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TOTAL MAXIMUM DAILY LOAD FOR METALS
LOS ANGELES RIVER AND TRIBUTARIES

U.S. Environmental Protection Agency

Region 9

California Regional Water Quality Control Board

Los Angeles Region

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LIST OF TABLES

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LIST OF ACRONYMS

ACF	Acute Conversion Factor
AU	Analytical Unit
BLM	Biotic Ligand Model
BMPs	Best Management Practices
Caltrans	California Department of Transportation
CCC	Criteria Continuos Concentration
CCF	Chronic Conversion Factor
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CMC	Criteria Maximum Concentration
CTR	California Toxics Rule
CWA	Clean Water Act
EFDC1D	Environmental Fluid Dynamics Code 1-D
EMC	Event Mean Concentration
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
GWR	Ground Water Recharge
HSPF	Hydrologic Simulation Program-Fortran
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
LSPC	Loading Simulation Program in C++-
MCLs	Maximum Contaminant Levels
MGD	Million Gallons Per Day
MS4	Municipal Separate Storm Sewer System
MUN	Municipal Supply
NCDC	National Climatic Data Center
NHD	National Hydrography Dataset
NPDES	National Pollutant Discharge Elimination System
POTW	Publicly Owned Wastewater Treatment Works
SCAG	Southern California Association of Governments
SCCWRP	Southern California Coastal Water Research Project
SIP	State Implementation Plan
TMDL	Total Maximum Daily Loads
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VOCs	Volatile Organic Compounds
WASP5	Water Quality Analysis Simulation Program
WDRs	Waste Discharge Requirements
WER	Water Effect Ratio
WLA	Waste Load Allocation

WMP	Watershed Monitoring Program
WQBELs	Water Quality Based Effluent Limits
WQOs	Water Quality Objectives
WRPs	Water Reclamation Plants

1. INTRODUCTION

Segments of the Los Angeles River and its tributaries (Figure 1) exceed water quality objectives for a variety of metals. These segments (*i.e.,* reaches) of the Los Angeles River and tributaries are included on the California 303(d) list of impaired waterbodies (LARWQCB, 1998a and 2002). The Clean Water Act requires a Total Maximum Daily Load (TMDL) be developed to restore the impaired waterbodies, including the Los Angeles River, to its full beneficial uses. Table 1-1 summarizes the stream reaches of the Los Angeles River watershed included on the California 303(d) list for metals.

Table 1-1. Segments of the Los Angeles River and tributaries listed as impaired for metals (LARWQCB, 1998a and 2002)

Listed Waterbody Segment	Copper	Cadmium	Lead	Zinc	Aluminum	Selenium
Aliso Canyon Wash						X
Dry Canyon Creek						N
McCoy Canyon Creek						N
Monrovia Canyon Creek			X			
Los Angeles River Reach 4 (Sepulveda Dam to Riverside Dr.)			X			
Tujunga Wash (from Hansen Dam to Los Angeles River)	X					
Burbank Western Channel		X				
Los Angeles River Reach 2 (from Figueroa St. to Carson St.)			X			
Rio Hondo Reach 1 (from the Santa Ana Fwy to Los Angeles River)	X		X	X		
Compton Creek	X		X			
Los Angeles River Reach 1 (from Carson St. to estuary)	N	N	X	N	N	

X: listed as impaired in 1998 303(d) list and part of analytical unit 13. N: New waterbody listing based on 2002 303(d) list, not part of analytical unit 13

This TMDL complies with 40 CFR 130.2 and 130.7, Section 303(d) of the Clean Water Act and U.S. Environmental Protection Agency (EPA) guidance for developing TMDLs in California (USEPA, 2000a). This document summarizes the information used by the EPA and the California Regional Water Quality Control Board, Los Angeles Region (Regional Board) to develop TMDLs and allocations for metals. The California Water Code (Porter-Cologne Water Quality Control Act) requires that an implementation plan be developed to achieve water quality objectives. Figure 1 shows the waterbodies addressed in this TMDL.

1.1. Regulatory Background

Section 303(d) of the Clean Water Act (CWA) requires that each State "shall identify those waters within its boundaries for which the effluent limitations are not stringent enough to implement any water quality objective applicable to such waters." The CWA also requires states to establish a priority ranking for waters on the 303(d) list of impaired waters and to 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 U.S. Environmental Protection Agency 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, 2000a).

The Regional Board identified over 700 waterbody-pollutant combinations in the Los Angeles Region requiring TMDLs (LARWCQB, 1996, 1998a). These are referred to as "listed" or "303(d) listed" waterbodies or waterbody segments. A schedule for development of TMDLs in the Los Angeles Region was established in a consent decree (Consent Decree) approved on March 22, 1999 (Heal the Bay Inc., et al. v. Browner, C 98-4825 SBA). For the purpose of scheduling TMDL development, the decree combined the more than 700 waterbody-pollutant combinations into 92 TMDL analytical units. The 303(d) list was updated in 2002. These updates and changes are not reflected in the Consent Decree.

This TMDL addresses Analytical Unit (AU) #13 of the Consent Decree which consists of segments of the Los Angeles River and tributaries with impairments by metals (cadmium, copper, lead, selenium, and zinc). Table 1-1 identifies the listed waterbodies by the metals causing impairments. The Consent Decree schedule requires that this TMDL be completed by March 22, 2004. If the Regional Board fails to develop the TMDL, EPA must promulgate the TMDL by March 22, 2005. The 2002 303(d) listings approved in 2003 are not required to be addressed per the Consent Decree; however, where appropriate, this TMDL addresses those listings as well.

This report presents the TMDLs for metals and summarizes the analyses performed by EPA and the Regional Board to develop this TMDL. This report does not address the metals TMDLs required for four lakes in the Los Angeles River watershed as part of Analytical Unit #20. These four lakes (Lake Calabasas, Echo Lake, Lincoln Park Lake and Peck Road Lake) are not hydrologically connected to the Los Angeles River or the listed tributaries. The TMDLs for these lakes are not scheduled in the Consent Decree but must be established by March 22, 2012. This report does not address metals impairments for Los Angeles Harbor or San Pedro Bay required under Analytical Units #75 and #78, respectively. These TMDLs have not been specifically scheduled in the Consent Decree, but are required to be completed by 2012

1.2 Environmental Setting

The Los Angeles River flows for 55 miles from the Santa Monica Mountains at the western end of the San Fernando Valley to Queensway Bay located between the Port of Long Beach and the City of Long Beach. It drains a watershed with an area of 834 square miles. Approximately 44% of the watershed area can be classified as forest or open space. These areas are primarily within the headwaters of the Los Angeles River in the Santa Monica, Santa Susana, and San Gabriel Mountains, including the Angeles National Forest, which comprises 250 square miles of the watershed. Approximately 36% of the land use can be categorized as residential, 10% as industrial, 8% as commercial, and 3% as agriculture, water and other. The more urban uses are found in the lower portions of the watershed.

The natural hydrology of the Los Angeles River Watershed has been altered by channelization and the construction of dams and flood control reservoirs. The Los Angeles River and many of its tributaries are lined with concrete for most or all of their lengths. Soft-bottomed segments of the Los Angeles River occur where groundwater upwelling prevented armoring of the river bottom. These areas typically support riparian habitat.

The mainstem of the Los Angeles River begins by definition at the confluence of Arroyo Calabasas (which drains the northeastern portion of the Santa Monica Mountains) and Bell Creek (which drains the Simi Hills). McCoy Canyon Creek and Dry Canyon Creek (listed for selenium) are tributary to Arroyo Calabasas. The river flows east from its origin along the southern edge of the San Fernando Valley. The Los Angeles River also receives flow from Browns Canyon, Aliso Canyon Wash (listed for selenium) and Bull Creek which drain the Santa Susana Mountains. The lower portions of Arroyo Calabasas and Bell Creek are channelized. Browns Canyon, Aliso Creek and Bull Creek are completely channelized.

Reach 5 of the Los Angeles River runs through Sepulveda Basin. There are no listings for metals in Reach 5 of the Los Angeles River. The Sepulveda Basin is a 2,150-acre open space designed to collect floodwaters during major storms. Because the area is periodically inundated, it remains in natural or semi-natural conditions and supports a variety of low-intensity land uses. The D.C. Tillman Wastewater Reclamation Plant (WRP), a publicly owned wastewater treatment works (POTW) operated by the City of Los Angeles, discharges to Reach 5 indirectly via two lakes in the Sepulveda Basin that are used for recreation and wildlife habitat. The POTW has a treatment design capacity of 80 million gallons per day (mgd) and contributes a substantial flow to the Los Angeles River. Most of the POTW flow discharges directly to Reach 4 of the Los Angeles River just below the Sepulveda Dam.

Reach 4 of the Los Angeles River runs from Sepulveda Dam to Riverside Drive. This section of the river is listed for lead. Pacoima Wash and Tujunga Wash are the two main tributaries to this reach. Both tributaries drain portions of the Angeles National Forest in the San Gabriel Mountains. Pacoima Wash is channelized below Lopez Dam to the Los Angeles River. Tujunga Wash (listed for copper) is channelized for the 10-mile reach below Hansen Dam. Some of the discharge from Hansen Dam is diverted to spreading grounds for groundwater recharge, but most of the flow enters the channelized portion of the stream.

Reach 3 of the Los Angeles River, which runs from Riverside Drive to Figueroa Street, is not listed for metals. The two major tributaries to this reach are the Burbank Western Channel and Verdugo which drain the Verdugo Mountains. Both tributaries are channelized. The Western Channel receives flow from the Burbank Water Reclamation Plant, a POTW with a design capacity of 9 mgd. The Burbank Western Channel is listed for cadmium.

At the eastern end of the San Fernando Valley, the Los Angeles River turns south around the Hollywood Hills and flows through Griffith Park and Elysian Park in an area known as the Glendale Narrows. This area is fed by natural springs during periods of high groundwater. The river is channelized and the sides are lined with concrete. The river bottom in this area is unlined because the water table is high and groundwater routinely discharges into the channel, in varying volumes depending on the height of the water table. The Los Angeles-Glendale Water Reclamation Plant, operated by the City of Los Angeles, has a design capacity of 20 mgd and discharges to the Los Angeles River in the Glendale Narrows.

Reach 2 of the Los Angeles River, which runs from Figueroa Street to Carson Street, is listed for lead. The first major tributary below the Glendale Narrows is the Arroyo Seco, which drains areas of Pasadena and portions of the Angeles National Forest in the San Gabriel Mountains. In wet periods, rising stream flows in the Los Angeles River above Arroyo Seco have been related to the increase of rising groundwater. There is up to 3,000 acre-feet of recharge from the Pollock Well Field area that adds to the rising groundwater. For the 2000-01 water year, the total rising groundwater flow was estimated at 3,900 acre-feet (ULARA Watermaster Report, 2000-2001 Water Year, May 2002).

The next major tributary is the Rio Hondo. The Rio Hondo and its tributaries drain a large area in the western portion of the watershed. Flow in the Rio Hondo is managed by the Los Angeles County Department of Public Works (LACDPW). At Whittier Narrows, flow from the Rio Hondo can be diverted to the Rio Hondo Spreading Grounds. During dry weather, virtually all the water in the Rio Hondo goes to groundwater recharge, so little or no flow exits the spreading grounds to Reach 1 of the Rio Hondo. During storm events, Rio Hondo flow that is not used for spreading, reaches the Los Angeles River. This flow is comprised of both storm water and treated wastewater effluent from the Whittier Narrows Water Reclamation Plant. Reach 1 of the Rio Hondo is listed for copper, lead, and zinc. Monrovia Canyon Creek is also listed for lead. This creek, located in the foothills of the San Gabriel Mountains in the National Forest, is a tributary to Sawpit Creek which runs into Peck Lake and ultimately to Rio Hondo Reach 2 above the spreading grounds.

Reach 1 of the Los Angeles River, which runs from Carson Street to the estuary, was listed for lead in 1998. Listings for aluminum, copper, cadmium, and zinc were added in 2002 based on exceedances of standards in storm water samples. Compton Creek (listed for copper and cadmium) is the last large tributary to the system before the river enters the estuary. The creek is channelized for most of its 8.5 mile length.

The tidal portion of the Los Angeles River begins at Willow Street and runs approximately three miles before joining with Queensway Bay located between the Port of Long Beach and the City of Long Beach. In this reach, the channel has a soft bottom with concrete-lined sides. Sandbars accumulate in the portion of the river where tidal influence is limited.

During dry weather, most of the flow in the Los Angeles River is comprised of wastewater effluent from the Tillman, Los Angeles-Glendale and Burbank treatment plants. In the dry season, POTW mean monthly discharges totaled 70% to 100% of the monthly average flow in the river. The median daily flow in the Los Angeles River is 94 mgd (145 cfs), based on flows measured at the LACDPW Wardlow station over a 12-year period (October 1998 through December 2000). During wet weather, the river's flow may increase by two to three orders of magnitude due to storm water runoff. Average daily flows greater than 322 mgd (501 cfs) were observed 10% of the time. In months with rain events, POTW monthly average discharges together were less than 20% of the monthly average flow in the river.

The high flows in the wet season originate as storm runoff both from the areas of undeveloped open space in the mountains of the tributaries' headwaters and from the urban land uses in the flat low-lying areas of the watershed. Rainfall in the headwaters flows rapidly because the watershed and stream channels for the most part are steep. In the urban areas, about 5,000 miles of storm drains in the watershed convey storm water flows and urban runoff to the Los Angeles River. The watershed produces storm flow in the river with a sharply peaked hydrograph where flow increases quite rapidly after the beginning of rain events in the watershed, and declines rapidly after rainfall ceases. The Los Angeles River metals TMDL therefore should account for differences in both flow and the relative contributions of pollutant sources between wet and dry periods.

