TOTAL MAXIMUM DAILY LOAD FOR METALS IN BALLONA CREEK AND BALLONA CREEK ESTUARY

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REGION 9
AND
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

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LIST OF ACRONYMS

µg/g	Micrograms per Gram
µg/L	Micrograms per Liter
ACF	Acute Conversion Factor
BMPs	Best Management Practices
CalTrans	California Department of Transportation
CCF	Chronic Conversion Factor
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
COMM	Commercial and Sport Fishing
CTR	California Toxics Rule
CWA	Clean Water Act
DL	Detection Limit
EST	Estuarine Habitat
FHWA	Federal Highway Administration
FR	Federal Register
GIS	Geographic Information System
HSPF	Hydrological Simulation Program FORTRAN
HTP	Hyperion Treatment Plan
IPWP	Integrated Plan for the Wastewater Program
IRP	Integrated Resources Plan
LACDPW	Los Angeles County Department of Public Works
LARWQCB	Los Angeles Regional Water Quality Control Board
MAR	Marine Habitat
mg/L	Milligrams Per Liter
MGD	Million Gallons Per Day
MIGR	Migration of Aquatic Organisms
MS4	Municipal Separate Storm Sewer System
MUN	Municipal and Domestic Water Supply
NA	Not Applicable
NAV	Navigation
ND	Non Detect
NHD	National Hydrography Data Set
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
ppt	Parts per Thousand
RARE	Rare, Threatened, or Endangered Species
REC1	Water Contact Recreation
REC2	Non-Contact Water Recreation
RL	Reporting Limit
SCCWRP	Southern California Coastal Water Research Project
SD	Standard Deviation
SHELL	Shellfish Harvesting
SMBRP	Santa Monica Bay Restoration Project

SPWN	Spawning, Reproduction, and/or Early Development
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USEPA	United State Environmental Protection Agency
VOCs	Volatile Organic Compounds
WARM	Warm Freshwater Habitat
WDRs	Waste Discharge Requirements
WER	Water-Effect Ratio
WILD	Wildlife Habitat
WLAs	Waste Load Allocations
WQA	Water Quality Assessment
WQOs	Water Quality Objectives

1 Introduction

This report presents the required elements of the Total Maximum Daily Load (TMDL) for metals in Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary (Estuary) and summarizes the technical analyses performed by the United States Environmental Protection Agency, Region 9 (USEPA) and the California Regional Water Quality Control Board, Los Angeles Region (Regional Board) to develop this TMDL. The goal of this TMDL is to determine and set forth measures needed to prevent impairment of water quality due to metals in Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary. This TMDL does not address impairments in sediment due to metals. These impairments will be address in the Total Maximum Daily Load for Toxic Pollutants in Sediment and Fish Tissue in Ballona Creek and Estuary.

Segments of Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary are listed for cadmium, copper, lead, selenium, silver, zinc and toxicity (Table 1-1). These segments (reaches) of Ballona Creek were included on the 1996, 1998 and 2002 California 303(d) list of impaired waterbodies (LARWQCB, 1996, 1998a, and 2002). On the 2002 303(d) list, the Regional Board delisted arsenic, copper, lead, and silver in fish tissue. The tissue listing for arsenic in Ballona Creek and Ballona Creek Wetlands was removed because the maximum tissue residue level upon which the 1998 listing was based does not protect aquatic life and does not exist for arsenic. The tissue listings for copper, lead, and silver were removed because the elevated data levels upon which the 1998 listings were based no longer reflect valid assessment guidelines. In addition, the Regional Board added new listings for dissolved copper, dissolved lead, dissolved zinc and total selenium in Ballona Creek based on elevated water quality data reported by the Los Angeles County Department of Public Works (LACDPW) storm water program. The Clean Water Act (CWA) requires a TMDL be developed to restore the impaired waterbodies, to their full beneficial uses. This TMDL will establish waste load allocations (WLAs) for total cadmium, copper, lead, selenium, silver and zinc. The water column toxicity will be addressed by the WLAs for the listed metals.

Table 1-1. List of impairments in the 2002 303(d) list for Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary

TMDL Analytical Unit 57	Ballona Creek	Sepulveda Canyon	Ballona Creek Estuary
Cadmium	Sediment		
Copper	Water column		
Lead	Water column	Water column	Sediment
Selenium	Water column		
Silver	Sediment		
Zinc	Water column		Sediment
Toxicity	Water column/Sediment		Sediment

This TMDL complies with 40 CFR 130.2 and 130.7, Section 303(d) of the CWA and USEPA guidance for developing TMDLs in California (USEPA, 2000a). This document summarizes the information used by the USEPA and the Regional Board to develop a TMDL for metals. The TMDL also includes an implementation plan and cost estimate to achieve the waste load allocations (WLAs) and attain water quality objectives (WQOs). The California Water Code (Porter-Cologne Water Quality Control Act) requires that an implementation plan be developed to achieve water quality objectives. The waterbodies addressed in this TMDL are shown in Figure 1. TMDLs for nearby Marina del Rey Harbor are not addressed in this document.

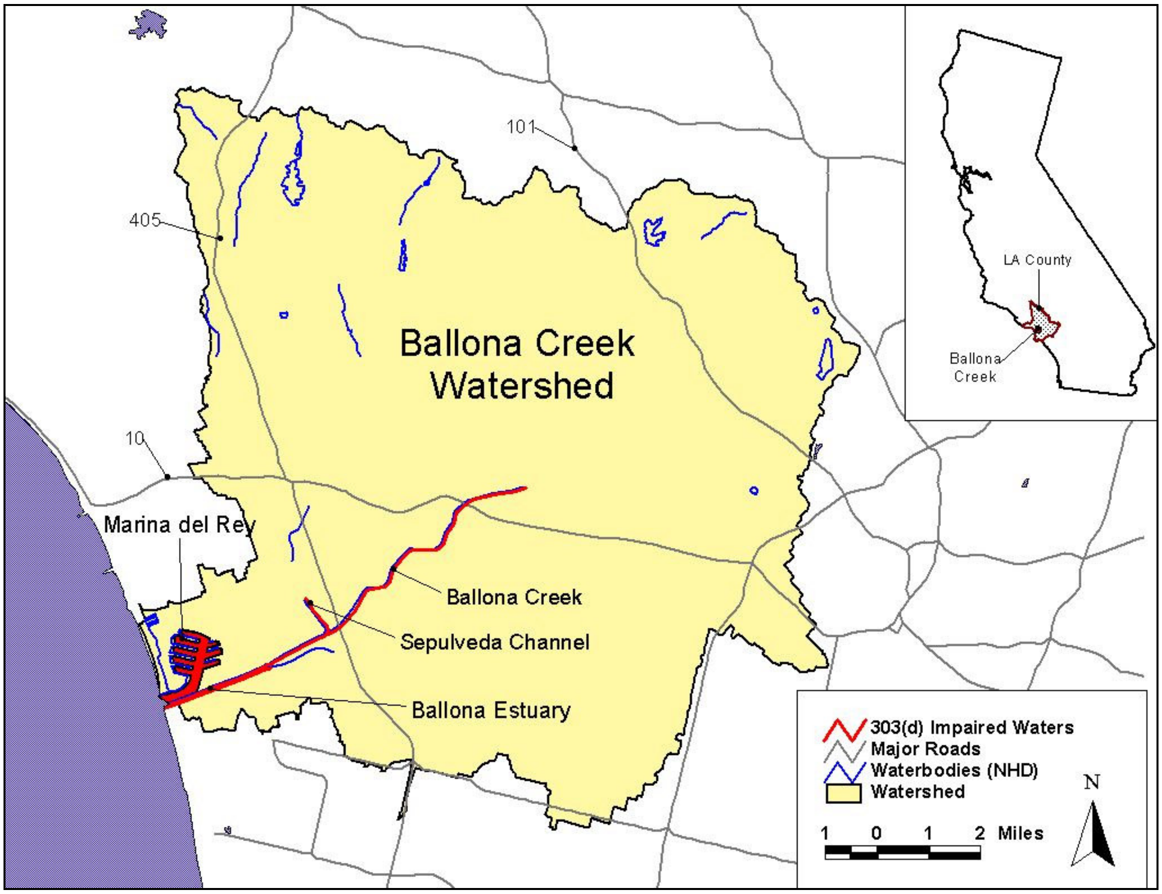

Figure 1. Impaired waterbodies of the Ballona Creek watershed

1.1 Regulatory Background

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

The elements of a TMDL are described in 40 CFR 130.2 and 130.7 and Section 303(d) of the CWA, as well as in the USEPA guidance (USEPA, 2000a). 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. A TMDL is also required to account for seasonal variations and include a margin of safety to address uncertainty in the analysis (USEPA, 2000).

States must develop water quality management plans to implement the TMDL (40 CFR 130.6). The USEPA has oversight authority for the 303(d) program and is required to review and either approve or disapprove the TMDLs submitted by states. In California, the State Water Resources Control Board (State Board) and the nine Regional Water Quality Control Boards are responsible for preparing lists of impaired waterbodies under the 303(d) program and for preparing TMDLs, both subject to USEPA approval. If USEPA disapproves a TMDL submitted by a state, it is required to establish a TMDL for that waterbody. The Regional Boards hold regulatory authority for many of the instruments used to implement the TMDLs, such as the National Pollutant Discharge Elimination System (NPDES) permits and state-specified Waste Discharge Requirements (WDRs).

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, 1998a). These are referred to as "listed" or "303(d) listed" waterbodies or waterbody segments. A 13-year schedule for development of TMDLs in the Los Angeles Region was established in a consent decree approved on March 22, 1999 (*Heal the Bay Inc., et al. v. Browner, et al.* C 98-4825 SBA).

For the purpose of scheduling TMDL development, the consent decree combined the more than 700 waterbody-pollutant combinations into 92 TMDL analytical units. This TMDL addresses the impairments in Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary associated with Analytical Unit 57 for metals (cadmium, copper, lead, selenium, silver, zinc and toxicity). The consent decree also prescribed schedules for certain TMDLs, and according to this schedule, a TMDL for Analytical Unit 57 was to be adopted by the Regional Board by March 22, 2004. Under the terms of the consent decree, USEPA must either approve a state TMDL or establish its own, by March 22, 2005.

On June 12, 2003, the Regional Board held a California Environmental Quality Act (CEQA) scoping meeting to solicit input from the public and interested stakeholders in determining the appropriate scope, content and implementation options of the proposed TMDL for metals in Ballona Creek and Estuary. At the scoping meeting, the CEQA checklist of significant environmental issues and mitigation measures were discussed. This meeting fulfilled the requirements under CEQA (Public Resources Code, Section 21083.9).

1.2 Environmental Setting

Ballona Creek flows as an open channel for just under 10 miles from Los Angeles (South of Hancock Park) through Culver City, reaching the Pacific Ocean at Playa del Rey. North of Hancock Park, the channels continue in a network of underground storm drains. Ballona Creek and its tributaries drain a watershed with an area of approximately 128 square miles. Approximately 60% of the land use can be categorized as residential, 17% as recreation/open space, 16% as commercial, 5% as industrial, and 2% as other. The Ballona Creek watershed is comprised of the Cities of Beverly Hills and West Hollywood, and portions of the cities of Culver City, Inglewood, Los Angeles, Santa Monica, and unincorporated areas of Los Angeles County.

Channelization and construction of Marina del Rey Harbor altered the natural hydrology of Ballona Creek Estuary, Ballona Creek and its tributaries. Except for the estuarine section of the creek, which is composed of grouted rip-rap sloped sides and an earth bottom, Ballona Creek is entirely lined in concrete and extends into a complex underground network of storm drains, which reaches north to Beverly Hills and West Hollywood. Tributaries of Ballona Creek include Centinela Creek, Sepulveda Canyon Channel, Benedict Canyon Channel, and numerous storm drains (Figure 1). All of these tributaries are concrete lined channels that lead to covered culverts upstream.

The *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* (*Basin Plan*) defines three sections of the creek based on hydrologic units. The section referred to as "Ballona Creek" (Reach 1) is a 2-mile stretch from Cochran Avenue to National Boulevard. This area is characterized by vertical concrete walls, which line the creek from the point where it emerges from the underground network of drains at Cochran Avenue, in the City of Los Angeles, to National Boulevard in Culver City. "Ballona Creek to Estuary" (Reach 2) is the longest segment of the creek (approximately 4 miles) continuing on from National Boulevard and ending at Centinela Avenue where the estuary begins. Sepulveda Canyon Channel discharges into Ballona Creek Reach 2. At National Boulevard the vertical walls transition to sloping walls that end in a box culvert at the base of the channel. "Ballona Creek Estuary" (Estuary) continues to the Pacific Ocean for 3.5 miles and its lower portion runs parallel to the main channel of Marina del Rey Harbor (Figure 1).

The bike path along the creek provides opportunities for recreation in the area. This path extends almost seven miles from Ballona Creek at National Boulevard in Culver City to the end of Ballona Creek Estuary in Marina del Rey. The bike path is connected to another path along Dockweiler Beach by the Pacific Bridge, which links Marina del Rey to Playa del Rey.

Dry-weather flows are estimated at 14 cubic feet per second (cfs) (Ackerman et al., 2003) and can be up to 36000 cfs - for a 100-year storm event (SMBRP, 1997). As shown in Figure 2 the average daily flows during dry weather in Ballona Creek are very consistent. The 90th percentile is considered the inflection point between dry and wet weather. Ballona creek was channeled to quickly convey storm water to the ocean. Therefore, the relationship between rain events in the watershed and increased flow in the creek is strong and immediate (Ackerman and Weisberg, 2003).

1.3 Elements of a TMDL; Organization of This Document

Guidance from USEPA (1991) identifies seven elements of a TMDL. Sections 2 through 8 of this document are organized such that each section describes one of the elements, with the analysis and findings of this TMDL for that element. The required elements are as follows:

- Section 2: Problem Identification. This section reviews the metals data used to add the waterbody to the 303(d) list, and summarizes existing conditions using that evidence along with any new information acquired since the listing. This element identifies those reaches that fail to support all designated beneficial uses; the beneficial uses that are not supported for each reach; the water quality objectives (WQOs) designed to protect those beneficial uses; and, summarizes the evidence supporting the decision to list each reach, such as the number and severity of exceedances observed.
- Section 3: Numeric Targets. For this TMDL, the numeric targets are based upon the WQOs described in the California Toxics Rule (CTR).

- Section 4: Source Assessment. This section develops the quantitative estimate of metals loading from point sources and non-point sources into Ballona Creek and Estuary.
- Section 5: Linkage Analysis. This analysis shows how the sources of metals pollutants into the waterbody are linked to the observed conditions in the impaired waterbody. The linkage analysis addresses the critical conditions of stream flow, loading, and water quality parameters.
- Section 6: Pollutant Allocation. Each pollutant source is allocated a quantitative load of metals that it can discharge to meet the numeric targets. Allocations are designed such that the waterbody will not exceed numeric targets for any of the compounds or related effects. Allocations are based on critical conditions, so that the allocated pollutant loads may be expected to remove the impairments at all times.
- Section 7: Implementation. This section describes the plans, regulatory tools, or other mechanisms by which the waste load allocations are to be achieved. This section also contains a cost analysis. The TMDL provides cost estimates to implement best management practices (BMPs) required throughout the Ballona Creek watershed to meet water quality objectives in the creek and estuary.
- Section 8: Monitoring. This TMDL includes a requirement for monitoring the waterbody to ensure that the water quality standards are attained. If the monitoring results demonstrate that the TMDL has not succeeded in removing the impairments, then revised allocations will be developed.

