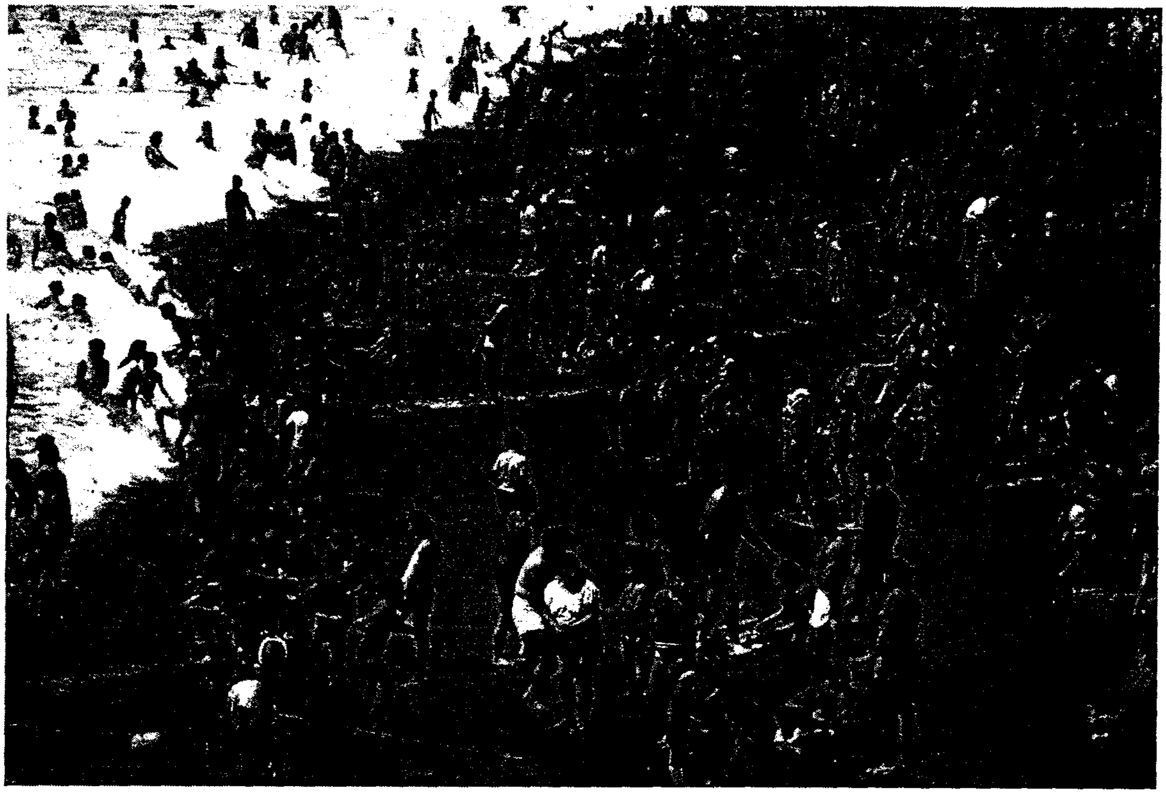
Draft

Total Maximum Daily Load to Reduce Bacterial Indicator Densities at Santa Monica Bay Beaches



Prepared by
California Regional Water Quality Control Board, Los Angeles Region

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Santa Monica Bay Beaches Bacteria TMDL

Draft – November 8, 2001

1 Introduction

This document covers the required elements of the Total Maximum Daily Load (TMDL) for bacteria at Santa Monica Bay beaches (SMB beaches) as well as providing a summary of some of the supporting technical analysis used in the development of the TMDL by the California Regional Water Quality Control Board, Los Angeles Region (Regional Board). The goal of this TMDL is to determine and set forth measures needed to prevent impairment of water quality due to bacteria for SMB beaches.[1] This TMDL is based on extensive information from other entities concerning bacteriological water quality at SMB beaches as well as an intensive wet weather sampling and modeling effort undertaken specifically to support the development of this and other TMDLs.

The TMDL has been prepared pursuant to state and federal requirements to preserve and enhance water quality in Santa Monica Bay and for the benefit of the 55 million beachgoers that visit the SMB beaches each year (Los Angeles County Fire Department, Lifeguard Operations, 2001). At stake is the health of swimmers and surfers and sizeable revenues to the local economy. Visitors to SMB beaches spend approximately $1.7 billion annually (Hanemann *et al.*, 2001).

What follows is a brief overview of the beaches included in this TMDL and the basis for their inclusion, the geographical setting, and the regulatory requirements for preparing this TMDL.

Santa Monica Bay is the major receiving water for one of the largest population centers in the United States. The principal geographic features that define its extent are Point Dume to the northwest and the Palos Verdes Peninsula to the southeast as depicted in Figure 1. For the

[1] Bacteria can cause disease in and of itself, but is also used as an indicator of the likely presence of other disease-causing pathogens, such as viruses. Viruses are the principal agent of waterborne diseases throughout the world (National Research Council, 1999).

purposes of this report, the Regional Board is concerned with the beaches from the Los Angeles/Ventura county line, to the northwest, to Outer Cabrillo Beach, just south of the Palos Verdes Peninsula. This area of concern covers approximately 55 miles of shoreline.

This TMDL includes 44 beaches along Santa Monica Bay. These beaches were listed on the state's 1998 303(d) list as impaired due to bacteria for two reasons – the total and/or fecal coliform water quality standards were exceeded based on shoreline monitoring data or there were one or more beach closures during the period assessed.

Fourteen of the 44 beaches on the 1998 303(d) list were listed due to exceedances of total and/or fecal coliform water quality standards (LARWQCB, 1996). (See Table 1 and Figures 2-4.) The assessment of these beaches was conducted during the 1996 regional water quality assessment (WQA). In the 1996 WQA, beaches were listed as impaired due to bacteria if, for the entire data set: (1) the fecal coliform standard of 400 organisms per 100 ml was exceeded in more than 15% of samples and/or (2) the total coliform standard of 10,000 organisms per 100 ml was exceeded in more than 20% of samples.[2]

In addition to the beaches above, four storm drains that discharge to SMB beaches are listed on the 1998 303(d) list as impaired due to coliform: Santa Monica Canyon; Ashland Avenue Drain; Sepulveda Canyon[3] and Pico Kenter Drain.

In addition, 42 beaches are listed on the 1998 303(d) list as impaired due to beach closures (LARWQCB, 1996). (See Table 2 and Figures 5-7.) Twelve of these are listed for both beach

[2] It should be noted that while this was the assessment guideline used in 1996, the fecal coliform assessment guideline recommended by the U.S. EPA (1997) is that no more than 10% of samples should exceed the fecal coliform objective of 400 organisms per 100 ml. Furthermore, the Water Quality Control Plan for Ocean Waters of California (California Ocean Plan) states that not more than 20% of samples shall exceed a density of 1,000 total coliform per 100 ml and that no single sample shall exceed a density of 10,000 total coliform per 100 ml. The 10% threshold is used in section 2.3 (below), which reviews more recent data to confirm water quality impairments due to bacteria.
[3] Sepulveda Canyon is a "tributary" to Ballona Creek, and as such will be dealt with in detail as part of the Ballona Creek Bacteria TMDL.

closures and coliform as indicated by a "*" in Table 2.[4] Nine more of these have been identified as exceeding water quality standards based on more recent data collected or analyzed by other entities, including the City of Los Angeles, Heal the Bay, and Santa Monica BayKeeper. These nine include: Nicholas Canyon Beach, Zuma Beach, Escondido Beach, Puerco Beach, Malibu Beach, Castlerock Beach, Hermosa Beach, Malaga Cove Beach, and Long Point. (See Table 2.)

The majority of beach closures are due to the release of inadequately treated sewage. Closures may also result from oil spills, vessel spills and persistent elevated bacteria densities.[5] These beaches were originally listed in 1996 because there were one or more beach closures during the period assessed. Sewage spills are primarily addressed through enforcement actions such as Administrative Civil Liability (ACL) fines, Cease and Desist Orders (CDOs), and litigation.[6]

1.1 Geographical Setting

The Santa Monica Bay watershed is 1,072 km^2 (414 mi^2) as shown in Figure 1 and has an estimated population of 1,950,265 based on the 2000 U.S. Census. Open space represents the primary land use in the watershed (55%), while high-density residential areas represent the largest developed area (25% of the total watershed). Low-density residential constitutes 5% of the land area. Commercial, industrial and mixed urban areas cover 10%. The remaining 5% of land area is covered by transportation (1.7%), educational institutions (1.6%), agriculture (0.8%), recreational uses (0.8%), public facilities and military installations (0.2%), and water (0.4%).

[4] It should be noted that some of the beaches listed as impaired for beach closures do not have shoreline monitoring stations; therefore, they should be considered unassessed in terms of actual monitoring data. These include Robert H. Meyer Beach, Sea Level Beach, Point Dume Beach, Carbon Beach, La Costa Beach, Las Tunas Beach, and many of the beaches along the Palos Verdes Peninsula.

[5] Beach postings on the other hand may result from routine monitoring that shows elevated bacteria densities at a particular sampling location.

[6] For example, the Los Angeles Regional Board is a plaintiff in a lawsuit against the City of Los Angeles regarding sewage spills (*United States, et al. v. City of Los Angeles*, U.S.D.C. Cent. Dist. Cal., CV No. 01-00191).

While this provides an overview of the watershed as a whole, land use is in fact highly differentiated within the watershed. For the purposes of this TMDL, the Regional Board has divided the watershed into 28 subwatersheds. The two largest of these, the Malibu Creek and Ballona Creek subwatersheds, are further divided into 6 and 7 subdrainages, respectively. (Figure 1) Subwatersheds in the northern part of the Bay (northwest of Santa Monica subwatershed) have on average 85% of their land area in open space. Subwatersheds in the central and southern portion of the Bay (southeast of Santa Monica Canyon subwatershed) have on average 16% of their area in open space. (See Table 3 and Figures 8-10 for land use breakdowns by subwatershed.)

1.2 Regulatory Background

The California Water Quality Control Plan, Los Angeles Region (Basin Plan) sets water quality standards for the Los Angeles Region, which include beneficial uses for surface and ground water, numeric and narrative objectives necessary to support beneficial uses, and the state's antidegradation policy, and describes implementation programs to protect all waters in the region. The Basin Plan establishes water quality control plans and policies for the implementation of the Porter-Cologne Water Quality Act within the Los Angeles Region and, along with the Water Quality Control Plan for Ocean Waters of California (California Ocean Plan), serves as the State Water Quality Control Plan applicable to Santa Monica Bay, as required pursuant to the federal Clean Water Act (CWA).

Section 303(d)(1)(A) of the CWA requires each state to conduct a biennial assessment of its waters, and identify those waters that are not achieving water quality standards. The resulting list is referred to as the 303(d) list. The CWA also requires states to establish a priority ranking for waters on the 303(d) list of impaired waters and to develop and implement TMDLs for these waters.

A TMDL specifies the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and allocates the acceptable pollutant load to point and nonpoint sources. 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 U.S. Environmental Protection Agency guidance

(U.S. EPA, 1991). By law, a TMDL is defined as the "sum of the individual waste load allocations for point sources and load allocations for nonpoint sources and natural background" (40 CFR 130.2) such that the capacity of the waterbody to assimilate pollutant loads (the Loading Capacity) is not exceeded. The Regional Board is also required to develop a TMDL taking into account seasonal variations and including a margin of safety to address uncertainty in the analysis (40 CFR 130.7(c)(1)). Finally, states must develop water quality management plans to implement the TMDL (40 CFR 130.6).

The U.S. EPA has oversight authority for the 303(d) program and is required to review and either approve or disapprove the state's 303(d) list and each TMDL developed by the state. If the state fails to develop a TMDL in a timely manner or if the U.S. EPA disapproves a TMDL submitted by a state, EPA is required to establish a TMDL for that waterbody (40 CFR 130.7(d)(2)).

As part of its 1996 and 1998 regional water quality assessments, the Regional Board identified over 700 waterbody-pollutant combinations in the Los Angeles Region where TMDLs would be required (LARWQCB, 1996, 1998). A 13-year schedule for development of TMDLs in the Los Angeles Region was established in a consent decree (*Heal the Bay Inc., et al. v. Browner, et al.* C 98-4825 SBA) approved on March 22, 1999.

For the purpose of scheduling TMDL development, the decree combined the over 700 waterbody-pollutant combinations into 92 TMDL analytical units. Analytical unit 48 consists of beaches and key storm drains/channels to Santa Monica Bay with impairments related to pathogens. (The beaches included in TMDL analytical unit 48 are listed in Tables 1 and 2.) The consent decree also prescribed schedules for certain TMDLs, and according to this schedule, a bacteria TMDL for SMB beaches is to be adopted by March 2002.

2 Problem Identification

This section briefly discusses the health risks associated with swimming in ocean water contaminated with human sewage and other sources of pathogens. It is these risks to public health that the Regional Board intends to reduce through the development and implementation of the TMDL. Second, the section describes the applicable water quality standards and provides background on their development. Finally, the section presents more recent data to support the original 303(d) listings made in 1996.

2.1 Health Risks of Swimming in Water Contaminated with Bacteria

Swimming in marine waters contaminated with human sewage has long been associated with adverse health effects (Favero, 1985). The most commonly observed health effect associated with recreational water use is gastroenteritis with symptoms including vomiting, fever, stomach pain and diarrhea. Other commonly reported health effects include eye, ear, and skin infections, and respiratory disease.

Since the 1950s, numerous epidemiological studies have been conducted around the world to investigate the possible links between swimming in fecal-contaminated waters and health risks. Recently, the World Health Organization completed a comprehensive review of 22 published epidemiological studies, 16 of which were conducted in marine waters (Pruss, 1998). Fourteen of the 16 marine water studies found a significant association between bacteria indicator densities and the rate of certain symptoms or groups of symptoms. Most significant associations were found for gastrointestinal illnesses. In a few studies, similar associations were found for respiratory, eye, ear, nose, throat, and skin symptoms. For marine waters, the bacteria indicators that correlated best with health effects were enterococci and fecal streptococci. Other indicators showing correlations were fecal coliform and staphylococci. The studies compel the conclusion that there is a causal relationship between gastrointestinal symptoms and recreational water quality, as measured by bacteria indicator densities.

2.1.1 Santa Monica Bay Epidemiological Study

One of the studies reviewed in Pruss (1998) was the Santa Monica Bay Restoration Project epidemiological study conducted in 1995. This was the first epidemiological study to specifically evaluate the increased health risks to people who swam in marine waters contaminated by *urban runoff* (Haile, *et al.*, 1996, 1999). The results of the Santa Monica Bay study provided much of the basis for the current recreational water quality standards for marine waters in California (e.g., standards developed by the California Department of

Health Services in response to Assembly Bill 411 (1997 Stats. 765)). The study collected health effects data from 11,793 individuals visiting three SMB beaches, including Santa Monica Beach, Will Rogers State Beach, and Surfrider Beach. Bacteria indicators measured in the study included total coliform, fecal coliform, *E. coli*, and enterococcus.

The epidemiological study was unique in two ways. First, the source of bacteria was not effluent from a sewage treatment plant, but instead urban runoff discharged from storm drains. Second, the study compared people swimming near a flowing storm drain to other people swimming 400 meters away from the drain. Positive associations were observed between adverse health effects and the distance an individual swam from the drain. The number of excess cases of illness attributable to swimming at the drain reached into the hundreds per 10,000 exposed participants, suggesting that significant numbers of swimmers in the water near flowing storm drains are subject to increased health risks. In addition, an increased health risk was associated with increasing densities of bacteria.

2.2 Water Quality Standards

The Basin Plan designates beneficial uses for waterbodies in the Los Angeles Region. These uses are recognized as existing (E), potential (P), or intermittent (I) uses. All beneficial uses must be protected. SMB beaches have a variety of beneficial use designations including Navigation, Contact and Non-contact Recreation, Commercial and Sport Fishing, Marine Habitat, Wildlife Habitat, Spawning, Reproduction and/or Early Development, and Shellfish Harvesting. However, the focus of this TMDL is on the Water Contact Recreation (REC-1) beneficial use, which is designated as an existing use for all SMB beaches.[7]

The REC-1 beneficial use is defined in the Basin Plan as "[U]ses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs" (Basin Plan, p. 2-2). The Basin Plan and the California Ocean Plan, the provisions of which are included in the Basin Plan by reference, contain bacteria water quality objectives to protect the REC-1 use. In the current plans, total and fecal coliform bacteria are used as indicators of the likely presence of disease-causing pathogens in surface waters.

On October 25, 2001, the Regional Board adopted a Basin Plan amendment updating the bacteria objectives for waters designated as REC-1 (Regional Board Resolution 01-018, see Appendix A). The revised objectives include geometric mean limits and single sample limits for four bacterial indicators, including total coliform, fecal coliform, the fecal-to-total coliform ratio, and enterococcus.

The revised Basin Plan objectives for marine waters designated for Water Contact Recreation (REC-1) are as follows:

1. <u>Geometric Mean Limits</u>
a. Total coliform density shall not exceed 1,000/100 ml.
b. Fecal coliform density shall not exceed 200/100 ml.
c. Enterococcus density shall not exceed 35/100 ml.

2. <u>Single Sample Limits</u>
a. Total coliform density shall not exceed 10,000/100 ml.
b. Fecal coliform density shall not exceed 400/100 ml.
c. Enterococcus density shall not exceed 104/100 ml.
d. Total coliform density shall not exceed 1,000/100 ml, if the ratio of fecal-to-total coliform exceeds 0.1.

The revised objectives are consistent with current U.S. EPA guidance (1986), which recommends the use of enterococcus in marine water based on more recent epidemiological studies (LARWQCB, 2001; Cabelli, 1983). The revised objectives are also consistent with recent state law (California Code of Regulations, title 17, section 7958, which implements Assembly Bill 411 (1997 Stats. 765)), which was passed in large part due to the Santa Monica Bay epidemiological study described above. Assembly Bill 411 resulted in changes to California Department of Health Services' regulations for public beaches and public water

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[7] Protection of REC-1 (the water contact recreation use) will result in protection of REC-2 (the non-contact recreation use) as the water quality objective for fecal coliform to protect REC-2 is set at 10 times the REC-1 fecal coliform objective.

contact sports areas. These changes included (1) setting minimum protective bacteriological standards for waters adjacent to public beaches and public water contact sports areas based on four indicators (total coliform, fecal coliform, enterococcus, and the fecal-to-total coliform ratio) and (2) altering the requirements for monitoring, posting, and closing certain coastal beaches based on these four bacterial indicators. Finally, the changes are consistent with those being drafted for the California Ocean Plan (Linda O'Connell, State Water Resources Control Board, personal communication). See Table 4 for the revised water quality objectives for protection of marine waters designated as REC-1 adopted by the Regional Board on October 25, 2001.

2.3 Data Review

Santa Monica Bay beaches are some of the most comprehensively and intensively monitored in the nation. Four agencies contribute to this wealth of data. The City of Los Angeles Environmental Monitoring Division at the Hyperion Wastewater Treatment Plant (Hyperion) monitors 20 locations on a daily basis; the Los Angeles County Department of Health Services monitors 33 locations on a weekly basis; and the County Sanitation Districts of Los Angeles County (CSDLAC) monitors eight locations, six daily and two weekly. Approximately one-third of these locations are 25 to 50 yards upcoast or downcoast of the mouth of a storm drain or creek.

Analysis of these data has consistently shown that bacteria densities at many SMB beaches exceed REC-1 bacteria objectives during both dry and wet weather. In the 1996 WQA, the Regional Board evaluated total and fecal coliform monitoring data collected between 1988 and 1994 by the agencies listed above to determine whether a beach was impaired due to exceedances of the existing water quality objectives. The 1996 WQA supported the conclusion that many SMB beaches exceed the REC-1 bacteria objectives.

More recent shoreline monitoring data (1996-2001) collected by the City of Los Angeles, Environmental Monitoring Division, County Sanitation Districts of Los Angeles County, and the Los Angeles County Department of Health Services, and analyzed by Heal the Bay, is summarized in Table 5 and confirms many of the listing decisions made in 1996. On average, during wet weather, 43 of the 56 shoreline locations monitored exceeded at least one indicator more than 10% of sample days per year.[8] During the winter months (November through March), but excluding wet weather, this number drops to 16 of 56 locations. Finally, during summer months (April through October), only seven sites exceeded the standards more than 10% of sample days – Surfrider (two locations), Malibu Pier, Big Rock Beach, Santa Monica Canyon, Santa Monica Pier and Ashland storm drain.

In addition to the above analysis, several other entities have collected and analyzed shoreline bacteriological monitoring data for SMB beaches. First, Heal the Bay compiles and analyzes data collected by local health agencies throughout Southern California. It publishes its results monthly on the Internet and in an annual Beach Report Card (BRC). The BRC assigns each beach a grade from A to F, taking into consideration the frequency and magnitude of indicator threshold exceedances over a 28-day period.[9] Table 6 summarizes the annual BRC grades for SMB beaches for the period April 2000 through March 2001. The 2000-01 BRC also confirms the findings of the Regional Board's 1996 WQA with some additions. Specifically, beaches not listed as impaired due to coliform in the 1996 WQA, but which received an annual BRC grade of "C" or worse include: Nicholas Canyon, Zuma, Puerco, Malibu Pier, Hermosa Pier, Malaga Cove, and Long Point.

Second, two dry-weather assessments of shoreline bacterial water quality have been conducted by the City of Los Angeles and Heal the Bay at selected storm drains since the 1996 WQA. In both studies, samples were taken in the storm drain, the "mixing zone"[10] and at various distances from the storm drain. The results presented in Table 7 are for samples collected in the mixing zone. All locations exceeded at least one single sample objective in more than 10% of mixing zone samples, while seven of 10 locations exceeded all three single

[8] In this analysis, wet weather was defined as rainfall of 0.1 inch or more plus the 3 days following the rain event following the protocol used by the Los Angeles County Department of Health Services to post beaches during and after a rain event.
[9] The indicator thresholds used in the BRC are the same as those recently adopted by the Regional Board for marine waters designated as REC-1 and those proposed as targets in the TMDL, which include total coliform, fecal coliform, enterococcus, and a fecal-to-total coliform ratio.
[10] The mixing zone is the volume of water into which the storm drain or creek empties and the effluent from the storm drain initially mixes with the receiving water. In the context of this TMDL, the mixing zone is the point at which the TMDL numeric targets will apply and is the same as "point zero" and the "wave wash" described in section 3 (below).

sample objectives (total coliform, fecal coliform, and enterococcus) in more than 10% of samples.

Finally, in support of the TMDL, the Southern California Coastal Water Research Project (SCCWRP) conducted a 5-year (1995-99) retrospective evaluation of shoreline bacteria data (SCCWRP, 2001). Rather than examining the percentage of samples that exceeded the water quality objectives for a particular monitoring location, SCCWRP analyzed the percentage of shoreline mile-days that exceeded water quality objectives.[11] It should be noted that while examining exceedances in terms of shoreline mile-days provides insight into the frequency of exceedances, it does not shed light on the magnitude of exceedances.

SCCWRP's evaluation reached several conclusions about the nature of bacteria contamination along beaches. First, SCCWRP found that only 13% of shoreline mile-days exceeded bacteria objectives during the 5-year period. This result highlights the fact that during dry weather most beaches do not exceed water quality standards. Second, SCCWRP found that although rainstorms are relatively infrequent in Southern California, the extent of water quality exceedances during and immediately following wet weather was similar to that of dry weather. Only one-quarter of the samples were collected during wet weather, but approximately 40% of fecal coliform exceedances, 50% of enterococcus exceedances, and 65% of total coliform exceedances occurred during wet weather.