1.3. Elements of a TMDL

Guidance from USEPA (2002a) 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 elements are:

- 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, in summary, 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 estimate of current metals loadings from point sources and non-point sources into the Los Angeles River.

- Section 5: Linkage Analysis. This analysis shows how the sources of metals compounds 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: TMDL and Pollutant Allocation. This section identifies the total allowable loads that can be discharged without causing water quality exceedances. Each pollutant source is allocated a quantitative load of metals that it can discharge without exceeding 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 attain water quality standards at all times.

- Section 7: Implementation. This section describes the plans, regulatory tools, or other mechanisms by which the waste load allocations and load allocations are to be achieved.

- 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 the TMDL has not succeeded in removing the impairments, then revised allocations will be developed. It also describes special studies to address uncertainties in assumptions made in the development of this TMDL and the process by which new information may be used to refine the TMDL.

2. PROBLEM IDENTIFICATION

This section provides an overview of water quality standards for the Los Angeles River and reviews water quality data used in the 1998 water quality assessment, the 2002 303(d) listing and any additional data which may be pertinent to the assessment of condition.

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, beneficial uses are defined by the Regional Water Quality Control Boards (Regional Boards) in the Water Quality Control Plans (Basin Plans). Numeric and narrative objectives are specified in each region's Basin Plan. These are designed to be protective of the beneficial uses in each waterbody in the region 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 Region (1994) defines 13 beneficial uses for the Los Angeles River. These uses are summarized in Table 2-1. The Basin Plan (1994) identifies beneficial uses as existing (E), potential (P), or intermittent (I) uses. Those uses that are most likely to be impacted by metals loadings to the Los Angeles River are the beneficial uses associated with aquatic life (i.e., wildlife habitat, warm freshwater water habitat, rare threatened or endangered species, wetland habitat, and marine habitat) and water supply (i.e., groundwater recharge).

Existing use designations for warm freshwater, wildlife, wetland, and rare, threatened or endangered species habitats (WARM, WILD, WET, and RARE) apply over much of the mainstem and Compton Creek in the lower part of the watershed. The WARM designation applies as either an intermittent or potential use to the remaining listed tributaries. The WILD designation is for the protection of fish and wildlife. This use applies to much of the mainstem of the Los Angeles River, as an intermittent use in Rio Hondo, and as potential use in the remainder of the tributaries. Water quality objectives developed for the protection of fish and wildlife are applicable to the reaches with the WARM, WILD, WET and RARE designations.

Table 2-1. Beneficial uses in listed reaches of the Los Angeles River (LARWQCB, 1994)

STREAM REACH	MUN	GWR	REC1	REC2	WILD	WARM	SHELL	RARE	MIGR	SPWN	WET	MAR	IND	PROC
Aliso Canyon Wash	P*	I	I[1]	I	E	I								
Dry Canyon Creek	P*	I	I[1]	I	E	I								
McCoy Canyon Creek	P*	I	I	I	E	I								
Monrovia Canyon Creek	I	I	I	I	E	I					E			
Los Angeles River (Reach 4)	P*	E	E	E	E	E					E		P	
Tujunga Wash	P*	I	P[1]	I	P	P								
Burbank Western Channel	P*		P[1]	I	P	P								
Los Angeles River (Reach 2)	P*	E	E[1]	E	P	E							P	
Rio Hondo (Reach 1)	P*	I	P[1]	E	I	P								
Compton Creek	P*	E	E[1]	E	E	E					E			
Los Angeles River (Reach 1)	P*	E	E[1]	E	E	E	P[1]	E	P	P		E	P	P

*Municipal designations marked with an asterisk are conditional.
E: Existing beneficial use, P: Potential beneficial use, I: Intermittent beneficial use, 1: Use restricted by LACDPW

The municipal supply (MUN) use designation applies to several tributaries to the Los Angeles River and all groundwater in the Los Angeles River watershed. Other waterbodies within Region 4 also have a conditional designation for MUN. These waterbodies are indicated with an asterisk in the Basin Plan. Conditional designations are not recognized under federal law and are not water quality standards requiring TMDL development at this time. (See Letter from Alexis Strauss [USEPA] to Celeste Cantú [State Board], Feb. 15, 2002.) The ground water recharge (GWR) use designation applies to the Los Angeles River and its tributaries as either an existing or intermittent beneficial use.

2.1.2 Water Quality Objectives (WQOs). Narrative water quality objectives are specified by the 1994 Regional Board Basin Plan. The following two narrative standards 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 substances shall not be present at levels that will bioaccumulate in aquatic life resources to levels which are harmful to aquatic life or human health.

All waters shall be maintained free of toxic substance in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.

Numeric water quality objectives for several pollutants addressed in this TMDL were promulgated by EPA in 2000 in the California Toxics Rule (CTR). The listed pollutants covered by CTR objectives include selenium, cadmium, copper, lead, and zinc (Table 2-2). The selenium and cadmium objectives were established contingent on an EPA commitment to revise the objectives to better protect wildlife. The freshwater CTR values for cadmium, copper, lead, and zinc are based on the dissolved fraction and are hardness dependent (USEPA 2000a). The freshwater CTR standard for selenium is based on the total recoverable metals concentration.

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.

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 ($CaCO_3$). 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.

Table 2-2. Water quality objectives established in CTR. Values in table are based on a hardness value of 100 mg/L as calcium carbonate. Metals values reported as µg/L.

Metal	Freshwater Chronic	Freshwater Acute
Cadmium (dissolved)	2.2	4.3
Copper (dissolved)	9	13
Lead (dissolved)	2.5	65
Selenium (total recoverable metals)	5	Reserved
Zinc (dissolved)	120	120

The formula for calculating the acute and chronic objectives for cadmium, copper, lead, and zinc in the CTR take the form of the following equations:

$$CMC = WER * ACF * EXP[(m_a)(\ln(hardness)+b_a] \quad (1)$$
$$CCC = WER * CCF * EXP[(m_c)(\ln(hardness)+b_c] \quad (2)$$

Where:

CMC = Criteria maximum concentration
CCC – Criteria continuous concentration
WER = Water Effects Ratio (assumed to be 1)
ACF = Acute conversion factor (to convert from the total recoverable metals concentration to the dissolved fraction)
CCF = Chronic conversion factor (to convert from the total recoverable metals concentration 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 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 correlation 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 the Los Angeles River. Therefore, a WER default value of 1.0 is assumed.

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

$$\text{Cadmium ACF} = 1.136672 - [(\ln\{hardness\})(0.041838)] \quad (3)$$
$$\text{Cadmium CCF} = 1.101672 - [(\ln\{hardness\})(0.041838)] \quad (4)$$
$$\text{Lead ACF} = 1.46203 - [(\ln\{hardness\})(0.145712)] \quad (5)$$
$$\text{Lead CCF} = 1.46203 - [(\ln\{hardness\})(0.145712)] \quad (6)$$

Table 2-3. Coefficients used in formulas for calculating CTR standards

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*	1.2730	-1.460	0.791*	1.2730	-4.705
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

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 is designed to achieve compliance with existing water quality standards.

2.2 Water Quality Data Review

This review section summarizes water quality data used to develop this TMDL. The summary includes data considered by the Regional Board and EPA in developing the 1998 and the 2002 303(d) listings for metals and additional data submitted by the City of Los Angeles, the City of Burbank and the County of Los Angeles.

The receiving water data collected by the City of Los Angeles and the City of Burbank as part of NPDES monitoring requirements for D.C. Tillman WR, the Los Angeles-Glendale WRP, and the Burbank WRP were reviewed to evaluate dry-weather conditions. The City of Los Angeles measures metals and hardness in receiving waters from several locations upstream and downstream of its treatment plants (Figure 1) on a quarterly basis. The data from the Tillman and Glendale receiving water stations represent six locations sampled from February 1998 to November 2002. The City of Burbank samples water quality in the Burbank Western Channel on a quarterly basis. The data from the Burbank WRP represent four stations sampled from November 1998 to December, 2003. Data from these programs were compared to the hardness adjusted dissolved criteria in the CTR using the hardness value for each sample. As both agencies analyze for concentrations of total recoverable metals, the comparison of their data to the dissolved criteria provides a conservative assessment of water quality impairment. These NPDES monitoring programs provide water quality information for Reaches 3, 4 and 5 of the Los Angeles River and the Burbank Western Channel, the results of which are summarized in Tables 2-4 and 2-5.

Table 2-4. Summary of dry-weather chronic metals criteria exceedences. Values in table reflect number of samples exceeding the chronic criteria over the total number of samples (Values below detection levels counted as zero). Source: City of Los Angeles and City of Burbank WRP NPDES monitoring

Metals by Reach	LA River Reach 5	LA River Reach 4	LA River Reach 3	Burbank Western Channel
Cadmium	0/16	0/36	0/54	1/96
Copper	1/17	18/34	6/51	41/96
Lead	2/17	12/34	6/48	2/96
Zinc	0/17	0/34	0/51	1/96

Table 2-5. Summary of dry-weather acute metals criteria exceedences. Values in table reflect number of samples exceeding the acute criteria over the total number of samples (Values below detection levels counted as zero). Source: ambient water quality data from NPDES monitoring programs for total recoverable metals.

Metals by Reach	LA River Reach 5	LA River Reach 4	LA River Reach 3	Burbank Western Channel
Cadmium	0/16	0/34	0/42	0/96
Copper	0/18	4/36	0/51	10/96
Lead	0/17	0/34	0/48	0/96
Zinc	0/17	0/34	0/51	1/96

In January 2002, the City of Los Angeles began their Watershed Monitoring Program (WMP) which involves the monthly collection of water quality data at eight stations along the Los Angeles River (Figure 2). In this program, water quality samples are analyzed for both total recoverable and dissolved metals at eight stations along the entire length of the River. The data that were assessed were collected through May 2003, which included 17 samples collected at each station. These data provide information on spatial variability in water quality in all six reaches of the Los Angeles River (Figures 3a-3d) but cannot be used to assess compliance with CTR criteria because hardness data were not collected.

We also evaluated the results of storm water data collected by LACDPW as part of the NPDES municipal storm water permit monitoring requirements. The LACDPW has been sampling approximately five storms per year at the Wardlow gage station since 1996. LACDPW samples hardness and metals (both dissolved and total) from composite storm water samples. The results of these data are summarized in Table 2-6.

Table 2-6. Summary of wet-weather accute and chronic metals criteria exceedences. Values in table reflect number of samples exceeding the criteria over the total number of samples (Values below detection levels counted as zero). Source: NPDES MS4 Monitoring at LACDPW Wardlow station between 1996 and 2002.

Metal	# >Detection Level	Number > Chronic Criteria	Number > Acute Criteria
Cadmium (dissolved)	3/42	3/42	3/42
Copper (dissolved)	32/42	19/42	13/42
Lead (dissolved)	11/42	11/42	4/42
Selenium-(total)	1/42	NA	0/42
Zinc (dissolved)	18/42	6/42	6/42

2.2.1. Summary of Results

Cadmium – The Burbank Western Channel and Reach 1 of the Los Angeles River (from Carson Street to the estuary) are listed for cadmium. Cadmium was detected in only 1 of 96 samples in any of the samples from Burbank Western Channel. A large number of samples, the reported detection limits were greater than the chronic criteria. The most recent data has detection limits that are below the chronic criteria. Cadmium was detected in 3 out of 42 storm water samples collected at Los Angeles River Reach 1 (Table 2-6). All three samples exceeded both the chronic and acute criteria. There were no exceedances of cadmium in Reaches 5, 4 or 3 of Los Angeles River based on data collected by the City.

In summary, there is no evidence that cadmium is being exceeded in Burbank Western Channel or any other reach during dry weather. There are occasional exceedances of the cadmium standard in storm water samples.

Copper – The listings for copper are in Tujunga Wash, Rio Hondo (Reach 1), and Compton Creek. There are no new data on copper concentrations in these reaches. In the 2002 303(d) list, a copper listing was added for Reach 1 of the Los Angeles River based on storm water data. Copper was detected in 32 out of 42 storm water samples, 19 samples exceeded the chronic criteria and 13 samples exceeded the acute criteria. The data from the POTWs (Table 5 and 6) indicate that there are exceedances of both the chronic and acute criteria in the Los Angeles River (Reaches 3, 4 and 5) and in the Burbank Western Channel.

In summary, TMDLs are required for Tujunga, Rio Hondo, Tujunga, and LA Reach 1. Data also indicates need to address impairments in Reach 4 and 3 of the LA River downstream of the treatment plants. Copper loadings from these reaches contribute to the downstream reaches.

Lead – The lead listings are for Monrovia Canyon Creek, Rio Hondo (Reach 1), Compton Creek, and the Los Angeles River (Reaches 4, 2 and 1). There no new data for Monrovia Canyon, Rio Hondo or Compton Creek.

A review of the dry-weather data for the Los Angeles River indicates occasional exceedances of the chronic standard in Los Angeles River (Reaches 3, 4, and 5) and Burbank Western Channel (Table 5). The reported detection limits for lead in many of the samples from the Burbank Western Channel were higher than the chronic standard, complicating the assessment for 38 out of 96 of the samples. High detection levels were not an issue in comparing reported data with the acute standard (Table 6). There were no exceedances of the acute standard in samples from the Burbank Western Channel or Reaches 3, 4 or 5 of the Los Angeles River. There were exceedances of both the acute and chronic standard in Reach 1 of the Los Angeles River during storms (Table 7). Of the 11 samples with lead concentrations greater than the detection limit, 11 samples exceeded the chronic criteria and 4 samples exceeded the acute criteria.