2 Problem Identification

This section provides an overview of water quality standards for Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary and reviews water quality data used in the 1998 water quality assessment (WQA), the 2002 303(d) listing, and additional data used to analyze sources in this TMDL.

2.1 Water Quality Standards

California state water quality standards consist of the following elements: 1) beneficial uses; 2) narrative and/or numeric water quality objectives; and 3) an antidegradation policy. In California, the Regional Boards define beneficial uses in their *Basin Plans*. Numeric and narrative objectives designed to be protective of these beneficial uses are specified in each region's *Basin Plan*, or State Water Quality Control Plans. Numeric objectives for toxics can be found in the California Toxics Rule (40 CFR 131.38).

2.1.1 Beneficial Uses

The *Basin Plan* for the Los Angeles Regional Board (1994) defines 13 existing (E), potential (P), or intermittent (I) beneficial uses for Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary (Table 2-1). The municipal and domestic supply (MUN) use designation is conditional, as noted by the asterisk in Table 2-1. Conditional designations are not recognized under federal law and are not subject to water quality objectives requiring TMDL development at this time. (Letter from Alexis Strauss [USEPA] to Celeste Cantú [State Board], February 15, 2002.)

Table 2-1. Beneficial Uses of Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary (LARWQCB, 1994)

Ballona Creek Watershed	Hydro Unit #	MUN	NAV	REC1	REC2	COMM	WARM	EST	MAR	WILD	RARE	MIGR	SPWN	SHELL
Ballona Creek Estuary	405.13		E	E	E	E		E	E	E	Ee	Ef	Ef	E
Ballona Creek to Estuary	405.13	P*		Ps	E		P			P				
Ballona Creek and Sepulveda Canyon Channel	405.15	P*		Ps	E		P			E				

Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.
E: Existing beneficial use
P: Potential beneficial use
s: Access prohibited by Los Angeles County Department of Public Works
e: One or more rare species utilize all oceans, bays, estuaries, and wetlands for foraging and/or nesting.
f: Aquatic organisms utilize all bays, estuaries, lagoons, and coastal wetlands, to a certain extent, for spawning and early development. This may include migration into areas that are heavily influenced by freshwater inputs.
* Conditional designation

Metals loading to these waterbodies may result in impairments of beneficial uses associated with aquatic life (WARM, EST, MAR, WILD, RARE, MIGR, and SPWN), human use of these resources (COMM and SHELL), and recreational uses (REC1 and REC2).

Ballona Creek Estuary has existing designated uses to protect aquatic life that use the estuarine, marine, and wildlife habitat (EST, MAR and WILD). The RARE use designation is designed to protect rare, threatened or endangered species that may utilize the estuary and adjacent wetlands for foraging or nesting habitat. Also, there are existing uses to protect aquatic organisms utilizing the estuary for migration (MIGR) or for spawning, reproduction, and/or early development (SPWN). There are also beneficial uses associated with human use of the estuary including navigation (NAV), commercial and sport fishing (COMM), and shellfish harvesting (SHELL). In the creek, there are potential designated beneficial uses to protect warm freshwater habitat (WARM) and wildlife habitat (WILD). The recreational use for water contact (REC1) applies as an existing use for the estuary and a potential use in the creek. The secondary non-contact water recreation (REC2) applies as an existing use in both the estuary and creek.

2.1.2 Water Quality Objectives

As stated in the *Basin Plan,* water quality objectives (WQOs) are intended to protect the public health and welfare and to maintain or enhance water quality in relation to the designated existing and potential beneficial uses of the water. Narrative WQOs are specified in the 1994 Regional Board *Basin Plan*. The following narrative objectives are most pertinent to the metals TMDL.

> *Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.*
>
> *Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels, which are harmful to aquatic life or human health.*
>
> *All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that product detrimental physiological responses in human, plant, animal, or aquatic life.*

Numeric water quality objectives for pollutants addressed in this TMDL were promulgated by USEPA in 2000 in the California Toxics Rule (CTR). The CTR establishes freshwater and saltwater aquatic life criteria for 23 priority toxic pollutants and numeric human health criteria for 57 priority toxic pollutants. The selenium and cadmium objectives were established contingent on an USEPA commitment to revise the objectives promptly to better protect wildlife.

The CTR establishes short-term (acute) and long-term (chronic) aquatic life criteria for metals in both freshwater and saltwater. The acute criterion, defined in the CTR as the Criteria Maximum Concentration, equals the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time without deleterious effects. The chronic criterion, defined in the CTR as the Criteria Continuous Concentration, equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects. Freshwater aquatic life criteria apply to waters in which the salinity is equal to or less than 1 part per thousand (ppt) 95 percent or more of the time. Saltwater aquatic life criteria apply to waters in which salinity is equal to or greater than 10 ppt 95 percent or more of the time.

For waters in which the salinity is between 1 and 10 ppt, the more stringent of the freshwater or saltwater aquatic life criteria apply.

CTR freshwater aquatic life criteria for certain metals are expressed as a function of hardness because hardness and/or water quality characteristics that are usually correlated with hardness can reduce or increase the toxicity of some metals. Hardness is used as a surrogate for a number of water quality characteristics, which affect the toxicity of metals in a variety of ways. Increasing hardness has the effect of decreasing the toxicity of metals. Water quality criteria to protect aquatic life may be calculated at different concentrations of hardness measured in milligrams per liter (mg/L) as calcium carbonate (CaCO3). The CTR lists freshwater aquatic life criteria based on a hardness value of 100 mg/L and provides hardness dependent equations to calculate the freshwater aquatic life metals criteria using site-specific hardness data.

In the CTR, freshwater and saltwater criteria for metals are expressed in terms of the dissolved fraction of the metal in the water column. These criteria were calculated based on methods in USEPA's *Summary of Revisions to Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (50 FR 30792, July 29, 1985), developed under Section 304(a) of the CWA. This methodology is used to calculate the total recoverable fraction of metals in the water column and then appropriate conversion factors, included in the CTR are applied, to calculate the dissolved criteria.

Table 2-2 summarizes the applicable aquatic life criteria for metals in Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary expressed in terms of the dissolved fraction of the metal in the water column.

Table 2-2. Water quality objectives established in the CTR for the protection of aquatic life. Objectives are established for dissolved metals concentrations except selenium as noted.

Metal	**Freshwater Acute*** (µg/L)	**Freshwater Chronic*** (µg/L)	**Saltwater Acute** (µg/L)	**Saltwater Chronic** (µg/L)
Cadmium	4.3	2.2	42	9.3
Copper	13	9.0	4.8	3.1
Lead	65	2.5	210	8.1
Selenium	Reserved	5.0**	290	71
Silver	3.4	---	1.9	--
Zinc	120	120	90	81

* *Criteria are hardness dependent. Values in the table are based on a hardness of 100 mg/L.*
** *This criterion is expressed in the total recoverable form and is not hardness dependent.*

The CTR allows for the adjustment of criteria through the use of a water-effect ratio (WER) to assure that the metals criteria are appropriate for the site-specific chemical conditions under which they are applied. A WER represents the ratio between metals that are measured and metals that are biologically available and toxic. A WER is a measure of the toxicity of a material in site water divided by the toxicity of the same material in laboratory dilution water. No site-specific WER has been developed for Ballona Creek, Sepulveda Canyon Channel, or Ballona Creek Estuary. Therefore, a WER default value of 1.0 is assumed.

The equations for calculating the freshwater criteria for metals are:

Acute Criterion = WER x ACF x $EXP[(m_a)(\ln(hardness))+b_a]$
Chronic Criterion = WER x CCF x $EXP[(m_c)(\ln(hardness))+b_c]$

Where: WER = Water Effects Ratio (assumed to be 1)
ACF = Acute conversion factor (to convert from the total to the dissolved fraction)
CCF = Chronic conversion factor (to convert from the total to the dissolved fraction)
m_a = slope factor for acute criteria
m_c = slope factor for chronic criteria
b_a = y intercept for acute criteria
b_c = y intercept for chronic criteria

The coefficients needed for the calculation are provided in the CTR for most metals (Table 2-3). The conversion factors for cadmium and lead in freshwater are hardness-dependent. The following equations can be used to calculate the conversion factors based on site-specific hardness data:

$$\text{Cadmium ACF} = 1.136672 - [(\ln\{\text{hardness}\})(0.041838)]$$
$$\text{Cadmium CCF} = 1.101672 - [(\ln\{\text{hardness}\})(0.041838)]$$
$$\text{Lead ACF} = 1.46203 - [(\ln\{\text{hardness}\})(0.145712)]$$
$$\text{Lead CCF} = 1.46203 - [(\ln\{\text{hardness}\})(0.145712)]$$

Table 2-3. Coefficients used in formulas for calculating CTR freshwater criteria for metals.

Metal	ACF	m_a	b_a	CCF	m_c	b_c
Cadmium	0.944*	1.128	-3.6867	0.909*	0.7852	-2.715
Copper	0.960	0.9422	-1.700	0.960	0.8545	-1.702
Lead	0.791*	1.273	-1.460	0.791*	1.273	-4.705
Silver	0.85	1.72	-6.52	**	**	**
Zinc	0.978	0.8473	0.884	0.986	0.8473	0.884

** The ACF and CCF for cadmium and lead are hardness dependent. Conversion factors are based on a hardness of 100 mg/L.*
*** No value was reported in the CTR*

2.1.3 Antidegradation

State Board Resolution 68-16, 'Statement of Policy with Respect to Maintaining High Quality Water in California," known as the "Antidegradation Policy," protects surface and ground waters from degradation. Any actions that can adversely affect water quality in all surface and ground waters must be consistent with the maximum benefit to the people of the state, must not unreasonably affect present and anticipated beneficial use of such water, and must not result in water quality less than that prescribed in water quality plans and policies. Furthermore, any actions that can adversely affect surface waters are also subject to the federal Antidegradation Policy (40 CFR 131.12). The proposed TMDL will not degrade water quality, and will in fact improve water quality as it will lead to compliance with water quality standards.

2.2 Water Quality Data Review

This section evaluates and summarizes water quality data pertaining to metals for Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary. The summary includes data considered by the Regional Board and USEPA in developing the 1998 and 2002 303(d) list and subsequent data. The data was evaluated based the CTR metals criteria adjusted for site-specific hardness during dry and wet weather. This is a different approach then was used during the 2002 303(d) list data evaluation, which looked at the default CTR criteria (Table 2-2) based on a hardness of 100 mg/L. Due to the variation of methods of transport during dry and wet weather (Section 4), data are summarized by the weather condition during which the data were collected. The following sections describe the data evaluated during dry- and wet-weather conditions and the applicable targets.

2.2.1 Summary of Dry-Weather Conditions

Water quality during dry conditions was assessed using two data sets provided by the City of Los Angeles and the Southern California Coastal Water Research Project (SCCWRP). Metals concentrations were compared to CTR values to analyze the relative frequencies of exceedances of acute and chronic criteria. To calculate the freshwater criteria for cadmium, copper, lead, silver, and zinc, a hardness value of 300 mg/L was used, which was the median value of the dry-weather hardness data collected in the freshwater portions of Ballona Creek by SCCWRP (2004).

Metals data collected by the City of Los Angeles, April 2001 through May 2003, from four locations along Ballona Creek at National Boulevard, Overland Avenue, Centinela Boulevard, and Pacific Avenue were evaluated. The data from National and Overland Boulevards are representative of Ballona Creek Reaches 1 and 2, respectively. Data from these sites were compared to the freshwater criteria based on CTR values (Table 2-4). The data from Centinela Boulevard and Pacific Avenue are representative of the estuary and were compared to the saltwater criteria (Table 2-5).

Table 2-4. Summary of 2001-2003 Ballona Creek dry-weather metals data relative to freshwater criteria (hardness of 300 mg/L). Data are based on dissolved metals concentrations except selenium, which is based on total selenium. (Source: City of LA).

Metal	N	DL (µg/L)	# > DL	# > Acute	# > Chronic
Cadmium	48	1	1	0	0
Copper	48	10	16	4	7
Lead	48	10	7	0	7*
Total Selenium	44	10	0	NA	0*
Silver	48	5	2	1	NA
Zinc	47	10	31	2	2

* Detection limit higher than the CTR criterion.

In Ballona Creek, the City of Los Angeles detected seven samples that exceeded the chronic criterion for lead. However, the detection limits for lead were in many cases above the chronic criterion. If the actual concentration is assumed to be equal to the detection limit, a conservative assumption, then the chronic criterion for lead was exceeded in 34 samples. There were no exceedances of the chronic criterion for total selenium; however, the detection limit exceeded the criterion.

Table 2-5. Summary of 2001-2003 Ballona Creek Estuary dry-weather dissolved metals data relative to saltwater criteria. (Source: City of LA)

Metal	N	DL (µg/L)	# > DL	# > Acute	# > Chronic
Cadmium	48	1	3	0	0
Copper	48	10	10	10*	10*
Lead	48	10	7	0	7*
Selenium	44	10	4	0	0
Silver	48	5	0	0*	NA
Zinc	48	10	18	2	2

* Detection limit higher than the CTR criterion.

In Ballona Creek Estuary, the City of Los Angeles detected ten samples that exceeded the acute and chronic criteria for copper. However, the detection limits for copper were in many cases above the acute and chronic criteria. If the actual concentration is assumed to be equal to the detection limit, a conservative assumption, then the acute and chronic criteria for copper were exceeded in 41 and 46 samples, respectively. As was the case with the freshwater samples, the detection limits for lead were above the saltwater chronic criterion. Treating the detection limits as true values, then the chronic criterion for lead was exceeded in 36 samples. No samples exceeded the acute criterion for silver, however, the detection limit was higher than the acute criterion. Assuming the detection limits are the true values, then 47 samples exceeded the silver acute criterion.

In 2003, SCCWRP (2004) performed a characterization study of Ballona Creek to identify relative metals contributions of runoff discharges during dry conditions. Sampling throughout the Ballona Creek watershed was conducted on May 17, July 16, and September 24, 2003. Sampling was performed at 12 in-stream sites and at the discharge of 35-40 storm drains (number depended on whether there was flow from the drain on the sampling day). Of the Ballona Creek and Estuary in-stream sites, three were located downstream of Centinela Blvd. (including the site at Centinela Blvd.) and were assumed representative of Ballona Creek Estuary. The remaining nine sites were representative of conditions in Ballona Creek. An additional site was sampled at the discharge of Sepulveda Canyon Channel. Summaries of the metals concentrations relative to applicable CTR criteria for Ballona Creek (freshwater), Sepulveda Canyon Channel (freshwater), and Ballona Creek Estuary (saltwater) are provided in Tables 2-6, 2-7, and 2-8, respectively. (The analysis includes all replicate samples collected on each day.)

Table 2-6. Summary of 2003 Ballona Creek dry-weather metals data relative to freshwater criteria (hardness of 300 mg/L). Data are based on dissolved metals concentrations except selenium, which is based on total selenium. (Source: SCCWRP)

Metal	N	DL/RL (µg/L)**	# > DL/RL**	# > Acute	# > Chronic
Cadmium	70	10	0	0	0*
Copper	70	10	10	0	0
Lead	70	5	10	0	0
Total Selenium	70	100	0	NA	0*
Silver	50	10	0	0	NA
Zinc	70	20	27	0	0

* Detection limit higher than the CTR criterion.
** DL/RL reported as the maximum of the detection limit (DL) or the reporting limit (RL).