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[11] Shoreline mile-days are calculated as follows:

$$SMD = \frac{\sum_{i=1}^{n} s_i \times d_i \times 200}{\sum_{i=1}^{n} d_i \times 200}$$

Where:
SMD = proportion of shoreline mile-days that exceed a water quality threshold for a stratum (i.e., storm drain, open beach)
s_i = samples that exceed water quality threshold for indicator y (i.e., fecal coliform) for strata i
d_i = temporal weighting equivalent to the number of days until the next sampling event in strata i
200 = shoreline distance weighting (in meters)
The water quality objectives used in the evaluation are the single sample objectives recently adopted by the Regional Board and proposed as the numeric targets in the TMDL.

SCCWRP's analysis also enables the Regional Board to rank sites, and groups of sites, in terms of their relative contribution to the total number of shoreline mile-days that exceed the bacteria objectives. For both wet and dry weather, 53% of exceedances occurred near storm drains, while 40% occurred on sandy beaches. (It should be noted that the influence of storm drains may have been underestimated in the analysis, since sampling sites are located 50 meters north or south of storm drains and water quality impairments may have occurred at less than 50 meters.[12])

Five freshwater outlets/storm drains (Malibu Creek, Santa Monica Pier, Santa Monica Canyon, Pico-Kenter, and Topanga Point) accounted for over half of the drain-related exceedances during dry weather. Exceedances were more evenly spread across storm drain-impacted beaches during wet weather. For open beach sites, the top five most contaminated sites (Surfrider, Malibu Pier, Big Rock Beach, Las Flores Beach, and Paradise Cove) accounted for 37% of exceedances during dry weather, but only 27% of exceedances in wet weather. See Appendix B for the complete retrospective evaluation published in SCCWRP's 2000-01 Annual Report.

In summary, most of the monitored beaches in Santa Monica Bay have been identified by the Regional Board in its 1996 WQA or more recently by other entities as impaired due to exceedances of bacteriological water quality standards.

3 Numeric Target

The TMDL will have a multi-part numeric target based on the bacteria objectives for marine waters designated for contact recreation (REC-1), specified in the Basin Plan amendment adopted by the Regional Board on October 25, 2001. As stated earlier, these objectives are consistent with those specified in the California Code of Regulations, title 17, section 7958 "Bacteriological Standards" and "Ambient Water Quality for Bacteria – 1986" (U.S. EPA,

[12] A recent Southern California Bight-wide summer shoreline bacteriological survey showed that 90% of all exceedances of health standards observed during the 5-week study occurred near a flowing storm drain (Noble *et al.* 1999).

1986). The objectives include four bacterial indicators: total coliform, fecal coliform, enterococcus, and the fecal-to-total coliform ratio. (See Table 4.)

For the TMDL, the numeric targets will be the same as the recently adopted Basin Plan objectives, as measured at point zero (also referred to as the "mixing zone" or "wave wash").[13] For beaches without freshwater outlets (i.e., storm drains or coastal creeks), the targets will apply at existing or new monitoring sites, with samples taken at ankle depth. These targets apply during both dry and wet weather, since there is water contact recreation throughout the year, including during wet weather, at the beaches. The geometric mean targets are based on a rolling 30-day period, and may not be exceeded at any time.

For the single sample targets, the Regional Board has chosen to set an allowable number of exceedance days for each shoreline monitoring site based on one of two criteria. The two criteria require that: (1) bacteriological water quality at any site is *at least* as good as at a designated reference site and (2) there is no degradation of existing shoreline bacteriological water quality if historical water quality at a particular site is *better than* the designated reference site. Applying these two criteria allows the Regional Board to avoid imposing requirements to treat natural sources of bacteria from undeveloped areas. Based on these criteria, no exceedances will be allowed during summer dry weather (April 1 to October 31). This approach, including the allowable exceedance levels during wet weather and winter dry weather, is further explained in section 7, Load Allocations.

4 Assessing Sources

The TMDL requires an estimate of loadings from point sources and nonpoint sources. In the TMDL process waste load allocations are given for point sources and load allocations for nonpoint sources. Point sources typically include discharges from a discrete human-engineered point (e.g., a pipe from a wastewater treatment plant or industrial facility). These

[13] Point zero is the point at which water from the storm drain or creek initially mixes with ocean water. Point zero has been selected as the compliance point for the numeric target because access to these drains is, on the whole, not restricted, with the exception of efforts by lifeguards to prevent beach goers from swimming in or adjacent to a storm drain. People are often observed swimming near storm drains, and in addition, children are often observed wading in the storm water flowing across the beach. (See Figure 11.)

types of discharges are regulated through a National Pollutant Discharge Elimination System (NPDES) permit, typically issued in the form of Waste Discharge Requirements (WDRs) issued by the Regional Board.

Nonpoint source by definition includes pollutants that reach waters from a number of diffuse sources. However, the regulatory distinction between point and nonpoint sources is blurred in the Los Angeles Region. This is because urban runoff to Santa Monica Bay is regulated under two storm water NPDES permits. The first is the Los Angeles County Municipal Storm Water NPDES Permit, which was renewed in 1996 and is currently in the process of being updated. There are 86 co-permittees covered under this permit including 85 cities and the County of Los Angeles. The second is a separate storm water permit specifically for the California Department of Transportation (Caltrans). Though considered point sources from a regulatory perspective because the storm water discharges from the end of a storm water conveyance system, the Regional Board treats urban runoff as a nonpoint source for the purposes of source characterization and load allocations.

In general, sources of elevated bacteria to marine waters include sanitary sewer and sewage plant overflows and spills, illegal discharges from boats, malfunctioning septic tanks, illicit discharges from private drains, and urban runoff discharged from publicly owned storm drain systems. Urban runoff from the storm drain system may have elevated levels of bacterial indicators due to sanitary sewer leaks and spills, illicit connections of sanitary lines to the storm drain system, runoff from homeless encampments, illegal discharges from recreational vehicle holding tanks, and malfunctioning septic tanks among other things. Swimmers can also be a direct source of bacteria to recreational waters. The bacteria indicators used to assess water quality are not specific to human sewage; therefore, fecal matter from animals and birds can also be a source of elevated levels of bacteria, and vegetation and food waste can be a source of elevated levels of total coliform bacteria, specifically.

4.1 Point Sources

There are seven major NPDES permit discharges in the Santa Monica Bay Watershed. Three are Publicly Owned Treatment Works (POTWs) (two with direct ocean discharges), one is a refinery, and three are electricity generating stations. The three POTWs are Hyperion Treatment Plant, Joint Water Pollution Control Plant, and Tapia Wastewater Reclamation Plant. In light of their operations, the refinery and the three generating stations are not considered probable sources of bacteria.

Hyperion is a full secondary treatment plant with a dry weather design capacity of 450 MGD and wet weather peak hydraulic capacity of 850 MGD. The treated wastewater from Hyperion discharges through a 5-mile outfall pipe into Santa Monica Bay. Hyperion discharges approximately 360 MGD to the Bay during dry weather. As part of its permitted operations, Hyperion measures physical, chemical and microbiological parameters at an array of 11 inshore locations five times per month to determine whether the effluent plume reaches the shore. In its 1997-98 Santa Monica Bay Biennial Assessment Report, the City concludes that bacteria loads from Hyperion are not impacting the shoreline. Inshore stations showed 100% compliance with bacteriological receiving water limits with the exception of a few stations in the vicinity of Ballona Creek and Marina del Rey and King Harbor, which may be impacted by boat activity, birds, harbor runoff, and flow from Ballona Creek. (CLA-EMD, 1999).

The Joint Water Pollution Control Plant (Joint Plant) is a partial secondary treatment plant with a design capacity of 385 MGD. Treated wastewater from the Joint Plant discharges through an approximately 2 mile-long outfall network onto the Palos Verdes Shelf. The Joint Plant discharges 334 MGD to the Bay, and continuously disinfects its discharge. The Joint Plant measures total coliform, fecal coliform, and enterococcus at its two main outfalls as well as at six inshore stations located near the 9-meter isobath. In 2000, the inshore stations monitored by the Joint Plant consistently met REC-1 bacteriological water quality objectives. In addition, the Joint Plant Annual Monitoring Report for 2000 shows that the monthly geometric mean densities of total coliform, fecal coliform and enterococcus from the two outfalls are consistently low (CSDLAC, 2001).

The Tapia Wastewater Reclamation Plant is a tertiary treatment plant with a design capacity of 16.1 MGD. It discharges approximately 8-10 MGD to Malibu Creek during the winter season only (November 16 to April 16).[14] Tapia also disinfects before discharging to Malibu Creek. Tapia's 1999 Annual Report indicates that total coliform is less than 1.1 MPN/100 ml based on monthly monitoring of the effluent discharged to Malibu Creek (LVMWD, 1999).

There are 21 minor NPDES permitted discharges in the Santa Monica Bay watershed. In addition, there are numerous discharges covered under general permits or industrial and construction storm water permits. The bacteria loads associated with these dischargers are largely unknown. Most do not monitor for bacteria. The discharge flows associated with these permits are generally low. In addition, many of these permits are for episodic discharges rather than continuous flows. Rather than attempt to compile the data from all the minor NPDES permits, general permits, and industrial and construction storm water permits in the Santa Monica Bay Watershed, the Regional Board assumes that bacteria loadings from these point source discharges will be accounted for in the watershed-wide assessment of nonpoint source loadings, discussed below.

4.2 Nonpoint Sources

As mentioned above, urban runoff to Santa Monica Bay is primarily regulated under the Los Angeles County Municipal Storm Water NPDES Permit.

4.2.1 Existing Data Characterizing Sources

The following section summarizes existing data on bacteria densities for a variety of land uses and receiving water sites for dry and wet weather. Despite an intensive shoreline bacteriological monitoring program, there is little routine monitoring in the subwatersheds draining to the impaired beaches. The Los Angeles County Department of Public Works, the lead permittee for the existing municipal storm water permit,[15] conducts a storm water monitoring program, which is the principal source of data on water quality during wet weather.

[14] Based on data from 1996-2000.
[15] In the draft permit under consideration by the Regional Board at the time this report was prepared, the Los Angeles County Flood Control District is named the principal permittee.

Additional data for Ballona Creek is collected by the City of Los Angeles, Environmental Monitoring Division and for Malibu Creek by the Las Virgenes Municipal Water District. In addition, there are several volunteer monitoring groups that collect data on a regular basis. Volunteer sampling programs usually focus on dry weather due to the difficulties associated with mobilizing volunteers on short notice to sample during a storm. Finally, several agencies have conducted "snapshot" surveys of water quality at key storm drains/freshwater outlets draining to the Bay.

Summaries of data on dry weather sources of bacteria, and then wet weather sources are presented below.

4.2.2 Dry Weather Source Characterization

Many of the canyon creeks and storm drains to Santa Monica Bay flow during both wet and dry weather. Dry weather flows are not directly attributable to precipitation, but rather to natural springs, over-irrigation of lawns, and other activities in the watershed. Dry weather flows and associated pollutant loads are not well documented in the Santa Monica Bay watershed, and to accurately describe them would require a detailed sanitary survey of each subwatershed. Such detailed surveys were outside the initial scope of the TMDL development; however, staff identified several sources of data characterizing bacteria densities during dry weather in Ballona Creek, Malibu Creek, and major storm drains that empty to the Bay.

Tables 8 through 10 summarize these data sets. Table 8 is a summary of data for 13 major storm drains discharging to Santa Monica Bay, collected by the City of Los Angeles, Los Angeles County, and Heal the Bay between 1998-2001. Ten of the 13 drains exceeded the single sample total coliform objective in more than 50% of samples. All 13 exceeded the single sample fecal coliform objective in more than 50% of samples, and 11 of 13 exceeded the single sample enterococcus objective in more than 50% of samples.

Table 9 is a summary of data for Ballona Creek, collected by the City of Los Angeles, Los Angeles County, and Santa Monica BayKeeper. Again, overall the data show that the total coliform, fecal coliform, and enterococcus single sample objectives are exceeded frequently and by a significant amount.

Table 10 is a summary of data for Malibu Creek and Lagoon, collected by Los Angeles County and Heal the Bay. Data collected by Heal the Bay indicate that the single sample objective for total coliform is exceeded in 31% of samples, for fecal coliform in 85% of samples, and for enterococcus in 23% of samples.

In addition to the above sources of data, the City of Los Angeles conducted a one-time dry weather sanitary survey in Temescal (Pulga) Canyon (see Figure 3), sampling ten locations from September to October 2000. The City found that almost all locations exceeded the REC-1 single sample bacteria objectives. Specifically, 80% of samples exceeded the total coliform objective and/or the enterococcus objective. (The City also tested for *E. coli*; 74% of samples exceeded the *freshwater* single sample objective of 235 organisms per 100 ml.[16])

Finally, the BeachKeeper volunteer monitoring program administered by the Santa Monica BayKeeper takes quarterly samples from up to 342 coastal drains from Point Dume to Malaga Cove with the potential to discharge to the beach, including private drains, large publicly-maintained storm drains, and creeks such as Malibu, Topanga, and Escondido. Their results show that during dry weather half of the samples from these coastal drains and creeks exceeded the marine single sample objective of 10,000 total coliform per 100 ml (104 out of 203 samples, or 51.2%) and the freshwater single sample objective of 235 *E. coli* per 100 ml (109 out of 207 samples, or 52.7%) for the period 1999 to 2001 (Santa Monica BayKeeper, unpublished data).[17]

4.2.3 Wet Weather Source Characterization

Data to characterize wet weather sources of bacteria to beaches is available from the monitoring program conducted as a requirement of the Los Angeles County Municipal Storm

[16] There is no marine water quality objective for *E. coli*.

[17] See Appendix C for a complete list of these drains/freshwater outlets, as compiled by Santa Monica BayKeeper. Only a small number of these (perhaps 3 dozen) are large systems. Fewer still are among those currently proposed for diversion during low flows.

Water NPDES Permit as well as other storm water NPDES permits throughout Southern California. The Los Angeles County permit requires monitoring of both instream water quality (to calculate mass emissions for various pollutants) as well as land use monitoring to attempt to quantify pollutant loads from specific land uses.

Table 11 summarizes the wet weather data for specific land uses collected by Los Angeles County under the Municipal Storm Water Permit for the period 1994-2000, as well as similar land use specific data from all storm water monitoring programs in Southern California for the period 1990-1999. All land use sites in both data sets exceeded the objectives for total coliform, fecal coliform and enterococcus. The Los Angeles County data set indicated that the high-density/single-family residential category had the highest densities of all three bacterial indicators, followed by the commercial land use for total coliform and fecal coliform, and the light-industrial land use for enterococcus. SCCWRP's aggregated data set from all of the storm water monitoring programs in Southern California indicated that the industrial land use category had the highest densities of all three indicators (SCCWRP, 2001).

Table 12 summarizes the wet weather data collected under the Los Angeles County Storm Water Monitoring Program for Ballona Creek (between Sawtelle and Sepulveda Boulevards) and Malibu Creek (south of Piuma Road). As expected, the yearly geometric mean bacteria densities for all three indicators far exceeded the thresholds for all six years in both creeks.

While the storm water monitoring program collects valuable data to help characterize wet weather bacteria densities, there remain significant data gaps. For example, the samples collected under the storm water monitoring program are grab samples, which do not allow an evaluation of changes in bacteria density during the course of a storm event. In addition, the storm water monitoring program is limited in terms of the types of "critical sources" of bacteria that are sampled. Both of these types of data are valuable when exploring management scenarios.

4.2.3.1 Wet Weather Source Characterization Study – Phase I

In response to the data gaps mentioned above, the Regional Board in partnership with other entities[18] undertook a study to characterize wet-weather bacteria densities from various land uses and in major watercourses (SCCWRP, 2000).

The sample design entailed sampling eight key land uses during multiple storms. In addition, the sample design entailed sampling multiple sites within a general land use to characterize the range of bacteria densities that might be found within each land use category. The study also included sampling at two instream stations – one in Ballona Creek and one in Santa Monica Canyon channel. See Table 13 for a list of the eight general land uses, 21 land use sites and two instream stations, and the targeted number of samples and number of samples collected at each location during Phase I. Two-thirds of the targeted site-events were sampled between January and April, 2001. The remaining sites, as well as additional open space and instream sites, will be sampled during the 2001-02 wet season.

Table 14 summarizes the initial results from the land use and instream sites sampled under Phase I of the wet weather characterization study.[19] All land use sites except for open space and transportation exceeded REC-1 single sample bacteria objectives for total coliform, fecal coliform and enterococcus. As might be expected, the horse stable and nursery sites had the highest values for all three bacterial indicators. Overall, total coliform was exceeded by a factor of 3 (low-density residential) to 230 (agriculture-nursery). Fecal coliform was exceeded by a factor of 3 (industrial) to 660 (recreation-horse stable). Enterococcus was exceeded by a factor of 4 (open space) to 2,900 (agriculture-nursery). Ballona Creek and Santa Monica Canyon channel instream sites exceeded water quality standards for all indicators. In general, total coliform was exceeded by a factor of 32, fecal coliform by a factor of 28, and enterococcus by a factor of 330 at the two instream sites.

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[18] The other entities included: Southern California Coastal Water Research Project, City of Los Angeles, County of Los Angeles, County Sanitation Districts of Los Angeles County, Heal the Bay, Santa Monica Bay Restoration Project, and others.

[19] Note that the bacteria densities presented in this table cannot be directly compared to those presented in Tables 11 and 12 as the values are flow-weighted geometric means, rather than arithmetic means.

5 Linkage Analysis

The linkage analysis for this TMDL was performed using the BASINS/HSPF model (Better Assessment Science Integrating Point and Nonpoint Sources/Hydrologic Simulation Program-FORTRAN, hereafter HSPF). HSPF is a dynamic watershed and receiving water quality-modeling program, meaning that it provides continuous simulation of bacteria build-up and wash-off, bacteria loading and delivery, point source discharges and instream water quality response.

The HSPF model is one of the most complete watershed models available that deals with both urban and non-urban watersheds, and has undergone extensive development and application since the mid-1970s. It is currently supported by both the U.S. EPA and the United States Geological Survey (USGS), and is included as a component in U.S. EPA's BASINS program. Finally, HSPF is endorsed by the U.S. EPA specifically for use in developing TMDLs.

The focus of modeling was on wet weather. The reason for this was three-fold. First, wet weather represents the critical condition in the TMDL (as discussed below). Second, dry weather bacteria loads tend to be less predictable and therefore more difficult to model. Third, the Regional Board expects that, in most cases, dry weather bacteria loads to Santa Monica Bay beaches from storm drains will be addressed through diversion of dry weather flows from these systems to wastewater treatment plants. (See section 8, Implementation.)

5.1 Critical Condition

The critical condition in a TMDL defines an extreme condition for the purpose of setting load allocations to meet the TMDL numeric target. While a separate element of the TMDL, it may be thought of as an additional margin of safety such that the load allocations are set to meet the numeric target during an extreme (or above average) condition.[20]

[20] Critical conditions are often defined in terms of flow, such as the seven-day-ten-year low flow (7Q10), but may also be defined in terms of rainfall amount, days of measurable rain, etc.

Unlike many TMDLs, the critical condition for bacteria loading is not during low flow conditions or summer months, but rather during wet weather. It is during wet weather that data typically demonstrate the highest densities of bacteria along the shoreline, and it is during wet weather that data demonstrate the most days of exceedance of bacteria objectives (see section 2.3).

To determine the necessary reduction in "exceedance days" to meet the numeric target, a design year was selected for modeling purposes based on the number of rain days. It was decided that the 90th percentile year in terms of the number of rain days would be used as the design year (i.e., critical condition) for running the model. The number of rain days was selected instead of total rainfall because staff found that, based on 50+ years (1947-2000) of rainfall data from LAX, 50% of the rain days had daily rainfall of 0.1 inch or less. Furthermore, a retrospective evaluation of shoreline data showed that the number of sampling events during which greater than 10% of samples exceeded the fecal coliform objective on the day after a rain was nearly equivalent for rainstorms less than 0.5 inch and those greater than 0.5 inch, concluding that even small storms represent a critical condition. This is particularly true since the TMDL's numeric target is based on number of days of exceedance, not on the magnitude of the exceedance.

To identify the 90th percentile year in terms of rain days, staff examined a cumulative frequency distribution of rainfall at LAX from 1947-2000 (see Appendix D for annual rainfall data at the LAX meteorological station). The 90th percentile year in terms of number of rain days was 1993. In 1993, there were 33 days with measurable rainfall (0.05 inch or more) and 29 days with 0.1 inch or more of rain. The total annual rainfall was 20.67 inches.[21]

5.2 Model Development and Results

Water quality modeling is used to: (1) determine the contributions of different sources to bacteria loads (source characterization), (2) relate these loadings to water quality responses in the receiving water, (3) estimate the necessary load reductions necessary to meet the numeric

[21] It turned out that 1993 was also the 90th percentile year in terms of annual rainfall amount.

targets, and (4) simulate potential management scenarios. The analysis described below focuses on (2) and (3).[22]

The objective of the modeling exercise was to develop time variable subwatershed models to estimate bacterial loadings to SMB beaches during wet weather, and ultimately the number of days of exceedance during wet weather for each subwatershed system. Detailed technical reports (prepared by SCCWRP) on the development of the hydrologic and water quality models and model results will be included in Appendix E when they are available.

It must be emphasized that the model as developed in this context only estimates bacteria loadings from storm water runoff. At this stage, the Regional Board lacks the necessary data on bacteria levels in dry-weather runoff and groundwater to calibrate and validate bacteria loads during dry weather or from groundwater contributions. Therefore, a key model assumption for most subwatersheds was that bacteria loads during dry weather or from groundwater equaled zero. As a result, where there are groundwater or dry-weather urban runoff sources of bacteria to the surf zone, the model has most likely *underestimated* bacteria densities as well as the number of exceedance days of bacteria objectives for the design year.

The Santa Monica Bay watershed was divided into 28 subwatersheds based on CALWATER 2.0 watersheds and the storm drain network mapped by the Los Angeles County Department of Public Works. The model was run for each of the 28 subwatersheds.[23] The Malibu Creek and Ballona Creek subwatersheds were further divided into 6 and 7 sub-drainage areas, respectively. (Figure 1) Stream geometry was described using simplified storm drain maps based on a detailed GIS coverage from the Los Angeles County Department of Public Works.

The model was set-up using a variety of local data on meteorology (e.g., rainfall, temperature, etc.), hydrology (e.g., stream geometry), topography, land use, stream flow (for

[22] The first and fourth uses of the model will be discussed once additional wet weather sampling data is collected and incorporated into the model.
[23] The TMDL is in fact 28 "mini" TMDLs, one for each subwatershed.

Ballona and Malibu creeks), point source discharges (for Tapia WRP), and water quality (for Ballona Creek and Santa Monica Canyon channel). The rainfall pattern throughout the Santa Monica Bay watershed is variable, therefore, data from nearby gages, including the LAX gage, were used to model the subwatersheds. Rainfall for each subwatershed was scaled using the PRISM model, which was used to create an isohyetal map of rainfall for the state of California using all rain gages in the state that had historical data as well as elevation. Other meteorological conditions used in the model development were based on data from the LAX meteorological station.

Land use data from the Southern California Association of Governments (SCAG, 1993) was aggregated into 13 land uses, corresponding to the categories used in previous TMDLs (LARWQCB, 2000). (See Table 15.) The percent imperviousness values used were the same as those specified in the Los Angeles County's storm water model (LAC-DPW, 1999).

5.2.1 Hydrologic Model

For the hydrologic model, the Malibu watershed and Ballona watershed were selected as the calibration and validation watersheds, respectively, because of the availability of historical flow data and because they represent two extremes in terms of land use, with Malibu 83% open space and Ballona 15% open space. Ten years of historical stream flow data (1988-98) for Malibu Creek and Ballona Creek were used to calibrate and validate the model. The hydrologic model performed well in these watersheds of comparable size, but with very different land use patterns; therefore, the application of the model to unmonitored watersheds was assumed appropriate. Thus, the derived hydrology parameters were applied to the 26 unmonitored subwatersheds.

