Appendix A

Draft Multi-Pollutant TMDL Implementation for the Unincorporated County Area of Ballona Creek (October 26, 2009)

Total Maximum Daily Load for Bacterial Indicator Densities in Ballona Creek, Ballona Estuary, and Sepulveda Channel – Draft Implementation Plan (November 30, 2009)

DRAFT

Multi-Pollutant TMDL Implementation for the Unincorporated County Area of Ballona Creek

Submitted to:

California Regional Water Quality
Control Board — Los Angeles Region
320 West 4th Street, Suite 200
Los Angeles, CA 90013-2343

Submitted by:

County of Los Angeles
Chief Executive Office
Kenneth Hahn Hall of Administration
500 W. Temple Street
Los Angeles, CA 90012

October 26, 2009

Executive Summary

This report documents the results of the County of Los Angeles effort to address impairments in the Ballona Creek watershed with a comprehensive, phased approach of best management practice (BMP) implementation. The goal of the multi-pollutant implementation plan is to address all current Total Maximum Daily Loads (TMDLs) established for waters within the Ballona Creek watershed. The metals, bacteria, and toxics TMDLs are considered the primary focus of this implementation plan. A secondary focus is placed on trash, because reporting on progress toward TMDL implementation occurs annually and through a separate process.

This implementation plan describes management options that are limited to unincorporated County areas outside federal lands. To develop this plan, BMPs to treat stormwater and dry weather flows to reduce metals, bacteria, and toxic pollutants were identified and selected. As part of this process, benefits of management activities were estimated, in terms of pollutant load reductions or improvement in water quality, to meet wasteload allocations (WLAs) defined by approved TMDLs. The process of BMP selection included considering cost-effectiveness to provide assurance that the plan is practical and implementable. The plan also includes integrated water resources approaches that consider BMPs that can address multiple pollutants cost-effectively, while considering parallel water resources planning strategies for the watershed.

The TMDLs include schedules for implementing associated WLAs. For metals and bacteria WLAs, different implementation schedules are defined for wet and dry weather. However, the metals implementation schedules are based on phases expressed as the percent of total drainage area served by the municipal separate storm sewer system (MS4) that is effectively meeting the WLAs. The phases can be considered as interim goals for developing strategies to address TMDL implementation. The toxic pollutant WLAs are also scheduled for phased implementation based on percent of drainage area meeting the WLAs, although they are only defined for wet weather. A summary of the various WLAs and associated compliance schedules are summarized in the Table ES-1.

Table ES-1. WLA Implementation Schedules for Ballona Creek TMDLs

TMDL[a]	Flow Addressed	Interim Phased Implementation	Final Compliance[b]
Metals	Wet weather	• January 11, 2012: 25% of total drainage area • January 11, 2016: 50% of total drainage area	January 11, 2021: 100% of total drainage area
	Dry weather	• January 11, 2012: 50%of total drainage area • January 11, 2014: 75% of total drainage area	January 11, 2016: 100% of total drainage area
Bacteria	Wet weather	Not applicable	July 15, 2021
	Dry weather	Not applicable	April 27, 2013
Toxics	Wet weather	• January 11, 2013: 25% of total drainage area • January 11, 2015: 50% of total drainage area • January 11, 2017: 75% of total drainage area	January 11, 2021: 100% of total drainage area

a. Trash not included due to separate implementation planning and progress reporting process.
b. Assumes an integrated water resources approach.

To meet the phased TMDL implementation schedules, a combination of structural and nonstructural BMPs were identified to be implemented in increasing number and intensity. A self-evaluation was conducted to identify opportunities for improvements to existing nonstructural BMPs and new nonstructural BMPs that would support meeting WLAs. Table ES-2 lists the new nonstructural BMPs, enhancements to existing nonstructural BMPs, and the TMDL pollutants and flow conditions addressed.

Table ES-2. Summary of Nonstructural Solutions to Support TMDL Implementation

Structural BMP	Flow Addressed		TMDL Pollutant Addressed			
	Wet Weather	Dry Weather	Bacteria	Metals	Non-Metal Toxics	Trash
Enhancements to Existing BMPs						
Smart Gardening Program Enhancements	✓	✓	◗	◗	◗	○
TMDL-specific Stormwater Training	✓	✓	◗	◗	◗	◗
Enhancement of Commercial and Industrial Facility Inspections	✓	✓	◗	◗	◗	○
Enforcement Escalation Procedures	✓	✓	◗	●	◗	○
New BMP						
Reduction of Irrigation Return Flow	✓	✓	●	●	◗	○

● addresses the pollutant
◗ partially addresses the pollutant
○ does not address the pollutant

For identification of structural BMPs, both distributed and centralized BMPs were considered. Distributed BMPs refer to those practices that provide the control or treatment (or both) of stormwater runoff at the site level. Centralized BMPs refer to stormwater treatment, storage, or infiltration facilities that provide benefits on a larger scale (e.g., regional). Table ES-3 summarizes the structural BMPs identified to address TMDL implementation.

Table ES-3. Summary of Structural Solutions to Support TMDL Implementation

Structural BMP	Flow Addressed		TMDL Pollutant Addressed			
	Wet Weather	Dry Weather	Bacteria	Metals	Non-Metal Toxics	Trash
Catch Basin Distributed BMPs						
Full Capture Devices	✓		○	○	○	●
Catch Basin Inserts	✓		○	●	◗	●
Other Public Property Distributed BMPs						
Distributed BMPs on Public Land	✓	✓	●	●	●	●
Pilot Distributed BMP Project for a County Road	✓	✓	●	●	●	●
Centralized BMPs on Public Land						
West Los Angeles Community College	✓	✓	●	●	●	●
Ladera Park	✓	✓	●	●	●	●
Centralized BMPs on Private Land						
Infiltration Basins	✓	✓	●	●	●	●
Dry Detention Basins	✓	✓	●	●	●	●

● addresses the pollutant
◗ partially addresses the pollutant
○ does not address the pollutant

Qualitative and quantitative analyses were performed to evaluate the ability of BMPs to meet load reduction targets associated with WLAs. For most nonstructural BMPs, quantification of benefits in terms of pollutant load reductions are challenging and often require extensive survey and monitoring information to gage performace. For the purposes of this plan, a qualitative approach was used to evaluate the effectiveness and feasibility of the nonstructural BMPs. Additional modeling analysis was performed to provide optimization of the most cost-effective combination and size of structural BMPs to meet WLAs. Two optimization scenarios were formulated as shown in Table ES-4. Figure ES-1 summarizes results of optimization for zinc, which was determined the limiting pollutant for metals (i.e., controlling zinc tends to ensure that other metals WLAs are met). Table ES-5 summarizes specific points in the optimization curve, including the type of BMPs considered and associated pollutant load reductions achieved. Results are based on simulation of hydrologic year 2003, which was determined to best represent typical rainfall frequencies and magnitudes observed over the recent 20-year rainfall record.

Table ES-4. Optimization Scenario Matrix

Scenario	Baseline Scenario (Catch Basin Inserts and Reduction of Irrigation Return Flows)	Structural BMPs	
		Public Centralized and Distributed	Private Centralized
1	Fixed	Variable	
2	Fixed	Fixed (Optimal solution derived in 1)	Variable

Fixed: Corresponding BMPs are included as a fixed condition
Variable: Corresponding BMPs are included as decision variables to be optimized for cost-effectiveness

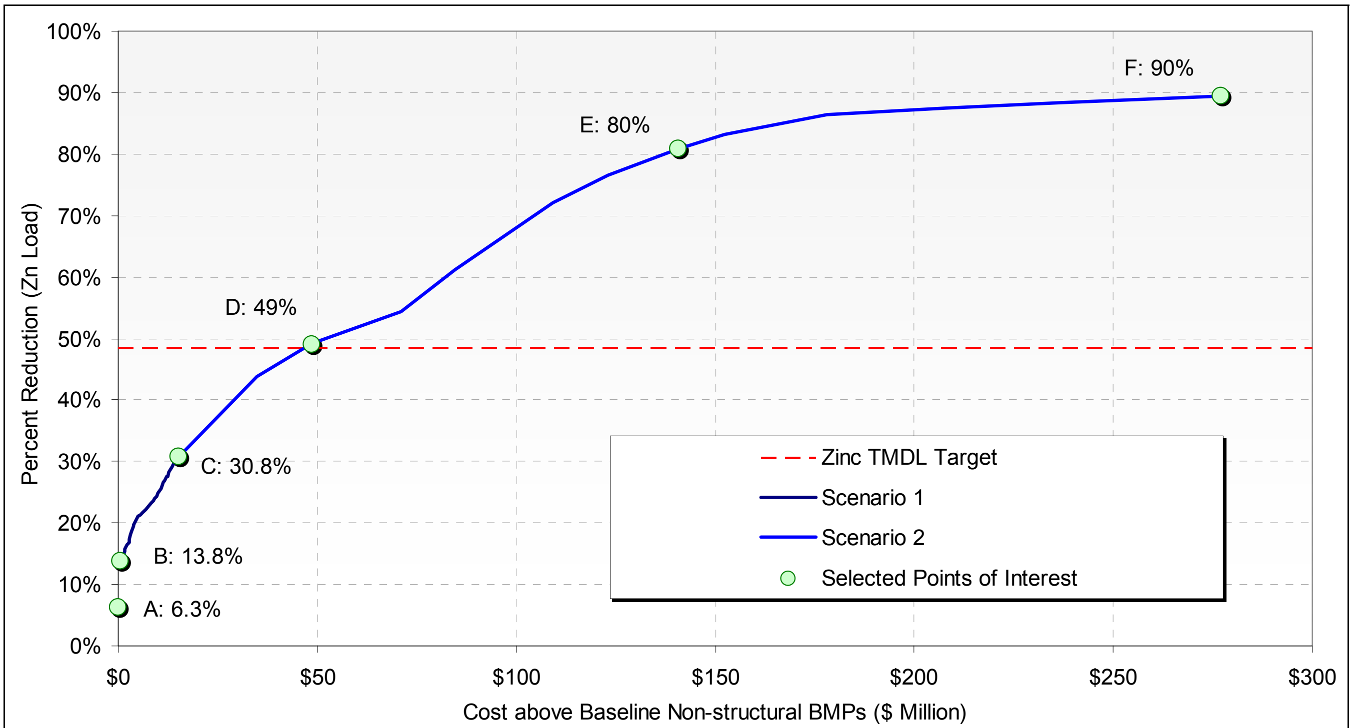


Figure ES-1. Pollutant Reduction vs. Minimum Cost Relationship Derived from Scenarios 1 and 2

Table ES-5. Costs and Pollutants Reduction of the Selected Solutions Corresponding to Figure ES-1

Pollutants	Existing Load (lb/yr)	TMDL Reduction Targets (%)	A: Baseline Scenario	Scenario 1		Scenario 2		
				B: Public Central.	C: Public Max	D: Metals TMDL	E	F
TSS (lb/yr)	268,422	90%	5.9%	13%	37%	52%	81%	88%
Copper (lb/yr)	97	24%	6.3%	14%	31%	46%	79%	88%
Lead (lb/yr)	85	0%	7.4%	15%	22%	42%	78%	88%
Zinc (lb/yr)	944	48%	6.2%	14%	31%	49%	81%	90%
F.C. Exceedance Days (days/yr)	35	78%	5.9%	6%	6%	10%	10%	10%
F.C. Counts (#/yr)	1.40E+14	--	1.4%	9%	15%	43%	75%	87%

The following conclusions were drawn from the optimization analysis:

- The metals TMDL reduction target (indicated as 48 percent reduction in zinc annual load) can be met by implementing centralized BMPs on public and private land.
- For bacteria, additional structural BMPs showed minimal effect at reducing the number of exceedance days. Evaluation of bacteria load reduction (#/year) confirmed that structural BMPs provided a significant reduction in bacteria total counts, which is achieved primarily through stormwater volume reduction. Direct source control (i.e., nonstructural BMPs) is assumed to provide a more reliable method of controlling bacteria levels than structural BMPs, when the exceedance days objective is considered.
- The results for modeled TSS can be assumed consistent for toxics, which are typically transported with TSS during wet weather. To achieve the toxics WLAs with structural BMPs only, a 91 percent reduction in TSS is required. This is not a cost-effective solution, therefore additional nonstructural BMPs are required to address the toxics WLAs. However, meeting the metals TMDL reduction target will result in 52 percent TSS (and potentially associated toxics), providing some progress toward meeting the WLAs.

The optimization results provided the foundation for BMP strategies recommended for phasing of TMDL implementation. Results informed the recommended order and phasing for the structural BMPs and one nonstructural BMP (reduction in irrigation return flow). The remaining nonstructural BMPs were placed in implementation phases on the basis of the feasibility of accomplishing a BMP within a phase and the need for achieving a WLAs requirement by a certain date.

The TMDL Implementation Plan provides the timing and planning-level costs for BMPs in the unincorporated County areas of the Ballona Creek watershed. Table ES-6 summarizes the BMP strategies to meet phased WLAs. These stategies will be implemented by the County as funding becomes available.

This TMDL Implementation Plan is meant to be iterative and adaptive to allow for modifcations informed by continued study of the drainage system and diagnosis of problem sources or storm drains, and new technologies for dry and wet weather treatment that continue to emerge.

Table ES-6. Recommended TMDL Implementation BMPs

Phase	BMP Type	Cost
1	Structural BMP: Ladera Park Centralized BMP - Infiltration Basin	$3,150,000
	Structural BMP: West Los Angeles Community College Centralized BMP - Detention Basin	$1,460,000
	Structural BMPs: Pilot Distributed BMP Project for a County Road	$210,000
	Structural BMPs: Distributed BMPs on Public Land	$3,180,000
	Nonstructural BMPs: TMDL-specific Stormwater Training	$326,000
	Nonstructural BMPs: Commercial and Industrial Facility Inspection Audits	$11,000
	Nonstructural BMPs: Smart Gardening Workshops in Ballona Creek	$5,000
	Total Phase 1 Costs	**$8,342,000**
2	Nonstructural BMPs: Smart Gardening Workshops in Ballona Creek	$44,000
	Nonstructural BMPs: Smart Gardening Tip Cards on Water Quality	$4,000
	Structural BMPs: Catch Basin Inserts (30% of catch basins)	$800,000
	Structural BMPs: Distributed BMPs on Public Land	$7,230,000
	Nonstructural BMPs: Reduction in Irrigation Return Flow	$1,160,000
	Nonstructural BMPs: Strengthen Enforcement of Violations Identified	$0
	Total Phase 2 Costs	**$9,238,000**
3	Structural BMPs: Distributed BMPs on Public Land	$950,000
	Structural BMPs: Centralized BMPs on Private Land: Infiltration Basins	$16,700,000
	Structural BMPs: Centralized BMPs on Private Property: Detention Basins	$10,100,000
	Structural BMP: Catch Basin Inserts Phase 3 (70% of catch basins)	$1,270,000
	Total Phase 3 Costs	**$29,020,000**
Total TMDL Implementation Plan Costs		**$46,600,000**

Contents

Tables

Figures

Acronyms

ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
BMP	best management practice
BMPDSS	Best Management Practice Decision Support System
Caltrans	California Department of Transportation
CARB	California Air Resources Board
CASQA	California Stormwater Quality Association
CCR	California Code of Regulations
CCTV	closed circuit television
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CESA	California Endangered Species Act
CSLC	California State Lands Commission
CWA	Clean Water Act
DDT	dichlorodiphenyltrichloroethanes
DEM	digital elevation model
DFG	Department of Fish and Game
DSOD	Division of Safety of Dams
EA	environmental assessment
EIS	environmental impact statement
EMC	event mean concentration
ERL	Effects Range-Low
ESA	Endangered Species Act
FONSI	finding of no significant impact
GIS	geographic information system
HCP	habitat conservation plan
HRU	hydrologic response unit
HSG	hydrologic soil group
HSPF	Hydrologic Simulation Program—FORTRAN
HY	hydrologic year
IRWMP	Integrated Regional Watershed Management Plan
LACDPW	County of Los Angeles Department of Public Works
LACSD	Los Angeles County Sanitation Districts
LARWQCB	Los Angeles Regional Water Quality Control Board
LID	low impact development
LSPC	Loading Simulation Program in C++
MS4	municipal separate storm sewer system
NEPA	National Environmental Policy

NOAA	National Oceanic and Atmospheric Administration
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
O&M	operation and maintenance
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PERP	Portable Equipment Registration Program
PSA	public service announcement
PV	present value
RCRA	Resource Conservation and Recovery Act
RWQCB	Regional Water Quality Control Board
SCAG	Southern California Association of Governments
SCCWRP	Southern California Coastal Water Research Project
SEA	Significant Ecological Areas
SSMP	Sewer System Management Plan
SSO	sanitary sewer overflow
SUSMP	Standard Urban Stormwater Mitigation Plan
SWPPP	stormwater pollution prevention plan
SWRCB	State Water Resources Control Board
TMDL	total maximum daily load
TN	total nitrogen
TP	total phosphorus
TRI	Toxics Release Inventory
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WDR	Waste Discharge Requirements
WLA	wasteload allocation

1. Introduction

This report documents the results of an effort to address impairments in the Ballona Creek watershed with a comprehensive, phased approach of best management practice (BMP) implementation. To develop this plan, BMPs to treat stormwater and dry weather flows to reduce metals, bacteria, and toxic pollutants were identified and selected. As part of this process, benefits of management activities were estimated, in terms of pollutant load reductions or improvement in water quality, to meet wasteload allocations (WLAs) defined by approved total maximum daily loads (TMDLs) established for waters within the Ballona Creek watershed. The process of BMP selection included considering cost-effectiveness to provide assurance that the plan is practical and implementable. The plan also includes integrated approaches that consider BMPs that can address multiple pollutants cost-effectively, while considering parallel water resources planning strategies for the watershed.

The report includes background information on the Ballona Creek watershed and its impairments and associated TMDLs (Sections 1 and 2). In Section 3, pollutants and their sources are characterized and evaluated. Section 4 details an evaluation of the County's existing programs, mainly nonstructural in nature, to address the pollutants of concern. Section 5 presents candidate sites for structural BMP implementation, and Section 6 presents a quantitative evaluation of different structural and nonstructural BMP management options. Section 7 includes a discussion of the integrated nature of the plan and its relation to other water resources efforts in the region. Section 8 describes the regulatory and permit requirements that might apply to the proposed BMPs and that might affect the timing, feasibility, and cost of management alternatives. Section 9 presents cost estimates for the BMP alternatives, and Section 10 analyzes the alternatives on the basis of a number of criteria, including effectiveness, cost, feasibility, and other factors. Section 11 documents schedules for implementing BMPs to meet phased WLA schedules.

1.1. Geographic Setting

The Ballona Creek watershed (Figure 1) covers an area of approximately 130 square miles and is in the coastal plain of the Los Angeles Basin. Its boundaries are defined by the Santa Monica Mountains to the north, the Harbor Freeway (110) to the east, and the Baldwin Hills to the south. The watershed includes the cities of Beverly Hills and West Hollywood, portions of the cities of Culver City, Inglewood, Los Angeles, Santa Monica, areas owed and maintained by California Department of Transportation (Caltrans), and the unincorporated County areas of West Los Angeles, Ladera Heights/Viewpark-Windsor Hills, West Fox Hills, Franklin Canyon, and Ballona Wetlands (LARWQCB 2006).

Ballona Creek flows as an open channel for just under 10 miles from Los Angeles (South of Hancock Park) through Culver City, reaching the Pacific Ocean at Playa del Rey. North of Hancock Park, the channels continue in a network of underground storm drains. Ballona Creek and its tributaries drain a watershed with approximately 60 percent of the land use categorized as residential, 17 percent as recreation/open space, 16 percent as commercial, 5 percent as industrial, and 2 percent as other (SCAG 2005).

Channelization and construction of Marina del Rey Harbor altered the natural hydrology of Ballona Creek Estuary, Ballona Creek, and its tributaries. Except for the estuarine section of the creek, which is composed of grouted riprap, sloped sides, and an earthen bottom, Ballona Creek is entirely lined in concrete and extends into a complex underground network of storm drains. The network reaches north to Beverly Hills and West Hollywood. Tributaries of Ballona Creek include Centinela Creek, Sepulveda Canyon Channel, Benedict Canyon Channel, and numerous storm drains. All these tributaries are concrete-lined channels that lead to covered culverts upstream (LARWQCB and USEPA 2005a).

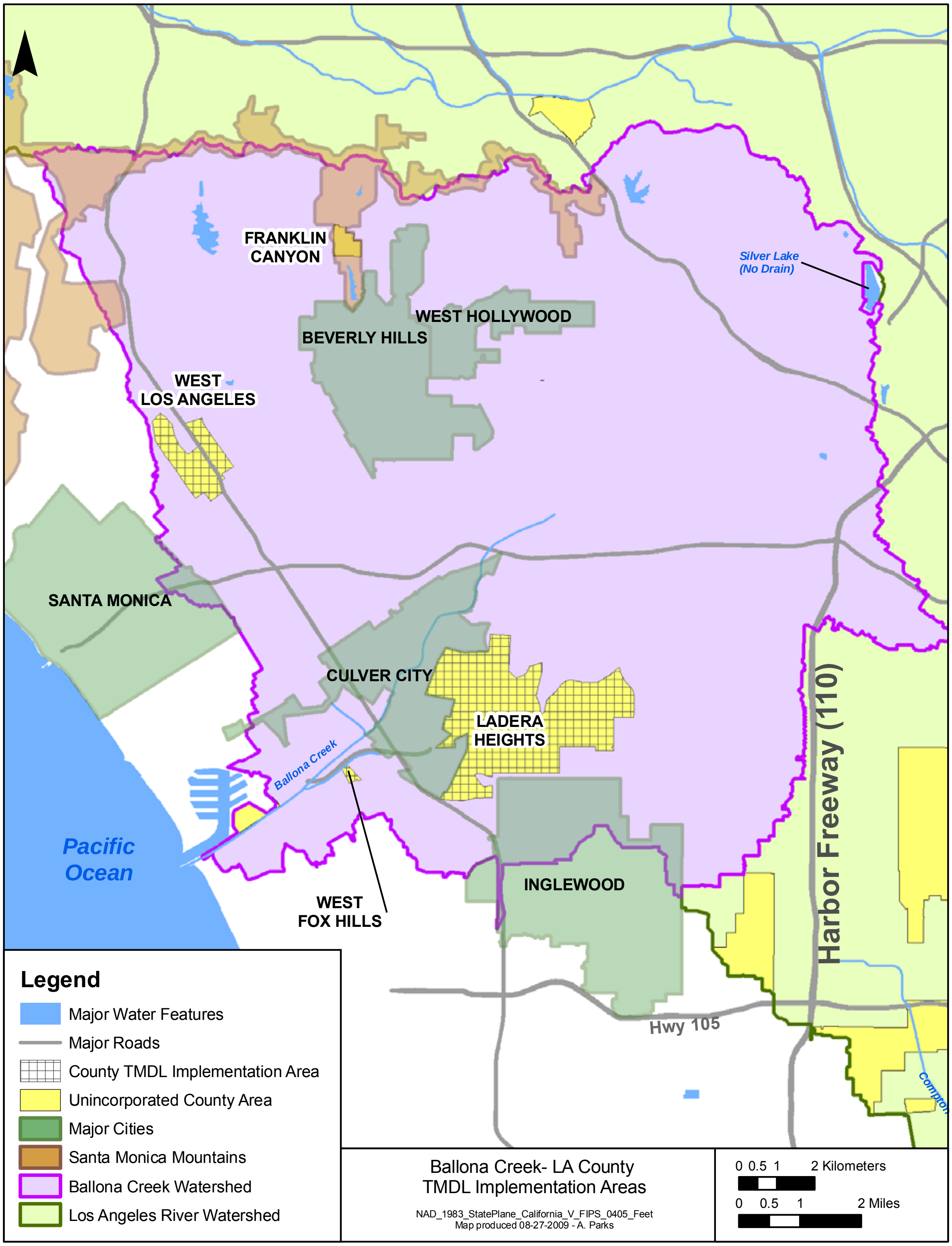


Figure 1. Ballona Creek Watershed with Major Cities, Unincorporated County Areas, and TMDL Implementation Areas

The *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* (Basin Plan) defines three sections of Ballona Creek by hydrologic units. The section referred to as *Ballona Creek* (Reach 1) is a 2-mile stretch from Cochran Avenue to National Boulevard. That area is characterized by vertical concrete walls, which line the creek from the point where it emerges from the underground network of drains at Cochran Avenue, in the city of Los Angeles, to National Boulevard in Culver City. *Ballona Creek to Estuary* (Reach 2) is the longest segment of the creek (approximately 4 miles) continuing on from National Boulevard and ending at Centinela Avenue where the estuary begins. Sepulveda Canyon Channel discharges into Ballona Creek Reach 2. Centinela Creek drains directly to Ballona Creek Estuary just below the boundary with Reach 2. The estuary continues to the Pacific Ocean for 3.5 miles, and its lower portion runs parallel to the main channel of Marina del Rey Harbor (LARWQCB and USEPA 2005a).

1.2. History of Impairments and TMDLs

The federal Clean Water Act (CWA) requires the Los Angeles Regional Water Quality Control Board (LARWQCB) to develop water quality objectives to protect beneficial uses for each waterbody in its region. Comparing water quality data to those objectives resulted in the LARWQCB identifying portions of Ballona Creek as impaired for several pollutant classes. The CWA Section 303(d) list identifies water quality limited segments within the Ballona Creek watershed for Ballona Creek, Sepulveda Canyon, Ballona Creek Estuary, and Ballona Creek Wetlands. These segments are shown in Figure 2. Table 1 summarizes the pollutant/stressor for each segment included in the 1998 and 2006 303(d) lists.

On the basis of the impairments and a 1999 Consent Decree between the U.S. Environmental Protection Agency (USEPA); Heal the Bay, Inc.; and BayKeeper, Inc., USEPA and the LARWQCB were compelled to develop TMDLs for the impaired waters within 13 years of the Consent Decree. Since then, the LARWQCB approved four TMDLs for Ballona Creek and Ballona Creek Estuary: trash, toxics, metals, and bacteria. These approved TMDLs are reflected in the 2006 303(d) list of impairments summarized in Table 1, which is limited to the remaining impairments requiring TMDLs. The schedule for developing and approving Basin Plan amendments for the TMDLs varies depending on the pollutants addressed. A summary of each TMDL, along with TMDL effective dates and implementation plan due dates, is included for all Ballona Creek and Ballona Creek Estuary TMDLs in Table 2. Appendix A includes amendments to the Basin Plan to incorporate the TMDLs for the Ballona Creek watershed.

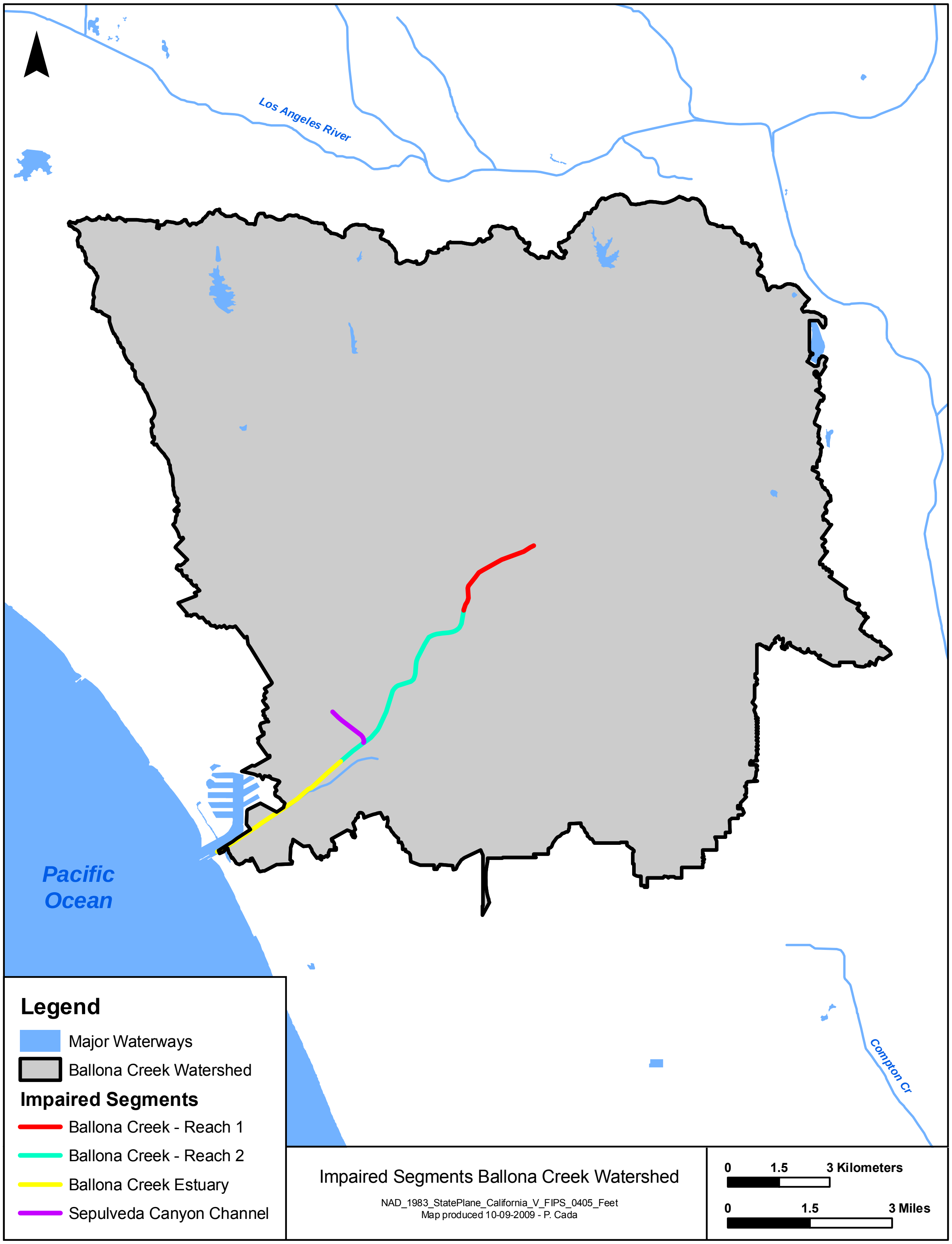


Figure 2. Water Quality Impaired Segments within the Ballona Creek Watershed

Table 1. History of Impairments for Ballona Creek, Ballona Creek Estuary, and Ballona Creek Wetlands

Pollutant/Stressor	Ballona Creek & Sepulveda Canyon		Ballona Creek Estuary & Ballona Creek Wetlands[a]	
	1998 303(d)	2006 303(d)[b]	1998 303(d)	2006 303(d)[b]
Bacteria				
Indicator of coliform bacteria	X[d]		X	
Metals[c]				
Lead	X[d]		X	
Zinc			X	
Copper	X			
Cadmium	X	X		
Selenium				
Silver		X		
Arsenic	X		X	
Organic Chemicals[c]				
Total Polycyclic Aromatic Hydrocarbons (PAHs)			X	
Polychlorinated Biphenyls (PCBs)	X		X	
Dichlorodiphenyltrichloroethanes (DDT)	X		X	
Chlordane	X		X	
Dieldrin	X			
ChemA pesticides	X			
Tributyltin	X			
Arochlor			X	
Other				
Trash	X		X	
Ammonia	X[e]	X[e]		
Cyanide		X		
Toxicity or Sediment Toxicity	X		X	

Source: 1998 and 2006 CWA section 303(d) lists.

a. Ballona Creek Estuary is also listed for shellfish harvesting advisory; Ballona Creek Wetlands also listed for exotic vegetation, hydromodification, habitat alterations, and reduced tidal flushing.

b. List limited to remaining segments requiring TMDLs.

c. Listed for elevated levels in fish tissue and/or sediment. Typically associated with impairments associated with Toxicity or Sediment Toxicity.

d. Both Ballona Creek and Sepulveda Canyon listed.

e. Limited to Sevulveday Canyon.

Table 2. Approved TMDLs for Segments within the Ballona Creek Watershed

TMDL Parameter Group	Dates	Description
Bacteria	TMDL Effective: April 27, 2007 TMDL Implementation Plan Due: October 27, 2009	Ballona Creek, Sepulveda Canyon Channel, and Ballona Estuary were listed on California's 1998 303(d) list as impaired due to exceedances of total or fecal coliform water quality standards. TMDLs were subsequently developed for multiple bacteria indicators: fecal coliform, total coliform, *Escherichia coli*, and enterococcus. The Ballona Creek TMDL (LARWQCB 2006) for bacteria has multipart, wet weather, numeric targets based on the updated bacteria objectives for marine and fresh waters designated for contact recreation (REC-1), and fresh waters with Limited REC-1 and non-contact recreation (REC-2) beneficial use designations. Both single-sample and 30-day geometric mean limits apply to Ballona Creek Reaches 1 and 2 and Sepulveda Channel. Dry weather urban runoff and stormwater, both conveyed by storm drains, are the primary sources of elevated bacterial indicator densities to Ballona Creek and Estuary during dry and wet weather. No wastewater discharges are permitted in the watershed. In addition, there are no agriculture-based sources.
Metals	TMDL Effective: October 29, 2008 TMDL Implementation Plan Due: January 11, 2010	Segments of Ballona Creek and Sepulveda Canyon Channel were listed for cadmium, copper, lead, selenium, silver, zinc and toxicity (LARWQCB and USEPA 2005b). Numeric targets for the TMDL were calculated on the basis of the numeric objectives in the California Toxics Rule. Separate numeric targets were developed for dry and wet weather because hardness values and flow conditions in Ballona Creek and its tributaries differ significantly between these conditions. TMDLs and allocations were developed for copper, lead, zinc, and selenium. Concentration-based and mass-based WLAs were developed for dry weather urban runoff and mass-based WLAs for stormwater runoff. The combined stormwater WLA is partitioned among all the municipal separate storm sewer system (MS4) permittees (77,546 acres), general industrial and construction discharges, and Caltrans (1,080 acres) using an estimate of the percentage of land area covered under each permit. Concentration-based WLAs are developed for all other National Pollutant Discharge Elimination System (NPDES) permitted discharges on the basis of dry and wet weather conditions.
Trash	TMDL Effective: August 11, 2005 Annual Compliance Report Due: August 15, 2009	As part of California's 1996 and 1998 303(d) list submittals, the LARWQCB identified the reaches of Ballona Creek as impaired due to trash and subsequently developed a trash TMDL for Ballona Creek (LARWQCB 2004). The numeric target for this TMDL is zero trash by 2015. WLAs were assigned to the permittees and co-permittees of the County Municipal Storm Water Permit and Caltrans.
Toxics	TMDL Effective: January 11, 2006 TMDL Implementation Plan Due: January 11, 2011	Segments of Ballona Creek and Ballona Creek Estuary are listed for a variety of toxic pollutants, including historic pesticides, legacy organics, the analytical suite of organic pesticides, and sediment toxicity. The impaired segments of Ballona Creek and the estuary by toxic pollutants were included on the 1996, 1998, and 2002 California 303(d) list. TMDLs that address toxic pollutants in the Ballona Creek Estuary have been developed (LARWQCB and USEPA 2005b), which include WLAs for cadmium, copper, lead, silver, zinc, chlordane, DDTs, total polychlorinated biphenyls (PCBs), and total PAHs. The TMDL states that the most prevalent metals in urban stormwater are consistently associated with suspended solids. As a result, the WLAs were based on an estimate of annual sediment loading, multiplied by sediment quality guidelines (Effects Range-Low [ERL] targets) compiled by the National Oceanic and Atmospheric Administration.

2. Objectives of the TMDL Implementation Plan

2.1. Focus of the Plan

The Ballona Creek TMDL Implementation Plan must include implementation methods, a schedule, and proposed milestones to achieve compliance of the TMDL WLAs. That requires identifying and selecting BMPs to treat stormwater or reduce pollutant loads, as well as developing estimates of benefits in terms of load reductions to meet WLAs. However, the BMP selection process must consider the cost-effectiveness to provide assurance that plans are practical and implementable.

The goal of the multi-pollutant implementation plan is to address all current TMDLs, with consideration of future potential TMDLs. The metals, bacteria, and toxics TMDLs are considered the primary focus of this implementation plan. A secondary focus is placed on trash, because reporting on progress toward TMDL implementation occurs annually and through a separate process. However, BMPs that address trash have the potential to provide added benefit in addressing other pollutants, which is assessed in this implementation plan. Total nitrogen (TN) and total phosphorus (TP) source characterizations are provided in the plan, although nutrients do not contribute to current impairments. This information can support future initiatives for watershed and BMP planning.

This implementation plan includes integrated approaches that consider BMPs that can address multiple pollutants cost-effectively. Additional benefits of BMPs, such as water storage/recharge and reuse, providing recreation space, improved natural habitat, and such, are also considered in this implementation plan.

This implementation plan describes management options that are limited to unincorporated County areas outside federal lands. This area is often termed the County TMDL Implementation Area[1] in this report and represents the double-hatched area in Figure 1. Some of the proposed nonstructural or programmatic BMPs, such as staff training or education programs, could apply countywide.

2.2. TMDL Targets

Key factors influencing the level of BMP implementation are the stormwater management targets expected to be achieved. For this project, multiple TMDLs and associated WLAs for stormwater runoff have been developed for Ballona Creek, which must be considered as a priority for developing the multi-pollutant TMDL implementation plan. The following provides a summary of applicable wet and dry weather TMDL WLAs and implementation requirements, and methods for translating the requirements into management targets to address wet weather pollution.

---

[1] Note that the County TMDL Implementation Area does not include unincorporated County area for Ballona Wetlands. LARWQCB (2006) states that preliminary data suggest that the Ballona Wetlands are a sink for bacteria from Ballona Creek and it is therefore not considered a source to this TMDL. LARWQCB and USEPA (2005b) state that nonpoint sources are not considered a significant source of toxic pollutants in the toxics TMDL for Ballona Estuary and that urban runoff from Ballona Wetland is considered a nonpoint source because the area discharges directly to the estuary through a tide gate. They further state that Ballona Wetlands cover only 0.6 percent of the Ballona Creek watershed; therefore, loading from the source is considered insignificant.

2.2.1. Metals

The Ballona Creek metals TMDL includes WLAs for both wet and dry weather, expressed as flow/volumes multiplied by applicable numeric concentration targets. The following summarizes those WLAs and associated implementation schedules.

Wet Weather Metals WLA

For the Ballona Creek metals TMDL (LARWQCB and USEPA 2005a), allowable loads were based on the California Toxics Rule and locally derived particulate/dissolved conversion factors (assuming a hardness of 77 mg/L). The total wet weather WLAs assigned to County TMDL Implementation Area are stated as follows:

- Total recoverable copper (kg/day): 1.8×10^{-8} (18 micrograms per liter [µg/L]) × daily volume (L)
- Total recoverable lead (kg/day): 5.9×10^{-8} (59 µg/L) × daily volume (L)
- Total recoverable selenium (kg/day): 0.5×10^{-8} (5.0 µg/L) × daily volume (L)
- Total recoverable zinc (kg/day): 1.19×10^{-7} (119 µg/L) × daily volume (L)

The WLAs for the unincorporated County areas of Ballona Creek can be determined on the basis of the above numeric targets (with unit conversion) combined with observed or model-predicted flows/volumes. The result will be a total allowable daily load of each metal during storms, which can be used to calculate annual loads.

Dry Weather Metals WLA

Consistent with wet weather, the Ballona Creek metals TMDL (LARWQCB and USEPA 2005a) expresses allowable loads based on the California Toxics Rule and locally derived particulate/dissolved conversion factors (assuming a hardness of 300 mg/L). The total dry weather WLAs assigned to the County TMDL Implementation Area are stated as follows:

- Total recoverable copper (kg/day): 2.4×10^{-8} (24 µg/L) × daily volume (L)
- Total recoverable lead (kg/day): 1.3×10^{-8} (13 µg/L) × daily volume (L)
- Total recoverable selenium (kg/day): 0.5×10^{-8} (5.0 µg/L) × daily volume (L)
- Total recoverable zinc (kg/day): 3.04×10^{-7} (304 µg/L) × daily volume (L)

2.2.2. Indicator Bacteria

The bacteria TMDL has multipart, wet and dry weather numeric targets based on the updated bacteria objectives for marine and fresh waters designated for contact recreation (REC-1), and fresh waters with Limited REC-1 and REC-2 beneficial use designations. Both single-sample and 30-day geometric mean limits apply to Ballona Creek Reaches 1 and 2 and Sepulveda Channel. All applicable bacteria objectives are presented in Table 3.

The TMDL for indicator bacteria for Ballona Creek, Ballona Estuary, and Sepulveda Channel (LARWQCB 2006) includes WLAs for both wet and dry weather, expressed as the number of daily or weekly sample days that may exceed the single sample targets, hereafter referred to as *allowable exceedance days*. Allowable exceedance days are set for three periods: summer dry weather (April 1 to October 31), winter dry weather (November 1 to March 31), and wet weather days (defined as days of 0.1 inch or rain or more plus 3 days following the rain event). WLAs are also expressed with a rolling 30-day geometric mean.

Table 3. Water Quality Objectives for Ballona Creek, Ballona Estuary, and Sepulveda Channel

Water Quality Objectives	Ballona Estuary (marine REC-1)	Sepulveda Channel (freshwater REC-1)	Ballona Creek Reach 2 (LREC-1)[b]	Ballona Creek Reach 1 (REC-2)
Single Sample				
E. coli (#/100 mL)	n/a	235	576	n/a
Fecal coliform (#/100 mL)	400	400	--[b]	4,000
Enterococcus (#/100 mL)	104	n/a	n/a	n/a
Total coliform[a] (#/100 mL)	10,000	n/a	n/a	n/a
Geometric Mean				
E. coli (#/100 mL)	n/a	126	126	n/a
Fecal coliform (#/100 mL)	200	200	200	2,000
Enterococcus (#/100 mL)	35	n/a	n/a	n/a
Total coliform (#/100 mL)	1,000	n/a	n/a	n/a

a. Total coliform density must not exceed 1,000/100 milliliters (mL), if the ratio of fecal-to-total coliform exceeds 0.1
b. LREC-1 has not been assigned a fecal coliform single sample limit.
n/a = not applicable

Wet Weather Bacteria WLA

To implement the single-sample bacteria objectives for waters designated REC-1 and LREC-1, and to set wet weather allocations using the single-sample targets, TMDL targets were set as a number of allowable exceedance days for each reach. As a result, wet weather WLAs for the REC-1 and LREC-1 waters are also expressed as allowable exceedance days. The resulting WLAs are presented in Table 4. The geometric mean targets, which are based on a rolling 30-day period, may not be exceeded at any time.

The Basin Plan bacteria objectives for REC-2 serve as the numeric target in Reach 1. The REC-2 objectives allow for a 10 percent exceedance frequency of the single sample limit in samples collected during a 30-day period. This allowance, which is based on an acceptable level of health risk, is applied in Reach 1 in lieu of the allowable exceedance days discussed earlier. As with the other reaches, the geometric mean target, which is based on a rolling 30-day period, may not be exceeded at any time.

Table 4. Wet weather WLAs and LAs for Tributaries to the Impaired Reaches of Ballona Creek Watershed

Tributary	Point of Application	Water Quality Objectives	WLA (no. exceedance days)
Ballona Creek Reach 1	At confluence with Reach 2	LREC-1 Freshwater	Single sample objectives: 17[a]
			Geometric mean objectives: 0
Benedict Canyon Channel	At confluence with Reach 2	LREC-1 Freshwater	Single sample objectives: 17 [a]
			Geometric mean objectives: 0
Ballona Creek Reach 2	At confluence with Ballona Estuary	REC-1 Marine water	Single sample objectives: 17
			Geometric mean objectives: 0
Centinela Creek	At confluence with Ballona Estuary	REC-1 Marine water	Single sample objectives: 17
			Geometric mean objectives: 0
Del Rey Lagoon	At confluence with Ballona Estuary	REC-1 Marine water	Single sample objectives: 17
			Geometric mean objectives: 0

a. At the confluence with Reach 2, the greater of the allowable exceedance days under the reference system approach or high-flow suspension will apply.

As projection and tracking of BMP effectiveness are performed in the watershed, the focus on allowable exceedance days might not be useful. Determining allowable exceedance days was based on conditions observed at a reference unimpaired beach, where the frequency of exceedance of the REC-1 fecal coliform water quality objective was observed for 22 percent of the wet days that occur in any year. Using a critical wet year identified as 1993, which included 75 wet days, the total allowable exceedance days was calculated as 0.22 × 75 = 17 days. Because different years or possibly even different locations in the watershed (with different number, magnitude, and duration of rainfall events) will result in varying number of wet days, it is recommended that TMDL implementation focus on the reference condition of 22 percent of annual wet days allowed to exceed the targets. Furthermore, because this reference condition was based on the exceedance of the fecal coliform water quality objective, it is also recommended that fecal coliform be used as the target indicator bacteria for evaluation of effectiveness of BMP implementation plans to achieve the WLAs. As a result, a conservative objective target of no more than 22 percent of wet days exceeding the fecal coliform objective is recommended, which can apply to any wet year.

Dry Weather Bacteria WLA

Dry weather WLAs for the REC-1 and LREC-1 waters are also expressed as allowable exceedance days. The resulting WLAs are presented in Table 5. The rolling 30-day geometric mean targets may not be exceeded at any time.