Zinc – The Rio Hondo is listed for zinc. There are no new data for the Rio Hondo. In 2002, a listing for dissolved zinc was added for Reach 1 of the Los Angeles River, based on the LACDPW storm water data. There do appear to be some exceedances of the zinc standard in during storms (Table 7). Of the 18 samples with zinc concentrations greater than the detection limit, 6 samples exceeded the chronic and acute criteria. There do not appear to be any exceedances of the acute or chronic zinc criteria in Reaches 3, 4 and 5 of the Los Angeles River (Tables 5 and 6). There was one incidence of elevated zinc in the Burbank Western Channel.

With the possible exception of Rio Hondo, there are no dry-weather impairments associated with zinc. Zinc occasionally exceeds the acute criteria in storm water samples.

Aluminum – This is not part of analytical unit #13, but aluminum was added in 2002 based on LACDPW storm water data. The total aluminum value was compared to the maximum contaminant level (MCL) of 1 mg/L. The MCL was exceeded in only 2 out of 26 storm water samples collected since the year 2000. Although the MCL has been incorporated into the Basin Plan to protect the MUN beneficial use, conditional designations are not recognized under federal law and are not water quality standards requiring TMDL development at this time. (See Letter from Alexis Strauss [USEPA] to Celeste Cantú [State Board], Feb. 15, 2002.)

Selenium – Aliso Canyon Wash was listed for selenium on the 1998 303(d) list. In 2002, two more tributaries (McCoy Canyon Creek and Dry Canyon Creek) were listed for selenium. We analyzed selenium data collected by the City of Calabasas on a monthly basis between July 2000 and July 2002 as part of a 319h grant provided by the Regional Board. At the two stations in McCoy Canyon Creek, the CTR value of 5 µg/l was exceeded in 27 out of 29 samples. The maximum measured value was 44 µg/l. The selenium values were lower at the two Dry Canyon Creek stations. At these stations, values greater than 5 µg/l were observed in 12 out of 54 samples. We also assessed selenium data collected by the City of Los Angeles at eight stations along the Los Angeles River in 2002 and 2003 as part of their Watershed Monitoring Program. Selenium values greater than 5 µg/l were observed in 14 out of 136 samples. All of these were from the Los Angeles River Reach 6 (where 14 out of 17 exceeded the CTR value). None of the other samples from any of the downstream stations on the Los Angeles River exceeded the CTR value. The selenium issue seems to be confined to the upper reaches of the watershed and tributaries draining to Reach 6. Because much of the area is open space and there is little industrial activity, we believe that the selenium in the waterbody originates from natural sources such as marine shales (EDAW, 2003). A concentration-based load allocation is therefore being assigned to Reach 6 and its tributaries.

Conclusions. Our review of the data indicates that there are occasional exceedances of copper and lead during dry-weather conditions. A single exceedance for cadmium was identified in the Burbank Western Channel during dry weather. There are also occasional exceedances of CTR criteria in storm water for copper, lead and to a lesser extent for zinc and cadmium. High selenium values were only observed in the dry-weather at stations located in the upper portion of the watershed, which we believe are associated with natural sources. Finally, we find that a TMDL for aluminum is not warranted to protect a conditional use.

Dry-weather TMDLs will be developed for the following pollutant waterbody combinations:

Copper for the Los Angeles River and tributaries which drain to the river
Lead for the Los Angeles River, tributaries which drain to the river and Monrovia Canyon Creek
Zinc for Rio Hondo Reach 1
Selenium for Aliso Creek, Dry Canyon Creek, McCoy Canyon Creek and other tributaries which drain to Reach 6 of the Los Angeles River

Wet-weather TMDLs will be developed for cadmium, copper, lead and zinc

Table 2-7. Summary of data review

Listed Waterbody Segment	Cadmium	Copper	Lead	Zinc	Aluminum	Selenium
Aliso Canyon Wash						No new data
Dry Canyon Creek						93%
McCoy Canyon Creek						22%
Los Angeles River Reach 6						10%
Los Angeles River Reach 5	0%	6%	12%	0%		
Los Angeles River Reach 4 (Sepulveda Dam to Riverside Dr.)	0%	53%	35%	0%		
Tujunga Wash (from Hansen Dam to Los Angeles River)	No new data					
Burbank Western Channel	1%	4%	2%			
Los Angeles River Reach 3	0%	12%	13%			
Los Angeles River Reach 2 (from Figueroa St. to Carson St.)			No new data			
Monrovia Canyon Creek			No new data			
Rio Hondo Reach 1 (from the Santa Ana Fwy to Los Angeles River)	No new data		No new data	No new data		
Compton Creek	No new data		No new data			
Los Angeles River Reach 1 (from Carson St. to estuary)			No new data			
Listed Waterbody Segment (Wet)	**Cadmium**	**Copper**	**Lead**	**Zinc**	**Aluminum**	**Selenium**
Los Angeles River Reach 1 (from Carson St. to estuary)	7%	31%	10%	14%	8%	0%

3. NUMERIC TARGETS

Numeric targets for the TMDL have been calculated based on the numeric standards in the CTR. The TMDL targets are expressed in terms of total recoverable to address the potential for transformation between the total and the dissolved metals fraction.

Separate targets were developed for dry and wet weather because hardness values and flow conditions in the Los Angeles River and tributaries vary between the dry and wet weather. In this TMDL, dry-weather targets were based on chronic criteria. Wet-weather targets were developed for storm conditions based on acute criteria because it would be inappropriate to apply criteria based on long-term exposure (4-days) to storms which are generally short-term and episodic in nature. Another reason for developing distinct targets dry and wet-weather conditions is to account for differences, such as hardness or differences in fractionation between dissolved and total recoverable metals, which may affect the numeric target. The wet-weather storm condition is operationally applied when storm volumes are greater than 500 cfs at the LA River Wardlow Station. The 500 cfs value represents the 90th percentile flow of average daily flow at that station (1998 – 2000). The dry-weather targets apply to conditions when storm volume in the River is less than 500 cfs.

3.1. Dry-Weather Targets

Dry-weather numeric targets are developed for copper and lead for all reaches of the Los Angeles River and for tributaries feeding into the Los Angeles River. Dry-weather targets are also developed for lead in Monrovia Canyon Creek, Zinc in the Rio Hondo, and selenium for Los Angeles River Reach 6 and its tributaries.

The dry-weather targets for copper, lead and zinc are dependent on hardness and metals translators. Hardness data for Burbank Western Channel and Reaches 3,4,5 of the LA River was obtained from NPDES ambient monitoring data collected by the three POTWs in the ambient water upstream and downstream of the plants. Additional hardness data for the LA River upstream and downstream of the Tillman and Glendale plants came from a special study to develop site-specific translators for copper upstream (LWA, 2004).

Information on Reaches 1 and 2 of the Los Angeles River and the listed tributaries was obtained from the LACDPW which had dry-weather hardness data from samples collected between 1988 and 1995 for the entire river. To assess the comparability of these older data, we compared the historic hardness data associated with Reaches 4 and 3 collected by LACDPW with the more recent data collected by the Tillman and Glendale POTWs in these same reaches. The results from the two data sets were extremely close (within 10 mg/), suggesting that the older data from 1988 to 1995 are comparable to the newer data and therefore appropriate for setting numeric targets. Dry-weather hardness data are presented in Table 3-1. Hardness values were not available for the Arroyo Seco, Verdugo Wash or the Tujunga Wash.

Table 3-1. Summary of dry-weather reach-specific hardness data (mg/L as CaCO3) for Los Angeles River and listed tributaries.

River Reach	Number of measurements	10th Percentile	Median	90th Percentile
LA River Reach 5. Above Tillman (Station LAR-9)	40	608	702	832
LA River Reach 4. Below Tillman (Stations LAR-7 and LAR-8)	69	196	246	400
LA River Reach 3. Above Glendale (Station LAG-7)	17	232	282	330
LA River Reach 3. Below Glendale (Stations LAG-4, and LAG-5)	69	242	278	322
Western Channel Above Burbank (Station 1)	41	272	326	395
Western Channel Below Burbank (Stations 1.5, 2 and 5)	61	197	229	275
LA River Reach 2	83	221	268	322
Rio Hondo Reach 1	74	111	141	199
LA River Reach 1	82	219	282	340
Compton Creek	65	148	225	296
Monrovia Canyon Creek	81	182	209	239

The target for the chronic criteria was based on the 50th percentile of the hardness data for each reach. This is consistent with the Policy for Implementation of Toxics Objectives for Inland Surface Waters, Enclosed Bays, and Estuaries, or SIP, (SWRCB, 2000). Targets for Tujunga Wash, Verdugo Wash and Arroyo Seco were based on hardness values in the Los Angeles River Reaches 4, 3 and 2, respectively. Targets for Reach 6 and Bell Creek were based on hardness values for Reach 5. [NOTE: The City of Downey questioned the hardness values used for Rio Hondo. The source water to these reaches provided by the City of Commerce, Downey, Montebello, Pico Rivera, South Gate has hardness values that average around 242 mg/l].

Table 3-2. Dry-weather numeric targets (ug/l). Reach-specific targets based on chronic criteria and 50th percentile hardness. Conversion of dissolved to total recoverable based on default conversion factors or site specific translators.

Los Angeles River	Dissolved Copper	CCF	Total recoverable Copper	Dissolved Lead	CCF	Total recoverable Lead
LA Reach 6	29	0.96	30	11	0.51	22
LA Reach 5 above Tillman	29	0.96	30	11	0.51	22
LA Reach 4 below Tillman	19	0.92	26	6.6	0.66	10
LA Reach 3 Above LAG WRP	22	0.96	23	7.6	0.64	12
LA Reach 3 below LAG WRP	21	0.89	26	7.5	0.65	12
LA Reach 2	21	0.96	22	7.3	0.65	12
LA Reach 1	22	0.96	23	7.6	0.64	11
Tributaries	**Dissolved Copper**	**Conversion**	**Total recoverable Copper**	**Dissolved Lead**	**Conversion factor**	**Total recoverable Lead**
Bell	29	0.96	30	11	0.51	22
Tujunga	19	0.96	20	6.6	0.66	10
Verdugo Wash	22	0.96	23	7.6	0.64	12
Burbank (above WRP)	25	0.96	26	9.1	0.67	14
Burbank (below WRP)	18	0.96	19	6.1		9.1
Arroyo Seco	21	0.96	22	7.3	0.65	11
Compton Creek	18	0.96	19	6.0	0.67	8.9
Rio Hondo	12	0.96	13	3.7	0.74	5.0
Monrovia Canyon Creek	17	0.96	18	5.6		8.2

The City of Los Angeles proposed local dry-weather translator numbers for copper for the areas downstream of the Tillman Plant (Reach 4) and the Glendale Plant (Reach 3) based on a study performed by Larry Walker and Associates (LWA) (LWA, 2003). For the area downstream of the Tillman Plant, the proposed translators for copper were 0.57 for chronic and 0.72 for acute. For the area downstream of the Glendale Plant, the proposed translators were 0.77 for chronic and 0.84 for acute. EPA and the Regional Board expressed concern about the use of these numbers given the lack of consistent relationships between total and dissolved concentrations in the dataset.

Suspecting that relationship may be affected by total suspended solids, LWA used partition coefficient modeling to account for variation due to total suspended solids. In this approach, the translator is the dissolved fraction (fd), calculated using a site a specific partition coefficient (Kp) and total suspended solids. This is in accordance with EPA guidance for calculating metals translators (USEPA, 1996) and is allowed for in the SIP (SWRCB, 2000). Using this approach LWA proposed using 0.74 as a chronic translator and 0.92 as an acute translator for the area downstream of Tillman. For the area downstream of Glendale, they proposed translators of 0.80 for chronic and 0.89 for acute. These values provide a reasonable approximation of the partitioning of copper between dissolved and particulate phase and the proposed translators for copper will be used in this TMDL for the areas of the River downstream of the Tillman and Glendale plants. CTR default conversion factors are copper in the other reaches. CTR default values are used for dry-weather targets for lead and zinc. Application of these conservative default values is applied to the margin of safety for the TMDL.

The City of Los Angeles is currently pursuing an alternative method for determining site-specific copper water quality criteria based on the Biotic Ligand Model (BLM). This TMDL will include a re-opener to allow for application of site specific-water quality criteria for copper if and when these site-specific water quality criteria approved by U.S. EPA and the Regional Board.

The dry-weather target for zinc in the Rio Hondo is 128 ug/l. The dry-weather target for selenium in Aliso Creek is 5 ug/l

3.2. Wet-Weather Targets

The wet-weather condition has been operationally defined as occurring when storm volume measured at the Wardlow station is greater than 500 cfs (the upper 10th percentile of flow). Wet-weather targets are defined for cadmium, copper, lead and zinc were based on hardness value of 80 mg/l. This represents the median hardness value from 42 storm composite samples collected by LACDPW at Wardlow Station between 1996 and 2002.

The LACDPW at Wardlow was also used in a regression analysis to evaluate the relationship between dissolved and total recoverable metals in storm water metals. The slope of the reflects the ratio of the dissolved to total concentration; the r-squared value reflects the strength of the relationship.

Table 3-3. Relationship between dissolved and total metals in storm water data at Wardlow Station (1996-2002) and CTR default conversion factors

Metal	LADPW Storm water data			Acute Coversion Factors
	N	Slope	R^2	(ACF)
Cadmium	3	-	-	0.95*
Copper	33	0.65	0.69	0.960
Lead	13	0.82	0.98	0.791*
Zinc	20	0.61	0.61	0.978

These regressions suggest that the CTR default translators generally overestimate the dissolved portion of metals in storm water. Data from literature confirm this and suggest that an even greater portion of metals is associated with particulates in wet weather. Young et al. 1980 estimated that the 90% of the cadmium, copper, lead, and zinc in storm water samples were associated with the particle phase. McPherson et al. 2004 found similar results in storm water from nearby Ballona Creek. In that study 83% of the cadmium, 63% of the copper, and 86% of the lead were associated with the particle phase. Use of the CTR default values for wet-weather would be overly conservative, we therefore propose using slope of the regression as translators for copper, lead and zinc. The default CTR translator was used for cadmium because there is insufficient local data for site-specific value.