5.2.1.1 Hydrology Model Results

For Malibu Creek watershed, the calibration watershed, the measured and modeled annual volumes match well. Storm hydrographs also simulated well – both storm volume and peak flows were modeled well. A linear regression of modeled and measured daily flows for 9 years shows that modeled flows explain 88% of measured flows during that time period (Figure 12). Finally, a comparison of the Malibu modeled error to USGS criteria illustrates that the model is within the acceptable error range for all parameters except low flows.

Similar results were achieved in Ballona Creek watershed, the validation watershed. (Figure 13.) The model was again within the acceptable error range for all parameters except low flows. Finally, for specific storm events, the hydrologic model predicted peaks in the hydrograph fairly well for both land use sites and receiving water sites.

5.2.2 Water Quality Model

Preliminary estimates of wet-weather bacteria loads were made by calibrating the model to small single land use sites based on the wet-weather source characterization data.[24] The model was validated for short and long time scales using (1) data on instream water quality for Santa Monica Canyon channel and Ballona Creek collected under the wet-weather source characterization study; (2) historical water quality data for Ballona and Malibu creeks; and (3) data on bacteria build-up, wash-off and degradation.[25]

Several assumptions were made in the water quality model. First, it was assumed that the bacteria degradation rate for all indicators was 0.8 d^{-1}. (See Appendix F for a description and discussion of the bacterial degradation experiments conducted in support of the TMDL.) Second, it was assumed that because the water quality data for the various land use types was collected from storm water runoff only, that bacteria loads were from the monitored surface flows only, not from groundwater contributions or dry-weather runoff. Finally, because the model was successfully applied to Malibu and Santa Monica canyons (largely undeveloped) and the Ballona subwatershed (largely urbanized), it was assumed that the model could be applied in unmonitored subwatersheds.

5.2.2.1 Water Quality Model Results

Measured bacteria densities are highly variable. Likewise, there is high variability in modeled bacteria densities. However, a comparison of modeled versus measured bacteria densities for dry days and wet days in Ballona Creek and Malibu Creek shows that the geometric mean densities estimated for the design year are close to the measured geometric

[24] Due to the fact that only one sample was obtained for the open space land use category, additional local data were used to derive the model input values for this land use category. See Appendix E for a more detailed description of how the model was calibrated for open space.

mean densities and the confidence intervals overlap for all indicators. As one might expect, the model underestimates bacteria densities as compared to measured values, with the exception of Malibu Creek during wet days.[26] (Figures 14 and 15.) As for individual storm events, the model is able to generally predict peaks in bacteria densities for both land use sites and receiving water sites.

Once a comparison of modeled and measured values was completed, the model was run to determine the number of days of exceedance that would occur at the base of each subwatershed during wet weather. Two additional key assumptions were made at this stage. First, it was assumed that there was no dilution between the drain (or freshwater outlet/creek) and the wave wash (compliance point). Second, it was decided that the 90th percentile hourly bacteria density for each day would be used to compare with the water quality objective. This translates to approximately the third highest modeled value in a day.[27] This was done for each of the four single sample bacteria objectives. If any one of the four modeled values exceeded the associated water quality objective, the subwatershed was identified as exceeding for the day. (See section 6 for further discussion of these assumptions as they relate to the Margin of Safety.) The model results are presented by subwatershed in Table 16 and Figure 16.

6 Margin of Safety

A margin of safety has been implicitly included through several conservative model assumptions and the selection of model output values. In addition, an explicit margin of safety has been incorporated, as the load allocations will allow exceedances of the single sample targets no more than 8% of the time on an annual basis (described in section 7

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[25] Data for Ballona Creek were submitted by the City of Los Angeles, Environmental Monitoring Division, and for Malibu Creek by LVMWD.
[26] This may be because staff was able to account for some groundwater contributions of bacteria in the Malibu watershed by using data collected to develop the Malibu Creek watershed bacteria TMDL.
[27] In other words, the 24 modeled hourly bacteria values for a day were rank-ordered and the 90th percentile value (i.e., the 22nd value when ranked from low to high) was selected as the value for comparison with the numeric target.

below). In contrast, the Regional Board concludes that there is water quality impairment if more than 10% of samples at a site exceed the single sample bacteria objectives annually.[28]

6.1 Dilution between Drain and Wave Wash

First, the model assumes no dilution between the storm drain and the wave wash. Several studies have examined dilution between the storm drain and wave wash during dry weather, though no similar studies have been conducted during wet weather (Taggart, 2001; City of Los Angeles, 2001). The study conducted by Taggart shows that dilution is site-specific and dependent on tide height, longshore velocity in the surf zone, wave height, and wind speed (see Appendix G).

In the two studies conducted at storm drains discharging to Santa Monica Bay, researchers have observed dilution between the storm drain and wave wash ranging from 100% to negative values (indicating higher densities in the wave wash than in the storm drain). Because of the high variability in the amount of dilution temporally, spatially, and among bacterial indicators, staff decided to select a conservative dilution factor based on approximately the 10th percentile dilution factor from the two studies mentioned above. The 10th percentile ranged from -10% for total coliform, -19% for fecal coliform, and -40% for enterococcus (see Appendix G). Instead of specifying a negative dilution ratio, we chose on the basis of the data to specify 0% dilution between the drain and the wave wash. Zero percent dilution corresponded to the 11th percentile for total coliform and 12th percentile for fecal coliform and enterococcus.

6.2 Bacterial Degradation

Based on three experiments, two in fresh water and one in marine water, bacterial degradation was shown to range from hours to days. Transport time from most subwatersheds during wet weather is short. Therefore, the conclusion is that bacteria

[28] We are hesitant to base an impairment decision on a single sample, knowing that bacteria densities can be highly variable (Noble *et al.* 1999, 2000a, 2000b; Taggart, 2001). Some researchers contend a single sample is of limited value because of the high variability in bacteria densities, and central tendencies and variability are needed to define water quality at a particular site (Pike, 1992; Cheung, *et al.*, 1990). Therefore, we conclude that while single sample objectives may be appropriate for public notification purposes, they are not appropriate for evaluating water quality to determine impairment.

degradation is not fast enough to greatly affect bacteria densities in the wave wash. Based on the results of the fresh water experiments, the model assumes a bacteria die-off rate of 0.8 d^{-1}. (Degradation rates were shown to be as high as 1.0 d^{-1}.) (See Appendix F for a discussion of the experimental design and results of the bacteria degradation study.)

6.3 Selection of Modeled Bacteria Values

Staff chose to model the bacteria loads and days of exceedance based on the 90th percentile hourly density for each of the bacterial indicators, as modeled on a daily basis. This works out to be approximately the third highest modeled hourly value in a day.[29]

7 Load Allocations

Load allocations in this TMDL are expressed in a unique way. Load allocations are expressed as the number of sample days at a shoreline monitoring site that may exceed the single sample targets identified in section 3. For each shoreline monitoring site and corresponding subwatershed, allowable exceedance levels are set on an annual basis as well as for three other time periods. These three periods are: (1) summer dry weather (April 1 to October 31), (2) winter dry weather (November 1 to March 31), and (3) wet weather (days of 0.1 inch of rain or more plus three days following the rain event).

7.1 Why load allocations are defined as allowable exceedance days: The role of natural subwatersheds

The bacteria indicators used to assess water quality are not specific to human sewage. Fecal matter from wildlife and birds can be a source of elevated levels of bacteria, and vegetation can be a source of elevated levels of total coliform bacteria, specifically.

As discussed in section 1.1, subwatersheds in the northern part of the Bay have on average 85% of their land area in open space. (See Figures 8 and 9.) The model, which gives an estimate of the number of wet-weather exceedance days for a simulation year, estimates that

[29] Hourly values for each indicator are determined by calculating the geometric mean of the 15-minute values generated by the model. The hourly values for each indicator are then ranked on a daily basis and the 90th percentile value for each indicator is chosen to determine whether the day exceeds any of the bacteria objectives.

for these subwatersheds the number of wet-weather exceedance days for the simulation year ranges from 24 to 64. For the two most undeveloped subwatersheds, Arroyo Sequit Canyon and Solstice Canyon, the model estimates 28 days of wet-weather exceedances during the simulation year.[30] (See Table 16.)

Strictly applying the single sample objectives identified in section 3 would likely require the implementing agencies to capture or treat wet-weather runoff from natural areas given the preliminary model results. It is not the intent of this TMDL to require diversion of natural coastal creeks or to require treatment of natural sources of bacteria from undeveloped areas. Therefore, the approach staff has chosen is to define reference subwatershed(s) and beach(es) within Santa Monica Bay, which can then be used to set the allowable number of exceedance days. Arroyo Sequit Canyon, mentioned above, and the beach to which it drains, Leo Carrillo Beach, have been selected as the reference system. This system was selected for three reasons: (1) Arroyo Sequit is the most undeveloped subwatershed in the Santa Monica Bay watershed, (2) there is a freshwater outlet (creek), which drains to the beach, and (3) staff have both model results and historical shoreline monitoring data for this system.

7.2 Two methods for measuring exceedance days: The role of modeling and shoreline monitoring data

Staff have used two methods to determine the number of days that exceed the single sample objectives at various shoreline locations. The first method is the water quality model described in section 5.2.2. The second method is a site-by-site evaluation of historical shoreline bacteriological monitoring data for the 5-year period 1996-2000. Each of these is described in detail below.

7.2.1 Method I: The water quality model

Under this method, staff used the model results presented in section 5.2.2 to determine the predicted number of wet-weather exceedance days for the design year at the base of each of the 28 subwatersheds illustrated in Figure 1. Because staff is allowing no dilution between

[30] Arroyo Sequit Canyon is approximately 12 square miles in size and is 98% open space. Solstice Canyon is approximately 4½ square miles and is 97.2% open space.

the storm drain or creek and the "wave wash," the model results can be directly applied to the shoreline compliance point, which is the "wave wash." It must be emphasized again that a significant shortcoming of this method is that it only estimates the number of exceedance days during *wet weather*. The model provides no estimate of exceedances during dry weather.[31] Therefore, it is likely that the model is under-estimating the number of exceedance days for the entire year. Furthermore, the wet weather model is based on many assumptions and limited data. As a result, staff expects that the model may be *over-estimating* wet-weather contributions of bacteria from open space and, therefore, may be over-estimating the number of wet-weather exceedance days in Arroyo Sequit Canyon, the designated reference system.

7.2.2 Method II: Historical shoreline bacteriological data

Under this method, staff used the most recent five years of shoreline monitoring data (1996-2000) to determine the average percent exceedance for each shoreline monitoring site.[32] This was calculated for each of the three time periods of concern (i.e., summer dry weather, winter dry weather, and wet weather).[33] There are two important distinctions between the measured exceedance days under this method as compared to Method I. First, shoreline monitoring sites are typically located 50 yards upcoast or downcoast of a storm drain or creek. The shoreline compliance point set for this TMDL is the "wave wash" or "point zero" rather than 50 yards away. Therefore, it is likely that historical shoreline monitoring data *under-estimates* the average percent exceedance that would be observed at a beach if the sample were collected from the wave wash. Second, an average percent exceedance value is calculated for each shoreline monitoring site, rather than for a subwatershed. In some cases, one subwatershed is the drainage area for multiple shoreline monitoring sites. (See Figure 3, for example.)

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[31] As discussed in section 5, the decision to focus the modeling effort on wet weather was one made by the TMDL Steering Committee early in the development of the TMDL. The decision to focus on wet weather was made because wet weather is generally the critical condition in the case of bacteria. That is, it is during wet weather that data typically demonstrate the highest densities of bacteria indicators and the highest frequency of exceedance days.

[32] Only four years of data (1997-2000) were available for the County Sanitation Districts' sites on the Palos Verdes Peninsula.

7.3 Criteria for determining allowable exceedance days: The role of the reference system and antidegradation

Staff has chosen to set the number of allowable exceedance days for each beach to ensure that (1) shoreline bacteriological water quality is at least as good as that of a largely undeveloped system and (2) there is no degradation of existing shoreline bacteriological water quality. The selected approach prevents the undesirable result of requiring natural sources of bacteria from undeveloped areas to be treated. Staff achieves this result by using the smaller of two measurements of exceedance days. These are: (1) exceedance days in the reference system, or (2) exceedance days based on historical bacteriological data at a particular shoreline monitoring site. In other words, if the number of dry-weather or wet-weather exceedance days in the reference system surpasses historical levels at another shoreline monitoring site, then the historical levels at the other site will apply to that particular site (i.e., the site-specific historical exceedance levels would override the "default" exceedance levels of the reference system). Below are discussions of the two criteria used to determine the allowable exceedance days during wet weather and the two criteria used to consider allowable dry weather exceedances.

7.3.1 Exceedance criteria for wet weather

For wet weather, staff used one of two criteria: (1) exceedance days in the reference system, or (2) exceedance days as measured by historical bacteriological data at a particular site.

The first of these – exceedance days measured in our reference system – is based on averaging the exceedance-day measurements made under Methods I and II described above (section 7.2). Specifically, due to the shortcomings of Methods I and II, staff chose to use the average of the exceedance levels as measured from Methods I and II. Method I, the water quality model, estimates 28 days of wet-weather exceedances (for the simulation year) at the base of Arroyo Sequit Canyon, the reference subwatershed. Under Method II, an analysis of historical shoreline monitoring data for Leo Carrillo Beach, the reference beach, shows that

[33] Wet weather was defined as those days with 0.1 inch of rain or more, and the three days following the rain event. This definition is the same as that used by the Los Angeles County Department of Health Services for rain-related beach postings.

the site exceeds on average 22% of wet-weather sample days (or an estimated 26 days).[34] The average of these is 27 days.[35]

The second criterion is the exceedance level as measured by site-specific historical shoreline bacteriological data. This criterion relies exclusively on exceedance-day measurements made under Method II.

Remember that the smaller of these two criteria (or exceedance-day measurements) holds for wet weather. In other words, looking at Table 17, if a shoreline monitoring site exceeded the single sample objectives more than 27 days (or 23% of the time) during wet weather, the "Wet Weather Daily Sampling" column was re-set to 27 days and the "Wet Weather Weekly Sampling" column to 4 days. If a site exceeded less than or equal to 27 days (or 23% of the time) during wet weather, the two columns were left unchanged. That is, the exceedance days remain the same as the number of exceedance days extrapolated from the 5-year average percent exceedance for that particular shoreline monitoring site. In Table 18, staff present the site-by-site 5-year average percent exceedance for wet weather and the corresponding required reduction in wet-weather exceedance days for daily sampling regimes.

7.3.2 Exceedance criteria for dry weather

For dry weather, staff again used one of two criteria: (1) exceedance days in the reference system or (2) exceedance days as measured by historical bacteriological data at a particular site. However, the dry-weather exceedance level in the reference system is calculated differently than the wet-weather exceedance level in the reference system. The key difference is that staff only rely upon Method II (historical data) to determine the dry-weather exceedance days in the reference system. Recall that for wet weather staff took the average number of exceedance days from the two methods. For dry weather, however, staff do not

[34] Staff extrapolated from the 5-year average percent exceedance to an estimated number of days by using rainfall data for 1993, the design year for the model. In 1993, there were 29 days with 0.1 inch or more of rain. Staff added to that the three days following a rain event, resulting in an estimated 116 days of wet weather.
[35] Staff recognizes that the number of wet-weather days (and dry-weather days) will change from year-to-year and, therefore, 22% of wet-weather days will not always equate to 26 days. However, staff is setting the allowable number of exceedance days based on the design year, rather than allowing the number to "float" based on the number of wet and dry days in a particular year.

have any measurement of exceedance days from Method I (the model). Historical data for Leo Carrillo Beach shows 0% exceedance during summer dry weather and 3% exceedance during winter dry weather. Therefore, the reference system criterion is 0% exceedance days for summer dry weather and 3% exceedance (or two days under a daily sampling regime) during winter dry weather.[36]

The second criterion is the exceedance level as measured by historical bacteriological data for a particular shoreline monitoring site. As with wet weather, this criterion relies exclusively on exceedance-day measurements made under Method II (historical data).

Again, remember that the smaller of these two criteria (or exceedance-day measurements) holds for dry weather. For summer dry weather this is very straightforward – no exceedances are allowed at any site, since 5 years of historical data for Leo Carrillo Beach, the reference beach, show on average no exceedances during this period. For winter dry weather, look again at Table 17, if a shoreline monitoring site exceeded the single sample objectives more than two days under a daily sampling regime (or 3% of the time) during winter dry weather, the "Winter Dry Weather Daily Sampling" column was re-set to two days and the "Winter Dry Weather Weekly Sampling" column was re-set to one day. If a site exceeded two days or less based on a daily sampling regime (or 3% of the time) during winter dry weather, the two columns were left unchanged. That is, the exceedance days remain the same as the historical 5-year average exceedance level for that particular shoreline monitoring site. In Table 18, staff presents the site-by-site 5-year average percent exceedance for winter dry weather and the corresponding required reduction in winter dry weather exceedance days for daily sampling regimes.

7.3.3 Annual exceedance criteria

On an annual basis, the allowable number of sample days that may exceed the single sample targets must be the smaller of two criteria. These criteria are: (1) 29 days based on a daily sampling regime or five days based on a weekly sampling regime (or 8% of sample days) or

[36] Again, we extrapolated from the 5-year average percent exceedance to an estimated number of exceedance days during winter dry weather by using rainfall data for 1993. There are 151 days from November 1 to March
(Footnote continued on next page)

(2) the sum of the site-specific exceedance levels for wet weather and winter dry weather as presented in Table 17. The first criterion of 8% of sample days is simply the sum of the wet-weather and winter dry-weather exceedance days calculated for the reference system in sections 7.3.1 and 7.3.2 above. The second criterion can be looked up on Table 17 for a particular shoreline monitoring site. Take for example Hermosa Beach Pier. Summing the number of "daily sampling" exceedance days for wet weather (12) and the number for winter dry weather (1) equals 13 allowable exceedance days annually.

7.4 Future growth

Potential growth is implicitly addressed, since the numeric targets are based on bacteria density and the number of allowable exceedance days, not a total load. The numeric targets must be met at any beach monitoring location a minimum of 92% of the time annually. The actual reductions in the number of days necessary to meet this target may change based on growth; however, the final compliance target will remain the same.

7.5 Re-evaluating allowable exceedance levels and interim compliance

Due to shortcomings of both Methods I and II described above, the Regional Board intends to re-open the TMDL five years after adoption to re-evaluate the allowable exceedance levels defined above. For Method I, the water quality model, staff intends to collect additional monitoring data over the next one to two years to better calibrate and validate the model and improve the accuracy of estimates of wet-weather exceedance days for the reference system. Specifically, additional data will be collected from open land use sites to better characterize average bacteria densities from undeveloped areas. Additional data will also be collected from an instream site in Arroyo Sequit Canyon Creek (the reference system) and possibly from an instream site in another largely natural system (e.g., Solstice Canyon Creek). Staff will incorporate the revised model estimates for wet-weather exceedance days in the reference system(s), as well as in each of the other subwatersheds when the TMDL is re-opened.

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31. Subtracting from this the 116 wet-weather days leaves 35 winter dry-weather days.

For Method II, historical shoreline bacteriological data, where there is a freshwater outlet (drain or creek) that reaches the surf zone during wet weather, shoreline monitoring stations will need to be placed (or re-located) at the "wave wash" (the compliance point for the TMDL). As stated earlier, many shoreline monitoring locations are currently located 50 yards upcoast or downcoast of a storm drain or creek. Once the Regional Board has five years of shoreline monitoring data from the "wave wash," the Regional Board will re-open the TMDL and revise as necessary the average percentage of exceedance days during the three time periods for both the reference system(s) and each individual beach monitoring location.[37]

Until the TMDL is re-opened, the allowable number of exceedance days will remain as presented in Table 17 with one exception. For *subwatersheds* that have more than 28 days of wet-weather exceedance based on the model simulation year (see Table 16), staff does not expect implementing agencies to reduce *wet-weather exceedances* below this level until additional wet-weather monitoring and model calibration and validation are completed. This is because, as discussed earlier, the model estimates that the two most undeveloped subwatersheds will exceed 28 days during wet weather. In section 7.3.1 above, staff took the average of the model estimate for Arroyo Sequit Canyon and the exceedance level measured by shoreline monitoring data for Leo Carrillo Beach to arrive at 27 days of allowable wet-weather exceedances based on daily sampling. However, there is uncertainty about how much the shoreline monitoring data is under-estimating wet-weather exceedances at Leo Carrillo Beach, given that the sampling point is located 50 yards away from the freshwater outlet, rather than in the wave wash.

Re-opening the TMDL will not create a conflict in the interim, since the TMDL does not require compliance during winter dry weather until six years after the effective date of the TMDL, and for wet weather not until ten years after the effective date of the TMDL. Therefore, the TMDL will be re-opened and the allowable exceedance levels for these two time periods will be revised as necessary before the compliance deadlines.

[37] Collecting samples from the "wave wash" will also allow the Regional Board to more directly compare the model results for wet weather with shoreline monitoring data. This is because, from the model, staff estimates
(Footnote continued on next page)

8 Implementation

8.1 Regulatory Mechanisms

As required by the Clean Water Act, discharges of pollutants to Santa Monica Bay from storm water are prohibited, unless the discharges are in compliance with a NPDES permit. In June 1990, the Regional Board's first Municipal NPDES Storm Water Permit was issued jointly to Los Angeles County and 86 cities as co-permittees. The Los Angeles County Municipal Storm Water NPDES Permit will be a key implementation tool for this TMDL. Because bacteria is primarily considered a storm water contaminant, the numeric targets presented in this TMDL will be incorporated as effluent limits in future storm water permits, which will be modified in order to address implementation and monitoring of this TMDL.

Discharges of waste that may affect the quality of the waters of the region must file a Report of Waste Discharge (ROWD) and obtain the appropriate discharge permits. Santa Monica BayKeeper has identified 342 potential discharges to the shore between Malaga Cove and Point Dume. Ten to 12 of these are natural creeks or washes; the status of the remaining 330 to 332 discharges is unknown at this time. Within 120 days of the effective date of this TMDL, ROWDs must be filed for these discharges if they have not been already individually reported or if the discharges are not already regulated by the Los Angeles County Municipal Storm Water Permit.

Finally, per the California Ocean Plan, no discharge of waste to an Area of Special Biological Significance (ASBS) is allowed. In the Santa Monica Bay watershed, the area from Latigo Point to Point Mugu (beyond the County line) is designated an ASBS. Therefore, no discharge of waste to the shore is allowed in this region. Santa Monica BayKeeper has identified 271 potential waste discharges to the shore in this area; the status of these is unknown at this time. Within 120 days of the effective date of this TMDL, these discharges must be identified and all illegal discharges eliminated.

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the number of exceedance days at the base of the subwatershed, but allows no dilution of bacteria between the storm drain or creek and the "wave wash."

8.2 Phased Implementation Schedule

The general implementation schedule includes three phases and is summarized in Table 19.

Phase I: Compliance during Summer Dry Weather. Within three years of the effective date of this TMDL, there may be no exceedances at any location during summer dry weather (April 1 to October 31). This compliance target may be achieved by diverting storm drain flows to treatment plants (where possible); eliminating illicit discharges; controlling sources of bacteria (including groundwater sources); or implementing "end-of-pipe" treatment. The County of Los Angeles, City of Los Angeles and several other cities adjacent to Santa Monica Bay are well on the way to achieving this goal through aggressive summer, dry-weather storm drain diversion programs. Thus far 11 of 27 major storm drains have been diverted and funding is secured for another six to be diverted. This leaves only 10 major drains discharging to Santa Monica Bay beaches during dry weather from April 1 to October 31.

Phase II: Compliance during Winter Dry Weather. Within six years of the effective date of this TMDL, compliance with the allowable number of exceedance days during winter dry weather must be achieved. (See Table 17.) This compliance target may be achieved by diverting dry weather storm drain flows to treatment plants year-round, where possible; or by any of the other methods listed above.