Table 2-7. Summary of 2003 Sepulveda Canyon Channel dry-weather metals data relative to freshwater criteria (hardness of 300 mg/L). Data are based on dissolved metals concentrations except selenium, which is based on total selenium. (Source: SCCWRP)

Metal	N	DL/RL (µg/L)**	# > DL/RL**	# > Acute	# > Chronic
Cadmium	6	10	0	0	0*
Copper	6	10	2	0	0
Lead	6	5	0	0	0
Total Selenium	3	100	0	NA	0*
Silver	4	10	0	0	NA
Zinc	6	20	0	0	0

* Detection limit higher than the CTR criterion.
** DL/RL reported as the maximum of the detection limit (DL) or the reporting limit (RL).

Based on the three dry-weather sampling events conducted by SCCWRP in 2003, there were no exceedances of the acute or chronic criteria in Ballona Creek or Sepulveda Canyon Channel. However, the reporting limits for dissolved cadmium and total selenium were both greater than the chronic criteria for these metals. Although, no exceedances were confirmed during the 2003 dry-weather sampling, the variability in the sampling data supports the previous finding in the 2002 WQA that exceedances occur infrequently during episodic events.

Table 2-8. Summary of 2003 Ballona Creek Estuary dry-weather dissolved metals data relative to saltwater criteria. (Source: SCCWRP)

Metal	N	DL/RL (µg/L)**	# > DL/RL**	# > Acute	# > Chronic
Cadmium	27	10	0	0	0*
Copper	27	10	5	5*	5*
Lead	27	5	15	0	5
Selenium	27	100	0	0	0*
Silver	18	10	0	0*	NA
Zinc	27	20	10	0	0

* Detection limit higher than the CTR criterion.
** DL/RL reported as the maximum of the detection limit (DL) or the reporting limit (RL).

The reporting limits were greater than the chronic criterion for cadmium, the acute and chronic criteria for copper, the chronic criterion for selenium and the acute criterion for silver. These higher reporting limits may have prevented observed exceedances of these criteria. For example the acute and chronic criteria for copper was exceeded in five samples, which may be a low estimate.

The dry-weather characterization report, (SCCWRP, 2004) stated that the higher lead concentrations in the estuary were influenced by high concentrations observed in September at Pacific Avenue near the mouth of the estuary. Lead concentrations located at Pacific Avenue in September were more than double those observed in May and June.

2.2.2 Summary of Wet Conditions

To assess wet-weather conditions, we evaluated dissolved metals and hardness data collected from Ballona Creek by the LACDPW storm water program at Sawtelle Boulevard (1996 – 2002). The LACDPW has been sampling approximately five storms per year since 1996 for hardness, dissolved and total metals from composite storm water samples. The storm water data were compared to the freshwater CTR values based on the actual hardness measured for each sample. The results are summarized in Table 2-9.

Table 2-9. Summary of 1996-2002 Ballona Creek wet-weather metals data relative to freshwater criteria. Data are based on dissolved metals concentrations except selenium, which is based on total selenium. (Source: LACDPW).

Metal	N	# > DL	# > Acute	# > Chronic
Cadmium	55	2	1	1
Copper	55	50	10	17
Lead	55	7	2	2
Total Selenium	55	3	NA	2
Silver	55	1	0	NA
Zinc	55	22	6	6

2.2.3 Conclusions of Water Quality Assessment

This re-assessment confirms the existence of metals impairments identified in the 2002 303(d) list. The evidence for impairments associated with copper, lead, and zinc is clear. The evidence for impairments associated with cadmium and silver are also clear, but less compelling in terms of the magnitude, frequency, and extent of the impairment. The data for the selenium impairment is the least conclusive, since, the detection and reporting limits are greater than the water quality criteria. Further characterization is needed to clearly identify impairment, however, a TMDL has been developed since selenium is on the 2002 303(d) list. If additional data, indicates that there is no impairment then the TMDL can be revisited. Table 2-10 summarizes the review of data used to develop the TMDL. An "x" indicates that at least one sample exceeded the hardness adjusted CTR criteria for freshwater or saltwater during dry or wet weather.

Table 2-10. Summary of exceedances of water quality criteria in Ballona Creek, Sepulveda Canyon Channel and Ballona Creek Estuary.

Waterbody	Pollutant	Exceedances during Dry Weather	Exceedances during Wet Weather*
Ballona Creek:	Cadmium		X
	Copper	X	X
	Lead	X	X
	Selenium		X
	Silver	X	
	Zinc	X	X
Sepulveda Canyon Channel:	Lead		
Ballona Creek Estuary:	Cadmium		
	Copper	X	
	Lead	X	
	Selenium		
	Silver		
	Zinc	X	

*** Wet-weather data was not available for Sepulveda Canyon Channel and Ballona Creek Estuary.**

3 Numeric Targets

Numeric targets for the TMDL have been calculated based on the numeric objectives in the CTR. The numeric objectives in the CTR are expressed in terms of dissolved metals (USEPA 2000a) because the dissolved forms are the most bioavailable to aquatic organisms. However, the pollutant allocations developed in this TMDL will be expressed as total metals to ensure that the water quality standards are met for the listed metals.

USEPA and the Regional Board recognize the potential for transformation between total metals and the dissolved metals fraction. The partitioning between dissolved and particulate phases of total metals is highly dependent upon the conditions observed during the period of sampling. During dry conditions, metals are primarily in the dissolved state, which is consistent with default conversion factors defined in the CTR. For wet conditions, the partitioning between particulate and dissolved metals often does not achieve equilibrium as the metals are transported with storm flows. Conversion factors are used to convert the dissolved metal numeric targets to total metals for calculation of the WLAs in this TMDL. The linkage analysis and pollutant allocations to meet the numeric targets (Section 5 and 6) will be based on total metals.

Separate numeric targets were developed for dry and wet weather because conditions in the Ballona Creek and tributaries vary dramatically between dry and wet weather. The following sections describe the numeric targets for this TMDL.

3.1 Dry-Weather TMDL Targets

As discussed in Section 2, the freshwater aquatic life criteria for metals in the CTR are expressed as a function of hardness of the receiving water. Dry-weather hardness data, reported by SCCWRP (2004), for Ballona Creek were analyzed and a median hardness value of 300 mg/L was determined. Saltwater aquatic life criteria for metals in the CTR are independent of the hardness of the receiving water. The chronic criteria are the most limiting values for cadmium, copper, lead, selenium, and zinc (Table 3-1), therefore, were used as the basis for developing waste load allocations for dry weather. For silver there is no chronic criterion, therefore, the acute criterion was used for developing the waste load allocations.

Table 3-1. Dry-weather numeric targets expressed in terms of the dissolved fraction except selenium as noted.

Metal	Freshwater Target* (µg/L)		Saltwater Target (µg/L)	
	Acute	Chronic	Acute	Chronic
Cadmium	14	5.0	42	9.3
Copper	38	23	4.8	3.1
Lead	209	8.1	210	8.1
Selenium		5.0**	290	71
Silver	23		1.9	
Zinc	300	300	90	81

* *Freshwater targets are based on a hardness of 300 mg/L.*
** *This criterion is expressed in the total recoverable form.*

The numeric targets in Table 3-1 require conversion to total metals concentrations for comparison to existing conditions for TMDL development. The freshwater chronic criterion for selenium is expressed as total metals; therefore, no conversion is required. Site-specific conversion factors were developed using existing data collected by SCCWRP (2004) and LACDPW (data for 2002 and 2003). To establish the relationship, dissolved metal concentrations were regressed against total metal concentrations. The slope reflects the relationship between the dissolved and total metal concentration; the r-squared value reflects the strength of the relationship.

No significant relationship could be established (R^2=0.45 for Se; no other metals had R^2 values greater than 0.01) to justify using values other than the CTR conversion factors (Table 3-2). As discussed in Section 2.1.2, freshwater conversion factors for cadmium and lead are dependent on hardness. Based on analysis of 2003 sampling data (SCCWRP, 2004), the freshwater dry-weather median hardness value was 300 mg/L. Therefore, a hardness value of 300 mg/L was used to calculate the freshwater conversion factors for cadmium and lead (Table 3-2).

Table 3-2. Default CTR factors for conversion of total metals to dissolved metals concentrations

Metal	Conversion Factor for Freshwater Chronic Criteria	Conversion Factor for Saltwater Chronic Criteria*
Cadmium	0.863**	0.994
Copper	0.96	0.83
Lead	0.631**	0.951
Selenium		0.998
Silver	0.85***	0.85***
Zinc	0.986	0.946

** Conversion factors for saltwater acute criteria have been used for both acute and chronic saltwater criteria, because conversion factors for saltwater chronic criteria are not currently available.*
*** Conversion factor is hardness dependent, based on a hardness of 300 mg/L.*
**** Conversion factor is for acute criteria (Table 3-1) not chronic.*

3.2 Wet-Weather TMDL Targets

As discussed above, the freshwater aquatic life criteria for metals in the CTR are expressed as a function of hardness of the receiving water. For the wet-weather numeric target, we evaluated hardness values from storm water data collected in Ballona Creek by the LACDPW as part of the NPDES program. These data represent 55 storm water composite samples collected between 1996 and 2002. The average and median hardness from these data were 108 mg/L and 77 mg/L, respectively. These values do not vary greatly from the CTR default hardness of 100 mg/L. However, using the default hardness value of 100 mg/L may not be fully protective. Therefore, the median hardness of 77 mg/L is assumed to be representative of wet-weather conditions.

The chronic criteria are typically based on exposures, which occur over a 4-day time interval. Storms of this duration are a rare occurrence in Southern California. Most storms are of shorter duration. Most rainfall events in the Ballona Creek watershed are less than 6 hours in duration, with only 6% of the storms greater than 1 day (Ackerman and Weisberg, 2003). The acute criteria are typically based on 1-hour time intervals and are more appropriate for setting numeric targets for wet-weather conditions. For selenium there is no acute criterion, therefore, the chronic criterion was used for developing the waste load allocations for wet weather. The freshwater and saltwater numeric targets used to calculate the wet-weather waste load allocations are listed in Table 3-3.

Table 3-3. Wet-weather numeric targets expressed in terms of the dissolved fraction except for selenium as noted.

Metal	Freshwater Target* (µg/L)	Saltwater Target (µg/L)
Cadmium	3.2	42
Copper	11	4.8
Lead	49	210
Selenium	5.0**	290
Silver	2.2	1.9
Zinc	94	90

* *Freshwater targets are based on a hardness of 77 mg/L.*
** *For selenium, the chronic criterion is used, since, there is not an acute criterion included in the CTR. This criterion is expressed in the total recoverable form.*

To evaluate the potential for site-specific wet-weather conversion factors, storm water data collected by LACDPW from Ballona Creek between Sawtelle and Sepulveda Boulevards was evaluated. To establish the relationship, dissolved metals were regressed against total metals in the storm water data set. Data from December 1994 through January 2002, were regressed and conversion factors determined for copper, lead, and zinc. There were not enough samples with detectable levels of dissolved cadmium, selenium, or silver present to determine a relationship for these metals. The resulting conversion factors for freshwater are listed in Table 3-4 along with the default CTR conversion factors for comparison. As stated previously, a conversion factor is not needed for the freshwater selenium chronic criterion, since, this criterion is already expressed as a total recoverable metal. The freshwater CTR conversion factors for cadmium and lead were calculated based on a hardness of 77 mg/L.

Table 3-4. Conversion factors for total metals to dissolved metals concentrations.

Metal	CTR Conversion Factor for Freshwater Acute Criteria	CTR Conversion Factor for Saltwater Acute Criteria	Wet-Weather Data (LACDPW)		
			N	Conversion Factor	R^2
Cadmium	0.955*	0.994	2	-	-
Copper	0.96	0.83	50	0.62	0.70
Lead	0.829*	0.951	7	0.60	0.77
Selenium	---	0.998			
Silver	0.85	0.85	1	-	-
Zinc	0.978	0.946	22	0.79	0.89

* *Conversion factor is hardness dependent, based on a hardness of 77 mg/L.*

These results suggest that a large fraction of the total metals in storm water is associated with the particles. This is consistent with expectations and with values from the literature. McPherson et al., 2004 estimated that 83% of the cadmium, 63% of the copper, and 86% of the lead were associated with the particle phase in Ballona Creek. Use of the CTR default values would be overly conservative, therefore, we propose using the slope of the regression as conversion factors for copper and zinc. There, were not enough detectable samples (n=7) of lead to justify using the calculated site-specific conversion factor. Therefore, the default CTR conversion factors will be used for lead, as well as for cadmium, and silver.

4 SOURCE ASSESSMENT

The TMDL requires an estimate of loading 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. These types of discharges are regulated through the federal National Pollutant Discharge Elimination System (NPDES) program, which the Regional Boards have been delegated to implement through the issuance of Waste Discharge Requirements (WDRs). Nonpoint sources, by definition, include pollutants that reach surface waters from a number of diffuse land uses and activities. The Regional Board, under the authority of the Porter-Cologne Water Quality Control Act, issues WDRs for discharges to groundwater from nonpoint sources.

The distinction between point and nonpoint sources is not always clear in the Ballona Creek watershed area. For example, in Los Angeles County urban runoff to Ballona Creek and Estuary is regulated under two storm water NPDES permits. The first is the County of Los Angeles Municipal Storm Water NPDES permit (MS4 Permit), which was renewed in December 2001 and is on a five-year renewal cycle. There are 85 co-permittees covered under this permit including 84 cities and the County of Los Angeles. The second is a separate statewide storm water permit specifically for the California Department of Transportation (Caltrans). Runoff from construction and industrial activities is also subject to a statewide NPDES permit for storm water.

The major contributor of flows and associated metals loading to Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary is assumed dry- and wet-weather urban runoff discharges from the storm water conveyance system. This section presents the approach used to identify and quantify these sources of metals to the impaired waterbodies in the Ballona Creek watershed. Both in-stream monitoring data and storm water collection system discharge data were used to identify potential sources and characterize the relationship between point and nonpoint source loading and in-stream response under dry- and wet-conditions. Because the relative loads from these sources vary depending on dry- or wet-conditions, assessment of loads required separate analyses.

4.1 Point Sources

A point source, according to 40 CFR 122.3, is defined as "any discernable, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged." The NPDES program, under CWA Sections 318, 402, and 405, requires permits for the discharge of pollutants from point sources.

Other than the MS4 and Caltrans Storm Water Permits, there are no major individual NPDES permitted discharges in the Ballona Creek watershed. The NPDES permits issued in the Ballona Creek watershed are for minor or general discharges, as listed in Table 4-1. The discharge flows associated with the individual and general NPDES permits are, by definition, less than 1 million gallons per day (MGD). There are fourteen industrial dischargers with storm water NPDES permits within the watershed. The permitting process defines these discharges as point sources because the storm water discharges from the end of a storm water conveyance system. Since, the industrial storm water discharges are enrolled under NPDES permits, these permits are treated as point sources in this TMDL.