Table 5. Dry weather WLAs and LAs for Tributaries to the Impaired Reaches of Ballona Creek Watershed

Tributary	Point of Application	Water Quality Objectives	WLA (no. exceedance days)
Ballona Creek Reach 1	At confluence with Reach 2	LREC-1 Freshwater	Single sample objectives: • Summer dry weather: 0 • Winter dry weather: 3 Geometric mean objectives: 0
Benedict Canyon Channel	At confluence with Reach 2	LREC-1 Freshwater	Single sample objectives: • Summer dry weather: 0 • Winter dry weather: 3 Geometric mean objectives: 0
Ballona Creek Reach 2	At confluence with Ballona Estuary	REC-1 Marine water	Single sample objectives: • Summer dry weather: 0 • Winter dry weather: 3 Geometric mean objectives: 0
Centinela Creek	At confluence with Ballona Estuary	REC-1 Marine water	Single sample objectives: • Summer dry weather: 0 • Winter dry weather: 3 Geometric mean objectives: 0
Del Rey Lagoon	At confluence with Ballona Estuary	REC-1 Marine water	Single sample objectives: • Summer dry weather: 0 • Winter dry weather: 3 Geometric mean objectives: 0

2.2.3. Total Suspended Solids (Toxicity)

The *Ballona Creek Estuary Toxic Pollutants TMDL* (LARWQCB and USEPA 2005b) addresses toxic pollutants and includes WLAs for cadmium, copper, lead, silver, zinc, chlordane, DDTs, total PCBs, and total PAHs. The TMDL states that the most prevalent metals in urban stormwater are consistently associated with suspended solids. As a result, the WLAs were based on an estimate of annual sediment loading, multiplied by sediment quality guidelines (ERL targets) compiled by the National Oceanic and Atmospheric Administration. Those numeric targets are summarized below:

Cadmium	1.2 milligrams per kilogram (mg/kg)
Copper	34 mg/kg
Lead	46.7 mg/kg
Silver	1.0 mg/kg
Zinc	150 mg/kg
Chlordane	0.5 micrograms per kilogram (µg/kg)
DDTs	1.58 µg/kg
Total PCBs	22.7 µg/kg
Total PAHs	4,022 µg/kg

The transport of metals and organics within sediment transported in stormwater has been substantially documented (Buffleben et al. 2002; Caltrans 2003; Hoffman et al. 1982; Lau and Stenstrom 2005; Longanathan et al. 1997; Stein et al. 2006; Yunker et al. 2002). Compliance to the WLA will therefore depend on the amount of sediment transported from the areas served by the MS4, which will vary as a function of area, rainfall, and the amount of resulting stormwater transporting sediment. In summary, BMP implementation scenarios within unincorporated County areas will consider compliance with WLAs established for the Ballona Creek Estuary sediment toxicity TMDL. However, results will be highly driven by total suspended solids (TSS) load reductions (and associated stormwater volume reductions) that can be achieved with BMPs.

2.2.4. Trash

The trash TMDL for Ballona Creek provides zero allowable load. The trash reduction requirements are being addressed by the full capture device installation program, which is currently in progress with a separate implementation planning and reporting process.

2.3. TMDL Implementation Schedule

The Ballona Creek TMDLs include schedules for implementing associated WLAs, which vary for each pollutant and in some cases for wet and dry weather conditions. With an integrated water resources approach to TMDL implementation, responsible agencies must achieve compliance with the wet weather WLAs by 2021. It is the purpose of this TMDL implementation plan to outline an integrated water resources approach, taking advantage of parallel watershed planning initiatives and providing overall responsible management of water resources affected by stormwater from the County TMDL Implementation Area.

For metals and bacteria WLAs, different implementation schedules are defined for wet and dry weather. However, the metals implementation schedules are based on phases expressed as the percent of total drainage area served by the municipal separate storm sewer system (MS4) that is effectively meeting the WLAs. The phases can be considered as interim goals for developing strategies to address TMDL implementation. The toxic pollutant WLAs are also scheduled for phased implementation based on percent of drainage area meeting the WLAs, although as discussed WLAs are only defined for wet weather. A summary of the various Ballona Creek WLAs and associated compliance schedules are summarized in Table 6

Table 6. WLA Implementation Schedules for Ballona Creek TMDLs

TMDL[a]	Condition	Interim Phased Implementation	Final Compliance[b]
Metals	Wet weather	• January 11, 2012: 25% of total drainage area • January 11, 2016: 50% of total drainage area	January 11, 2021: 100% of total drainage area
	Dry weather	• January 11, 2012: 50%of total drainage area • January 11, 2014: 75% of total drainage area	January 11, 2016: 100% of total drainage area
Bacteria	Wet weather	Not applicable	July 15, 2021
	Dry weather	Not applicable	April 27, 2013
Toxics	Wet weather	• January 11, 2013: 25% of total drainage area • January 11, 2015: 50% of total drainage area • January 11, 2017: 75% of total drainage area	January 11, 2021: 100% of total drainage area

a. Trash not included due to separate implementation planning and progress reporting process.
b. Assumes an integrated water resources approach.

3. Pollutant Source Characterization and Prioritization

This section identifies the potential sources of the pollutants of concern derived from both point and nonpoint sources. The discussion is provided in several parts: modeling results, specific pollutant sources, and a source prioritization. Watershed monitoring summaries are presented for reference in Appendix B. The focus of this characterization and prioritization is primarily within the County TMDL Implementation Area. Both wet and dry conditions are discussed.

3.1. Pollutant Loading Analysis

3.1.1. Wet Weather Loading

Through a joint effort of the LARWQCB, USEPA, Southern California Coastal Water Research Project (SCCWRP), and Tetra Tech, a regional modeling approach was developed to simulate the hydrology and transport of sediment and metals. The approach is based on the Hydrologic Simulation Program–FORTRAN (HSPF) and Loading Simulation Program C++ (LSPC), a version of HSPF, recoded into C++. The regional approach has been used to support metals TMDLs for Ballona Creek and the Los Angeles River.

The County is consolidating and modifying the models to support development of the Los Angeles County BMP Decision Support System (BMPDSS). Each model of County watersheds is being converted to a single, consistent model version of LSPC to serve as a foundation for addressing watershed management needs. The LSPC watershed modeling system simulates hydrology, sediment, and general water quality on land and is combined with a stream fate and transport model. Wet weather loading was developed for the unincorporated County areas. Wet weather loading estimates were developed using the modeled constituents including copper, zinc, lead, TN, TP, fecal coliform, and TSS. The results in terms of average annual loads (based on a 10-year simulation) are provided in Table 7. Results represent runoff-based loads by unincorporated County areas.

Table 7. Wet weather Loading by Community

Community Name	Total Acres	Total Loads (lbs/yr)							
		TN	TP	Copper	Zinc	Lead	Fecal Coliform[a]	TSS[b]	PAHs
West Fox Hills	30.8	105	78	1.04	10.1	0.9	1.50E+12	1.407	0.096
Franklin Canyon	0.5	1.5	1.0	0.01	0.08	0.0	1.30E+10	0.021	0.001
Ladera Heights/ Viewpark-Windsor Hills	3,079.0	6,448	5,207	64.9	567.8	57.6	1.18E+14	84.579	6.913
West Los Angeles	577.8	4,286	2,697	26.2	243.9	15.0	4.05E+13	53.180	2.052
Total	3,688	10,840	7,983	92.1	822	73.6	1.60E+14	139	9.1

a. Units are in #/year
b. Units are in tons/year

Because chlordane, DDT, PCBs, selenium, cadmium, and PAHs are not modeled, a different method was used to develop loading estimates. Total PAH loads by community were developed using surface runoff from the watershed model and event mean concentrations (EMCs) by land use developed by Stein et al. (2006). Cumulative loads for the County TMDL Implementation Areas were developed for the remaining parameters (Table 8). The loads are based on the total TSS load from all County TMDL Implementation Areas in Ballona Creek with applicable sediment concentrations reported in *Watershed Model Development for Simulation of Loadings to the Los Angeles/Long Beach Harbors* (USEPA and LARWQCB 2006). The values from the nearby

Los Angeles River Estuary were selected; comparable values were not available for the Ballona Creek estuary. The watersheds likely share similar histories in terms of legacy pollutants and common sources of cadmium and selinium. Cadmium and selenium loads are based on total modeled surface flow multiplied by EMC values at the mass emissions site.

Table 8. Total Wet Weather Loading Estimate (Chlordane, DDT, PCBs, Cadmium, Selenium)

Pollutant	Pollutant Load (lb/yr)
Chlordane	1.43E-06
DDT	3.71E-05
PCBs	1.03E-04
Cadmium	5.0
Selenium	13.3

Average annual loads for the small unincorporated County areas are dwarfed by the loads from the Ladera Heights/Viewpark-Windsor Hills area and the community of West Los Angeles. Area-based loads (pollutant per acre) were also developed using the modeling results and are displayed in Figure 3 through Figure 10. Those presentations tell a slightly different story. Here, loading rates are higher in West Los Angeles compared to Ladera Heights/Viewpark-Windsor Hills. West Fox Hills rates typically fall between the two larger communities.

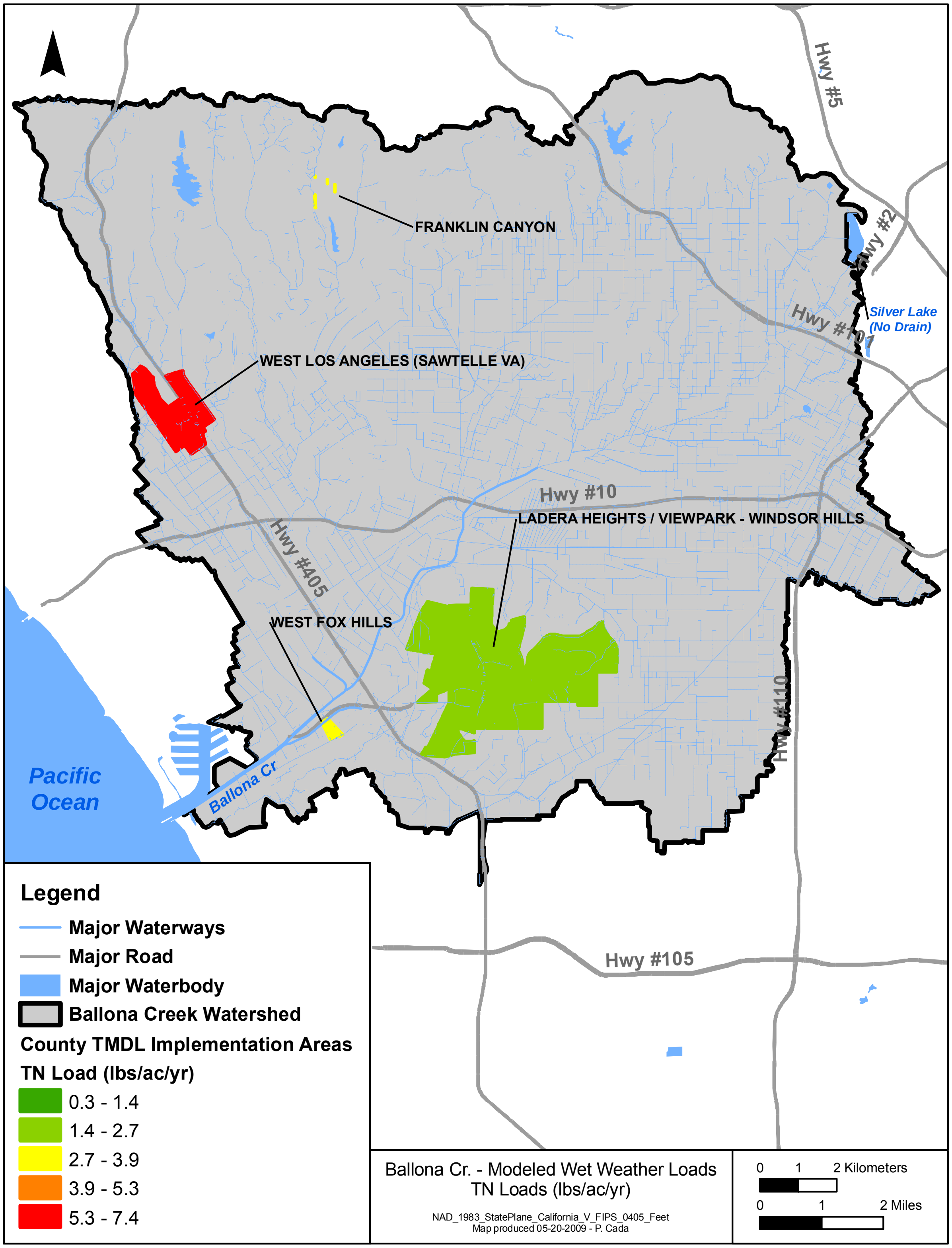


Figure 3. Wet weather Loading—TN

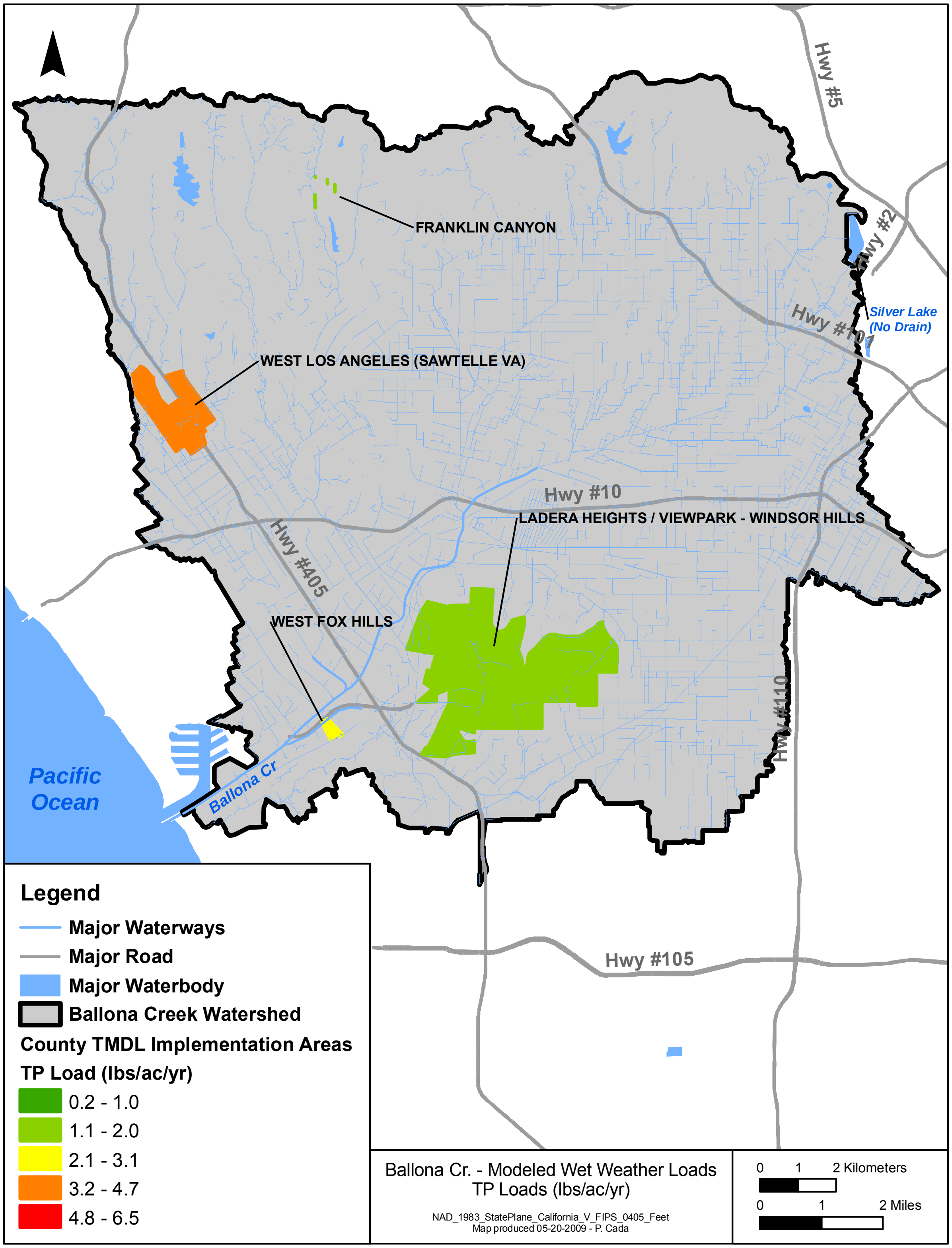


Figure 4. Wet weather Loading—TP

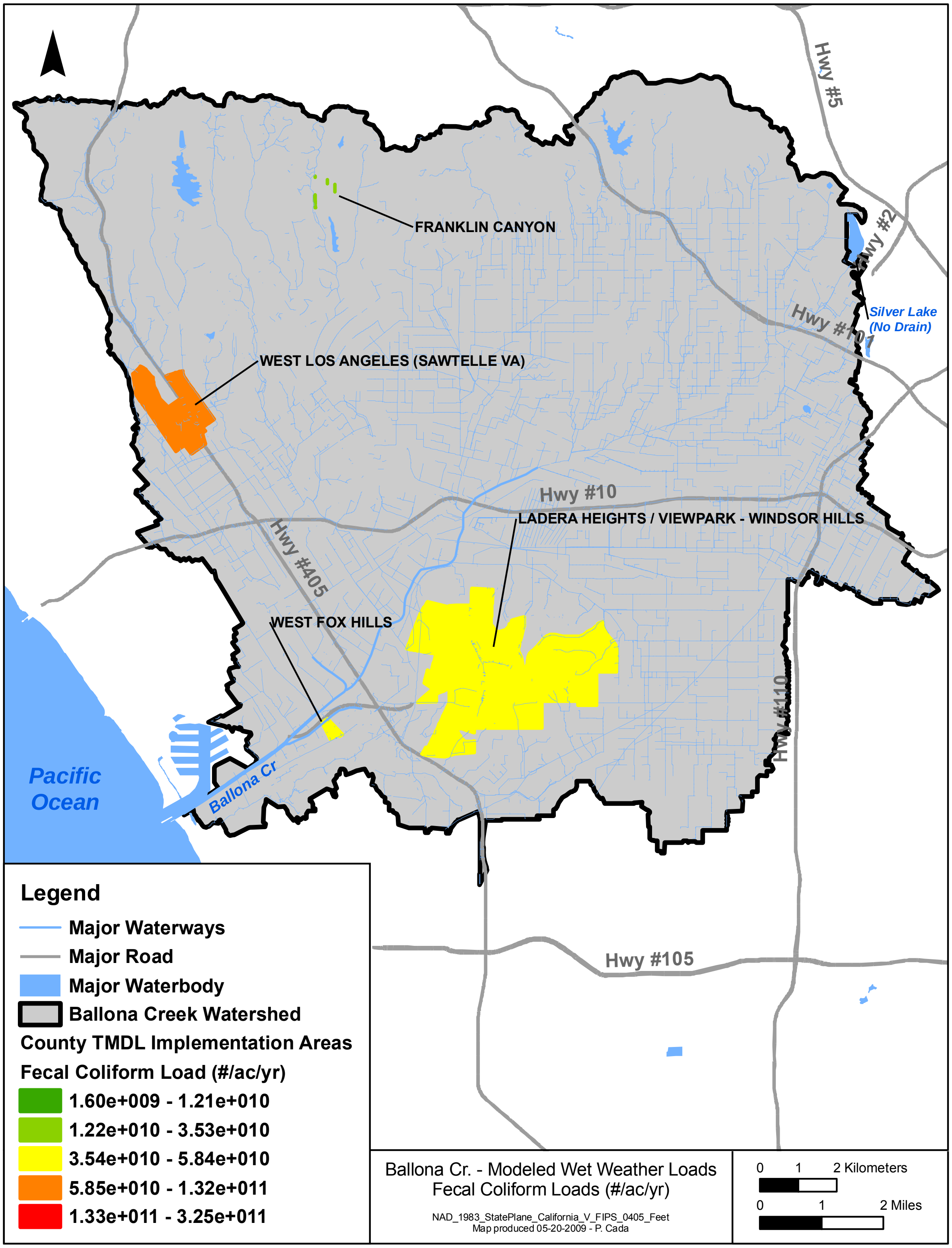


Figure 5. Wet weather Loading—Fecal Coliform

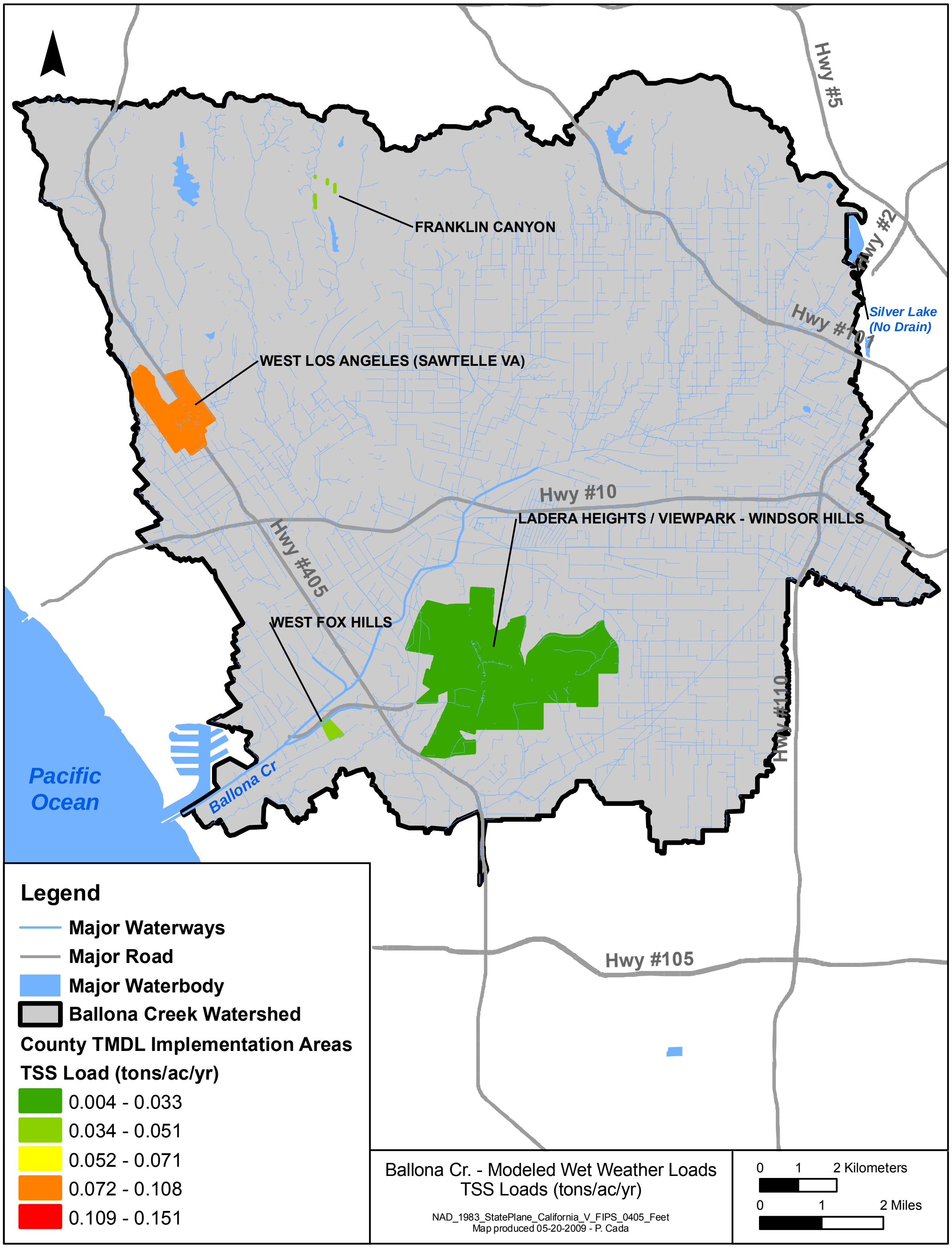


Figure 6. Wet weather Loading—TSS

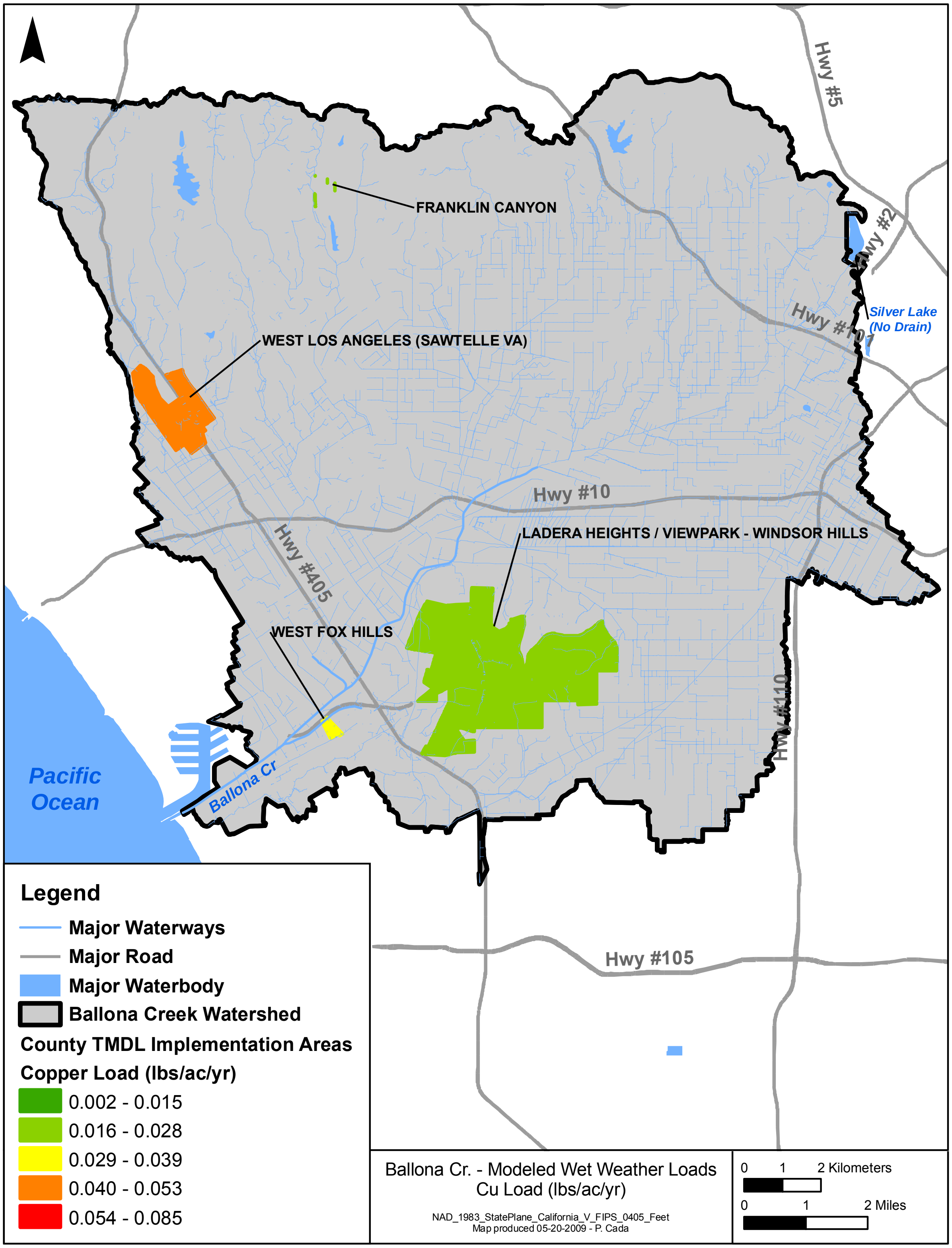


Figure 7. Wet weather Loading—Copper

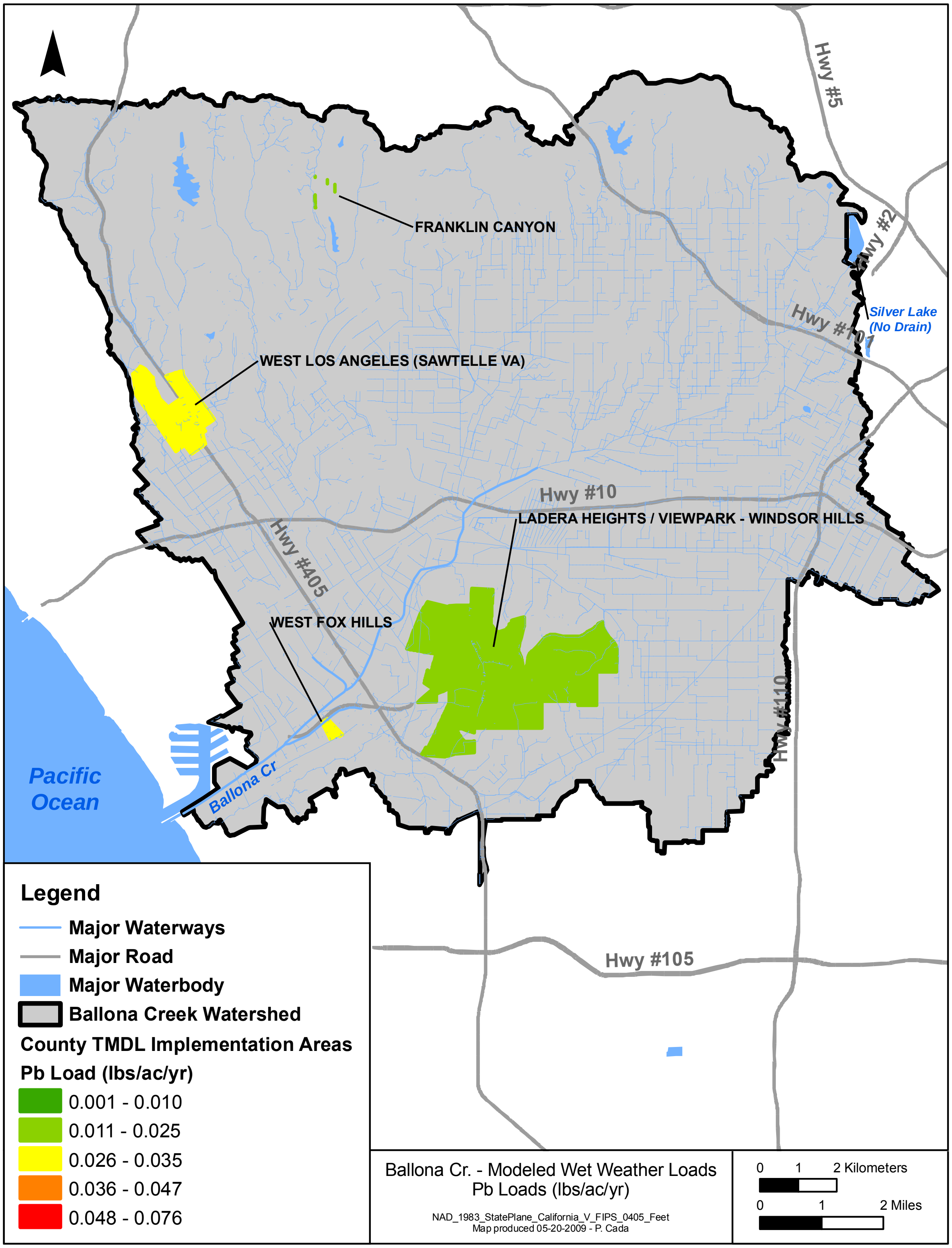


Figure 8. Wet weather Loading—Lead

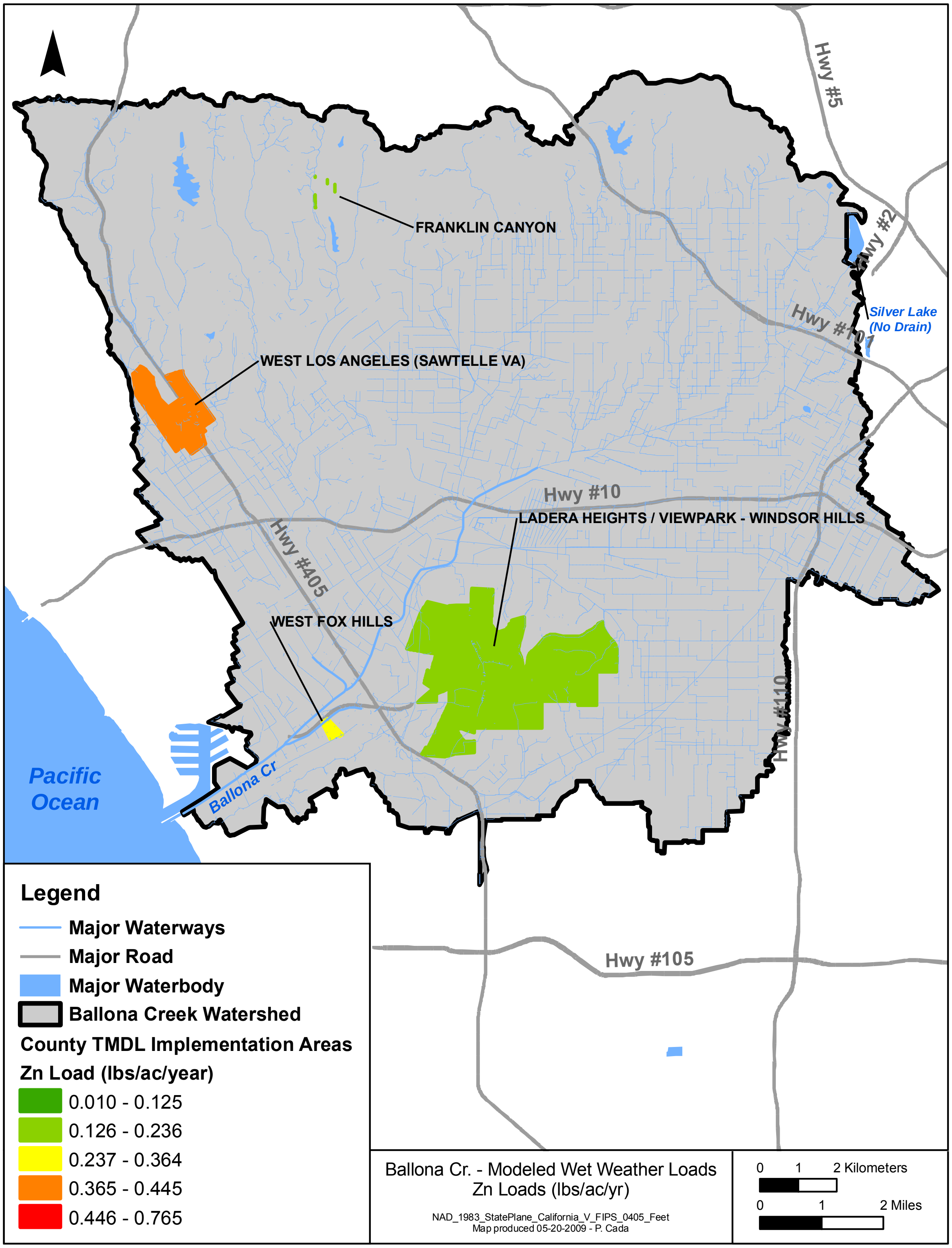


Figure 9. Wet weather Loading—Zinc

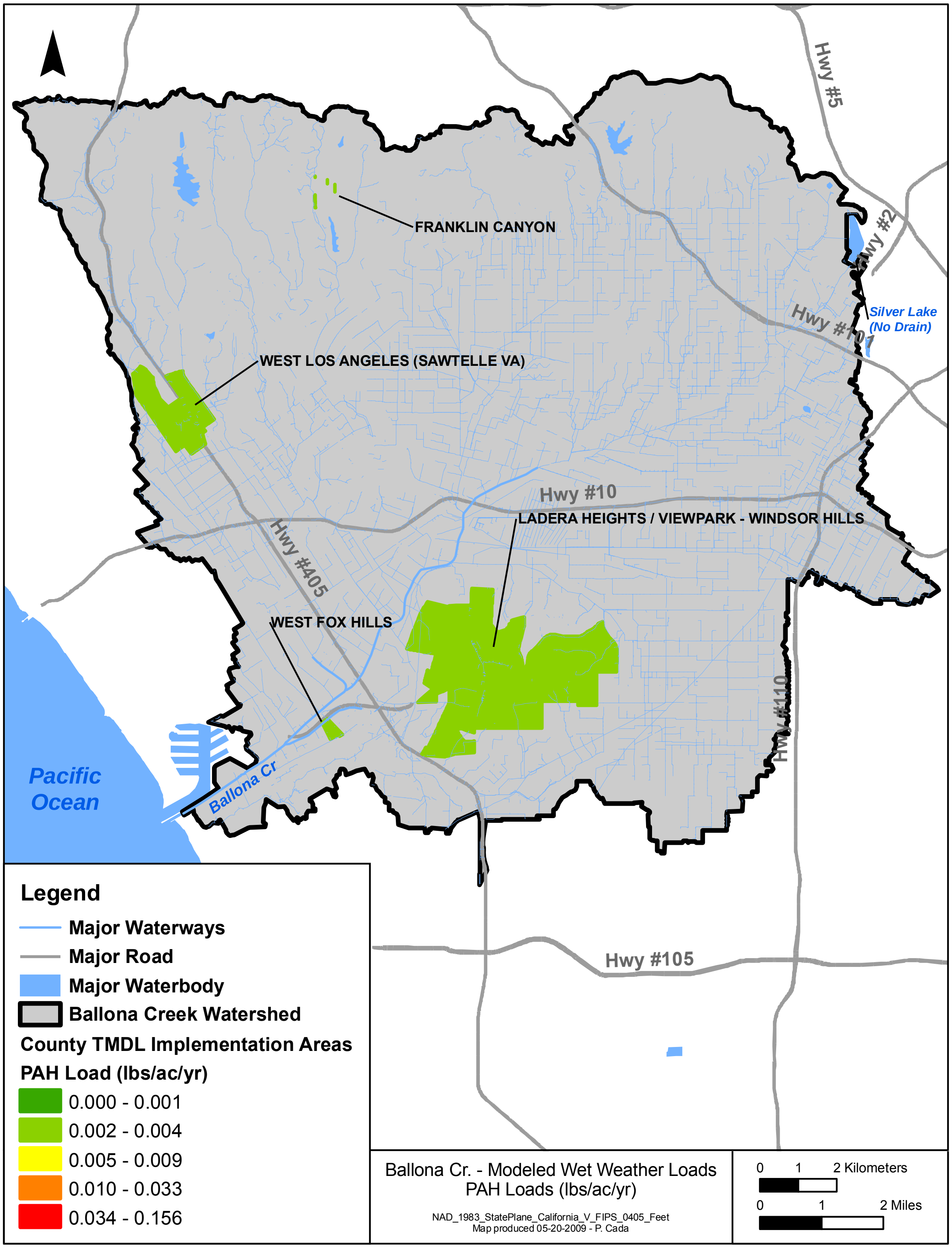


Figure 10. Wet weather Loading—Total PAHs

3.1.2. Dry Weather Loading

Dry weather can also be a significant source of pollutant loading. Modeling dry weather flows has been shown to be difficult (Ackerman et al. 2005); therefore, dry weather loading from unincorporated County areas were assessed using a combination of non-modeling techniques. Models have been developed for the Ballona Creek TMDLs for dry conditions; however, they provide an assessment of only the assimilative capacity of the waterbodies and not enough information to fully characterize dry weather pollutant sources. However, as part of the modeling for the Los Angeles and Long Beach Harbors (USEPA and LARWQCB 2006), a linear regression was developed that relates dry weather flows to urban land use (and excludes publicly owned treatment works flows) using a regional comparison of dry weather flows by Stein and Ackerman (2007). The following equation describes this relationship.

$$Flow = 0.0024 \times (UrbanArea) \qquad \text{(equation 1)}$$

Where, *Flow* is in cubic meters per second (m^3/s) and *UrbanArea* is the sum of commercial, residential (high and low density), industrial, and mixed urban land uses in square kilometers (km^2).

Dry weather pollutant loading from urban land uses by subwatershed was based on estimated flows using equation (1) and assigned typical concentrations appropriate for the Ballona Creek watershed (Table 9). Concentrations were taken from Table 7 (mean storm drain concentrations by watershed) in Stein and Ackerman (2007) with the exception of fecal coliform in both watersheds and nutrients in the Ballona Creek watershed, which were based on geometric mean (fecal coliform) and average (nutrients) EMCs from Los Angeles County Department of Public Works (LACDPW) monitoring data at mass emission sites. The results follow similar trends as the wet weather loading estimates, but they should be understood in light of the difficulty in predicting dry weather loading.

Table 9. Dry Weather Annual Loading

Community Name	Acres of Urban Land	Flow (m^3/s)	TSS (lbs/yr)	Copper (lbs/yr)	Lead (lbs/yr)	Zinc (lbs/yr)	TN (lbs/yr)	TP (lbs/yr)	Fecal Coliform (#/year)
Concentrations			22 mg/L	19 µg/L	4 µg/L	79 µg/L	3.4 mg/L	0.34 mg/L	2,887 MPN/100mL
West Fox Hills	30.8	0.0003	458	0.40	0.08	1.65	70.42	7.11	2.73E+11
Franklin Canyon	0.36	3.5E-06	5	0.00	0.00	0.02	0.83	0.08	3.21E+09
Ladera Heights/ Viewpark - Windsor Hills	2,830	0.0275	42,042	36	7.64	151	6,462	653	2.50E+13
West Los Angeles	552	0.0054	8,197	7.08	1.49	29.44	1,260	127	4.88E+12

Note that dry weather loading of toxics is not provided. There are typically very low or undetectable concentrations of these constituents during dry weather according to monitoring conducted to date. Therefore, loading is assumed to be zero for the purposes of this document during such periods.

3.2. Pollutant Source Characterization

The locations and density of pollutant sources within the watersheds are keys to understanding where BMPs and other implementation components should be focused. Typical sources for the pollutants of concern are summarized in Table 10. The following sections provide a detailed inventory and characterization of pollutant sources in the Ballona Creek watershed with a focus on the locations, densities, and areas. Summaries are provided for the following sources: land use, impervious cover, NPDES permits, road density, Toxics Release

Inventory (TRI) emissions, Resource Conservation and Recovery Act (RCRA) and Superfund sites, and sanitary sewers.

Table 10. Typical Sources of Pollutants

Parameter	Potential Sources
Indicator or coliform bacteria	Wildlife, pets, sewer leaks, sanitary sewer overflows (SSOs), wastewater discharges, humans (e.g., homeless), animal operations, illicit discharges, septic systems, land application
Lead	Lead-zinc batteries, electroplating, metallurgy, construction materials, coating and dyes, electronic equipment, plastics, veterinary meds, fuels, radiation shielding, ammunition, corrosive-liquid containers, paints, glassware, solder, piping, cable sheathing, roofing, atmospheric deposition
Zinc	Smelting, refining, wood combustion, waste incineration, iron and steel production, and tire wear, atmospheric deposition
Copper	Mining, smelting, refining, copper wire mills, coal burning, iron/steel industry, copper brake pads, some algaecides and pesticides, sewage treatment plants, atmospheric deposition
Nutrients	Fertilizers (residential and agricultural), atmospheric deposition, wastewater, leaking sewers, septic systems, animal operations, pets, native geology
Chlordane	Legacy pesticide – residual storage in sediment; refuse sites
DDT	Legacy pesticide – residual storage in sediment; refuse sites
PAHs	Combustion sources, transportation, atmospheric deposition, wastewater discharge, coal storage, wood treatment plants, petroleum pressing, oil
PCBs	Legacy pollutant – A variety of compounds used in dielectric fluids for transformers and capacitors, heat transfer fluids, and lubricants; refuse sites, abandoned facilities; residual storage in sediment

3.2.1. Land Use and Impervious Cover

A breakdown of the land uses (SCAG 2005) in the County TMDL Implementation Area is shown in Table 11. Much of the unincorporated County areas in the Ballona Creek watershed are high-density, single-family residential areas (38 percent) and industrial areas (21 percent). Those land uses are concentrated in the southern portion of the watershed in the Ladera Heights/Viewpark-Windsor Hills communities as shown in Figure 11. For industrial areas, the land use can be categorized as a single type: oil and gas extraction (Figure 12). The majority of the northern unincorporated County areas are used for commercial purposes.