Phase III: Compliance during Wet Weather. Within ten years of adoption, compliance with the allowable number of wet-weather exceedance days at all beach monitoring locations must be achieved. (See Table 17.) The strategies may include many of the same ones listed above as well as capture of a portion of storm flows for diversion or treatment. Table 20 provides an estimate of the total storm flow that would need to be captured and treated or diverted in each subwatershed to reduce the number of wet-weather exceedance days to the number estimated for the reference system using the model.

Each permittee or group of permittees within a subwatershed may decide how to achieve the necessary reductions in number of days of exceedance at each shoreline location by employing one or more of the strategies listed in Table 19. (In many cases there are multiple incorporated and unincorporated areas within a subwatershed; therefore, all jurisdictions within a subwatershed are jointly responsible for achieving the necessary reductions in days of exceedance. See Appendix H for responsible jurisdictions by subwatershed.) Staff expects that after an additional year or two of sampling, the source characterization study and model results will assist municipalities in focusing their implementation efforts.

8.3 Implementation Approach

As mentioned earlier, the necessary reductions in the number of days of exceedance must be achieved in the wave wash or at ankle depth for "open beach" monitoring stations (i.e., monitoring stations located away from any storm drain or coastal creek). This means that cities, or groups of cities/permittees, will be required to meet the total reduction in the subwatershed associated with the shoreline monitoring station, not necessarily an allocation for their municipality or for specific land uses. Clearly the focus should be on developed areas or areas with significant human use (i.e., open space heavily used for recreation). Flexibility will be allowed in determining how to reduce bacteria densities as long as the required allocations are achieved in the wave wash or at ankle depth.

8.4 Cost Considerations

To estimate the cost of implementing the TMDL, staff has compiled (1) the capital costs of diverting the remaining 10 major storm drains and the operation and maintenance (O&M) costs of diverting all the major storm drains entering Santa Monica Bay during the period from April 1 to October 31, (2) the additional O&M costs to divert the 27 major storm drains during dry weather throughout the year, (3) the cost to address dry weather runoff from natural creeks, and finally (4) the additional cost to treat a portion of storm flows in selected drainage systems. The costs to treat dry weather runoff are presented first, followed by the costs to treat wet weather runoff. The costs for beaches drained by the Malibu Creek watershed and Ballona Creek watershed are not addressed below, as there are separate TMDLs for bacteria for these two systems. As such, cost considerations will be considered in the individual bacteria TMDLs for these two systems.

8.4.1 Dry Weather Treatment Costs

The total estimated costs for low-flow diversion of the 27 major storm drains entering Santa Monica Bay during the period April 1 to October 31 are as follows. These costs are based on a report prepared by the City of Los Angeles (2001), discussions with staff at the City of Los Angeles, Bureau of Sanitation, and proposals submitted to the Regional Board and Santa Monica Bay Restoration Project under the Clean Beaches Initiative and Proposition 12. The annualized capital cost to construct the remaining 10 low-flow diversions is estimated at $717,386, assuming financing for 20 years at 7 percent. The operation and maintenance costs during the period from April 1 to October 31 for all 27 diversions are estimated at approximately $1.7 million. (See Table 21.) For households in the SMB watershed, this translates into an annual cost of $3.23.[38]

The total estimated costs for diverting the 27 major storm drains during dry weather from November 1 to March 31 are as follows. If charged, the one-time sewer facility charge is estimated at approximately $28 million (or $2.65 million in annualized costs). The annual operation and maintenance costs are estimated at $872,841. (See Table 21.) For households in the SMB watershed, this translates into an annual cost of $4.72 per household.

Staff has also estimated the cost of addressing dry weather runoff from some of the natural creeks that impact beaches, such as Topanga Creek. We expect that similar prevention and treatment measures to those being implemented in the Malibu watershed will be needed. Specifically, we expect that some storm drain disinfection systems may need to be installed and, in addition, a watershed source control program will need to be implemented to reduce anthropogenic nonpoint sources of bacteria such as from malfunctioning septic systems. The estimated cost per watershed is estimated at $1.0 to $2.0 million (based on cost estimates for similar management measures in the Malibu watershed). Dry weather implementation programs are likely to be needed in eight subwatersheds based on the historical data analysis: Nicholas Canyon, Trancas Canyon, Zuma Canyon, Latigo Canyon, Corral Canyon, Las

[38] Based on the 2000 U.S. Census, there are approximately 744,376 households in the SMB watershed. (This was derived based on the total population in the watershed (1,950,265) and the average number of people per household in the watershed (2.62).)

Flores Canyon, Piedra Gorda Canyon, and Topanga Canyon. Estimating on average $1.5 million per watershed equals a total cost of $12 million ($1.1 million in annualized costs). Again, for households in the Santa Monica Bay watershed, this translates into an annual cost of $1.52 per household.

Collectively, the estimated annual cost per household to achieve compliance with the TMDL during *dry weather* throughout the year is $9.50.

8.4.2 Wet Weather Treatment Costs

Reductions in the number of exceedance days during wet weather may be achieved by capturing and treating storm water at the "end-of-the-pipe." This would be the most costly means of achieving compliance with the TMDL. However, the necessary reductions in the number of days exceeding the numeric targets might also be attained through the cumulative impacts of less costly methods requiring municipal and agency collaboration and community involvement. These may include controlling sources of bacteria, eliminating illicit discharges to the storm drain system, and capturing and treating a portion of runoff from smaller, targeted land use areas or critical sources.

Below, rough estimates of the cost of "end-of-the-pipe" storm water treatment are given. For the northern SMB subwatersheds (northwest of Pulga Canyon), the model results (Table 20) and historical data (Table 18) indicate that 10 subwatersheds are likely to need some storm water treatment to achieve the necessary reductions in the number of exceedance days during wet weather. The model estimated that approximately 10,000 gallons per day (gpd) would need to be captured and treated during wet weather from the subwatersheds to comply with the TMDL.

To estimate the cost of this treatment, staff relied on cost estimates for package wastewater treatment systems with disinfection. It is estimated that these cost approximately $32,000 for a system with a capacity of 10,000 gpd. The systems require approximately ¼ acre of land, at an estimated cost of $250,000. Operation and maintenance costs are estimated at approximately $25,000 per year. Therefore, for 10 of these systems the cost is estimated to be

$266,188 in annualized capital costs and $250,000 in recurring annual costs over a 20-year period. As an example, if these costs were evenly distributed among households in the Santa Monica Bay watershed, the annual cost per household would be approximately $0.70.

The model results and historical data indicate that storm water treatment would also be required in most if not all of the subwatersheds southeast of Santa Ynez Canyon. The estimated flow capture needed during wet weather for these subwatersheds is significantly more than for the more sparsely developed northern SMB subwatersheds – with a maximum of 32 million gallons per day (MGD) for Santa Monica Canyon (see Table 20).

To estimate the cost of treating this volume of storm water, staff relied on cost estimates for wastewater treatment facilities of similar size. It is estimated that two facilities with a capacity of 50 MGD during wet weather would be needed – one for Pulga Canyon, Santa Monica Canyon and Santa Monica subwatersheds, and the other for Dockweiler, Hermosa, Redondo and Palos Verdes subwatersheds. The estimated capital cost is $150 million per facility with ultraviolet (UV) disinfection. It is estimated that approximately 12 acres would be needed per facility at a cost of $1 million per acre. Operation and maintenance costs are estimated at approximately $6.7 million per year. Therefore, for two of these wastewater treatment facilities the cost is estimated to be $30.6 million in annualized capital costs and $13.5 million in annual costs. Again, if these costs were evenly distributed among households in the Santa Monica Bay watershed, the annual cost per household would be approximately $59.00.

Collectively, the estimated annual cost per household to achieve compliance with the TMDL during *wet weather* is $60.00. It should be noted that this implementation approach would not only achieve compliance with the bacteria TMDL, but could also achieve compliance with other TMDLs.

9 Monitoring Programs

The monitoring program for the TMDL consists of two key components: a source characterization component and a shoreline compliance monitoring component.

9.1 Source Characterization

The purpose of the source characterization component is three-fold. Each of these purposes is described below. First, it will allow the Regional Board to refine estimates of the "baseline" level of exceedance in the reference system. The TMDL load allocations are set such that the number of days of exceedance at the base of a subwatershed should be the lesser of that observed in the reference system or existing levels of exceedance for a particular shoreline site. Staff selected Arroyo Sequit Canyon and Leo Carrillo Beach as the "reference" system for the purpose of defining a baseline level of exceedance. At the time of writing, staff did not have data on bacteria densities at the mouth of this system (i.e., the wave wash). Over the course of the year, staff will be collecting data from this system, and potentially one other, to better define the baseline level of exceedance observed in local natural systems during both wet and dry weather.

The second purpose of the source characterization component is to allow the Regional Board to better calibrate and validate the model and refine estimates of the necessary reductions in the number of days of exceedance for each subwatershed and by municipality. Over the next one to two years, a coalition of agencies will collect water quality data under wet weather conditions to refine estimates of bacteria densities from particular land uses and critical sources and at various instream locations. This will be a continuation of the wet weather sampling program described in section 4.

Finally, the source characterization component will assist municipalities implementing the TMDL. The data collected on average bacteria densities from different land uses, and the range of bacteria densities within a land use and during different storm events will be used in the model to evaluate different management scenarios and prioritize areas for implementation of storm water best management practices.

An additional component of the source characterization monitoring program will be to identify the ownership and status of all private drains identified by the Santa Monica BayKeeper through its BeachKeeper monitoring program. As stated earlier, Santa Monica BayKeeper has documented approximately 600 storm drains that discharge to SMB beaches from the Ventura County line to Malaga Cove. (See Appendix C.) Responsible agencies and/or individuals must notify the Regional Board within 120 days after the effective date of this TMDL of any additions, deletions, or changes to this list. Furthermore, the Regional Board must be notified of the ownership of the discharge (if applicable), the type of discharge, and any permits held for the discharge.

9.2 Compliance Determination

Compliance will be determined by daily or weekly sampling in the wave wash at all major drains and creeks or at existing monitoring stations at beaches without storm drains or freshwater outlets.[39] During wet weather, samples should be taken as close as possible to the wave wash, and no further away than 10 meters down current of the storm drain or outlet.[40] At all locations, samples must be taken at ankle depth, on an incoming wave, when the tide height is less than +2 feet. If any geometric mean target is exceeded for a rolling 30-day period, or if the number of days exceeding the single sample objectives exceeds the allowable levels set in Table 17 for any of the three time periods of concern, the contributing area and responsible jurisdictions will be considered out-of-compliance with the TMDL.

9.2.1 Follow-up Monitoring

If a single sample shows the discharge or contributing area to be out of compliance, daily sampling in the wave wash or at the existing open shoreline monitoring location shall be conducted (if it is not already) until all single sample objectives are below the thresholds. Furthermore, if a beach location is out-of-compliance, responsible municipalities will be required to conduct a sanitary survey of the subwatershed(s) per Assembly Bill 538 protocols to more specifically locate the source of the problem, and may wish to conduct compliance monitoring at key municipal boundaries as part of this effort.

The County of Los Angeles and municipalities within the Santa Monica Bay watershed are strongly encouraged to pool efforts and coordinate with other appropriate monitoring

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[39] The frequency of sampling (i.e., daily versus weekly) will be at the discretion of the implementing agencies. However, the number of sample days that may exceed the objectives will be scaled accordingly (see Table 17).
[40] Safety considerations during wet weather may preclude taking a sample in the wave wash.

agencies in order to meet the challenges posed by this TMDL by developing cooperative compliance monitoring programs.

10 References

Cabelli, V. J. 1983. Health effects criteria for marine recreational waters. U.S. Environmental Protection Agency, EPA-600/1-80-031, Cincinnati, Ohio.

California Code of Regulations, title 17, section 7958.

Cheung, W.H.S., Chang, K.C.K., Hung, R.P.S. 1990. Variations in microbial indicator densities in beach waters and health-related assessment of bathing water quality. Epidemiol. Infect. 106:329-344.

City of Los Angeles. 2001. Low-flow diversion of dry weather urban runoff. January 12, 2001.

City of Los Angeles. 1999. Santa Monica Bay Biennial Assessment Report 1997-98. Environmental Monitoring Division.

County Sanitation Districts of Los Angeles County. 2001. Joint Water Pollution Control Plan Annual Monitoring Report 2000. NPDES No. CA0053813.

Favero, M.S. 1985. Microbiologic indicators of health risks associated with swimming. AJPH 75(9):1051-1053.

Haile, R.W., Witte, J.S. 1997. Addendum to "An epidemiological study of possible adverse health effects of swimming in Santa Monica Bay." Santa Monica Bay Restoration Project.

Haile, R.W., Witte, J.S., Gold, M., Cressey, R., McGee, C., Millikan, R.C., Glasser, A., Harawa, N., Ervin, C., Harmon, P., Harper, J., Dermond, J., Alamillo, J., Barret, K., Nides, M., Wang, G. 1999. The health effects of swimming in ocean water contaminated by storm drain runoff. Epidemiology 10(4):355-363.

Haile, R.W., Alamillo, J., Barret, K., Cressey, R., Dermond, J., Ervin, C., Glasser, A., Harawa, N., Harmon, P., Harper, J., McGee, C., Millikan, R.C., Nides, M., Witte, J.S. 1996. An epidemiological study of possible adverse health effects of swimming in Santa Monica Bay, Santa Monica Bay Restoration Project.

Hanemann, Michael, Pendleton, Linwood, Layton, David. 2001. "Modeling the regional economic and social impact of marine pollution in southern California." Address to the California Coastal Commission. August 6, 2001.

Heal the Bay, Inc. 2001. Eleventh annual beach report card.

Las Virgenes Municipal Water District. 1999. Tapia Water Reclamation Facility 1999 Annual Report.

Los Angeles Regional Water Quality Control Board. 2001. "Proposed amendment of the Water Quality Control Plan - Los Angeles Region to revise bacteria objectives for waters designated for contact recreation." July 31, 2001.

Los Angeles Regional Water Quality Control Board. 2000. Trash TMDL for the Los Angeles River Watershed. Preliminary Technical Draft, March 17, 2000.

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

Los Angeles Regional Water Quality Control Board. 1996. Regional Water Quality Control Board, Los Angeles Region 1996 California Water Quality Assessment – 305(b) Report: Supporting Documentation for Los Angeles Region.

Los Angeles Regional Water Quality Control Board. 1994. Water Quality Control Plan, Los Angeles Region.

Los Angeles County Department of Public Works. 1999. Los Angeles County 1998-99 Stormwater Monitoring Report. July 14, 1999.

Los Angeles County Fire Department, Lifeguard Operations. 2001. www.lacountylifeguards.org.

National Research Council. 1999. Monsoons to microbes: Understanding the ocean's role in human health. National Academy Press, Washington, D.C.

National Technical Advisory Committee. 1968. Water Quality Criteria. Federal Water Pollution Control Administration, Department of Interior, Washington, D.C.

Noble, Rachel T., J.H. Dorsey, M.K. Leecaster, M. Mazur, C.D. McGee, D. Moore, V. Orozco-Borbon, D. Reid, K. Schiff, P.M. Vainik, S.B. Weisberg. 2000a. Southern California Bight 1998 Regional Monitoring Program: III. Storm event shoreline microbiology. Southern California Coastal Water Research Project, Westminster, CA

Noble, Rachel T., Dorsey, J., Leecaster, M., Mazur, M., McGee, C., Moore, D., Victoria, O., Reid, D., Schiff, K., Vainik P., Weisberg, S. 2000b. Southern California Bight 1998 Regional Monitoring Program, Vol II: Winter shoreline microbiology. Southern California Coastal Water Research Project, Westminster, CA.

Noble, Rachel T., Dorsey, J., Leecaster, M., Mazur, M., McGee, C., Moore, D., Victoria, O., Reid, D., Schiff, K., Vainik P., Weisberg, S. 1999. Southern California Bight 1998 Regional Monitoring Program, Vol I: Summer shoreline microbiology. Southern California Coastal Water Research Project, Westminster, CA.

O'Connell, Linda. 2001. State Water Resources Control Board, Division of Water Quality. Personal communication.

Pike, E.B. 1992. "Statistical aspects of microbial populations in recreational waters" in Recreational water quality management, Volume I: Coastal waters, Kay, D. (ed.). Ellis Horwood Limited, England.

Pruss, A. 1998. Review of epidemiological studies on health effects from exposure to recreational waters. International Journal of Epidemiology 27:1-9.

Santa Monica BayKeeper. 2001. Unpublished data.

Southern California Association of Governments. 1993. GIS coverage of land use.

SCCWRP, 2001. "Retrospective evaluation of shoreline water quality along Santa Monica Bay beaches" in Southern California Coastal Water Research Project Annual Report 1999-2000.

SCCWRP, 2001. Unpublished data.

Southern California Coastal Water Research Project. 2000. General workplan for wet weather modeling of the Los Angeles River and Santa Monica Bay watersheds.

SWRCB. 1997. Water Quality Control Plan for Ocean Waters of California. Sacramento, CA.

Taggart, Mitzy. 2001. Heal the Bay, Unpublished data.

United States District Court, Northern District of California. 1999. Heal the Bay Inc., *et al.* v. Browner, *et al.* Case No. 98-4825 SBA. March 22, 1999.

U.S. EPA. 1997. Guidelines for preparation of the comprehensive state water quality assessments (305(b) Reports) and electronic updates: Supplement. EPA 841-B-97-002B. Office of Water, Washington, D.C.

U.S. EPA. 1991. Guidance of water quality-based decisions: The TMDL process. EPA 440/4-91-001. Office of Water Regulations and Standards, Washington, D.C.
U.S. EPA. 1986. Ambient water quality criteria for bacteria – 1986. EPA 440/5-84-002, Office of Water Regulations and Standards, Criteria and Standards Division, Washington, D.C.

U.S. Environmental Protection Agency. 1976. Quality Criteria for Water. U.S. EPA, Washington, D.C.

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Table 1. Santa Monica Bay Beaches Listed for Coliform (LARWQCB, 1996)

Beach (North to South)	**Miles Affected**
Leo Carillo Beach	1.15
Trancas Beach (Broad Beach)	2.02
Paradise Cove Beach	1.33
Dan Blocker Memorial Beach (Corral Beach)	1.04
Surfrider Beach	0.66
Las Flores Beach	0.76
Big Rock Beach	1.09
Topanga Beach	1.01
Will Rogers State Beach	2.2
Santa Monica Beach	2.95
Venice Beach	1.5
Dockweiler Beach	5.4
Redondo Beach	1.37
Torrance Beach	0.58
Total miles affected	*23.06*

Table 2. Santa Monica Bay Beaches Listed for Beach Closures (LARWQCB, 1996)

Beach (North to South)	Miles Affected
Leo Carillo Beach[*^]	1.15
Nicholas Canyon Beach[^]	1.94
Robert H. Meyer Memorial Beach	1.23
Sea Level Beach	0.67
Trancas Beach[*^]	2.02
Zuma Beach[^]	1.65
Point Dume Beach	0.95
Paradise Cove Beach[*^]	1.33
Escondido Beach[#]	2.05
Puerco Beach[^]	1.68
Malibu Beach[^]	0.53
Surfrider Beach[*^]	0.66
Carbon Beach	1.48
La Costa Beach	0.74
Big Rock Beach[*^]	1.09
Castlerock Beach[+]	0.81
Las Tunas Beach	1.25
Topanga Beach[*^]	1.01
Will Rogers State Beach[*^]	2.2
Santa Monica Beach[*^]	2.95
Venice Beach[*^]	1.5
Dockweiler Beach[*^]	5.4
Manhattan Beach	2.08
Hermosa Beach[^]	1.88
Redondo Beach[*^]	1.37
Torrance Beach[*]	0.58
Malaga Cove Beach[^]	1.13
Flat Rock Point Beach Area	0.3
Bluff Cove Beach	0.61
Rocky Point Beach	0.52
Lunada Bay Beach	0.35
Resort Point Beach	0.49
Point Vicente Beach	2.13
Long Point[^]	0.45
Abalone Cove Beach	0.94
Inspiration Point Beach	0.3
Portuguese Bend Beach	2.2
Palos Verdes Shoreline Park Beach	0.12
Royal Palms Beach	1.06
Whites Point Beach	0.7
Point Fermin Park Beach	1.5
Cabrillo Beach (Outer)	0.51
Total miles affected	*53.51*

[*]Denotes that the beach is listed as impaired due to beach closures <u>and</u> coliform in the 1996 regional water quality assessment.
[^]Denotes that the beach was given an annual (2000-01) BRC grade of "C" or worse by Heal the Bay, Inc.
[#] Denotes that the beach exceeds water quality standards based on Santa Monica BayKeeper's BeachKeeper monitoring data.
[+] Denotes that the beach exceeds water quality standards based on the City of Los Angeles' Low-Flow Diversion Study monitoring data.