Table 3-4. Wet-weather targets.

Metal	Wet-weather Target Dissolved (ug/l)	Conversion Factor	Wet-weather Target Total Recoverable (ug/L)
Cadmium (µg/l)	3	0.95	3.2
Copper (µg/l)	11	0.65	17
Lead (µg/l)	51	0.82	62
Zinc (µg/l)	97	0.61	159
Selenium	NA	NA	5

4. SOURCE ASSESSMENT

This section identifies the potential sources of metals to the Los Angeles River and tributaries. The toxic pollutants can enter surface waters from both point and nonpoint sources. In the context of TMDLs, pollutant sources are either point sources or nonpoint sources. Point sources include discharges for which there are defined outfalls such as wastewater treatment plants, industrial discharges and storm drain outlets. These discharges are regulated National Pollution Discharge Elimination System (NPDES) permits. Nonpoint sources, by definition, include pollutants that reach waters from a number of diffuse land uses and source activities that are not regulated through NPDES permits. An example of this would be the runoff from the National Forest and State Parks. While not subject to a NPDES permit, pollutant loadings from these areas must be dealt with in the TMDL.

4.1 Point Sources.

Table 4-1. Summary of permits in Los Angeles River watershed. (SOURCE RWQCB).

Type of Permit	No. of Permits
Publicly Owned Treatment Works	6
Municipal Storm water	3
Industrial Storm water	1336
Construction Storm water	456
Other Major NDPES Discharges	2
Minor NPDES Discharges	28
General NPDES Discharges	
Construction Dewatering	33
Treated Groundwater from Construction Dewatering	9
Petroleum Fuel Cleanup Sites	12
VOCs Cleanup Sites	6
Hydrostatic Test Water	12
Non-Process Wastewater	15
Potable Water	17
Total	**1652**

4.1.1. Publicly Owned Treatment Works (POTWs)

There are several POTWs that either discharge, or have the potential to discharge into the Los Angeles River or listed tributaries. The three largest POTWs (Donald G. Tillman Water Reclamation Plant, Los Angeles-Glendale Water Reclamation Plant, and Burbank Water Reclamation Plant) constitute the major sources in the watershed.

- Tillman is a tertiary treatment plant with a design capacity of 80 mgd. The Tillman plant discharges approximately 53 mgd to the Los Angeles River. Most of the flow is discharged directly into the Los Angeles River (Reach 4). However, a portion of the flow goes into a recreation lake, which then drains into Bull Creek and Hayvenhurst Channel and back into the Los Angeles River (Reach 5). Another portion of the flow goes to a wildlife lake, which then drains into Haskell Channel and ultimately back into the Los Angeles River (Reach 5).

- The Los Angeles-Glendale POTW is a 20-mgd design capacity plant that discharges approximately 13 mgd directly into the Reach 3 of the Los Angeles River in the Glendale Narrows. Approximately 4 mgd of the treated wastewater is used for irrigation and industrial uses.

- Burbank has a design capacity of 9 mgd. Approximately 4 mgd is discharged directly into the Burbank Western Channel. The City of Burbank and Caltrans reclaim a portion of the effluent for irrigation (freeway landscapes, golf courses, parks etc.). Treated water from the plant is also used as cooling water for the Burbank Steam Power Plant.

- The Tapia Water Reclamation Facility (Tapia) is a 16-mgd plant that discharges into Malibu Creek. However, due to a discharge prohibition in Malibu Creek from April 15 to November 15, the permittee is allowed to discharge up to 1 mgd of wastewater to the Los Angeles River. However, this discharge is infrequent. The permitted flow from the Tapia is less than 2% of the mean flows from the major POTWs discharging to the Los Angeles River.

- The Whittier Narrows Water Reclamation Plant discharges to the Rio Hondo above the Whittier Narrows Dam, into spreading grounds where most of the effluent enters the groundwater. It has been estimated that less than 1% (0.1mgd) of Whittier Narrows WRP effluent remains in the channel downstream of the spreading grounds.

- The Los Angeles Zoo Wastewater Facility has a 1.8 million gallon retention basin, and discharges into Reach 3 of the Los Angeles River near the Glendale Narrows only during wet weather when the retention capacity is exceeded.

4.1.2. Storm water Permits

Storm water runoff in the Los Angeles River Watershed is regulated through a number of permits. There are the municipal storm water (MS4) permits issued to the Los Angeles County and the City of Long Beach. There is the statewide storm water permit issued to Caltrans. There are about 1,336 permits issued under the Statewide Industrial Activities Storm Water General Permit and about 456 permits issued under the Statewide Construction Activities Strom Water General Permit.

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 MS4 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
- Municipally owned 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

The County of Los Angeles Municipal Storm Water NPDES permit (MS4 Permit) was renewed in December 2001 (Regional Board Order No. 01-182) 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 City of Long Beach MS4 was renewed on [GET DATE] and is renewed on a five year cycle.

Caltrans Storm Water Permit

Caltrans is regulated by a statewide storm water discharge permit that covers all municipal storm water activities and construction activities (Order No. 99-06-DWQ). 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 Los Angeles River watershed. A conservative estimate of the percentage of the Los Angeles River watershed covered by state highways is 1.3% (approximately 6,950-acres). This percentage does not represent all the watershed area that Caltrans is responsible for under the storm water 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 zinc and copper used in tires and brake pads.

General Storm Water Permits

Federal regulations for controlling pollutants in storm water discharges were issued by the USEPA on November 16, 1990 (40 Code of Federal Regulations [CFR] Parts 122, 123, and 124). The regulations require operators of specific categories of facilities where discharges of storm water associated with industrial activity occur to obtain an NPDES permit and to implement Best Available Technology Economically Achievable (BAT) and Best Conventional Pollutant Control Technology (BCT) to reduce or prevent pollutants associated with industrial activity in storm water discharges and authorized non-storm discharges. In addition, the regulations require discharges of storm water to surface waters associated with construction activity including clearing, grading, and excavation activities (except operations that result in disturbance of less than five acres) to obtain an NPDES permit and to implement BAT and BCT to reduce or eliminate storm water pollution. On December 8, 1999, federal regulations promulgated by USEPA (40CFR Parts 122, 123, and 124) expanded the NPDES storm water program to include storm water discharges from construction sites that resulted in land disturbances equal to or greater than one acre but less then five acres.

On April 17, 1997, State Board issued a statewide general NPDES permit for Discharges of Storm Water Associated with Industrial Activities Excluding Construction Activities Permit (Order No. 97-03-DWQ). This Order regulates storm water discharges and authorized non-storm water discharges from ten specific categories of industrial facilities, including but not limited to manufacturing facilities, oil and gas mining facilities, landfills, and transportation facilities. On August 19, 1999, State Board issued a statewide general NPDES permit for Discharges of Storm Water Runoff Associated with Construction Activities (Order No. 99-08-DQW). All dischargers covered under these general NPDES storm water permits are required to develop and implement an effective Storm Water Pollution Prevention Plan (SWWPPP) and Monitoring Program. The SWPPP has two main objectives. One, to identify and evaluate sources of pollutants associated with industrial or construction activities that may affect the quality of storm water discharges. Two, to identify and implement site-specific BMPs to reduce or prevent pollutants associated with industrial activities in storm water discharges.

There are about 1,336 dischargers enrolled under the general industrial storm water permit in the watershed, the largest numbers occur in the cities of Los Angeles, Vernon, South Gate, Long Beach, Compton, and Commerce. Metal plating, recycling and manufacturing, transit, trucking and warehousing, and wholesale trade are a large component of these facilities. There is a potential for metals loadings from these types of facilities, especially metal plating, transit, and recycling facilities. Facilities enrolled under this permit are required to sample runoff and report monitoring data twice annually. A review of the available monitoring data demonstrates that several industrial facilities are exceeding applicable CTR values and are therefore a source of metals loadings to the Los Angeles River.

There are a total of 456 construction sites enrolled under the construction storm water permit. The larger sites are in the upper watershed (which includes the San Fernando Valley) and the construction in this watershed is fairly evenly divided between commercial and residential. Potential pollutants from construction sites include sediment, which may contain metals as well as metals from construction materials and the heavy equipment used on construction sites. During wet weather, runoff from construction sites has the potential to contribute metals loadings to the river.

4.1.3. Other NPDES Permits

The individual NPDES permit is classified as either major or minor permits. The discharges flows associated with minor individual NPDES permits and general NPDES permits are typically less than 1 million gallons per day (MGD). Many of these are for episodic discharges rather than continuous flows.

Major Individual NPDES Permits

There are two major NPDES facilities in addition to the POTWs. These permits are for storm water discharges and would therefore exert the greatest potential influence on metals loadings during wet weather.

Pacific Terminals LLC Dominguez Hills Tank Farm has a permitted discharge of up to 4.32 mgd of storm water and miscellaneous designated wastewater to Compton Creek. This permit contains effluent limits for metals, but since the permit was issued prior to the adoption of CTR, there is the potential for the facilities to discharge metals in exceedance of the numeric targets. This permit is scheduled for renewal in 2005.

The Boeing Company Santa Susana Field Lab discharges up to 160 mgd of storm water (based on the 24-hour duration, 10 year return storm event) mixed with industrial wastewater to Bell Creek via two discharge points. Discharges from these two points have a low potential to contribute to metals loading because the permit contains CTR-based effluent limits, based on a total hardness of 100 mg/l or other hardness values when applicable. However, storm water is also discharged to Bell Creek through another discharge point, for which there are no effluent limitations for metals. There is a potential for metals loadings from this point. The permit requires monitoring and the imposition of effluent limits if monitoring indicates reasonable potential.

Minor Individual NPDES Permits

Minor permits cover miscellaneous wastes such as ground water dewatering, recreational lake overflow, swimming pool wastes, and ground water seepage. Some of these permits contain effluent limits for metals. However, some of these permits were issued prior to the adoption of CTR and there is the potential for these facilities to discharge metals in exceedance of the numeric targets in this TMDL. There are 28 minor NPDES permits in the Los Angeles River watershed.

Other General NPDES Permits

Pursuant to 40 CFR parts 122 and 123, the State Board and the Regional Boards have the authority to issue general NPDES permits to regulate a category of point sources if the sources: involve the same or substantially similar types of operations; discharge the same type of waste; required the same type of effluent limitations; and require similar monitoring. The Regional Board has issued general NPDES permits for seven categories of discharges: construction and project dewatering; treated groundwater from construction dewatering, non-process wastewater; petroleum fuel cleanup sites; volatile organic compounds (VOCs) cleanup sites; potable water; and hydrostatic test water.

The general NPDES permit for Discharges of Groundwater from Construction and Project Dewatering to Surface Waters (Order No. R4-2003-0111) covers wastewater discharges, including but not limited to, treated or untreated groundwater generated from permanent or temporary dewatering operations. Currently, there are 33 dischargers enrolled under this Order in the Los Angeles River watershed. There are 9 dischargers with permits for the Discharge of Treated Ground Water from Construction Dewatering. There are 15 discharges enrolled under general NPDES permit for Discharges of Nonprocess Wastewater to Surface Waters (Order No. R4-2004-0058) which covers waste discharges, including but not limited to, noncontact cooling water, boiler blowdown, air conditioning condensate, water treatment plant filter backwash, filter backwash, swimming pool drainage, and/or groundwater seepage.

Discharges from construction dewatering and nonprocess wastewater have a low potential to contribute to metals loadings. In order to be eligible to be covered under this Order, a discharger must perform an analysis using a representative sample of the groundwater or nonprocess wastewater to be discharged. The sample is analyzed and the data compared to the water quality screening criteria for metals, which are based on the CTR criteria. The permit includes effluent limitations for metals, which are based on the CTR. For the hardness dependent metals, the effluent limitations are based on site-specific hardness values.

The general NPDES permit for Treated Groundwater and Other Wastewaters from Investigation and/or Cleanup of Petroleum Fuel-Contaminated Sites to Surface Waters (Order No. R4-2002-0125) covers discharges, including but not limited to, treated groundwater and other wastewaters from the investigation, dewatering, or cleanup of petroleum contamination arising from current and former leaking underground storage tanks or similar petroleum contamination. Currently, there are 12 dischargers enrolled under this Order in the Los Angeles River watershed. There are approximately 6 dischargers enrolled under the general NPDES permit for Discharges of Treated Groundwater from Investigation and/or Cleanup of VOCs-Contaminated Sites to Surface Waters (Order No. R4-2002-0107) which includes but is not limited to, treated groundwater and other wastewaters from the investigation, cleanup, or construction dewatering of VOCs only (or VOCs commingled with petroleum fuel hydrocarbons) contaminated groundwater.

Discharges from site cleanup operations have a low potential to contribute to metals loadings. In order to be eligible to be covered under these Orders, the discharger must demonstrate that a representative sample of the contaminated groundwater to be treated and discharged does not exceed the water quality screening criteria for metals, which are based on the CTR criteria. In addition, the permit includes effluent limitations for lead. The effluent limitations for lead are based on the CTR default hardness value of 100 mg/L.

The general NPDES permit for Discharges of Groundwater from Potable Water Supply Wells to Surface Waters (Order No. R4-2003-0108) covers discharges of groundwater from potable supply wells generated during well purging, well rehabilitation and redevelopment, and well drilling, construction and development. Currently, there are 17 dischargers enrolled under this Order in the Los Angeles River watershed. The general NPDES permit for Discharges of Low Threat Hydrostatic Test Water to Surface Waters (Order No. R4-2004-0109) covers waste discharges from hydrostatic testing of pipes, tanks, and storage vessels using domestic/potable water. Currently, there are 12 dischargers enrolled under this Order in the Los Angeles River watershed.