Table 4-1. NPDES Permits in the Ballona Creek Watershed

Type of NPDES Permit	Number of Permits
Municipal Storm water	1
California Department of Transportation Storm water	1
Minors	16
General Permits:	
Construction Dewatering	83
Treated Groundwater from Construction Dewatering	15
Petroleum Fuel Cleanup Sites	18
VOCs Cleanup Sites	7
Potable Water	6
Non-Process Wastewater	3
Hydrostatic Test Water	1
General Construction Storm water	17
General Industrial Storm water	14
Total	**182**

4.1.1 MS4 Storm Water Permits

In 1990 USEPA developed rules establishing Phase I of the NPDES storm water program, designed to prevent harmful pollutants from being washed by storm water runoff into municipal separate storm sewer systems (MS4s) (or from being dumped directly into the MS4s) and then discharged from the MS4s into local waterbodies. Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or more) to implement a storm water management program as a means to control polluted discharges from the MS4s. Approved storm water management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipally owned operations, and hazardous waste treatment. Large and medium operators are required to develop and implement Storm Water Management Plans that address, at a minimum, the following elements:

- Structural control maintenance
- Areas of significant development or redevelopment
- Roadway runoff management
- Flood control related to water quality issues
- Municipally owned operations such as landfills, and wastewater treatment plants
- Hazardous waste treatment, storage, or disposal sites
- Application of pesticides, herbicides, and fertilizers
- Illicit discharge detection and elimination
- Regulation of sites classified as associated with industrial activity

- Construction site and post-construction site runoff control
- Public education and outreach

Phase II of the rule extends coverage of the NPDES storm water program to certain small municipalities with a population of at least 10,000 and/or a population density of more than 1,000 people per square mile. A small MS4 is defined as any MS4 that is not covered by Phase I of the NPDES Storm Water Program. In addition, under Phase II separate permits will be written for state and federal facilities, including public educational institutions and military installations.

As stated previously, in the Ballona Creek watershed, all discharges of urban runoff are regulated as a point source under the Los Angeles County MS4 Permit and the Caltrans Storm Water Permit. Discharges from the storm water collection systems can be categorized as dry- or wet-weather runoff corresponding to the method and conditions of transport through the watershed. The following sections describe the relative contributions of metals loads resulting from dry- and wet-weather condition.

4.1.1.1 Dry-Weather Urban Runoff

Dry-weather urban runoff is a major source of metals loading to receiving waters in the watershed. From 1991 to 1996, dry-weather flows accounted for 10-30% of the annual volume of discharge from the watershed (McPherson et al., 2002). For the 2000-2001 and 2001-2002 dry seasons, the volume of runoff during these periods accounted for the majority of the annual volume of discharge to Ballona Creek (SCCWRP, 2003). Dry-weather runoff often varies substantially over any given period. For instance, flows in the morning can be much greater than flows in the afternoon, but these flows can increase again in the evening. SCCWRP (2003) reported that dry-weather flows could also vary significantly from year to year.

Although dry-weather runoff accounts for the majority of the annual volume of water discharged from the watershed, the contribution to the annual load of metals is much less. SCCWRP (2003) reported that the majority of lead was discharged during the wet season (based on data from the 2000-2001 and 2001-2002 dry seasons). However, average loads of copper and zinc were reported as more evenly distributed between wet and dry season. During years of less rainfall, such as 2001-2002, dry seasonal loads of metals may account for 25% to 35% of the total annual load (SCCWRP, 2004). Although, wet-weather conditions can result in higher contributions of metals loads to the waterbodies, dry-weather conditions can still result in exceedances of water quality criteria (McPherson et al., 2002). During dry weather, when metals concentrations are predominately in the dissolved phase, the toxicity associated with metals is amplified since dissolved metals are generally more bioavailable (SCCWRP, 2004).

In sampling events of the 2003 dry season, SCCWRP (2004) found consistent concentrations of metals at both in-stream sampling sites and at the discharge of storm drains. In-stream data from the dry-weather characterization study were summarized in Section 2.2.1. Average total metals concentrations from storm drain samples are reported in Table 4-2. The dissolved fraction of total metals concentrations during the dry period was observed as close to unity. SCCWRP (2004) further analyzed the spatial distribution of metals concentrations and loads from storm drains relative to in-stream levels. They found that high concentrations of metals in the creek and estuary correspond to locations of storm drains associated with high concentrations. They further concluded that although most in-stream metals samples were below water quality criteria during the 2003 sampling events, the magnitude and variability of storm drain concentrations lead to reasonable assumptions that in-stream concentrations may exceed water quality objectives at some point in time. Such exceedances have been observed from historic data sets, as summarized in Section 2.2.1.

Table 4-2. Average total metals concentrations (µg/L) from storm drains in Ballona Creek during three sampling events of 2003. In all cases n = 103. (Source: SCCWRP, 2004).

Metal	Numeric Target*	Mean	SD	% ND
Cadmium	5.8	0.13	0.33	75%
Copper	24	19.85	28.98	3%
Lead	13	4.41	12.66	60%
Selenium	5	7.19	12.72	53%
Silver	27	0.47	1.54	93%
Zinc	300	83.25	241.18	2%

* Numeric Target is based on a hardness of 300 mg/L and is expressed as total metals.

Based on three sampling events, Sepulveda Canyon Channel is a major tributary to the bottom portion of Reach 2 of Ballona Creek above Centinela Avenue. Centinela Channel drains directly to Ballona Creek Estuary, downstream of the boundary with Ballona Creek. SCCWRP (2004) determined that 2003 dry-weather flows from these channels accounted for 50% of the daily dry-weather storm drain volume and between 48% and 77% of the daily storm drain metals loading to the tidal portion of Ballona Creek. Average total metals loads (based on the three sampling events in 2003) from Centinela Channel, Sepulveda Canyon Channel, and the portion of Ballona Creek (at Overland Avenue) upstream of the discharge of Sepulveda Canyon Channel are listed in Table 4-3.[1] Relative locations of discharge points for each channel are shown in Figure 3. These three discharge points are considered to be major contributors of metals loads to Ballona Creek Estuary. Additional small storm drain loads to Ballona Creek downstream of Overland Avenue[2] (not including Sepulveda Canyon Channel and Centinela Channel) were also estimated from the 2003 monitoring study (Table 4-3). Metals loads from these smaller drains account for less than 1% of the total load to Ballona Creek Estuary. However, there is much uncertainty associated with small storm drain load estimates due to a large uncertainty with the methods of flow measurements from these drains. Therefore, only flows measured directly from channels (e.g., Ballona Creek at Overland Avenue, Sepulveda Canyon Channel, and Centinela Channel) were considered for TMDL development (Section 5).

[1] Daily loads differ from estimates reported by SCCWRP (2004) due to differences in methods of calculation (e.g., treatment of detection limits; flow-weighted estimates verses independent averages of flows and metals concentrations)

[2] Loads from small storm drains were quantified for Ballona Creek and Ballona Creek Estuary between Overland Avenue and Pacific Avenue. Upstream storm drain loads are included in the Ballona Creek (at Overland) loads.

Table 4-3. Average dry-weather total metals loads (grams/day) from Ballona Creek (at Overland Avenue), Sepulveda Canyon Channel, Centinela Channel, and small storm drain loads to Ballona Creek (below Overland). (Source: data from 2003 SCCWRP monitoring study)

Waterbody/Discharge	Cadmium	Copper	Lead	Selenium	Silver	Zinc
Ballona Creek at Overland Avenue	2	348	97	97	6	1493
Sepulveda Canyon Channel	2	328	37	163	2	540
Centinela Channel	0.5	201	37	252	25	354
Small Storm Drains Below Overland	0.2	13	3	14	0.1	42
Ballona Creek Estuary	4.7	890	174	526	33.1	2429

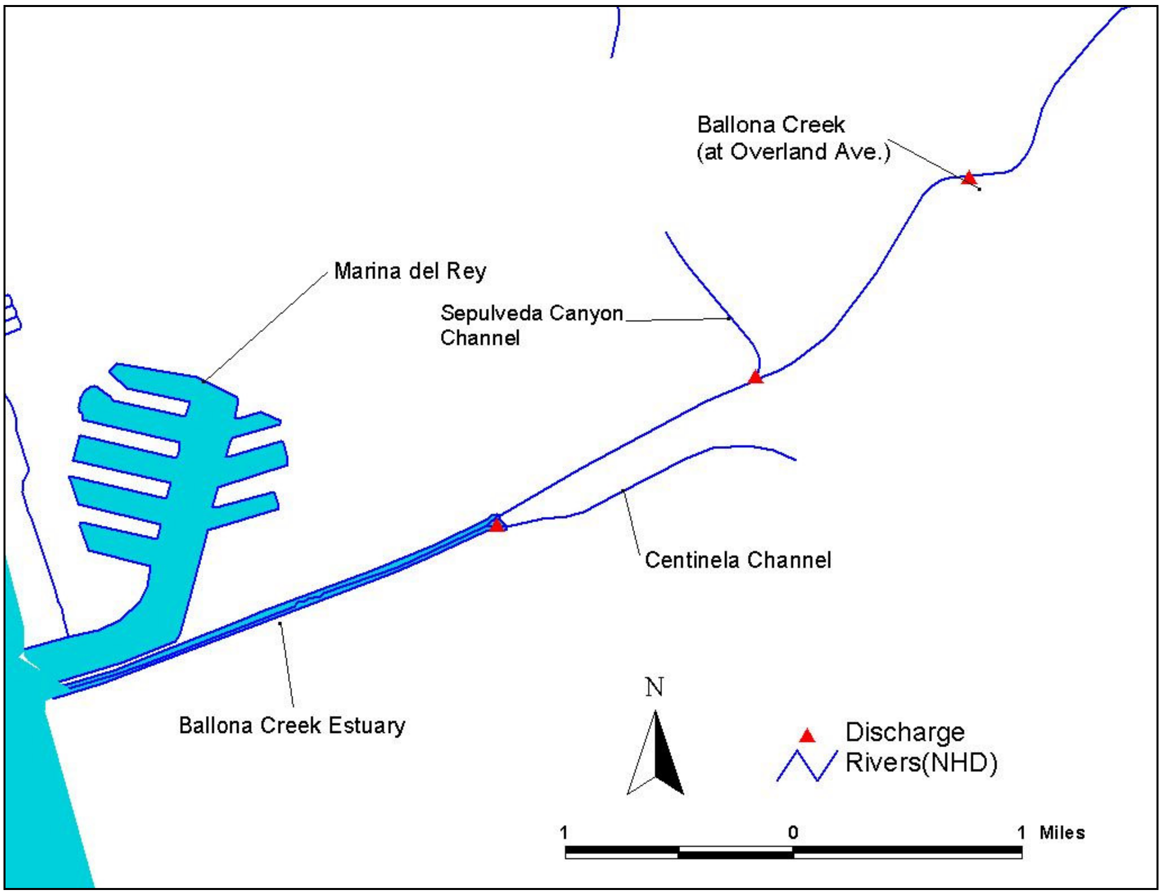

Figure 3. Locations of major low-flow discharges to Ballona Creek Estuary

4.1.1.2 Wet-Weather Urban Runoff

The metals that build up on the surface as the result of various land use activities, are washed off during rainfall events and into the waterbodies. McPherson et al. (2002) estimated that 70% to 90% of the annual volume of water (average annual volume based on conditions from 1991 to 1996) discharged from the Ballona Creek watershed is from wet-weather runoff, accounting for 58%, 91%, and 92% of the cadmium, copper, and lead annual watershed loads, respectively. However, for other periods associated with less rainfall, the proportion of wet-weather runoff to annual volume of watershed runoff differs. For the 2001-2002,which was a period of low-rainfall, SCCWRP (2003) estimated that less of the annual volume of watershed runoff occurs during the wet season than the dry season. They determined that even with less runoff volume, the wet season was associated with higher loads of lead from watershed runoff than the dry period; for copper and zinc, loads during the wet season were close to those for the dry season.

SCCWRP (2003) estimated 30-year average wet-weather loads of cadmium, copper, lead, selenium, and zinc based on land use distributions, historic rainfall, and land use runoff data from LACDPW. In addition, LACDPW (2000 and 2001) estimated annual loads (1996-2001) of copper, lead, and zinc using annual mean concentrations and annual runoff volumes from a mass emission station located between Sawtelle and Sepulveda Boulevards at the non-tidal portion of Ballona Creek. Table 4-4 presents these loads for comparison (no values were reported for silver).

Table 4-4. Typical annual wet-weather loading (kg) to Ballona Creek. (Source: SCCWRP, 2003; LACDPW, 2000 and 2001)

Metal	Typical Year (SCCWRP)	1996/97 (LACDPW)	1997/98* (LACDPW)	1998/99 (LACDPW)	1999/2000 (LACDPW)	2000/01 (LACDPW)
Cadmium	7	-	-	-	-	-
Copper	1,081	328	889	251	398	432
Lead	381	239	794	86	122	179
Selenium	16	-	-	-	-	-
Zinc	6,901	2,195	8,618	1,266	1,810	2,545

* Sampler was out of service the month of February 1998.

4.1.2 Caltrans Storm Water Permit

As stated previously, Caltrans holds a statewide storm water discharge permit that covers all municipal storm water activities and construction activities. The Caltrans storm water permit authorizes storm water discharges from Caltrans properties such as the state highway system, park and ride facilities, and maintenance yards. The storm water discharges from these Caltrans properties and facilities eventually ends up in either a city or county storm drain. The metals loading specifically from Caltrans properties have not been determined in the Ballona Creek watershed. A conservative estimate of the percentage of the Ballona Creek watershed covered by state highways is 1% (approximately 970 acres). This percentage does not represent all the watershed area that Caltrans is responsible for under the stormwater permit. The park and ride facilities and the maintenance yards were not included in the estimate. Although, the percentage is low the associated metals loading may be high especially for copper since brake pads are a know source of copper loading. The Caltrans properties contribute to the overall metals loading as discussed in Section 4.1.1.

4.2 Nonpoint Sources

A nonpoint source is, by definition, runoff that is not covered under any of the storm water permits. An example of this would be the runoff from National Parks and State lands. In the

Ballona Creek watershed National Park Service and State lands cover approximately 430 acres[3] (0.5% of the watershed). While not subject to the MS4 Permit, the contribution of runoff from these exempted areas must be accounted for in the TMDL. This can be done through the development of pollutant allocations for the National Parks and State lands or by treating the runoff from these areas as natural background in the TMDL calculation.

Atmospheric deposition is another potential nonpoint source of metals to the watershed, through either direct deposition or indirect deposition. Direct atmospheric deposition can be quantified by multiplying the surface area of the waterbody times the rate of atmospheric deposition. These numbers are generally small because the portion of Ballona Creek watershed that is covered by water is small, approximately 480 acres (0.6% of the watershed). Therefore, direct deposition of metals is insignificant relative to the annual dry-weather loading or the total annual loading. Indirect atmospheric deposition reflects the process by which metals deposited on the land surface may be washed off during storm events and delivered to Ballona Creek and its tributaries. The loading of metals associated with indirect atmospheric deposition are accounted for in the estimates of the storm water loading.

[3] This acreage does not include the approximate 400 acres that the State purchased from the Playa Capital Company LLC in 2003. This land is open space and is not expected to contribute to the metals loading in Ballona Creek or estuary.

5 Linkage Analysis

Information on sources of pollutants provides one part of the TMDL equation. To determine the effects of these sources on water quality, it is also necessary to determine the carrying capacity of the receiving water. The delivery of metals to Ballona Creek and the assimilative capacity of the creek to accommodate these loadings can be strongly affected by variations between dry and wet weather. Given the differences in sources and flows between dry and wet weather, two distinct approaches were developed for dry and wet weather. This section describes the use of a hydrodynamic and water quality models to assess the effects of metals loading in Ballona Creek on water quality under both dry- and wet-weather conditions.

5.1 Dry-Weather Modeling Analysis

In 2003, a detailed monitoring study was performed for Ballona Creek during three dry days for which no rainfall had occurred within the preceding two weeks of each sampling event (SCCWRP, 2004). Results of this study are summarized in Sections 2 and 4. These data were used to develop a receiving water model of Ballona Creek and Ballona Creek Estuary for analysis of dry-weather conditions in the waterbodies. The model was used to simulate total metals concentrations in the waterbodies during steady state, low-flow conditions representative of average dry-weather conditions.