Table 3. L[illegible] Use as a Percent of Total Subwatershed Area

Subwatershed	Agriculture	Commercial	Education	High Density Residential	Industrial	Low Density Residential	Military	Mixed Urban	Open	Public Facilities	Recreation	Transportation	Water	Total Land Area (acres)
Las Virgenes	1.2%	0.8%	0.5%	4.2%	0.3%	1.1%	0.0%	0.2%	90.9%	0.0%	0.0%	0.9%	0.1%	15,554
Lidero Canyon	0.1%	2.0%	0.6%	11.2%	1.6%	7.7%	0.0%	0.4%	74.4%	0.7%	0.0%	1.1%	0.1%	11,455
Monte Nido	0.3%	0.4%	0.0%	0.1%	0.3%	5.5%	0.0%	0.1%	93.4%	0.0%	0.0%	0.0%	0.0%	13,432
Russell Valley	0.1%	5.9%	0.2%	11.6%	2.0%	15.7%	0.0%	0.1%	60.5%	1.0%	1.1%	1.7%	0.1%	9,165
Sherwood	12.9%	0.0%	0.0%	0.0%	0.1%	3.5%	0.0%	0.0%	82.1%	0.0%	0.0%	0.0%	1.2%	10,739
Triunfo Canyon	0.7%	0.1%	0.0%	1.3%	0.0%	6.4%	0.0%	0.2%	89.2%	0.0%	0.0%	0.0%	2.0%	10,064
Malibu Creek Total	**2.4%**	**1.4%**	**0.2%**	**4.5%**	**0.7%**	**6.0%**	**0.0%**	**0.2%**	**83.1%**	**0.2%**	**0.1%**	**0.6%**	**0.5%**	**70,410**
Arroyo Sequit	0.3%	0.1%	0.0%	0.0%	0.1%	1.5%	0.0%	0.0%	98.0%	0.0%	0.0%	0.0%	0.0%	7,549
Carbon Canyon	0.0%	1.2%	0.0%	5.6%	0.0%	8.5%	0.0%	0.0%	84.7%	0.0%	0.0%	0.0%	0.0%	2,320
Castlerock	0.0%	0.7%	0.2%	12.5%	0.1%	1.3%	0.0%	0.0%	85.0%	0.0%	0.0%	0.0%	0.3%	4,976
Corral Canyon	0.1%	0.8%	4.1%	3.4%	0.2%	1.7%	0.0%	0.0%	89.6%	0.0%	0.2%	0.0%	0.0%	4,280
Encinal Canyon	0.8%	0.0%	0.0%	3.9%	0.0%	4.7%	0.0%	0.0%	90.5%	0.0%	0.0%	0.0%	0.0%	1,794
Escondido Canyon	0.0%	0.0%	0.0%	1.1%	0.0%	10.3%	0.0%	0.0%	88.6%	0.0%	0.0%	0.0%	0.0%	2,295
Las Flores Canyon	0.5%	0.5%	0.0%	1.9%	0.1%	6.5%	0.0%	0.0%	90.4%	0.0%	0.0%	0.0%	0.0%	2,897
Latigo Canyon	0.0%	0.1%	0.0%	2.0%	0.0%	6.9%	0.0%	0.0%	91.0%	0.0%	0.0%	0.0%	0.0%	813
Los Alisos Canyon	1.0%	0.1%	0.0%	0.9%	0.0%	7.8%	0.0%	0.0%	90.3%	0.0%	0.0%	0.0%	0.0%	2,396
Nicholas Canyon	0.0%	0.4%	0.0%	1.8%	0.0%	4.5%	0.0%	1.6%	91.6%	0.0%	0.0%	0.0%	0.0%	1,235
Pena Canyon	0.0%	0.0%	0.0%	2.9%	0.0%	0.0%	0.0%	0.0%	97.1%	0.0%	0.0%	0.0%	0.0%	608
Piedra Gorda Canyon	0.0%	0.0%	0.0%	18.1%	0.0%	0.0%	0.0%	0.0%	81.9%	0.0%	0.0%	0.0%	0.0%	644
Pulga Canyon	0.0%	3.0%	2.0%	17.8%	0.3%	0.2%	0.0%	0.0%	76.6%	0.0%	0.0%	0.0%	0.1%	1,955
Ramirez Canyon	0.3%	0.5%	0.1%	2.3%	0.0%	18.5%	0.0%	0.1%	78.3%	0.0%	0.0%	0.0%	0.0%	3,334
Santa Monica Canyon	0.0%	0.4%	0.3%	11.6%	0.0%	8.5%	0.0%	0.0%	77.6%	0.0%	1.6%	0.0%	0.0%	10,088
Solstice Canyon	0.0%	0.1%	0.0%	0.0%	0.0%	2.7%	0.0%	0.0%	97.2%	0.0%	0.0%	0.0%	0.0%	2,841
Topanga Canyon	0.3%	0.2%	0.1%	0.8%	0.0%	8.7%	0.0%	0.2%	89.8%	0.0%	0.0%	0.0%	0.0%	12,575
Trancas Canyon	0.3%	0.3%	0.4%	1.8%	0.0%	6.7%	0.0%	0.1%	88.4%	0.0%	1.8%	0.0%	0.1%	6,514
Tuna Canyon	0.0%	0.0%	0.0%	1.3%	0.0%	2.3%	0.0%	0.0%	96.4%	0.0%	0.0%	0.0%	0.0%	1,013
Santa Ynez	0.0%	1.5%	0.6%	49.4%	0.0%	2.5%	0.0%	0.0%	46.1%	0.0%	0.0%	0.0%	0.0%	1,203
Zuma Canyon	1.7%	0.7%	0.0%	1.1%	0.0%	10.5%	0.0%	0.0%	85.8%	0.0%	0.0%	0.0%	0.1%	6,339
Other Northern Bay Total	**0.3%**	**0.5%**	**0.4%**	**4.8%**	**0.0%**	**6.5%**	**0.0%**	**0.1%**	**87.0%**	**0.0%**	**0.4%**	**0.0%**	**0.0%**	**77,671**
Northern Bay Total	**1.3%**	**0.9%**	**0.3%**	**4.6%**	**0.3%**	**6.3%**	**0.0%**	**0.1%**	**85.2%**	**0.1%**	**0.3%**	**0.3%**	**0.3%**	**148,081**
Cienega	0.1%	13.8%	4.2%	59.2%	8.3%	0.1%	0.0%	6.8%	4.5%	0.0%	0.0%	2.9%	0.1%	16,624
Culver City	0.0%	4.0%	1.2%	32.8%	5.9%	15.3%	0.0%	0.4%	34.1%	0.0%	4.6%	0.8%	0.9%	8,011
Hollywood	0.0%	16.1%	2.0%	52.7%	2.1%	3.0%	0.0%	9.1%	13.1%	0.0%	0.6%	0.9%	0.4%	29,602
Marina Del Rey	0.0%	10.5%	4.2%	44.0%	9.5%	0.0%	0.0%	1.0%	24.5%	0.0%	0.0%	0.2%	6.1%	5,241
West Los Angeles	0.0%	10.7%	5.3%	40.9%	2.9%	2.5%	0.0%	0.1%	29.7%	0.0%	2.7%	4.6%	0.4%	10,127
Westwood Village	0.0%	8.4%	5.1%	59.9%	5.6%	7.5%	0.0%	0.6%	6.8%	0.0%	4.4%	0.9%	0.8%	6,086
Windsow Hills	0.0%	13.3%	1.4%	55.9%	13.4%	0.3%	0.1%	2.4%	9.1%	0.0%	0.0%	4.1%	0.1%	6,288
Ballona Creek Total	**0.0%**	**12.7%**	**3.1%**	**50.8%**	**5.4%**	**3.5%**	**0.0%**	**5.0%**	**15.4%**	**0.0%**	**1.3%**	**2.0%**	**0.7%**	**81,980**
Dockweiler	0.0%	4.8%	2.8%	27.0%	19.9%	0.0%	0.0%	0.3%	12.8%	0.0%	1.1%	31.1%	0.2%	6,573
Hermosa	0.0%	10.8%	5.5%	71.5%	3.7%	0.0%	0.2%	5.2%	2.9%	0.0%	0.0%	0.0%	0.4%	2,624
Palos Verdes	0.5%	1.6%	2.0%	51.1%	0.9%	4.5%	1.5%	0.1%	33.6%	0.0%	2.9%	1.2%	0.1%	10,023
Redondo	1.7%	11.6%	8.0%	57.5%	4.1%	0.0%	0.0%	11.2%	5.5%	0.0%	0.1%	0.0%	0.2%	3,544
Santa Monica	0.0%	11.9%	3.0%	54.3%	3.7%	4.6%	0.0%	4.6%	13.0%	0.0%	2.3%	2.6%	0.0%	8,850
Other Southern Bay Total	**0.3%**	**7.1%**	**3.4%**	**49.4%**	**6.2%**	**2.7%**	**0.5%**	**3.1%**	**17.8%**	**0.0%**	**1.8%**	**7.6%**	**0.1%**	**31,614**
Southern Bay Total	**0.1%**	**11.1%**	**3.2%**	**50.4%**	**5.6%**	**3.3%**	**0.1%**	**4.5%**	**16.1%**	**0.0%**	**1.4%**	**3.5%**	**0.6%**	**113,594**
Grand Total	**0.8%**	**5.3%**	**1.6%**	**24.5%**	**2.6%**	**5.0%**	**0.1%**	**2.0%**	**55.2%**	**0.1%**	**0.8%**	**1.7%**	**0.4%**	**261,675**

Table 4. Bacteria Objectives for REC-1 Designated Marine Waters (LARWQCB, 2001)

Parameter	Geometric Mean	Single Sample
Total Coliform	1,000	10,000
Fecal Coliform	200	400
Fecal-to-Total Coliform Ratio	N/A	Total Coliform 1,000 if ratio > 0.1
Enterococci	35	104

Table 5: Average Percentage of Days Exceeding Any Bacterial Indicator for Shoreline Bacteriological Monitoring Stations in Santa Monica Bay (1996-2000)

Station ID	Location Name	Average Percent Exceedance (1996-2000)		
		April 1-Oct. 31	Nov. 1-Mar. 31	Wet Weather
City of Los Angeles, Environmental Monitoring Division				
S1	Surfrider Beach (breach point) - daily	0.22	0.38	0.60
S2	Topanga State Beach	0.04	0.12	0.32
S3	Pulga Canyon storm drain - 50 yards east (Will Rogers)	0.02	0.09	0.29
S4	Santa Monica Canyon, Will Rogers State Beach	0.17	0.11	0.32
S5	Santa Monica Municipal Pier - 50 yards southeast (Santa Monica)	0.25	0.29	0.43
S6	Santa Monica Beach at Pico/Kenter storm drain (Santa Monica)	0.07	0.26	0.56
S7	Ashland Av. storm drain - 50 yards south (Venice)	0.07	0.10	0.27
S8	Venice City Beach at Windward Av. - 50 yards north	0.01	0.01	0.16
S10	Ballona Creek entrance - 50 yards south (Dockweiler)	0.03	0.06	0.36
S11	Dockweiler State Beach at Culver Bl.	0.03	0.04	0.28
S12	Imperial Highway storm drain - 50 yards north (Dockweiler)	0.03	0.02	0.22
S13	Manhattan State Beach at 40th Street	0.00	0.01	0.04
S14	Manhattan Beach Pier - 50 yards south	0.00	0.01	0.06
S15	Hermosa Beach Pier - 50 yards south	0.00	0.02	0.10
S16	Redondo Municipal Pier - 50 yards south	0.07	0.13	0.17
S17	Redondo State Beach at Avenue I	0.01	0.03	0.08
S18	Malaga Cove, Palos Verdes Estates - daily	0.00	0.01	0.04
Los Angeles County Department of Health Services				
DHS (010)	**Leo Carillo Beach (REFERENCE BEACH)**	**0.00**	**0.03**	**0.22**
DHS (009)	Nicholas Beach	0.03	0.00	0.20
DHS (010a)	Broad Beach	0.01	0.07	0.20
DHS (008)	Trancas Beach entrance	0.02	0.00	0.27
DHS (007)	Westward Beach, SE end	0.03	0.00	0.22
DHS (006)	Paradise Cove	0.07	0.13	0.31
DHS (005)	26610 Latigo Shore Drive	0.05	0.18	0.44
DHS (005a)	Corral Beach	0.01	0.08	0.22
DHS (004)	Puerco Beach	0.00	0.11	-
DHS (003)	Malibu Point, Malibu Colony Dr.	0.10	0.10	0.24
DHS (003a)	Surfrider Beach, Malibu, 50 yds.	0.27	0.32	0.60
DHS (002)	Malibu Pier	0.19	0.19	0.60
DHS (001a)	Las Flores Beach	0.08	0.11	0.35
DHS (001)	Big Rock Beach	0.15	0.26	0.38
DHS (101)	17200 Pacific Coast Hwy.	0.01	0.13	0.29
DHS (102)	Bel Air Bay Club, 16801 Pacific	0.06	0.09	0.36
DHS (103)	Temescal Storm Drain	0.08	0.03	0.42
DHS (104a)	San Vicente Blvd. extended	0.03	0.03	0.44
DHS (104)	Montana Ave. Storm Drain	0.03	0.03	0.40
DHS (105)	Wilshire Blvd., Santa Monica	0.07	0.07	0.42
DHS (106)	Strand Street extended	0.03	0.10	0.49
DHS (106a)	Ashland Storm Drain	0.11	0.05	0.51
DHS (107)	Venice City Beach at Brooks Av.	0.01	0.15	0.29
DHS (108)	Venice Pier, Venice	0.01	0.03	0.22
DHS (109)	Topsail Street extended	0.05	0.03	0.51
DHS (110)	World Way extended	0.02	0.04	0.40
DHS (111)	Opposite Hyperion Plant, 1 mile	0.01	0.07	0.24
DHS (112)	Grand Avenue extended	0.04	0.09	0.33
DHS (113)	26th Street extended	0.02	0.00	0.16
DHS (114)	Herondo Street extended	0.02	0.04	0.24
DHS (115)	Topaz Street extended	0.03	0.17	0.22
*County Sanitation Districts of Los Angeles County**				
LACSD1	Long Point	0.003	0.001	0.03
LACSD2	Abalone Cove	0.002	0.000	0.01
LACSD3	Portuguese Bend Cove	0.003	0.007	0.01
LACSD5	Royal Palms	0.003	0.010	0.04
LACSD6	Wilder Annex	0.003	0.003	0.01
LACSD7	Cabrillo Beach, oceanside	0.003	0.007	0.01
LACSDMC	Malaga Cove	0.005	0.004	0.05
LACSDBC	Bluff Cove	0.000	0.007	0.00

* Average percent exceedance for County Sanitation Districts' data is for 4-year period (1997-2000).

Table 6. Heal the Bay's Annual BRC Grades for SMB Beaches (2000-01)

Beach/Monitoring Location	Dry Weather	Wet Weather
Leo Carrillo Beach	A	F
Nicholas Canyon Beach	A	F
Trancas Beach (Broad Beach)	A	F
Westward Beach (Zuma Beach)	A	D
Paradise Cove	B	F
Latigo Canyon Creek entrance (Corral Beach)	B	F
Puerco Beach	A	F
Surfrider Beach (near Malibu Colony)	C	F
Surfrider Beach (@ breach location)	F	F
Malibu Pier	C	F
Big Rock Beach	F	F
Topanga State Beach	B	F
Will Rogers Beach (@ PCH & Sunset Blvd.)	A	F
Will Rogers Beach (near Bel Air Bay Club)	B	F
Will Rogers Beach (Pulga Canyon storm drain)	A	F
Will Rogers Beach (Temescal Canyon)	C	F
Will Rogers Beach (Santa Monica Canyon)	F	F
Santa Monica Beach (Montana Ave.)	A	F
Santa Monica Beach (Arizona Ave.)	A	F
Santa Monica Pier	B	F
Santa Monica Beach (Pico-Kenter storm drain)	C	F
Santa Monica Beach (Strand St.)	A	F
Ocean Park Beach (Ashland Ave. storm drain)	A	F
Venice Beach (Brooks Ave.)	A	F
Venice Beach (Windward Ave.)	A	D
Venice Pier	A	C
Venice Beach (Topsail St.)	A	F
Dockweiler Beach (south of Ballona Cr.)	A	F
Dockweiler Beach (Culver Blvd.)	A	F
Dockweiler Beach (D&W jetty)	A	C
Dockweiler Beach (Imperial Hwy. storm drain)	A	F
Dockweiler Beach (opposite Hyperion)	A	C
Dockweiler Beach (Grand Ave.)	A	F
Manhattan Beach (40th St.)	A	B
Manhattan Pier	A	A
Hermosa Beach (26th St.)	A	A
Hermosa Pier	A+	C
Herondo St. storm drain	B	F
Redondo Pier	C	D
Redondo Beach (Topaz St.)	A	D
Redondo Beach (Ave. I)	A	B
Malaga Cove	A	A
Malaga Cove	A+	F
Bluff Cove	A	A+
Long Point	A	F
Abalone Cove	A	B
Portuguese Bend	A+	A
Royal Palms Beach	A	B
Cabrillo Beach (Outer)	A	A

Table 7: Summary of Dry-weather Bacteria Counts in the Mixing Zone at Various Storm Drains Discharging to Santa Monica Bay

	Location	Date	Total Coliform N	Total Coliform Arithmetic Mean	Total Coliform Percent (%) Exceedance	Fecal Coliform N	Fecal Coliform Arithmetic Mean	Fecal Coliform Percent (%) Exceedance	Enterococcus N	Enterococcus Arithmetic Mean	Enterococcus Percent (%) Exceedance
LA City	Castlerock	2000	17	62,941	76.5	17	1,672	58.8	17	4,248	94.1
	Santa Ynez Canyon		15	50,065	40.0	15	558	40.0	15	1,586	60.0
	Marquez		8	135	0.0	9	114	11.1	8	78	0.0
	Pulga Canyon		18	1,335	0.0	18	123	56.0	18	181	27.8
	Temescal Canyon		17	24,898	41.2	17	326	29.4	17	1,432	76.5
	Santa Monica Canyon		17	19,676	41.2	17	1,605	94.1	17	1,187	100.0
	North Westchester		16	1,714	6.3	16	1,568	63.0	16	1,319	63.0
	Imperial Highway		16	4,944	12.5	16	161	63.0	16	184	25.0
HTB	Malibu	2000	13	5,957	23.1	13	652	53.8	13	105	38.5
	Santa Monica Canyon	2000	22	3,474	4.5	22	459	31.8	22	215	68.2
	"	2001	4	4,343	25	4	428	50	4	250	50

HTB: Heal the Bay

Table 8: Summary of Dry-weather Bacteria Counts in Storm Drain Discharges to Santa Monica Bay

Location		Date	Total Coliform			Fecal Coliform			Enterococcus		
			N	Arithmetic Mean	Percent (%) Exceedance	N	Arithmetic Mean	Percent (%) Exceedance	N	Arithmetic Mean	Percent (%) Exceedance
LA County	Herondo	1998	2	91,000	100.0	2	1,515	50.0	2	9,150	100.0
	Pershing		1	3,000,000	100.0	1	30,000	100.0	1	300,000	100.0
	Brooks		2	195,000	100.0	2	1,250	50.0	2	1,500	100.0
	Ashland		2	8,450,000	100.0	2	495,000	100.0	2	900,000	100.0
LA City	Castlerock	1999	12	163,333	100.0	12	13,304	100.0			
	Santa Ynez Canyon		11	30,818	81.8	11	1,430	45.5			
	Marquez		13	298,462	100.0	13	11,967	46.2			
	Pulga Canyon		14	12,157	28.6	14	231	14.3			
	Temescal Canyon		14	78,343	85.7	14	2,872	85.7			
	Santa Monica Canyon		14	57,043	92.9	14	3,210	85.7			
	North Westchester		14	29,193	64.3	14	1,212	92.9			
	Imperial Highway		14	48,125	92.9	14	2,278	92.9			
	Castlerock	2000	17	398,083	100.0	17	10,783	100.0	17	20,633	94.1
	Santa Ynez Canyon		15	34,253	53.3	15	1,469	80.0	15	3,603	73.3
	Marquez		16	287,438	100.0	16	5,806	100.0	16	6,989	100.0
	Pulga Canyon		18	6,039	11.1	18	589	50.0	18	340	33.3
	Temescal Canyon		17	143,000	100.0	17	4,015	94.1	17	8,833	100.0
	Santa Monica Canyon		17	40,106	88.2	17	3,764	100.0	17	3,029	8.2
	Venice Pavilion		4	161,750	100.0	4	5,600	100.0	4	6,553	100.0
	North Westchester		9	1,233	0.0	9	800	77.8	9	174	22.2
	Imperial Highway		15	69,407	16.7	15	3,787	80.0	15	1,476	60.0
HTB	Santa Monica Canyon	2000	22	36,468	63.6	22	6,100	81.8	22	2,252	100
	"	2001	4	64,000	100	4	2,265	100	4	2,575	100

HTB: Heal the Bay

Table 9: Summary of Dry-weather Bacteria Counts for Ballona Creek & Lagoon

Location		Date	Total Coliform			Fecal Coliform			Enterococcus		
			N	Arithmetic Mean	Percent (%) Exceedance	N	Arithmetic Mean	Percent (%) Exceedance	N	Arithmetic Mean	Percent (%) Exceedance
LA City	BC @ Centinela	1996	213	166,974	79.3	212	11,829	91.5	209	3,265	90.0
		1997	119	62,292	84.9	119	2,303	92.4	118	595	82.2
		1998	200	141,269	92.5	188	4,728	93.1	112	3,488	93.8
		1999	204	86,374	83.3	209	3,442	78.0			
		2000	161	77,794	69.6	185	3,644	81.1			
	BC @ Pacific	1996	33	38,097	15.2	33	2,649	36.4	31	470	48.4
		1997	17	332	0.0	15	406	26.7	17	165	11.8
		1998	24	10,497	16.7	25	2,620	56.0	23	856	69.6
		1999	28	9,703	14.3	28	606	17.9	25	586	48.0
		2000	29	11,880	13.8	29	1,893	41.4	28	1,276	67.9
SMBK	BC 5	2000	2	3,150	0	3	100	0			
	BC30	"	2	153,400	100	2	3,010	100			
	BC31	"	1	36,540	100	1	860	100			
	BC40	"	3	101,959	100	2	7,095	100	1	100	0
	BC41	"	1	57,940	100	1	100	0	1	100	0
	BC90	"	1	2,064	0	1	740	100			
	BC95	"	1	36,540	100	1	1,080	100			
	BC119	"	2	50,020	100	2	625	100			
	BC120	"	2	185,958	100	2	17,970	100			
	BC121	"	1	111,965	100	1	520	100			
	BC122	"	1	28,510	100	1	100	0			
	Ballona Lagoon	"	8	62,868	87.5	8	235	12.5	2	100	0
LA County	BC @ Culver & Beloit	1994-2000	9	44,156		9	2,426		9	2,581	

BC: Ballona Creek; SMBK: Santa Monica BayKeeper

Table 10: Summary of Dry-weather Bacteria Counts for Malibu Creek and Lagoon

Location		Date	Total Coliform			Fecal Coliform			Enterococcus		
			N	Arithmetic Mean	Percent (%) Exceedance	N	Arithmetic Mean	Percent (%) Exceedance	N	Arithmetic Mean	Percent (%) Exceedance
LA County	MC @ Malibu Cyn Rd.	1994-2000	6	16,633		6	265		5	250	
HTB	Malibu Lagoon SD	2000	13	9,000	30.8	13	832	84.6	13	120	23.1

MC: Malibu Creek; HTB: Heal the Bay; SD: Storm drain

Table Summary of Bacteria Densities from Various Land Uses during Wet Weather

Data Source	Land Use	Total Coliform N	Total Coliform Arithmetic Mean	Fecal Coliform N	Fecal Coliform Arithmetic Mean	Enterococcus N	Enterococcus Arithmetic Mean
SCCWRP (2001)	Agriculture	15	399,333	15	89,133	NS	NS
	Commercial	75	353,767	85	130,690	35	92,163
	Industrial	68	665,218	85	268,899	17	1,081,368
	Open	48	209,435	48	101,505	40	98,606
	Residential	98	401,424	113	185,254	47	305,536
LA County (1994-2000)	Commercial	8	1,140,000	8	528,740	8	86,250
	Light Industrial	5	454,000	5	338,220	5	98,200
	Vacant	21	9,187	21	1,397	21	679
	HD/SF Residential	3	1,366,667	3	933,333	3	610,000
	Transportation	4	692,500	4	328,750	4	32,000

Table 12. Yearly geometric mean stormwater bacteria densities for Ballona and Malibu Creeks (MPN/100 ml), 1994-2000 (LAC-DPW, 2000)

Site Name	Year	Total Coliform	Fecal Coliform	Enterococcus
Ballona Creek				
	94-95	518,004	198,738	151,008
	95-96	2,623,967	684,899	1,001,181
	96-97	667,467	67,466	90,000
	97-98	1,120,085	522,415	no data
	98-99	326,580	30,930	137,594
	99-00	280,332	87,737	43,877
Malibu Creek				
	94-95	160,000	22,000	2,400
	95-96	120,240	13,221	6,996
	96-97	58,285	8,794	30,000
	97-98	239,022	53,312	no data
	98-99	35,502	3,866	4,538
	99-00	34,594	10,792	5,386

Table 13. Wet-weather Source Characterization Sites

Land Use Category	Critical Sources within Land Use	Target Number of Samples	Number Collected
High Density Residential	Mixed	2	2
	High pet density	1	0
Low Density Residential	Sewered	2	2
	Unsewered	1	0
Commercial	Mixed	2	2
	Mixed, with homeless population	1	0
	Restaurant	1	0
	Shopping mall	1	0
Industrial	Mixed	2	2
	Food industry	1	0
	Auto salvage	1	1
	Metal plating	-	- (????)
	Oil extraction	1	0
Agriculture	Mixed	2	2
	Nursery	1	1
Recreation	Golf course	1	0
	Horse stable	2	2
Transportation	Freeway	-	- (????)
	Rail yard	1	1
	Gas station	1	0
Open Space	Open	2	1
Instream	Ballona Creek	2	2
	Santa Monica Canyon	2	2
Total		30	20

Table 14. Wet-weather Source Characterization Study: First-Year Data Summary (Flow-weighted Geometric Means)