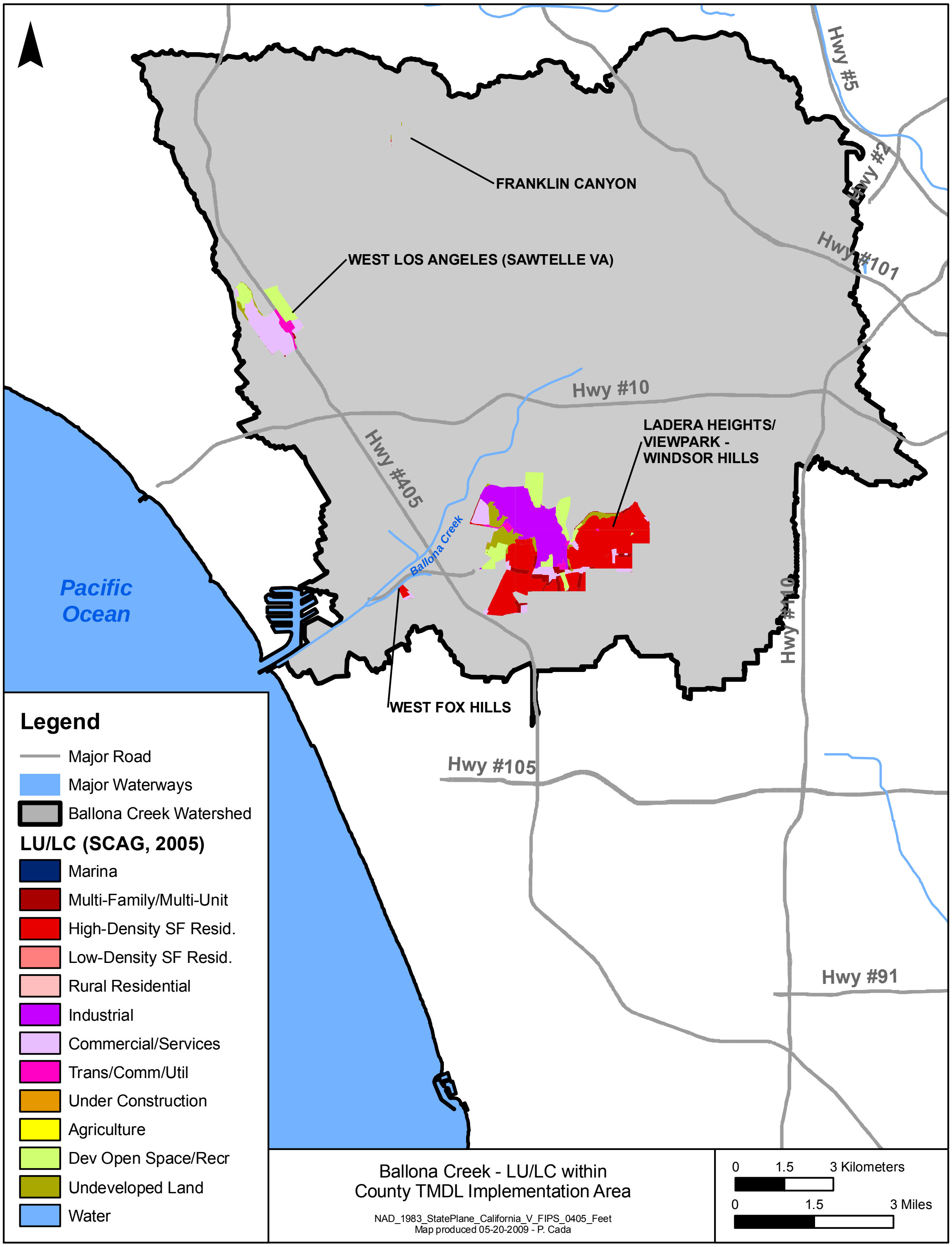


Figure 11. Land Use in Nonfederal Unincorporated County Area

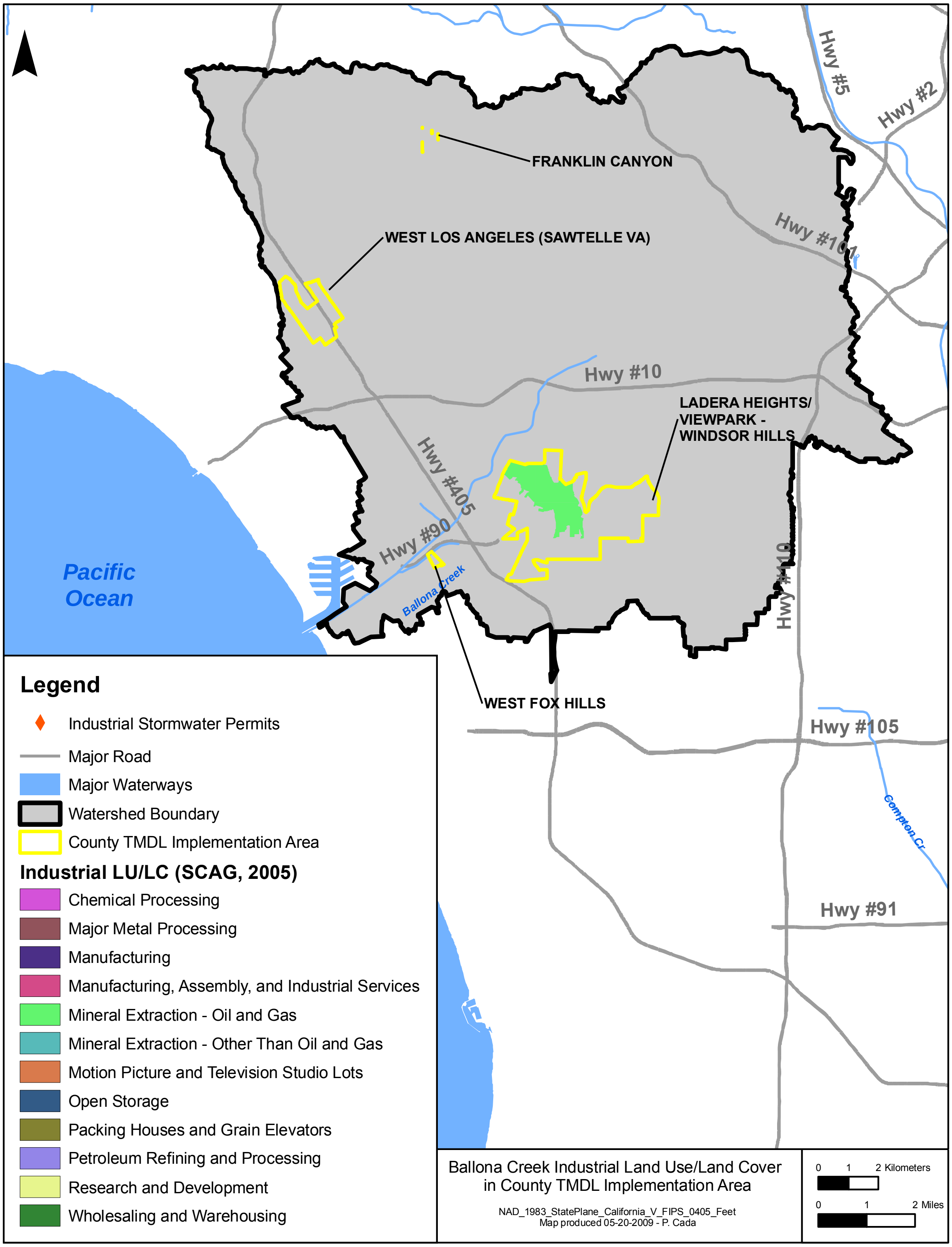


Figure 12. Industrial Land in the Ballona Creek Watershed—County TMDL Implementation Area

Table 11. Land Use in the County TMDL Implementation Area

Land Use	Acres	Percentage
High-Density, Single-Family Residential	1,402	38%
Industrial	764	21%
Commercial and Services	550	15%
Developed Open Space/Recreational	517	14%
Undeveloped Land	230	6%
Multi-Family/Multi-Unit	139	4%
Transportation, Communications, Utilities	84	2%
Water	0	--
Low-Density, Single-Family Residential	0	--
Agriculture	0	--
Rural Residential	0	--
Under Construction	0	--
Total	3,691	

As an initial indicator of the potential sources of pollutants from relevant land uses listed above, a summary of wet weather concentrations from several citations is provided. The data represent wet weather EMCs for the Los Angeles region from Stein et al. (2008), geometric mean concentrations based on studies in the Southern California Bight from Ackerman and Schiff (2003), and storm EMCs from LACDPW monitoring 1994–2000 (Table 12, Table 13, and Table 14). With the exception of runoff from open space, agriculture, other areas that might not flow to the storm drain network, runoff from most of the other developed land uses drains to the stormwater network.

Typical dry weather concentrations for select pollutants are shown in Table 15. These were taken from Stein and Ackerman (2007) and land use-based monitoring by LACDPW (1994–2000). Concentrations of organic toxic chemicals are typically not detected or occur at relatively low concentrations in dry weather flows.

Table 12. Concentrations by Land Use

Land Use	Total Copper (µg/L)	Total Lead (µg/L)	Total Zinc (µg/L)	Total PAHs (µg/L)
High-Density Residential	26.0	28.4	207.7	4.4E+03
Low-Density Residential	29.9	6.0	87.1	1.4E+03
Commercial	38.1	20.4	362.2	1.2E+03
Industrial	70.3	24.1	599.1	1.5E+03
Recreational	38.0	16.3	131.5	4.6E+02
Transportation	9.8	3.3	92.6	4.8E+02
Open Space	7.6	1.2	23.2	1.38E+02[a]

Source: Stein et al. 2008

a. Open space PAH is from Stein et al. 2005.

Table 13. Concentrations by Land Use

Land Use	Ammonia (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)	Copper (µg/L)	Lead (µg/L)	Zinc (µg/L)	Cadmium (µg/L)	Selenium (µg/L)	DDT (µg/L)
Residential	0.42	0.08	0.57	16.2	3.98	69.7	0.20	0.15	0.0
Commercial	0.45	0.09	0.49	20.8	3.65	159	0.26	0.13	0.0
Industrial	0.34	0.06	0.37	28.4	5.86	196	0.46	0.23	0.0
Open	0.07	0.02	--	5.04	0.69	3.19	0.09	0.09	0.0

Source: Ackerman and Schiff 2003

Table 14. Concentrations by Land Use

Land Use	TN (mg/L)	TP (mg/L)	Fecal Coliform (MPN/100 mL)	Copper (µg/L)	Lead (µg/L)	Zinc (µg/L)	Cadmium (µg/L)	Pyrene (PAH) (µg/L)	Phenanthrene (PAH) (µg/L)
Mixed Residential	3.51	0.26	--	17.33	8.7	184.85	--	0.53	0.73
High-Density Residential (SF)	3.93	0.39	1.09E+06	15.3	9.59	80.35	--	1.5	--
Multifamily Residential	3.67	0.19	--	12.23	5.13	134.88	--	--	--
Retail/Commercial	4.09	0.41	1.07E+06	34.77	11.53	238.53	0.71	--	--
Education	2.33	0.31	--	21.49	4.53	123.69	--	--	--
Light Industrial	4.02	0.44	6.53E+05	31.04	14.87	565.6	--	--	--
Transportation	2.65	0.44	1.34E+06	51.86	9.08	279.45	1.05	--	--
Vacant	1.97	0.11	2.17E+03	9.12	n/m	38.81	--	--	--

Source: LACDPW Monitoring 1994–2000

TN = TKN plus Nitrate-N plus Nitrite-N

Table 15. Typical Dry weather Concentrations in the Ballona Creek Watershed

	Units	Ballona Creek
TSS	mg/L	22
Copper	µg/L	19
Lead	µg/L	4
Zinc	µg/L	79
TN	mg/L	3
TP	mg/L	0.34
Fecal Coliform	MPN/100 mL	2,887

All concentrations are from Stein and Ackerman (2007), with the exception of fecal coliform and nutrients, which were averaged from County monitoring data.

The amount of impervious cover provides an indication of the degree of urbanization and the amount of stormwater that can be conveyed directly to the MS4. The imperviousness of the County TMDL Implementation Area is shown in Figure 13. The least permeable areas are the commercial land uses followed by high-density residential.

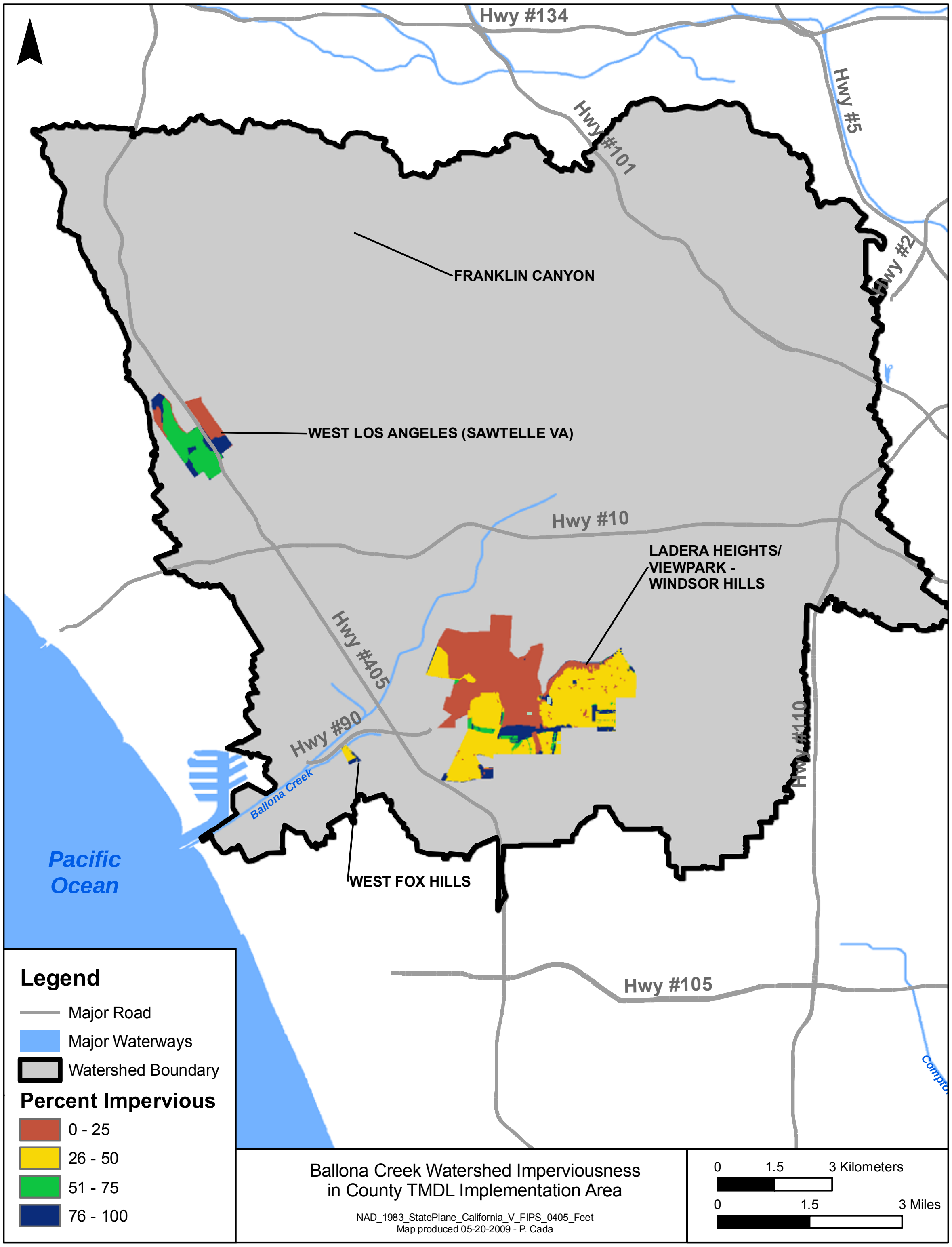


Figure 13. Imperviousness in Nonfederal Unincorporated County Area—Ballona Creek Watershed

3.2.2. NPDES Permits

A point source, according to Title 40 of the *Code of Federal Regulations* section 122.3, is any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, and vessel or other floating craft from which pollutants are or can be discharged. The NPDES program, established under CWA Parts 318, 402, and 405, requires permits for the discharge of pollutants from point sources. Point sources also include stormwater that is regulated through the NPDES program.

The Ballona Creek watershed contains 124 total NPDES discharge permits, but only 4 are in the County TMDL Implementation Area (Table 16). Of the four, one is a construction permit, and three are minor dischargers. Maps indicating the location of the facilities in the Ballona Creek watershed are shown in Figure 14 and Figure 15. Note that construction permits are temporary in nature; however, including them in this evaluation can be an important component for understanding historical monitoring data (TSS, for example) and serves as an indicator of the overall land disturbance that could occur in certain areas of the watershed. The permits overlap in time and space; therefore, as an aggregate, they represent a more continuous source. In addition, sediment that leaves a site could remain in the drainage system for some time.

Table 16. NPDES Permits in the Ballona Creek Watershed

Permit Type	Ballona Creek Watershed	County TMDL Implementation Area Only
Publicly Owned Treatment Works	0	0
Municipal Stormwater	1	1
Industrial Stormwater	68	0
Construction Stormwater	47	1
Caltrans Stormwater	1	0
Other Major NPDES Discharges	0	0
Minor NPDES Discharges	7	3
Total NPDES Discharges	124	4

Stormwater runoff in the Ballona Creek watershed is regulated through four types of permits: an MS4 permit issued to the County, a statewide stormwater permit for Caltrans, a statewide Construction Activities Storm Water General Permit, and a statewide Industrial Activities Storm Water General Permit. The County Permit includes 84 cities and the County. Major and minor permits are mainly issued for industrial and manufacturing activities. Other minor permits are issued to residential and apartment communities, medical facilities, laboratories and other various agencies.

The Caltrans statewide stormwater discharge permit authorizes stormwater discharges from Caltrans properties and facilities, such as the state highway system, park facilities, and maintenance yards. Most of those discharges eventually run to a city or County storm drain. The NPDES industrial general permit regulates stormwater discharges and authorized non-stormwater discharges from several categories of industrial facilities. That permit regulates stormwater discharges and authorizes non-stormwater discharges from 10 specific categories of industrial facilities, including manufacturing facilities, oil and gas mining facilities, landfills, and transportation facilities. Covered activities specific to County watersheds include sand and gravel operations as well as oil and natural gas, metal plating, transportation, recycling, and manufacturing facilities.

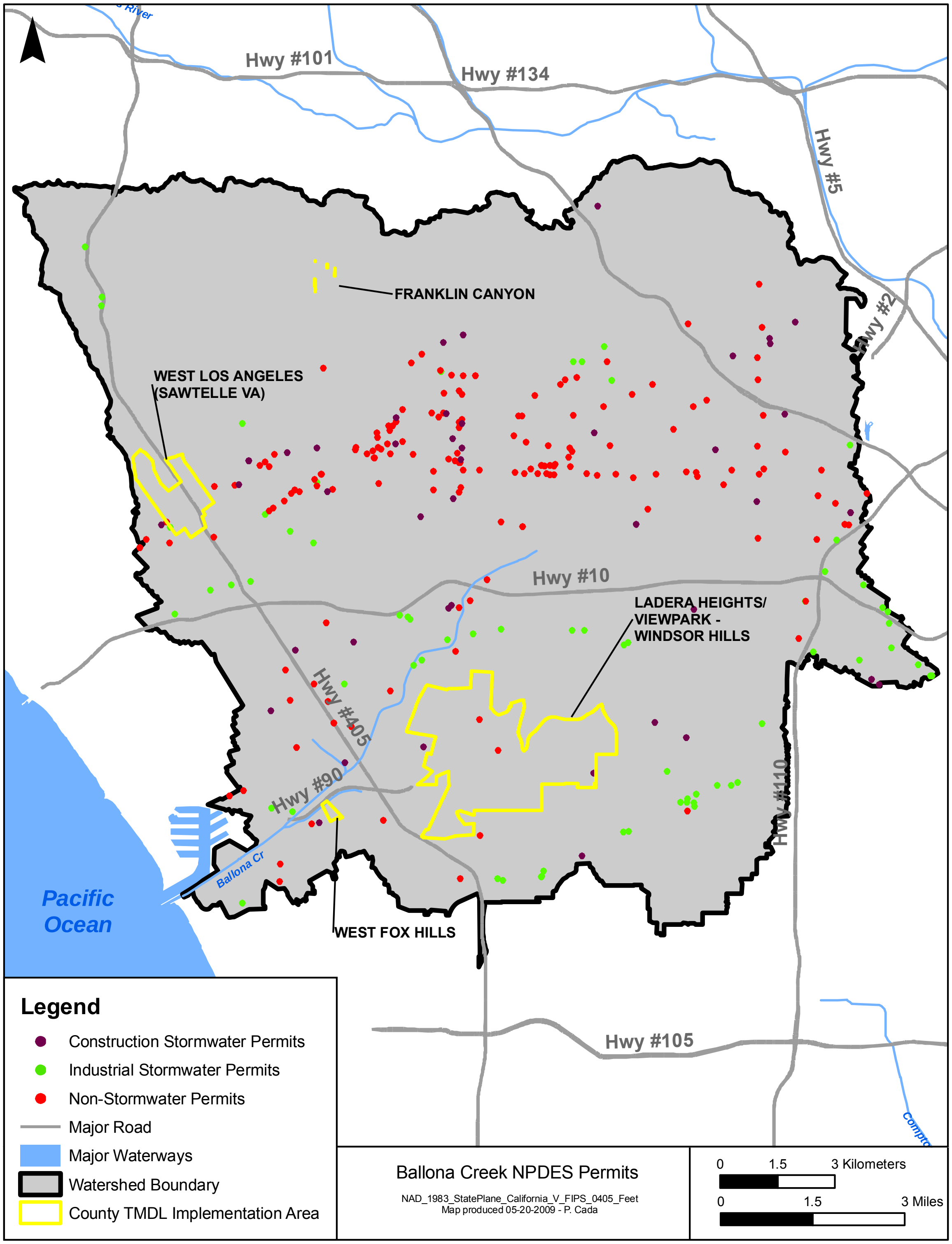


Figure 14. NPDES Permits in the Ballona Creek Watershed

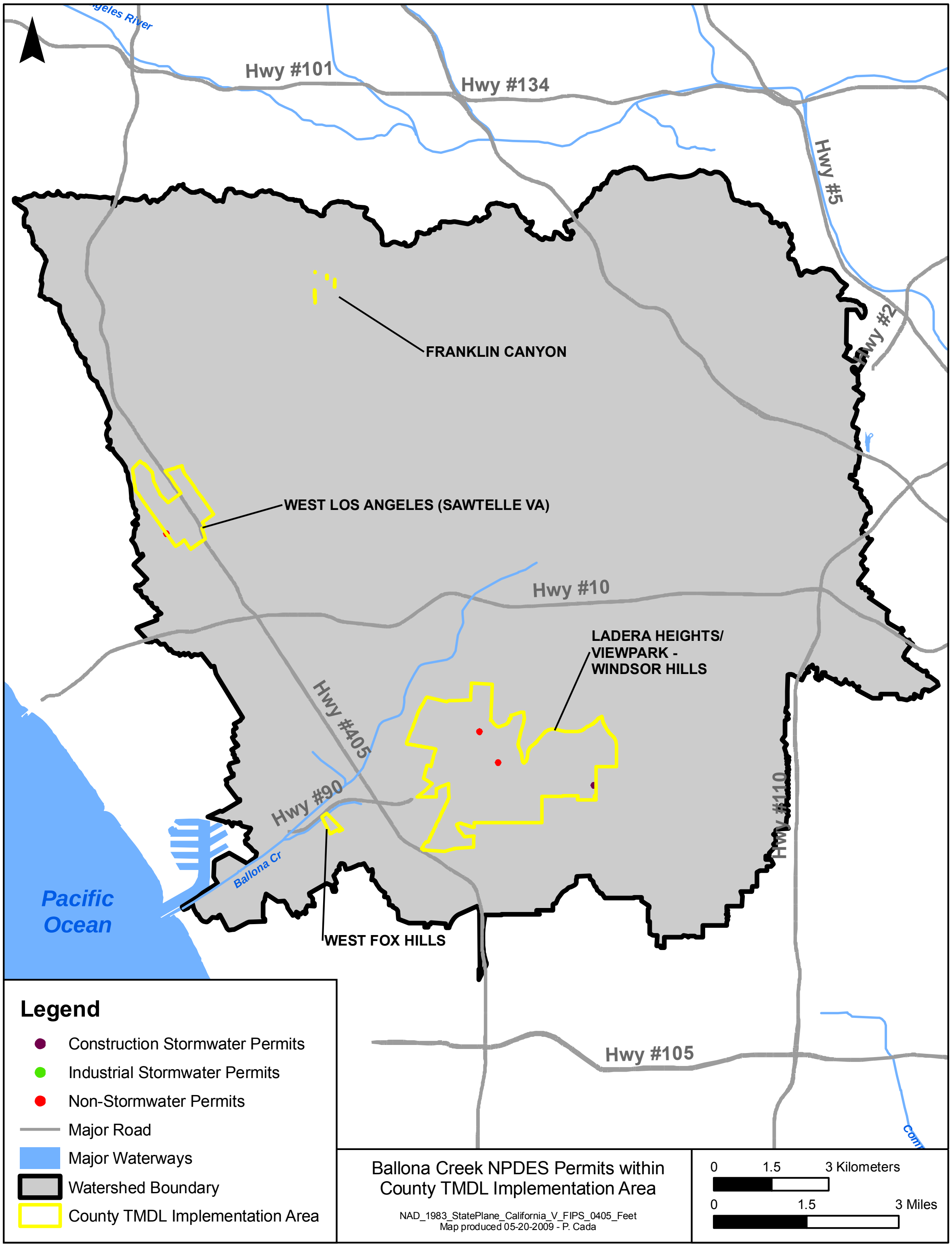


Figure 15. NPDES Permits in the Ballona Creek Watershed—County TMDL Implementation Area

The stormwater outfalls in the County TMDL Implementation Area are shown in Figure 16. Note that although industrial land use is present, according to the geographic information system (GIS) layer, no industrial permits were received from LARWQCB.

The location and density of stormwater outfalls can provide a general indicator of the significance of stormwater-based sources in an area. However, that does not take into account the specific land-use-based sources draining to the outfalls. The drains can also be candidates for diversion of dry weather flows to sanitary sewers or alternative treatments as described in the *Dry Weather Discharge Treatment Feasibility Report* prepared for LACDPW (2003).

Regulated stormwater can be a significant source of pollutant loads derived from residential, commercial, transportation, and industrial activities flowing to storm drains. The following provides additional discussion regarding the presence of pollutants in stormwater runoff.

Metals

The sources and delivery of metals can vary depending on weather and flow conditions. SCCWRP conducted two monitoring events in September 2002 and September 2003 (Ackerman et al. 2004a). The monitoring consisted of synoptic sampling of flow and metals concentrations from Water Reclamation Plants, storm drains, and open channels. Often, wet weather metal loadings are greater than dry weather loadings, even in dry years, with wet weather stormwater runoff shown to be the dominant source of annual metals loading (LARWQCB and USEPA 2005a).

Dry weather runoff or nuisance flow and/or discharges from other NPDES permitted sources are a significant source of metals in the Los Angeles Region (LARWQCB and USEPA 2005a). However, dry weather flows are highly variable on a daily and annual basis. Metals concentrations are also highly variable between storm drain locations. During dry weather, the metals are primarily in the dissolved phase and could be more bioavailable (LARWQCB and USEPA 2005a; SCCWRP 2004).

All the types of facilities covered under the industrial general permit have the potential for metal loads, especially metal plating, transportation, recycling, and manufacturing facilities (LARWQCB and USEPA 2005a; Stenstrom and Lee 2005). Stormwater runoff from industrial sites has the potential to contribute to metals loading during wet weather; although, during dry weather, the potential is low.

Discharges covered under the statewide construction general permit also have the potential to contribute metals loading from construction sites. Sediment delivered from construction sites can contain metals from construction materials and heavy equipment. Additionally, metals can leach out of building materials and construction waste exposed to stormwater (Raskin et al. 2004). During redevelopment of former industrial sites, there is a higher potential for discharge sediments to contain metals. Wet weather runoff from construction sites has the potential to contribute metals loading; however during dry weather, the potential contribution of metals loading is low because non-stormwater discharges are prohibited or controlled by the permit (LARWQCB and USEPA 2005a).

Toxic Organic Chemicals

The fertilizers used for lawn and landscape maintenance of municipal areas are also a source of metals and organic chemicals. Fertilizers, herbicides, and pesticides contain metals such as cadmium, copper, mercury, zinc, lead, iron, and manganese, which are also distributed when applying fertilizers and pesticides. Heavy metals in municipal stormwater can also come from car debris, roof shingles, building materials, and plastics (Van Metre and Mahler 2003; Walch 2006; Ellis and Revitt 1982; van Breemen and Vermij 2007).

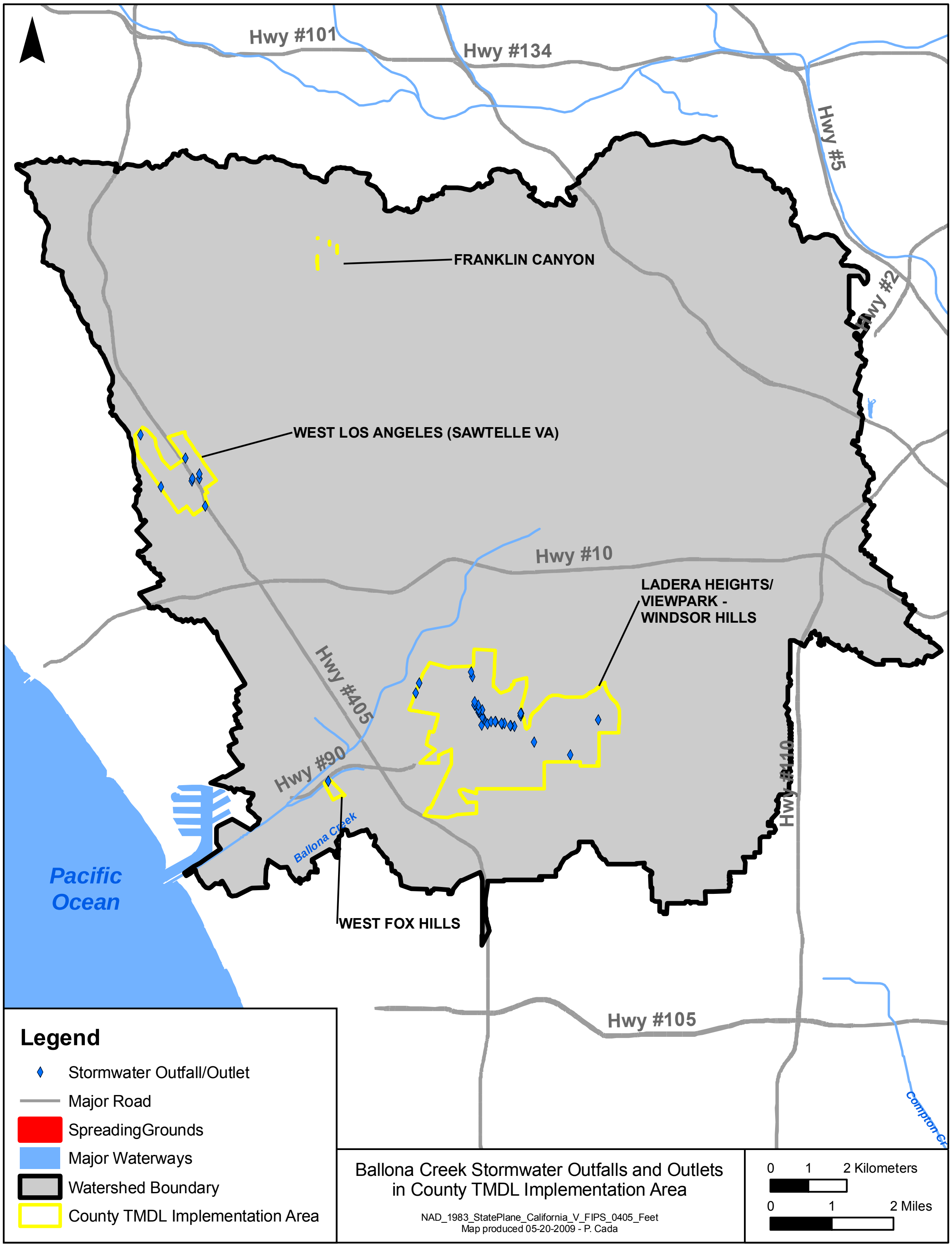


Figure 16. Stormwater Outfalls in the Ballona Creek Watershed—County TMDL Implementation Area

Residential fertilizers and pesticides also contain toxic chemicals such as dioxins, organophosphates, and organochlorides. Concentrations of certain pesticides, such as diazinon and chlorpyrifos, are found in higher concentrations from residential areas than agricultural areas because they are so heavily used in home applications (Katznelson and Mumley 1997; McPherson et al. 2005; Schiff and Sutula 2001).

In addition to the fertilizers and pesticides used in commercial areas, runoff from parking lots contains oil, grease, and litter. Litter loads from commercial facilities are a major source of chemicals from the breakdown of trash. Phthalate esters, which had been released from the breakdown of paper, plastic bags, and Styrofoam, were found in large concentrations in the Los Angeles region runoff (Stenstrom et al. 1998). Organic chemicals, such as phthalate esters are also associated with PVC manufacturing plants, textiles, paper mills, landfills, and incinerators (Makepeace 1995).

Commercial areas might also have toxic contaminants from dry cleaners, degreasing facilities, firing ranges, fuel terminals, car washes, car repair areas, paint stripping facilities, and others. Commercial areas with significant amounts of hazardous chemicals are reported by RCRA and discussed in later sections.

PAHs, a group of more than 200 different chemicals, are found in nature in coal and crude oil and in emissions from combustion of fossil fuels, forest fires and volcanoes. Most PAHs entering the environment are formed during burning (coal, oil, wood, gasoline, garbage, tobacco and other organic material) or in certain industrial processes. The primary source of PAHs to Ballona Creek and Estuary is urban stormwater runoff. Research by Stein et al. (2006) found that the dominant source of origin was pyrogenic (combustion of organic matter) in the Los Angeles region that were deposited through atmospheric deposition.

Fecal Coliform

Bacterial contamination is generated throughout the watershed and then transported by the storm drain system regulated under the MS4 permit. In the Los Angeles River and Ballona Creek watersheds, storm drain bacteria concentrations are high during both wet and dry weather and contribute the vast majority of the bacteria loads (Ackerman et al. 2005). Storm drain system discharges can have elevated levels of bacterial indicators from sanitary sewer leaks and spills; illicit connections of sanitary lines to the storm drain system; runoff from homeless encampments; pet waste; organic debris from gardens, landscaping and parks; food waste; and illegal discharges from recreational vehicle holding tanks, among others (LARWQCB 2006). The bacteria indicators used to assess water quality are not specific to human sewage; therefore, fecal matter from animals and birds can also be a source of elevated levels of bacteria, and vegetation and food waste can be a source of elevated levels of total coliform bacteria, specifically (LARWQCB 2006).

During dry weather, storm drain flows are attributable to nuisance flows caused by over-irrigating lawns, car washing, restaurant washout and other activities in the watershed, and intermittent permitted discharges. Data available through the County MS4 permit monitoring program and SCCWRP were evaluated as part of the Ballona Creek bacteria TMDLs to identify potential sources. Although all land use sites exceeded the objectives for bacteria, the LACDPW data set for 1994–2000 shows stormwater originating from the high-density, single-family residential category had the highest densities of fecal coliform indicators, followed by commercial land use. In the SCCWRP 2001–2004 data set, the highest fecal coliform levels were from the low-density, residential land use category, followed by commercial land use (LARWQCB 2006).

Illegal connections and discharges are also very likely sources of bacteria in stormwater discharge. The County's MS4 permit requires the identification and elimination of illicit discharges and connections through a comprehensive program including identification, investigations, mapping, and public reporting of illicit activities.

Nutrients (Total Nitrogen and Total Phosphorus)

The potential nutrient sources for the MS4 include fertilizer used for lawns and landscaping; organic debris from gardens, landscaping, and parks; phosphorus in detergents used to wash cars or driveways; trash such as food wastes; domestic animal waste; and human waste from areas inhabited by the homeless. Those pollutants build up, particularly on impervious surfaces, and are washed into the waterways through storm drains when it rains. Such loads are typically highest during the first major storms after extended dry periods, when the pollutants have accumulated. Activities such as watering lawns and landscaping, washing cars, and washing parking lots and driveways can contribute pollutants between storms (USEPA 2003b). High nitrogen and phosphorus loadings are associated with urban wet weather runoff from residential, commercial, and industrial land uses (SCCWRP 2000; LARWQCB 2003; USEPA 2003b). Effluent irrigation from water reclamation facilities is considered a source of nitrogen and phosphorus, with higher contributions during the summer (USEPA 2003a).

Indirect atmospheric deposition is the process by which nutrients deposited on the land surface are washed off during storm events and delivered to waterbodies. Indirect atmospheric deposition of nutrients is accounted for in stormwater runoff (USEPA 2003b; LARWQCB 2008). This is discussed in more detail in Section 3.2.4.

Dry weather contributions from storm drains were quantified for the Los Angeles River watershed (SCCWRP 2000). Storm drains were shown to contribute 34 percent of the nitrate load and only 2 percent of the total nitrogen load. The LARWQCB estimated that 78 percent of the nitrogen loads (wet and dry weather combined) from the storm drain system were associated with urban runoff (LARWQCB 2003).

3.2.3. Road Infrastructure

Most of the pollutant load attributed to runoff from highways and roads are regulated under either the Caltrans or MS4 permits. It is conservatively estimated that 1.3 percent of the Ballona Creek watershed is covered by state highways, not including other Caltrans properties and facilities covered under the permit (LARWQCB 2005; USEPA 2005). Pollutants originate from cars, roadway degradation, and landscaping surrounding the highways. Most of the discharges eventually run to a city or County storm drain.

The use and wear of cars is the most prevalent source of roadway pollutants. A California study found that cars are the leading source of metal loads in stormwater, producing over 50 percent of the copper, cadmium, and zinc loads (Schueler and Holland 2000). Wear from brake pads, tires, and engine parts is a significant source of metal pollutants. For example, almost 50 percent of the copper loads in roadway stormwater originates from brake pads (Davis et al. 2001), and tire wear accounts for over 50 percent of the total cadmium and zinc loads delivered to the San Francisco Bay each year (Santa Clara Valley Nonpoint Source Control Program 1992). Such conditions are likely similar for the Los Angeles region. Leaking oil, grease, and coolant also contribute metals and PAHs to the roadway loads.

PAHs are present in coolants, oil, and grease. They are also emitted from asphalt coatings and vehicle exhaust (Lau et al. 2009). Other organic chemicals, such as gasoline additives and dioxins from fertilizers are also present in roadway runoff. Table 17 shows common sources of contaminants in runoff from roads and highways.
Road density can be used to indicate the extent of traffic volume and consequential pollutant generation. Road density is defined as the total area of the impervious road pavement. A calculation of road density percentile distribution suggests that a cutoff for road density of 20 percent could delineate low and high density using a clear inflection point in the data. Therefore, the following two categories of road network density are defined:

- High Road Density: Road density is greater than 20 percent.
- Low Road Density: Road density is less or equal to 20 percent.

Most of the County TMDL Implementation Area has low road densities, as shown in Figure 17. One area of relatively high density is in the West Los Angeles community.

Table 17. Common Sources of Roadway Pollutants

	Cadmium	Chromium	Copper	Iron	Nickel	Lead	Zinc	PAHs	Nutrients	Synthetic Organic Chemicals
Gasoline	•		•			•	•			
Exhaust					•	•		•		•
Motor Oil and Grease				•	•	•	•	•		
Antifreeze	•	•	•	•		•	•	•		
Undercoating						•	•			
Brake linings			•	•	•	•	•			
Tires	•		•			•	•	•		
Asphalt	•		•		•		•	•		
Concrete			•		•		•			
Diesel oil	•	•				•	•			•
Engine wear				•	•	•	•			
Fertilizers, Pesticides, and Herbicides	•		•	•	•		•		•	•

Adapted from Nixon and Saphores (2007); Lau et al. 2009; Stein 2007; Davis et al. 2001; Schueler and Holland 2000

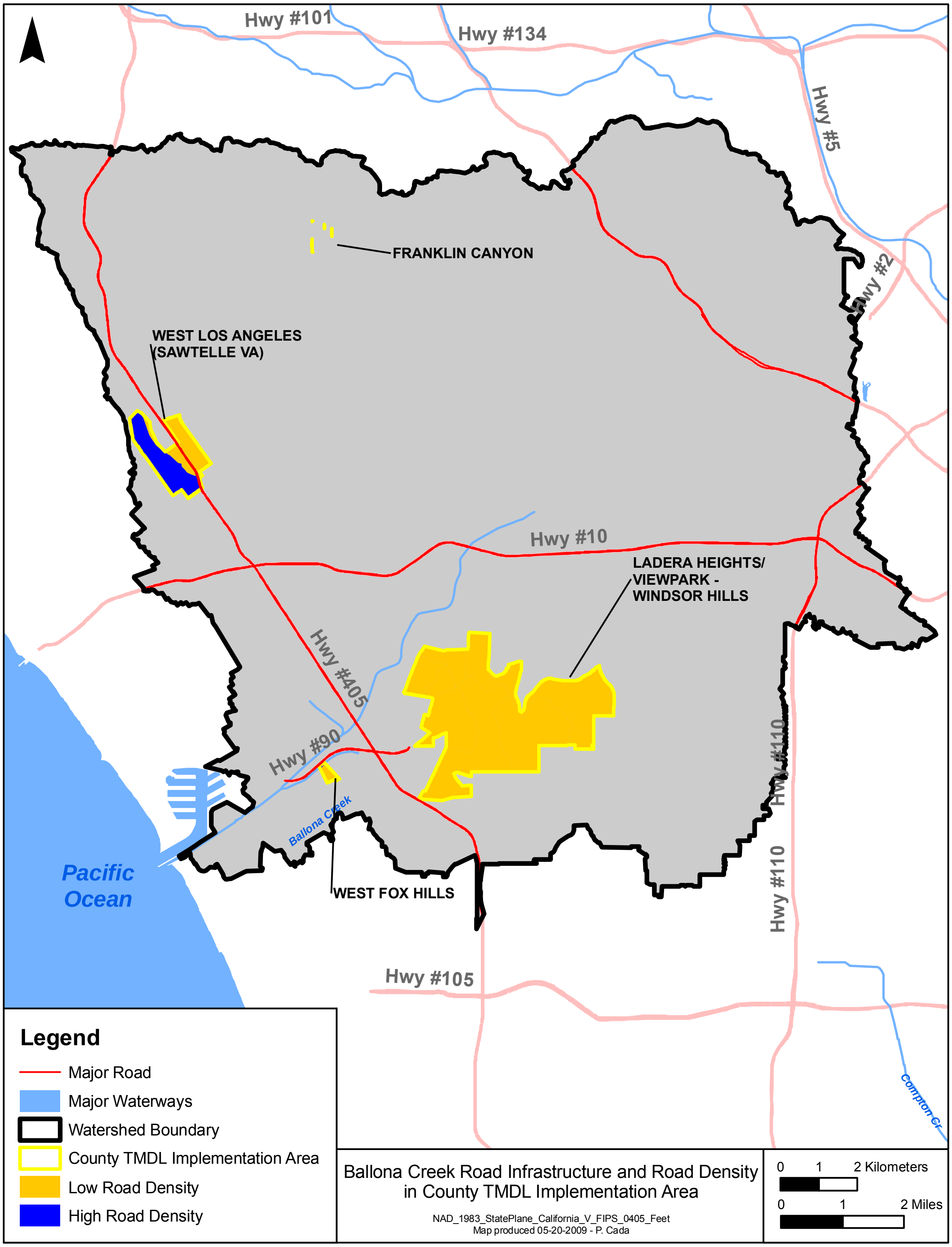


Figure 17. Road Density in the Ballona Creek Watershed—County TMDL Implementation Area

3.2.4. Atmospheric Deposition

Atmospheric deposition of pollutants, either directly to a waterbody surface or indirectly to the watershed land surface, can be a large source of contamination to surface waters near urban centers. Indirect atmospheric deposition is the process by which pollutants are deposited on the land surface, washed off during storm events, and delivered to waterbodies. While this atmospheric source ultimately becomes a part of stormwater, it is important to understand the pathways from initial source (e.g., industrial facility emitting metals into the air) and transport (from air to land to water) processes. Direct dry deposition to waterbodies in the Ballona Creek watershed is not a significant factor because of the small water surface on which to receive direct deposition. Pollutants also exist in wet deposition, which occurs during rain and snow fall. In California, wet deposition is not a significant source of pollutants in comparison to dry depositions because there are so few rain events (Lu et al. 2003).

As much as 50–100 percent of trace metals in stormwater runoff in highly impervious, urban catchments of Southern California comes from dry depositions (SCCWRP 2008). Although the atmospheric deposition of lead has decreased over the past 30 years, atmospheric deposition of copper and zinc has increased along the coast near the Los Angeles Harbor (SCCWRP 2008). Recently, aerial deposition of copper, zinc, and lead were measured at Santa Monica Bay (Stolzenbach 2006). Table 17 compares the contributions of trace metals from aerial deposition, sewage treatment plants, industrial activities, and power plants.

Table 18. Comparison of Source Annual Loadings to Santa Monica Bay

(metric tons/year)	Aerial Deposition	Non-Aerial Sources		
		Sewage Treatment Plants	Industrial	Power Plants
Chromium	0.5	0.6	0.02	0.14
Copper	2.8	16	0.03	0.01
Lead	2.3	< 0.01	0.02	< 0.01
Nickel	0.45	5.1	0.13	0.01
Zinc	12.1	21	0.16	2.4

Source: Stolzenbach 2006

Nutrients are also atmospherically deposited. The annual loading of nitrogen through atmospheric deposition in the Ballona Creek watershed is 845 tons per year (Lu et al. 2004). Phosphorous deposition rates in Southern California have been reported in a wide range, from 0.108 to 12.4 tons/year (Anderson 2001; Anderson and Oza 2003; Jassby et al. 2004).

In addition to trace metals and nutrients, atmospheric deposition of PAHs is very common. PAHs occur naturally in oil, coal, and tar deposits. They are also created by the incomplete combustion of wood, coal, diesel, and gasoline. The occurrence of specific ratios of individual PAHs is used to identify the source of the contaminants. Studies in Southern California have determined the leading source of PAHs in the Los Angeles region comes from incomplete fuel combustion from mobile sources, such as cars and trains. This also accounts for the seemingly ubiquitous presence of PAHs (Stein 1995; Stein 2006).

The atmospheric releases based on TRI data for copper, lead, zinc and PAHs near the Ballona Creek watershed are shown in Figure 18 through Figure 21. Though few origins of the emissions are in the Ballona Creek watershed, TRI sites outside the Ballona Creek watershed are also relevant because atmospheric transport occurs across watershed boundaries.