The goal of model development was to provide analysis of the linkage between metals sources and conditions within Ballona Creek and Ballona Creek Estuary. We reviewed a two-dimensional model previously developed by the U.S. Army Corps of Engineers (USACE) for use in predicting sediment transport at the mouth of Ballona Creek Estuary (Mofatt and Nichol Engineers, 1999; USACE, 2002). Due to the vertical stratification observed in the estuary, a two-dimensional model of the estuary was determined inadequate for accurate predictions of metals transport and water column concentrations in the estuary. A three-dimensional model of the estuary is proposed for a future study to provide complete understanding of the system. However, the portion of the USACE model configured for Ballona Creek was determined useful for prediction of metals transport through the creek. This model was upgraded and calibrated for metals transport through the creek, which can be used in future studies for prediction of boundary conditions for a separate or linked three-dimensional model of the estuary.

For this TMDL, dry-weather loading analysis was based strictly on empirical data collected in 2003 and reported by SCCWRP (2004). This TMDL and associated waste load allocations are the first step in defining the necessary load reductions to ensure that beneficial uses of the waterbodies are met. Once additional models are developed that better predict conditions in the estuary, the TMDL can be revised to reflect this information. In the meantime, we have determined that this dry-weather TMDL, based on empirical data rather than predictive models, is sufficient over the interim period until a better understanding of the system is reached.

5.1.1 Dry-Weather Model

The dry-weather model is based on RMA2 and RMA4 models first developed by Norton, King and Orlob (1973), of Water Resources Engineers, for the U.S. Corps of Engineers, with subsequent enhancements by U.S. Army Engineer and Development Center at the Waterways Experiment Station Coastal and Hydraulics Laboratory.

RMA2 is a two-dimensional, depth-averaged, finite element, hydrodynamic numerical model. It computes water surface elevations and horizontal velocity components for sub-critical, free-surface, two-dimensional flow fields. RMA2 computes a finite element solution of the Reynolds form of the Navier-Stokes equations for turbulent flows. Friction is calculated with the Manning's or Chezy equation. Both steady and unsteady (dynamic) problems can be analyzed.

The water quality model, RMA4 is designed to simulate the depth-average advection-diffusion process in an aquatic environment. The model can be used for the evaluation of any conservative substance that is either dissolved in the water or can be assumed neutrally buoyant within the water column. The model is also used for investigating the physical processes of migration and mixing of a soluble substance in reservoirs, rivers, bays, estuaries and coastal zones. The model utilizes the depth-averaged hydrodynamic flow field results from RMA2.

The model was configured and calibrated using data collected in the 2003 monitoring study (SCCWRP, 2004). Model simulations were performed assuming steady-state conditions representative of each sampling event. A complete description of the model, including configuration and calibration, is provided in Appendix A.

This model serves two purposes: (1) it can serve as a foundation of future modeling work for simulation of boundary conditions of Ballona Creek Estuary, and (2) it can be used as a management tool for assessment of alternative management schemes. Until future models are developed, the technical approach for this TMDL does not require model simulation. Rather, analysis of empirical data is determined sufficient in developing a TMDL for Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary.

5.2 Wet-Weather Modeling Analysis

Wet-weather sources of metals are generally associated with wash-off of pollutant loads accumulated on the land surface. During rainy periods, these metals loads are delivered to the waterbody through creeks and storm water collection systems. Often, metals sources can be linked to specific land use types that have higher relative accumulation rates of metals, or are more likely to deliver metals to waterbodies due to transport through storm water collection systems. To assess the link between sources of metals and the impaired waters, a modeling system may be utilized that simulates the build up and wash off of metals and the hydrologic and hydraulic processes that affect delivery. Understanding and modeling of these processes provides the necessary decision support for TMDL development and allocation of loads to sources.

5.2.1 Wet-Weather Model

The wet-weather TMDL calculation was based on a watershed model of the drainage area associated with each impaired waterbody. USEPA's Hydrological Simulation Program – FORTRAN (HSPF) was selected to simulate the hydrologic processes and metals loading from the Ballona Creek watershed. The HSPF model was configured for seven subwatersheds of the Ballona Creek and Marina del Rey watersheds. This TMDL, used model results from the six sub-watersheds upstream of Ballona Creek Estuary to define loading conditions to Ballona Creek, Sepulveda Canyon Channel, and Centinela Channel (Figure 4).

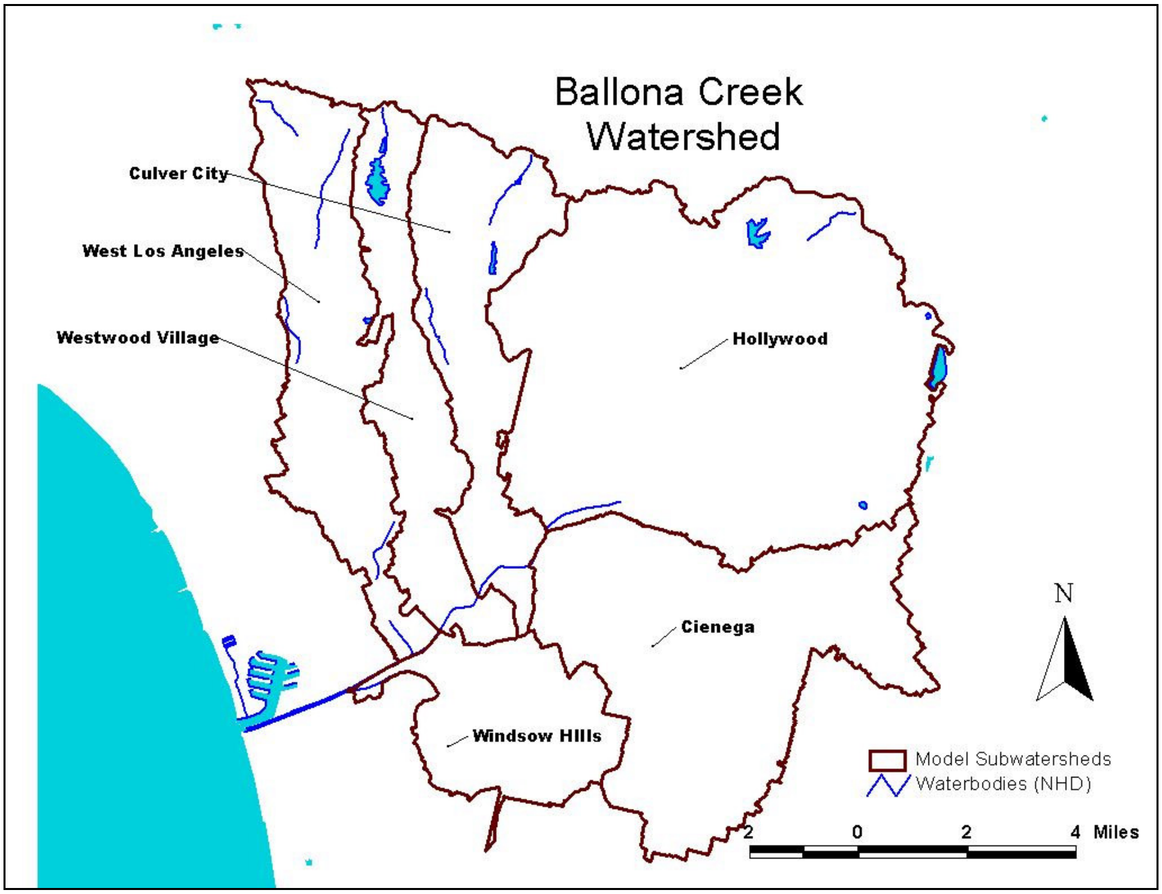

Figure 4. Model subwatersheds for simulation of wet-weather conditions

Configuration of the watershed model involved consideration of four major components: meteorological data, land use representation, hydrologic and pollutant representation, and waterbody representation. These components provided the basis for the model's ability to estimate flow and pollutant loading. Meteorological data essentially drive the watershed model. Rainfall and other parameters are key inputs to HSPF's hydrologic algorithms. The land use representation provides the basis for distributing soils and metals loading characteristics throughout the basin. Hydrologic and pollutant representation refers to the HSPF modules or algorithms used to simulate hydrologic processes (e.g., surface runoff, evapotranspiration, and infiltration) and pollutant loading processes. Waterbody representation refers to HSPF modules or algorithms used to simulate flow and pollutant transport through streams and rivers.

Loading processes for metals (copper, lead, and zinc) for each land-use was represented in HSPF through their associations with sediment. The accumulation and washoff of sediments were modeled using the SDMNT module for pervious lands and the SOLIDS module for impervious lands. Sediments washed off by rain are delivered to the stream channel by overland flow. Processes such as transport, deposition and scour of sediments in the stream channels were modeled using the SEDTRN module. These processes depend on sediment characteristics such as particle size distribution (which define settling velocities and the critical shear stresses for deposition and re-suspension), and the bottom shear stress predicted by the model.

The model was then used to simulate the in-stream total suspended solids concentrations. Metals associated with these sediments were simulated using the HSPF water quality module. The relationships between sediment and total metals (copper, lead and zinc) were parameterized as potency factors developed by SCCWRP. In brief, the potency factor reflects the ratio of total metals loading to sediment loading. Potency factors were defined for copper, lead and zinc for each of seven land-uses categories (agriculture, commercial, high-density residential, industrial, low-density residential, mixed urban and open). After the model was configured, model calibration and validation were performed. This is generally a two-phase process, with hydrology calibration and validation completed before repeating the process for water quality. Total suspended solids and the potency factors were developed and calibrated by SCCWRP at specific watersheds in the Los Angeles area. These were validated for use in the Ballona Creek watershed. Upon completion of the calibration and validation at selected locations, a calibrated data set containing parameter values for each modeled land use and pollutant was developed. A complete description of model configuration and calibration is provided in Appendix B.

6 Pollutant Allocation

In this section, we develop the loading capacity and pollutant allocations for metals Ballona Creek and Estuary. USEPA regulations require that a TMDL include waste load allocations (WLAs), which identify the portion of the loading capacity allocated to existing or future point sources (40 CFR 130.2(h)). It is not necessary that every individual point source have a portion of the allocation of pollutant loading capacity. It is necessary, however, to allocate the loading capacity among individual point sources as necessary to meet the water quality objective.

As discussed in previous sections, the sources of metals and the relative magnitude of the inputs vary between dry and wet periods. In this TMDL concentration-based and mass-based waste load allocations were developed for dry-weather urban runoff and mass-based waste allocations for stormwater runoff. Concentration-based waste load allocations are developed for all other NPDES permitted discharges based on dry- and wet-weather conditions.

6.1 Dry-Weather Load Estimates

The analysis of the loading capacity of the listed waterbodies is based on review of empirical data and comparison to numeric TMDL targets at critical locations. These critical locations were selected based on maximum metals concentrations or loadings observed to occur in the freshwater system. For the estuary, additional studies are recommended in the TMDL implementation plan (Section 7) to provide further analysis of transport, sources, and loading capacity of metals in the estuary. During the interim period, this TMDL addresses metals load reductions from controllable sources from the watershed through analysis of critical loads from freshwater discharges to the estuary.

As shown in Section 4.2.1.b, dry-weather runoff is primarily transported to Ballona Creek Estuary via three major channels: Ballona Creek, Sepulveda Canyon Channel, and Centinela Channel. Two of these tributaries, Ballona Creek and Sepulveda Canyon Channel, are listed as impaired waterbodies due to metals. The discharge points of these tributaries to Ballona Creek Estuary are assumed to be critical locations where water quality is most problematic in the estuary. At increasing distances from the discharge points, dilution and settling processes in the estuary are assumed to result in decreased concentrations.

The discharge points of Ballona Creek and Sepulveda Canyon Channel are also assumed to correspond to critical points for these waters. At increasing distances downstream, metals loads increase with additional contributions from storm drains. Therefore, critical points in Ballona Creek and Sepulveda Canyon Channel are at the bottom of their respective watersheds. Although there is about one mile between the loads observed in Ballona Creek at Overland Avenue and the confluence of Sepulveda Canyon Channel (Figure 3), no considerable storm drain loads to Ballona Creek were observed downstream of Overland Avenue other than from Sepulveda Canyon Channel. Therefore, conditions of Ballona Creek at Overland Avenue are assumed to be representative of the Ballona Creek dry-weather loading, unaffected by discharges from Sepulveda Canyon Channel. The freshwater portion of Ballona Creek ends at Centinela Avenue, located less than a mile downstream of the discharge from Sepulveda Canyon Channel.

Existing dry-weather loads at critical points were derived from flow and water quality data collected during the SCCWRP (2004) monitoring study of 2003. Average metals concentrations and average flows of the three sampling events were calculated at the discharge of Sepulveda Canyon Channel, Centinela Channel, Ballona Creek at Overland Avenue, and various small storm drains in Ballona Creek and Ballona Creek Estuary. These flows and concentrations were used to calculate the existing loads reported in Table 4-3. For TMDL development, dry-weather existing loads were defined using critical flow conditions defined in loading capacity (Section 6.1.1). Metals concentrations and associated loads at critical points were compared to numeric targets for TMDL development.

6.1.1 Dry-Weather Loading Capacity

Dry-weather loading capacities for Ballona Creek and Sepulveda Canyon Channel were determined through assessment of in-stream water quality at critical points identified. For Ballona Creek Estuary, the specific loading capacity of the waterbody could not be established without more intensive modeling analysis of transport and assimilation properties. Until such studies are performed, this TMDL addresses conditions at the critical points of discharge defined in the previous section, and assumes that these are the locations in the estuary with highest metals concentrations in the water column. The sum of the loading capacity at these critical discharge points is assumed to be the loading capacity for Ballona Creek Estuary. This TMDL is presented as total metals for quantification of total metals loads to the estuary.

To predict the capacity of Ballona Creek, Sepulveda Canyon Channel, and Centinela Channel, two site-specific variables were required. A dry-weather hardness was determined for Ballona Creek, based on analysis of 2003 in-stream monitoring data, for identification of numeric targets (Section 3). Next, a critical dry-weather flow was determined for each reach. The allowable load for each reach was then derived for each metal by multiplying the hardness-adjusted numeric target, as defined in the CTR, by the critical flow assigned to each reach.

Based on long-term flow records, Ackerman et al. (2003) estimated dry-weather flows in Ballona Creek to be 14 cfs. This flow was used to define the critical dry-weather flow for Ballona Creek at Overland Avenue (upstream of Sepulveda Canyon Channel). There were no historic flow records to determine the average long-term flows for Sepulveda Canyon Channel and Centinela Channel, so a different method was used to estimate their respective critical flows.

Dry-weather flows measured at Overland Avenue in 2003 were 17.7 cfs on May 17th, 23.2 cfs on July 16th, and 15.5 cfs on September 24th, however, the larger flow on July 16th was determined to be an anomaly resulting from discharges upstream. Removing the flow on July 16th, the average of the two remaining flows is 16.6 cfs. This 2003 average was comparable to the long-term average of 14 cfs. Based on this analysis, we assumed that flow conditions in the 2003 study were representative of the system during typical dry days throughout the year. Therefore, in the absence of historical records for Sepulveda Canyon Channel and Centinela Channel, the 2003 measurements were assumed reasonable estimates of flows for these reaches.