Sampling Sites		N	Total Coliform (#/100 ml)		Fecal Coliform (#/100 ml)		Enterococcus (#/100 ml)	
			Mean	S.D.	Mean	S.D.	Mean	S.D.
Land Use Sites	Open Space	10	6,453	.	59	.	382	.
	Transportation (Railyard)	12	6,557	.	130	.	3,591	.
	Recreation (Horse Stable)	24	1,031,356	729,189	265,481	205,721	82,856	21,980
	Agriculture (Nursery)	13	2,347,197	.	56,223	.	302,199	.
	Agriculture	36	202,079	75,518	22,898	21,176	26,186	8,521
	Industrial	18	31,630	18,468	1,071	651	2,445	1,591
	Industrial (Auto Salvage)	12	160,185	.	13,673	.	65,931	.
	Commercial	22	284,558	266,134	3,198	2,949	20,020	19,452
	High Density Residential	22	75,557	24,679	14,620	8,700	8,260	3,734
	Low Density Residential	23	52,643	28,484	4,898	1,615	8,706	2,038
Instream Sites	Santa Monica Canyon	21	352,610	268,670	10,805	5,160	28,162	19,417
	Ballona Creek	21	288,291	182,230	11,480	5,602	40,292	24,129

Table 15. Land Use Categories used in Wet-weather Model

Agriculture
Commercial
Education
High Density Residential
Industrial
Low Density Residential
Military Installations
Mixed Urban
Open
Public Facilities & Institutions
Recreation
Transportation
Water

Table 16. Number of Days of Exceedances by Subwatershed for Design Year based on Daily 90th Percentile Modeled Values

Subwatershed	Modeled Number of Days of Exceedance for Design Year				
	Total Coliform	Fecal Coliform	TC/FC ratio	Enterococcus	Total Exceedances
Arroyo Sequit	26	26	28	28	28
Nicholas Canyon	22	24	15	26	26
Los Alisos Canyon	23	24	17	26	26
Encinal Canyon	23	24	15	26	26
Trancas Canyon	27	28	16	29	29
Zuma Canyon	28	29	17	31	31
Ramera Canyon	23	25	13	27	27
Escondido Canyon	26	27	18	29	29
Latigo Canyon	24	25	18	28	28
Solstice Canyon	26	27	28	28	28
Corral Canyon	25	26	13	28	28
Malibu	33	46	35	62	62
Carbon Canyon	23	23	15	26	26
Las Flores Canyon	22	23	17	24	24
Piedra Gorda Canyon	23	23	11	25	25
Pena Canyon	24	25	18	28	28
Tuna Canyon	24	25	20	27	27
Topanga Canyon	26	28	19	29	29
Castlerock	26	28	17	29	29
Santa Ynez Canyon	24	27	8	27	27
Pulga Canyon	27	30	15	33	33
Santa Monica Canyon	53	59	21	64	64
Santa Monica	73	73	1	75	75
Ballona - 15 cfs	99	101	2	100	101
Dockweiler	29	30	3	33	33
Hermosa	30	31	0	31	31
Redondo	34	34	1	35	35
Palos Verdes	30	32	4	32	32

Table 17: Allowable Number of Days per Year that May Exceed Any Bacterial Indicator Based on Daily or Weekly Sampling Regimes for Existing Shoreline Monitoring Stations

Station ID	Location Name	Winter Dry Weather		Wet Weather	
		Daily sampling (No. days)	Weekly sampling (No. days)	Daily sampling (No. days)	Weekly sampling (No. days)
City of Los Angeles, Environmental Monitoring Division Sites					
S1	Surfrider Beach (breach point) - daily	2	1	27	4
S2	Topanga State Beach	2	1	27	4
S3	Pulga Canyon storm drain - 50 yards east (Will Rogers)	2	1	27	4
S4	Santa Monica Canyon, Will Rogers State Beach	2	1	27	4
S5	Santa Monica Municipal Pier - 50 yards southeast (Santa Monica)	2	1	27	4
S6	Santa Monica Beach at Pico/Kenter storm drain (Santa Monica)	2	1	27	4
S7	Ashland Av. storm drain - 50 yards south (Venice)	2	1	27	4
S8	Venice City Beach at Windward Av. - 50 yards north	1	1	19	3
S10	Ballona Creek entrance - 50 yards south (Dockweiler)	2	1	27	4
S11	Dockweiler State Beach at Culver Bl.	2	1	27	4
S12	Imperial Highway storm drain - 50 yards north (Dockweiler)	1	1	26	4
S13	Manhattan State Beach at 40th Street	1	1	5	1
S14	Manhattan Beach Pier - 50 yards south	1	1	7	1
S15	Hermosa Beach Pier - 50 yards south	1	1	12	2
S16	Redondo Municipal Pier - 50 yards south	2	1	20	3
S17	Redondo State Beach at Avenue I	1	1	9	2
S18	Malaga Cove, Palos Verdes Estates - daily	1	1	5	1
Los Angeles County Department of Health Services Sites					
DHS (010)	Leo Carillo Beach (REFERENCE BEACH)	2	1	26	4
DHS (009)	Nicholas Beach	0	0	24	4
DHS (010a)	Broad Beach	2	1	24	4
DHS (008)	Trancas Beach entrance	0	0	27	4
DHS (007)	Westward Beach, SE end	0	0	26	4
DHS (006)	Paradise Cove	2	1	27	4
DHS (005)	26610 Latigo Shore Drive	2	1	27	4
DHS (005a)	Corral Beach	2	1	26	4
DHS (004)	Puerco Beach	2	1	27	4
DHS (003)	Malibu Point, Malibu Colony Dr.	2	1	27	4
DHS (003a)	Surfrider Beach, Malibu, 50 yds.	2	1	27	4
DHS (002)	Malibu Pier	2	1	27	4
DHS (001a)	Las Flores Beach	2	1	27	4
DHS (001)	Big Rock Beach	2	1	27	4
DHS (101)	17200 Pacific Coast Hwy.	2	1	27	4
DHS (102)	Bel Air Bay Club, 16801 Pacific	2	1	27	4
DHS (103)	Temescal Storm Drain	2	1	27	4
DHS (104a)	San Vicente Blvd. extended	2	1	27	4
DHS (104)	Montana Ave. Storm Drain	2	1	27	4
DHS (105)	Wilshire Blvd., Santa Monica	2	1	27	4
DHS (106)	Strand Street extended	2	1	27	4
DHS (106a)	Ashland Storm Drain	2	1	27	4
DHS (107)	Venice City Beach at Brooks Av.	2	1	27	4
DHS (108)	Venice Pier, Venice	2	1	26	4
DHS (109)	Topsail Street extended	2	1	27	4
DHS (110)	World Way extended	2	1	27	4
DHS (111)	Opposite Hyperion Plant, 1 mile	2	1	27	4
DHS (112)	Grand Avenue extended	2	1	27	4
DHS (113)	26th Street extended	0	0	19	3
DHS (114)	Herondo Street extended	2	1	27	4
DHS (115)	Topaz Street extended	2	1	26	4
County Sanitation Districts of Los Angeles County Sites					
LACSD1	Long Point	1	1	4	1
LACSD2	Abalone Cove	0	0	2	1
LACSD3	Portuguese Bend Cove	1	1	2	1
LACSD5	Royal Palms	1	1	5	1
LACSD6	Wilder Annex	1	1	2	1
LACSD7	Cabrillo Beach, oceanside	1	1	2	1
LACSDMC	Malaga Cove	1	1	6	1
LACSDBC	Bluff Cove	1	1	0	0

Notes: The number of allowable exceedances days was calculated based on the model design year (1993).
1993 had 29 days of rainfall >=0.1 inch. Adding the 3 days following the rain event equals 116 rain-affected days (wet weather days).
There were an estimated 35 days of non-AB411 dry weather in 1993.
The number of allowable weekly sampling days that may exceed was calculated by simply dividing the number of days for the period of concern by 7, and then multiplying by the exceedance percentage.
The percentage & number of allowable exceedances is based on the lesser of (1) the reference beach or (2) existing levels of exceedance based on historical shoreline data as summarized in Table 5.
Allowable wet weather exceedances are set at 27 days - instead of 26 - due to the fact that the shoreline data may underestimate the number of exceedances, since samples are taken 50 yards upcoast or downcoast from freshwater outlets.
Because these historical exceedance levels may underestimate exceedance levels in the wave wash (the compliance point for the TMDL), they will be re-evaluated once sampling locations are located in the wave wash.

Table 18: Average Percentage of Days Exceeding Any Bacterial Indicator and the Required Reduction in the Number of Days of Exceedance to Achieve Compliance with the TMDL*

		Summer Dry Weather		Winter Dry Weather		Wet Weather		
Location Name	Subwatershed	April 1-Oct. 31 Average Percent Exceedance	Required Reduction in No. Daily Sample Days	Nov. 1-Mar. 31 Average Percent Exceedance	Required Reduction in No. Daily Sample Days	Wet Weather Average Percent Exceedance	Required Reduction in No. Daily Sample Days	Short-term Required Reduction in No. Days*
City of Los Angeles, Environmental Monitoring Division Sites								
Surfrider Beach (breach point) - daily	Malibu Canyon	0.22	48	0.38	12	0.60	43	42
Topanga State Beach	Topanga Canyon	0.04	10	0.12	3	0.32	10	9
Pulga Canyon storm drain - 50 yards east (Will Rogers)	*Pulga Canyon*	0.02	4	0.09	2	0.29	7	6
Santa Monica Canyon, Will Rogers State Beach	Santa Monica Canyon	0.17	36	0.11	2	0.32	10	9
Santa Monica Municipal Pier - 50 yards southeast (Santa Monica)	Santa Monica	0.25	54	0.29	8	0.43	24	23
Santa Monica Beach at Pico/Kenter storm drain (Santa Monica)	Santa Monica	0.07	15	0.26	8	0.56	38	37
Ashland Av. storm drain - 50 yards south (Venice)	Santa Monica	0.07	16	0.10	2	0.27	5	4
Venice City Beach at Windward Av. - 50 yards north	Ballona	0.01	3	0.01	0	0.16	0	0
Ballona Creek entrance - 50 yards south (Dockweiler)	Dockweiler	0.03	7	0.06	1	0.36	15	14
Dockweiler State Beach at Culver Bl.	Dockweiler	0.03	6	0.04	0	0.28	6	5
Imperial Highway storm drain - 50 yards north (Dockweiler)	Dockweiler	0.03	7	0.02	0	0.22	0	0
Manhattan State Beach at 40th Street	Hermosa	0.00	1	0.01	0	0.04	0	0
Manhattan Beach Pier - 50 yards south	Hermosa	0.00	1	0.01	0	0.06	0	0
Hermosa Beach Pier - 50 yards south	Hermosa	0.00	2	0.02	0	0.10	0	0
Redondo Municipal Pier - 50 yards south	Redondo	0.07	16	0.13	3	0.17	0	0
Redondo State Beach at Avenue I	Redondo	0.01	2	0.03	0	0.08	0	0
Malaga Cove, Palos Verdes Estates - daily	Palos Verdes	0.00	1	0.01	0	0.04	0	0
Los Angeles County Department of Health Services Sites								
Leo Carillo Beach (REFERENCE BEACH)	**Arroyo Sequit Canyon**	**0.00**	0	**0.03**	0	**0.22**	0	0
Nicholas Beach	Nicholas Canyon	0.03	7	0.00	0	0.20	0	0
Broad Beach	Trancas Canyon	0.01	3	0.07	1	0.20	0	0
Trancas Beach entrance	Trancas Canyon	0.02	5	0.00	0	0.27	5	4
Westward Beach, SE end	Zuma Canyon	0.03	8	0.00	0	0.22	0	0
Paradise Cove	Ramirez Canyon	0.07	16	0.13	3	0.31	10	9
26610 Latigo Shore Drive	Latigo Canyon	0.05	11	0.18	5	0.44	25	24
Corral Beach	Latigo Canyon	0.01	3	0.08	1	0.22	0	0
Puerco Beach	Corral Canyon	0.00	0	0.11	2	-	-	-
Malibu Point, Malibu Colony Dr.	Malibu Canyon	0.10	23	0.10	2	0.24	2	1
Surfrider Beach, Malibu, 50 yds.	Malibu Canyon	0.27	58	0.32	10	0.60	43	42
Malibu Pier	Malibu Canyon	0.19	42	0.19	5	0.60	43	42
Las Flores Beach	Las Flores Canyon	0.08	18	0.11	2	0.35	14	13
Big Rock Beach	Piedra Gorda Canyon	0.15	32	0.26	8	0.38	17	16
17200 Pacific Coast Hwy.	Santa Ynez Canyon	0.01	3	0.13	3	0.29	7	6
Bel Air Bay Club, 16801 Pacific	Santa Ynez Canyon	0.06	14	0.09	2	0.36	15	14
Temescal Storm Drain	Pulga Canyon	0.08	17	0.03	0	0.42	22	21
San Vicente Blvd. extended	Santa Monica	0.03	7	0.03	0	0.44	25	24
Montana Ave. Storm Drain	Santa Monica	0.03	7	0.03	0	0.40	20	19
Wilshire Blvd., Santa Monica	Santa Monica	0.07	15	0.07	1	0.42	22	21
Strand Street extended	Santa Monica	0.03	8	0.10	2	0.49	30	29
Ashland Storm Drain	Santa Monica	0.11	24	0.05	0	0.51	33	32
Venice City Beach at Brooks Av.	Ballona	0.01	3	0.15	4	0.29	7	6
Venice Pier, Venice	Ballona	0.01	4	0.03	0	0.22	0	0
Topsail Street extended	Ballona	0.05	11	0.03	0	0.51	33	32
World Way extended	Dockweiler	0.02	5	0.04	0	0.40	20	19
Opposite Hyperion Plant, 1 mile	Dockweiler	0.01	3	0.07	1	0.24	2	1
Grand Avenue extended	Dockweiler	0.04	8	0.09	2	0.33	12	11
26th Street extended	*Hermosa*	0.02	5	0.00	0	0.16	0	0
Herondo Street extended	Hermosa	0.02	5	0.04	0	0.24	2	1
Topaz Street extended	Redondo	0.03	8	0.17	4	0.22	0	0
County Sanitation Districts of Los Angeles County								
Long Point	Palos Verdes	0.003	1	0.00	0	0.03	0	0
Abalone Cove	Palos Verdes	0.002	1	0.00	0	0.01	0	0
Portuguese Bend Cove	Palos Verdes	0.003	1	0.01	0	0.01	0	0
Royal Palms	Palos Verdes	0.003	1	0.01	0	0.04	0	0
Wilder Annex	Palos Verdes	0.003	1	0.00	0	0.01	0	0
Cabrillo Beach, oceanside	*Palos Verdes*	0.003	1	0.01	0	0.01	0	0
Malaga Cove	Palos Verdes	0.005	2	0.00	0	0.05	0	0
Bluff Cove	Palos Verdes	0.000	0	0.01	0	0.00	0	0

*Average percentage of days exceeding any bacterial indicator is taken from Table 5.

Table 19. Implementation Schedule

Year	Compliance Point	Implementation Methods
3	No exceedance days from April 1 to October 31	• Divert dry weather storm drain flows to treatment plants, where possible • Eliminate illicit discharges • Control sources of bacteria (including groundwater sources) and/or • Implement "end-of-pipe" treatment
5	Re-open TMDL to revise as necessary allowable exceedance days based on shoreline monitoring data collected in the wave wash and additional data on reference system(s)	N/A
6	Compliance with allowable winter dry weather exceedance days as set forth in Table 17	Same as above
10	Compliance with allowable wet weather exceedance days as set forth in Table 17	• Divert or capture & treat a portion of storm flows • Capture and treat a portion of rainfall from targeted land use areas and/or critical sources • Eliminate illicit discharges and/or • Control sources

Table 20: Estimated Flow Capture Needed during Wet Weather to Achieve Allowable Exceedance Days (by Subwatershed)

Subwatershed	Total Days of Modeled Exceedances	Reduction in Exceedance Days to Achieve "Baseline"	Estimated Flow Capture Needed during Wet Weather (MGD)
Arroyo Sequit	28	0	-
Nicholas Canyon	26	0	-
Los Alisos Canyon	26	0	-
Encinal Canyon	26	0	-
Trancas Canyon	**29**	**1**	0.01
Zuma Canyon	**31**	**3**	0.01
Ramera Canyon	27	0	-
Escondido Canyon	**29**	**1**	0.01
Latigo Canyon	28	0	-
Solstice Canyon	28	0	-
Corral Canyon	28	0	-
Malibu	**62**	**34**	To be addressed separately
Carbon Canyon	26	0	-
Las Flores Canyon	24	0	-
Piedra Gorda Canyon	25	0	-
Pena Canyon	28	0	-
Tuna Canyon	27	0	-
Topanga Canyon	**29**	**1**	0.01
Castlerock	**29**	**1**	0.01
Santa Ynez Canyon	27	0	-
Pulga Canyon	**33**	**5**	0.04
Santa Monica Canyon	**64**	**36**	31.78
Santa Monica	**75**	**47**	25.79
Ballona*	**101**	**73**	To be addressed separately
Dockweiler	**33**	**5**	11.99
Hermosa	**31**	**3**	4.56
Redondo	**35**	**7**	6.98
Palos Verdes	**32**	**4**	14.36

Subwatersheds in bold indicate those for which the model indicates reductions in wet weather exceedance days are necessary.
* Ballona flow capture is in addition to 15 cfs of low flow captured.

Table 2 Capital Costs and Annual Costs for Low Flow Diversions of Major Storm Drains to Santa Monica Bay

	Major Storm Drains to SMB	Adjacent Beach	Drainage Area	Schedule	Estimated Construction Cost	Phase I O&M Costs	Phase I Treatment Costs	Phase II Sewer Facility Charge (SFC)	Phase II O&M Costs	Phase II Treatment Costs
1	Castlerock (& Parker Canyon)	Castlerock	Castlerock	not prop	800,000	25,000	14,992	600,000	17,857	4,463
2	Santa Ynez (Sunset Blvd.)	Will Rogers	Castlerock		800,000	50,000	99,420	600,000	35,714	29,595
3	Bay Club Dr.	Will Rogers	Santa Ynez	operational		17,000	6,312	600,000	12,143	1,879
4	Marquez Ave.	Will Rogers	Santa Ynez		800,000	18,000	64	600,000	12,857	19
5	Pulga	Will Rogers	Pulga		800,000	25,000	26,039	3,300,000	17,857	7,751
6	Temescal	Will Rogers	Pulga	2002		22,000	19,332	3,300,000	15,714	5,755
7	Palisades Park	Will Rogers	Pulga	operational		20,000	15,000	1,200,000	14,286	5,000
8	Santa Monica Canyon	Will Rogers	Santa Monica Canyon	2002		54,000	370,854	8,400,000	38,571	110,394
9	Montana Ave.	Santa Monica	Santa Monica		600,000	25,000	15,000	300,000	17,857	10,714
10	Wilshire Blvd.	Santa Monica	Santa Monica		600,000	25,000	15,000	300,000	17,857	5,000
11	Santa Monica Pier	Santa Monica	Santa Monica	operational		25,000	15,000	300,000	17,857	5,000
12	Pico-Kenter	Santa Monica	Santa Monica	operational		50,000	15,781	1,100,000	35,714	4,698
13	Ashland Ave. & Rose Ave.	Venice	Santa Monica	operational		28,000	15,000	180,000	20,000	5,000
14	Thornton Ave.	Venice	Santa Monica	operational		50,000	15,000	130,000	35,714	5,000
15	Brooks Ave.	Venice	Santa Monica	operational		19,000	15,000	285,000	13,571	5,000
16	Windward Ave./Venice Pavilion	Venice	Santa Monica	2002		25,000	15,000	260,000	17,857	5,000
17	Playa del Rey/Culver Blvd.	Dockweiler	Dockweiler	operational		20,000	15,000	675,000	14,286	5,000
18	North Westchester	Dockweiler	Dockweiler		800,000	50,000	15,000	500,000	35,714	5,000
19	Imperial Highway	Dockweiler	Dockweiler	2002		20,000	11,047	1,300,000	14,286	3,288
20	El Segundo Blvd./Grand Ave.	Dockweiler	Dockweiler		800,000	50,000	15,000	500,000	35,714	5,000
21	South of Dockweiler Jetty	Dockweiler	Dockweiler	operational		50,000	15,000	500,000	35,714	5,000
22	27th St., Manhattan Beach	Manhattan Beach	Hermosa	2002		20,000	15,000	500,000	14,286	5,000
23	Manhattan Beach Pier	Manhattan Beach	Hermosa	operational		50,000	15,000	500,000	35,714	5,000
24	Hermosa Beach Pier	Hermosa Beach	Hermosa		800,000	20,000	15,000	500,000	14,286	5,000
25	Herondo St.	Hermosa Beach	Redondo	operational		50,000	15,000	500,000	35,714	5,000
26	Redondo Beach Pier	Redondo Beach	Redondo		800,000	20,000	15,000	500,000	14,286	5,000
27	Avenue I/Miramar	Redondo Beach	Palos Verdes	2003		25,000	15,000	500,000	17,857	5,000
	Totals				7,600,000	853,000	833,840	27,930,000	609,286	263,555

Cost estimates are based on a report prepared by the City of Los Angeles (2001); personal communication with Mike Mullin, City of Los Angeles, Bureau of Sanitation; project proposals submitted to the Regional Board; and other sources.