Discharges of potable water from water supply wells and from hydrostatic testing have a low potential to contribute metals loadings to the Los Angeles River or its tributaries, since these pollutants are not expected to be in potable water. In order to be eligible to be covered under this Order, the discharger must demonstrate that concentrations are not greater than the maximum contaminant levels (MCLs). The MCLs are health protective drinking water standards adopted by the California Department of Health Services. The MCLs define the maximum permissible level of a contaminant in water delivered to any user of a public drinking water supply system. In general, the MCLs for the metals are greater than the numeric targets.

Table 4-2. Summary of permits in Los Angeles River watershed.

Type of NPDES Permit	Number of Permits	Screening for Pollutants	Permit Limits for metals?	Potential for significant contribution
Publicly Owned Treatment Works	6	Yes	Yes	High
Municipal Storm water	3	Yes	No	High
Industrial Storm water	1336	Yes	No	High
Construction Storm water	456	Yes	No	High
Other Major NDPES Discharges	2	Yes	Yes	Medium
Minor NPDES Discharges	28	Yes	varies	Medium
Other General NPDES Discharges				
Construction Dewatering	33	Yes	Yes	Low
Treated Groundwater from Construction Dewatering	9	Yes	Yes	Low
Non-Process Wastewater	15	Yes	Yes	Low
Petroleum Fuel Cleanup Sites	12	Yes	Lead only	Low
VOCs Cleanup Sites	6	Yes	Lead only	Low
Hydrostatic Test Water	12	Yes	Not CTR	Low
Potable Water	17	Yes	Not CTR	Low
Total	**1652**			

4.3. Quantification of loads

4.3.1. Dry Weather Loadings

During low flow periods the three major POTWs typically account for 60% to 80% of the total volume of discharge in the river. The remaining 20% to 40% of the dry weather flow represents a combination of tributary flows, groundwater discharge, flows from other permitted NPDES discharges within the watershed (Table 4-31, and dry-weather urban runoff.

The total metals loads from the Tillman, Burbank and Glendale WRPs were estimated using monthly flow and effluent concentration data provided as part of the annual self monitoring reports (Table 4-3). On a daily basis these three POTWs contribute approximately 0.2 kg/d of cadmium, 4.5 kg/d of copper, 0.5 kg/d of lead and 12.8 kg/d of zinc to the Los Angeles River.

Table 4-3. Total annual metals loadings from three POTWs (kg/yr).

Metal	Facility	1998	1999	2000	2001	2002	Ave
Cadmium	Tillman	105	59	53	33	33	57
	Burbank2	7	4	14	13	1	8
	Glendale	19	16	15	16	16	16
	Total	**131**	**79**	**82**	**62**	**50**	**81**
Copper	Tillman	1427	1292	1690	1574	1260	1449
	Burbank2	27	24	37	8	66	32
	Glendale	119	135	166	205	150	155
	Total	**1573**	**1451**	**1893**	**1787**	**1476**	**1636**
Lead	Tillman	122	105	120	94	86	105
	Burbank2	46	26	64	95	3	47
	Glendale	29	30	32	24	24	28
	Total	**197**	**161**	**216**	**213**	**113**	**180**
Zinc	Tillman	4134	2955	4398	3671	2994	3630
	Burbank2	157	138	238	353	207	219
	Glendale	1002	814	771	801	749	827
	Total	**5293**	**3907**	**5407**	**4825**	**3950**	**4676**

To assess the relative contributions of metals during dry weather, sampling was conducted in September 2000 and July 2001. The monitoring consisted of synoptic sampling of flow and concentration from the three POTWs, the headwaters of the tributaries, and 49 storm drains on September 11-12, 2000 (Ackerman et al., 2003). This was followed up by another synoptic survey in July 2001. In this second survey, more focus was put on the storm drains, and the number of storm drains sampled during this event was 84. Table 4-4 provides the summary results from these two surveys in terms of total mass for each metal and the relative contribution from each major source.

Table 4-4. Relative loading (%) of total metals by source to the Los Angeles River during dry-weather conditions (Based on data from 2000 and 2001 Los Angeles River synoptic surveys).

Sources	Cadmium		Copper		Lead		Zinc	
	2000	2001	2000	2001	2000	2001	2000	2001
Tributaries	7%	6%	8%	5%	10%	6%	5%	3%
POTWs	59%	39%	69%	38%	55%	41%	81%	51%
Dry Weather Runoff	34%	55%	23%	57%	35%	53%	14%	46%
Total Mass (kg/d)	0.3	0.3	5.6	6.9	2.8	2.4	14.8	20.4

The POTWs contribute a fairly large percentage of the total dry-weather metals loadings. The concentrations of metals in the POTWs may be low, but loadings are high because the POTW flows are large. The storm drains also contribute a large percentage of the loadings. Storm drain flows are typically low during dry weather, but concentrations of metals in urban runoff may be quite high. In calculating the dry-weather loadings estimates in Table 4-4, non-detects were treated as ½ the detection limit. Lead and to a lesser extent for cadmium were generally below detection limits on both sampling dates. We did not treat detection limits as zeros because these metals have been frequently detected in POTW effluent monitoring data supplied by the dischargers and in dry-weather urban runoff, as reported by LACDPW.

During dry weather, background concentrations may come from tributaries which drain the hills of the Angeles National Forest and the open areas of the Santa Monica Mountains. The flows from these areas are relatively small during dry weather and much of it is captured behind dams. The metals concentrations in flows from these areas are also likely to be low. The estimated loadings from the tributaries were generally less than 10%. This may be an overestimate, since the sites for the tributary samples were not selected for the purpose of defining natural background conditions. Rather sites were selected to define conditions at the boundary of the listed reaches and in many cases there are inputs from storm drains upstream of the listed reaches.

4.3. Wet Weather Loadings

Most of the annual metals loadings to the Los Angeles River are associated with wet weather (Stein, 2003). In addition to the MS4 and Caltrans storm water permits, there are more than one thousand industrial facilities in the Los Angeles River watershed that are enrolled under the statewide NPDES general storm water permit for industry (Table 4-1). However, the data collected under the monitoring program for this permit are not of sufficient frequency or quality to be used to estimate loadings (Duke et al., 1998). Therefore, to assess total storm water loadings we relied on the LACDPW storm water monitoring data from the mass emission station at Wardlow (LACDPW, 2000). Table 4-5 summarizes the aggregate seasonal loads from flow-weighted composites of multiple storms sampled between 1996 and 2002.

Wet weather loadings can vary by an order of magnitude depending on the rainfall and size of storms in a given year. In a report to the State Water Resources Control Board, SCCWRP estimated the mass loadings for a typical year (Stein et al., 2003). These values are generally consistent with the average loadings calculated from the LACDPW mass emission stations.

Table 4-5. Seasonal storm water total metals loadings (kg/yr) to Los Angeles River watershed. Data are from LACDPW and Stein et al., 2003.

LACDPW	Cadmium	Copper	Lead	Zinc
96/97	-	3,629	3,760	16,692
97/98	-	36,741	94,347	210,012
98/99	-	1,075		6,078
99/00	-	286	207	1,012
00/01	-	1,409	879	5,645
01/02	-	514	106	1022
Average	-	7,276	19,860	40,077
SCCWRP	**Cadmium**	**Copper**	**Lead**	**Zinc**
Typical year	62	6,960	2,304	42,479

Average annual POTW loadings (Table 4-3) can be compared to the typical storm water loadings (Table 4-5) to provide an indication of the relative contributions from these sources. On an annual basis, storm water contributes about 40% of the cadmium loading, 80% of the copper loading, 95% of the lead loading, and 90% of the zinc loading.

Atmospheric deposition is another potential source of metals to the watershed. Deposition of metals to the surface area of the Los Angeles River watershed may be substantial, on the order of several thousand kilograms per year (Sabin et al., 2004). Direct atmospheric deposition was quantified by multiplying the surface area of the river times the rate of atmospheric deposition. These numbers (Table 4-6) are generally small because the actual surface area of the river system is small. Direct deposition of metals is insignificant relative to either the annual dry-weather loadings or the total annual loadings. Indirect atmospheric deposition reflects the process by which metals deposited on the land surface may be washed off during rain events and be delivered to the Los Angeles River and tributaries. Not all the metals deposited on the land from the atmosphere are loaded to the river By dividing the calculated total metals loadings to the river. Estimates of metals deposited on land (Table 4-6) are much higher than estimates of loadings to the river (Table 4-5). Sabin et al. (2004) calculated the ratio of wet-weather water runoff to indirect atmospheric deposition as 19% for copper, 9% for lead, and 22% for zinc. The loadings of metals associated with indirect atmospheric deposition are accounted for in the estimates of the storm water loadings.

Table 4-6. Estimates of direct and indirect deposition (kg/year). Source: Sabin et al., 2004.

Type of deposition	Copper	Lead	Zinc
Indirect	16,000	12,000	80,000
Direct	3	2	10

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 assimilative capacity of the receiving water. Variations between wet and dry weather can strongly affect the delivery of metals to the Los Angeles River and the assimilative capacity of the river to accommodate these loadings so that standards are met. Given the differences in sources and flows between dry- and wet-weather, two distinct approaches for the linkage analysis were taken. This section describes the use of hydrodynamic and water quality models to assess the effects of metals loadings in the Los Angeles River on water quality under both dry and wet weather conditions.

5.1. Development of the Dry-Weather Model

The Environmental Fluid Dynamics Code 1-D (EFDC1D) was used to model the hydrodynamic characteristics of the river. The hydrodynamic model (EFDC) was utilized to simulate the flow and pollutant loading within the 303(d) listed segments of the Los Angeles River and tributaries (Table 5-1) under dry-weather conditions. EFDC1D is a one dimensional variable cross-section model for flow and transport in surface water systems. The river system was divided into a total of 302 grid cells averaging 600 meters in length.

Table 5-1. Los Angeles River segments modeled for linkage analysis

Los Angeles River Mainstem	Los Angeles River Tributaries
Reach 6: above Sepulveda Flood Control Basin	Bell Creek
Reach 5: within Sepulveda Basin	Tujunga Wash
Reach 4: Sepulveda Dam to Riverside Dr	Burbank Western Channel
Reach 3: Riverside Dr to Figueroa St	Verdugo Wash
Reach 2: Figueroa St to Carson St	Arroyo Seco
Reach 1: Carson St to Estuary	Rio Hondo River
	Compton Creek

To support the model development a comprehensive set of in-stream hydrodynamic and water quality data were collected in the late summer of 2000 (September 11-12) and summer of 2001 (July 29-30). These data were used to calibrate and validate the models. The details associated with development of the dry-weather model are presented in Appendix I.

5.2. Calibration and Validation of the Dry-Weather Model. There are four stream gages along the mainstem of the Los Angeles River (Figure 5). The upper-most station (designated F300-R) is in Reach 4 of the Los Angeles River below Tillman plant. The lowest station is the Wardlow gage station (designated F319-R), which is below the confluence of all tributaries within the Los Angeles River and all simulated point sources. The variability in daily flow measured at these gages is high. On September 11, 2000 the measured flows ranged from 50 to 120 cfs at the upper most station to 135 to 200 cfs at the lowest station. On July 29, 2001 the measured flow ranged from 50 and 75 cfs at the upper-most station and 170 to 200 cfs at the lowest station. The long-term median flows (12-year) at Tujunga, Firestone and Wardlow are 78 cfs, 124 cfs, and 145 cfs respectively. The days selected for the calibration and validation of the model are generally representative of the low-flow condition. A comparison of the measured flow on September 11 at these four stations to the modeled dry-weather flow is presented in (Figure 6).

For simulation of the water quality within the Los Angeles River, the EFDC model was linked to the Water Quality Analysis Simulation Program (WASP5). Model results were compared to observed data. The first comparison of the dry-weather water quality model was performed using field measurements collected on September 10, and 11, 2000 (Tables 5-2). The second comparison of the dry-weather water quality model was performed using field measurements from July 29 and 30, 2001 (Tables 5-3).

Table 5-2. Flow (cfs) and concentrations of total metals (µg/l) used in model comparison based on samples collected on September 10 and 11, 2000 for point source discharges.

POTWs	**Flows**	**Cd[1]**	**Cu**	**Pb[2]**	**Zn**
Tillman POTW					
Direct Discharge	53.3	0.5	13	5	39
Japanese Gardens	7.4	0.5	13	5	39
Recreation Lake	27.0	0.5	13	5	39
Wildlife Lake	9.1	0.5	13	5	39
Glendale POTW	14.4	0.5	5	5	30
Burbank POTW	14.3	0.5	18	5	52
Tributaries	**Flows**	**Cd[1]**	**Cu**	**Pb[2]**	**Zn**
Bell Creek	4.3	0.5	15	5	5
Tujunga Wash	0.7	0.5	18	5	16
Burbank Western Channel	1.4	0.5	18	5	52
Verdugo Wash	2.8	0.5	14	19	41
Arroyo Seco	3.7	0.5	5	5	5
Compton Creek	3.1	0.5	5	5	11

1 – Detection limit for cadmium was 1 µg/L. Non-detects were treated as ½ the detection limit.
2 - Detection limit for lead was 10 µg/L. Non-detects were treated as ½ the detection limit

Table 5-3. Flows (cfs) and concentrations of total metals (µg/l) used in model comparison based on samples collected on July 29 and 30, 2001 for point source discharges.