In the 2003 study, flow was measured at the mouth of Sepulveda Canyon Channel on two dry days: 4.9 cfs on May 17th, and 7.7 cfs on September 24th. The average flow is 6.3 cfs, which we used to define the critical dry-weather flow for the channel.

Flows at the mouth of Centinela Channel were measured on three dry days of 2003: 5.3 cfs on May 17th, 5.0 cfs on July 16th, and 4.7 cfs on September 24th. There was not much variability in flows between the three measurements. The critical dry-weather flow for the channel was defined as the average flow of 5.0 cfs.

Multiplying critical flows by numeric targets defined in Section 3, the loading capacity is obtained. For Ballona Creek, Sepulveda Canyon Channel, and Centinela Channel, freshwater numeric criteria were applicable. The combined loading capacities of these waterbodies were assumed to define the loading capacity of Ballona Creek Estuary. Further study is suggested to validate that the estuary's calculated loading capacity is protective of its beneficial uses (Section 7).

6.2 Dry-Weather Allocations

Storm drain discharges are the major source of metals loading during dry-weather conditions in the watershed (Section 4). Mass-based (Table 6-1) and concentration-based waste load allocations (Table 6-2) were developed for dry-weather discharges from the MS4 system and the Caltrans stormwater permits. Concentration-based waste load allocations are expressed as total metals based on the numeric targets described in Section 3. Three critical discharge points were identified to address development of the mass-based waste load allocations for Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary. These locations were identified in Section 5.1, along with the flows, and correspond to Ballona Creek at Overland Avenue (14 cfs), and the mouths of Sepulveda Canyon Channel (6.3 cfs), and Centinela Channel (5.0 cfs). For each of these critical points, waste load allocations were developed based on loading capacities. The combined waste load allocations at the three critical points constitute the total waste load allocations for discharges to Ballona Creek Estuary. Table 6-1 presents the waste load allocations for each critical discharge and waterbody.

Table 6-1. Dry-weather waste load allocations for Ballona Creek, Sepulveda Canyon Channel, Centinela Channel, and Ballona Creek Estuary (grams/day of total metals)

Waterbody/Discharge	Cadmium	Copper	Lead	Selenium	Silver	Zinc
Ballona Creek (at Overland)	198	821	440	171	927	10,423
Sepulveda Canyon Channel	90	371	199	77	419	4,712
Centinela Channel	71	294	157	61	332	3,728
Ballona Creek Estuary	359	1,486	796	309	1,678	18,863

The existing dry-weather metals loading reported in Table 4-3 were based on an average of three sampling events conducted in 2003, however, the metals concentrations and dry-weather flows are very episodic. Therefore, long-term monitoring results are required to provide useful predictions of average loading conditions for comparison to the waste load allocations. Numeric load reductions, expressed as percent reductions to meet the waste load allocations, are not presented in this TMDL for dry weather. Recognizing that episodic conditions likely result in exceedances of water quality criteria, the TMDL implementation plan (Section 7) provides recommendations for addressing sources of metals from dry-weather runoff.

Concentration-based WLAs, which are based on the numeric targets, have been developed during dry weather for the minor and general NPDES discharges. This was done since there is insufficient flow information from these discharges to develop individual mass-based WLAs. Similarly, concentration-based limits are being placed on dry-weather flows associated with the general industrial storm water permits and the general construction storm water permits. The waste load allocations during dry weather for all minor NPDES, general NPDES, general industrial storm water and general construction storm water permits are listed in Table 6-2 adjusted for hardness. Monitoring requirements will be placed on these discharges as appropriate in their respective NPDES permits. Any future minor NPDES permits or enrollees under a general NPDES permit, general industrial storm water permit or general construction storm water permit will also be subject to the WLAs in Table 6-2. In the storm water permits, permit writers may translate numeric waste load allocations to BMPs, based on BMP performance data.

Table 6-2. Dry-weather waste load allocations expressed in terms of total recoverable metals.

Metal	Freshwater WLAs* (µg/L)	Saltwater WLAs (µg/L)
Cadmium	5.8	9.4
Copper	24	3.7
Lead	13	8.5
Selenium	5.0	71
Silver	27	2.2
Zinc	300	86

* *Freshwater targets are based on a hardness of 300 mg/L.*

Dry-weather load allocations for nonpoint sources were not developed for this TMDL. Two potential nonpoint sources are urban runoff from areas not covered by the MS4 or Caltrans Storm Water Permits and atmospheric deposition. Specific load allocation for natural background were not developed because most of the land area in the watershed is covered under the storm water permit with the exception of the area of National or State Parks. No allocations were given to these areas because dry-weather loads from these areas are assumed insignificant. The background metals concentrations associated with these flows from these areas are expected to be low. Allocations for atmospheric deposition were not developed because the loading associated with direct deposition is insignificant relative to the total allowable load (Sabin et al., 2004) and the loading associated with indirect deposition is addressed in the waste load allocations for storm water.

6.3 Wet-Weather Load Estimates

The calibrated watershed model was used to simulate flow and metals concentrations from January 1990 through December 1999, providing 10 years of continuous hourly predictions. Next, hourly flows and metals concentrations were condensed to daily flow volumes and metals loads. These data were compared to daily rainfall records to aggregate data into storm loads. Since a single storm event can last several days, daily flow volumes and metals loads were added for each identified storm.

A single storm was defined as either (1) a day that rainfall occurs plus all consecutive days that flow is above base flow (Ballona Creek the base flow was estimated to be 20 cfs), or (2) rainfall that occurs following a day of no rainfall, even if flow is still above base flow. The first criterion ensures that dry conditions are not included within a storm period. Following a rainfall event, the hydrograph can take several days for the flow to returned to base flow due to delayed conveyance of storm water through groundwater. The second criterion ensures that two consecutive storms are not combined. Since by criterion one, a dry day following a day of rainfall, will be assigned to the previous storm if flow has not returned to base flow. However by criterion two, if another day of rainfall follows a dry day, even if only one dry day occurred following the last day of rainfall, the second wet day is categorized as the beginning of a separate, distinct storm.

For the entire 10-year model simulation period, we aggregated storm volumes, storm loads, and accumulated rainfall (in inches) over each storm's period. Thus by including all storm loads over the 10-year period, analysis of critical conditions was provided.

6.3.1 Wet-Weather Loading Capacity

For assessment of the loading capacity of Ballona Creek, Sepulveda Canyon Channel, and Ballona Creek Estuary, assessment was performed using critical discharge points consistent with those used for dry-weather TMDL development. Watershed model output corresponded to critical points associated with discharge from Ballona Creek (near Overland Avenue), Sepulveda Canyon Channel, and Centinela Channel, all three of which ultimately discharge to Ballona Creek Estuary. Ballona Creek discharge, upstream of the discharge of Sepulveda Canyon Channel near Overland Avenue, corresponded to the combined model output of subwatersheds "Cienega," "Hollywood," "Culver City," and " Westwood Village." Model output from the "Windsow Hills" subwatershed corresponded to the discharge of Centinela Channel. Model output from the "West Los Angeles" subwatershed corresponded to the discharge of Sepulveda Canyon Channel.

The HSPF model was used to simulate storm volumes and associated metals loads over the 10-year period (Section 5.2 and Appendix B). These metals loads were ranked by the amount of rainfall that occurred over the storm period. Loading capacities for each storm were then calculated by multiplying the storm volume by the appropriate numeric water quality target (storm load capacity = storm volume x numeric water quality target). This TMDL is based on total metals concentrations, so for those metals with criteria expressed as dissolved metals concentrations, targets were converted to total metals concentrations using appropriate conversion factors.

6.4 Wet-Weather Allocations

Waste load allocations were developed as a grouped allocation for the MS4 storm water permittees and Caltrans. USEPA requires that waste load allocations be developed for NPDES-regulated storm water dischargers. Allocations for NPDES-regulated storm water discharges from multiple point sources may be expressed as a single categorical waste load allocation when data and information are insufficient to assign each source or outfall individual allocations. USEPA recognizes that these storm water allocations may be fairly rudimentary because of data limitations and variability in the system.

Waste load allocations are based on loading capacities calculated at critical points in the system. The loading capacities were calculated by multiplying the storm volumes (determined through watershed modeling analysis) by the numeric freshwater targets (Section 3) for each metal. Waste load allocations are assigned to Ballona Creek (at Overland Avenue), Sepulveda Canyon Channel, and Centinela Channel, with a combined waste load allocation for the discharge to Ballona Creek Estuary. The waste load allocations for the MS4 permittees and Caltrans are defined as the load duration curves and load capacity curves presented in Appendix C. The load duration curves were generated for cadmium, copper, lead, selenium, silver and zinc at each critical discharge point. The load duration analysis provides a comprehensive assessment of varying storm loads over a 10-year period from January 1990 through December 1999, which represents various conditions that impact the loading of metals from storm water runoff.

The metals loading capacities and model-predicted historic loads for copper, lead and zinc are plotted in the load-duration curves provided in Appendix C. For these figures, C-1 through C-9, loads below the load-capacity curve are represented as vertical bars and loads above the curve are represented as horizontal bars. Determination of required loads reductions assumed that all loads below the load-capacity curve are allowable and loads above the load-capacity curve are not allowed. The percent reduction is calculated by dividing the required load reduction by the total historic load. Since cadmium, selenium and silver were not modeled, the model-predicted historic loads could not be simulated for inclusion with the load capacity curves.

Further characterization of selenium is needed to clearly identify if there is impairment. At this time a TMDL has been developed based on the 2002 303(d) listing. If additional data, indicates that there is no impairment then the TMDL can be revisited. If there is no impairment then the permittees will be able to meet the WLAs with no load reduction necessary.

As with the dry weather, concentration-based WLAs were developed during wet weather for the minor and general NPDES discharges. This was done since there is insufficient flow information from these discharges to develop individual mass-based WLAs. Similarly, concentration-based limits are being placed on wet-weather flows associated with the general industrial storm water permits and the general construction storm water permits. The waste load allocations during wet weather for all minor NPDES, general NPDES, general industrial storm water and general construction storm water permits are listed in Table 6-3 adjusted for hardness. Monitoring requirements will be placed on these discharges as appropriate in their respective NPDES permits. Any future minor NPDES permits or enrollees under a general NPDES permit, general industrial storm water permit or general construction storm water permit will also be subject to the WLAs in Table 6-3. In the storm water permits, permit writers may translate numeric waste load allocations to BMPs, based on BMP performance data.

Table 6-3. Wet-weather waste load allocations expressed in terms of total recoverable metals.

Metal	Freshwater WLAs* (µg/L)	Saltwater WLAs (µg/L)
Cadmium	3.4	42
Copper	11	5.8
Lead	59	220
Selenium	5.0	290
Silver	2.6	2.2
Zinc	96	95

* *Freshwater targets are based on a hardness of 77 mg/L.*

As with the dry-weather condition, no wet-weather load allocations were developed for background or atmospheric deposition. The rationale is similar, most of the area in the watershed is covered under the storm water permit. The areas within the National Park or State Park system that are not covered under the storm water permit are unlikely to contribute significantly to the overall load. The wet-weather loading from open space is also believed to be minor (Table 7-1). Therefore, it is not necessary or desirable to develop load allocations for metals from these areas. Allocations for atmospheric deposition were not developed because the loading associated with direct deposition is insignificant relative to the total allowable load (Sabin et al., 2004) and the loading associated with indirect deposition is address through the storm water waste load allocations.

6.5 Margin of Safety

The statute and regulations require that a TMDL include a margin of safety to account for any lack of knowledge concerning the relationships between effluent limitations and water quality. A margin of safety is appropriate for each TMDL because there is significant uncertainty in the analysis of pollutant loads and effects on water quality. This TMDL utilizes an implicit margin of safety through the use of conservative assumptions. The following conservative assumptions apply to the technical approaches used for the dry- and wet-weather analyses.

- Conservative values were used for the conversion of dissolved metals numeric targets to total metals.
- Analyses were performed at three critical discharge points determined to be locations associated with higher metals loading. (Centinela Channel is currently not listed as impaired, although TMDL analysis was performed at this critical point to ensure that the loading capacity of Ballona Creek Estuary is addressed).
- For assessment of historic wet-weather loads of copper, lead, and zinc, and comparison to loading capacities for determination of required reduction, calculations were based on existing loads below the load capacity (Appendix C). Calculations did not assume that historic loading capacities were allowable if they were not achieved (i.e., predicted load was less than the loading capacity). Therefore, calculations of required percent reductions relied on historic loads below the load capacity curve, rather than the load capacity itself, for determination ([%reduction] = [load above load capacity curve] / [historic loads]).

7 IMPLEMENTATION

7.1 Introduction

As required by the federal Clean Water Act, discharges of pollutants to Ballona Creek and its tributaries from municipal storm water conveyances are prohibited, unless the discharges are in compliance with a NPDES permit. In December 2001, the Los Angeles County Municipal NPDES Storm Water Permit was re-issued jointly to Los Angeles County and 84 cities as co-permittees. The Los Angeles County Municipal Storm Water NPDES Permit and the State of California Department of Transportation (Caltrans) Storm Water Permit will be key implementation tools for this TMDL. Future storm water permits will be modified in order to address implementation and monitoring of this TMDL and to be consistent with the waste load allocations of this TMDL.

The administrative record and the fact sheets for the MS4 permittees and Caltrans must provide reasonable assurance that the BMPs selected will be sufficient to implement the waste load allocations in the TMDL. We expect that reductions to be achieved by each BMP will be documented and that sufficient monitoring will be put in place to verify that the desired reductions are achieved. The permits should also provide a mechanism to make adjustments to the required BMPs as necessary to ensure their adequate performance. If non-structural BMPs alone adequately implement the waste load allocations then additional controls are not necessary. Alternatively, if the non-structural BMPs selected prove to be inadequate then structural BMPs or additional controls may be imposed.

The County of Los Angeles, City of Los Angeles, Beverly Hills, Culver City, Inglewood, Santa Monica, West Hollywood, and Caltrans are jointly responsible for meeting the waste load allocations. The primary jurisdiction for the Ballona Creek watershed is the City of Los Angeles. Staff expects that after additional studies and monitoring are conducted, the new information will assist municipalities in focusing their implementation efforts on key land uses, critical sources and/or storm periods.

The County of Los Angeles, City of Los Angeles, Beverly Hills, Culver City, Inglewood, Santa Monica, West Hollywood, and Caltrans may jointly decide how to achieve the necessary reductions in metals loading by employing one or more of the implementation strategies discussed below or any other viable strategy. The Porter Cologne Water Quality Control Act prohibits the Regional Board from prescribing the method of achieving compliance with water quality standards, and likewise TMDLs. Below staff have identified some potential implementation strategies; however, there is no requirement to follow the particular strategies proposed herein as long as the allowable metals loading is not exceeded.

As mentioned earlier, each municipality and permittee will be required to meet the waste load allocations at the designated compliance assessment points, not necessarily an allocation for their jurisdiction or for specific land uses. Therefore, the focus should be on developed areas where the contribution of metals is highest and areas where activities occur that contribute significant loading of metals (e.g., high-density residential, industrial areas and highways). Flexibility will be allowed in determining how to reduce metals as long as the waste load allocations are achieved.

To achieve the necessary reductions to meet the allowable waste load allocations presented in Section 6, Regional Board staff recognizes the need to balance short-term capital investments directed to addressing this and other TMDLs in the Ballona Creek watershed with long-term planning activities for storm water management in the region as a whole. It should be emphasized that the potential implementation strategies discussed below may contribute to the implementation of other TMDLs for Ballona Creek and estuary. Likewise, implementation of other TMDLs in the Ballona Creek Watershed may contribute to the implementation of this TMDL.