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Figure 1: Santa Monica Bay Watershed Management Area
Major Watersheds, Subwatersheds, Streams and Lakes

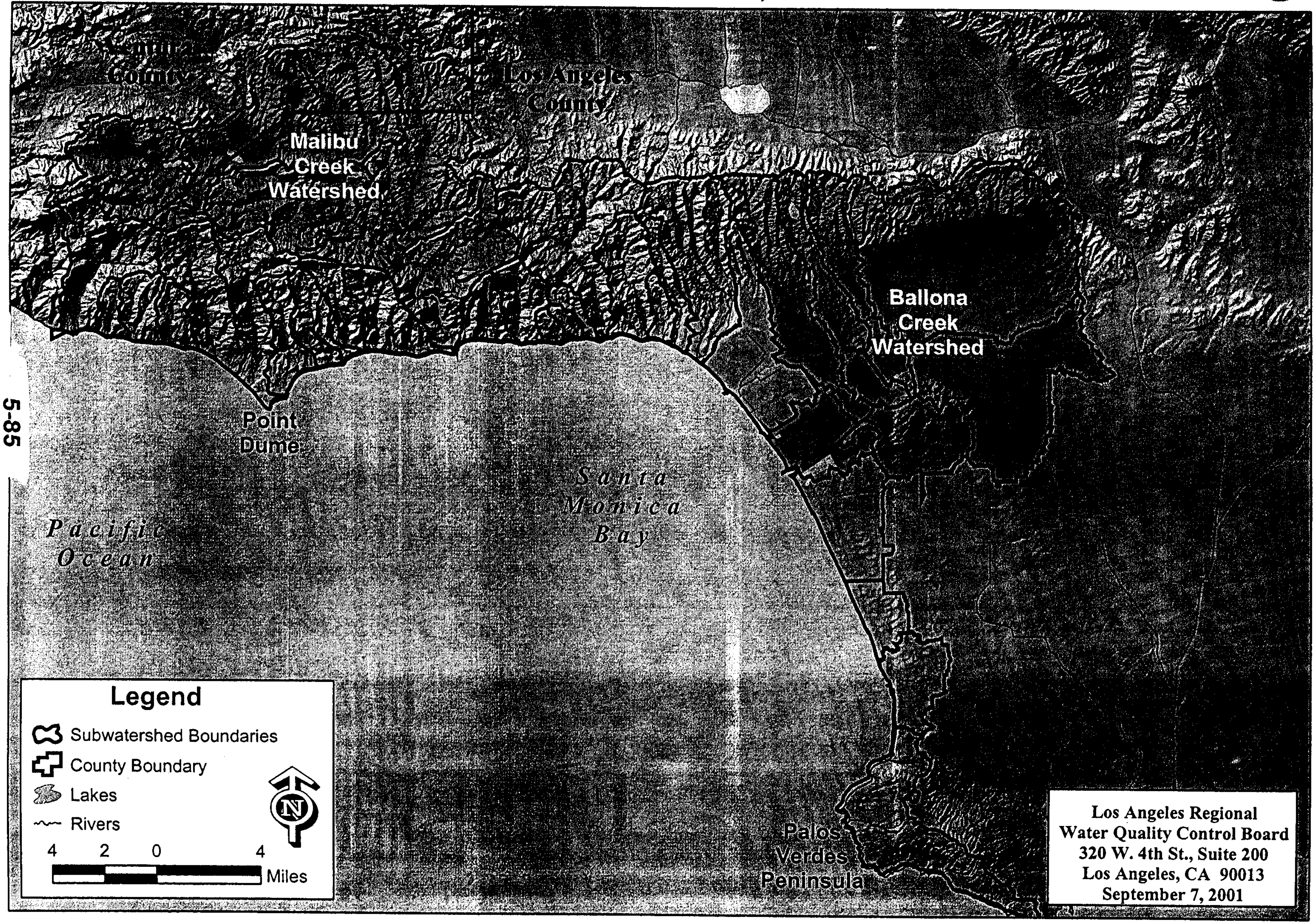

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Figure 2: Northern Santa Monica Bay Watershed Management Area Beaches Listed as Impaired due to Exceedances of Bacteria Standards

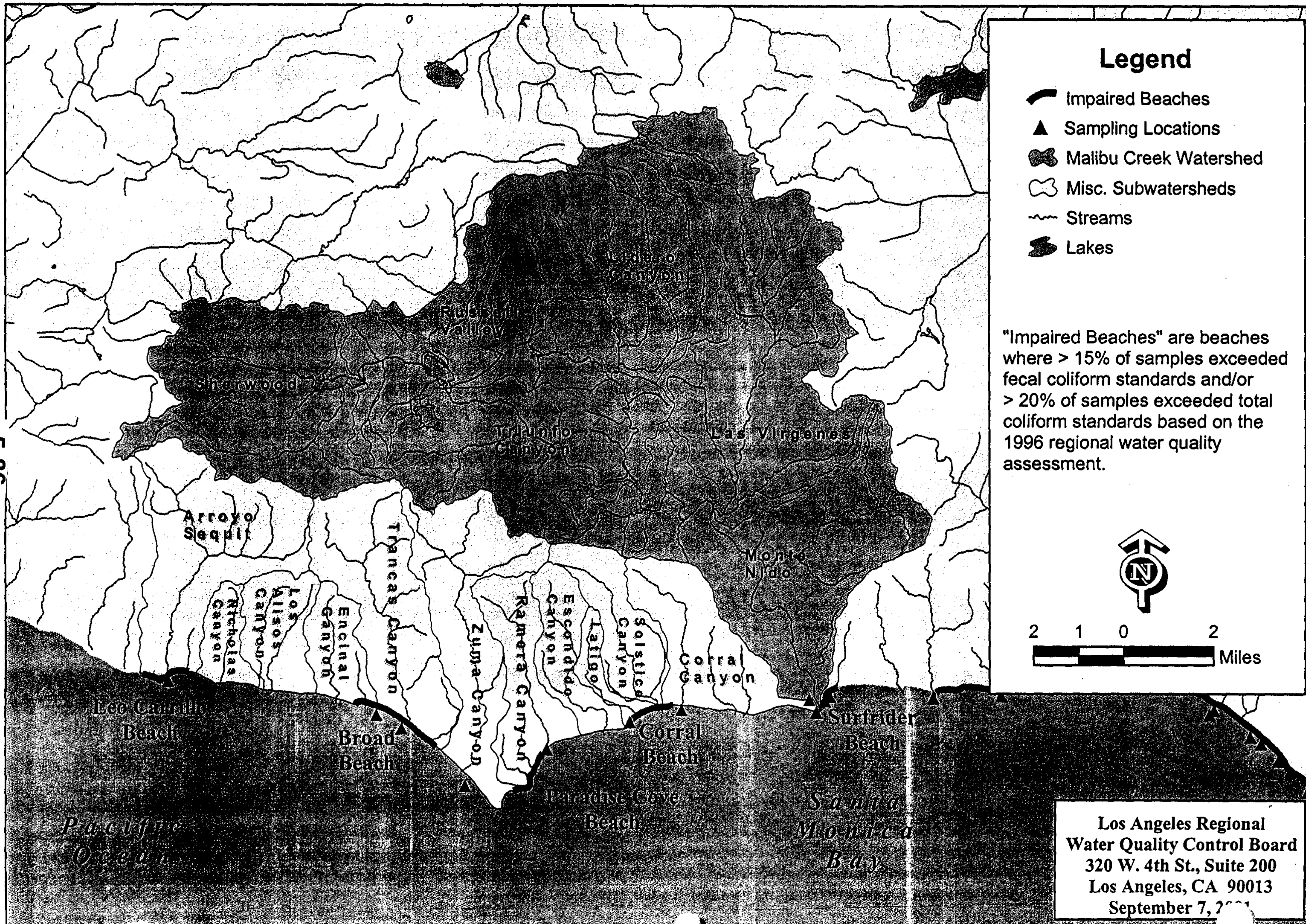

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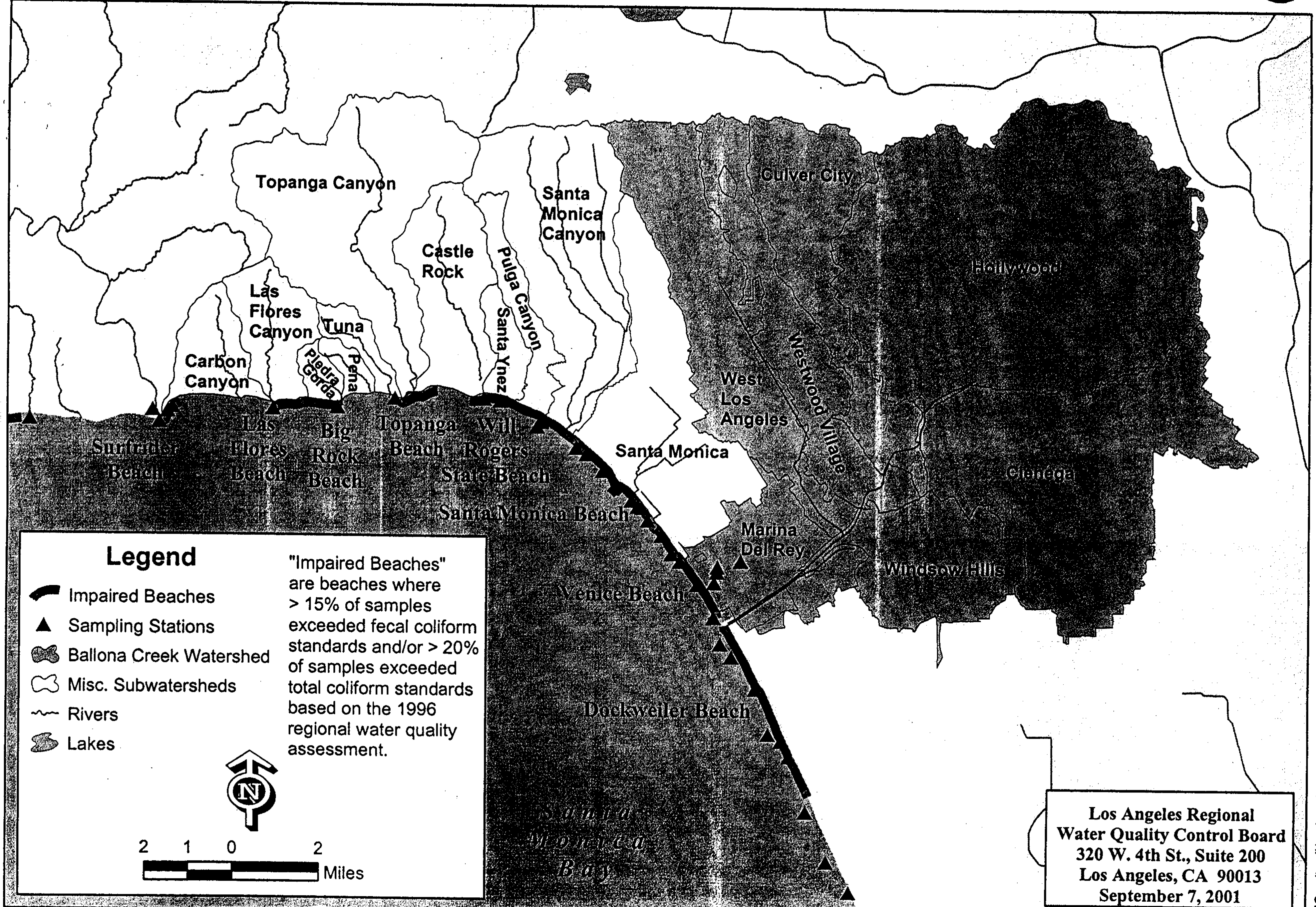
Figure 3: Central Santa Monica Bay Watershed Management Area
Beaches Listed as Impaired due to Exceedances of Bacteria Standards

Cal/EPA



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R100623

Figure 4: Southern Santa Monica Bay Watershed Management Area Beaches Listed as Impaired due to Exceedances of Bacteria Standards

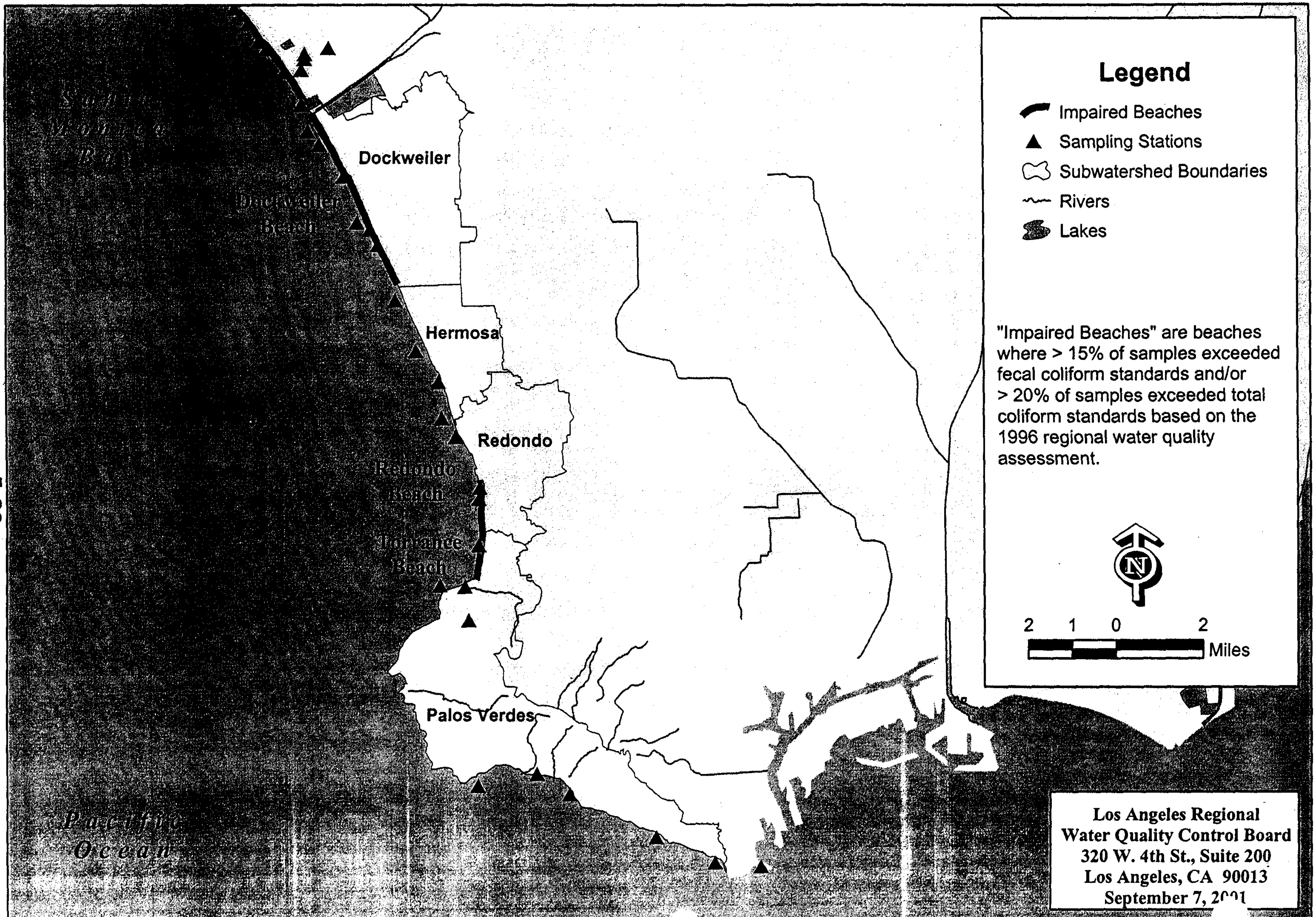
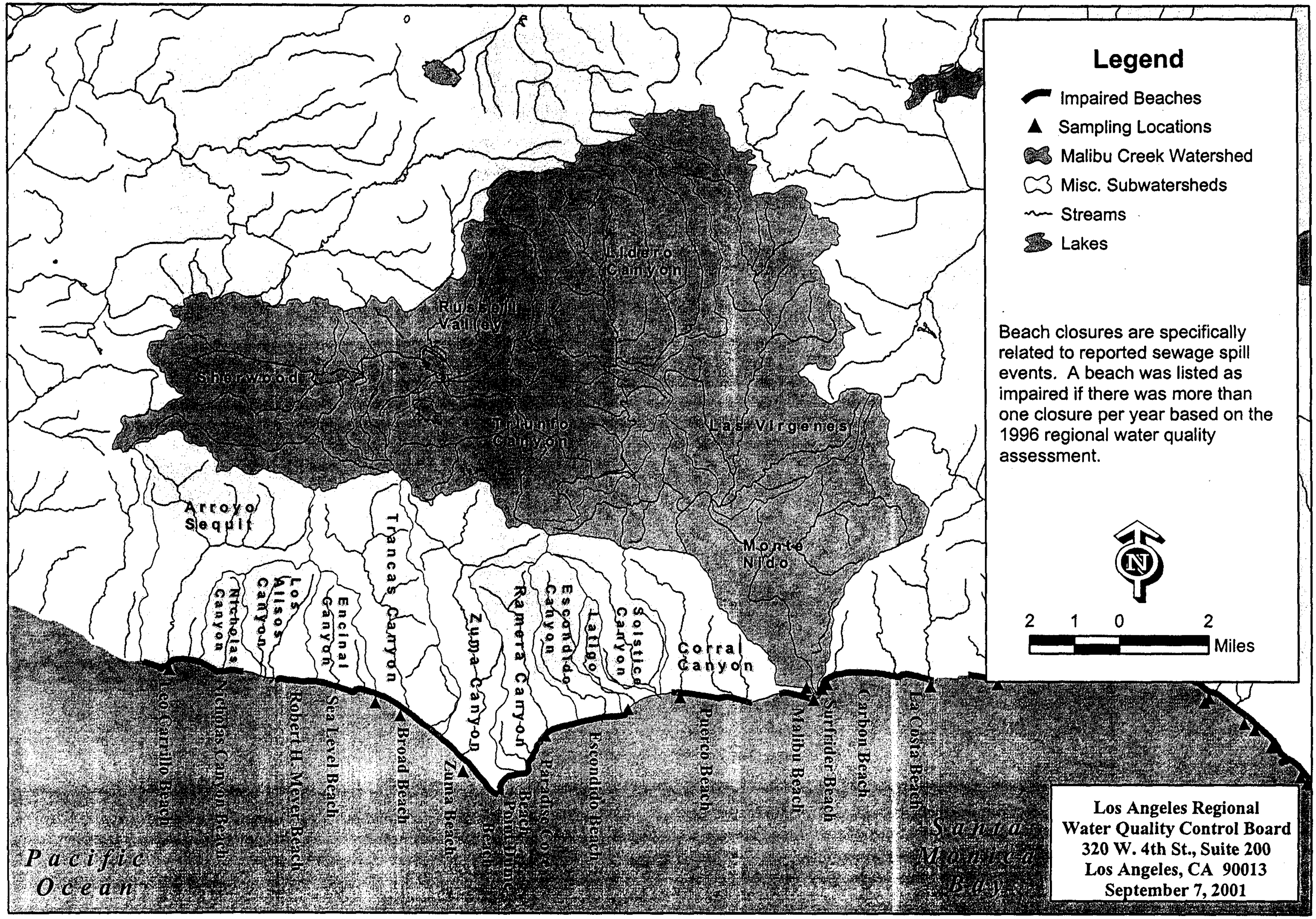


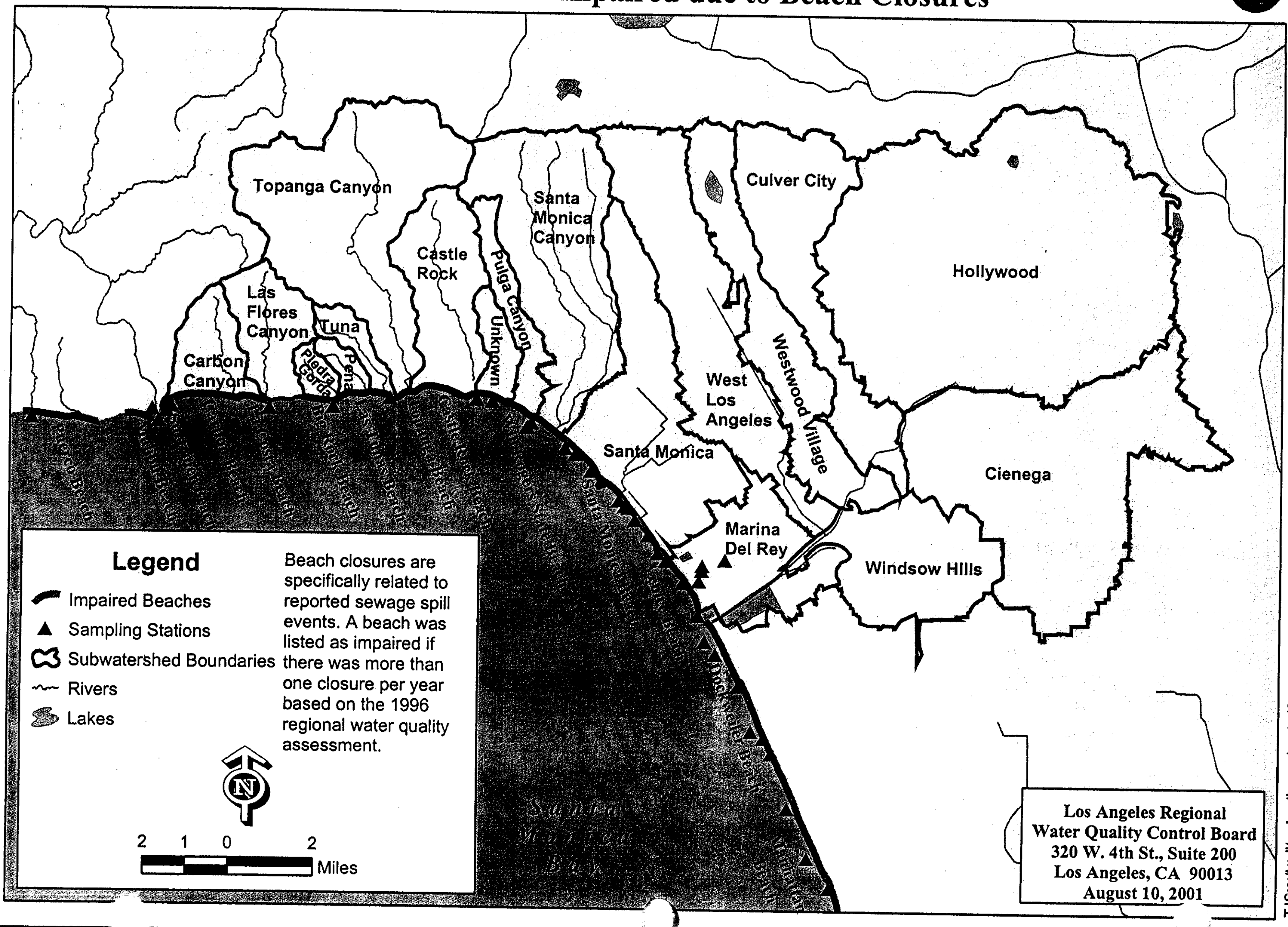
Figure 5: Northern Santa Monica Bay Watershed Management Area
Beaches Listed as Impaired due to Beach Closures



TJS:e:/tmdl/smbpathogen/north3a.mxd

R100625

Figure 6: Central Santa Monica Bay Watershed Management Area
Beaches Listed as Impaired due to Beach Closures



R100626

Figure 7: Southern Santa Monica Bay Watershed Management Area
Beaches Listed as Impaired due to Beach Closures