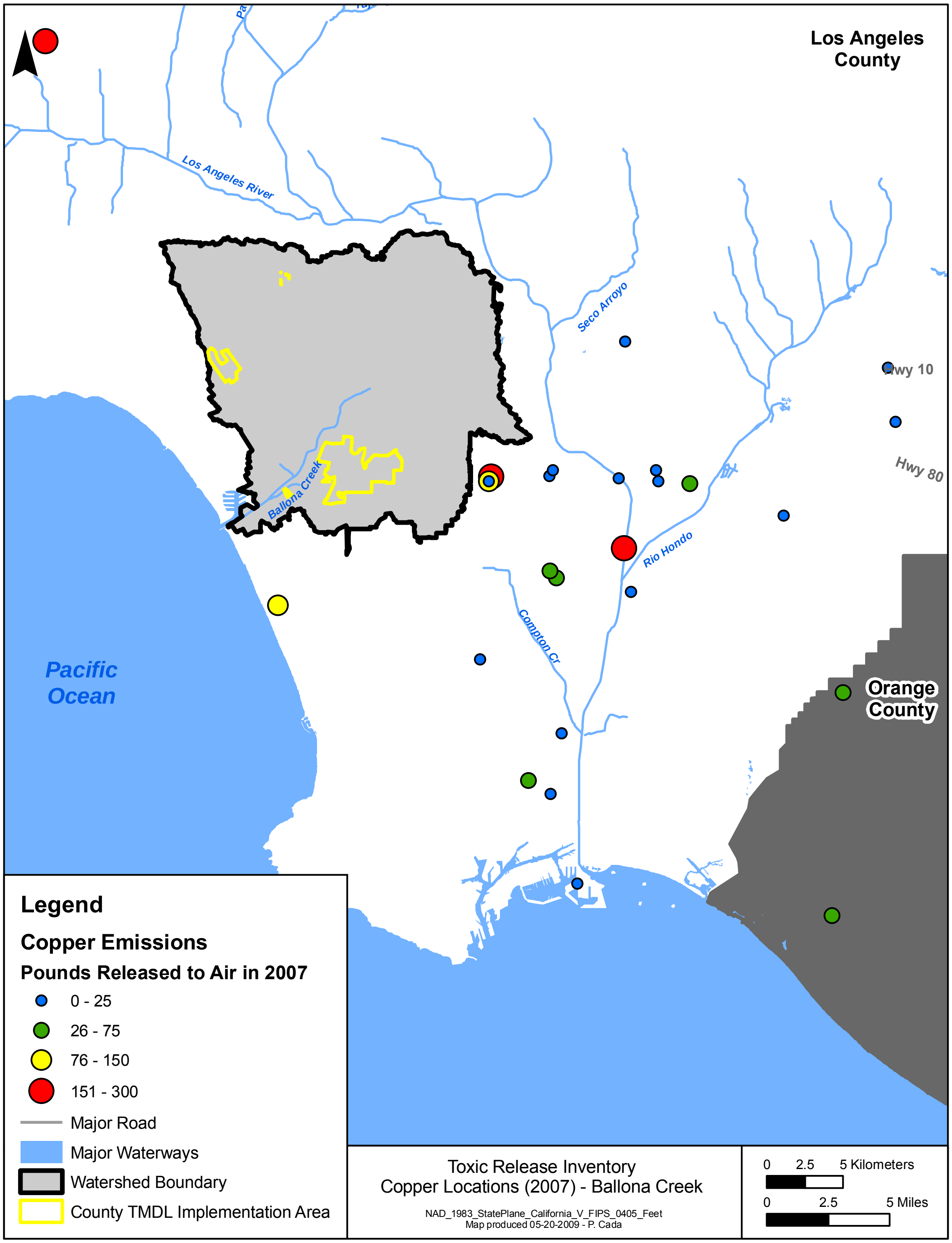


Figure 18. TRI Atmospheric Releases in the Ballona Creek Watershed—Copper

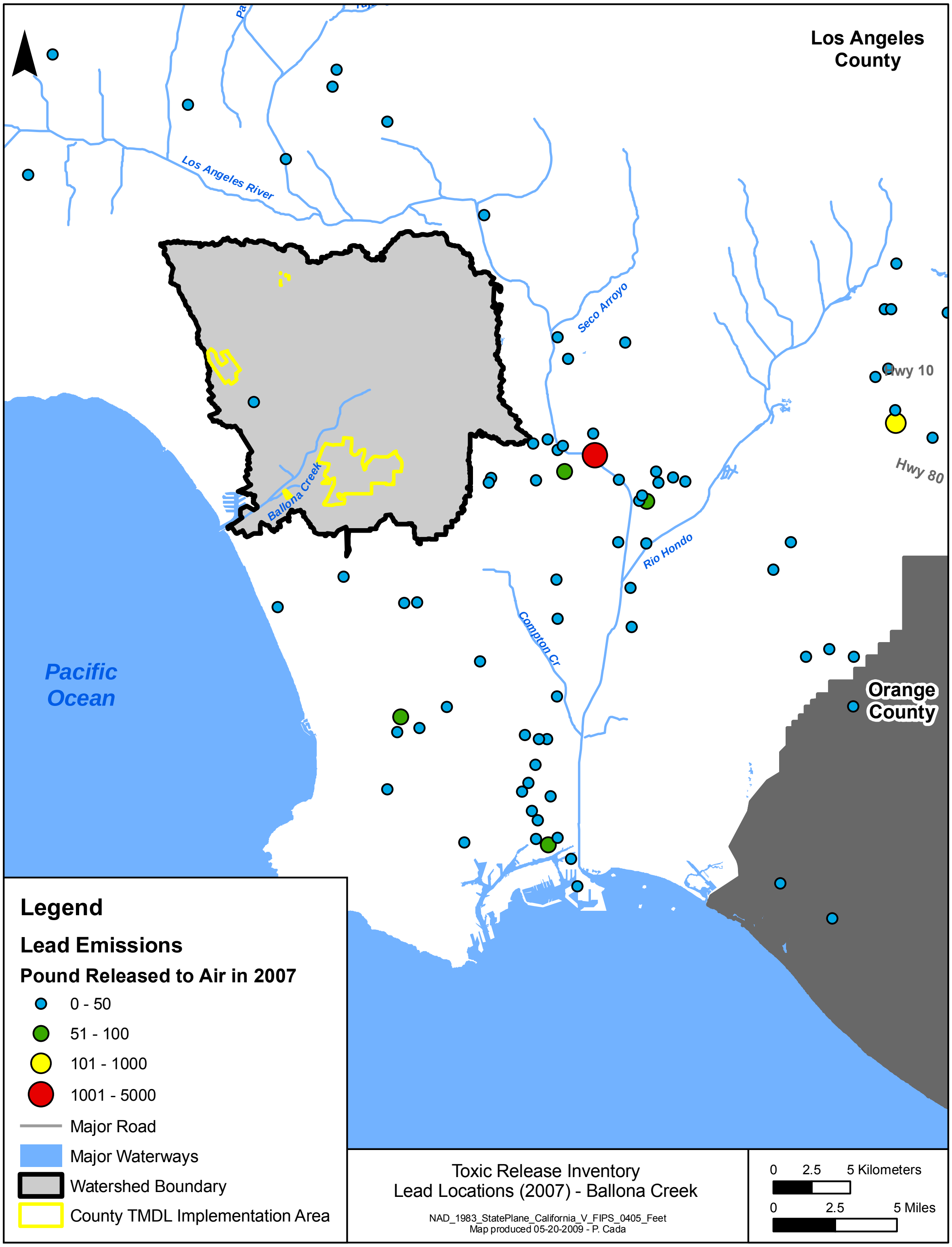


Figure 19. TRI Atmospheric Releases in the Ballona Creek Watershed—Lead

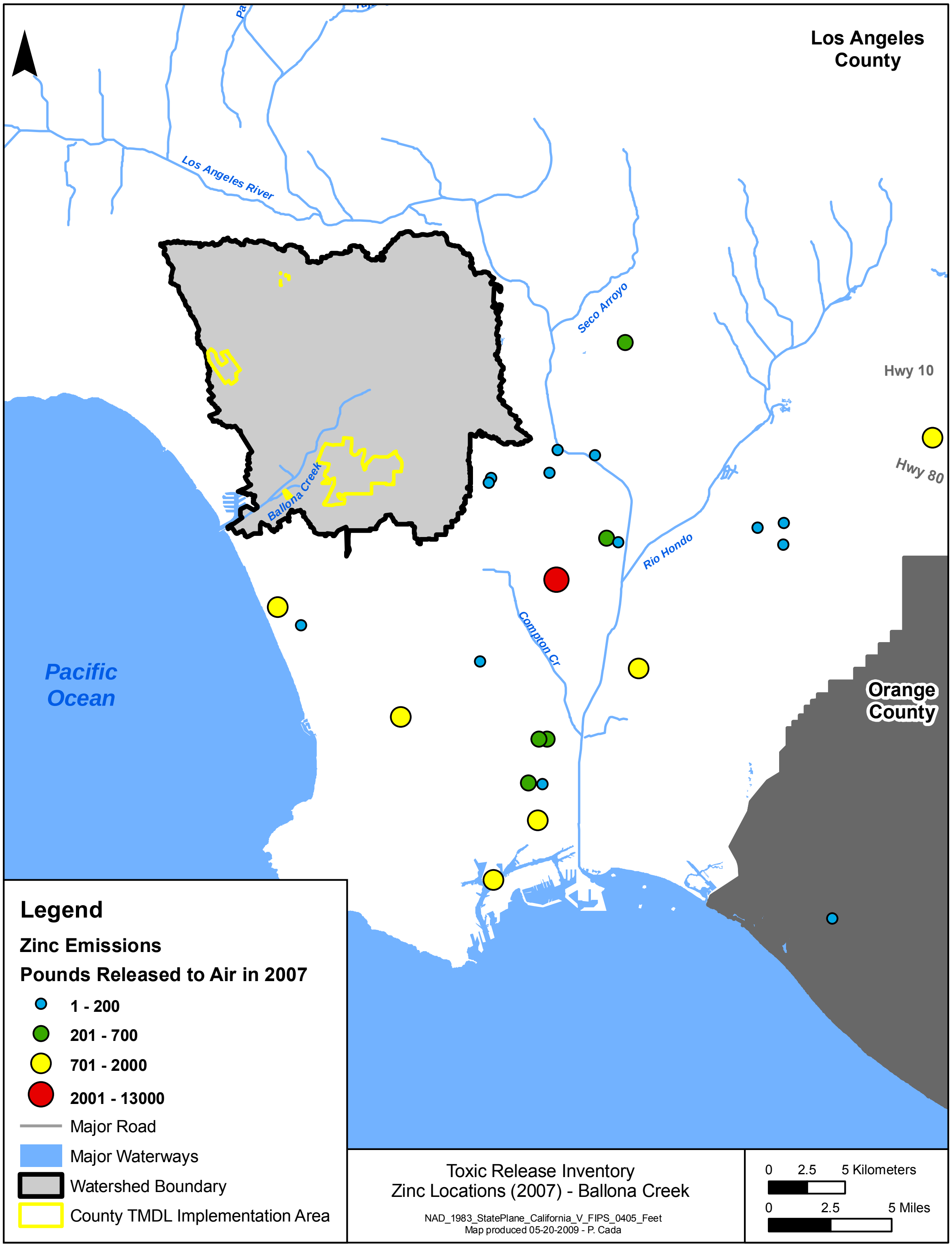


Figure 20. TRI Atmospheric Releases in the Ballona Creek Watershed—Zinc

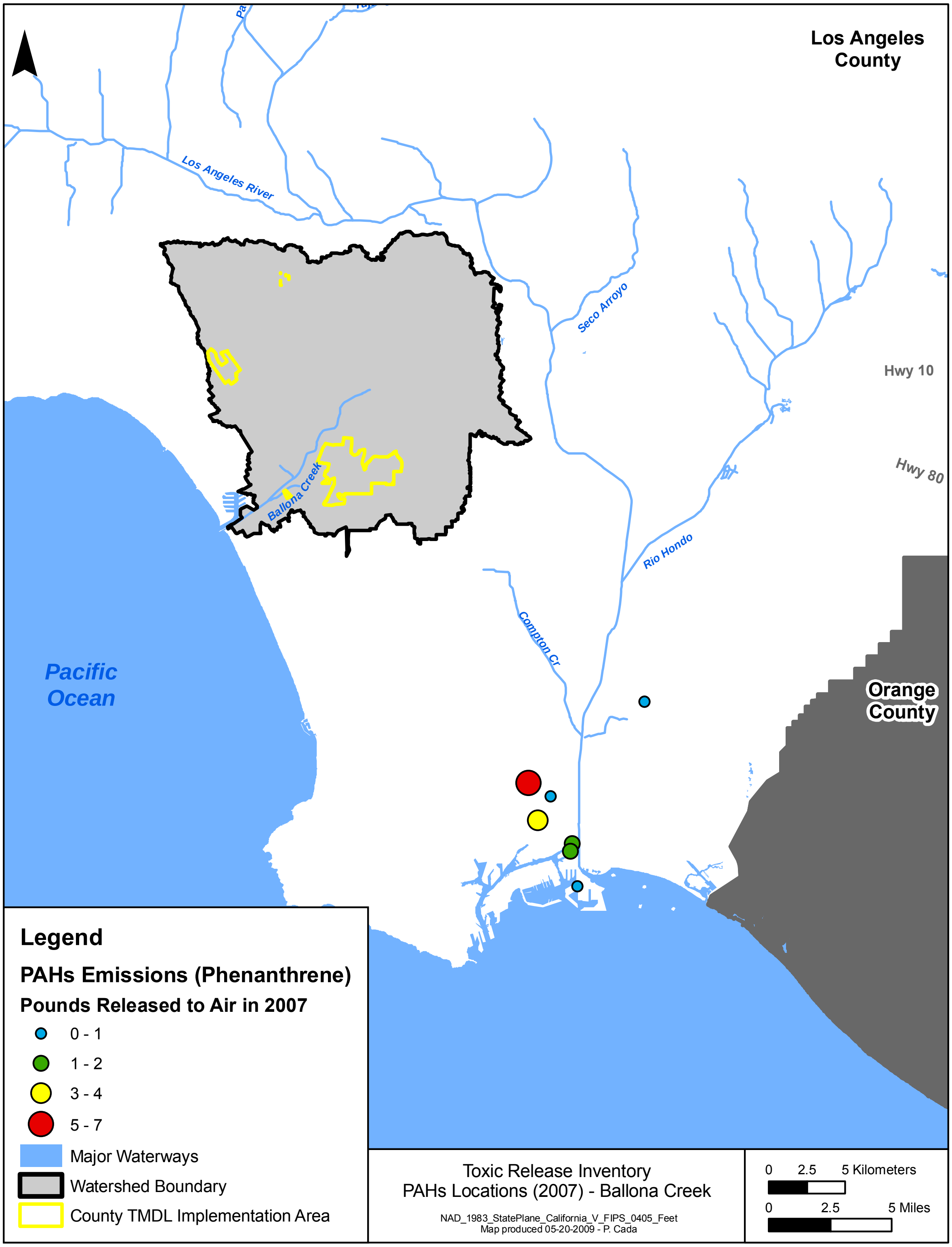


Figure 21. TRI Atmospheric Releases in the Ballona Creek Watershed—PAHs

In California in 2007, 81 industries released copper or copper compounds into the air. The largest emission of copper was 250 pounds. Three companies each released 250 pounds: Shultz Steel Company in Southgate, FTG Circuits in Chatsworth, and Data Electronic Surfaces in Santa Ana.

In 2007, 281 industries reported atmospheric emissions of lead. The largest emission was 3,434 pounds from Exide Technologies (electronics) in Los Angeles. The next largest release was 538 pounds from Quemetco, Inc., just to the east of the Los Angeles River watershed. All other industries emitted less than 100 pounds.

Zinc was released from 66 industries in 2007. The largest emitter of zinc was Custom Alloy Sales in Los Angeles. Custom Alloy Sales reported 8,787 pounds of air emissions. The second largest release was 1,920 pounds from ExxonMobile Refinery in Torrance, south of Ballona Creek and on the southwest side of the Los Angeles River watershed.

Only eight companies reported atmospheric releases of PAHs. Phenanthrene is used as an index chemical to represent PAHs because it tends to be the most common PAH found in the Los Angeles region (Sabin et al. 2004). The largest release of phenanthrene in 2007 was 7 pounds, from BP West Coast Products in Carson. All emitters of PAHs are at the southernmost portion of the Los Angeles River, and the majority of emissions were from fugitive emissions (not stacks).

Also, three companies reported atmospheric releases of PCBs in 2007 in California (not shown). The sum of PCB releases from all the companies is less than 0.5 pound, and those sites are all more than 100 miles away from the watersheds.

It is important to note that TRI data show only a portion of air pollutants that could be deposited in the Los Angeles region. Many metals and chemicals are regularly deposited hundreds of miles away from their original source (Daggupaty et al. 2006; Bozó et al. 1991). Recent studies of air pollution in Southern California have shown that a large portion of the mercury, nitrates, sulfates, and other toxins in the Los Angeles region actually comes from industrial practices in China. The location of Los Angeles (coastal and at the foot of a mountain range) causes the chemicals to concentrate in this terrain (Hotz 2007; Bradsher and Barboza 2006; Chea 2006).

3.2.5. Waste Sites

The RCRA was added to the Solid Waste Disposal Act (1965) in 1976 to regulate the disposal of municipal, industrial, and hazardous waste. It controls the generation, transportation, treatment, storage and disposal of hazardous and non-hazardous wastes. The term *RCRA site* generally refers to a site of waste storage or disposal. RCRA sets specific criteria for the containment at these sites; however a site in violation has the potential to emit pollutants into the environment (USEPA 2008).

Many other waste sites (landfills, recycling areas, battery reclamation sites, incinerators, unauthorized dumping grounds) could be possible pollutant sources that are not listed under RCRA. Superfund sites, which are hazardous waste sites that have been inactive or abandoned, are not regulated under RCRA. Such hazardous waste areas, and areas of accidental pollutant release (i.e., spills), are controlled under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA 1980). Those areas are called Superfund sites because they receive federal funding to assist with removal and cleanup processes. Only severely contaminated sites qualify for Superfund and are placed on the National Priorities List to receive funding. Many data sets are generated from the Superfund site, including data to establish the site on the National Priorities List, monitor progress of cleanup efforts, and long-term monitoring to ensure success of the cleanup.

Typical contaminants that can migrate from Superfund and RCRA sites to the environment are widespread. The top 10 pollutants on CERCLA's National Priority List include arsenic, lead, mercury, vinyl chloride, PCBs, benzene, PAHs, cadmium, benzo(A)pyrene, and benzo(B)fluoranthene. Dense and light non-aqueous phase liquids, which include chlorinated solvents, petroleum components, PCBs, and PAHs, are some of the worst contaminants found in hazardous waste sites because they are able to travel long distances in groundwater, are slow to degrade, and are toxic at very low concentrations.

RCRA and Superfund sites in Southern California were researched using the California EnviroStor public database. For both data sets, the facility name associated with each site is provided along with the facility address, coordinates, and permit numbers. RCRA data also describe the state of the cleanup efforts (e.g., active, completed, no action required, backlog) and the type of cleanup (voluntary, hazardous waste permit, state response, school clean up, and such).

Only one RCRA site is in the County TMDL Implementation Area. The site is registered to Eastern Ridgeline Project and used as an oil field. The soil on-site is actively being cleaned as a voluntary effort (not a corrective action or state response). The entire Ballona Creek watershed has 51 RCRA sites, most of which are voluntary cleanups or school sites (Table 19). Most sites are actively being mitigated, or cleanup has been completed (Table 20). Contaminants on those sites could include lead, cyanide, arsenic, PCBs, volatile organic compounds, and petroleum products. A map of RCRA sites in the County TMDL Implementation Area is shown in Figure 22.

Table 19. RCRA Sites in the Ballona Creek Watershed—Cleanup Type

Site Type	Total Sites in Watershed
Permitted hazardous waste facilities performing corrective actions	3
Federal superfund—delisted (cleaned up) site	0
Federal superfund—listed (cleanup is active or beginning)	0
Federal superfund—proposed (needs cleanup, not confirmed for federal funding yet)	0
Permitted hazardous waste facilities currently operating	0
School sites (proposed and existing) being cleaned or evaluated	26
Confirmed release sites (generally high-priority and high potential risk)	4
Voluntary cleanup sites (not required by law)	18

Table 20. RCRA Sites in the Ballona Creek Watershed—Cleanup Status

State of Action	Total Sites in Watershed
Action needed	7
Active	29
Complete	15
Referred	0

Only one Superfund site is in the Ballona Creek watershed, which is in the incorporated area of the County, in the northern third of the watershed. This site is 280 acres of contaminated groundwater and soil from the Del Amo Facility. The pollutants of concern are benzene, toluene, PAHs, and petroleum.

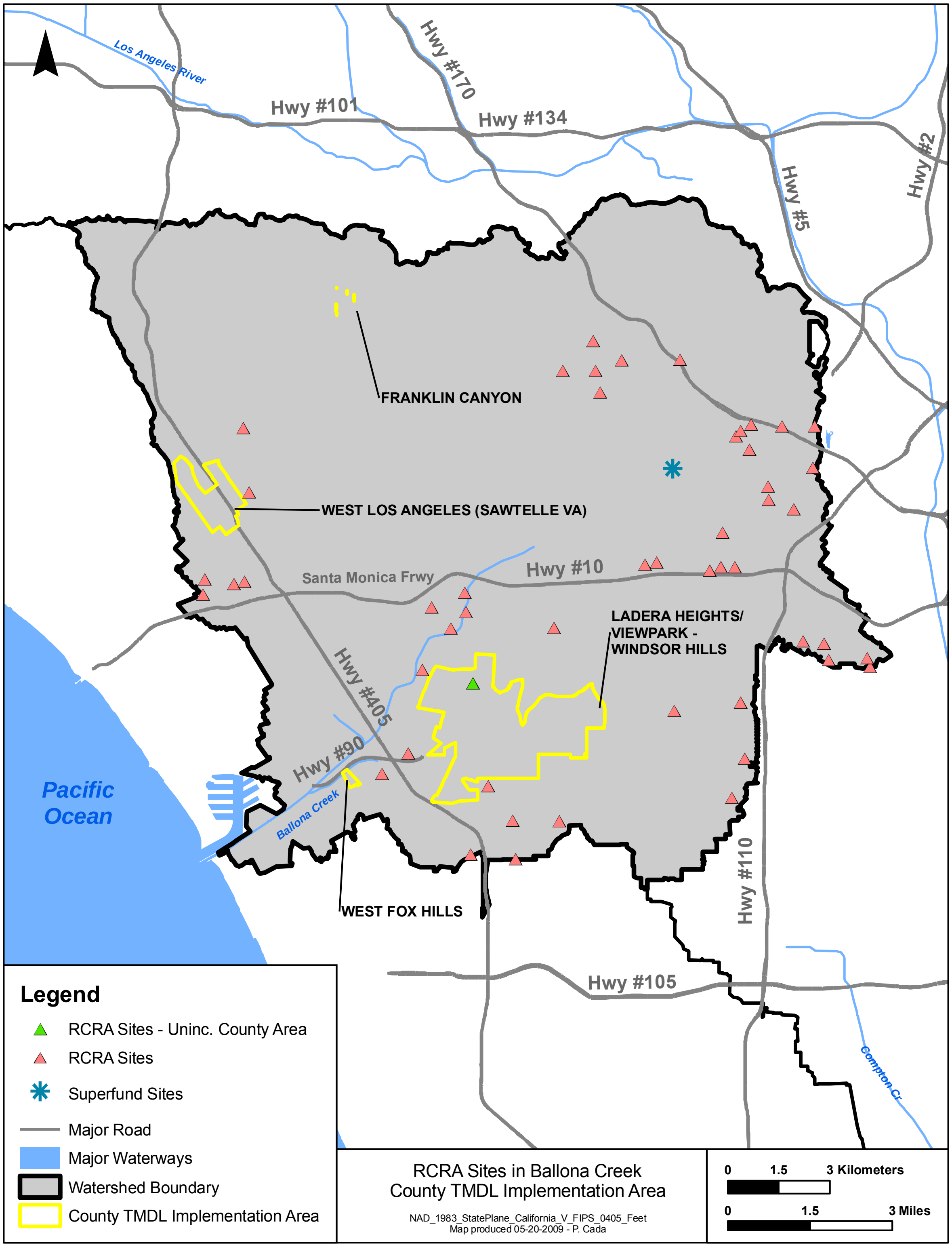


Figure 22. RCRA Sites in the Ballona Creek Watershed—TMDL Implementation Area Only

3.2.6. Sanitary Sewer and SSOs

When sanitary sewers overflow or leak, they can release raw sewage into the environment. Many sanitary sewer networks in the United States were installed decades ago and are in need of replacement. Aging systems are a major source of sanitary sewer leakage. Severe weather, improper system operation and maintenance (O&M), clogs, and root growth could contribute to sanitary sewer leaks and overflows. Overflows can affect nearby waters and also back up into streets and basements (USEPA 2009). Raw sewage contains high concentrations of bacteria and nutrients from human and kitchen waste, as well as organic chemicals and metals.

Chemicals are present in sewage water from household use of cleaners, disinfectants, personal care products, treated swimming pools and pharmaceuticals. Personal care products and pharmaceuticals have recently been scrutinized for their potential to be harmful endocrine disrupting chemicals (Boyd et al. 2004). Chemicals from laboratory sinks are also present in raw sewage (USEPA 2009).

Los Angeles has been recognized for the severe corrosion rates occurring within its sanitary sewers caused by sulfate-reducing bacteria (Morton et al. 1991; Zhang 2008). Wastewater from corroded sewers contains several metals, including cadmium, copper, iron, lead, and nickel (Ablin and Kinshella 2004).

The sanitary sewer network within the County TMDL Implementation Area is shown in Figure 23. The SSOs recorded between November 2006 and June 2009 are shown in Figure 24. The range of overflow volumes was between 20 and 500 gallons.

Ten SSOs are in the County TMDL Implementation Area. The main reported causes of those spills are grease and root intrusions. Three overflows were transported to Ballona Creek, and three others flowed into unidentified surface waters. This is summarized in Table 21. While some of the causes might have been addressed in certain spills, the number of SSOs can be viewed as an indicator of risk for future spills.

Table 21. SSOs in the County TMDL Implementation Area

Cause of Spill	Number of SSOs	Receiving Surface Water	Number of SSOs
Grease deposition (FOG)	3	Ballona Creek	3
Root intrusion	3	Other surface water	3
Other	4	Did not reach surface water	4

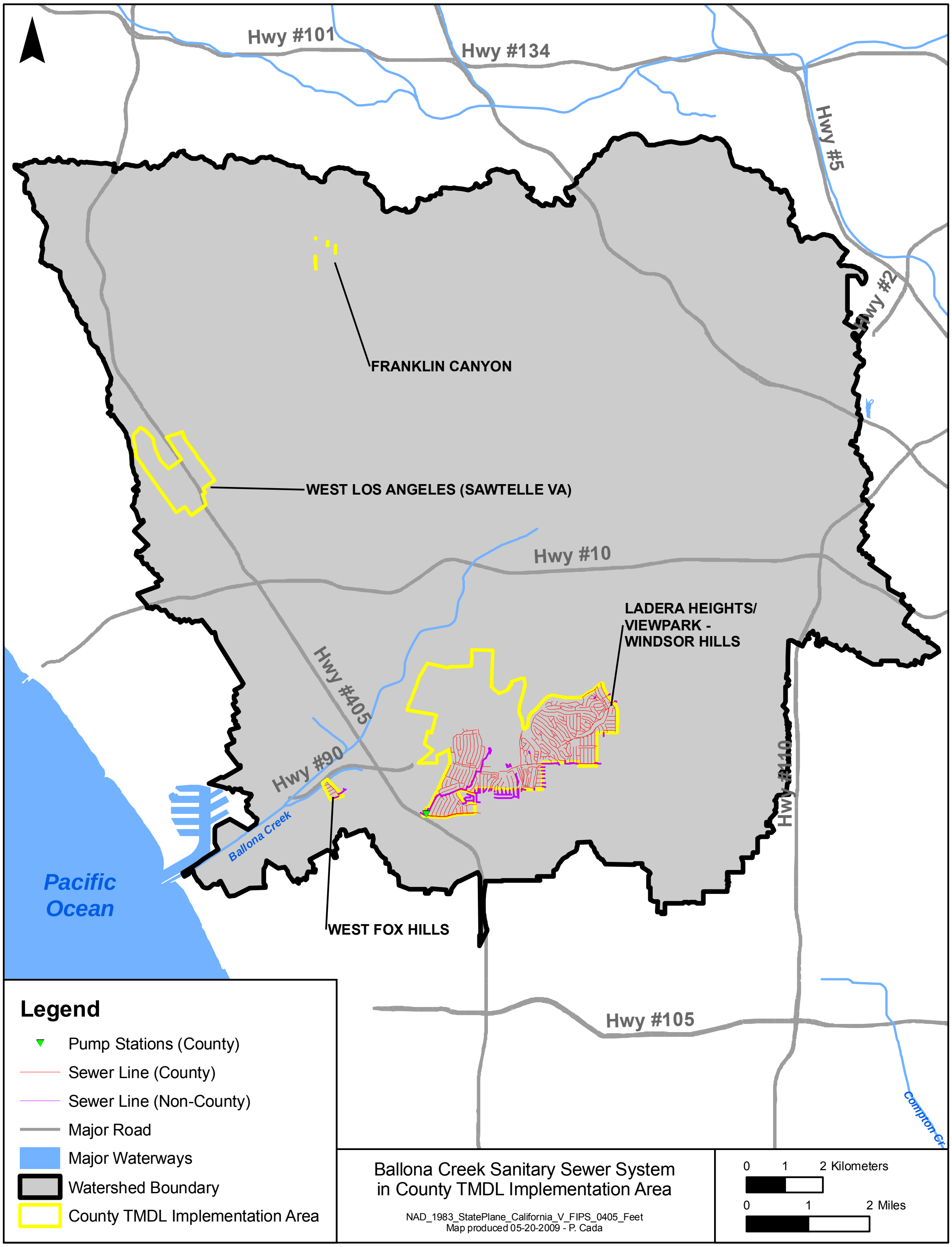


Figure 23. Sanitary Sewer Network in the Ballona Creek Watershed—County TMDL Implementation Area Only

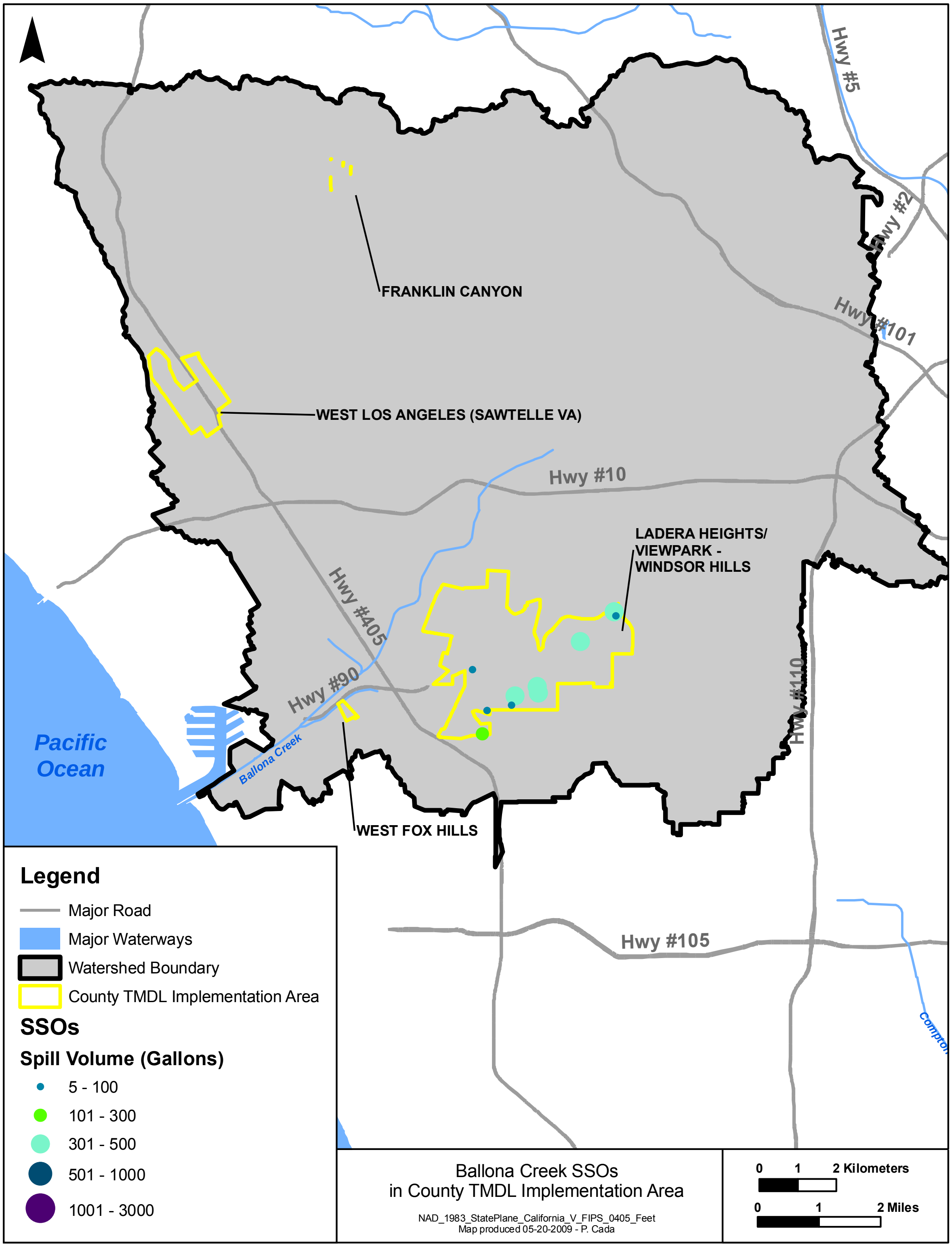


Figure 24. SSOs in the Ballona Creek Watershed—County TMDL Implementation Area Only

3.3. Pollutant Source Prioritization

To help develop implementation strategies, a prioritization of pollutant loading by community and potential sources was developed. The effort is concentrated on wet weather loading, with the assumption that BMPs targeted for the watershed would be designed to treat both wet and dry weather flows that drain to the BMP. Many dry weather implementation strategies would involve programs that address excessive irrigation, illicit discharges, and leaking sewer lines rather than structural BMPs.

Wet weather loads by unincorporated community were converted to area loads (e.g., pounds per acre per year [lb/ac/yr]) for use in the pollutant source prioritization. This provides a normalized view for targeting management in that it shows where the rates are highest. Area loads for each constituent were then ranked by community. Values were assigned quartiles as follows: 1 for the lowest 25th quartile, 2 for values between the 25th and 50th quartile, 3 for values between the 50th and 75th quartile, and 4 for the highest quartile. Results for metals and bacteria were weighted slightly higher (× 1.5). PAHs are included. Other toxics were omitted because they were not modeled, and sufficient information by land use was not available to calculate loads by community. Scores for each community were totaled and ranked. A ranking of dry weather total loading is also provided; however, because the area is a linear determinant of the load (according to the regression described earlier), the total loads rather than area-based loads are used. The final rankings are presented separately for wet and dry weather area-based loads in Table 22 and Table 23, respectively.

A tabulation of pollutant sources by community in the Ballona Creek watershed has also been prepared in Table 24 based on information reported earlier in this section. The table includes acres of industrial land use; acres of high-density, single-family residential land use; acres of commercial land use; number of TRI sites within 20 miles; number of RCRA sites; number of SSOs; and percent of area that has a high road density. Results can be compared with load rankings in Table 22 and Table 23 to understand sources contributing to loads in each community.

The highest ranking communities in terms of area-based pollutants loads (wet weather) are West Los Angeles and West Fox Hills. An evaluation of sources within those communities helps to explain the loads. Both West Los Angeles and West Fox Hills have the highest road densities. Transportation land uses are important sources of copper, zinc, and fecal coliform, among others. Commercial land use is a second factor important to the high rankings of West Los Angeles and West Fox Hills. Though metals concentrations can often be lower in runoff from commercial land uses compared to industrial land, commercial land typically has greater levels of imperviousness. Fecal coliform loads also tend to be highest in commercial areas and similar to high-density residential land use on the basis of land-use-based monitoring. This can partially be attributed to higher impervious values. Pet waste is an important source of fecal coliform in residential land uses. While the Ladera Heights/ Viewpark-Windsor Hills area has larger total pollutant loads and can be important for targeting management opportunities, it ranked lower in this list because of the mix of land uses and associated per acre loads. The remaining, low-ranking communities have relatively small footprints and therefore fewer sources of pollutants.

Two of the three highest ranking communities for wet weather loads (area-based) are also in the top three for dry weather loads (total loads). The high ranking for Ladera Heights/Viewpark-Windsor Hills in terms of dry weather loads is attributable to the large area of urban land, especially residential land use and associated irrigation. A comparison of rankings for dry and wet weather loads is difficult given the different methodologies: wet weather uses area-based loads, and dry weather uses total loads for reasons discussed earlier.

Table 22. Wet Weather Load Ranking by Community (Area Loads)

Community Name	Parameter Score								Total Score	Score Rank	Area Rank
	TN	TP	Copper	Zinc	Lead	Fecal Coliform	TSS	PAHs			
West Los Angeles	4	4	6	6	4.5	6	4	4	38.5	1	2
West Fox Hills	4	3	4.5	4.5	6	4.5	3	3	32.5	2	3
Franklin Canyon	3	2	3	1.5	1.5	1.5	2	2	16.5	3	4
Ladera Heights/ Viewpark-Windsor Hills	1	1	1.5	3	3	3	1	1	14.5	4	1
Weighting	*1*	*1*	*1.5*	*1.5*	*1.5*	*1.5*	*1*	*1*			

Table 23. Dry Weather Load Ranking by Community (Total Loads)

Community Name	Parameter Score							Total Score	Score Rank
	TN	TP	Copper	Zinc	Lead	Fecal Coliform	TSS		
Ladera Heights/ Viewpark-Windsor Hills	4	4	6	6	6	6	4	36	1
West Los Angeles	4	4	6	6	6	6	4	36	1
West Fox Hills	3	3	4.5	4.5	4.5	4.5	3	27	3
Franklin Canyon	1	1	1.5	1.5	1.5	1.5	1	9	4
Weighting	*1*	*1*	*1.5*	*1.5*	*1.5*	*1.5*	*1*		

Table 24. Source Tabulation by Community

Community Name	Industrial Land Use (acres)	High-Density Residential Land Use (acres)	Commercial Land Use (acres)	TRI (#)	RCRA (#)	SSO (#)	High Road Density (%)
West Los Angeles			329.3	85			60
West Fox Hills	0.1	20.7	9.4	112			8
Franklin Canyon		0.4		129			
Ladera Heights/Viewpark - Windsor Hills	763.5	1,381.3	211.6	121	1	10	

Several caveats are important in understanding this prioritization. The rankings should be put in the context of the small number of communities and limited amount of unincorporated County areas in the Ballona Creek watershed. In addition, the targeting and implementation of actual BMPs also depends on the availability of suitable and feasible sites.

(This page intentionally left blank.)

4. Development of Nonstructural Solutions

A comprehensive program has been developed and implemented to reduce or eliminate the amount of pollutants in stormwater and urban runoff. This program meets a variety of regulatory requirements, including those of the LARWQCB adopted Order R4-2007-0042 for municipal stormwater and urban runoff discharges within the County (LARWQCB 2007). An evaluation was conducted to identify opportunities for improvements to existing programs and new programs that would help meet TMDL WLAs and to determine the level of success in implementing these programs. Existing nonstructural BMPs are described in Section 4.1 and new nonstructural BMPs are proposed in Section 4.2. Considered holistically, these existing, improved, and new programs are expected to contribute to the reduction of TMDL pollutant loads and meet WLAs.

4.1. Existing Nonstructural BMPs

The following provides a summary of existing nonstructural BMPs that were evaluated to determine if enhancements can be made to specifically support TMDL implementation. This discussion provides an overview of relevant programs that can directly support the control of pollutants in stormwater. For those BMPs determined to be candidates for enhancements, a summary of proposed changes to the program is provided.

4.1.1. Public Information and Participation Program

The Public Information and Participation Program includes a variety of outreach campaigns and programs that address stormwater quality, including the following:

- **Stormwater/Urban Runoff Education**—a comprehensive outreach campaign that targets urban and polluted stormwater runoff. Audiences include "do-it-yourselfers," the general public, and commercial industry. It also includes a variety of formats such as public service announcements, tip cards, billboards, and movie theater advertisements.
- **Used Oil and Filter Recycling**—an outreach campaign that targets home mechanics and encourages them to recycle used oil and oil filters. The campaign includes public service announcements, brochures, and collection events. The campaign materials have been translated into English, Spanish, Chinese, Korean, Vietnamese, and Cambodian.
- **Environmental Defenders**—a 30-minute school assembly program for elementary school children. The program involves two professional children's theater actors and teaches children how to protect the environment.
- **Generation Earth**—a program presented by TreePeople for secondary school children that encourages students to make a difference in their local environment through campus and eco-projects.
- **Plan-It Earth**—a program that involves an 8-week subscription to the *Los Angeles Times* to educate sixth- to ninth-grade children on environmental issues by reading the paper. The program also involves a teacher's guide and lesson plans. Students also can write an essay or create a piece of art related to environmental issues. The winner's essay or art is published in the *Los Angeles Times*.
- **Restaurant Training**—an education program that includes restaurant BMP guidelines, a watershed model showing the potential for oil and grease to affect the watershed, a PowerPoint presentation, and collateral material for restaurant owners, including posters, buckets with BMPs printed on them, and brochures.
- **888-Clean-LA**—a waste-reduction and recycling program, which includes a website with information on a wide variety of topics, including recycling, household hazardous waste disposal, the Smart Gardening Program, and illegal dumping.

Each campaign and/or program has its own goals and objectives, unique target audiences, a variety of message packaging formats, distribution mechanisms, and evaluation methods. Although these programs are implemented Countywide, there is a separate budget and contract for each. A detailed description of the components of the above outreach and campaigns and programs is provided in Appendix C.

Public participation events are sponsored through the Stormwater/Urban Runoff Education Program, the 888-Clean-LA Program, and the Smart Gardening program (described below). Also, organizations frequently request staff attendance at community events to provide informational materials, collateral items, and watershed model displays.

Funding and support have been provided for the Brake Pad Partnership, a collaborative group of brake manufacturers, environmentalists, stormwater management entities, and regulators committed to reducing the amount of copper in brake pad materials, which the organization's research has determined to be a significant source of copper that threatens water quality.

The following sections focus on two key programs that were evaluated for enhancements to address TMDL implementation: water conservation/smart gardening and stormwater training.

Water Conservation/Smart Gardening

Currently there are two programs that address overwatering and reduction of dry weather flows from landscape irrigation; the water conservation ordinance and Smart Gardening Program. In October 2008 a water conservation ordinance was passed that applies to the unincorporated County areas of Los Angeles. The ordinance prohibits various washing and watering activities that can lead to waste or runoff (a detailed list of prohibited activities is provided in Appendix I). The Smart Gardening Program educates homeowners on reducing inputs for gardening and landscaping and to encourage green waste reduction. The program includes learning centers and workshops and covers backyard composting, worm composting, grass recycling, water conservation, and fire risk reduction topics. The target audience is citizens of all ages, although most attendees are aged 50 to 80.

Currently there are 11 learning centers, which are permanent locations for workshops that are conducted most weekends. The learning centers include a demonstration garden with educational signage, drip irrigation, and composting bins. A variety of resources were developed to complement the workshops, including

- Tip cards
- A website
- Billboards
- Postcards sent to residents within 5 miles of the learning centers
- Press releases
- DVDs available at libraries
- Event booths

Enhancements to Address TMDL Implementation

Expanding the reach of the Smart Gardening Program to the County TMDL Implementation Area can better address the TMDL pollutants of concern. At this time there are no Smart Gardening learning centers in the Ballona Creek watershed, and because advertising for workshops and other program activities are sent to residents within five miles of learning centers, Ballona Creek watershed residents are less likely to participate. Also, a new tip card can be developed that addresses stormwater quality and encourages water conservation and proper chemical application techniques. The tip cards can be distributed to Ballona Creek residents and can describe landscaping and gardening practices to reduce pollutants in both wet weather and dry weather discharges.

Implementing those practices or other gardening/landscaping-related programs in the watershed can benefit water quality by reducing nuisance flows and associated pollutants, including metals, bacteria, and toxics, as well as wet weather toxics and bacteria. The Smart Gardening Program promotes practices that conserve water and reduce irrigation return flow. The program also promotes pest management practices that can reduce loads of toxic chemicals in runoff. By expanding the reach of the program into the Ballona Creek watershed, and by enhancing the educational materials to include discussion of water quality benefits, the Smart Gardening Program can become an important public outreach tool to promote the goals of the TMDL Implementation Plan.

Stormwater Training

Stormwater-related training is held annually for staff that implement portions of the stormwater management program. The training is tailored to *train the trainers*, who then take the information to their individual staff. The training covers stormwater pollution prevention and provides information on specific issues (e.g., case studies) that were applicable during the past year. Presentations cover such topics as construction, planning, public agency activities, and illicit connections/illicit discharges, and sessions include a handout and a quiz. The presentations described various stormwater management programs, including background and regulatory information, BMPs, and tracking and reporting.

Enhancements to Address TMDL Implementation

To improve stormwater-related training to address the pollutants of concern in the Ballona Creek watershed, additional, TMDL-specific training can be implemented that focuses specifically on the requirements of the TMDLs and the County's activities under the implementation plan. Background on the TMDLs, pollutants of concern, BMPs proposed in the implementation plans, and other applicable information can be presented to staff whose work could affect stormwater pollution, including those who attend the annual stormwater-related training. This would ensure that applicable staff are educated about the TMDLs and reinforce the need for diligence in implementing wet and dry weather BMPs. Effectiveness can be assessed with a survey that would gauge employees' knowledge before and after the training. The training is expected to improve the effectiveness of existing programs at reducing all of the pollutants of concern in the Ballona Creek watershed.

4.1.2. Industrial/Commercial Facilities Control Program

There are 87 industrial and commercial facilities[2] in the Ballona Creek watershed and 3,454 facilities in the County as a whole. Pollutant source control and structural BMPs are implemented at those industrial and commercial facilities, which are considered critical sources of pollutants in stormwater. The Industrial/Commercial Facilities Control Program tracks, inspects, and ensures compliance at industrial and commercial facilities.

Industrial and commercial facility data are tracked using the Hazardous Materials System database, which includes facility information, including name, location, contact information, SIC code, status, stormwater certificate data, and inspections. Facility operators are referred to the California Stormwater Quality Association (CASQA) *Stormwater BMP Handbook: Industrial and Commercial* fact sheets (CASQA 2003a) for guidance on stormwater pollution prevention BMPs. A minimum number of BMPs must be implemented at existing and new industrial and commercial facilities, as verified by inspection, including the following:

- Terminating all unauthorized non-stormwater discharges to the storm drain system
- Exercising general good housekeeping practices

[2] This value includes commercial facilities, such as restaurants, that are not covered under the General Industrial Activities Storm Water Permit.

- Incorporating regularly scheduled preventive maintenance into operations
- Maintaining spill prevention and control procedures
- Implementing soil erosion control
- Posting signage on private storm drains to indicate that they are not to receive liquid or solid wastes
- Implementing regular cleaning of the on-site private storm drain system
- Ensuring that stormwater runoff is directed away from operating, processing, fueling, cleaning and storage areas

All facilities are inspected for stormwater issues at least once a year, and facilities are re-inspected when problems are identified. If problems are identified, the facility owner is required to take action by implementing one or more recommended BMPs listed on the inspection form. If remedial action is not taken, enforcement is initiated according to the following enforcement escalation procedure:

1. The inspector withholds a signature from the certification portion of the inspection form (the permittees must obtain County certification each year).
2. A notice of noncompliance is issued.
3. The facility is referred to the RWQCB, County District Attorney or County Nuisance Abatement Team (or both), and the County counsel.

Enhancements to Address TMDL Implementation

Additional water quality benefits, specifically for bacteria, metals, and toxics, could be achieved with a more in-depth training for inspectors and staff addressing TMDL pollutants of concern, their sources, and the use of pollutant-specific BMPs. The enforcement escalation procedures could also improve by strengthening partnerships with enforcement agencies.