7.2 Implementation Strategies of related TMDLs in Ballona Creek Watershed

The Regional Board supports in concept an integrated water resources approach to improving water quality during wet weather, such as the City of Los Angeles' Integrated Plan for the Wastewater Program (IPWP). An integrated water resources approach takes a holistic view of regional water resources management by integrating planning for future wastewater, stormwater, recycled water, and potable water needs and systems, and focusing on beneficial re-use of stormwater at multiple points throughout a watershed to preserve local groundwater resources and reduce the need for imported water where feasible. The City's IPWP is intended to meet the wastewater and water resource management needs for year 2020.

The Integrated Resources Plan (IRP) is Phase 2 of the IPWP. The IRP is a City-wide strategy developed by the City of Los Angeles and does not specifically focus on the Ballona Creek Watershed. The goal of the plan is to capture and beneficially use 50% of the annual average wet-weather urban runoff; however, it is not known what portion of this runoff will be in the Ballona Creek Watershed. Furthermore, capture and beneficial use of 50% of the annual average wet-weather urban runoff may not achieve the waste load allocations during very wet years. The implementation strategy proposed below could be designed to achieve the TMDL requirements, while remaining consistent with the goals of the City's IPWP and addressing any shortfall of the IRP in achieving implementation with this TMDL.

One component of the IRP is a Runoff Management Plan, which could provide a framework for implementing runoff management practices to meet the IRP goals and address protection of public health and the environment. The Runoff Management Plan as described in the IRP will include consideration of structural Best Management Practices (BMPs) to achieve reduction of pollutant loadings to receiving waters. Urban runoff can be treated at strategic locations throughout the watershed or subwatersheds. This is also similar to the structural and non-structural BMPs described below.

The Ballona Creek and Wetlands Trash TMDL, effective date August 2, 2002, is now in its first year of implementation. Compliance with the Trash TMDL requires permittees to install either full capture systems, partial capture systems and/or implement institutional controls. At a minimum, the full capture systems must be designed to treatment the peak flow rate resulting from a one-year, one-hour storm. A secondary benefit of the trash removal systems also referred to as gross solids removal systems, such as vortex separation systems or catch basin inserts, has been the removal of sediments and other pollutants.

7.3 Potential Implementation Strategies

The implementation strategy selected will need to address the different sources of metals loading during dry and wet weather. During dry weather, metals loading are predominately in the dissolved phase as demonstrated by the default CTR conversion factors. During wet weather, the metals loading are predominately bound to sediment, which are transported with storm runoff. During rain events, partitioning between particulate and dissolved metals often does not reach equilibrium. Municipalities may employ a variety of implementation strategies to meet the required WLAs such as non-structural and structural best management practices, and/or diversion and treatment. Specific projects, which may have a significant impact, would be subject to a separate environmental review. The lead agency for subsequent projects would be obligated to mitigate any impacts they identify, for example by mitigating potential flooding impacts by designing the BMPs with adequate margins of safety.

7.3.1 Non-Structural Best Management Practices

The non-structural best management practices (BMPs) are based on the premise that specific land uses or critical sources can be targeted to achieve the TMDL waste load allocations. Non-structural BMPs provide several advantages over structural BMPs. Non-structural BMPs can typically be implemented in a relatively short period of time. The capital investment required to implement non-structural BMPs is generally less than for structural BMPs. However, the labor costs associated with non-structural BMPs may be higher, therefore, in the long-term the non-structural BMPs may be more costly. Examples of non-structural controls include more frequent and appropriately timed storm drain catch basin cleanings; improved street cleaning by upgrading to vacuum type sweepers; and, educating industries of good housekeeping practices.

Since, dry-weather exceedances appear to be episodic the permittees are encouraged to initially concentrate on source reduction strategies including detection and elimination of illicit discharges, reduction of dry-weather nuisance flows, and increased inspection of industrial facilities. In addition, improved enforcement of BMPs for construction sites and improved detection and elimination of illicit connections to the storm drain system may result in significant reductions in discharges of metal pollutants to Ballona Creek. Special attention should be focused on the source of high lead concentrations entering the Ballona Creek Estuary near Pacific Avenue.

A known source of copper loading is from brake pads. The permittees could sponsor legislative actions with state and federal agencies to pursue the development of alternative materials for brake pads. The use of alternative materials for brake pads would help to reduce the discharge of metals in all watersheds. Just as the phase out of leaded gasoline resulted in the gradual decline of lead concentrations in the environment, a phase out of copper brake linings would also be expected to reduce the amount of copper in storm water runoff.

7.3.2 Structural Best Management Practices

The structural BMPs are based on the premise that specific land uses, critical sources, or specific periods of a storm event can be targeted to achieve the TMDL waste load allocations. Structural BMPs may include placement of storm water treatment devices specifically designed to reduce metals loading such as infiltration trenches or filters at critical points in the storm water conveyance system. During storm events, when flow rates are high these types of filters may require surge control, such as an underground storage vault or detention basin. If these filters are placed in series with the gross solids removal systems being installed to meet the Ballona Creek Trash TMDL, then these filters will operate more efficiently and will require less maintenance. These structural solutions may be designed to capture the runoff from a specific storm period such as the first 0.1 inch or 0.5 inch.

To assist responsible jurisdictions and agencies in identifying potential upstream structural BMPs for targeted land uses or critical areas in the Ballona Creek watershed, an analysis was performed to assess land-use-specific contributions to the total existing metals loading from the watershed. The wet-weather watershed model was used to simulate metals loading from surface runoff from each land use included in the model. Contributions to the total copper, lead, and zinc loads are expressed as percentages in Table 7-1. Relative contributions of loadings from land uses are consistent among the metals. High-density residential areas contributed the highest percentage between 70.8 and 75.8%. This may be due in part because high-density residential accounts for the majority of the land use in the Ballona Creek watershed. The commercial areas also contributed a high loading between 18.8 and 20.2%. The relatively high metals loading from these land uses results from a combination of higher percentage of land use area in the watershed, as well as relatively high loadings rates associated with these land use practices.

Table 7-1. Land use contributions to total metals loads from surface runoff from the Ballona Creek watershed

Land Use	% of Land Use	Copper	Lead	Zinc
Agricultural	0.0%	0.0%	0.0%	0.0%
Commercial	15.8%	18.8%	19.8%	20.2%
High-Density Residential	55.7%	72.0%	75.8%	70.8%
Industrial	5.1%	5.8%	3.1%	8.1%
Low-Density Residential	3.6%	2.8%	1.0%	0.6%
Mixed Urban	0.1%	0.2%	0.1%	0.1%
Open Space	17.1%	0.4%	0.2%	0.1%

The information presented in Table 7-1 provides useful information for watershed planning and design of BMPs. Land use distributions in the watershed can guide planners in determining key locations where metals reductions need to be focused, and can be determined from aerial photography or commonly used GIS data sets, including, but not limited to, data sets from the Southern California Association of Governments (used for this modeling analysis) or the U.S. Geological Survey's Multi-Resolution Land Characteristic.

In addition, the Regional Board encourages the responsible agencies to utilize the results of the "Characterization of Dry Weather Metals and Bacteria Levels in Ballona Creek" (SCCWRP, 2004) study to identify potential structural or non-structural controls for targeted land uses, or critical storm drains.

7.3.3 Diversion and Treatment Strategy

The diversion and treatment strategy includes the installation of facilities to provide capture and storage of dry- and/or wet-weather runoff and diversion of the stored runoff to the wastewater collection system for treatment at the City's Hyperion Treatment Plant (HTP) during low flow conditions at the plant (typically during the early morning hours of 12-6 a.m.), if possible. If diversion to the HTP is not an option, other strategies such as small dedicated runoff treatment facilities such as the Santa Monica Urban Runoff Recycling Facility or alternative BMPs may be implemented to meet the TMDL requirements.

The volume of flow requiring storage and treatment would have to be estimated to size the storage facilities and estimate diversion flow rates, and the affected collection system and treatment capacities to accommodate these diverted flows. These storage and diversion facilities will be sized to accommodate the requisite storage volumes and appropriate rates of diversion to the collection system to avoid overflows. Wet-weather flows beyond the capacities of these facilities will be bypassed, however, a portion of these larger storm events will still be captured and treated, thereby eliminating the metals loading of small storms and reducing those of larger storms. Overflows from these systems could be routed through structural BMPs designed to remove sediment for further reduction of metal loads.

To assist responsible jurisdictions and agencies in determining the optimal volume of flow, analyses were performed to assess relative improvements and benefits associated with capture of storm volumes. The capture of storm volumes reduces the associated metals loads, and therefore reduces the likelihood of exceedances of loading capacities of the receiving waters. These analyses were based primarily on conceptual assumptions and analyses of model results for guidance in future planning.

The initial step in the analyses was the prediction of storm volumes resulting from total amounts of rainfall for each storm. Model-predicted storm volumes (Section 5.2) were compared to total rainfall over the storm periods to determine if relationships could be established. Figures D-1 through D-3 of Appendix D show results of these analyses. For storms with rainfall greater than 0.1 inch, a correlation could be established for Ballona Creek, Sepulveda Canyon Channel, and Centinela Channel for prediction of storm volumes as a function of rainfall. For storms less than 0.1 inch, no correlation was found.

For Ballona Creek, Sepulveda Canyon Channel, and Centinela Channel, storm volumes were predicted for various rainfalls greater than 0.1 inch (using regression equations reported in Figures D-1 through D-3). These volumes were assumed to be equivalent to design volumes for storm capture. For example, capture of 0.1 inch of rainfall in Ballona Creek is equivalent to approximately 44 million gallons of storm volume from the watershed. For each storm predicted over the 10-year modeling period for TMDL analysis, assumed volumes associated with storm capture were subtracted from the total storm volume to simulate varying benefits resulting from different volumes of design. Metals loads associated with these storm captures were estimated using model-predicted event mean concentrations specific to each storm. The results of this analysis can be translated to benefits received from the capture of various amounts of storm volumes in terms of inches of rainfall.

Figures D-4 through D-12 report results of these analyses. For these figures, the "percent exceedance" corresponds to the number of storms exceeding the loading capacity defined for each waterbody and metal in the load duration analyses utilized for TMDL development (Appendix C). This percentage should not be confused with the TMDL percent reductions, which are expressed as reductions in loads rather than number of storms that exceedances were observed. A single storm that an exceedance of the loading capacity is predicted can have a large load associated, which results in a relatively large load reduction required.

In Figures D-4 through D-12, reductions in the percent exceedances were predicted for various magnitudes of storm capture volumes (expressed as inches of rainfall). By increasing the storm volume captured, reductions in the likelihood of exceedances of the loading capacities and corresponding WQOs were determined to be possible. The model suggest that the percent of storms exceeding the allowable loads are reduced to 10% for copper and zinc through the capture of a 0.5 inch storm in Ballona Creek. These analyses are provided as guidance only and are not meant to imply that facilities designed to capture stormwater are necessary to meet the load reductions prescribed in this TMDL. Clearly a combination of approaches will be required utilizing BMPs that result in source reduction and load reduction. Additional studies that evaluate the effect of short duration rainfall intensity (i.e., one-year, one-hour rainfall event) on the mobilization and transport of metals are encouraged and would be useful in designing the flow through design capacity of in-line BMPs.

The value of the facilities installed for this strategy can be realized as part of a long-term integrated water resources strategy by planning for the future use of the collection, storage and transmission facilities to provide stormwater for potential reuse opportunities.

7.4 Implementation Schedule

The proposed implementation schedule shall consist of a phased approach, with compliance to be achieved in prescribed percentages of the watershed, with total compliance to be achieved within 15 years, as summarized in Table 7-2. The dry-weather compliance schedule is more accelerated because the dry-weather exceedances occur infrequently and major structural BMPs are not anticipated. The municipalities and Caltrans are encourage to work together to identify subwatershed areas to be addressed first.

The Regional Board intends to reconsider this TMDL in six years after the effective date of the TMDL to re-evaluate the waste load allocations for Ballona Creek Estuary based on the additional data obtained from the fate and transport study of metals and sediment and the causes of sediment toxicity in Ballona Creek Estuary. Until the TMDL is revised, the waste load allocations will remain as presented in Tables 6-1 and 6-2 and Appendix C. Regional Board staff do not recommend revising the waste load allocations until significant reductions have been achieved. Revising the TMDL will not create a conflict, since full compliance with the dry-weather WLAs and wet-weather WLAs are not required until 10 and 15-years after the effective date, respectively.

Table 7-2. Implementation Schedule

Date	Action
Effective date of the TMDL	NPDES permits, other than the MS4 and Caltrans permits, to incorporate concentration-based WLAs (Tables 6-2 and 6-3) at the time of permit issuance or re-issuance.
120 days after the effective date of the TMDL	Responsible jurisdictions and agencies must submit a coordinated monitoring plan, to be approved by the Executive Officer, which includes both ambient monitoring and compliance assessment monitoring. Once the coordinated monitoring plan is approved by the Executive Officer ambient monitoring shall commence.
12 months after effective date of TMDL (Draft Report) 16 months after effective date of TMDL (Final Report)	Responsible jurisdictions and agencies shall provide a written report to the Regional Board outlining the drainage areas to be address and how these areas will achieve compliance with the waste load allocations. The report shall include implementation methods, an implementation schedule, proposed milestones, and any applicable revisions to the compliance assessment monitoring plan.
6 years after effective date of the TMDLs	The Regional Board shall reconsider this TMDL to re-evaluate the waste load allocations for Ballona Creek Estuary.
6 years after effective date of the TMDL	50% of the total drainage area shall achieve compliance with the dry-weather waste load allocations and 25% of the total drainage area will achieve compliance with the wet-weather waste load allocations.
8 years after effective date of the TMDL	75% of the total drainage area shall achieve compliance with the dry-weather WLAs.
10 years after effective date of the TMDL	100% of the total drainage area shall achieve compliance with the dry-weather WLAs and 50% of the total drainage area will achieve compliance with the wet-weather WLAs.
15 years after effective date of the TMDL	100% of the total drainage area shall achieve compliance with both the dry-weather and wet-weather WLAs.

7.5 Implementation Cost Analysis

This section takes into account a reasonable range of economic factors in estimating potential costs associated with this TMDL in fulfillment of the applicable provisions of the California Environmental Quality Act (Public Resources Code Section 21159.)

This cost analysis focuses on compliance with the grouped waste load allocation by the NPDES regulated storm water permittees in the urbanized portion of the watershed[4]. An evaluation of the costs of implementing this TMDL amounts to evaluating the costs of preventing metals and sediment from entering storm drains and/or reaching the Ballona Creek. Most permittees would likely implement a combination of the structural and non-structural BMPs to achieve compliance with their waste load allocations. This analysis considers a potential strategy combining structural and non-structural BMPs through a phased implementation approach and estimates the costs for this strategy.

In this cost analysis, it is assumed that compliance could be achieved in 30% of the urbanized portion of the watershed through an IRP, compliance in another 30% of the urbanized portion of the watershed could be achieved through various iterations of non-structural BMPs, and/or with

[4] The Ballona Creek watershed is 128 square miles. Open space comprises 17.5 square miles and water comprises 0.75 square miles of the Ballona Creek watershed. The remaining 110 square miles will be considered the urbanized portion of the watershed for the purposes of this TMDL.

BMPs being installed to comply with the Ballona Creek Trash TMDL. It will be important to document reductions in metals loading achieved via BMPs currently being implemented under the Trash TMDL. Compliance with the remaining 40% of the urbanized portion of the watershed could be achieved through structural BMPs.