POTWs	**Flows**	**Cd[1]**	**Cu**	**Pb[2]**	**Zn**
Tillman POTW					
Direct Discharge	14.4	0.5	12.5	5	50.6
Japanese Gardens	7.0	0.5	5	5	35.1
Recreation Lake	27.0	0.5	14.7	5	67.2

Wildlife Lake	8.8	0.5	5	5	35.1
Glendale POTW	14.3	0.5	20.1	5	43.1
Burbank POTW	8.1	0.5	16.2	5	69.7
Tributaries	**Flows**	**Cd[1]**	**Cu**	**Pb[2]**	**Zn**
Bell Creek	2.7	0.5	6.9	5	5
Tujunga Wash	0.4	0.5	32.2	5	17.9
Burbank Western Channel	1.4	0.5	16.2	5	69.7
Verdugo Wash	2.2	0.5	17.9	5	25.3
Arroyo Seco	3.3	0.5	5	5	1.08
Rio Hondo	0.5	0.5	18.2	25.5	33.2
Compton Creek	1.8	0.5	9.2	5	24.9

1 – Detection limit for cadmium was 1 μg/L. Non-detects were treated as ½ the detection limit.
2 - Detection limit for lead was 10 μg/L. Non-detects were treated as ½ the detection limit

The model performs well in predicting the average concentrations of these metals (Figure 7b.). These can be compared to the long-term averages as represented by the City of Los Angeles Watershed monitoring program (Figures 3a – 3d). On both days, the model indicated that concentrations were below the CTR standards. This is consistent with our expectation, since the POTWs that provide most of the dry-weather flows to the river are generally discharging effluent that meets the water quality standards. The model is not able to represent all the temporal and spatial variability observed in the in-stream metals concentrations due to the inherent variability and uncertainty associated with estimates of storm drain flow and concentrations. The variability in concentrations seen over time in the City's data set suggests that episodic exceedances in water quality are likely to be a result of irregular inputs from urban runoff rather than the more stable POTW flow. The model provides a reasonable assurance that we understand the relationship between in-stream loads and targets.

5.3 Development of the Wet-Weather Model

Wet-weather sources are generally associated with wash-off of pollutant loads accumulated on the land surface. During a rainy period, these loads are delivered to the waterbody through creeks and storm water collection systems. USEPA's Loading Simulation Program in C++ (LSPC) was selected to simulate the hydrologic processes and pollutant loading from the Los Angeles River watershed. LSPC is a recoded C++ version of USEPA's Hydrologic Simulation Program-Fortran (HSPF). The details associated with the development and validation of the wet-weather model system are presented in Appendix II.

The Los Angeles River watershed area was divided into thirty-five smaller, discrete sub-watersheds for modeling and analysis (Figure 8). This subdivision was primarily based on the stream and storm sewer networks and topographic variability. Other factors such as the presence of existing watershed boundaries, consistency of land use, and the locations of existing monitoring stations were also considered in delineation. Each delineated subwatershed was represented with a single stream reach from the National Hydrography Dataset (NHD) stream network. Information on the length, slope, mean depth and channel widths for each reach was used to route flow and pollutants through the watershed.

Two sources of land use data were used in this modeling effort. The primary source of data was the Southern California Association of Governments (SCAG) 2000 land-use dataset that covers Los Angeles County. This data set was supplemented with land-use data from the 1993 USGS Multi-Resolution Land Characteristic data to fill data gaps. Land-use categories were grouped into seven categories for modeling (Residential, Commercial, Industrial, Open, Agriculture, Water, and Other). Table 5-4 presents the land use distribution within the watershed for each of the 35 sub-watersheds.

Hourly rainfall data were obtained from the National Climatic Data Center for 11 weather stations located in and around the Los Angeles River watershed for October 1998 through December 2001 (Figure 9). The USDA's STATSGO soils data base served as a starting point for hydrologic parameters such as infiltration and groundwater flow parameters. This was augmented with information from other modeling applications in the area (i.e., for Santa Monica Bay, Ballona Creek, San Gabriel River). These starting values were refined through the calibration process.

Loading processes for metals (copper, lead, and zinc) for each land use were represented in LSPC 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.

The model was then used to simulate the in-stream total suspended solids concentrations. Metals associated with these sediments were simulated using the LSPC water quality module. The relationships between sediment and metals (copper, lead and zinc) were parameterized as potency factors developed by SCCWRP (Ackerman et al., 2004). Potency factors were defined for copper, lead and zinc for each of seven land-uses categories (agriculture, commercial, industrial, residential, water, other, and open).

Table 5-4. Land use distribution in the watershed (square miles).

Watershed	Residential	Commercial	Industrial	Open	Agriculture	Water	Other	Total
1	8.55	0.87	0.52	7.44	0	0	0.32	17.69
2	7.91	0.91	0.28	5.17	0.08	0.04	0.44	14.83
3	4.49	0.60	1.55	15.75	0.20	0	0	22.59
4	4.53	1.23	0.87	5.96	0.40	0.04	0.08	13.12
5	9.86	1.91	2.86	6.52	0	0	0.32	21.47
6	8.67	1.39	0.60	1.67	0.08	0	0	12.41
7	8.11	1.15	3.38	8.23	0.24	0.28	0.12	21.51
8	10.94	1.91	0.44	3.34	0.24	0.12	0.36	17.34
9	17.93	3.58	2.78	4.89	0.48	0.16	0.04	29.86
10	0.76	0	0	33.00	0.04	0.20	0	34.00
11	7.04	1.67	1.67	6.88	0.48	0	0.08	17.81
12	7.59	1.59	1.19	0.76	0.16	0	0	11.29
13	4.10	0.36	2.19	120.09	0.12	0.08	0	126.9
14	0.56	0.04	0.24	20.32	0.28	0	0	21.43
15	3.14	0.4	2.62	3.74	0.16	0	0	10.06
16	6.68	1.03	0.95	0.28	0	0	0	8.95
17	5.49	1.59	1.95	0.52	0	0	0	9.54
18	0.95	0.04	0	0.08	0	0	0	1.07
19	9.42	1.55	5.49	12.21	0.12	0	0.20	28.99
20	6.64	1.67	1.59	2.98	0.08	0.04	0.08	13.08
21	9.86	1.35	0.76	13.04	0	0	0.08	25.09
22	2.58	0.28	0.72	4.49	0	0	0	8.07
23	17.5	2.15	2.15	28.39	0.08	0	0.04	50.30
24	10.66	2.07	3.82	7.67	0.08	0	0.28	24.57
25	16.62	6.76	17.5	4.49	0.08	0	0.24	45.69
26	0.00	0.04	0.04	10.42	0	0	0	10.50
27	9.15	1.55	2.74	15.35	0.56	0.32	0.12	29.78
28	16.06	2.86	1.47	12.29	0.36	0	0	33.04
29	10.74	2.58	1.19	0.99	0	0	0.04	15.55
30	18.37	4.29	2.11	1.99	0.32	0.04	0.12	27.24
31	6.16	1.67	2.35	2.58	0.40	0.20	0	13.36
32	10.30	3.10	5.05	2.27	0.64	0	0.04	21.39
33	23.34	6.16	9.3	1.03	0.08	0.04	0.16	40.12
34	14.04	3.86	3.66	1.63	0.24	0	0.12	23.54
35	6.12	1.87	2.51	1.39	0.04	0.20	0.08	12.21
Total Area	304.86	64.08	86.54	367.85	6.04	1.76	3.36	834.39
Percent of Total Area	36.54%	7.68%	10.37%	44.08%	0.72%	0.21%	0.40%	834.39

5.3.1. Calibration and Validation of the Wet-Weather Model – Flow. Hydrology is the first model component calibrated because estimation of metals loading relies heavily on flow prediction. The hydrology calibration involves a comparison of model results to in-stream flow observations at selected locations. Key considerations in the hydrology calibration included the overall water balance, the high-flow/low-flow distribution, storm flows, and seasonal variation. Calibration was focused on flow gages with data for the entire period of record, including a gage in the upper portion of the watershed (Los Angeles River at Tujunga Avenue) and a gage in the more urban area of the watershed (Rio Hondo above Stuart and Gray Road). Validation was performed using data from 6 other gages in the water shed (Table 5-6). The validation essentially confirmed the applicability of the hydrologic parameters derived during the calibration process.

Table 5-6. Stream gage stations used for calibration and validation of flow data.

Gage Number	Station description	Use
F-45B-R	Rio Hondo above Stuart and Gray Road	Calibration
F-300-R	Los Angeles River at Tujunga Avenue	Calibration
F-285-R	Burbank Western Stormdrain at Riverside Drive	Validation
F-37B-R	Compton Creek near Greenleaf Drive	Validation
F252-R	Verdugo Wash at Estelle Avenue	Validation
F57C-R	Los Angeles River above Arroyo Seco	Validation
F34D-R	Los Angeles River below Firestone Boulevard	Validation
F319-R	Los Angeles River below Wardlow	Validation

Figure 10a depicts a time-series plot of modeled and observed daily flows at the bottom of the watershed (Los Angeles River below Wardlow River Rd.). A regression of average monthly model-predicted and observed flows (Figure 10b) indicates a slight under-prediction of measured flows. This under-prediction is due mostly to events occurring in the winter of 1992-1993 and 1994-1995 (Figure 10a). Flow volumes generated by the model were compared under different flow regimes and seasonal periods (Table 5-7). For higher flows (highest 10%), the model performs well in predicting storm volumes with an error of –4%. However, for lower flows (lowest 50%) the model is less accurate in predicting flow volumes (–17%) due largely to the inability of the model to simulate variability in point sources and dry-weather urban runoff. A review of the time-series plots also shows that the model is less accurate for low-flow conditions. This is justification for a separate approach for expressing dry-weather allocations and compliance assurance. Hydrology calibration and validation results, including time series plots and relative error tables, are presented for each gage in Appendix II.B.

Table 5-7. Volumes (acre-feet) and relative error of modeled flows versus observed flow for the Los Angeles River at Wardlow (10/1/1989 – 3/3/1998).

Flows Volumes	Simulated Flow	Observed Flow	Error (%)	Recommended Criteria (%)
Total Stream Volume	394,911	431,200	-9	±10
Highest 10% flows	307,787	320,578	-4	±15
Lowest 50% flows	39,309	46,158	-17	±10
Summer flow volume	20,205	24,797	-23	±30
Fall flow volume	70,661	63,764	10	±30
Winter flow volume	275,206	311,727	-13	±30
Spring flow volume	28,840	30,912	-7	±30

Overall, during model calibration the model predicted storm volumes and storm peaks well. Since the runoff and resulting streamflow are highly dependent on rainfall, occasional storms were over-predicted or under-predicted depending on the spatial variability of the meteorological and gage stations. The validation results also showed a good fit between modeled and observed values, thus confirming the applicability of the calibrated hydrologic parameters to the Los Angeles River watershed.

5.3.2. Calibration and Validation of the Wet-Weather Model - Pollutant Loading. Total suspended solids (TSS) and the potency factors used to determine the relationships between sediment and total metals were developed and calibrated by SCCWRP at specific watersheds in the Los Angeles area. These were validated for use in the Ballona Creek watershed. We did not re-calibrate these parameters for the Los Angeles River. Use of these parameters for the Los Angeles River was validated by comparing model output to in-stream water quality measurements collected during storms. In the validation process, we tested the ability of the model to predict 1) the event mean concentration (EMC) at the watershed scale, 2) the EMC at the sub-watershed scale and 3) changes in the instantaneous concentrations over the course of a storm.

The EMCs predicted by the model at the bottom of the watershed were comparable to EMCs calculated from composite measurements made by the LACDPW at the Wardlow Station (1994-2001). To evaluate the model performance at the sub-watershed scale, EMCs were calculated for Verdugo Wash, Arroyo Seco, Los Angeles River above Arroyo Seco and Los Angeles River at Wardlow based on storm water sampling that was conducted in 2001. Two to three storms were sampled at each of these subwatersheds. TSS and metals concentrations were measured numerous times (8 to 12) over the course of the individual storms. There is quite a bit of variability in the EMCs calculated from the monitoring data. The predicted EMCs for TSS were generally within the range of the calculated EMCs. The predicted EMCs for copper, lead and zinc were generally higher than the calculated EMCs. The model was not able to adequately represent the variability in concentrations within a storm at the sub-watershed scale.

We conclude that the wet-weather model performs better at the watershed level than at the sub-watershed level. The model provides reasonable estimates of storm water EMCs, but is not refined enough to predict instantaneous storm water concentrations. The EMCs for TSS were comparable to estimates based on storm water composites. The EMCs for copper, lead and zinc tend to be higher than predicted from storm water composite samples.

5.4. Summary of Linkage Analysis

The dry-weather model is able to predict flow and concentration in the Los Angeles River. The wet-weather model predicts storm flow reasonably well. Estimates of storm loadings predicted by the model tend to be higher than loadings estimated form monitoring data. The models were not used in developing load capacity but should prove useful in evaluating management scenarios to help achieve load reductions in TMDL implementation.

6. Total Maximum Daily Loads

In this section we develop the loading capacity and allocations for metals in the Los Angeles River. EPA regulations require that a TMDL include waste load allocations (WLAs), which identify the portion of the loading capacity allocated to existing and future point sources (40 CFR 130.2(h)). It is not necessary that every individual point source have a portion of the pollutant allocation 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 flows, sources of metals and the relative magnitude of inputs vary between dry-weather and wet-weather periods. TMDLs are developed to address both dry and wet-weather conditions.

6.1 Dry-Weather Loading Capacity and TMDL

The dry-weather loading capacity for each of the listed reaches was determined by multiplying the reach-specific dry-weather targets expressed as a total recoverable metals (Table 3-2) by a critical flow assigned to each reach.

