention: (Calculated)	0.0	days

$6,300 cost per unit
5440 acres to treat
$34,272,000 total cost

* Performance of the STS System has been verified up to a maximum flow rate of 1.00 gpm.
** Include catch/detention basins, pipe(s) between basin(s) and STS Unit(s).

Appendix 7 - Heal the Bay's Water Quality Monitoring Data