In addition to achieving compliance with this TMDL, such a strategy could be used to achieve compliance with the Ballona Creek and Wetlands Trash TMDL as well as the upcoming Ballona Creek and Estuary Toxics and Bacteria TMDLs. Therefore, this cost analysis reflects the potential costs of compliance with multiple TMDLs based on likely implementation scenarios.

7.5.1 Phased Implementation

The first step of the potential phased approach would include the implementation of non-structural BMPs by the permittees, such as increasing the frequency and efficiency of street sweeping. In their National Menu of Best Management Practices for Stormwater – Phase II, USEPA reports that conventional mechanical street sweepers can reduce non-point source pollution by 5 to 30% (USEPA, 1999a). The removal efficiencies of sediment for conventional sweepers are dependent on the size of particles. Conventional sweepers, including mechanical broom sweepers and vacuum-assisted wet sweepers, have removal efficiencies of approximately 15 to 50% for particles less than 500 micrometers and up to approximately 65% for larger particles (Walker and Wong, 1999). USEPA reports that vacuum-assisted dry street sweeping can remove significantly more pollution, including fine sediment and metals, before the pollutants are mobilized by rainwater. USEPA reports a 50 to 88% overall reduction in annual sediment loading for residential areas by vacuum-assisted dry street sweepers. Sutherland and Jelen (1997) showed a total removal efficiency of 70% for fine particles and up to 96% for larger particles by vacuum – assisted dry sweepers (also known as small-micron surface sweepers.) Upgrading to vacuum-assisted dry sweeping would translate to a significant reduction of metals in the particulate phase. In their 1999 Preliminary Data Summary of Urban Stormwater Best Management Practices, USEPA estimated cost data for both standard mechanical and vacuum-assisted dry sweepers as shown in Table 7-3.

Table 7-3. Estimated costs for two types of street sweepers. (Source: USEPA, 1999b.)

Sweeper Type	Life (Years)	Purchase Price ($)	O&M Cost ($/curb mile)
Mechanical	5	75,000	30
Vacuum-assisted	8	150,000	15

Table 7-3 illustrates that while the purchase price of vacuum-assisted dry sweepers is higher, the operation and maintenance costs are lower than for standard sweepers. Based on this information, USEPA determined the total annualized cost of operating street sweepers per curb mile, for a variety of frequencies (Table 7-4). In their estimates, USEPA assumed that one sweeper serves 8,160 curb miles during a year and assumed an annual interest rate of 8 percent (USEPA, 1999b). According to Table 7-4, permittees would save money in the long-term by switching to vacuum-assisted dry sweepers.

Table 7-4. Annualized sweeper costs, including purchase price and operation and maintenance costs ($/curb mile/year).

Sweeper Type	Sweeping Frequency					
	Weekly	Bi-weekly	Monthly	Quarterly	Twice per year	Annually
Mechanical	1,680	840	388	129	65	32
Vacuum-Assisted	946	473	218	73	36	18

Under a phased implementation approach, the permittees could monitor compliance using flow-weighted composite sampling of runoff throughout representative storms to determine the effectiveness of this first step of implementing non-structural BMPs. If monitoring showed non-compliance, permittees could adapt their approach by increasing frequency of street sweeping or incorporating other non-structural BMPs.

If compliance could still not be achieved through non-structural BMPs, permittees could incorporate structural BMPs. Two potential structural BMPs were analyzed in this cost analysis:

1. Infiltration trenches
2. Sand filters

Both approaches can be designed to capture and treat 0.5 to 1 inches of runoff. When flow exceeds the design capacity of each device, untreated runoff is allowed to bypass the device and enter the storm drain.

Both infiltration trenches and sand filters must be used in conjunction with some type of pretreatment device such as a biofiltration strip or gross solids removal system to remove sediment and trash in order to increase their efficiency and service life. This combination could be used to achieve compliance with both the Ballona Creek Trash TMDL and the Metals TMDL. The Trash TMDL provided a cost estimate of gross solids removal systems, including structural vortex separation systems and end of pipe nets. This analysis provides an estimate of the additional costs associated with installing sand filters or infiltration trenches.

In addition, both infiltration trenches and sand filters are efficient in removing bacteria and could be used to achieve compliance with the upcoming bacteria TMDL. USEPA reports that sand filters have a 76% removal rate and infiltration trenches have a 90% removal rate for fecal coliform (USEPA National Menu of Best Management Practices for Stormwater - Phase II, USEPA 832-F-99-007, 1999).

As stated previously, it is assumed that 40% of the urbanized portion of the watershed would need to be treated by structural BMPs. In this cost analysis, it was assumed that 20% of the watershed would be treated by infiltration trenches and sand filters would treat the other 20%. Costs were estimated using data provided by USEPA in their 1999 National Menu of Best Management Practices for Stormwater - Phase II and the Federal Highway Administration (FHWA) in their Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring. Where costs were reported as ranges, the highest reported cost was assumed. These costs were then compared to costs determined by Caltrans in their BMP Retrofit Pilot Program (2004).

Infiltration trenches. Infiltration trenches store and slowly filter runoff through the bottom of rock-filled trenches and then through the soil. Infiltration trenches can be designed to treat any amount of runoff, but are ideal for treating small urban drainage areas less than five to ten acres. Soils and topography are limiting factors in design and siting, as soils must have high percolation rates and groundwater must be of adequate depth. Infiltration trenches are reported to achieve 75 to 90% suspended solids removal and 75 to 90% metals removal by USEPA and FHWA. In their BMP Retrofit Pilot Program, Caltrans assumed that constituent removal was 100 percent for storm events less than the design storm, because all runoff would be infiltrated.

Table 7-5 presents estimated costs for infiltration trenches designed to treat 0.5 inches of runoff over a five-acre drainage area with a runoff coefficient equal to one. Staff determined that 2,816 devices, designed to treat five acres each, would be required to treat 20% of the urbanized portion of the watershed.

Table 7-5. Estimated Costs for Infiltration Trenches.

	Construction Costs ($ million)	Maintenance Costs ($ million/year)
Based on USEPA estimate (Brown and Schueler, 1997, SWRPC, 1991)	128	26
Based on FHWA estimate (Young et al., 1996, Schueler, 1987)	122	Not reported

Sand Filters. Sand filters work by a combination of sedimentation and filtration. Runoff is temporarily stored in a pretreatment chamber or sedimentation basin, and then it flows by gravity or is pumped into a sand filter chamber. The filtered runoff is then discharged to a storm drain or natural channel. The costs of two types of sand filters were analyzed: 1) the Delaware sand filter, which is installed underground and suited to treat drainage areas of approximately one acre and 2) the Austin sand filter, which is installed at-grade and suited to larger drainage areas up to 50 acres.

USEPA estimated a 70% removal of total suspended solids and 45% removal of lead and zinc for both types of sand filters. FHWA reported high sediment, zinc and lead removal, but low copper removal for Austin sand filters and high sediment and moderate to high metals removal for Delaware sand filters. Caltrans reported a 50% reduction in total copper, a 7% reduction in dissolved copper, an 87% reduction in total lead, a 40% reduction in dissolved lead, an 80% reduction in total zinc and a 61% reduction in dissolved zinc by the Austin sand filters they tested. Caltrans reported a 66% reduction in total copper, a 40% reduction in dissolved copper, an 85% reduction in total lead, a 31% reduction in dissolved lead, a 92% reduction in total zinc and a 94% reduction in dissolved zinc by the Delaware sand filter they tested.

USEPA and FHWA reported costs per acre for 0.5 inches of runoff. Total costs were calculated by multiplying the per-acre cost by the total acreage of the urbanized portion of the watershed not addressed through an integrated resources plan or non-structural BMPs. Estimated costs are presented in Table 7-6. There are significant economies of scale for Austin filters. USEPA reported that costs per acre decrease with increasing drainage area. FHWA reported two separate costs based on drainage area served. Economies of scale are not a factor for Delaware filters, as they are limited to drainage areas of about one acre.

Table 7-6. Estimated Costs for Austin and Delaware Sand Filters

	Austin Sand Filter Construction Costs ($ million)	Austin Sand Filter Maintenance Costs ($ million/year)	Delaware Sand Filter Construction Costs ($ million)	Delaware Sand Filter Maintenance Costs ($ million/year)
Based on USEPA estimate (1999)	130	7	77	4
Based on FHWA estimate* (Schueler, 1994)	24	Not reported	99	Not reported

*FHWA cost estimate for Austin filter was calculated assuming a drainage area greater than five acres. The costs would be $113 million for Austin filters designed for a drainage area of less than two acres.

Based on the adaptive management approach, and some assumptions about the efficiencies of each stage of the approach, the cost analysis arrived at the total costs for compliance with the Metals TMDL as shown in Table 7-7. The total costs do not include the cost savings associated with switching to vacuum-assisted street sweepers. As stated previously, the costs associated with this adaptive management approach could be applied towards the cost of compliance with the Metals TMDL, and upcoming Toxics and Bacteria TMDLs.

Table 7-7. Total Estimated costs of adaptive management approach.

	Total Construction ($ million)	Total Maintenance ($ million/year)
Based on USEPA estimate (1999)	336	36
Based on FHWA estimate (Schueler, 1994)	245	Not reported

7.5.2 Comparison of Costs Estimates with Caltrans Reported Costs

Estimated costs for structural BMPs were compared to costs reported by Caltrans in their BMP Retrofit Pilot Program (Caltrans, 2004). Caltrans sited five Austin sand filters and one Delaware sand filter as part of their study. The five Austin sand filters served an average area of 2 acres and the Delaware sand filter served an area of 0.7 acres. Caltrans sited two infiltration trench/biofiltration strip combinations as part of their study. Each trench and biofiltration strip used in combination served an area of 1.7 acres. Based on these drainage areas, the average adjusted cost of the Austin sand filters in the Caltrans study was $156,600 per acre, the adjusted cost of the Delaware filter was $310,455 per acre and the average adjusted cost of the infiltration trench/biofiltration strips was $84,495 per acre. These costs are approximately an order of magnitude greater than the costs determined using estimates provided by USEPA and FHWA.

The Caltrans study was subject to a third party review, conducted by Holmes & Narver, Inc. and Glenrose Engineering (Caltrans, 2001). The review compared adjusted Caltrans costs with costs of implementing BMPs by other state transportation agencies and public entities. The adjusted costs exclude costs associated with the unique pilot program and ancillary costs such as improvements to access roads, landscaping or erosion control, and non-BMP related facilities. For the comparison, all costs were adjusted for differences in regional economies. The third party review determined that the median costs reported by Caltrans were higher than the median costs reported by the other agencies for almost every BMP considered, including sand filters and infiltration BMPs. The review attributed the higher Caltrans costs to the small scale and accelerated nature of the pilot program. The third party review then gave recommendations for construction cost reductions based on input from other state agencies. These included simplifying design and material components, combining retrofit work with ongoing construction projects, changing methods used to select and work with construction contractors, allowing for a longer planing horizon, constructing a larger number of BMPs at once, and implementing BMPs over a larger drainage area.

8 MONITORING

The monitoring program has three objectives. The first is to collect additional water quality data (e.g., hardness and background total and dissolved metals concentrations) to evaluate assumptions made in the TMDL, including the frequency and extent of exceedances. The second is to assess compliance with the WLAs. The third is to conduct special studies to address the uncertainties in the TMDL and to assist in the design and sizing of BMPs and stormwater retention facilities.

8.1 Ambient Monitoring

An ambient monitoring program is required to assess water quality throughout Ballona Creek and its tributaries. Data on background water quality will help refine the numeric targets and confirm selenium impairment. At a minimum, ambient monitoring shall be conducted at the locations listed in Table 8-1. Samples shall be shall be analyzed for hardness, and total and dissolved metals at detection limits that are lower than the CTR criteria to determine if water quality objectives are being met.

Table 8-1. Ambient Monitoring Locations

Waterbody	**Ambient Monitoring Location**
Ballona Creek	Sawtelle Boulevard
Sepulveda Canyon Channel	Just Above the Confluence with Ballona Creek
Centinela Channel	Just Above the Confluence with Ballona Creek
Ballona Creek Estuary	Centinela Avenue

8.2 Compliance Assessment Monitoring

At a minimum, compliance will be assessed based on monthly sampling at the ambient monitoring locations listed in Table 8-1 in accordance with the implementation schedule, Table 7-2. The MS4 co-permittees and Caltrans may demonstrate compliance with concentration-based or mass-based WLAs during dry weather. However, reliable flow measurements must be provided if compliance with mass-based WLAs is selected. Data suggest that water quality complies with applicable CTR limits most of the time during dry weather, but episodic exceedances occur. Therefore, analysis of randomly selected discrete samples is preferred over time-weighted composite samples, as compositing may mask short-term episodic exceedances. If compliance is to be demonstrated based on concentration-based WLAs, discrete samples shall be collected every hour during a 24-hour period at each monitoring location. Out of the 24 samples collect for each monitoring location at least four samples shall be randomly selected to be analyzed. All samples collected during the randomly selected time period shall be analyzed for total metals, dissolved metals and hardness. Detection and reporting limits must be below the WLA concentration limit. If analysis indicates that the WLA has been exceeded, samples taken prior to and subsequently shall be analyzed to determine the duration of the exceedance. In addition, an investigation shall be undertaken in an effort to identify the source of the exceedance.

The MS4 and Caltrans stormwater NPDES permittees will be deemed in compliance with the waste load allocations during dry weather if the in-stream pollutant concentrations at the downstream ambient monitoring location is at or less than the corresponding numeric target. Alternatively, compliance with interim compliance targets may be assessed at the storm drain outlet based on the numeric target for the receiving water. For storm drains that discharge to other storm drains, the numeric target will be based on the numeric target for the ultimate receiving water for that storm drain system.

In order to determine compliance with the wet-weather waste load allocations, an in-stream flow meter is required at each of the ambient monitoring locations. At a minimum, during wet weather, the MS4 co-permittees and Caltrans must collect a flow-weighted composite sample for six storm events per storm year[5] or all storm events per year, which ever is less, downstream from the drainage area where compliance is required. For each sampling event, the parties must report the total metals concentrations, the dissolved metals concentration, hardness, total storm volume, calculated total metals load and the total inches of rainfall that fell during the rain event. A storm event is defined as a day that rainfall occurs plus all consecutive days that flow is above base flow; rainfall that occurs following a day of no rainfall, even if flow is still above base flow, is considered a separate storm event. The MS4 and Caltrans stormwater NPDES permittees will be deemed in compliance with the waste load allocations during wet weather if the pollutant load at the downstream monitoring location is at or less then the load capacity as determined from the corresponding load duration curve (Appendix C).

8.3 Special Studies

The implementation schedule (Table 7-2) allows time for special studies that may serve to refine the estimate of loading capacity, waste load allocations, and other studies that may serve to optimize implementation efforts. The Regional Board will re-consider the TMDL in the sixth year after the effective date in light of the findings of these studies. Studies may include:

- Refinement of the hydrologic and water quality models, especially for the estuary
- Additional source assessment
- Refinement of the potency factors correlation between total suspended solids and metals loading during dry and wet weather
- Correlation between short-term rainfall intensity and metals loading for use in sizing in-line structural BMPs
- Correlation between storm volume and total metals loading for use in sizing stormwater retention facilities
- Refined estimates of metals partitioning coefficients, metal translators and site-specific toxicity.

[5] The storm year is defined as November 1st through October 31st.

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