4.1.3. Development Planning Program

The Development Planning program focuses on mitigating the long-term hydrologic and pollutant impacts of the built environment and changes in land use. Development Planning involves establishing requirements for post-construction BMPs, reviewing plans to ensure that proposed drainage plans meet water quality and hydrologic performance standards, and ensuring long-term O&M of post-construction BMPs through a maintenance and acceptance program. Such program areas apply to both public and private development projects.

Pollutant removal standards have been developed and adopted as part of the *Stormwater Best Management Practice Design and Maintenance Manual for Publicly Maintained Storm Drain Systems* (LACDPW 2009). This manual is updated when new information on BMP effectiveness and appropriate BMPs is available. In addition, the Standard Urban Stormwater Mitigation Plan (SUSMP) guidelines (County of Los Angeles 2000), which developers use to design stormwater management features of their sites, have been adopted to quantify the hydrologic calculation and evaluate each plan for feasibility.

Public road and flood projects adhere to the standards outlined in the *Stormwater Best Management Practice Design and Maintenance Manual for Publicly Maintained Storm Drain Systems*, and a low impact development (LID) infrastructure manual is currently being developed. The SUSMP guidelines and *Low Impact Development Standards Manual* (County of Los Angeles 2009b) are used to review private construction projects. Site plans are also reviewed for green building requirements and drought-tolerant landscaping requirements to the extent these requirements apply to the development. The LID, green building, and drought-tolerant landscaping requirements are described in greater detail in Appendix I.

Privately owned BMPs are inspected periodically, and O&M of such BMPs are performed by the property owner or homeowners association. Oversight is addressed through a covenant or agreement that is recorded indicating that the owner is aware of and agrees to operate and maintain the stormwater BMP, including a diagram of the site indicating the location and type of each feature incorporated into the development. The covenant or agreement is recorded before final map approval for subdivisions and before a grading permit is issued (or a building permit if no grading permit is required), for all other developments.

4.1.4. Development Construction Program

The Development Construction Program addresses runoff from both public and private construction projects. Public construction projects are of two types: linear (road, utility) and vertical (capital improvement). Stormwater pollution prevention plans (SWPPPs) are developed and reviewed for all construction projects, and all sites are inspected for stormwater compliance. Every grading project disturbing an area one acre or greater is inspected at least once per year during the rainy season. Employees involved in construction activities, including inspectors, project engineers, resident engineers, utility staff, plan checkers, and office engineers, are trained annually on regulatory requirements, construction site BMPs and their applicability, and enforcement escalation procedures.

All construction activity is tracked using the Web-based Drainage and Grading Database that includes the number and status (active/inactive/completed) of construction sites; the number, frequency, results, and follow-up actions resulting from inspections; the actions taken to resolve the issues and dates when compliance was achieved; and complaints submitted by the public. Enforcement actions taken at sites in violation is tracked separately.

Public Construction Projects

All public construction sites must abide by either the *Construction Site Best Management Practices Manual* or the *Stormwater Best Management Practice Handbook: Construction* (CASQA 2003b). Both manuals describe the minimum BMPs that each construction site operator must install, including wind and water erosion control, sediment control, tracking control, non-stormwater management, and waste management/good housekeeping. Additional BMPs can be included in the project contract's special provisions if necessary. Construction site BMPs are required to be implemented year-round during construction activities, including during any temporary suspension of work. Site operators are required to regularly self-inspect and maintain the construction site BMPs before a forecast storm; after a rainstorm that causes site runoff; at 24-hour intervals during extended precipitation events; and routinely, a minimum of once every week.

Stormwater pollution prevention is specified in contracts with construction firms hired to complete public construction projects, including compliance with all the requirements in the NPDES permit and development and implementation of a SWPPP.

Plans for public construction projects are reviewed for water quality and quantity concerns, including sites larger than one acre, which triggers SUSMP requirements, as well as smaller sites that do not meet the threshold for SUSMP. Any projects that are within incorporated areas that connect to the County drainage system are checked to ensure that they have appropriate drainage and pollution controls.

If public construction projects do not conform to the SWPPP or other construction documents, a verbal notice is provided to the contractor. If follow up is needed, an inspection report is issued. If the problem persists or is not corrected in a timely manner, a notice of noncompliance is issued, which allows for retention of a percentage of pay from the contractor's monthly pay request and fines of up to $1,000 per day per violation.

Private Construction Projects

All operators of private construction sites must abide by the *Construction Site Best Management Practices Manual* (LACDPW 2007). The manual details the minimum BMPs that each construction site operator must install as well as self-inspection requirements. Inspectors require that certain additional BMPs are installed prior to the rainy season. Inspectors visit each construction site and inspect for erosion and sediment controls and good housekeeping practices as well as other issues. Inspection frequency is increased before and during the rainy season.

Plan submittal requirements are provided to applicants upon request for all construction projects. The plan review process includes assessment of the adequacy of erosion and sediment controls and good housekeeping practices as well as verification that a Notice of Intent has been filed with the State Water Resources Control Board (SWRCB) for all projects disturbing an area of one acre or more.

An enforcement escalation policy is used to address violations. If a violation is noted, the operator must stop work until the issue is addressed. A letter is sent if the problem persists. If there is no response and the issue is not resolved, a notice of violation is issued and a fine of $1,000 per day per violation is levied. If the issue is still not resolved, the District Attorney is notified, though most violations do not reach this step. In addition, a bond is collected for sites disturbing 1,000 or more yards of soil so that the site can be stabilized if the owner fails to take responsibility.

4.1.5. Public Agency Activities Program

A broad range of infrastructure and facility O&M activities occurs daily, including maintaining buildings and maintenance facilities; stormwater, wastewater, and drinking water infrastructure; roads, bridges, flood and management structures; and parks and landscaped areas. Maintenance activities often have water quality benefits in addition to utility and aesthetic benefits. For example, street sweeping and catch basin cleaning removes pollutants from the municipal storm drain system before they can enter waterways.

Sewage Systems Maintenance, Overflow, and Spill Prevention

Sewage system maintenance, overflow prevention and response, and spill prevention are addressed by the Sewer System Management Plan (SSMP). The SSMP also specifies staffing and equipment needs to carry out necessary inspection and mitigation. A Closed Circuit Television (CCTV) Program is used to detect sources of infiltration inflow into the sewer system, and once detected, serious problems are mitigated immediately. The CCTV program also helps to identify improper and unauthorized connections to the sanitary sewer that might contribute to SSOs.

Vehicle Maintenance/Material Storage Facilities/Corporation Yards Management

There are three co-located public facilities in the County TMDL Implementation Area, as shown in Table 25.

Table 25. Public Agency Facilities in the County TMDL Implementation Area

Division	Facility	Address	City
Flood	83rd St. Yard	5520 W. 83rd St.	Westchester
Fleet	Westchester	5530 W. 83rd St.	Westchester
Roads	MD3 - 233	5530 W. 83rd St.	Westchester

Each of the facilities is inspected twice annually. A database of facilities tracks location, division, facility operator/contact name and number, and inspection date, corrective action(s), and follow up. When potential problems are uncovered during inspections, inspection findings and corrective actions are conveyed to the facility operator, and a reinspection is conducted in a few weeks.

All main facilities have SWPPPs that describe the facilities, the activities that occur there, potential sources of stormwater pollution, and standard operating procedures, as well as stormwater BMPs and measures to prevent or respond to spills. Several BMPs are implemented at these facilities to reduce pollutant loading. For materials storage, inert materials are stored outdoors uncovered. Road supplies, which have a higher likelihood to be transported in stormwater, are generally stored outdoors under cover. Chemicals are stored indoors and protected, and trash is stored in covered containers. Most facilities do not have turf grass or landscaping that would require fertilizer/pesticide use or water conservation measures. Other source control and treatment BMPs at facilities include the following:

- Susceptible drains have petroleum booms or other BMPs.
- Dirt parking lots are controlled for sediment and petroleum.
- Restrooms are established buildings, not portable toilets except temporarily for some unmanned facilities.
- Parking lots/paved areas are swept once a month or as needed.
- Power-washing of buildings occurs, but BMPs are used to contain water.
- Wash racks have clarifiers and are connected to the sanitary sewer and covered.
- Sediment control BMPs protect outlets and the perimeter of disturbed areas.

Landscape and Recreational Facilities Management

Contractors are used to perform landscape maintenance along channels and right-of-ways and to apply herbicides in the right-of-way and at flood control/water conservation facilities. The contracts prohibit pollution of channels, storm drains, and/or gutters and, as applicable, require contractors to maintain pesticide handling licenses from the California Department of Pesticide Regulation.

Storm Drain Operation and Management

A GIS database is maintained of all inlets, catch basins, outfalls, and other storm drain infrastructure, including structural stormwater controls, and maps generated from the GIS are used to facilitate and track maintenance activities. Storm drain pipes that are 42 inches in diameter or larger are visually inspected for illegal connections or signs of disrepair, and pipes that are smaller than 42 inches are monitored by video.

Catch basins are cleaned at a frequency determined by the amount of trash collected, with certain areas or basins targeted for more frequent cleaning on the basis of flood prevention and aesthetics. The priority levels for determining the catch basin cleaning frequency are listed below and shown in Figure 25 for the County TMDL Implementation Area:

- Priority A – high volume of trash generated; cleaned once during the dry season, three times during the wet season.

- Priority B – moderate volume of trash generated; cleaned once during the dry season and once during the wet season.

- Priority C – low volume of trash generated; cleaned once during the dry season.

Contractors are hired to clean the basins and dispose of collected materials, and contracts contain specifications for standard operating procedures and stormwater BMPs. Complaint-based cleaning is performed as needed. Contractors generally hand-clean or vacuum (dry) catch basins, and when jetting clogged lines, wash water is required to be collected. Contractors dispose of materials removed from catch basins and pipes at their own facilities. When spot-cleaning of catch basins is performed, the collected materials are dewatered at maintenance yards, and the dry material is transported to a landfill.

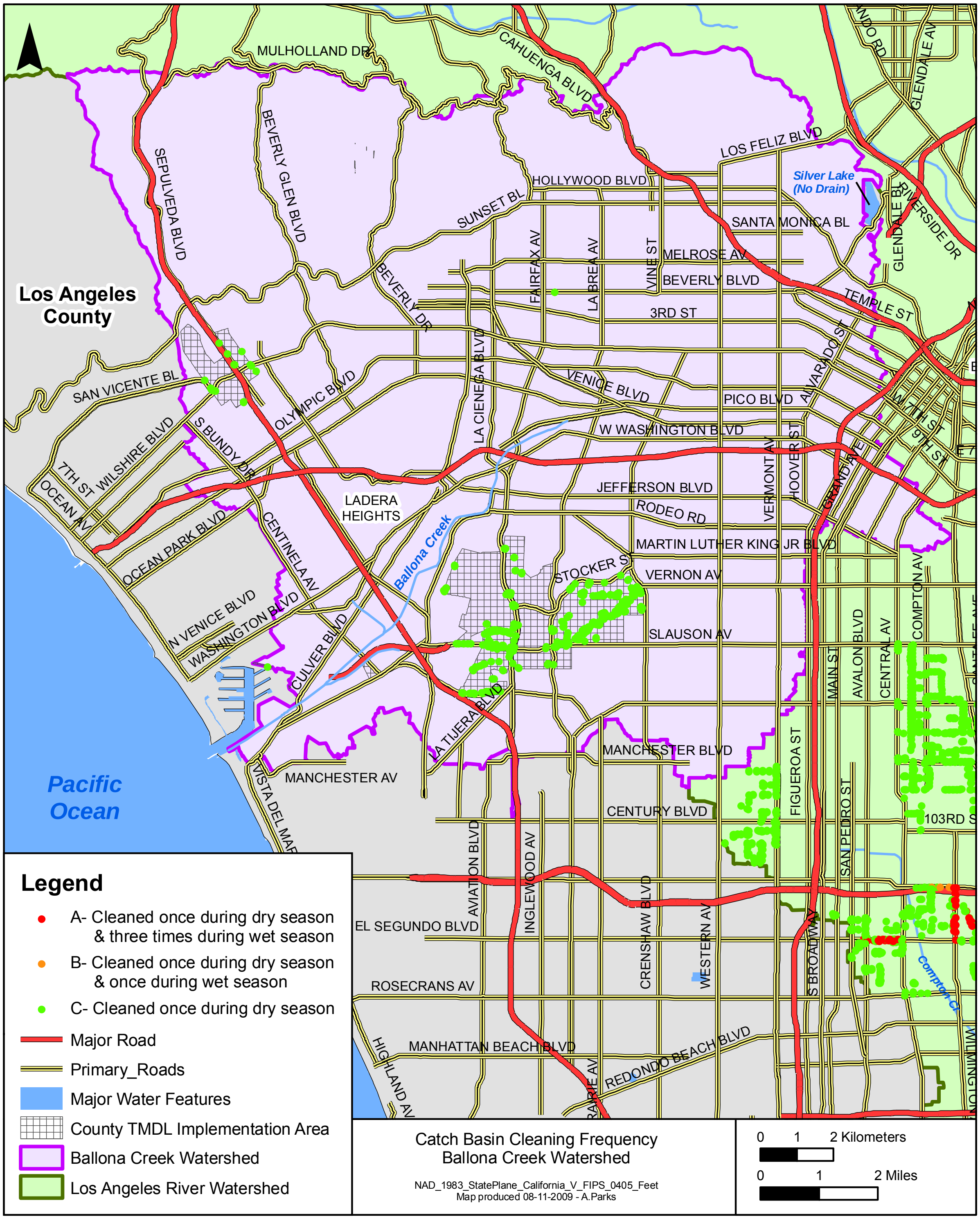


Figure 25. Catch Basins in the County TMDL Implementation Area and Associated Cleaning Frequencies

Streets and Road Maintenance

Street sweeping is performed in unincorporated County areas by a combination of staff and outside contractors. Most streets are swept weekly, although that frequency could soon be reduced to twice a month because the amount of materials being collected is small relative to the cost of such frequent cleaning. If the average frequency is reduced, streets would still be swept more frequently during the fall to collect seasonal debris. Sweepers with mechanical brooms and regenerative air/vacuum sweepers are both used, and swept material is transferred from broom sweepers, which have less capacity, to collection trucks. At the maintenance yards, collected materials are dewatered in clarifiers, and the dry solids are disposed of in landfills.

Trash Management

A maintenance contract is in place to remove trash from trash cans at bus stops every three to five days. Bus shelters and surrounding areas are power-washed every six weeks; BMPs are implemented to block catch basins and vacuum up the water to prevent it from entering the storm drain system.

4.1.6. Illicit Connections/Illicit Discharge Program

The Illicit Connections and Illicit Discharges Elimination Program aims to prevent, detect, and eliminate illicit connections and illicit discharges into the storm drain system and to document, track, and report on such incidents. If an illicit connection or evidence of past discharges is detected, an investigation is initiated within 21 days from the date it was discovered, and if confirmed, it is terminated within 180 days. A transition from illicit connection screening and correction to program maintenance is underway, and GIS data are being prepared of all permitted connections and of the locations and lengths of underground pipes 18 inches in diameter and larger.

The 888-Clean-LA hotline offers a means for the public or staff to report an illicit discharge incident or an observation. Operators dispatch field crews or notify other municipalities if the incident occurs in incorporated areas. Discharges are contained and sources and responsible parties are identified, and cleanup is performed if the responsible party is unwilling to do this. Follow up enforcement includes civil and criminal prosecution as well as reimbursement for public response and cleanup costs, if applicable.

4.2. Additional Nonstructural BMP

In addition to the existing nonstructural BMPs, a new BMP was identified to specifically address dry weather flows, which primarily result from over-irrigation practices.

4.2.1. Reduction of Irrigation Return Flow

In general, the County supports water conservation practices that reduce overall stress on the limited supplies available for the Los Angeles Region. Measures to reduce irrigation return flow in the County TMDL Implementation Area can be implemented wherever landscapes are irrigated – residential, commercial, recreational, and even industrial land uses can all be targeted by incentive policies and programs. Reducing irrigation return flow is especially important for meeting dry weather flow TMDL requirements for metals, bacteria, and toxics. Reducing irrigation use can also have an effect on wet weather loads; if the antecedent soil condition is drier before a storm, the peak flow and runoff volume can also be reduced, reducing pollutant transport.

A number of steps have been taken to promote efficient water use, including development of a drought-tolerant plant list and LID and green building requirements (these are described further in Appendix I). In addition to those tools, other programmatic methods can further provide reduction of irrigation return flow. A rebate program can be developed to encourage high-volume irrigators to install smart irrigation controllers.[3] These devices are used to reduce irrigation water use by meeting the actual needs of plants using prevailing weather conditions, current and historic evapotranspiration, soil moisture levels, and other relevant factors to adapt water application. Alternatively, implementation of a xeriscape conversion incentive program can facilitate a transformation of residential lawns and gardens to low-irrigation landscapes using drought-tolerant plants and encouraging soil preparation, mulching, and zoned irrigation to reduce water use. Or, partnerships with local water agencies can be supported to adjust water rate structures to target large-volume irrigators with higher rates and provide additional incentives to reduce water use. Because direct authority to alter rate structures to achieve demand-side management practices lies with other agencies, negotiations with local water agencies and administrative support, such as marketing and communications, would be needed.

4.3. Summary of Nonstructural Solutions to Support TMDL Implementation

As a result of the review of existing programs that address the TMDL pollutants, the following are recommended enhancements that will offer additional water quality benefits and contribute to TMDL implementation:

- **Smart gardening program enhancements** that will extend the reach of the water conservation and pollution prevention messages to the Ballona Creek watershed
- **TMDL-specific stormwater training** that emphasizes activities and BMPs that can cause or mitigate the TMDL pollutants of concern
- **Enhancement of commercial and industrial facility inspections** to ensure that activities associated with these businesses do not become sources of pollutants
- **Enforcement escalation procedures** that more effectively address known sources of pollution

Additionally, a new BMP is proposed to achieve a **reduction in irrigation return flow** through a variety of water conservation initiatives.

The remainder of the discussion and analysis pertaining to nonstructural solutions focuses on these five recommended BMPs, which are expected to contribute substantially to reductions in pollutant loads. Table 26 shows the extent to which each BMP enhancement or new BMP addresses the TMDLs. All of the proposed BMPs address the highest-priority pollutants: bacteria, metals, and non-metal toxics; TMDL-specific stormwater training is also expected to benefit the trash TMDL. All of the existing BMP enhancements address both wet and dry weather flows.

[3] Smart irrigation controllers are also referred to as ET controllers, weather-based irrigation controllers, or smart sprinkler controllers.

Table 26. Summary of Recommended Nonstructural Solutions

Structural BMP	Flow Addressed		TMDL Pollutant Addressed			
	Wet Weather	Dry Weather	Bacteria	Metals	Non-Metal Toxics	Trash
Enhancements to Existing BMPs						
Smart Gardening Program Enhancements	✓	✓	◗	◗	◗	○
TMDL-specific Stormwater Training	✓	✓	◗	◗	◗	◗
Enhancement of Commercial and Industrial Facility Inspections	✓	✓	◗	◗	◗	○
Enforcement Escalation Procedures	✓	✓	◗	●	◗	○
New BMP						
Reduction of Irrigation Return Flow	✓	✓	●	●	◗	○

● addresses the pollutant
◗ partially addresses the pollutant
○ does not address the pollutant

4.4. Additional Nonstructural Options for TMDL Implementation

Other opportunities may exist for targeted BMPs that address specific pollutants that can only be identified through additional pollutant source characterizations. Bacterial source identification studies can pinpoint whether high fecal coliform levels are of human or wildlife origin, and site-specific management practices can be implemented to address these sources. For example, if a bacterial source identification study indicates a significant presence of bird feces upstream of a waterbody, shoreline management practices and seasonal maintenance and clean-up can be implemented to reduce fecal loads.

Additionally, areas with significant dry weather flows can be targeted for detailed storm drain inspections and illicit connection/illicit discharge investigations to track down the sources of both chronic and episodic flows. Discharges from industrial and commercial areas can be addressed through existing inspection and enforcement procedures, and discharges from residential areas can be addressed through outreach, education, and, enforcement, if necessary.

Instream wet weather and dry weather monitoring data can be evaluated to identify pollution hot spots that warrant further investigation and potential site remediation or other measures. Additional long-term trend analysis can be used to identify the effects of longer-term land use changes on pollutant loads that might necessitate programmatic BMPs.

The TMDL implementation plan is meant to be iterative and adaptive to take advantage of these and other nonstructural BMPs determined in the future to provide the best strategy for addressing specific pollutant sources. The County will continue to implement necessary investigative studies to identify these opportunities and implement the most effective approaches to address pollutant loads from the County TMDL Implementation Area.

(This page intentionally left blank.)

5. Development of Structural Solutions

Meeting WLAs for the County TMDL Implementaiton Area will take advantage of the nonstructural BMPs , but structural solutions will provide the majority of the necessary load reductions required. However, structural BMPs are also the most costly, so careful consideration was made in the identification of opportunities for structural BMPs and collection of appropriate information to make cost-effective decisions regarding implementation.

Identification and assessment of opportunities for structural BMPs were focused on publicly owned land within the County TMDL Implementation Area. Both distributed and centralized structural BMPs were considered. Distributed structural BMPs refer to those practices that provide the control or treatment (or both) of stormwater runoff at the site level. Typical BMPs in this category include such features as porous pavement, grassed swales, bioretention, water harvesting systems, and other practices that can be implemented on individual parcels to store, infiltrate, and treat runoff from that parcel. Centralized BMPs refer to stormwater treatment, storage, or infiltration facilities that provide benefits on a larger scale (e.g., regional). Such projects might include neighborhood-scale or larger-scale facilities such as spreading grounds, flood control facilities, or even park space that provide treatment/infiltration of runoff from nearby areas.

The following sections describe the process used to assess opportunities for implementing structural BMPs, both distributed (Section 5.1) and centralized (Section 5.2). Section 6 describes the evaluation of BMP alternatives using an optimization process.

5.1. Assessment of Opportunities for Distributed Structural BMPs

It was not feasible within the TMDL Implementation Plan to identify and size each and every distributed structural BMP within the County TMDL Implementation Area. Rather, within specific classifications of land characteristics (e.g., impervious roads, land use, soil type), general assumptions were established that provided insight regarding the types and benefits of distributed BMPs that can be implemented at a larger scale. This resulted in identification of key distributed structural BMP projects that could be considered for TMDL implementation planning.

Two major categories of distributed structural BMPs were identified, which were based site characteristics and the types of BMPs determined feasible: (1) catch basin distributed BMPs, and (2) other distributed BMPs on public land. The following provides detailed discussions for these categories, and the proposed projects for TMDL implementation.

5.1.1. Catch Basin Distributed BMPs

Storm drain systems in developed areas typically begin with inlets at the street level. Stormwater inlets have a variety of names, and there are regional differences in terminology. Storm drain inlets are routinely called catch basins in California.

As discussed in the Section 3, roads represent a major source of TMDL pollutant loads, and therefore treatment of road runoff is considered a key strategy for multi-pollutant TMDL implementation. As shown in Figure 26, due to the number and spatial distribution of catch basins within the County TMDL Implementation Area, they represent an excellent opportunity for treatment of pollutants in addition to trash.

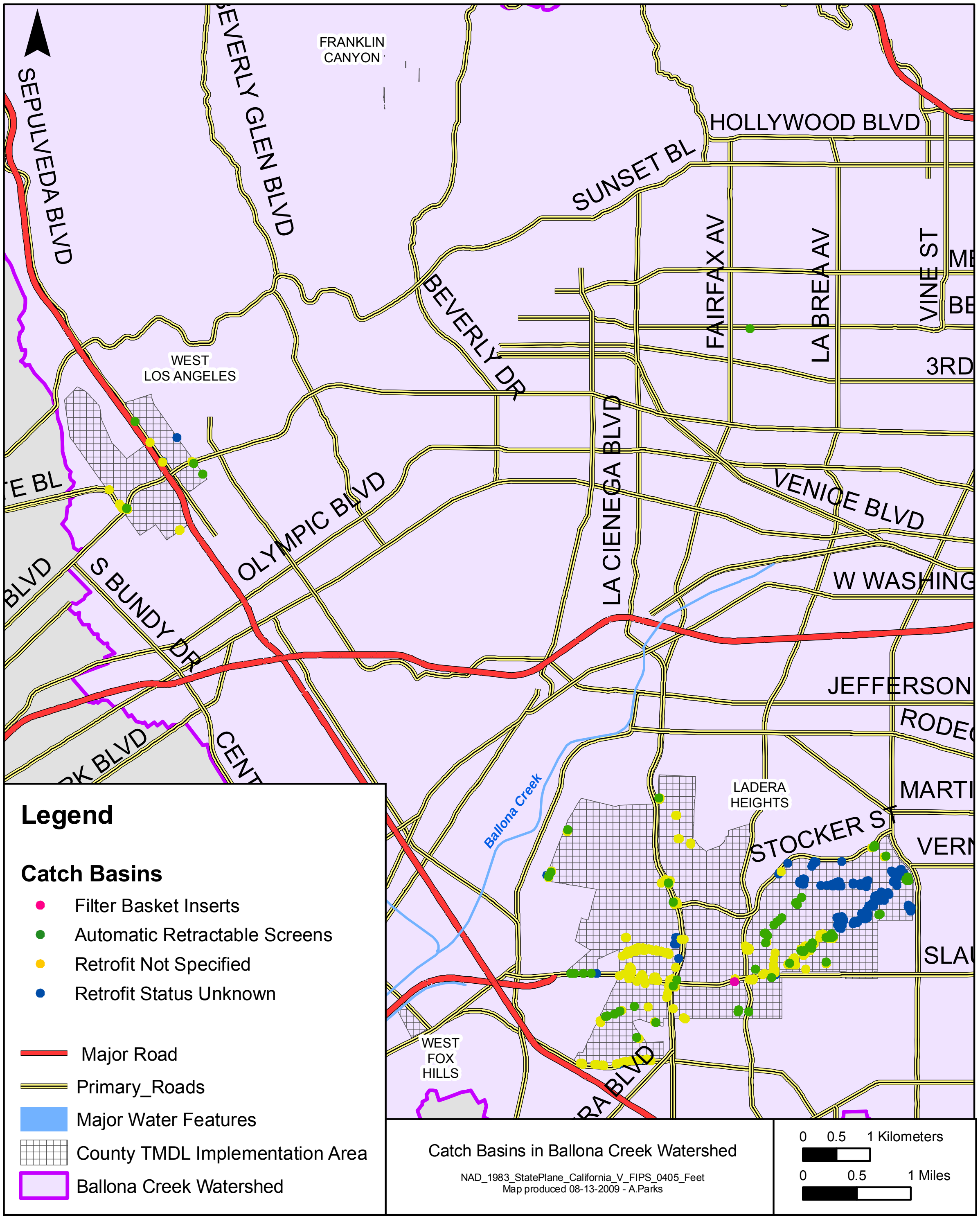


Figure 26. Catch Basins in the County TMDL Implementation Area

Full Capture Devices

Screen cover devices are currently being installed in catch basins to prevent trash and debris from entering the storm drain system. The screens (referred to as full capture devices) are of two types: connector pipe screens (≤ 5 mm mesh) inside the catch basin at the entrance to the collection pipe and automatic retractable screens at the curb inlet. Full capture devices in and of themselves do not provide for sediment capture – the 5 mm openings would allow for any suspended solids, even large sand particles, to pass through to the storm drain system. However, there is evidence from monitoring studies that catch basins, even without sumps below the drain discharge point, are capable of some pollutant removal. It is likely the accumulated trash and leaf matter provides some sorption/adsorption, as well as filtration. Full capture devices should enhance this effect.

Catch Basin Inserts

Catch basin inserts (Figure 27), which are devices designed specifically to capture trash, oil/grease, other floatables, sediment, organics, and other pollutants, can offer additional pollutant removal benefits. On the basis of a synthesis of available studies, catch basin inserts are expected to treat and remove a significant fraction of sediment (and associated metals) with treatment focused on runoff from the transportation network. The treatment efficiency of catch basin inserts for bacteria is poorly studied and unknown, but is likely to be very low unless the insert has a design element targeting bacteria. These devices tend to have a 1- to 3-year warranty and would need maintenance and/or replacement after this period. Catch basin inserts can replace full capture devices upon installation, though one type of insert, the Abtech Smart Sponge,™ can be used in addition to existing full capture devices.

Implementing catch basin inserts throughout the County TMDL Implementation Area is highly applicable because of the high density of catch basins. The County TMDL Implementation Area includes 370 catch basins, with installation of full capture devices finalizing completion for implementation of the trash TMDL. Therefore, implementation of catch basin inserts will require retrofit or replacement of the full capture devices. For the TMDL Implementation Plan, implementation of catch basin inserts is assumed to focus on replacement of existing full capture devices with catch basin inserts, which is a more resource-intensive, conservative approach. During actual implementation, other more cost-effective approaches for full capture device retrofit may be employed. The schedule for implementation of catch basin inserts within the TMDL Implemenation Plan considers maximizing the operational period and hence investment of currently installed full capture devices.

Implementation of catch basin inserts will involve internal planning, a pilot study to gain approval from the LARWQCB for attaining the trash TMDL requirements, device installation, and maintenance of the sediment-removal as part of the existing catch basin maintenance activities.

Figure 27. Example Catch Basin Insert

5.1.2. Other Distributed BMPs on Public Land

Before stormwater enters the storm drain systems, opportunities are available for the storage, infiltration, and treatment of runoff within publicly owned right-of-ways or parcels. These areas include road right-of-ways or other properties owned by public agencies for various purposes (e.g., parks, schools, storage, utilities). Figure 28 shows the publicly owned parcels within the County TMDL Implementation Area. In combination with road right-of-ways, this area represents a significant opportunity for onsite stormwater treatment.

Field Investigations for Distributed BMPs

Understanding of land and soil charateristics within the County TMDL Implementation Area is key to identifying the appropriate types of distributed structural BMPs that can provide meaningful benefit. Throughout the County TMDL Implementation Area, field investigations were performed to assess general land and soil characteristics that impact distributed BMP selection and performance. This information was used to establish assumptions for evaluating costs and benefits of distributed BMP implementation in Section 6.

Land characteristics were grouped into Management Categories that were assigned to distinct subwatersheds throughout Los Angeles County (LACDPW 2008b). All subwatersheds that have the same Management Category are likely to have similar opportunities and constraints for selecting and applying distributed structural BMPs. Management Categories were defined on the basis of the following selected key physiographic characteristics, which directly influence the planning, design, and construction of distributed structural BMPs: impervious cover, impervious density, land slope, and road density. When the four key characteristics that define the Management Categories were combined, they formed 16 possible combinations. Of those 16, only 6 combinations were found in the Ballona Creek watershed. Table 27 presents the definition of the six Management Category groups and the total area of each within the County TMDL Implementation Area. Figure 29 shows the Management Categories assigned to each community.

Table 27. Definition and Total Area of Management Categories

ID	Impervious Cover	Impervious Density	Road Density	Slope	Total Area (acres)
A	Urban	Concentrated	High	Moderate	333
B	Urban	Concentrated	Low	Steep	0.6
C	Urban	Concentrated	Low	Moderate	1,557
D	Urban	Dispersed	Low	Steep	596
E	Urban	Dispersed	Low	Moderate	1,325
G	Non-Urban	Concentrated	Low	Moderate	107

A GIS analysis was performed to identify 30 potential field investigation sites. Sites were identified representing a range of combinations of Management Categories and soil classifications (on the basis of the County's *Hydrology Manual*). Sites were further selected to be spatially dispersed within unincorporated County areas of the Ballona Creek watershed. The GIS analysis resulted in the selection of publicly owned parcels within unincorporated County areas with moderate slope areas that contain Hydrologic Soil Group (HSG) A-, B-, or C-type soils. Areas with these slope and HSG characteristics are typically suitable for distributed BMP implementation. For simplicity, potential investigation sites were grouped by HSG type and selected individual sites that included multiple parcels within a one-quarter-mile to one-half-mile radius that meet the selection criteria. The number of allocated HSG A-, B-, and C-type sites was proportioned on the basis of the number of HSG-type parcels among the total parcels (using location of each parcel's centroid to identify HSG type). To support a realistic implementation strategy, field investigation sites were selected from parcels outside any floodplains and 100-year floodways. That assessment yielded a total of six sites in the Ballona Creek watershed. Table 28 lists the potential field investigation sites and their characteristics, and Figure 30 shows the locations of the sites. Each site's HSG classification is included in the figure label.

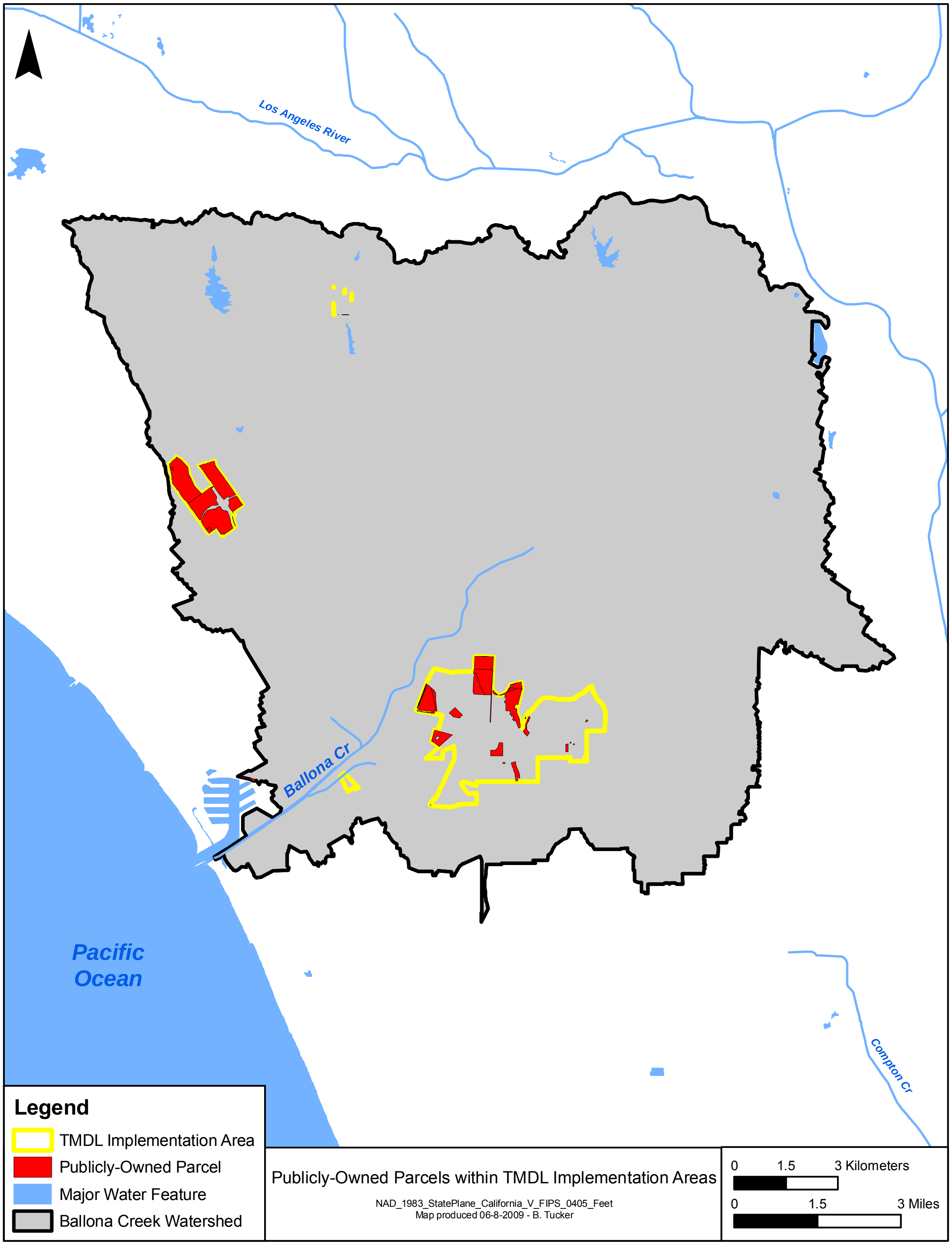


Figure 28. Publicly Owned Parcels within the County TMDL Implementation Area

Table 28. Potential Field Investigation Sites, Management Category, and Soil Characteristics

Site	Area	Management Category	Average Infiltration Rate (inches/hour)	Within HSG Range
4B	Kenneth Hann Park	C	6.0	yes
5B	West Los Angeles Community College	E	0.4	<
6B	Barrington Recreation Area	A	3.0	yes
7B	Ladera Park	C	11.8	>
1C	Westwood Park	D/A	3.2	>
4C	West Los Angeles Community College	E	1.3	>

Once the sites were identified, field investigations were conducted to verify soil conditions, particularly infiltration rates, and characterize the locations. A detailed field analysis report is presented in Appendix D. Each of the sites showed some variability in the measured surface infiltration rates. The variability at many sites could have been caused by variation in surface conditions. Many of the sites had an urban complex or mixture of soils in the top 1 to 2 feet, which affected the infiltration rate. The mixtures contained either sandier soils that cause higher than expected readings or soils with high organic content, specifically in the root zones, that would have caused lower than expected infiltration rates. Characteristic of many urban areas, most of the sites had experienced major disturbances from construction-related activities and continuing active recreation and management. Many sites had debris at the surface left over from construction, which would have caused higher than expected infiltration rates.

Each of the sites had an infiltration rate greater than the minimum infiltration rate of 0.5 inches per hour recommended by the County's *Low Impact Development Standards Manual*. In general, areas with a less concentrated impervious configuration showed a greater likelihood that the measured infiltration rates were consistent with the ranges reported by the Natural Resources Conservation Service for the respective HSGs. Many times, the reported HSG in less concentrated areas were found a few feet below the surface. Areas with greater urban density were much more prone to extensive disturbance from construction, with greater levels of disturbance showing mixing of the HSGs. Many of the sites are suitable for infiltration BMPs, while most of the sites would be suitable for infiltration BMPs with some soils amendments near the surface.

Information gained from the field investigations was used to develop assumptions (e.g., selecting appropriate BMPs, infiltration rates) for distributed structural BMPs evaluated for public land within the County TMDL Implementation Area. The information can further support implementation of distributed structural BMPs throughout the County TMDL Implementation Area over time, as new sites are identified and benefits in terms of infiltration capacity and pollutant load reduction are estimated.

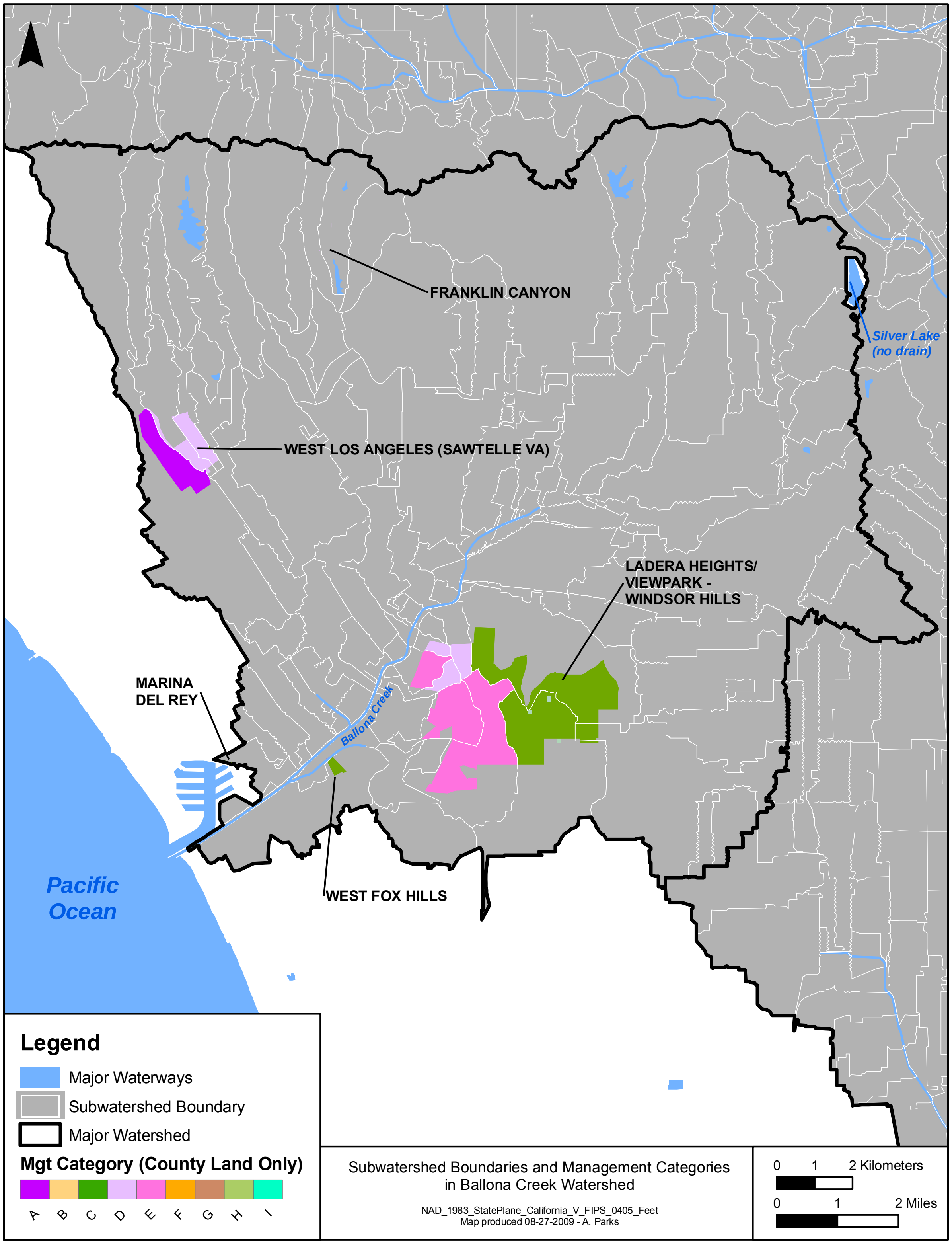


Figure 29. Management Categories in the County TMDL Implementation Area

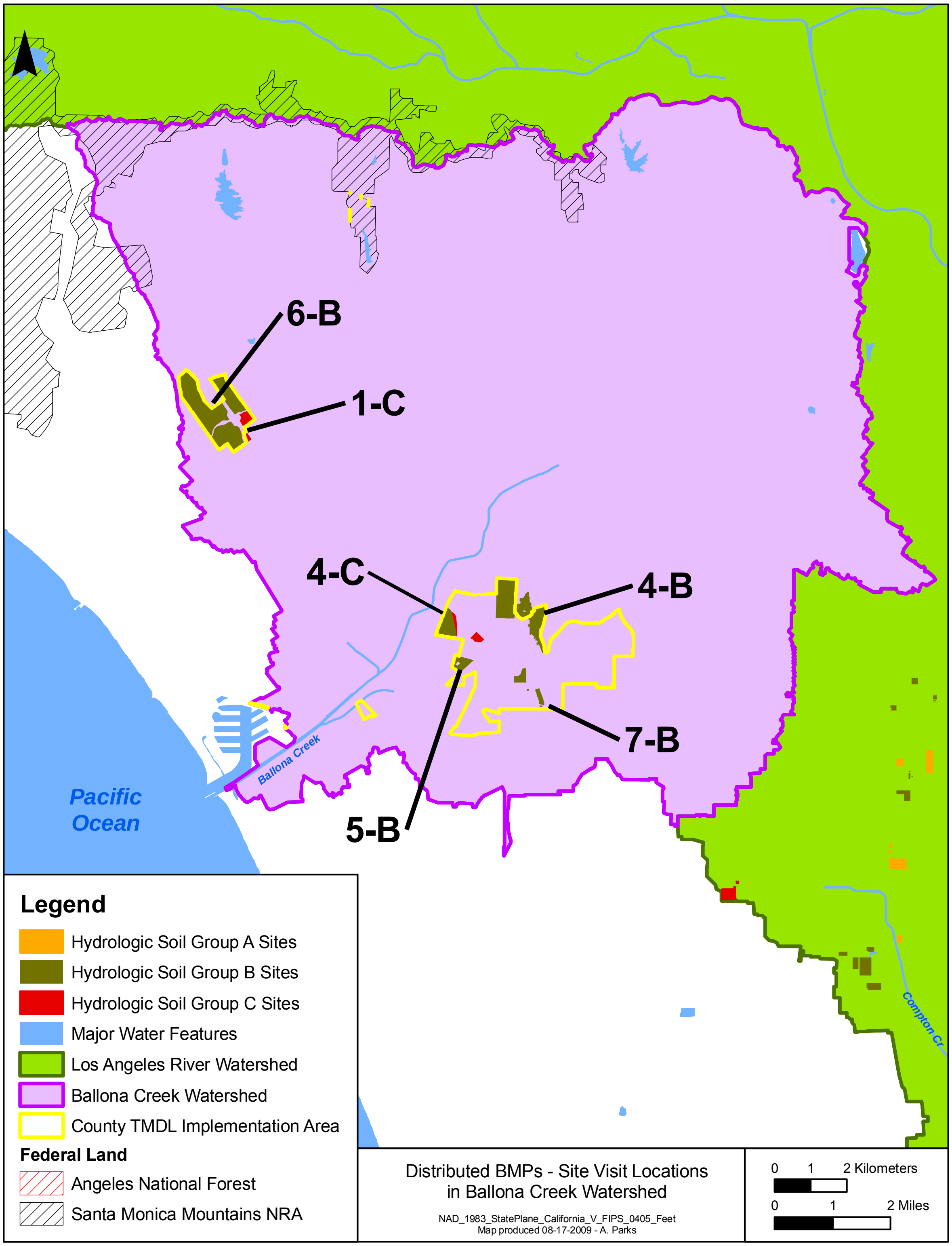


Figure 30. Field Investigation Sites for Distributed BMPs

Distributed Structural BMP Strategies for TMDL Implementation

For this TMDL implementation plan, two distributed BMP strategies are planned to reduce stormwater pollutant loads from the County TMDL Implementation Area. The following provides discussion of considerations for implementing these strategies. Distributed structural BMP options for these strategies were further evaluated, in terms of cost and benefit, during the process for evaluation of nonstructural and structural solutions.

Distributed BMPs on Publicly Owned Parcels

For all publicly owned parcels shown in Figure 28, distributed structural BMPs will be implemented to treat onsite runoff. The County owns a portion of these parcels, so for parcels owned and operated by other public agencies, partnerships will need to be established. Implementation of BMPs will occur as funding becomes available.