Dry-weather flows in the Los Angeles River are influenced highly by the amount of effluent discharge and by the presence of dams on the tributaries. Critical flows for each reach were established from the long-term flow records (1988-2000) generated by stream gages located throughout the watershed. In general, the median flow was selected as the critical flow. In areas where there were no flow records, an area-weighted approach was used to assign flows to these reaches. In reaches with POTW discharge, the critical flow was set equal to the median flow plus the design capacity of the POTWs that discharge to these reaches. To account for flow from Tillman the design flow of 124 cfs was applied to Reach 4. Similarly, 31 cfs was applied to Reach 3 to for flows from the Glendale plant and a design flow of 14 cfs was applied to the Burbank Western Channel to account for flows from the Burbank plant. Because these three major POTWs account for the majority of flow during dry weather, dry-weather flow is relatively constant. Critical dry-weather flows are presented in Table 6-1.

The critical flow for the entire river is thus equal to the design capacity of the three POTWs (169 cfs) plus the existing median flow from the storm drains and tributaries (34 cfs). The flow from the storm drains and tributaries is calculated by subtracting the existing combined median flow of the three POTWs (111 cfs) from the existing total median flow of the river as measured at Wardlow (145 cfs). The dry-weather loading capacity for each reach based on these critical flows is identified in Table 6-2.

Table 6-1. Critical dry-weather flows used to set dry-weather loading capacity.

Los Angeles River	Area of Subwatershed (acres)	Median Non-POTW Flow (cfs)	POTW design flow (cfs)	Critical Flow (cfs)
LA River Reach 6	53,860	7.27	-	7.27
LA River Reach 5	5593	0.75	-	0.75
LA River Reach 4	38,380	5.18	124.0	129.2
LA River Reach 3	36,231	4.89	31.0	35.9
LA River Reach 2	28,893	3.90	-	3.90
LA River Reach 1	19,330	2.61	-	2.61
Tributaries				
Bell Creek	11,357	0.55	-	0.55
Tujunga Wash	14,7448	0.15	-	0.15
Burbank-Western Channel	18,674	3.34	14.0	17.3
Verdugo Wash	16,117	3.30	-	3.3
Arroyo Seco	32,271	0.58	-	0.58
Rio Hondo	96,425	0.50	-	0.50
Compton Creek	25,506	0.90	-	0.90
Total	530,086	34	-	203

Table 6-2. Dry-weather loading capacity (TMDL) for the Los Angeles River and listed tributaries for total metals (kg/day)

Los Angeles River	Critical Flow (cfs)	Copper	Lead	Zinc
LA River Reach 6	7.27	0.54	0.39	
LA River Reach 5	0.75	0.06	0.04	
LA River Reach 4	129	8.11	3.16	
LA River Reach 3	36	2.30	1.03	
LA River Reach 2	3.90	0.21	0.11	
LA River Reach 1	2.61	0.15	0.08	
Tributaries	**Critical Flow (cfs)**	**Copper**	**Lead**	
Bell Creek	0.55	0.04	0.03	
Tujunga Wash	0.15	0.01	<0.01	
Verdugo Wash	3.3	0.18	0.10	
Burbank Western Channel	17.3	0.79	0.38	
Arroyo Seco	0.58	0.03	0.02	
Rio Hondo	0.50	0.02	0.01	
Compton Creek	0.90	0.04	0.02	

1. All Tillman flow assigned to Reach 4 for accounting purposes only.
2. Targets for Tujunga Wash, Verdugo Wash, and Arroyo Seco based on hardness in Los Angeles River

6.2 Dry-Weather Allocations

Mass-based waste load allocations were developed for the three POTWs (Tillman, Glendale, and Burbank) and a grouped mass-based waste load allocation was developed for storm water permitees (Los Angeles County MS4, the Long Beach MS4, Caltrans, General Industrial and General Construction). Concentration-based waste load allocations are developed for other point sources in the watershed.

6.2.1. Dry-weather waste load allocations for POTWs. Mass-based waste load allocations for Tillman, Los Angeles-Glendale and Burbank POTWs were developed (Table 6-3) to meet the reach-specific dry-weather targets for copper and lead (Table 3-2). For Tillman, the in-stream targets were based on 4 of the Los Angeles River below the plant. For Glendale, the in-stream targets are based on Reach 3 of the Los Angeles River below the Glendale Plant. The site-specific translator values for copper were used to adjust the targets for the area downstream of Tillman (Reach 4) and Glendale (Reach 3). For Burbank, the in-stream targets were based on conditions in the Burbank Western Channel downstream of the Burbank WRP.

The waste load allocations for each plant were calculated using procedures in the SIP to develop permit limits. The SIP procedures employ statistical analyses of effluent data to calculate daily maximum and 30-day average limits that ensure attainment with acute and chronic standards which are typically based on 1 hour and 4 day time frames respectively. The 30-day mass-based allocations were developed by multiplying the 30-day concentration limit by the design flow for each plant and expressing these in terms of kg/day. The daily mass-based allocations were developed by multiplying the target (Table 3-2) by the design flow. [NEED TO EXPLAIN THAT DAILY MAX PERMIT LIMIT BASED ON NEED TO MEET 4-DAY CHRONIC AND TMDL EXPRESSED AS DAILY]

Table 6-3. Proposed dry-weather waste load allocations for three POTWs (expressed as total metals)

Facility	Design Flow (cfs)	Avg Period	Copper	Lead (Kg/d)
Tillman	124	30-day conc	18 ug/l	7 ug/l
		30-day mass	5.5 Kg/d	2.1 Kg/d
		Daily max conc	27 ug/l	18 ug/l
		Daily max (mass)	7.8 Kg/d	3.0 Kg/d
Glendale	31	30-day conc	19 ug/l	8 ug/l
		30-day mass	1.4 Kg/d	0.6 Kg/d
		Daily max conc	35 ug/l	22 ug/l
		Daily max (mass)	1.2 Kg/d	??
Burbank	14	30-day conc	13 ug/l	6 ug/l
		30-day mass	0.4 Kg/d	0.2 Kg/d
		Daily max conc	27 ug/l	17 ug/l
		Daily max (mass)	0.5 Kg/d	0.7 Kg/d

6.2.2. Dry-weather waste load allocations for storm water permittees. A dry-weather mass-based waste load allocation has been developed for municipal storm water permittees (Table 6-4). It was calculated by multiplying reach specific median flows (minus median POTW flows) by reach-specific numeric targets. The allocations for storm water require that water quality standards be met within the receiving water for each of the reaches rather than at the end-of-pipe. The load allocations to the storm water

Table 6-4. Mass-based dry-weather waste allocations for storm water permittees (expressed as total metals)

Los Angeles River	**Critical Flow (cfs)**	**Copper (kg/day)**	**Lead (kg/day)**	**Zinc (Kg/d)ay**
LA River Reach 6	7.27	0.54	0.39	
LA River Reach 5	0.75	0.06	0.04	
LA River Reach 4	5.18	0.33	0.13	
LA River Reach 3	4.90	0.28	0.15	
LA River Reach 2	3.90	0.21	0.11	
LA River Reach 1	2.61	0.15	0.08	
Tributaries	**Critical Flow**	**Copper**	**Lead**	**Zinc**
Bell Creek	0.55	0.04	0.03	
Tujunga Wash (R4)	0.15	[redacted]	<0.01	
Verdugo Wash (R3)	3.3	0.18	0.10	
Burbank Western Channel (R3)	3.34	0.15	0.07	
Arroyo Seco (R2)	0.58	0.03	0.02	
Rio Hondo	0.50	[redacted]	[redacted]	[redacted]
Compton Creek (R1)	0.90	[redacted]	[redacted]	

6.2.3. Dry-weather waste load allocations for other NPDES permits.

Concentration-based waste load allocations have been developed for the minor NPDES dischargers and other major NPDES discharges (non-POTW). This was done since there is insufficient flow information from these discharges to develop individual mass-based waste load allocation and the expense of obtaining accurate flow measurements required for calculating loads is impractical. Concentration-based waste load allocations, based on reach-specific dry-weather numeric targets, expressed as total metals, to be applied to these permits are provided in Table 6-5.

Table 6-5. Concentration-based dry-weather waste load allocations (adjusted for hardness by reach) in terms of total metals concentrations (µg/L) for NPDES discharges, excluding Tillman, LA-Glendale, and Burbank POTWs

Los Angeles River	**Cu**	**Pb**	**Zn**	**Se**
LA River Reach 6	30	22		5
LA River Reach 5	30	22		
LA River Reach 4	26*	10		
LA Reach 3	26*	12		
LA Reach 2	22	11		
LA Reach 1	23	12		
Tributaries	Cu	Pb		
Bell Creek	30	22		5
Tujunga Wash	20	10		
Verdugo Wash	23	12		
Burbank (above Burbank WTP)	26	14		
Burbank (below Burbank WTP)	19	9.1		
Arroyo Seco	22	11		
Compton Creek	[redacted]	8.9		
Rio Hondo	[redacted]	5.0	[redacted]	
Monrovia Canyon Creek	18	8.2		

*Site-specific copper translators were used to adjust the targets downstream of Tillman and Glendale.

6.2.4. Dry-weather load allocation. We did not develop a dry-weather load allocation for cooper, lead, or zinc from natural background sources because most of the land area in the watershed is covered under the storm water permit. The exception is the area of the Angeles National Forest and the open areas of the Santa Monica Mountains. No allocation was given to these areas because dry-weather loads of copper and lead from these areas are thought to be insignificant. Little if any natural flow from these areas reaches the listed areas of the Los Angeles River watershed and the background metals concentrations associated with these flows are expected to be low. We did not develop allocations for atmospheric deposition because the loadings associated with direct deposition are insignificant relative to the total allowable load (less than 0.05%)

A concentration-based load allocation equal to 5 µg/L for selenium has been assigned to Reach 6 and its tributaries. This load allocation has not been assigned to a particular nonpoint source or group of nonpoint sources because the sources of selenium are uncertain. Separate studies are underway to evaluate whether selenium levels represent a natural condition for this watershed.

6.3. Wet-Weather Loading Capacity (Load-Duration Curves) and TMDLs

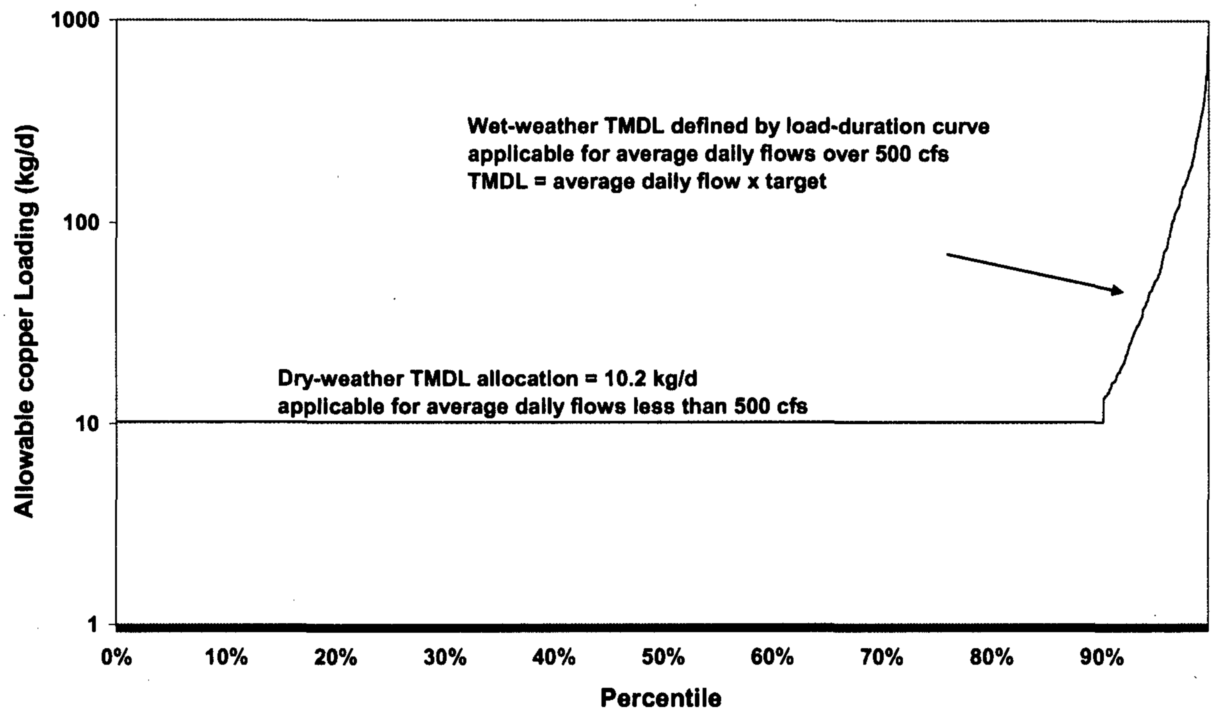
During wet weather, the allowable load is a function of the volume of water in the river. Given the variability in wet-weather flows, the concept of a single critical flow is not justified. Instead, a load-duration curve approach is used to establish the wet-weather loading capacity. In brief, a load-duration curve is developed by multiplying the wet-weather flows by the in-stream numeric target. The result is a curve which identifies the allowable load for a given flow. The wet-weather TMDLs for metals are defined by these load-duration curves. The wet-weather loading TMDLs apply for storm flows greater than 500 cfs, which represents the 90^{th} percentile flow.

Table 6-6. Wet-weather load capacity (TMDLs) for metals expressed in terms of total recoverable metal

Metal	Load Duration Curve
Cadmium	Storm volume x 3.1 µg/L
Copper	Storm volume x 17 µg/L
Lead	Storm volume x 62 µg/L
Zinc	Storm volume x 159 µg/L

An example of a load duration curve is presented in Figure x. For practical purposes the wet-weather loading capacity defined using the load-duration curve is equivalent to a storm water event-mean concentration based on a flow weighted composite.