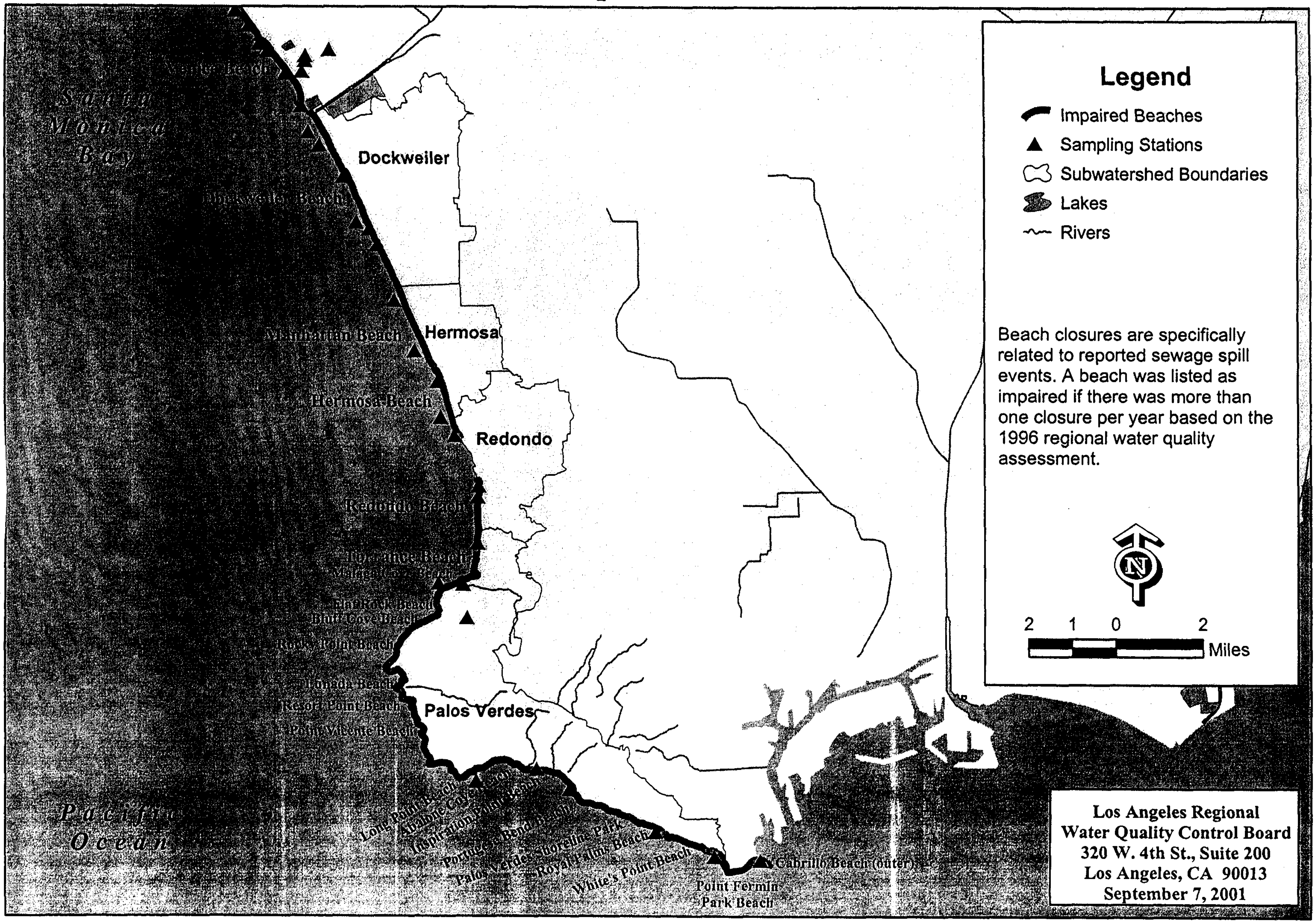
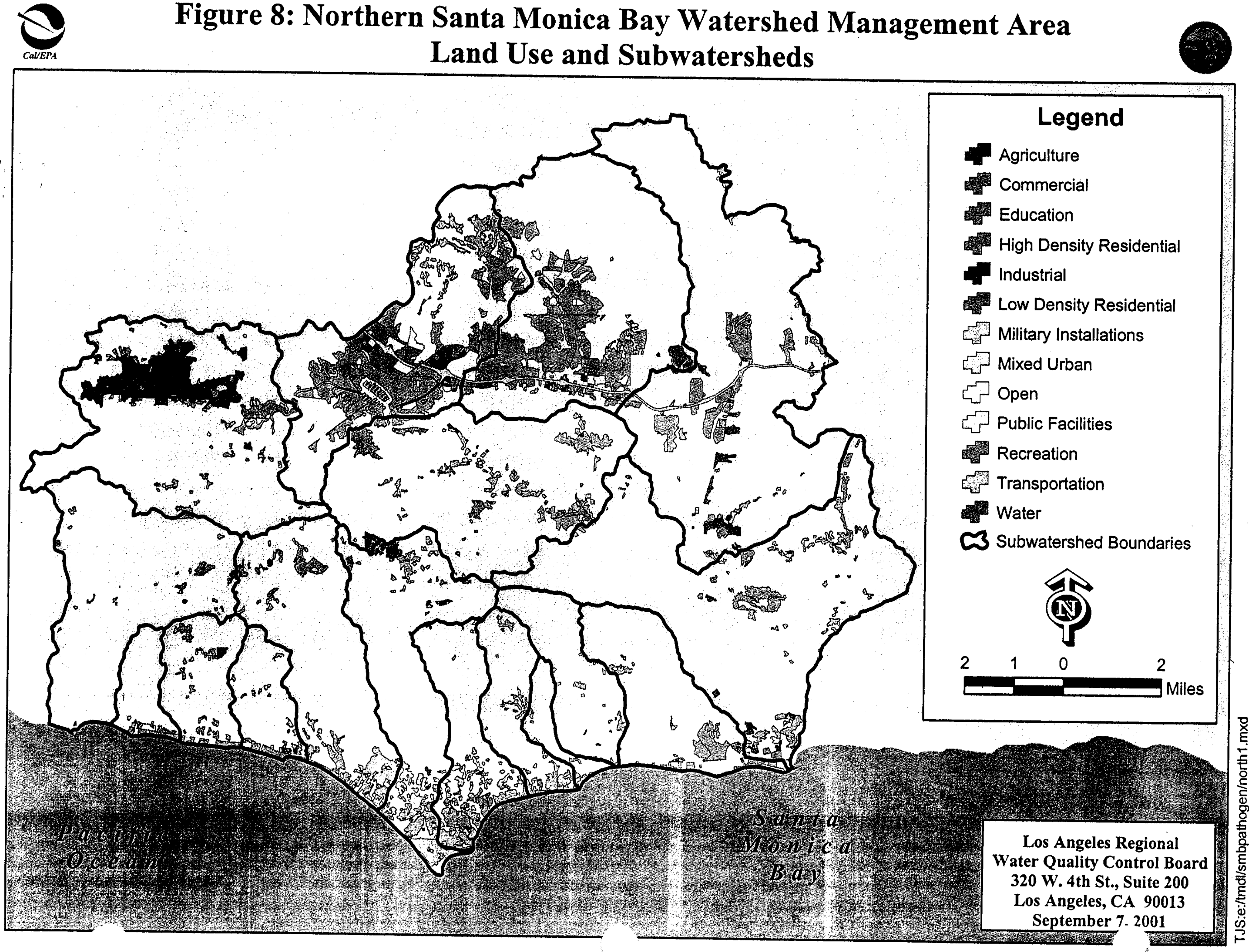
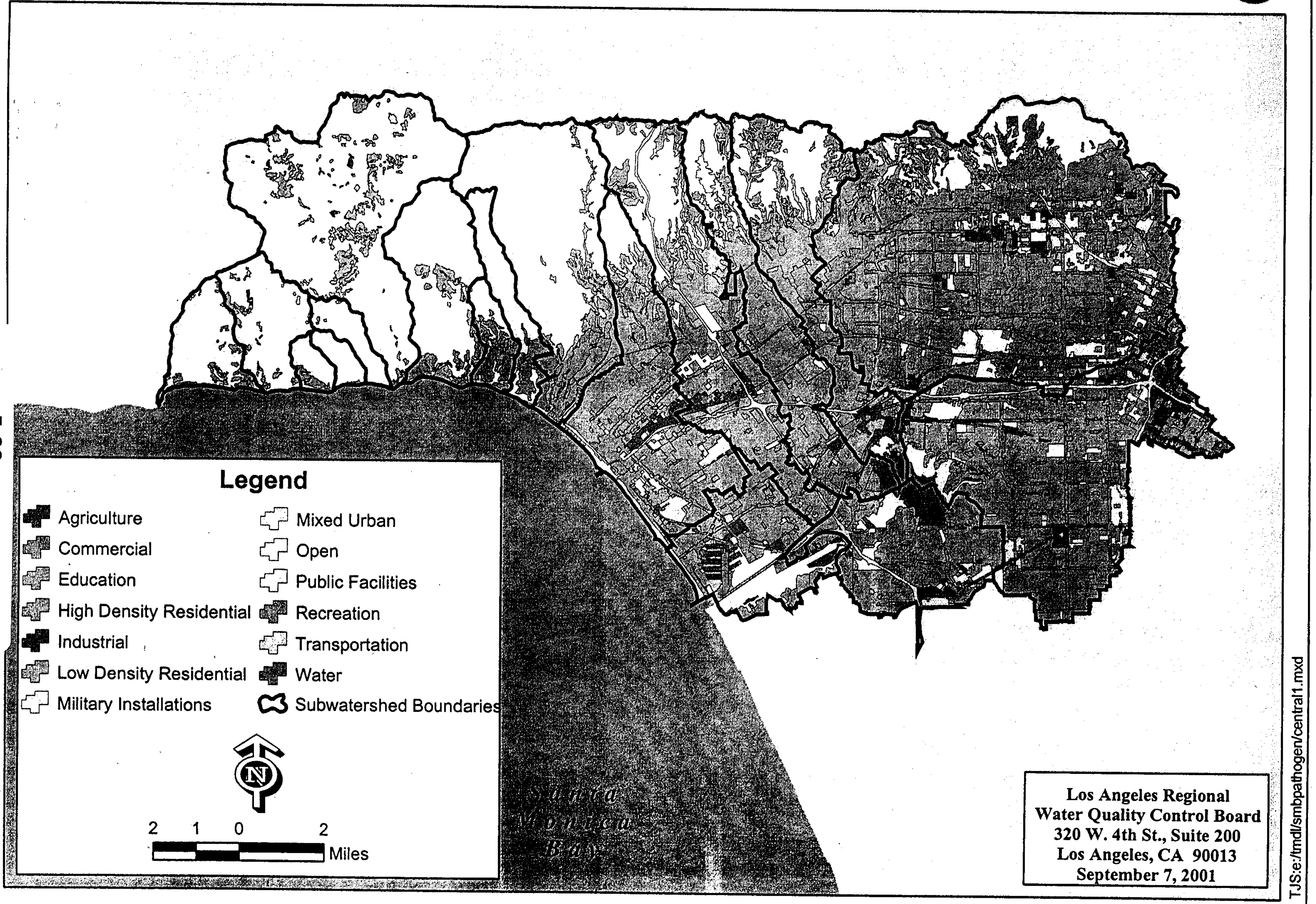


Figure 8: Northern Santa Monica Bay Watershed Management Area Land Use and Subwatersheds



R100628

Figure 9: Central Santa Monica B— Watershed Management Area
Land Use and Subwatersheds



R100629

Figure 10: Southern Santa Monica Bay Watershed Management Area Land Use and Subwatersheds

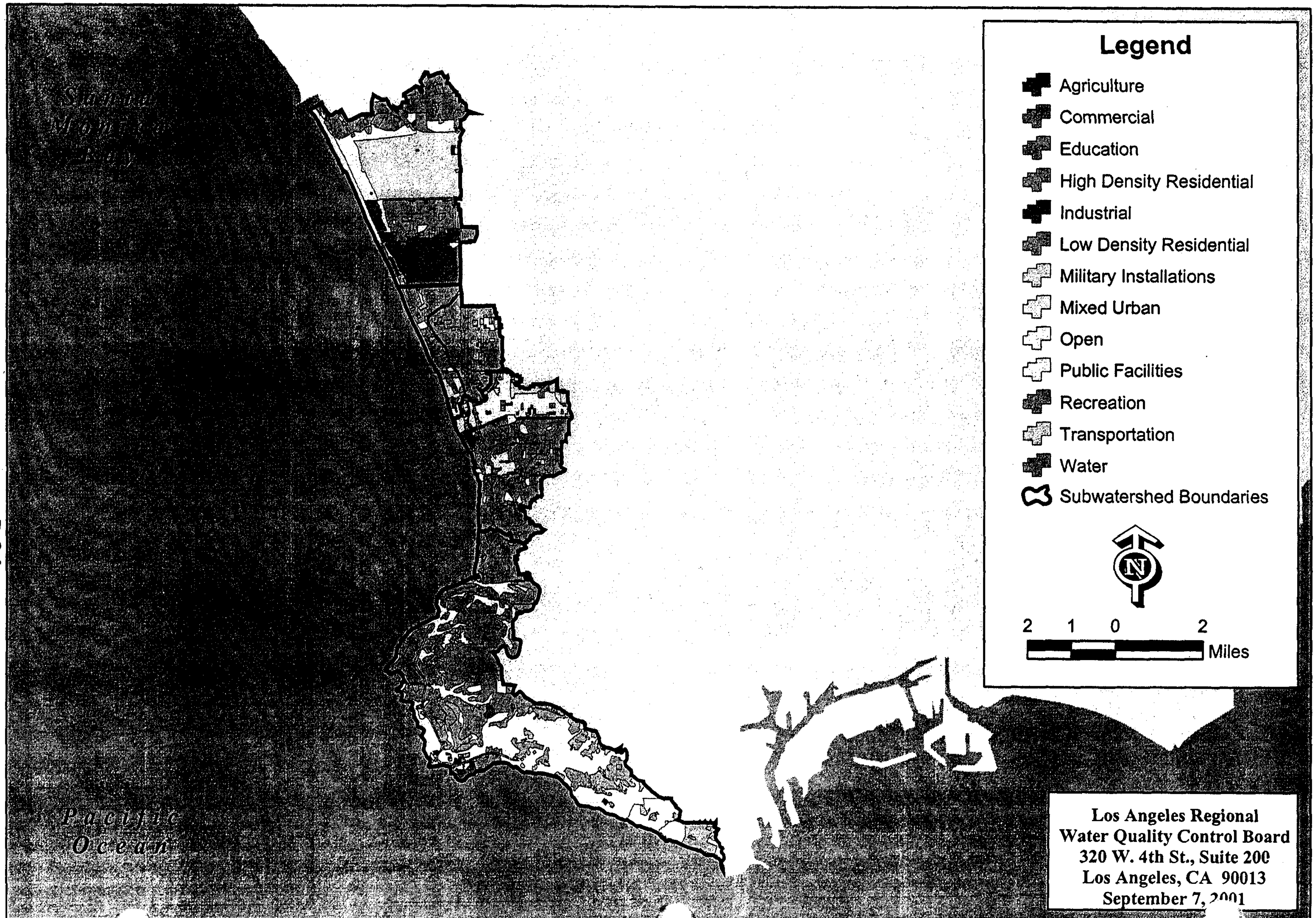


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Figure 11: Children Playing in Storm Drain at Paradise Cove Beach

Photo courtesy of Santa Monica BayKeeper

Figure 12
Malibu Daily Flow Comparison

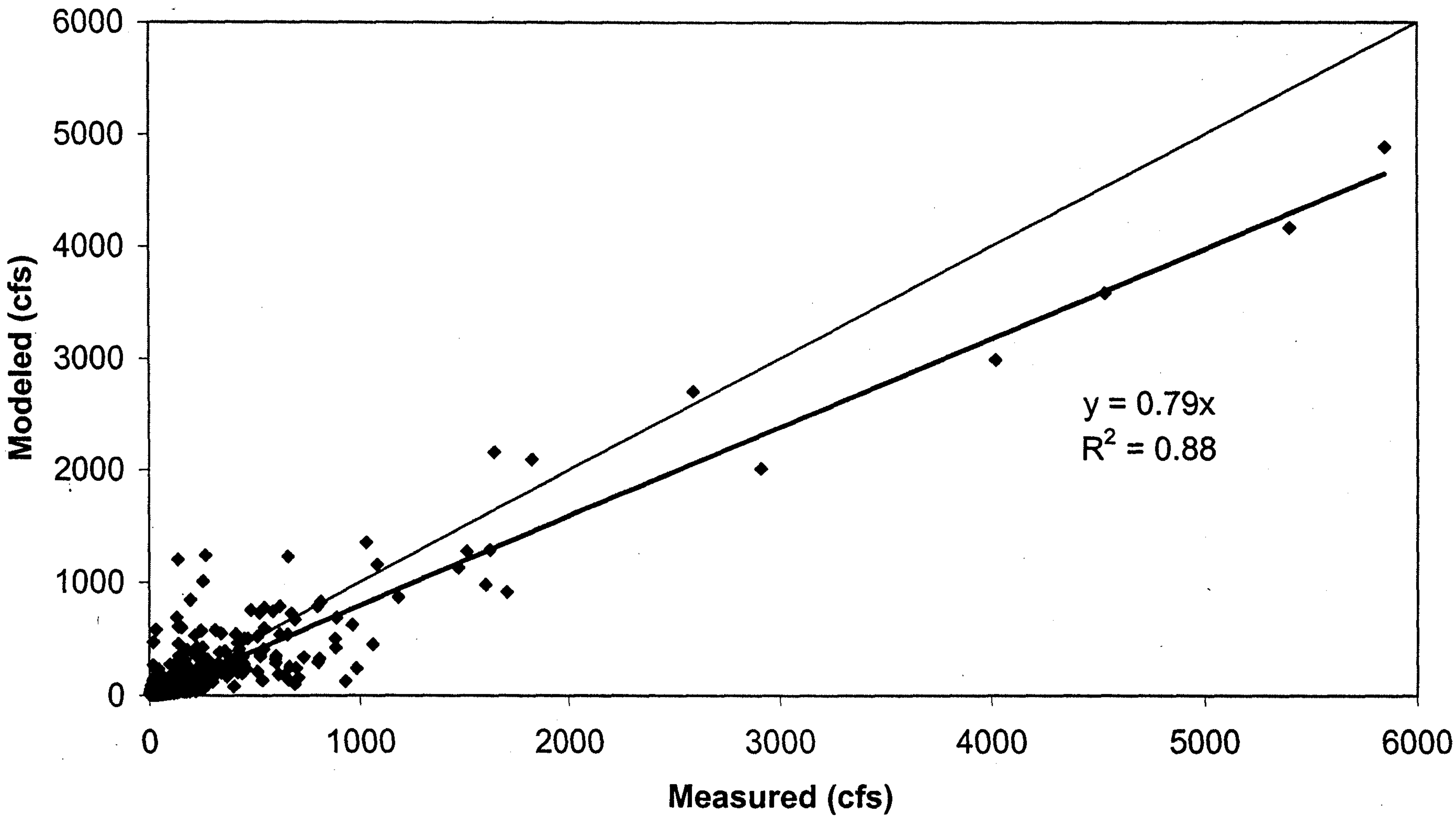

Figure 13
Ballona Daily Flow Comparison

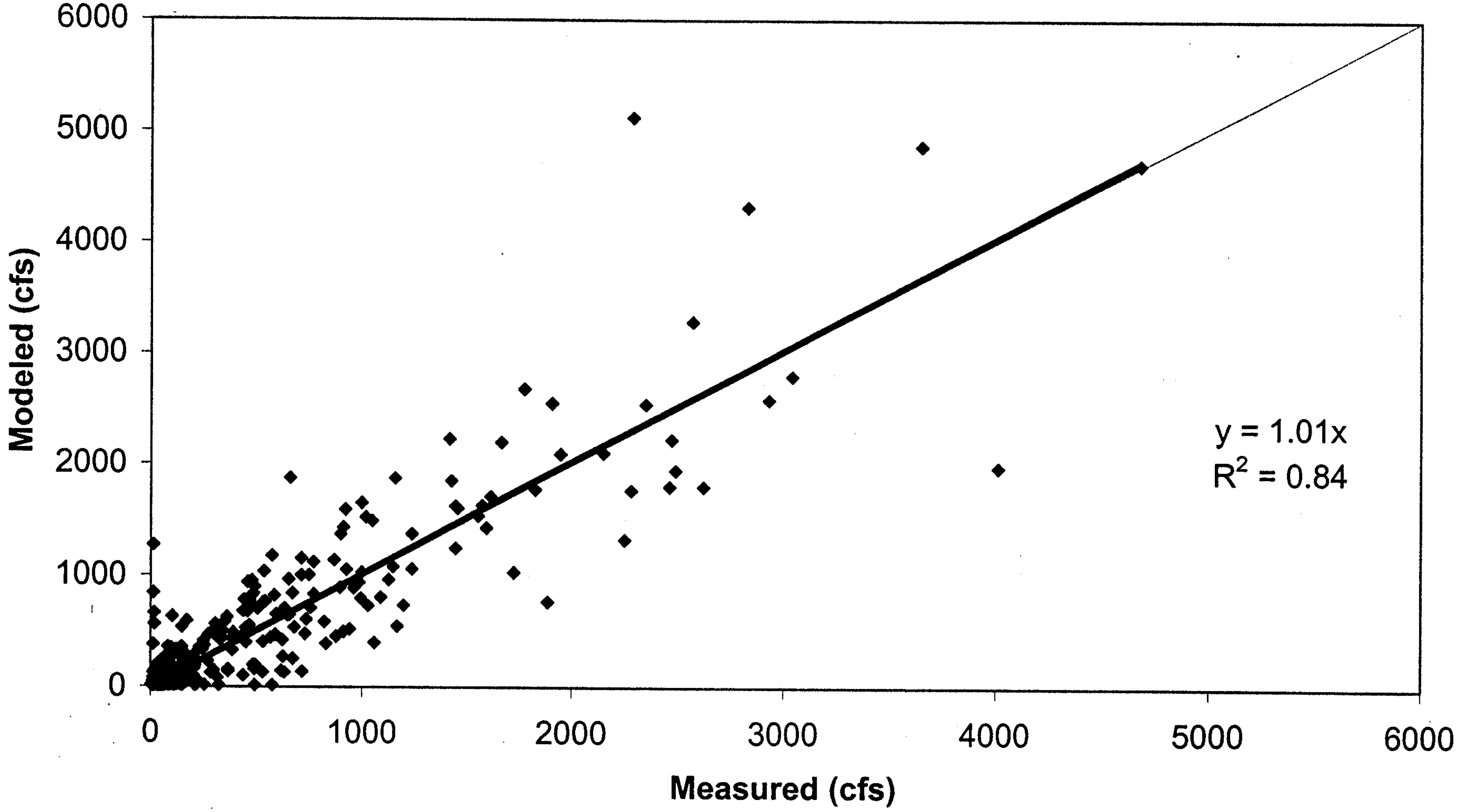

Figure 14
Dry Day Bacteria Comparison

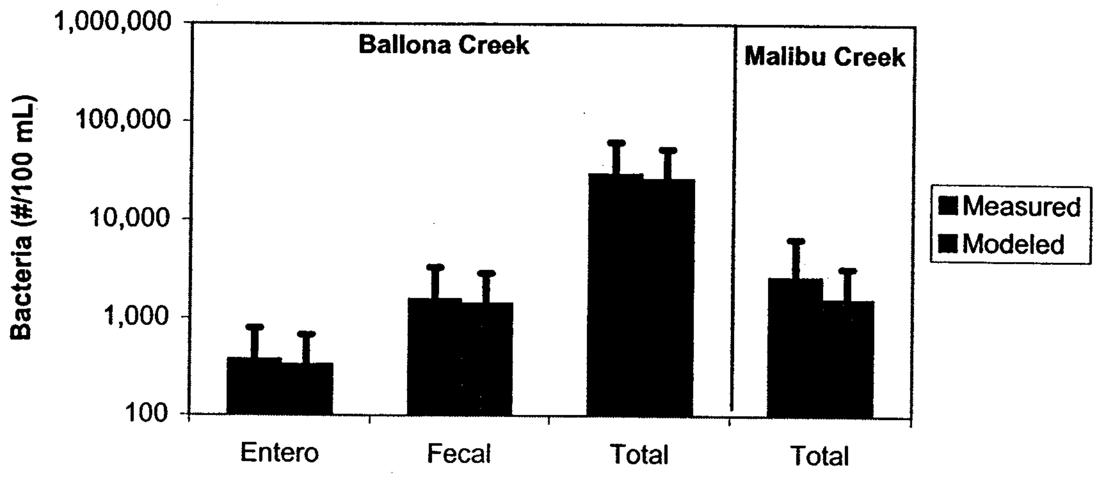

Figure 15
Wet Day Bacteria Comparison

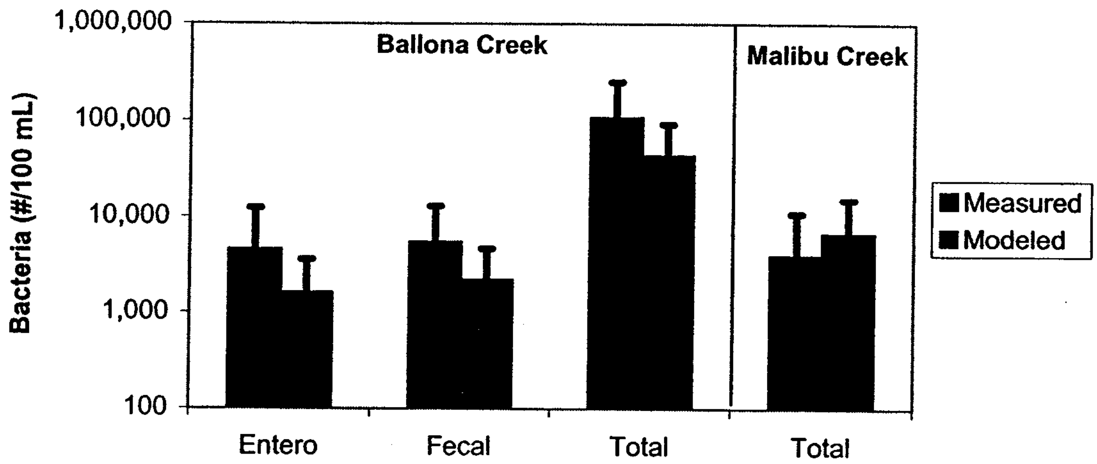

Figure 16: Santa Monica Bay Bacteria Exceedances by Subwatershed for Design Year (90th percentile hourly max, daily)