The publicly owned parcels are located throughout the County TMDL Implementation area in the unincorporated County communities of West Los Angeles and Ladera Heights/Viewpark-Windsor Hills. These areas were the highest priority for wet weather and dry weather pollutant loading, respectively, based on the pollutant source characterization and prioritization results.

For planning purposes, three typical distributed structural BMPs were identified and used to represent the typical functions utilized by most distributed BMPs: bioretention areas, porous pavement, and linear bioretention. This allowed for development of general assumptions for cost and pollutant load reduction, which were incorporated in TMDL implementation planning and scheduling. The following provides descriptions of the types of distributed BMPs considered.

Bioretention areas are vegetated shallow depressions that provide storage, infiltration, and evapotranspiration. Bioretention areas also remove stormwater pollutants by filtration and uptake by vegetation and filtering of the stormwater through the soil matrix. The components of bioretention facilities typically include a filter strip, sand bed, ponding area, planting soil, and plants. Bioretention areas can be incorporated into the design of a site as landscaping beds, landscaped islands in parking lots, and within the right-of-way along roads. An example of a bioretention area, installed in a parking lot, is shown in Figure 31.

Porous pavement is typically used in light vehicle loading areas, such as walkways, patios, plazas, driveways, parking lots, and some portions of streets subject to compliance with building codes. Numerous products and design approaches are available including special asphalt paving; manufactured products of concrete, plastic, and gravel; paving stones; and brick. Premeable pavement temporarily stores stormwater and promotes infiltration to the soil layers below. It typically consists of the driving surface, a bedding material of sand or stone, and a storage layer of structural stone typically a washed No 57. Examples of porous pavement and pervious concrete, as well as a site with porous pavement in a parking lot, are show in Figure 32.

Source: County of Los Angeles *Low impact Development Standards Manual*

Source: www.dot.ca.gov

Figure 31. Example Bioretention Areas

Source: County of Los Angeles *Low impact Development Standards Manual*

Source: www.calapa.org

Figure 32. Example Porous Pavement

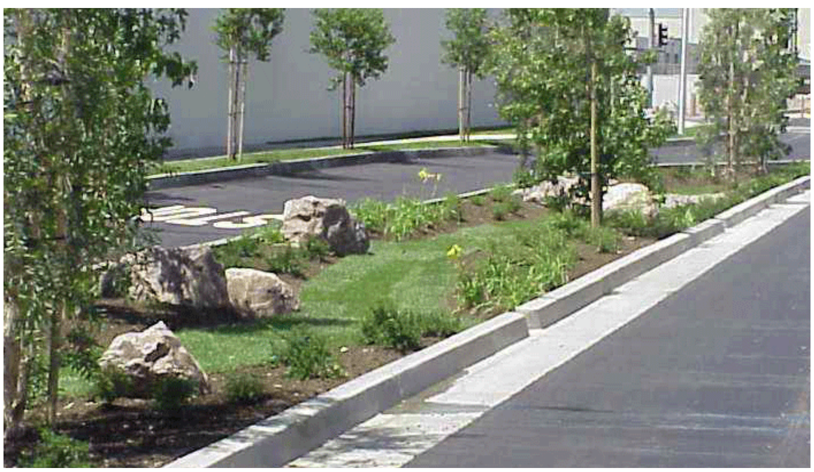
Although the assessment of large-scale distributed structural BMPs for public land was limited to bioretention and porous pavement, actual site design may include a number of options for BMPs that will depend on site characteristics and other design preferences. Examples include rain barrels, vegetated swales, buffer strips, and several others. It is important to note that many of these BMPs can be integrated into the landscaping of a site, and can even promote increased "green" aspects of the site that provide improved aesthetic value.

A secondary benefit of distributed structural BMPs on public land is the public education value. This is especially true for parks, libraries, schools, etc., that have frequent use. As the public learns more regarding the functionality and aesthetic value of these BMPs, they can be encouraged to implement similar practices on private properties. Essentially, this education and subsequent increased use of distributed structural BMPs can help change the way the public views landscaping practices, stormwater, environmental stewardship, and how these relate and can be impacted by simple changes in site design.

Pilot Distributed BMP Project for a County Road

A pilot distributed structural BMP project for a County road to store, infiltrate, and treat runoff from one acre of paved surface will be implemented. The location of the road has yet to be determined. The purpose of the project will be to demonstrate the benefits of distributed structural BMPs within road rights-of-way, and provide essential information regarding feasible designs and appropriate costs for design, construction, and maintenance. Successful implementation of this pilot project would provide political and regulatory buy-in for potential expanded implementation for other roads within the County TMDL Implementation Area. Implementation of the project will occur as funding becomes available.

For development of cost and pollutant load estimates for planning purposes, linear bioretention was assumed as the BMP to be implemented along the roadside or within the median for the road pilot project. Linear bioretention areas have the same function as bioretention areas but are narrow and are typcailly used to treat runoff from roads. Linear bioretention typically has a deeper storage capacity than standard bioretention areas. An example of a linear bioretention is show in Figure 33.



Source: Los Angeles Basin Water Augmentation Study – Neighborhood Retrofit Concept Plan
Figure 33. Example Linear Bioretention Area.

Although linear bioretention was assumed for planning purposes, actual implementation and design of the BMPs for the pilot project may include other BMPs, including vegetated swales or Filterra® Bioretention Systems. Selected BMPs can be based on site characteristics or other preferences for BMPs requiring pilot testing.

5.2. Assessment of Opportunities for Centralized Structural BMPs

To identify, evaluate, and ultimately select the optimal combination of centralized structural BMPs to address pollutant load reductions for the County TMDL Implementation Area, key information was required. Investigations were performed to identify and assess potential sites for placing centralized structural BMPs on public land. Priority locations of centralized structural BMPs were publicly owned properties to reduce the need for land acquisition. Additional consideration was made regarding the necessity for implemenetation of centralized structural BMPs on private land. Results of this assessment provided information necessary to support TMDL implementation planning.

5.2.1. Centralized BMPs on Public Land

Through analysis of GIS analysis, two publicly owned sites were identified to be suitable for implementation of centralized structural BMPs. Additional field investigations were performed for these locations to assess site and drainage area characteristics, and identify the ideal BMP that can be constructed for the site. The following provides a discussion of the findings from this assessment.

Site-Screening Methodology

A GIS analysis was performed of land ownership parcels and site characteristics to identify potential sites for centralized BMP placement on publicly owned parcels. Considerations in the analysis included the following:

- **Land cost**—Land costs were minimized by identifying publicly owned parcels.
- **Percent impervious**—Areas with higher percent imperviousness would produce more runoff during typical rain events. Higher impervious areas were targeted for greater potential volume reduction and water quality improvements.
- **Space requirements**—Sites were evaluated to determine if space is available to implement an appropriately sized BMP.
- **Watershed treatment area**—The size of the unincorporated County drainage area for each site was evaluated on the basis of available storm drain or Digital Elevation Model (DEM) data. Sites were identified that provide sufficient space for BMPs to adequately treat/store/infiltrate runoff from their respective drainage areas.
- **Soil type**—Soil type was evaluated as an initial estimate of the infiltration rate and capacity of the soils. Sites with infiltration rates suitable for infiltration BMPs were further investigated.
- **Slope**—Slopes of sites were considered on the basis of DEM or other available topography data sets. Sites with moderate slopes (less than 10 percent for GIS purposes) were considered for centralized BMPs. Slope was verified in the field investigation, and sites where the slope is inappropriate for a centralized BMP were eliminated.
- **Multi-benefit use**—Sites were identified that can serve multiple purposes. For instance, some stormwater practices, such as infiltration basins or grassed swales, can serve a dual purpose of stormwater management and community park space. Several parks could be altered to provided stormwater treatment and storage.

Those criteria were evaluated to identify sites where centralized BMPs would be feasible. Sites that could provide enough space to effectively treat the drainage area associated with the site, that have soils suitable for infiltration, and that are publicly owned (to reduce land acquisition costs) were preferred. Sites that could provide a multi-benefit use, such as parks or parking lots where belowground storage could be used, were considered ideal. From the GIS screening analysis, a list of potential locations for centralized BMPs was developed to address stormwater runoff from the County TMDL Implementation Area.

This GIS screening and additional field investigations narrowed the potential sites to two: West Los Angeles Community College and Ladera Park. These sites are depicted in Figure 34. The individual site characteristics and summary of field investigations and BMP recommendations are described below. Detailed field analyses are presented in Appendix E. Centralized structural BMP options for these sites were narrowed down to specific BMP types and sizes during the process for evaluation of nonstructural and structural solutions.

Figure 34. Selected Publicly Owned Parcels in Unincorporated County TMDL Implementation Areas of the Ballona Creek Watershed

West Los Angeles Community College

West Los Angeles Community College is undergoing massive expansion. Much of the parcel is built out, with the only remaining open space being athletic fields and an adjacent parking lot. It is in the headwaters of a subwatershed that drains directly to Ballona Creek. As shown in Figure 35, a centralized BMP at the site can treat 60 acres of the campus and 9 acres of the surrounding residential area. To treat the full 69 acres, the stormwater main at Overland Avenue and Freshman Drive would have to be altered to reroute the water to the athletic field and parking lot—a distance of approximately 600 feet.

The drainage area of this proposed project is in the Ladera Heights/Viewpark-Windsor Hills unincorporated County community, which is the lowest ranked community in terms of wet weather pollutant loading but the highest ranked for dry weather loading. Although the area is the lowest ranked for wet weather on the basis of pollutant area load estimates, the other three unincorporated County communities (West Los Angeles, West Fox Hills, and Franklin Canyon) are much smaller and are either proposed for implementation of other BMPs or no space is available for a single centralized structural BMP to treat the area. The site's drainage area is further characterized by a number of TRI sites within 20 miles, which have the potential of contributing to additional pollutant loading not represented in modeling analysis based on typical land use assumptions (the basis for wet weather prioritization for the unincorporated County communities). These additional sources provide further validation that a BMP would be advantageous at the site.

The available space for the centralized BMP is in the 14.5-acre area of the athletic fields and the adjacent parking lot on the campus of West Los Angeles Community College. The BMP area is reported to have HSG B soils. Field investigations showed that the surface infiltration rates at the site are in the range of HSG C; however, the soils at the site are HSG B soils according to the soil boring composition.

Analysis of the site indicates that an extended dry detention basin would be most appropriate for the site, with sufficient open area to allow for the storage space required. Extended dry detention basins are basins whose outlets have been designed to detain the runoff for 36 to 48 hours to allow sediment particles and associated pollutants to settle and be removed. Pollutants are also removed through filtration as the stormwater infiltrates into the soils at the base of the extended dry detention basin. Extended dry detention basins are suitable in areas with HSG C soils and soils in the lower range of HSG B where infiltration is possible but could take longer. The low measured infiltration rates would indicate that infiltration is possible but would require more time than expected for an infiltration basin. While stormwater is detained for up to 48 hours, extended dry detention basins are expected to infiltrate and dry completely between storm events making them suitable for multiple uses in addition to stormwater treatement, including open space and recreational activities. The available BMP area is an athletic field with ample access for maintenance.

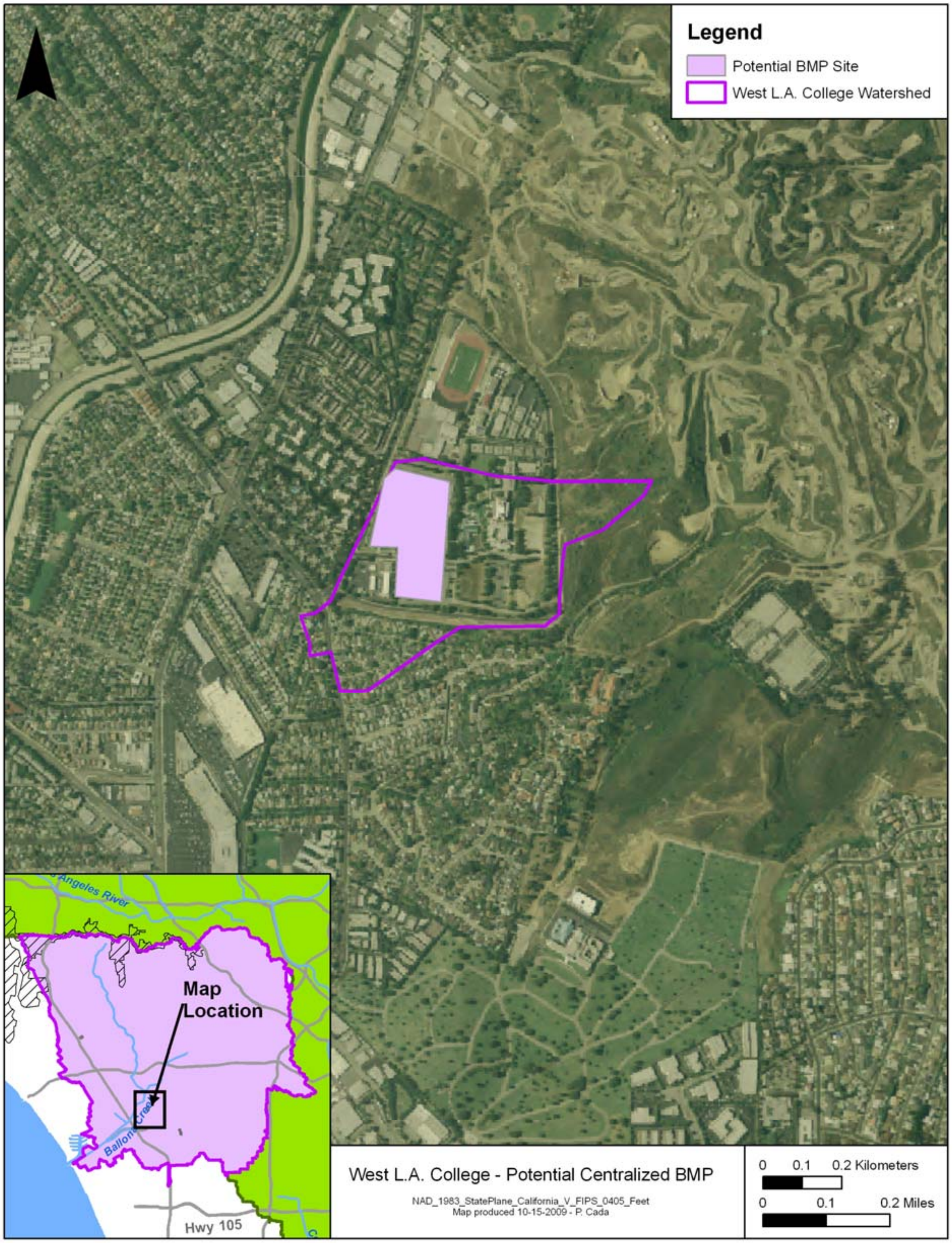


Figure 35. West Los Angeles Community College Watershed and Potential BMP Site

Ladera Park

Ladera Park is in what appears to be a gully that formed as a part of the historic drainage pattern that has been altered from years of development and added impervious areas. A large storm drain passes through the park with curb drains at the northern and southern ends of the park. There are several structures in the park including a restroom, an amphitheater, a basketball court, and a tennis court. There are also multiple mature Sycamore trees that are an obvious amenity to the park. As proposed in the Ladera County Park TMDL/LID Improvement Project identified in the Integrated Regional Watershed Management Plan (IRWMP) approximately 200 acres of unincorporated County area, identified as watershed 1, could be treated by daylighting the stormwater main that flows through Ladera Park. The stormwater is collected in a stormwater main that runs along West Slauson Avenue and enters the north end of the park. Watershed 1 consists of residential (single-family) and commercial land uses and is drained with curb drains along the major roads and at the north side of the park. An additional 75 acres, identified as watershed 2, is predominantly residential area that drains to the curb drain at the southern end of the park. The drainage system could be altered to force that drainage back into the park. The two watersheds are shown in Figure 36.

Ladera Park is also in the Ladera Heights/Viewpark-Windsor Hills unincorporated County community, providing an additional opportunity for BMP implementation in the area for reasons consistent with the discussion for the West Los Angeles Community College project. Given the significant size of the watershed, the benefit of this BMP could be significant. The drainage area also has a history of SSOs, which, like TRI sites, have the potential of contributing to additional pollutant loading not represented in modeling analysis used to prioritize unincorporated County communities. That provides additional indication that a BMP would be advantageous at the site.

Soils at the site are reported to be HSG B soils; however, the measured surface infiltration rates are within the HSG A range. The soil boring composition shows HSG A soils at the surface with HSG B soils approximately 2 feet below the surface.

Analysis of the site indicates that an infiltration basin would be the most appropriate centralized BMP. The higher surface infiltration rates at the site and HSG B soils below the surface indicate that there is a large capacity for infiltration. Infiltration basins are shallow surface basins that are designed to infiltrate stormwater through permeable soils. Infiltration basins require high infiltration rates and are not designed to store water for extended periods. Sediment particles and associated pollutants are removed through settlement and filtration as the water infiltrates through the surface of the infiltration basin. Infiltration areas could be used throughout the park using the infiltration capacity of the soil while minimizing effects on the numerous Sycamore trees. Because infiltration basins are designed to infiltrate quickly and dry out between storm events, they can be utilized as multi use facilities for recreation and open space in addition to stormwater treatment. The infiltratin basins would be maintained much like the open space in the park with ample space for access.

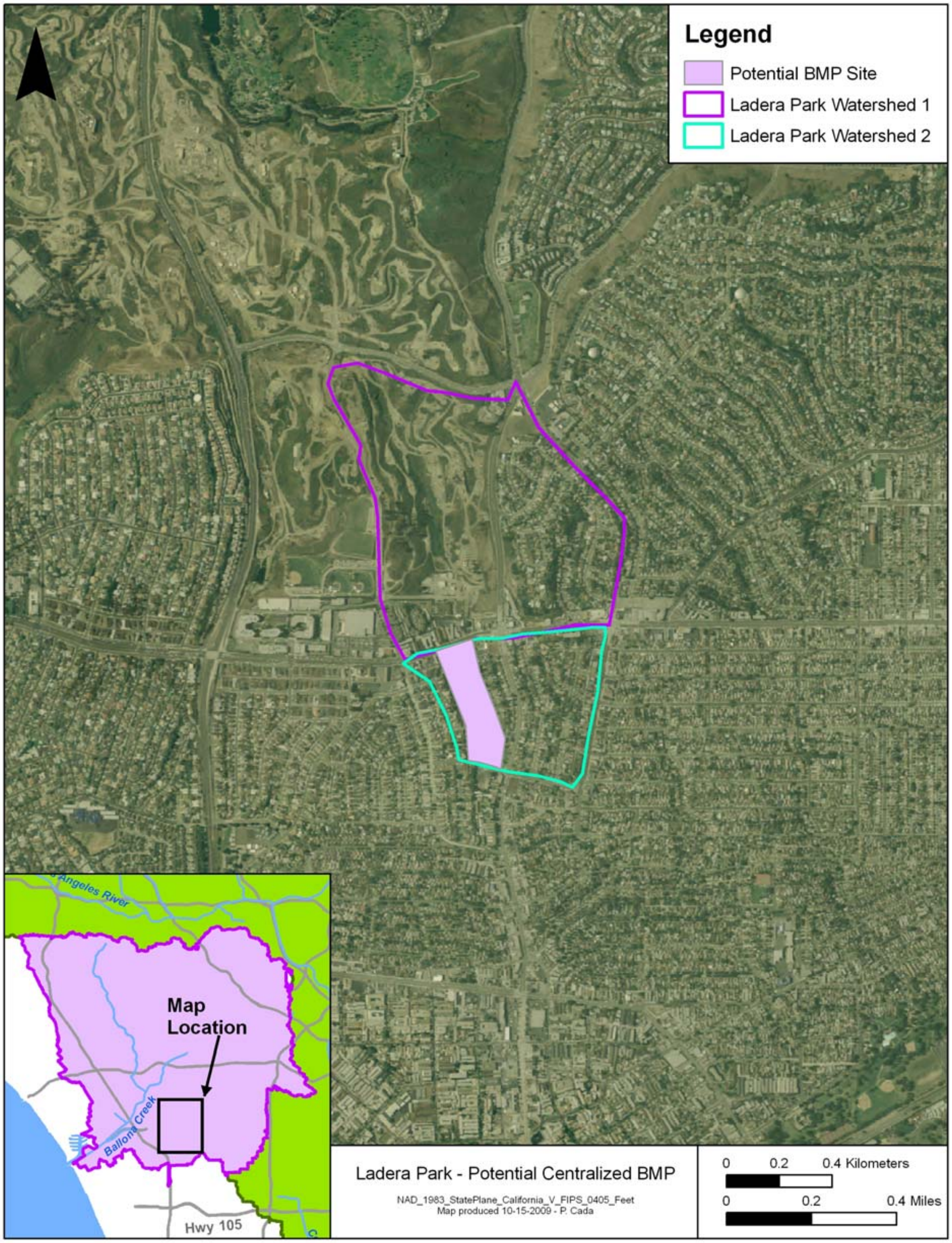


Figure 36. Ladera Park Watershed and Potential BMP Site

5.2.2. Centralized Structural BMPs on Private Land

It is recognized that the centralized BMP projects identified for public land will not likely provide the full pollutant load reductions necessary to meet the WLAs for the entire County TMDL Implementation Area. Essentially, not enough suitable public land is available to build centralized BMPs to treat the drainage area required. As a result, strategic acquisition of private land will be necessary to provide the space needed to site the BMPs. It is not the focus of this TMDL Implementation Plan to identify those privately owned parcels that should be targeted for acquisition. However, through the process of evalutation of structural and nonstructural BMPs, the necessary capacity of centralized BMPs on private land was determined. Knowing the necessary space requirements to build centralized BMPs will assist in a strategic land acquisition program that can be implemented throughout the TMDL implementation schedule to ensure that phased load reductions to meet WLAs are achieved. These lands will be aquired as private parcels become available and funding becomes available for purchasing.

For the porpose of projecting the necessary capacity of centralized structural BMPs on private land within the County TMDL Implementation Area, and estimating associated pollutant load reductions and cost, BMPs were assumed to represent a combination of multiple infiltration basins and dry detention basins. Descriptions of treatment processes for infiltration basins and dry detention basins were provided in the discussions for the West Los Angeles Community College and Ladera Park centralized BMPs.

5.3. Summary of Structural Solutions to Support TMDL Implementation

Table 29 lists the proposed distributed and centralized BMP projects to support TMDL implementation. The table also lists the dry or wet weather runoff that can be treated or infiltrated, as well as the TMDL pollutants that can be addressed.

Table 29. Summary of Structural Solutions

Structural BMP	Flow Addressed		TMDL Pollutant Addressed			
	Wet Weather	Dry Weather	Bacteria	Metals	Non-Metal Toxics	Trash
Catch Basin Distributed BMPs						
Full Capture Devices	✓		○	○	○	●
Catch Basin Inserts	✓		○	●	◗	●
Other Distributed BMPs on Public Land						
Distributed BMPs on Public Land	✓	✓	●	●	●	●
Pilot Distributed BMP Project for a County Road	✓	✓	●	●	●	●
Centralized BMPs on Public Land						
West Los Angeles Community College	✓	✓	●	●	●	●
Ladera Park	✓	✓	●	●	●	●
Centralized BMPs on Private Land						
Infiltration Basins	✓	✓	●	●	●	●
Dry Detention Basins	✓	✓	●	●	●	●

● addresses the pollutant
◗ partially addresses the pollutant
○ does not address the pollutant

5.4. Additional Structural Options for TMDL Implementation

Through additional monitoring, pollutant source characterizations, and site investigations throughout the duration of the TMDL implementation schedule, additional options for structural BMPs may be identified that can enhance or replace those BMPs identified in this plan. This is especially true for dry weather, when flows are highly variable throughout the storm drain system, and specific areas may require special methods for treatment of storm drain flows before they discharge to receiving waters. For storm drains with particularly high dry weather flows and associated pollutant loads where other nonstructural or structural BMPs are not providing a remedy, specific mechanical BMPs may be implemented. These BMPs could include diversions to wastewater treatment plants, or onsite treatment facilities that provide ultraviolet (UV) disinfection or other forms of treatment.

Likewise for wet weather, certain mechanical BMPs can be installed in problem storm drains where other nonstructural and structural BMPs are not providing a solution. There are several stormwater BMPs that are available for this purpose, which are based on a range of technologies that continue to evolve through continued research and development.

This TMDL Implementation Plan is intended to be iterative and adaptive to allow for modifcations as additional studies of the drainage system and diagnoses of problem sources are achieved, and new technologies for dry and wet weather treatment continue to emerge.

(This page intentionally left blank.)

6. Evaluation of Nonstructural and Structural Solutions

As shown in the previous sections, a number of nonstructural and structural BMP options were identified that can support TMDL implementation. An evaluation of these practices was performed, including optimization of the most cost-effective combination of BMPs to support meeting WLAs for the County TMDL Implementation Area. This process required both qualitative and quantitative evaluation techniques to support selection and sequencing of BMPs throughout the TMDL implementation period to meet phased WLAs. This section provides a summary of these evaluations.

6.1. Nonstructural BMP Evaluation

For most nonstructural BMPs, quantification of benefits in terms of pollutant load reductions are challenging and often require extensive survey and monitoring information to gage performace. For the purposes of this plan, a qualitative approach was used to evaluate the effectiveness and feasibility of the nonstructural BMPs identified in Section 4. Most of these BMPs focus on increased training/education and improved pollutant source control. However, the Reduction of Irrigation Return Flows will have a quantitative impact on dry weather flows and reduction of associated pollutant loads. For this reason, a modeling approach was used to provide additional quantitative evalutation of this BMP.

6.1.1. Qualitative Evaluation of Nonstructural BMPs

The nonstructural BMPs were evaluated for several factors that contribute to their success and effectiveness. A customized scoring system was developed to compare benefits across many quantitative and qualitative factors. The scoring was based on factors relevant to successfully achieving pollutant reduction benefits, which include inherent effectiveness, source contribution, and feasibility. Compliance resources were also considered as a factor for BMPs involving voluntary public participation, but none of the BMPs differed significantly for this factor. It was assumed that the materials or facilities needed for voluntary compliance would be available either through the programs or at local retailers.

The nonstructural BMPs were scored using a 3-point scale. Generally, 3 points indicate a high benefit for a particular factor, 2 points indicate a moderate benefit, and 1 point indicates a low or nonexistent benefit. The scores were defined differently for each factor but represent these general definitions. Guidelines were developed for each factor to ensure that the BMPs were scored consistently, as shown in Table 30.

Effectiveness, for the purposes of the scoring, was defined as the relative pollutant removal provided per unit of the BMP. The BMPs received a score for each parameter of concern (bacteria, metals, non-metal toxics, and trash). The source contribution factor considered how much of the total pollutant load a nonstructural BMP would address within the County TMDL Implementation Area. For example, the Smart Gardening Program targets pollutant loading from all residential areas within the watershed, which is a moderately significant portion of the implementation area.

Table 30. Factor-specific Guidelines Used When Scoring the Nonstructural BMPs

Factor	Score		
	3 Points	2 Points	1 Point
Effectiveness	Highly effective (pollutant removal likely about 25 percent reduction at an individual site).	Moderately effective (all training/education, practices that are likely to reduce load on an individual site by less than 25 percent)	Not significantly effective or does not address pollutant.
Source Contribution	Addresses a highly significant portion of the load.	Addresses a moderately significant portion of the load	Does not address a significant portion of the load.
Administrative Feasibility	Low effort and quick time frame; little or no constraints.	Moderate effort and time frame; some moderate constraints	Requires considerable effort, and startup process could take a long time; potential exists for significant administrative roadblocks and hurdles.
Political Feasibility and Public Interest	No objection from public or politicians expected.	Public or politicians might have some objections	Public or politicians would object strongly.

The factor Administrative Feasibility considered how difficult a BMP would be to implement and the likelihood that it would be implemented in a reasonable time frame. For example, Industrial and Commercial Facility Inspection Audits were expected to have high administrative feasibility since it would require minimal changes to the administrative structure. On the other hand, Enforcement Escalation Procedures could present administrative hurdles because multiple County departments will need to be involved. Administrative Feasibility is related to cost, but the scoring was based less on cost and more on the degree of difficulty and the potential for implementation delays. Some BMPs could have a promising feasibility score even though they presented a relatively high cost.

The factors Political Feasibility and Public Interest were combined because they tend to be correlated, and for each BMP, an assessment was made as to whether or not strong opposition was anticipated, either from politicians or the public. For example, strong political and public opposition was expected for Reduction of Irrigation Return Flow since it could involves changing the water supply rate structure, whereas little opposition was expected for the Smart Gardening Program since it provides a public service without mandates.

Table 31 summarizes the individual parameter scores for the four factors defined above. The three BMPs that received the highest benefit scores were: Enhancement of Commercial and Industrial Facility Inspections, TMDL-specific Stormwater Training, and Enforcement Escalation Procedures. These BMPs, in general, reflect a combination of moderate source contribution and a relatively high feasibility. The pollutant removal effectiveness of these BMPs varies from low to moderate. The advantage of these BMPs would be that they would be fairly easy to implement and have the potential to provide some pollutant removal toward meeting TMDL requirements.

Another promising BMP with moderate pollutant reduction and feasibility is the Smart Gardening Program Enhancements. The major constraint with enhancing this program for the Ballona Creek watershed is building an information center convenient to or within the watershed. If an additional center can be built or if residents can be reached through other methods, then this BMP provides another opportunity to contribute to TMDL requirements while using existing resources.

Independent of source contribution and feasibility, the BMPs with the highest pollutant removal effectiveness was Reduction of Irrigation Return Flow. Reduction of Irrigation Return Flow received a lower source contribution score, but it should be noted that this BMP addresses a large portion of dry weather sources despite the low overall source contribution. This BMP also had a low to moderate feasibility score. To achieve dry weather TMDL pollutant load reductions, the BMP has a promising opportunity if the feasibility constraints can be addressed. For instance, if this BMP is implemented through adjustment of water supply rate structures, this will have implications for both administrative and political feasibility.

Table 31. Nonstructural BMP Scores

Nonstructural BMP	BMP Effectiveness			
	Bacteria	Metals	Non-Metal Toxics	Trash
Reduction of Irrigation Return Flow	3.0	3.0	2.0	1.0
Smart Gardening Program Enhancements	2.0	2.0	2.0	1.0
TMDL-specific Stormwater Training	1.5	1.5	1.5	1.5
Enforcement Escalation Procedures	2.0	3.0	2.0	1.0
Enhancement of Commercial and Industrial Facility Inspections	2.0	2.0	2.0	1.0
Nonstructural BMP	**BMP Source Contribution**			
	Bacteria	**Metals**	**Non-Metal Toxics**	**Trash**
Reduction of Irrigation Return Flow	2.0	2.0	1.0	1.0
Smart Gardening Program Enhancements	2.0	2.0	2.0	1.0
TMDL-specific Stormwater Training	2.0	2.0	2.0	2.0
Enforcement Escalation Procedures	2.0	2.0	2.0	2.0
Enhancement of Commercial and Industrial Facility Inspections	2.0	2.0	2.0	2.0

Nonstructural BMP	Administrative Feasibility	Political Feasibility and Public Interest
Reduction of Irrigation Return Flow	1.0	1.0
Smart Gardening Program Enhancements	2.0	3.0
TMDL-specific Stormwater Training	3.0	3.0
Enforcement Escalation Procedures	2.0	3.0
Enhancement of Commercial and Industrial Facility Inspections	3.0	3.0

6.1.2. Quantitative Evaluation of Reduction of Irrigation Return Flow

Irrigation return flow can be significantly reduced via aggressive programs, including educational programs, rebates for irrigation water saving devices, tiered rate structures, xeriscaping, and other measures. Quantification of benefits of Reduction of Irrigation Return Flow assumed irrigation water demand is reduced by 25 percent; Gleick et al. (2003) indicate that California could reduce outdoor residential water use by 25 percent to 40 percent through improved landscape management practices and better application of available technology. An assumption of 25 percent reduction reflects a conservative estimate of what is achievable.

The LSPC model has an irrigation module that allows for representation of landscape irrigation that is sensitive to soil moisture content and irrigation efficiency. The model was calibrated to represent dry weather flows by comparing simulated to observed flow during dry periods. In the model as in the watershed, dry weather flows are dominated by irrigation return flow as the primary source. The model was further calibrated to represent pollutant concentrations and loads by applying fixed pollutant concentrations to groundwater/irrigation return flow inputs, and calibrating to observed low flow pollutant data. Reducing irrigation return flow resulted in a reduction in low flow pollutant loads.

Pollutant load reductions are shown in Table 32 for each of the County TMDL Implementation Areas for dry weather runoff. The pollutant loads reductions are significant, reflecting an average dry weather flow and load reduction of 43 percent. Much of the water applied to landscaping evaporates or is taken up and transpired by the vegetation, so a 25 percent reduction in total irrigation water use has a much larger influence on dry weather flow.

Table 32. Dry weather TMDL Pollutant Load Reductions Resulting from Reduction of Irrigation Return Flow

Total Copper	Area (acres)	Low Flow - Annual Load (lbs/year)		
		Baseline Load	Irrigation Return Flow	
			Load	% Reduction
West Fox Hills	30.8	0.24	0.13	45%
Ladera Heights/Viewpark-Windsor Hills	3,079.0	33.38	18.25	45%
West Los Angeles	577.8	4.55	3.55	22%
Total	3,687.6	38.2	21.9	43%
Total Zinc	**Area (acres)**	**Low Flow - Annual Load (lbs/year)**		
		Baseline Load	**Irrigation Return Flow**	
			Load	**% Reduction**
West Fox Hills	30.8	0.87	0.48	45%
Ladera Heights/Viewpark-Windsor Hills	3,079.0	122.41	66.92	45%
West Los Angeles	577.8	16.67	13.01	22%
Total	3,687.6	140.0	80.4	43%
Total Lead	**Area (acres)**	**Low Flow - Annual Load (lbs/year)**		
		Baseline Load	**Irrigation Return Flow**	
			Load	**% Reduction**
West Fox Hills	30.8	0.16	0.09	45%
Ladera Heights/Viewpark-Windsor Hills	3,079.0	22.26	12.17	45%
West Los Angeles	577.8	3.03	2.37	22%
Total	3,687.6	25.4	14.6	43%
Fecal coliform	**Area (acres)**	**Low flow - annual load (#/year)**		
		Baseline Load	**Irrigation Return Flow**	
			Load	**% Reduction**
West Fox Hills	30.8	2.5E+11	1.4E+11	45%
Ladera Heights/Viewpark-Windsor Hills	3,079.0	3.5E+13	1.9E+13	45%
West Los Angeles	577.8	4.8E+12	3.8E+12	22%
Total	3,687.6	4.0E+13	2.3E+13	43%

6.1.3. Summary of Qualitative and Quantitative Analysis Results and Recommendations

Final recommendations for nonstructural BMPs were based on the following decision criteria:

- Which nonstructural BMPs are likely to provide the greatest success at achieving TMDL implementation requirements?
- Which nonstructural BMPs provide significant dry weather pollutant load reduction?
- Which nonstructural BMPs are most cost-effective?

- Which nonstructural BMPs are the most feasible considering the County's current programs and resources?
- Which nonstructural BMPs present the least uncertainty, or greatest risk, regarding successful implementation and minimization of negative impacts?

Using the available information, the nonstructural BMPs that best meet the first criterion were those that are likely to achieve significant pollutant load reduction. The analysis described above indicated that Enforcement Escalation Procedures, TMDL-specific Stormwater Training, Enhancement of Commercial and Industrial Facility Inspections, and the Smart Gardening Program Enhancements could provide some pollutant reduction with relative ease of implementation. In addition, Reduction of Irrigation Return Flow is likely to provide relatively significant dry weather pollutant reductions if feasibility issues can be overcome.

The cost analysis (Section 9) indicated that the BMPs that build on existing programs (Smart Gardening Program Enhancements, TMDL-specific Stormwater Training, and Enhancement of Commercial and Industrial Facility Inspections) are the most cost-effective options. The incentives associated with Reduction of Irrigation Return Flow could result in high costs, reducing overall cost-effectiveness. Enforcement Escalation Procedures, though not requiring a significant capital outlay, could significantly increase staffing and administrative costs.

To summarize the results of this evaluation, Table 33 indicates which BMPs best meet the decision criteria, indicated by a checkmark (✓). The BMPs that best meet multiple decision criteria are Reduction of Irrigation Return Flow, the Smart Gardening Program Enhancements, TMDL-specific Stormwater Training, and Enhancement of Commercial and Industrial Facility Inspections.

Table 33. Nonstructural BMPs Meeting Multiple Decision Criteria

Criterion	Overall TMDL Implementation Requirements	Dry Weather Pollutant Load Reduction	Cost-effectiveness	Feasibility	Certainty
Reduction of Irrigation Return Flow	✓	✓			✓
Smart Gardening Program Enhancements	✓	✓	✓		
TMDL-specific Stormwater Training	✓		✓	✓	
Enforcement Escalation Procedures	✓				
Enhancement of Commercial and Industrial Facility Inspections	✓		✓	✓	

6.2. Evaluation of Structural Solutions

Given the number of BMP implementation options to be considered, there can be many different ways to achieve the targeted TMDL objectives. Each potential alternative has a range of individual nonstructural and structural BMP considerations and associated costs. Structural BMPs (either distributed or centralized) can alter hydrology and provide benefit from either the hydromodification process itself or in conjunction with additional water quality treatment. Nonstructural BMPs can provide a pollutant load reduction benefit that either operates in tandem with structural BMPs or in lieu of them. For phased implementation planning, it is often advantageous to consider multiple control objectives for different levels of management in terms of pollutant reduction goals or flow volume/peak control.

With all those considerations in place, the number of alternatives is expansive. At the same time, prescriptive BMP selection, even when based on the success of past implementation activities, faces the risk of adopting an inferior solution or one that might not be congruous with long-term, phased implementation objectives. Recognizing the nonlinear response of the watershed and associated hydrology, water quality, and benefits of BMPs, using an optimization search technique can provide meaningful insights and direction. Optimization can be used to identify near-optimum benefits at each cost interval within the search space of alternatives. In addition, on the basis of how the constraints are established, each successive solution could be additive of the previously identified solutions, producing a prioritization order and sequence of BMP implementation, which is also valuable for phased implementation and planning. An optimization can assist in navigating the choices of alternatives, understanding cause-effect relationships of different actions, and identifying cost-effective and actionable strategies for addressing the water quality concerns.

The Los Angeles County BMPDSS and LSPC were used to evaluate the benefits, in terms of pollutant load reductions, and costs of alternative combinations structural BMPs implemented in the County TMDL Implementation Area. This approach was focused on wet weather TMDL implementation, which represented the most critical condition for investment in structural BMPs. A background summary of LSPC and BMPDSS is provided in Appendix G.

To model structural BMPs for optimization of the most cost-effective combination for TMDL implementation, the following steps were taken.

- **Quantitative Evaluation of Catch Basin Distributed BMPs**—Catch basin distributed BMPs, including full capture devices and catch basin inserts, were evaluated to determine pollutant load reductions that can be achieved through their implementation. These were modeled within LSPC independent of other structural BMPs due to special considerations needed for representation of treatment processes and determination of pollutant load reductions, which due not rely on traditional storage or infiltration.
- **Development of Baseline Scenario**—A baseline runoff and pollutant load scenario was developed using LSPC. This baseline assumed that catch basin inserts and Reduction of Irrigation Return Flows were implemented. This basline scenario provided the starting point for determination of additional structural BMPs necessary for TMDL implementation. Consideration of catch basin inserts and Reduction of Irrigation Return Flows within the basline scenario ensured that associated load reductions were considered in combination with all other structural BMPs within the optimization.
- **Determination of TMDL Reduction Objectives—**Although specific WLAs have been assigned for each TMDL for Ballona Creek, some interpretation of these WLAs was necessary to provide meaningful objectives for BMP optimization.
- **Optimization Analysis**—Based on the baseline scenario, BMPDSS was used to deterime the most cost-effective combination of structural BMPs necessary to meet WLAs. This optimization considered conceptual costs as well as pollutant load reductions achieved for the BMPs, and resulted in determination of sizes and treatment capacities required for the BMPs to support more detailed cost estimates reported in Section 9.

6.2.1. Quantitative Evaluation of Catch Basin Distributed BMPs

Quantitative evaluation was performed for both Full Capture Devices and Catch Basin Inserts for relative comparison of benefits.

Full Capture Devices

The original LSPC watershed model was calibrated to conditions in the watershed prior to full capture device installation, so the influence of the full capture devices needed to be accounted for. To represent full capture devices in the model, annual pollutant removal rates were applied to surface runoff from the impervious secondary road transportation network, which was represented explicitly in the model.

Pollutant removal performance of full capture devices was estimated from a synthesis of monitoring studies. The Center for Watershed Protection (2006a) developed a conceptual model that defined the removal rates for catch basins and inlets. The street dirt load that enters the catch basins and inlets included such inputs as run-on, atmospheric deposition, vehicle emissions, littering, sanding, street breakup, and organic matter. The trapping efficiency was dependent upon the type of inlet, the capacity of the inlet, and the clean-out frequency. Using conditions representative of catch basins in the Chesapeake Bay watershed, they estimated that annual cleanouts will result in urban watershed scale reductions of 18 percent for total solids (TS), while semi-annual cleaning will result in reductions of 35 percent for TS. The model assumes catch basins have sumps below the drain discharge point. Catch basins without sumps have significantly less storage capacity. For instance, Pitt (1985) reports catch basins without sumps as having about half the accumulation rates as catch basins with sumps.

The following annual percentage removal rates were used to represent the effect of full capture devices on storm event runoff loads originating from the transportation network:

- 5 percent sediment and attached metals removal
- 0 percent bacteria removal

A conservative sediment removal rate was used to account for the lack of sumps below the drain discharge point, and to account for a lower available sediment yield because of advanced street sweeping practices used by the County. No information was available in monitoring studies to characterize bacteria removal, so it was not included.

Catch Basin Inserts

The pollutant removal efficiency of catch basins can be improved, in certain circumstances, by using inserts and other removal media. However, independent studies of catch basin and catch basin insert performance are uncommon. Morgan et al. (2005) found that catch basin inserts yielded an average TSS removal efficiency of 10 to 42 percent and an average total petroleum hydrocarbons removal efficiency of 10 to 19 percent. During the testing of the inserts, water flowed out of the bypasses of the inserts; therefore, sediment was removed from solution via settling because much of the inflow did not pass through the screens or over the absorbent material. The Stormwater Manager's Resource Center (http://www.stormwatercenter.net) cites two studies for catch basin inserts with sufficient data, one from 1997 showing 32 percent TSS removal, and another from 1982 with TSS removal ranging from 10 percent-25 percent. Edwards et al. (2004) tested four catch basin inserts with synthetic runoff (TSS 225 mg/L) and reported sediment removal from 11 percent to 42 percent.

The full capture device and catch basin insert removal rates are not additive; the inserts would provide direct sediment filtration and other pollutant capture, and they would likely be installed as a replacement to the trash screens. On the basis of a synthesis of available studies with best professional judgment, the following removal rates were used for catch basin inserts:

- 30 percent sediment and attached metals removal
- 0 percent bacteria removal

Results of Quantitative Evaluation of Catch Basin Distributed BMPs

Wet weather pollutant load reductions are shown in Table 34 for each of the unincorporated County communities within the County TMDL Implementation Areas. Full capture devices have little influence on pollutant loads, but are important to consider since full capture devices have already been installed throughout the County TMDL Implementation Area. Catch basin inserts performed considerably better, most notably for metals. Percent reductions vary on the basis of the relative land area of the transportation network within the various unincorporated County areas. Fecal coliform is not shown since no reduction was assumed for the scenarios.

Table 34. Full Capture Device and Catch Basin Insert Load Reductions

Total Copper	Area (acres)	High Flow - Annual Load (lbs/year)				
		Baseline Load	Full Capture Devices		Catch Basin Inserts	
			Load	% Reduction	Load	% Reduction
West Fox Hills	30.8	1.47	1.44	2.1%	1.29	12.4%
Ladera Heights/Viewpark-Windsor Hills	3,079.0	75.83	74.72	1.5%	69.14	8.8%
West Los Angeles	577.8	27.54	27.41	0.5%	26.77	2.8%
Total	3,687.6	104.8	103.6	1.2%	97.2	7.3%
Total Zinc	**Area (acres)**	**High Flow - Annual Load (lbs/year)**				
		Baseline Load	**Full Capture Devices**		**Catch Basin Inserts**	
			Load	**% Reduction**	**Load**	**% Reduction**
West Fox Hills	30.8	14.27	13.98	2.0%	12.55	12.0%
Ladera Heights/Viewpark-Windsor Hills	3,079.0	712.78	702.32	1.5%	650.05	8.8%
West Los Angeles	577.8	296.45	295.25	0.4%	289.26	2.4%
Total	3,687.6	1,023.5	1,011.6	1.2%	951.9	7.0%
Total Lead	**Area (acres)**	**High Flow - Annual Load (lbs/year)**				
		Baseline Load	**Full Capture Devices**		**Catch Basin Inserts**	
			Load	**% Reduction**	**Load**	**% Reduction**
West Fox Hills	30.8	1.36	1.33	2.2%	1.17	13.5%
Ladera Heights/Viewpark-Windsor Hills	3,079.0	71.73	70.62	1.6%	65.04	9.3%
West Los Angeles	577.8	17.15	17.02	0.7%	16.39	4.5%
Total	3,687.6	90.2	89.0	1.4%	82.6	8.5%

6.2.2. Development of Baseline Scenario

The baseline scenario provided the starting point for optimization of cost-effective BMPs to achieve WLAs for the County TMDL Implementation Area. With representation of BMPs in the baseline condition, their benefits were included prior to consideration of additional structural BMPs. The following provides discussion of key BMPs included within the baseline scenario.

Reduction of Irrigation Return Flows

The nonstructural BMP modeling scenario for Reduction of Irrigation Return Flows, reported earlier in this section, was represented in the baseline scenario for structural BMP implementation. This BMP will be implemented separately to address dry weather, however, there are small benefits for wet weather conditions as well. Reduction of irrigation to urban lawns results in less soil saturation, which provides additional soil storage for a rain event, and hence a reduction of stormwater runoff.