Total Maximum Daily Load for Copper



6.4 Wet-Weather Allocations

6.4.1. Wet-weather waste load allocations for POTWs. During wet weather, the Tillman, LA-Glendale, and Burbank POTWs will retain the concentration-based waste load allocations assigned for dry weather (Table 6-3) but the mass discharge limitations will not apply when influent flows exceed the design capacity of the treatment plants. The POTW loads represent an insignificant fraction of the total metals loading during large storms.

6.4.2. Wet-weather waste load allocations for storm water permittees. EPA allows allocations for NPDES-regulated municipal storm water discharges from multiple point sources to be expressed as a single categorical waste load allocation when data and information are insufficient to assign each source or outfall an individual allocation. We recognize that these municipal storm water allocations may be fairly rudimentary because of data limitations and variability in the system. Mass-based waste load allocations for cadmium, copper, lead, and zinc for the MS4 and Caltrans storm water permittees are equal to the daily flow multiplied by the numeric targets, which have been converted to total recoverable metals using applicable translators (see section 3.2). The wet-weather mass-based loading capacities are expressed as load duration curves. The mass-based wet-weather and waste load and load allocations are expressed as percentage of the loadings defined in the load duration curves (Table 6-7).

Table 6-7. Wet-weather mass-based waste load allocations and load allocations for metals (expressed as a percentage of total wet-weather loadings)

Waste Load Allocations	Cadmium	Copper	Lead	Zinc
MS4 Permit	97.5%	94.1%	96.2%	95.3%
Caltrans Storm water Permit	1.3%	1.3%	1.3%	1.3%
General Industrial Storm water	1.2%	1.2%	1.2%	1.2%
General Construction Storm water	0.4%	0.4%	0.4%	0.4%
Load Allocations	**Cadmium**	**Copper**	**Lead**	**Zinc**
Parks and open space (LA for non-permitted runoff)	??%	2.8%	0.7%	1.6%
Water (LA for direct atmospheric dep)	0.2%	0.2%	0.2%	0.2%

6.4.3. Wet-weather waste load allocations for other NPDES permits. Concentration-based WLAs are established for individual NPDES permits (other than POTW) and general NPDES permits (other than storm water permitees) that discharge to the Los Angeles River and its tributaries to ensure that these do not contribute significant loadings to the system. This was done since there is insufficient information to develop individual mass-based WLAs. The concentration-based WLAs are based on CTR targets adjusted for hardness and expressed as total recoverable metals. (Table 6-8.)

Table 6-8. Concentration-based wet -weather waste load allocations for total recoverable metals (µg/L).

Cadmium	Copper	Lead	Zinc
3.1	17	62	159

6.4.4. Wet-weather load allocations. 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. Based on results from wet-weather model, the wet-weather loadings from open space for cadmium, copper, lead and zinc are believed to be minor (Table 6-8). The percent contribution from open space was used to develop the open space load allocation (Table 6-7). An estimate of direct atmospheric deposition was developed based on the percent area of surface water which is about 0.2% of the total watershed area (Table 6-7). The load allocation for atmospheric deposition was based on this percentage. The loadings associated with indirect deposition are included in the wet weather storm water waste load allocations.

Table 6-7. Land use contributions to total metal loads from surface runoff from the Los Angeles River watershed. Add Source

Land Use	Cadmium	Copper	Lead	Zinc
Agriculture	?	0.5%	0.2%	0.5%
Commercial	?	13.4%	18.6%	18.2%
Industrial	?	11.2%	9.1%	19.9%
Mixed Urban	?	0.7%	0.3%	0.6%
Residential	?	71.5%	71.1%	59.3%
Open Space	?	2.8%	0.7%	1.6%

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. There is an implicit margin of safety that stems from the use of conservative values for the translation from total to the dissolved fraction during the dry and wet periods. In addition, the TMDL includes a margin of safety by evaluating wet-weather conditions separately from dry-weather conditions, which is in effect, assigning allocations for two distinct critical conditions.

7. IMPLEMENTATION

In this section, we describe the implementation procedures that will be used to provide reasonable assurances that water quality standards will be met.

The concentration-based waste load allocations for industrial and construction storm water discharges, minor NPDES discharges, NPDES discharges covered under a general permit and major NPDES discharges excluding the Tillman, LA-Glendale, and Burbank POTWs will be implemented through NPDES permit limits. Reach-specific dry-weather waste load allocations are described in Table 6-4 and 6-5. Dry-weather concentration based targets are presented in Table 6-6. Wet-weather targets are expressed as load-duration curves described in Table 6-6 and mass-based waste load allocations are expressed as percentage (Table 6-9). Concentration-based limits are presented in Table 6-7. Permit writers for the non-storm water permits may translate waste load allocations into effluent limits by applying the SIP procedures or other applicable engineering practices. Compliance schedules may be established in NPDES permits, allowing up to 5 years within a permit cycle to achieve compliance.

The Regional Board will develop watershed specific general industrial and construction storm water permits to incorporate waste load allocations. It is expected that permit writers will translate waste load allocations into BMPs. However, permit writers must provide adequate justification and documentation to demonstrate that specified BMPs are expected to result in attainment of the numeric waste load allocations.

The general storm water permits shall contain a model monitoring and reporting program to evaluate BMP effectiveness. A permittee enrolled under the general permits shall have the choice of conducting individual monitoring based on the model program or participating in a group monitoring effort. MS4 permittees are encouraged to take the lead in group monitoring efforts for industrial and construction facilities within their jurisdiction because compliance with waste load allocations by these facilities will translate to reductions in metals loads to the MS4 system. General industrial and construction storm water permittees are allowed interim waste load allocations based on benchmarks contained in EPA's Storm Water Multi-sector General Permit for Industrial Activities. The interim waste load allocations apply to all industry sectors and will apply for a period not to exceed ten years from the effective date of the TMDL.

Table 34. Interim wet- and dry- WLAs for general industrial and construction storm water permittees, expressed as total recoverable metals (µg/L):

Cadmium	Copper	Lead	Zinc
15.9	63.6	81.6	117

A grouped mass-based waste load allocation has been developed for the storm water system. EPA regulation allows allocations for NPDES-regulated storm water discharges from multiple point sources to be expressed as a single categorical waste load allocation when the data and information are insufficient to assign each source or outfall individual WLAs. The grouped allocation will apply to all NPDES-regulated municipal storm water discharges in the Los

Angeles watershed including the Los Angeles County MS4 permit, the City of Long Beach MS4 permit, the Caltrans storm water permit, the General Industrial storm water permit and the General Construction storm water permit.

EPA policy requires that the waste load allocations for storm water be expressed in numeric form. For the dry-weather condition, mass-based waste load allocations (Table 6-4) or concentration-based waste load allocations (Table 6-5) will be incorporated into the permits of the NPDES-regulated municipal storm water discharges. For wet weather, the municipal storm water waste load allocations are expressed as load capacity curves (Table 6-6). We envision that these will be allocated to each jurisdiction within the drainage to each reach.

A load-duration curve for the Los Angeles River was established using the 12-year flow record from the LACDPW station at Wardlow. Loading capacities were then calculated by multiplying daily flows by the numeric water quality target for each metal expressed as total recoverable metals concentrations (Table 6-3). The metals loading capacities are plotted in load-duration curves provided in Figure 11.

Figures 12 a-12c present the estimated load reductions needed to meet the wet-weather mass-based waste load allocations. In these figures, allowable loads are plotted against storm volume to assist permittees in the design of BMPs to achieve the necessary load reductions. As described in section 5.2, The LSPC model was used to simulate storm volumes and associated loads over a 12-year period. For these figures, the loading capacity is a green line, the model-predicted historical loads below the loading capacity are shaded with blue and the model-predicted historical loads above the loading capacity are shaded with red. Because the model tends to overestimate loads, actual reductions needed to meet the waste load allocations are likely less than predicted by the load-duration curves. Wet-weather historical loadings for cadmium were not modeled in this TMDL. A data review (section 2.2) provided little evidence of wet-weather exceedances for cadmium and estimates of wet-weather loadings of cadmium (LACDPW, 2000 and Ackerman and Schiff, 2003) were well below the allowable load.

Each municipality and permittee will be required to meet the waste load allocations, and will not necessarily be given a specific allocation for their jurisdiction or land uses under their jurisdiction. Therefore, the focus of compliance 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. The information provided in Table 5-7 is intended to help storm water permittees identify areas of high pollutant loading and may be used to target BMPs.

8. MONITORING

There are three objectives of the monitoring program. The first is to collect data (e.g., hardness, flow, and background concentrations) to evaluate the uncertainties and assumptions made in development of the TMDL. The second is to collect data to assess compliance with the waste load allocations. The third is to collect data to evaluate potential management scenarios. To achieve these objectives, the monitoring program for the TMDL consists of three components: (1) ambient monitoring, (2) compliance assessment monitoring and (3) special studies.

8.1 Ambient Monitoring

An ambient monitoring program is required to assess water quality throughout the Los Angeles River and its tributaries. The NPDES permittees assigned waste load allocations are jointly responsible for implementing the ambient monitoring program. The responsible agencies shall sample for total metals, dissolved metals, and hardness once per month at each ambient monitoring location. There are eight proposed ambient monitoring points on the Los Angeles River to reflect the reaches and the monitoring stations (Table 8-1). These stations correspond to the City of Los Angeles Watershed Monitoring Stations. The City currently samples for metals at these eight monitoring stations once per month. In early 2004, the City began sampling for hardness with the same frequency. The City plans to extend and modify their program to include metals sampling of the tributaries in the future.

Table 8-1. Ambient Monitoring Points on the Los Angeles River.

Ambient Monitoring Points	Corresponding Reaches
White Oak Avenue	LA River 6, Aliso Creek, McCoy Creek, Bell Creek
Sepulveda Avenue	LA River 5, Bull Creek
Tujunga Avenue	LA River 4, Tujunga Wash
Colorado Avenue	LA River 3, Burbank Western Channel, Verdugo Wash
Figueroa Street	LA River 3, Arroyo Seco
Washington Boulevard	LA River 2
Rosecrans Avenue	LA River 2, Rio Hondo
Willow Street	LA River 1, Compton Creek

8.2 TMDL Effectiveness Monitoring

The compliance assessment monitoring requirements for TMDL implementation will be specified in NPDES permits for the Tillman, LA-Glendale, and Burbank POTWs and the storm water permits. The permits should specify the monitoring necessary to determine if the expected load reductions are achieved. This is particularly critical for the storm water permits where the expectation is that load reductions will be achieved through application of BMPs.

For the Tillman, LA-Glendale, and Burbank POTWs, effluent monitoring requirements will be developed to ensure compliance with the daily and monthly limits for metals. Receiving water monitoring requirements in the existing permits to assess impact of the POTWs will not change as a result of this TMDL.

The storm water NPDES permittees are jointly responsible for assessing the effectiveness of the TMDL. The storm water NPDES permittees are required to submit for approval by the executive officer a coordinated monitoring plan that will demonstrate the effectiveness of the phased implementation schedule for this TMDL which requires that the waste load allocations be met in prescribed percentages of the watershed over a 22-year period. The monitoring locations specified for the ambient monitoring program (Table 8-1) may be used as effectiveness monitoring locations.

The storm water NPDES permittees will be found to be effectively meeting the dry-weather waste load allocations if the in-stream pollutant concentration or load at the first downstream effectiveness monitoring location is equal to or less than the corresponding concentration- or load-based waste load allocation. Alternatively, effectiveness of the TMDL 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 waste load allocation will be based on the waste load allocation for the ultimate receiving water for that storm drain system.

The storm water NPDES permittees will be found to be effectively meeting wet-weather waste load allocations if the loading at the downstream monitoring location (Wardlow) is equal to or less then the daily flow multiplied by the wet-weather numeric targets (converted to total recoverable metals using applicable translators) as defined in Table 6-6. For practical purposes this is when the EMC is less than or equal to the numeric target.

8.3 Special Studies

Additional monitoring and special studies may be needed to evaluate the uncertainties and the assumptions made in development of this TMDL.

1. Flow measurements. Better information is needed to define flow in the mainstem of the Los Angeles River and the tributaries where there are no stream gages. The biggest uncertainties are associated with low-flow in some of the listed tributaries. Better information is also needed about contributions of storm drains during low flow.

2. Water quality measurements. Information on background water quality will help refine the targets. Specifically, studies should be developed to provide a better assessment of background hardness values in areas where the data is old (lower reaches of Los Angeles River) or non-existent (Tujunga, Verdugo Wash, Arroyo Seco). Studies on background concentrations of total suspended solids and organic carbon will help with the refinement of the use of partition coefficients to define metals translators.

3. Effects studies. Special studies may be warranted to evaluate the targets. Los Angeles County Sanitation District and others are testing an approach to use the Biotic Ligand Model in the Los Angeles Region. Measurements of dissolved organic carbon, alkalinity, humic acid, and alkali/alkaline metals would support this effort.

4. Source studies. There is a need for better characterization of the loadings from natural sources to verify the assumptions that the loadings from natural sources for copper, lead and zinc

are generally low. A study should also be developed to verify the assumption that selenium concentrations observed in the upper reaches of the Los Angeles River are from natural background sources.

5. Other special studies. Special studies should also be considered to refine some of the assumptions used in the modeling, specifically the relationship between total and dissolved metals in storm water, the assumption that metals loadings are closely associated with suspended sediments, the accuracy and robustness of the potency factors, and the uncertainties in the understanding sediment washoff and transport. Studies should also be considered to evaluate the potential contribution of aerial deposition to metals loadings and sources of aerial deposition.

6. POTWs that are unable to demonstrate compliance with final waste load allocations must conduct source reduction audits within two years of the effective date of the TMDL.

7. POTWs that will be requesting the Regional Board to extend their implementation schedule to allow for the installation of advanced treatment must prepare work plans with time schedules to allow for the installation and operation of advanced treatment. The work plan must be submitted within four years from the effective date of the TMDL.

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