Catch Basin Inserts

As shown in the previous section, catch basin inserts provided a significant overall load reduction for the County TMDL Implementation Area. Catch basin inserts focus on treating road runoff, which is a significant source of metals and represents a large portion of impervious area that drains directly to the storm drain system. Considering the pollutant load reductions achieved and estimated costs of implementing catch basin inserts for the County TMDL Implementation Area (Section 9), this BMP was considered very cost-effective and therefore incorporated within the baseline scenario. With inclusion in the baseline scenario, this BMP is assumed for TMDL Implementation. As a result, the remaining discussion regarding optimization of distributed structural BMPs does not include catch basin inserts, but rather additional distributed BMPs required to meet the TMDLs.

6.2.3. Determination of TMDL Reduction Objectives

The metals, bacteria, and organic toxics TMDL targets for Ballona Creek watershed were converted to numerical percent reduction values for easy comparison and analysis with model results. The percent reduction required to meet the WLA was first determined by estimating the existing loads provided by the model. Table 35 presents the reduction percentage targets for the County TMDL Implementation Area. They were calculated on the basis of the existing and TMDL target values. Table 35 presents the copper, lead, and zinc existing and TMDL annual load targets, as well as fecal coliform (indicator bacteria) wet weather exceedance days existing value and TMDL target value. The existing values were estimated on the basis of continuous model simulation for hydrologic year (HY) 2003. Appendix G describes how that year was selected for analysis. The TMDL pollutant (copper, lead, and zinc) annual loading target values were derived using the target concentration multiplied by annual total flow volume. For fecal coliform, the wet weather exceedance days target (7.6 days) was calculated as 22 percent of wet days (34.4 wet days in HY 2003).

Table 35. TMDL Reduction Targets for the County TMDL Implementation Area

Pollutants	Existing Loading	TMDL Target Loading	TMDL Reduction Targets (%)
Copper (lb/yr)	96.6	73.6	24%
Lead (lb/yr)	84.9	241.4	0%
Zinc (lb/yr)	943.9	486.9	48%
Fecal coliform wet weather exceedance frequency (days/yr)	34.4	7.6	78%

It is important to note that the TMDL Reduction Targets were derived from summarizing time series of multiple storms throughout the model simulation period. They do *not* represent flat reductions applied uniformly to all flows and all loads. Of the metals, zinc had the highest required reduction to meet the TMDL target, as shown in Table 35. For that reason, zinc was determined the limiting pollutant for metals TMDL compliance in the County TMDL Implementation Area (i.e., controlling zinc tends to ensure that other metals TMDL targets are met); therefore, zinc load reduction was used as the control target for the optimization runs. Benefits of structural BMPs to address fecal coliform TMDL targets are also assessed.

To calculate the TMDL endpoints for organic toxics, the model-simulated average annual sediment load for the County TMDL Implementation Area was multiplied by ERL sediment quality screening levels for the selected organic toxics. This resulted in a target load for each consituent, which was compared to simulated loads to derive the TMDL percent reduction. Table 36 presents load reduction targets for toxics and indicates that targets for legacy pollutants such as chlordane, DDT, and PCB were unlikely to drive BMP optimization. However, the reduction target for PAHs, at 90 percent, was an important consideration.

Table 36. Sediment Load Reduction Target Calculated Using Toxics Targets

Toxic	Criteria (µg/kg)	TSS (tons/yr)	TMDL Target Loading (lbs/yr)	Existing Loading (lbs/yr)	TMDL Reduction Targets (%)
Chlordane	0.5	139.9	0.0001	2.68E-06	0%
DDTs	1.58	139.9	0.0004	6.93E-05	0%
Total PCBs	22.7	139.9	0.0064	0.000193	0%
Total PAHs	4,022	139.9	1.1254	11.1	90%

The transport of organics within sediment transported in stormwater has been substantially documented (Caltrans 2003; Hoffman et al. 1982; Lau and Stenstrom 2005; Longanathan et al. 1997; Stein et al. 2005; Yunker et al. 2002). Progress toward meeting the WLAs will therefore depend on the amount of sediment transported from the County TMDL Implementation Area, which will vary as a function of area, rainfall, and the amount of resulting stormwater transporting sediment. Structural BMP implementation scenarios considered compliance with WLAs established for the Ballona Creek Estuary sediment toxicity TMDL; however, results were highly driven by TSS load reductions (and associated stormwater volume reductions) that can be achieved with BMPs. As a result, load reductions for TSS were assessed in the optimization analysis to evaluate progress toward meeting the 90 percent TMDL reduction target for PAHs.

6.2.4. Optimization Analysis

Considering the large number of alternatives for combinations of structural BMPs, the BMP optimization scenarios required careful formulation to take into account the physical constraints (such as available land, land ownership, and soil properties), as well as political constraints (such as order preference and prioritization of actions). The BMP optimization scenarios were constructed to reflect management considerations for BMP implementation as follows:

- BMPs on public land are preferred over the BMPs on private land
- For BMPs on private land, centralized BMPs are the only options

Distributed and centralized BMPs on public and private land are consistent with those identified in Section 5. Appendix G provides a full description of modeling assumptions for representing the various distributed and centralized structural BMPs, including sizing criteria and configuration within their drainage areas.

With the above considerations, two optimization scenarios were formulated as shown in Table 37. Scenario 1 used the baseline scenario and considered only centralized or distributed BMPs on public land. Scenarios 2 was built on the maximum optimal solution derived from Scenario 1 and added centralized BMPs on private land.

Table 37. Optimization Scenario Matrix

Scenario	Baseline Scenario (Catch Basin Inserts and Reduction of Irrigation Return Flows)	Structural BMPs	
		Public Centralized and Distributed	Private Centralized
1	Fixed	Variable	
2	Fixed	Fixed (Optimal solution derived in 1)	Variable

Fixed: Corresponding BMPs are included as a fixed condition
Variable: Corresponding BMPs are included as decision variables to be optimized for cost-effectiveness

BMP Cost Functions

Cost estimation was a critical component in the optimization process, as the optimization process was dependent on evaluating and comparing the cost effectiveness of various BMP alternatives. Detailed BMP cost functions are discussed in Appendix G. These functions consider BMP construction, maintenance, and land acquisition for BMP implementation. However, it is important to note that resulting cost estimates were meaningful only for relative comparison of BMP implementation alternatives and should not be used directly for BMP planning. For those BMPs proposed for implementation in this plan, more detailed cost estimates are provided in Section 9.

Optimization Results

The cost-effective BMP solutions derived from the two optimization scenarios are distilled to produce Figure 37. Because zinc was determined to be the limiting pollutant, cost-effectiveness curves are presented for zinc only; however, the associated reductions for other pollutants of concern are also tabulated in Table 38. Figure 37 shows the zinc load reduction percentages and associated minimum cost that can be achieved at various BMP implementation levels.

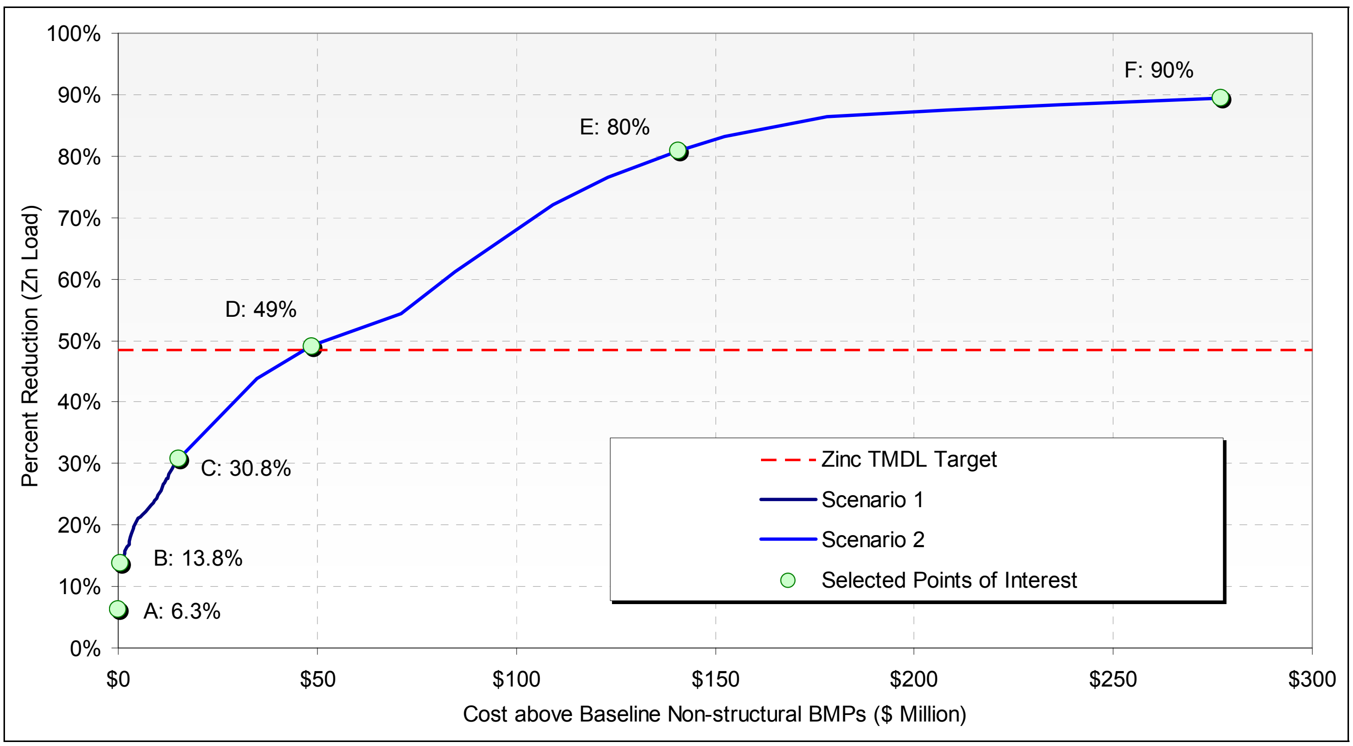


Figure 37. Pollutant Reduction vs. Minimum Cost Relationship Derived from Scenarios 1 and 2

Figure 37 presents two curve segments:

- Curve A-C contains the cost-effective solutions that are derived from the optimization scenarios only considering structural BMPs on public land (Scenario 1). Notice that point A seemingly represents a 6.3 percent reduction at no cost. This is because no cost estimate was specified for the baseline scenario on which it was developed. Therefore, all costs for all scenarios should be interpreted as cost above the baseline scenario. Point B indicates the cost and benefit of the solution including only centralized structural BMPs on public land. Point C represents the solution that achieves the maximum water quality benefits while applying centralized and distributed BMPs on public land.
- Curve C-F is built on point C (maximum solution from Scenario 1) and contains the cost-effective solutions that were derived from the optimization scenarios considering centralized BMPs on private land

(Scenario 2). Point D indicates the solution that meets the zinc TMDL reduction target (48.4 percent). Points E and F are two solutions that achieve higher reductions, i.e., 80 percent and 91 percent, respectively. It is important to note the percent reductions of Points D, E, and F are based on the assumption that 100 percent of the impervious drainage area that is not treated by public BMPs are treated with centralized BMPs on private land.

The slight depression in segment D-E was caused by discrete interval selection constraints for sizing infiltration and detention basins on private land. At the depression there is a general shift from infiltration- to detention-dominated sizing with increasing cost.

All six solutions (A, B, C, D, E, and F) were evaluated to estimate the removal effectiveness of other pollutants resulting from optimizing zinc reductions. The evaluation results are summarized in Table 38.

Table 38. Costs and Pollutants Reduction of the Selected Solutions for Optimization Scenarios (Scenario 1 and 2)—Corresponding to Figure 37

Pollutants	Existing Load (lb/yr)	TMDL Reduction Targets (%)	A: Baseline Scenario	Scenario 1		Scenario 2		
				B: Public Central.	C: Public Max	D: Metals TMDL	E	F
TSS (lb/yr)	268,422	90%	5.9%	13%	37%	52%	81%	88%
Copper (lb/yr)	97	24%	6.3%	14%	31%	46%	79%	88%
Lead (lb/yr)	85	0%	7.4%	15%	22%	42%	78%	88%
Zinc (lb/yr)	944	48%	6.2%	14%	31%	49%	81%	90%
F.C. Exceedance Days (days/yr)	35	78%	5.9%	6%	6%	10%	10%	10%
F.C. Counts (#/yr)	1.40E+14	--	1.4%	9%	15%	43%	75%	87%
Total Cost ($million)	--	--	--	$0.65	$15.15	$48.71	$140.77	$277.17

Below is a summary of some important observations:

- The metals TMDL reduction target (indicated as 48 percent reduction in zinc annual load) can be met by implementing private centralized BMPs in addition to the maximum public BMPs.
- For bacteria, the baseline scenario (i.e., catch basin inserts and Reduction of Irrigation Return Flows) had a direct linear effect on reducing the wet weather exceedance frequency; however, additional structural BMPs showed a different trend for the effect on the exceedance frequency. Bacteria load reduction was also included in the tables to confirm a BMP effect. It was confirmed that structural BMPs provided a significant reduction in bacteria total counts, which is achieved primarily through stormwater volume redcution. However, even though significant load reductions were predicted, whenever BMP effluent concentrations remain higher than the standard, the effect of attenuation is additional exceedance days because the duration of high bacteria densities in outflow becomes extended relative to the baseline condition.
- The previous observation suggests that direct source control (that is, through the use of nonstructural BMPs) is likely to provide a more reliable method of controlling bacteria levels than traditional structural BMPs, when the exceedance days standard is being considered.
- The results for modeled TSS, representing the effects of scenarios on toxics, follow trends similar to metals. However, assuming the reduction needed for TSS are linear to total PAHs, implementation at the high end (Point F) would be needed to achieve a 91 percent reduction. A 91 percent reduction in TSS is

not a cost-effective solution to implementation of TMDL reduction targets for PAHs. Rather, meeting the metals TMDL reduction target will result in 52 percent TSS (and potentially associated PAHs), and therefore additional nonstructural BMPs should focus on addressing the remaining PAHs load reduction necessary.

Table 39 summarizes the costs and BMP compositions of all solutions of interest. The BMP details of the selected solutions (points B to F in Figure 37) are summarized and analyzed in Appendix G. The details include a breakdown of the level of application for each BMP type within each subarea and selected scenario point. Information provided in Appendix G include BMP-specific pollutant load estimates as well as sizing information used to develop more detailed cost estimates reported in Section 9.

Table 39. Optimal Treatment Levels Considering Public Centralized and Distributed BMPs, and Private Centralized BMPs

Zinc Annual Load Reduction (%)			6.3% (Point A)	14% (Point B)	31% (Point C)	49% (Point D)	80% (Point E)	90% (Point F)
Total Cost ($million)			n/a	$0.65	$15.15	$48.71	$140.77	$277.17
Cost per lb load reduction ($/lb)			n/a	$5,072	$52,169	$104,919	$184,266	$327,930
Public	Centralized	Cost ($ million)		$0.65	$0.65	$0.65	$0.65	$0.65
		Storage (ac-ft)		19.4	19.4	19.4	19.4	19.4
		Surface Area (acre)		3.7	3.7	3.7	3.7	3.7
	Distributed	Cost ($ million)			$14.50	$14.50	$14.50	$14.50
		Storage (ac-ft)			36.5	36.5	36.5	36.5
		Surface Area (acre)			13.5	13.5	13.5	13.5
Private	Centralized	Cost ($ million)				$33.56	$125.62	$262.02
		Storage (ac-ft)				29.1	99.8	208.7
		Surface Area (acre)				5.8	21.9	45.8

Optimal Considerations for BMP Implementation Planning

Using the optimal solutions identified, this section discusses the prioritization order and phased sequence for BMP implementation to meet phased TMDL implementation requirements. The previous optimization assumed 100 percent of the drainage was treated, which is consistent with final TMDL implementation requirements reported in Table 6. However, treating 100 percent of the drainage area might not be practical or even possible. For that reason, alternatives treating less drainage area with high-end BMP design (as specified in Point E and F solutions) were developed. As indicated in Figure 38, Point E' presents a solution using the Point E BMP design. It is necessary to treat 39 percent of the impervious drainage area to achieve the TMDL target using the Point E design specifications. Similarly, when using the point F design specifications, solution F' requires that 33 percent of the impervious drainage area be treated to achieve the TMDL target.

The private centralized BMP cost and the percentage of treated drainage area required to meet the zinc TMDL target are plotted in Figure 39. Generally, the cost increases when the drainage area treated decreases, and the marginal cost dramatically increases after the treatment percentage drops below 39 percent (Point E').

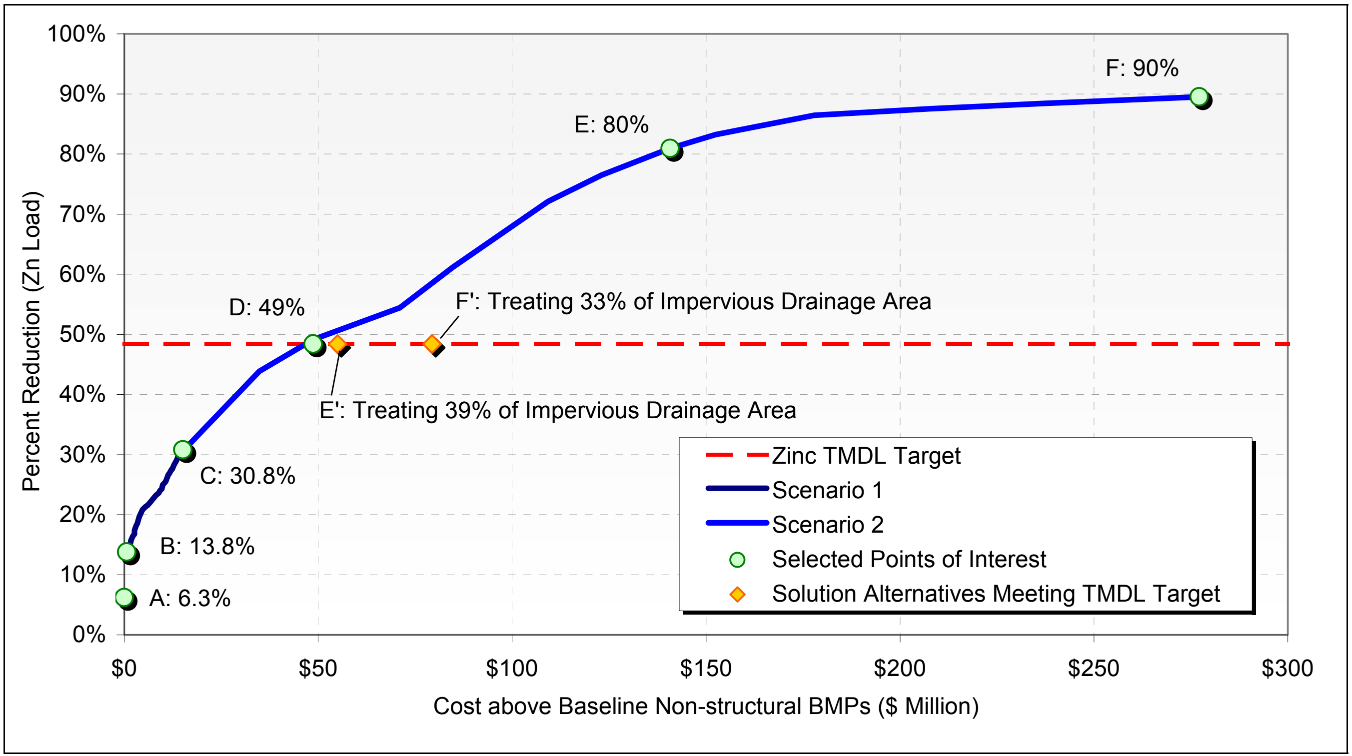


Figure 38. Solution Alternatives for Meeting the Zinc TMDL Target

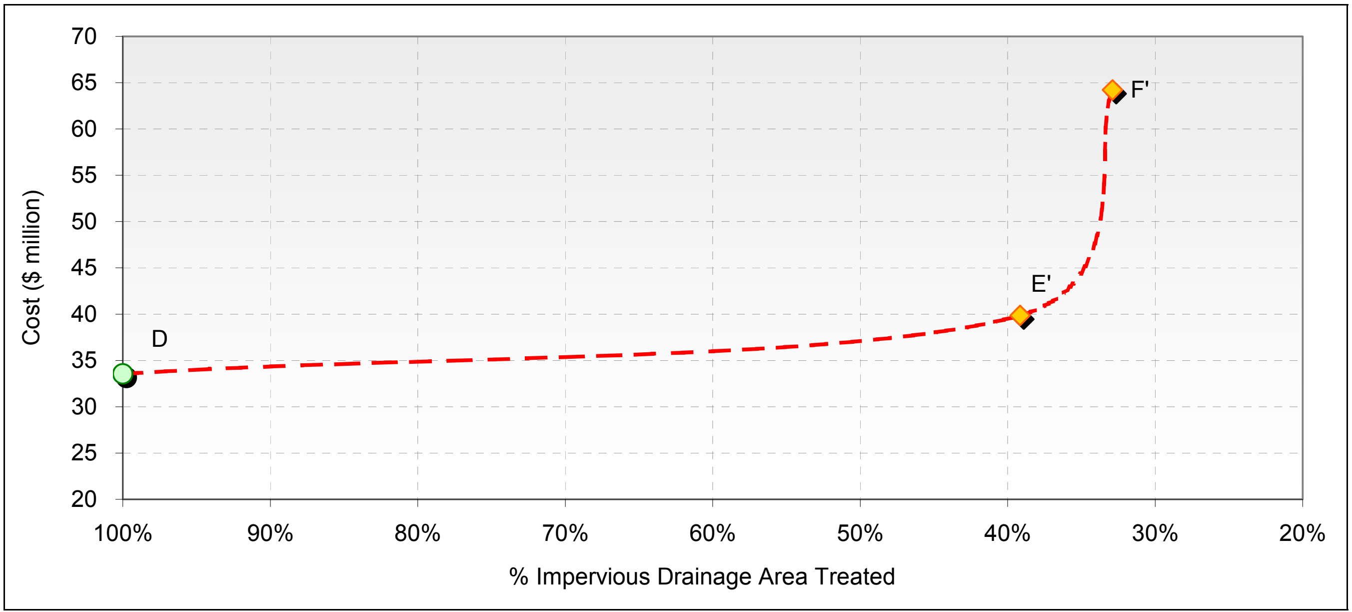


Figure 39. Tradeoff between Percent of Drainage Area Treated and Cost of Private Centralized BMPs for Meeting Zinc TMDL Target

Table 40 summaries BMP size, load reduction, and life cycle cost components by BMP type and/or land use. Life cycle cost represents the annualized total cost to design, construct, and maintain a BMP from conception to replacement. Three options are included for implementing centralized BMPs on private land, with different percentages of the drainage area treated. For distributed BMPs, porous pavement and bioretention components are disaggregated to show the relative load reduction and cost associated with each; however, the two BMPs act as one unit because porous pavement is selected whenever supplemental storage is needed, mainly to enhance bioretention performance (see the BMP implementation by land use group discussed in Appendix F). For the case of porous pavement for *Distributed on Public Land - High Infiltration Soil*, bioretention was determined sufficient for the site and porous pavement was not required to improve performance.

Table 40. BMP Size, Load Reduction, and Life Cycle Cost Associated with the Zinc TMDL Target Reduction

BMP Type and Location		BMP Drainage Area, Treatment		Load Reduction		Life Cycle Cost ($1,000)
		(Acres)	(% Treated)	(lb-Zinc/yr)	(% Total)	
Baseline Scenario		--	--	--	6.8%	--
Centralized	Ladera Park	271	100%	51.92	5.5%	$342
	WLA College	67.2	100%	17.94	1.9%	$206
Pilot Distributed BMP Project for a County Road	Bioretention	1	100%	0.91	0.0%	$56
Distributed on Public Land -High Infiltration Soil	Porous Pavement	3.9	0	--	0.0%	$0
	Bioretention	6.4	100%	3.60	0.4%	$350
Distributed on Public Land - Low infiltration Soil	Porous Pavement	160	6%	5.04	0.5%	$290
	Bioretention	260	100%	152.64	16.2%	$13,720
Centralized BMPs on Private Land Option 1: Point D	Infiltration Basin	210	100%	124.57	13.2%	$20,203
	Ex-Detention Pond	620	100%	68.54	7.3%	$13,358
Centralized BMPs on Private Land Option 2: Point E'	Infiltration Basin	210	100%	124.57	13.2%	$20,203
	Ex-Detention Pond	620	18.5%	68.30	7.2%	$19,503
Centralized BMPs on Private Land Option 3: Point F'	Infiltration Basin	210	100%	150.05	15.9%	$41,402
	Ex-Detention Pond	620	10.1%	43.08	4.6%	$22,283

The following describes the sequence of events for prioritizing and developing a phased implementation plan of action:

1. Cost-effectiveness for BMP implementation was computed by land use and BMP type using the life cycle cost and pollutant removal benefits presented in Table 40.
2. BMPs and land uses were ranked by cost-effectiveness (lowest to highest cost/lb- zinc removed).
3. Cumulative percent of target load reduction, percent of total cost, and percent of drainage area treated were computed according to the ranked order of cost-effectiveness as shown in Figure 40.
4. The phased, wet weather implementation schedule for metals (Table 6) was compared against the cost-effectiveness and cumulative progress benchmarks to determine a strategic order of management actions, with the catch basin inserts and Reduction of Irrigation Return Flows (baseline scenario) schedule determined on the basis of constraints identified by the County.

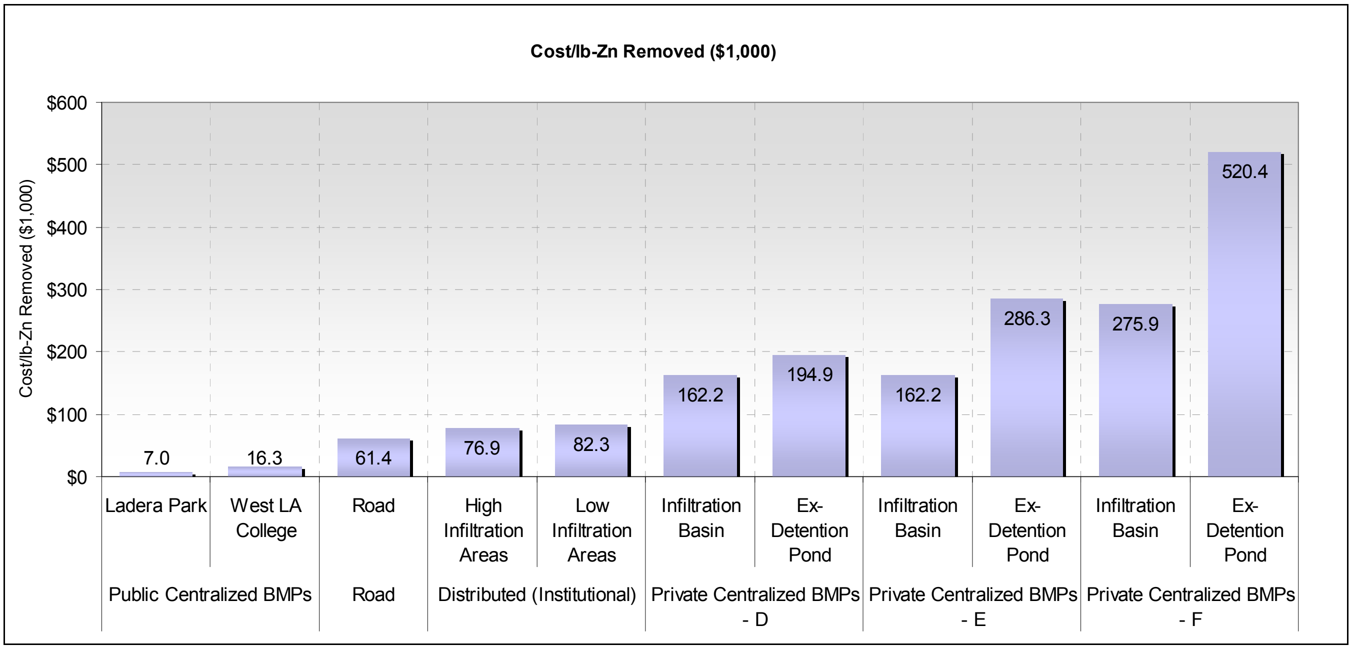


Figure 40. Incremental BMP Components for Phased Implementation Planning

Table 41 summarizes a proposed wet weather implementation action plan with projected outcomes. Table 41 also shows that by the time 100 percent of the TMDL target reduction for zinc (48 percent) has been achieved under Option 2 or 3, about 58.6 percent or 54.3 percent of the total drainage area has been treated. That suggests that using the percent of total drainage area as an implementation benchmark might not be the most meaningful and practical course of action. Instead, percent of progress toward achieving the TMDL target is a more reliable and measurable interpretation of the TMDL requirement.

In Table 35 attainment of the zinc TMDL target (48 percent load reduction) is normalized to 100 percent of progress achieved by 2021. As discussed, zinc is the limiting metals TMDL. Given the proposed schedule presented above, it is anticipated that the copper TMDL (24 percent) can be achieved earlier than the zinc TMDL, possibly in as much as in half the time.

For the phased, wet weather TMDL implementation schedule for bacteria also summarized in Table 35, less convincing evidence is available of this BMP strategy's performance on fecal coliform wet weather exceedance frequency reduction; however, analysis suggests that additional source controls are the most reliable means of achieving the TMDL.

Table 41. Proposed Phased, Wet weather Implementation Action Plan and Projected Outcomes

Plan Components	Schedule, Actions, and Projected Outcomes		
Date	1/11/2012	1/11/2016	1/11/2021
Target Interpretation	25% of TMDL target	50% of TMDL target	100% of TMDL target
Proposed Actions	• Centralized BMPs at Ladera Park and West LA College • Implement the Pilot Distributed BMP Project for a County Road • Implement 100% of Distributed BMPs on public land - high infiltration soil • Implement 25% of Distributed BMPs on public land BMPs on - low infiltration soil.	• Implement an additional 60% of distributed BMPs on public land - low infiltration soil. • Reduction in Irrigation Return Flow. • 30% of Catch Basin Inserts.	• Implement remaining 15% of distributed BMPs on Public Land • Remaining 70% of Catch Basin Inserts. • Centralized BMPs on private land: Option 1: Implement private centralized BMPs to treat 100% of remaining untreated impervious areas Option 2: Implement infiltration basins to treat 25.3% of untreated impervious area, and private extended detention basins to treat another 13.9% of untreated impervious area (see Table 40) Option 3: Implement infiltration basins to treat 25.3% of untreated impervious area, and extended detention basins to treat another 7.6% of untreated impervious area (see Table 40)
Actual Progress (% of Zinc TMDL Target)	25.0%	50.0%	100%
Actual Progress (% of Impervious Area Treated)	14.4%	28.4%	Option 1: 100.0% Option 2: 58.6% Option 3: 54.3%
Incremental Cost ($ Million)	$4.23	$7.79	Option 1: $40.9 Option 2: $47.2 Option 3: $71.6

Summary of Optimization Results

Optimization scenarios were constructed to reflect management considerations on BMP implementation preference. BMP selection on public land was prioritized over BMP selection on private land. The optimization scenarios generated valuable BMP implementation insights and recommendations. Some of the highlights are presented below:

- Implementing structural BMPs solely on public land does not result in meeting the metals TMDL reduction target. Therefore, implementing BMPs on private land is necessary.
- Centralized structural BMPs on public land tend to be preferentially selected over distributed structural BMPs, because of the inherent economy of scale.
- In general, bioretention is preferred over porous pavement because of its better pollutant-removal effectiveness, especially in low-infiltration areas. However, porous pavement (or some other similar supplemental storage practices) should also be considered because it provides additional storage that enhances/extends the treatment potential of downstream bioretention facilities.

- Nonstructural BMPs in the form of source control provide the most consistent and measurable effect on bacteria management in terms of the wet day exceedance frequency. Structural BMPs that attenuate flow can actually prolong or extend the frequency of wet day exceedances relative to the baseline condition.
- Private, centralized BMPs are needed to meet the metals TMDL targets. Assuming that 100 percent of the drainage can be treated, an optimal capacity of centralized BMPs on private land was determined. However, realistically, not enough opportunities may be identified to achieve the 100 percent drainage area treatment. Therefore, high-end designs are likely required to meet the target while treating less drainage area.

7. Identification of Water Resources and Other Opportunities

Water is one of the most precious of natural resources to the arid and highly urbanized Los Angeles region. Agencies work together to manage this resource and recognize the importance of an integrated approach to developing regional strategies for its optimization. Storage and reuse of stormwater runoff is a major component of an integrated water resources approach. This section includes an examination of the region's water supply, current management considerations, and plans for maintaining and enhancing those resources. Currently planned water resource projects were identified that could provide an opportunity to contribute to TMDL implementation including additional opportunities for distributed and centralized structural BMPs that can address in the County TMDL Implementation Area.

7.1. Hydrogeology and Groundwater Aquifer Characteristics

Historically, runoff from the Santa Monica Mountains flows south through a series of streams and drain toward the coastal plains. Percolation to groundwater would occur, and, in some areas, accumulating high groundwater would create marshes and swamps. Those areas of marshes and swamps include the area northeast of Baldwin Hills where runoff would accumulate as groundwater along the Newport/Inglewood Fault and rise to surface levels as seeps and springs. While the runoff from the mountains is predominately the same, urban development within the past century has altered many of the original flow paths and natural infiltration and storage areas.

The major groundwater basins in the Ballona Creek watershed are shown in Figure 41. The watershed is underlain by four major groundwater formations known as the Hollywood, Santa Monica, West Coast, and Central basins, all within the Los Angeles Coastal Plain Basin. A detailed description of these groundwater basin characterstics is provided in Appendix H. The Central Basin lies under the majority of the watershed and is along its southeastern portion. The County TMDL Implementation Area within the watershed is for the most part in hills and outside the boundaries of the Los Angeles Coastal Plain Basin. The basin characteristics for those areas are not conducive to significant artificial recharge. Also, shallow depth to groundwater at the downstream end of Ballona Creek does not allow for infiltration. Not surprisingly, no recharge basins exist in the County TMDL Implementation Area, nor are any significant water conservation or spreading grounds projects planned for the areas. However, projects are currently planned in the watershed that demonstrate a benefit in terms of collecting runoff generated in the County TMDL Implementation Area and in the remaining incorporated areas.

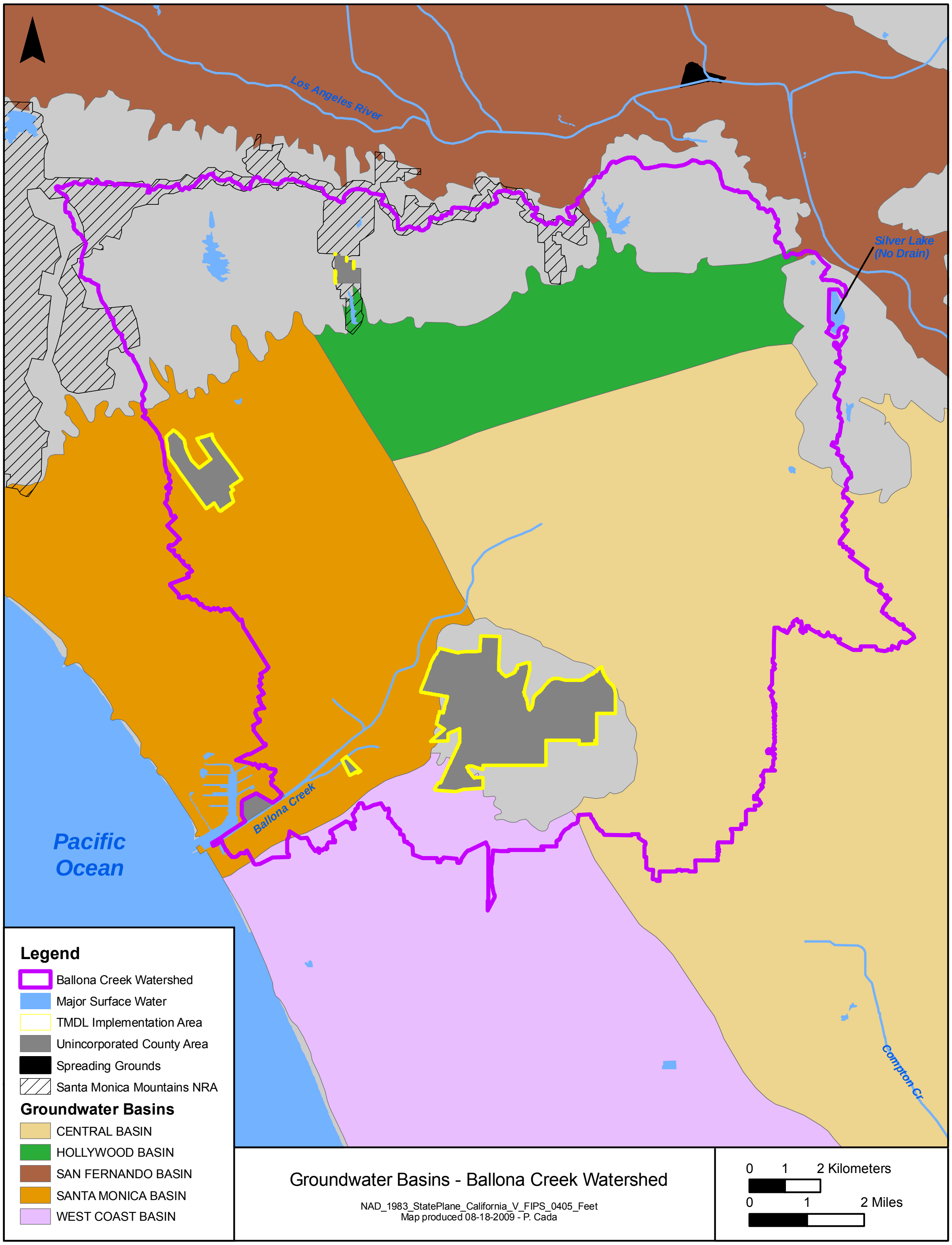


Figure 41. Groundwater Basins and TMDL Implementation Areas in the Ballona Creek Watershed

7.2. Merging Integrated Water Resources Planning Objectives with TMDL Implementation

Various strategic planning efforts are underway in the region that can be merged to ensure that integrated water resources plans are in line with TMDL implementation objectives, and vice versa. This TMDL Implementation Plan seeks to acknowledge those efforts and take advantage of planned project as opportunities for additional benefit in terms of BMP implementation in the County TMDL Implementation Area. Likewise, additional BMPs recommended in this plan can provide benefit to water resources in the watershed, which should be quantified so that future parallel integrated water resources plans can be consolidated with TMDL implementation efforts. Consideration of both aspects within this plan provides a comprehensive perspective for overall responsible management of water resources and improved water quality, resulting in an integrated watershed management framework for the County TMDL Implementation Area.

Managers are focused on optimizing water resources through developing strategic, regional, and multi-beneficial water quality and water supply projects. The project objectives are often interrelated, where targeting a primary goal could result in many secondary benefits. The goal for meeting TMDL requirements, for example, is potentially in alignment with several integrated water resources planning objectives outlined in the IRWMP, including the following:

- Improved water supply
    - Increase water supply reliability
    - Diversify water supply sources
    - Balance groundwater management
    - Promote water use efficiency
- Improved water quality
    - Protect and improve water quality
- Enhanced habitat
    - Protect and restore wildlife habitats/ecosystems
- Sustained infrastructure for local communities
    - Flood management and protection

Diversifying water supplies and, specifically, reducing reliance on imported supplies are central goals of water management for the region. Although because of the poor conditions for groundwater recharge in the Ballona Creek watershed, that is not a priority for managing water within the County TMDL Implementation Area. However, the goals of water conservation for water supply are in sync with the goal of TMDL compliance. The reduction or capture of runoff results in less water discharged to Ballona Creek, and consequently, reduces the transport and discharge of pollutants. The water quality benefits include removal of bacteria, nutrients, metals, toxics, and trash, which would otherwise discharge to Ballona Creek and the Pacific Ocean.

Projects identified within this TMDL implementation plan have a primary focus on water quality improvement to achieve TMDL compliance. Some of the projects would have additional benefits for regional water resources. These projects include:

- Reduction of Irrigation Return Flows provides a significant conservation of water supplies through improved water use efficiency
- All centralized and distributed structural BMPs that provide on-site storage can potentially also support rainwater capture and reuse opportunities for diversifying water supply sources, enhanced wildlife habitat/ecosystems, and recreational opportunities.

7.3. Consideration of Currently Planned Water Resources Projects

Several projects planned for the Ballona Creek watershed were reviewed and identified to have additional benefit of improving water quality in the watershed. A number of documents were reviewed for this task, but the IRWMP was the largest source of project-specific information. Once identified, the projects were screened to develop a priority list of projects for consideration in the TMDL implementation plan. The criteria for selecting projects is presented in Figure 42.

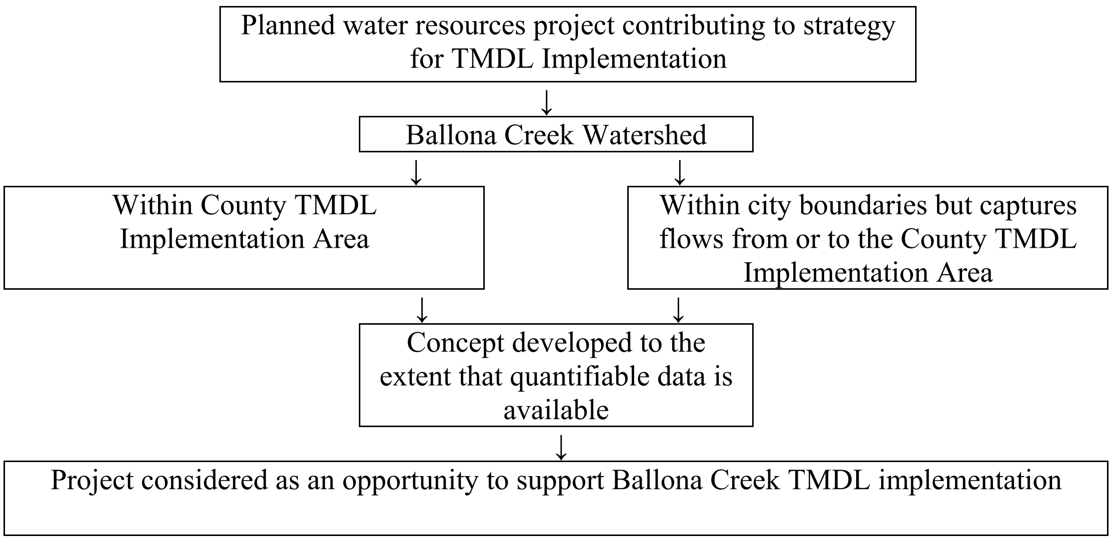


Figure 42. Criteria for Selecting Projects for Consideration in the TMDL Implementation Plan

Several of the identified projects for the Ballona Creek watershed were focused on improving water quality. The projects target TMDL compliance and have other benefits such as habitat restoration and recreational opportunities. Table 42 documents the identified Ballona Creek watershed projects planned or proposed that have quantifiable benefits. Figure 43 shows the location of the sole project in the County TMDL Implementation Area, the Ladera County Park TMDL/LID Improvement. This site is consistent with the Ladera Park centralized BMP project included in this TMDL implementation plan.

Table 42. Identified Ballona Creek Watershed Area Project Summaries

Agency	Location	Current Phase	Project Description	Characteristics	Benefits, Estimated Costs, Schedule
Ladera County Park TMDL/LID Improvement					
LACDPW	Ladera Park; south side of Slauson Avenue, west of La Brea Avenue in the County TMDL Implementation Area	Concept development in progress	Project proposes to daylight the storm drain through Ladera Park to provide on-site infiltration and stormwater treatment, and use LID elements throughout the park. It would add native landscaping, install porous pavement, green roofs, bioretention swales along the street frontage, and planter boxes near buildings.	15-acre park, 184 acres drain to detention	Water conservation, water quality enhancement, TMDL compliance and *green* enhancements to the park facility; $10 to $30 million; Proposed construction schedule is for 6/1/2010 to 6/1/2011
Rogers Park Watershed Runoff Treatment Reuse and Infiltration					
City of Inglewood	Centinela Creek in Inglewood, a Ballona Creek tributary	Concept development in progress	Project proposes a subterranean dry and wet weather treatment, storage and infiltration system. It would have cisterns, dry wells, and infiltration pits.	9-acre city park	Provides stormwater treatment and enhances current open space; $1 million; planned or under construction

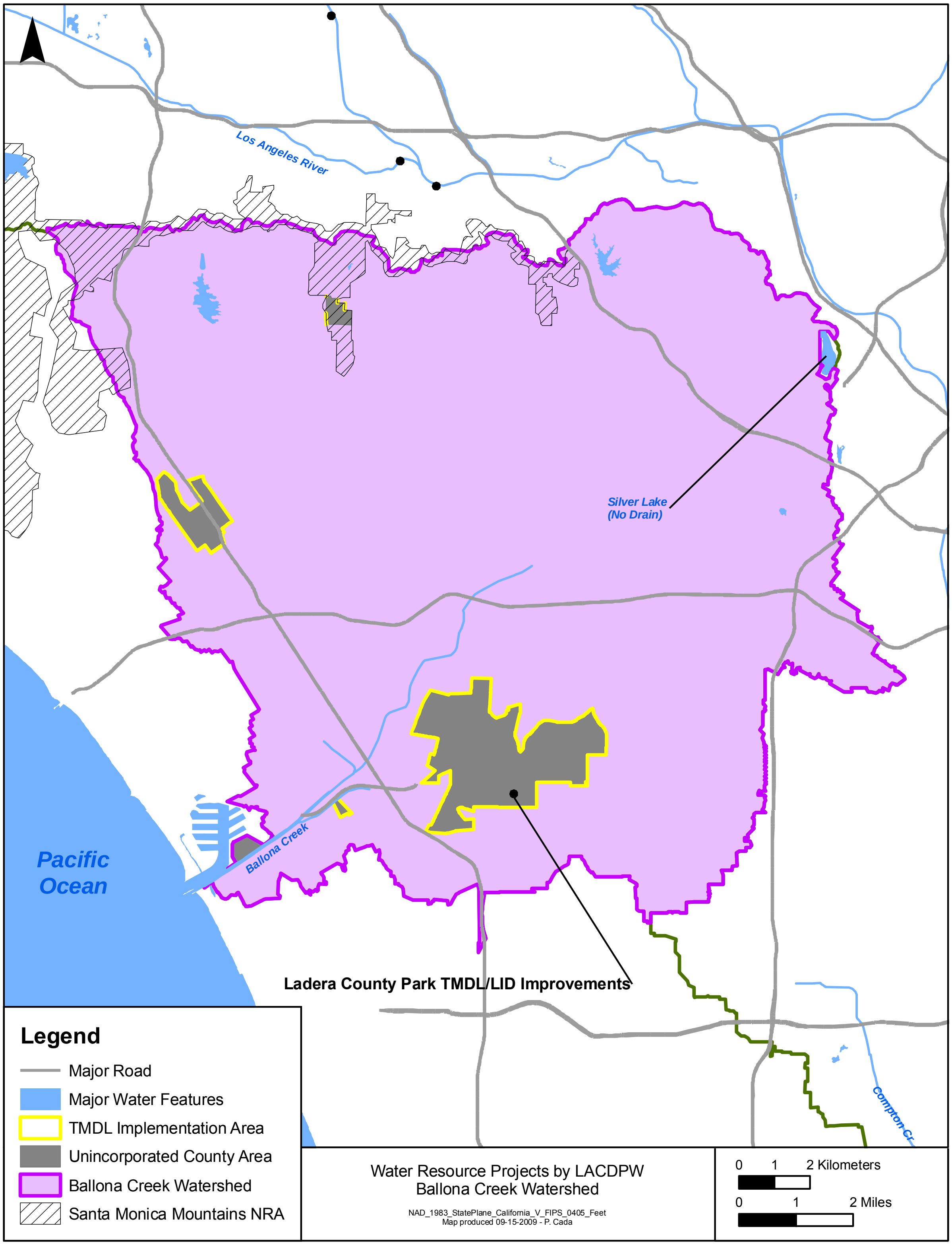


Figure 43. Planned Water Resource Opportunities in the County TMDL Implementation Area

The City of Inglewood also proposes to install a treatment system to remove pollutants from both dry and wet weather flows. The facility would also provide infiltration for groundwater recharge and cisterns for capture and beneficial use. Such practices would contribute to improved water quality in Centinela Creek, a tributary of Ballona Creek. The project is outside the County TMDL Implementation Area, but could reduce pollutant loading to the Ladera Heights/Viewpark-Windsor Hills unincorporated County area.

Additional planned projects were identified, but they are in the early planning stages and not fully developed to allow for quantifying benefits such as water storage, recharge, or treatment volumes. Those projects are listed in Table 43. Once project concepts are further developed, they could demonstrate potential contributions toward TMDL implementation. None of the projects are within the County TMDL Implementation Area, but each has the potential to reduce pollutant loads discharged to the Ladera Heights/Viewpark-Windsor Hills unincorporated County area (Figure 34).

Table 43. Projects in the Ballona Creek Watershed Not Having Quantified Benefits

Agency	Location	Current Phase	Project Description	Characteristics	Benefits, Estimated Costs, Schedule
Ballona Creek Stormwater Runoff Disinfection Project					
City of Inglewood	At the northwesterly border of the city where Centinela Creek flows out of the city toward Ballona Creek	Concept in progress	It would reduce the bacteria levels from stormwater runoff using UV treatment before the runoff empties in the Ballona Creek.	Volume to be treated has not been determined	Enhance water quality; $100,000 to $1 million; Schedule TBD
Centinela Creek Daylighting					
Santa Monica Bay Restoration Commission	Edward Vincent Park	Concept not yet initiated	Daylight historic Centinela Creek through Edward Vincent Park	TBD	Improve connection to stream and water quality; $1 to $4 million; Schedule TBD
Baldwin Hills Trail Under Utility Lines					
TBD	From La Cienega/Fairfax to Hills between Carmona and Hauser	Concept in progress	Bicycle, hiking, and habitat connection, including stormwater retention, recreation, etc.	TBD	Improve water quality and quantity control and recreational use; Cost TBD; Schedule TBD
Jefferson Boulevard Ballona Creek BMPs					
Santa Monica Bay Restoration Commission	Jefferson Boulevard	Concept in progress	Install BMPs along Jefferson Boulevard and industrial properties south of Ballona Creek to improve water quality that drains into the creek.	TBD	Water quality enhancements; Costs TBD; Schedule TBD

While the projects described above are not well defined, they could contribute to achieving TMDL compliance by adding UV treatment, daylighting streams, and installing retention ponds and other BMPs, all of which are known to have water quality improvements benefits. There is an expectation that all the projects would provide a reduction in pollutant loading, improved habitat, and enhanced aesthetics to the implementation areas and ultimately improve the overall water quality in Ballona Creek.

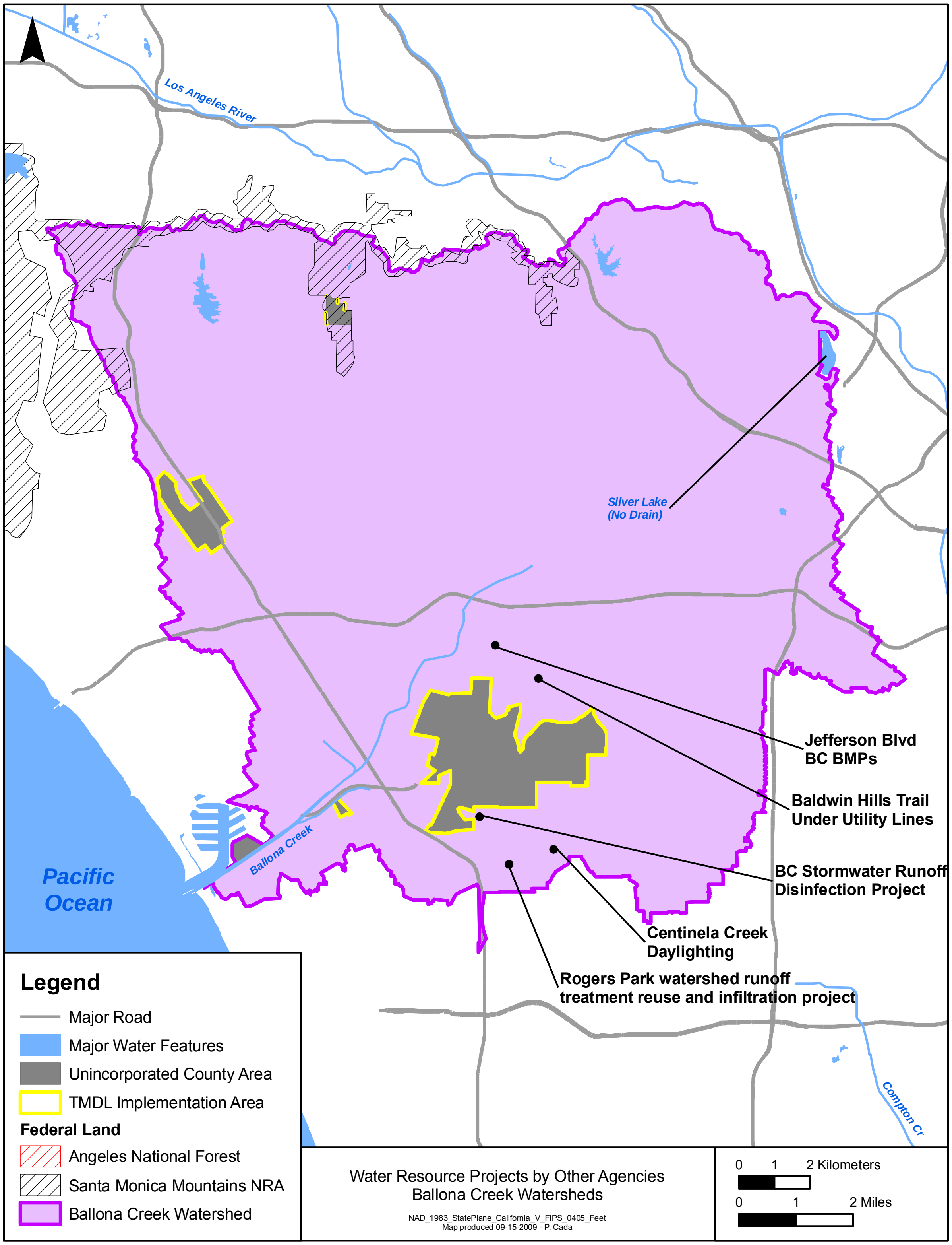


Figure 44. Planned Water Resource Opportunities outside the County TMDL Implementation Area

7.4. Linkage of Water Resources and TMDL Implementation Planning Efforts

The information gathered here is intended to support strategy development and planning of meaningful and quantifiable improvements in the region's water resources management. One project, the Ladera County Park TMDL/LID Improvement Project, was included as a centralized structural BMP project to address TMDL implementation. The remaining planned projects are within City incorporated jurisdictions, and although their implementation is promoted, there is limited ability for the County to lead such efforts without significant partnerships established with other agencies. However, partnerships can be sought in the future and as funding becomes available, potential participation in aspects of projects within incorporated areas can occur.

Additional site assessment and BMP evaluation resulted in identification of additional BMP strategies within public land that can further address integrated water resources planning objectives, including: the centralized structural BMP at the West Los Angeles Community College, distributed structural BMPs for all publicly owned parcels in the County TMDL Implementation Area (excluding catch basin distributed BMPs), and the Pilot Distributed BMP Project for a County Road.

To meet the WLAs, additional need for centralized structural BMPs on private land was identified, and analysis was performed to evaluate different options in terms of the type and size of the BMPs, as well as the drainage area treated. Although the exact locations of candidate private parcels were not identified for acquisition and BMP design, the conceptual BMP capacity proposed for private land provides a goal for implementation. When identifying opportunities for land acquisition, managers can consider other regional water resources planning objects to investigate potential multi-use projects.

Although the primary focus of the above BMPs is stormwater pollutant load reduction, a key process used in the BMPs is infiltration. Much of the infiltrated water is subject to evapotranspiration losses, but a portion of the water has the potential to provide recharge to local groundwater basins. Table 44 lists the structural BMPs proposed, as well as information regarding stormwater inflow and infiltration provided (presented in cubic feet per year for comparison). A considerable portion of stormwater inflow is infiltrated in many of the BMPs. Infiltration capacities are also presented in acre-feet per year for comparison to typical recharge rates of groundwater basins in the area discussed in Appendix H.

The proposed structural BMPs for the County TMDL Implementation Area overly portions of the Santa Monica Basin and potentially portions of the West Coast Basin. The estimated amount of infiltrated water that can serve to recharge the groundwater basins is uncertain without further detailed analysis and will depend on the characteristics of each basin and overlying soil and other obstructions. However, most of the BMPs in the Ladera Heights/Viewpark-Windsor Hills unincorporated County community will have limited ability to provide groundwater recharge because of its limited access to underlying basins. Those include the proposed centralized BMPs at Ladera Park and West Los Angeles Community College and a portion of the distributed BMPs on public land. Regardless, the estimated infiltration rates above present a promising example of secondary benefit of the BMPs and opportunity to merge with other regional water resource planning objectives to diversify supplies of water to groundwater basins or potential supplies for reuse. The BMPs can be viewed as tools for restoring the natural hydrologic processes that have been disrupted by development and resulting excess impervious areas, which stifled stormwater infiltration to groundwater.

Table 44. BMP Infiltration Benefits

BMP Type and Location		Flow Volume (ft^3/yr)[a] Inflow (ft^3/yr)	Infiltration (ft^3/yr)	Infiltration (acre-feet /year)
Centralized BMPs on Public Land	Ladera Park	3,694,234	3,676,129	84
	West Los Angeles Community College	1,371,548	1,361,894	31
Pilot Distributed BMP Project for a County Road	Bioretention	46,584	43,400	1
Distributed on Public Land - High-Infiltration Soil	Porous Pavement	--	--	--
	Bioretention	298,136	272,858	6
Distributed on Public Land - Low-Infiltration Soil	Porous Pavement	488,641	288,935	7
	Bioretention	12,423,722	11,277,969	259
Centralized on Private Land: Option 1	Infiltration Basin	10,263,104	2,057,700	47
	Extended Detention Pond	30,824,813	12,718,692	292
Centralized on Private Land: Option 2	Infiltration Basin	10,263,104	8,241,771	189
	Extended Detention Pond	3,181,916	2,445,874	56
Centralized on Private Land: Option 3	Infiltration Basin	10,263,104	9,868,172	227
	Extended Detention Pond	1,093,784	1,031,991	24

a. Based on model simulation of WY 2003.

8. Regulatory Requirements and Environmental Permits

This section presents an assessment of the regulatory requirements and environmental permits that could affect the implementation of the proposed BMPs. The discussion focuses on distributed and centralized structural BMPs at selected sites because the nonstructural BMPs are programmatic in nature and are not anticipated to trigger permit requirements.

This analysis considers a variety of federal, state, and local regulations and permits that can affect the feasibility and cost of BMP projects, including the following

Federal

- Clean Water Act
- Endangered Species Act
- Forest Service Permits
- Migratory Bird Treaty Act
- National Environmental Policy Act

State

- California Air Resources Board Regulations
- California Endangered Species Act
- California Environmental Quality Act
- California Coastal Act[4]
- Cultural Resources
- Dam Safety Laws
- Lake and Streambed Alteration Program
- State Lands Leasing and Permits Regulation
- State Park Permits

Local

- Drought-Tolerant Landscaping Requirements
- Geotechnical Reporting Requirements
- Green Building Requirements
- LID Requirements/LID Manual
- Sedimentation and Erosion Control Requirements
- Stormwater Requirements
- Tree Protection Requirements
- Additional County Permits (flood and road permits)
- Recycled Water Laws

[4] A portion of the Ballona Creek watershed in the coastal zone is designated by the California Coastal Commission as subject to coastal development requirements of the California Coastal Act. The only significant land in both the County TMDL Implementation Area and the coastal zone is also contiguous with the Ballona Creek Significant Ecological Area. No BMPs are proposed that would disturb the wetlands and other natural features in this land. Therefore, it is unlikely that Coastal Zone Development Requirements would affect TMDL implementation efforts in the Ballona Creek watershed. This regulation has been removed from consideration.

- Zoning Regulations
- General Land Use Plan Requirements
- Community Standards District Requirements
- Setback Requirements
- Significant Ecological Areas Requirements
- Sanitation Districts of Los Angeles Requirements
- Onsite Wastewater Treatment System Codes[5]

The regulatory requirements and environmental permits listed above are described in detail in Appendix I.

8.1. Distributed Structural BMPs

As stated in Section 5, distributed structural BMPs will be implemented at selected sites within unincorporated County areas. Recommended BMPs in this category include bioretention, linear bioretention trenches, and porous pavement, all of which can be implemented on individual parcels to store, infiltrate, and treat runoff from that parcel. It is important to note that while individual parcels and groups of parcels have been selected for the BMPs, exact locations of the proposed BMPs in those parcels have not been selected. Therefore, uncertainty exists as to whether natural feature disturbance would occur and whether regulations relating to wetlands, streams, hazards, and protected species would apply. In addition, because the BMPs themselves have not been designed, requirements triggered by size (e.g., local stormwater and planning requirements or dam safety laws) might or might not apply. This uncertainty is accounted for in the linkage tables below as "applicable depending on project characteristics."

On the basis of the BMP types selected for implementation, the regulatory requirements and environmental permit requirements that might be applicable are summarized in Table 45 through Table 48.

Table 45. Linkages between Distributed Structural BMPs and Federal Regulations

	Federal Regulations					
BMP	CWA Section 404	CWA Section 401	Endangered Species Act	Forest Service Permits	Migratory Bird Treaty Act	National Environmental Policy Act
Bioretention	○		○	○	○	○
Linear Bioretention Trenches	○		○	○	○	○
Porous Pavement				○		○

● Applicable to all projects
○ Applicable depending on project characteristics

[5] There are no onsite wastewater treatment systems in the County TMDL Implementation Area, so these codes were removed from consideration.

Table 46. Linkages between Distributed Structural BMPs and State Regulations

	State Regulations							
BMP	**CA Air Resources Board Regulations**	**CA Endangered Species Act**	**California Environmental Quality Act**	**Cultural Resources**	**Dam Safety Laws**	**Lake & Streambed Alteration Program**	**State Lands Leasing & Permits Regulation**	**State Park Permits**
Bioretention	●	○	○	○			○	○
Linear Bioretention Trenches	●	○	○	○			○	○
Porous Pavement	●		○	○			○	○

- ● Applicable to all projects
- ○ Applicable depending on project characteristics

Table 47. Linkages between Distributed Structural BMPs and Local Regulations

	Local/County Regulations						
BMP	**Drought-Tolerant Landscaping Requirements**	**Geotechnical Reporting Requirements**	**Green Building Requirements**	**LID Requirements/ LID Manual**	**Sedimentation & Erosion Control Requirements**	**Stormwater Requirements**	**Tree Protection Requirements**
Bioretention	○	○	○	○	●	○	●
Linear Bioretention Trenches	○	○	○	○	●	○	●
Porous Pavement		○	○	○	●	○	●

- ● Applicable to all projects
- ○ Applicable depending on project characteristics

Table 48. Linkages between Distributed Structural BMPs and Local Regulations (continued)

	Local/County Regulations							
BMP	**Additional County Permits**	**Recycled Water Laws**	**Zoning Regulations**	**General Land Use Plan Requirements**	**Community Standards District Requirements**	**Setback Requirements**	**Significant Ecological Areas Requirements**	**Sanitation Districts of Los Angeles**
Bioretention	○		●	●	○	●	○	
Linear Bioretention Trenches	○		●	●	○	●	○	
Porous Pavement	○		●	●	○			

- ● Applicable to all projects
- ○ Applicable depending on project characteristics

8.2. Centralized Structural BMPs

Centralized BMPs refer to stormwater treatment, storage, or infiltration facilities that provide a regional benefit. As described in Section 5, a screening analysis was conducted to identify publicly owned parcels in the unincorporated County areas of the Ballona Creek watershed that would be suitable for centralized BMP implementation. That analysis identified two candidate sites: West Los Angeles Community College and Ladera Park. The two sites differ by the type of BMP selected, which affects dam safety laws and drought-tolerant landscaping requirements. Also, the BMP site at West Los Angeles Community College is an athletic field with no mature trees that warrant special protection, whereas the Ladera Park site has a number of mature sycamore trees that would trigger tree protection requirements.

On the basis of the proposed BMPs and the characteristics of the sites selected, the regulatory requirements and environmental permit requirements for each site have been summarized in Table 49 through Table 52.

Table 49. Linkages between Centralized Structural BMPs and Federal Regulations

	Federal Regulations					
BMP	CWA Section 404	CWA Section 401	Endangered Species Act	Forest Service Permits	Migratory Bird Treaty Act	National Environmental Policy Act
West Los Angeles Community College - Dry Extended Detention Basin	○		○	○	○	○
Ladera Park - Infiltration Basin	○		○	○	○	○

● Applicable to all projects
○ Applicable depending on project characteristics

Table 50. Linkages between Centralized Structural BMPs and State Regulations

	State Regulations							
BMP	CA Air Resources Board Regulations	CA Endangered Species Act	California Environmental Quality Act	Cultural Resources	Dam Safety Laws	Lake & Streambed Alteration Program	State Lands Leasing & Permits Regulation	State Park Permits
West Los Angeles Community College - Dry Extended Detention Basin	●	○	○	○			○	○
Ladera Park - Infiltration Basin	●	○	○	○	○		○	○

● Applicable to all projects
○ Applicable depending on project characteristics

Table 51. Linkages between Centralized Structural BMPs and Local Regulations

	Local/County Regulations						
BMP	Drought-Tolerant Landscaping Requirements	Geotechnical Reporting Requirements	Green Building Requirements	LID Requirements/ LID Manual	Sedimentation & Erosion Control Requirements	Stormwater Requirements	Tree Protection Requirements
West Los Angeles Community College - Dry Extended Detention Basin	○	○	○	○	●	○	
Ladera Park - Infiltration Basin		○	○	○	●	○	●

● Applicable to all projects
○ Applicable depending on project characteristics

Table 52. Linkages between Centralized Structural BMPs and Local Regulations (continued)

	Local/County Regulations							
BMP	Additional County Permits	Recycled Water Laws	Zoning Regulations	General Land Use Plan Requirements	Community Standards District Requirements	Setback Requirements	Significant Ecological Areas Requirements	Sanitation Districts of Los Angeles
West Los Angeles Community College - Dry Extended Detention Basin	○		●	●	○	●	○	
Ladera Park - Infiltration Basin	○		●	●	○	●	○	

● Applicable to all projects
○ Applicable depending on project characteristics

(This page intentionally left blank.)

9. Cost Estimates

Cost estimates were developed at the level of detail necessary for planning and strategy development of the TMDL implementation. These estimates are based on detailed, site specific costs and refine the preliminary screening-level cost analysis performed for the optimization, which was based primarily on literature values.

The detailed costs are reported in 2009 dollars. Program costs can be updated by applying an approximate inflation rate of 3 percent per year. Capital costs can be updated by applying the *Engineering News–Record* Construction Cost Index as shown in the following equation:

New Base Year Cost = (Old Base Year Cost) × (New Base Year Index / Old Base Year Index)

The 2009 base year index of 9,765.44 has been used.

A period of 20 years was selected as a reasonable project duration for all BMPs, both structural and nonstructural. That period was used for all cost estimates under this task. The lifetime of structural BMPs is generally considered to be about 20 years, and that period is also reasonable for nonstructural BMPs because beyond that time frame, significant changes can occur to a program or practice.

Annual costs are estimated in present value (PV) terms. The PV is the 2009 value of the projected stream of annual cost. The process of calculating PV is known as discounting. Discounting is important because it accounts for how monetary values differ over time compared to a specific reference year and reflects the time preference for consumption. Although it is not synonymous with the interest rate, for governments, it often reflects the rate at which funds can be borrowed and loaned. A discount rate of 5 percent was applied to all annual costs. This is consistent with the discount rate used in the optimization. When cost estimates were prepared for most BMPs, unless otherwise noted, the planning through construction phases were assumed to occur in year 0, and annual costs, such as O&M, were assumed to begin in year 1. To calculate the PV of annual costs over time, the discount rate was applied beginning in year 1 through year 20. Depending on the BMP, the implementation schedules in Section 11 reflect a longer period for planning through construction than this 20-year period.

Appendix K provides detailed assumptions and cost estimates for all nonstructural and structural BMPs. Table 53 provides an initial comparison of the BMP cost estimates. The order of magnitude differences among the BMPs are expected. The centralized structural BMPs are estimated to cost more than most nonstructural BMPs because structural components are costly, and many of the nonstructural BMPs are based on existing County programs. Among the nonstructural BMPs, reduction in irrigation return flow presents cost more than $1 million greater than other nonstructural BMPs. Reduction in irrigation return flow is costly, in part, because it involves creating several new County programs and providing incentives. The cost of this BMP is also uncertain and could be reduced if a cost savings can be realized through reduced water usage.

The cost estimates in Table 53 are based on BMP unit prices and assume that all costs associated with planning though construction of the BMPs are incurred now (i.e., in year 0 of implementation), with annual recurring costs, such as O&M, beginning in 2010. Section 10 shows cost estimates associated with phased implementation of BMPs and incurring costs throughout the TMDL compliance period ending 2021.

Table 53. Summary of Structural and Nonstructural BMP Cost Estimates

BMP Description	Total PV
Nonstructural BMPs	
TMDL-specific Stormwater Training	$320,000
Enhancement of Commercial and Industrial Facility Inspections	$14,000
Smart Gardening Program Workshops in Ballona Creek Watershed	$56,000
Smart Gardening Workshop Tip Cards on Water Quality	$4,000
Reduction in Irrigation Return Flow	$1,370,000
Enforcement Escalation Procedures	N/A[a]
Distributed Catch Basin BMPs Phase 2	**$950,000**
Distributed Catch Basin BMPs Phase 3	**$1,870,000**
Distributed BMPs on Public Property without Monitoring	$18 to $21 per square foot of surface area
Distributed BMPs on Public Property with Monitoring	$21 to $24 per square foot of surface area
Centralized Structural BMPs on Public Property	
Ladera Park	$3,600,000
West Los Angeles Community College	$1,600,000
Centralized Structural BMPs on Private Property	Cost varies by treatment
Infiltration Basin	$200,000 per acre-foot of storage capacity
Extended Detention	$260,000 per acre-foot of storage capacity

a. As explained in the BMP-specific assumptions, a reasonably accurate cost could not be estimated for this BMP.

10. Recommended TMDL Implementation Plan

This section presents the recommendations for a Multi-pollutant TMDL Implementation Plan for Ballona Creek. The recommended BMPs for each of the three phases are presented with their associated costs. The TMDL Implementation Plan was evaluated using a range of criteria, including certainty of meeting TMDL requirements, the practical considerations of cost and feasibility, and how well the BMPs meet multiple community benefits. This evaluation identified current strengths of the TMDL Implementation Plan, and areas that might be revised and strengthened further in the future. An iterative and adaptive management approach is recommended to take advantage of new information or treatment technologies that can emerge in the future and result in more effective and efficient implementation the TMDL Implementation Plan's later phases.

10.1. Recommended BMPs for TMDL Implementation

The foundation of the TMDL Implementation Plan was the optimization results (Section 6), which recommended three phases to achieve the wet weather metals TMDL requirements. The optimization results provided the recommended order and phasing for the structural BMPs and one nonstructural BMP (reduction in irrigation return flow). The remaining nonstructural BMPs were placed in implementation phases on the basis of the feasibility of accomplishing a BMP within a phase and the need for achieving a TMDL requirement by a certain date.

Table 54 lists the BMPs recommended for achieving the TMDL requirements, as well as the estimated cost of each BMP during phased implementation. Generally, structural BMPs are recommended to address the drainage area treatment requirements for the wet weather metals requirements and to provide some progress in meeting the wet weather bacteria and toxics reduction requirements. The nonstructural BMPs are recommended to address the remaining pollutant reduction requirements for metals dry weather, toxics, bacteria dry weather, and bacteria wet weather. The nonstructural BMPs could also provide further reduction in wet weather metals loads, beyond the treatment provided by the structural BMPs.

The TMDL Implementation Plan provides the timing and planning-level costs for BMPs in the County TMDL Implementation Area. Planning efforts can be further defined to account for locations of pollutant loading priorities. Implementation of BMPs should be focused on the communities identified as the highest source of pollutant loading. West Los Angeles and West Fox Hills were the highest ranking communities in terms of area-based pollutant loads (wet weather). Implementing structural BMPs should be the highest priority in those communities, especially during Phase 1. Ladera Heights/Viewpark-Windsor Hills is ranked highest for dry weather sources; also, nonstructural BMPs, especially the smart gardening program workshops, should be given a higher priority in the community. Section 11 discusses the schedule for implementation in more detail.

Table 54. Recommended TMDL Implementation BMPs

Phase	BMP Type	Quantified in Model	Cost
1	Structural BMP: Ladera Park Centralized BMP - Infiltration Basin	●	$3,150,000
	Structural BMP: West Los Angeles Community College Centralized BMP - Detention Basin	●	$1,460,000
	Structural BMPs: Pilot Distributed BMP Project for a County Road	●	$210,000
	Structural BMPs: Distributed BMPs on Public Land	●	$3,180,000
	Nonstructural BMPs: TMDL-specific Stormwater Training	●	$326,000
	Nonstructural BMPs: Commercial and Industrial Facility Inspection Audits		$11,000
	Nonstructural BMPs: Smart Gardening Workshops in Ballona Creek		$5,000
	Total Phase 1 Costs		**$8,342,000**
2	Nonstructural BMPs: Smart Gardening Workshops in Ballona Creek		$44,000
	Nonstructural BMPs: Smart Gardening Tip Cards on Water Quality		$4,000
	Structural BMPs: Catch Basin Inserts (30% of catch basins)		$800,000
	Structural BMPs: Distributed BMPs on Public Land	●	$7,230,000
	Nonstructural BMPs: Reduction in Irrigation Return Flow		$1,160,000
	Nonstructural BMPs: Strengthen Enforcement of Violations Identified		$0
	Total Phase 2 Costs		**$9,238,000**
3	Structural BMPs: Distributed BMPs on Public Land	●	$950,000
	Structural BMPs: Centralized BMPs on Private Land: Infiltration Basins	●	$16,700,000
	Structural BMPs: Centralized BMPs on Private Property: Detention Basins	●	$10,100,000
	Structural BMP: Catch Basin Inserts Phase 3 (70% of catch basins)	●	$1,270,000
	Total Phase 3 Costs		**$29,020,000**
Total TMDL Implementation Plan Costs			**$46,600,000**

10.2. TMDL Implementation Plan Evaluation Criteria

The TMDL Implementation Plan described above was evaluated on the basis of criteria that reflect TMDL requirements, cost-effectiveness, and other considerations. Criteria identified to evaluate the implementation plan fall into six categories:

- **Certainty of Meeting TMDL Requirements**—As the BMPs are phased in over time, are TMDL requirements met for the County TMDL Implementation Area?
- **Cost Effectiveness**—How do the life cycle costs and cost-effectiveness compare across phases?
- **Complementary Integration**—How well do the BMPs complement each other in meeting water quality objectives (e.g., a vegetated swale draining to a bioretention cell)? Are certain projects time-sensitive or phase-sensitive (e.g., an upstream BMP might need to be implemented for a downstream BMP to function sustainably over time)?
- **Feasibility**—What constraints exist on-site or in the community that affect the feasibility of implementation?

- **Integrated Water Resources Planning**—How well do the BMPs meet the County's integrated water resources planning objectives?
- **Other Sustainability Benefits**—Do the BMPs provide other sustainability benefits or affect sustainability negatively?

The first four evaluation criteria were applied to evaluate and recommend BMPs for the TMDL Implementation Plan. The category Complementary Integration was used as a guide to the timing of BMP implementation. All the criteria were used to evaluate the recommended TMDL Implementation Plan both to identify areas of strength as well as areas that might be strengthened in the future through iterative and adaptive management. Appendix L provides more detail on the six categories and specific criteria.

Key findings of the evaluation include:

- The recommended TMDL Implementation Plan meets TMDL regulatory criterion because, despite some uncertainties, it was developed to maximize the available opportunities for meeting TMDL requirements. As noted above, it may prove difficult to treat 100 percent of the drainage area, but options are available to treat less land area with centralized BMPs and, therefore, meet WLA targets.
- The optimization identified the most cost-effective solutions in meeting the multiple TMDL requirements; however, the BMPs identified become significantly less cost effective in Phase 3. It was determined that the cost criterion is only partially met.
- A number of feasibility factors were considered across the proposed BMPs. It was determined that the implementation plan partially meets the feasibility decision criterion. However, where feasibility constraints exist, planning and implementation methods are available to minimize them.
- No implementation conflicts are posed among the BMPs recommended, and most of the recommended BMPs complement two or more of the other proposed BMPs. For example, the smart gardening workshops and tips could enhance the functioning of distributed BMPs along public roads, and support the program for reduced irrigation return flow. The TMDL-specific stormwater training would complement the smart gardening workshops.
- The TMDL Implementation Plan BMPs provide multiple water resources benefits, although somewhat limited.
- Half of the BMPs support five or more benefits, with all BMPs linked to at least two sustainability benefits. Table 55 indicates how each proposed BMP provides different sustainability benefits.

In summary, the most important criterion, certainty of meeting TMDL requriements, is fully met, while the next most important criteria, cost and feasibility, are partially met. The latter points to the need for the iterative and adaptive management approach to identify and employ new, cost effective BMPs or strategies as they become available in the later phases. On the whole, the recommended BMPs are successful at meeting multiple benefits and supporting other County policies and inititives.

Table 55. Other Sustainability Benefits

BMP	Integration of Natural and Built Environment	Integration of Water Cycle	Energy Reduction/Neutral	Neutral or Positive Air Quality Benefits	Hydrologically Neutral or Restorative	Supports Healthy and Enjoyable Living, Working, and Recreation Space	Supports/Enhances Social Consecutiveness
Centralized Structural BMPs on Public Land							
Ladera Park Centralized BMP	✓	✓			✓	✓	
West Los Angeles Community College Centralized BMP	✓	✓	✓		✓	✓	
Distriibuted Structural BMPs on Public Land							
Pilot Distributed BMP Project for a County Road	✓	✓	✓	✓	✓	✓	
Distributed Structural BMPs on Public Land	✓	✓	✓	✓	✓	✓	
Catch Basin Inserts			✓	✓			
Nonstructural BMPs							
TMDL-specific Stormwater Training			✓	✓			
Enhancement of Commercial and Industrial Facility Inspections			✓	✓			
Smart Gardening Program Enhancements	✓	✓	✓	✓		✓	
Reduction of Irrigation Return Flow		✓	✓	✓			
Enforcement Escalation Procedures			✓	✓			
Centralized Structural BMPs on Private Land	✓	✓	✓		✓	✓	

10.3. Special Considerations for Implementation of Centralized BMPs on Private Land

A major constraint for feasibility of centralized BMPs on private land is the ability to identify available and strategically located sites to treat 100 percent of the County TMDL Implementation Area per requirements of the phased WLAs for Ballona Creek TMDLs. However, as reported in Section 6, a robust quantitative analysis was performed that suggests alternative strategies for centralized BMP implementation could treat less than 100 percent of the drainage area and still meet TMDL reduction targets.

Three options were presented in Section 6.2.4 that illustrate alternative centralized BMP considerations with different drainage areas addressed. Analysis revealed that although incremental phased drainage area percentages for these options do not match phased WLAs, progress toward ultimately meeting TMDL reduction targets can still be measured in terms of incremental load reductions. However, as shown in Figure 45 (based on detailed cost estimation procedures reported in Section 9), implementation of options to treat less that 100 percent of the drainage area is estimated to increase costs due to the fact that larger BMPs are needed to provide equal load reduction. Essentially, treating less than 100 percent of the drainage area does not take advantage of treating first flush for untreated areas, requiring greater load reductions for areas treated to compensate and ultimately provide an equal overall load reduction for the entire County TMDL Implementation Area.

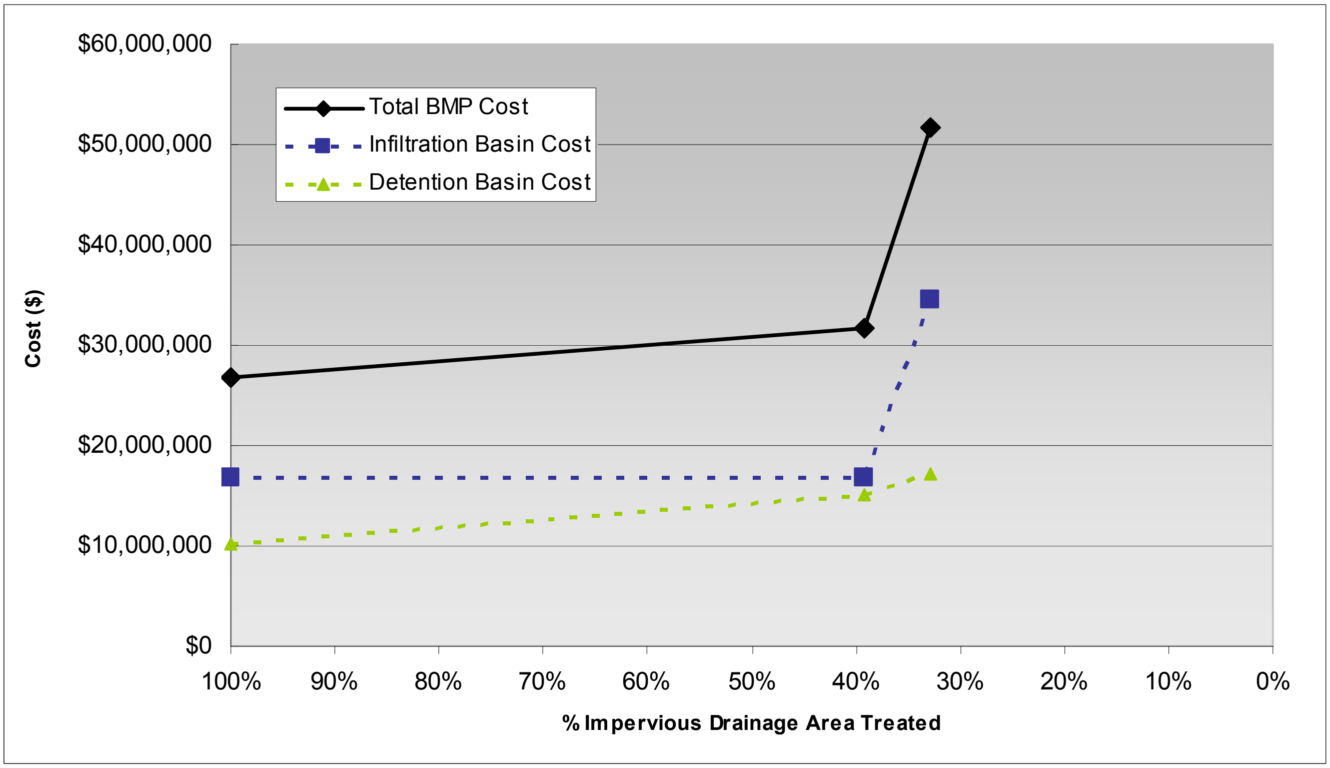


Figure 45. Centralized BMPs on Private Land – Relationship of Cost and Percent of Drainage Area Treated

Although the TMDL Implementation Plan assumes 100 percent of the drainage area is treated using centralized BMPs on private land, it is acknowledged that actual implementation of these BMPs will require strategic planning that could result in less area treated with more expensive options that are more feasible. Implementation of BMPs on private land can be based on the following process:

1. Identification of available privately owned parcels for acquisition as sites for implementation of centralized BMPs. Sites should consider:
   - *Proximity to the drainage network*: A drainage network should be located in close proximity to the parcel where stormwater can be routed to minimize the cost of modifying the drainage system.
   - *Percent impervious area*: Locations with a higher percent of impervious area should be targeted for greater potential volume reduction and water quality improvements.
   - *Watershed treatment area*: there should be sufficient space on the parcel for BMPs to adequately treat, store, and infiltrate runoff from the Unincorporated County drainage area.
   - *Soil type*: Soil type serves as a proxy for infiltration rate and water holding capacity. Sites with Hydrologic Soil Group A, B, or C soils have suitable infiltration for infiltration BMPs and should be further investigated. Soil types should be verified in the field.
   - *Slope*: Sites should be screened for moderate slopes (less than 10%). If moderate slopes are present (as verified in the field), the sites can be considered for centralized BMPs.
   - *Multi-benefit use*: Centralized BMPs can offer multiple benefits. For example, infiltration basins can be used for stormwater management and community park space. Parks or open space can be altered to enhance stormwater treatment and storage.

- *Other site characteristics*: Surface infiltration rate and depth to the seasonal high groundwater table should be verified in the field.

2. Comparison of available sites to priority areas established in the Pollutant Source Characterization and Prioritization process.

3. Estimation of pollutant load reductions achieved through BMP implementation at each site, and incorporation within a decision framework used to compare site-specific benefits relative to other sites for prioritization of aquisition.

4. Implementation of a land acquisition program.

5. Design and construction (including pre- and post-construction monitoring) of centralized BMPs on aquired land.

The above process will be further refined through the iterative and adaptive approach to TMDL implementation, which will improve as new information becomes available and decision support systems evolve. Private land will be aquired and BMPs will be designed and constructed as funding becomes available.

11. Implementation Schedules

The schedule presented in Table 56 was prepared for the implementation alternatives to reflect the time frames needed to implement each proposed BMP. Assumptions used to develop the schedules for each type of BMP is further discussed in Appendix M.

The time frame for funding has not been included in the schedules. Funding allocation for Phases 2 and 3 could be accomplished before implementing the phases. However, if Phase 1 funding is not available at the beginning of the phase, the allocation of funding for the phase would likely delay the start and end dates of implementation.

Table 56. BMP Implementation Scheduling

BMP	Duration (Months)	Implementation Year											
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021[a]
PHASE 1													
Ladera Park Centralized BMP													
Planning through construction	32												
Maintenance	244												
Pre- and post-construction Monitoring	12												
West Los Angeles Community College Centralized													
Planning through construction	20												
Maintenance	244												
Pre- and post-construction Monitoring	12												
Pilot Distributed BMP Project for a County Road													
Planning through Construction	14												
Maintenance (20-year lifetime)	244												
Pre- and post-construction Monitoring	12												
Distributed BMPs on Public Land - High Infiltration Soils (100%)													
Planning through Construction	14												
Maintenance (20-year lifetime)	244												
Pre- and post-construction Monitoring	12												
Distributed BMPs on Public Land - Low Infiltration Soils (25%)													
Planning through Construction	14												
Maintenance (20-year lifetime)	244												
Pre- and post-construction Monitoring	12												
Nonstructural BMP: TMDL-specific Stormwater Training													
Planning	6												
Program Operation and Periodic Evaluation	244												
Nonstructural BMP: Enhancement of Commercial and Industrial Facility Inspections													
Planning	3												

BMP	Duration (Months)	Implementation Year											
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021[a]
Program Operation and Periodic Evaluation	244												
Nonstructural BMP: Smart Gardening Program Enhancements - Workshops in Ballona Creek Watershed													
Initial Workshops Planning	6												
Initial Workshops Program Operation and Periodic Evaluation	37												
Information Center Planning through Construction	18												
Information Center Program Operation and Periodic Evaluation	207												
Nonstructural BMP: Smart Gardening Program Enhancements - Workshop Tip Cards on Water Quality													
Planning through materials design	6												
Program Operation and Periodic Evaluation	244												
PHASE 2													
Distributed BMPs on Public Land - Low Infiltration Soils (60%)													
Planning through Construction (Tier 1)	14												
Maintenance (20-year lifetime)	244												
Post-construction Monitoring	37												
Planning through Construction (Tier 2)	14												
Maintenance (20-year lifetime)	244												
Post-construction Monitoring	37												
Planning through Construction (Tier 3)	14												
Maintenance (20-year lifetime)	244												
Post-construction Monitoring	37												
Planning through Construction (Tier 4)	14												
Maintenance (20-year lifetime)	244												
Post-construction Monitoring	37												
Planning through Construction (Tier 5)	14												
Maintenance (20-year lifetime)	244												
Post-construction Monitoring	37												
Planning through Construction (Tier 6)	14												
Maintenance (20-year lifetime)	244												
Post-construction Monitoring	37												
Structural BMP: Catch Basin Inserts Phase II (30%)													
Planning through Construction	21												
Program Operation and Periodic Evaluation	244												
Nonstructural BMP: Reduction of Irrigation Return Flow													
Initial Planning	61												

BMP	Duration (Months)	Implementation Year											
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021[a]
Initial Program Operation and Periodic Evaluation	244												
Nonstructural BMP: Enforcement Escalation Procedures													
Planning	37												
Program Operation and Periodic Evaluation	244												
PHASE 3													
Distributed BMPs on Public Land - Low Infiltration Soils (15%)													
Planning through Construction	14												
Maintenance (20-year lifetime)	244												
Post-construction Monitoring	37												
Centralized BMPs on Private Land: Infiltration Basins													
Land acquisition	6												
Planning through construction	32												
Maintenance	244												
Pre- and post-construction Monitoring	12												
Centralized BMPs on Private Land: Detention Basins													
Land acquisition	6												
Planning through construction	20												
Maintenance	244												
Pre- and post-construction Monitoring	12												
Structural BMP: Catch Basin Inserts Phase III (70%)													
Planning through Construction	37												
Program Operation and Periodic Evaluation	244												

a. O&M continues 20 years past the start date.

Planning through construction
O&M
Land acquisition
Pre-construction monitoring
Post-construction monitoring

(This page intentionally left blank.)

12. References

Ablin, R.L., and P. Kinshella. 2004. Accelerated corrosion rate threatens Phoenix sewers. *Presented at North American Society for Trenchless Technology*. New Orleans, Louisiana. March 22–24, 2004.

Ackerman, D., and K. Schiff. 2003. Modeling storm water mass emissions to the Southern California Bight. *Journal of Environmental Engineering* 129(4):308–317.

Ackerman D., K. Schiff, and E. Stein. 2004. Wet Weather Model Development for Trace Metal Loading in an Arid Urbanized Watershed: Ballona Creek, California. Prepared for USEPA Region 9 and the Los Angeles Regional Water Quality Control Board by the Southern California Coastal Water Research Project, Westminster, CA.

Ackerman, D., E.D. Stein, and K. Schiff. 2005. Dryseason water quality in the San Gabriel River watershed. *Bulletin (Southern California Academy of Sciences)*. December 1, 2005.

Ackerman, D., K. Schiff, H. Trim, and M. Mullin. 2003. Characterization of water quality in the Los Angeles River. *Bulletin (Southern California Academy of Sciences)*. April 1, 2003.

Ackerman, D., K.C. Schiff, and S.B. Weisberg. 2005. Evaluating HSPF in an arid, urbanized watershed. *Journal of the American Water Resources Association* 41(2):477–486.

Ackerman, D., Stein, E.D., and Schiff, K. 2005. Dryseason water quality in the San Gabriel River watershed. *Bulletin (Southern California Academy of Sciences)*. December 1, 2005.

Albuquerque Bernalillo County. 2009. *Xeriscape Rebates*. Albuquerque Bernalillo County Water Utility Authority. Accessed September 2009. www.abcwua.org/content/view/132/222/

Anderson, M.A. 2001. *Internal Loading and Nutrient Cycling in Lake Elsinore*. Final report submitted to Santa Ana Regional Water Quality Control Board.

Anderson, M.A., and H. Oza. 2003. *Internal Loading and Nutrient Cycling in Canyon Lake*. Final report submitted to Santa Ana Regional Water Quality Control Board.

Aquacraft, Inc. 2009. *Evaluation of California Weather-Based "Smart" Irrigation Controller Programs*. Facilitated by California Urban Water Conservation Council. Prepared by Peter Mayer, William DeOreo, Matt Hayden, and Renee Davis Aquacraft, Inc., Water Engineering and Management, Boulder, CO, Erin Caldwell and Tom Miller, National Research Center, Inc., Boulder, CO, and Dr. Peter J. Bickel Berkeley, CA.

Aydinalp, C., and S. Marinova. 2003. Distribution and forms of heavy metals in some agricultural soils. *Polish Journal of Environmental Studies* 12(5):629–633.

BDB (Biogeographic Data Branch). 2009. California Natural Diversity Database. Biogeographic Data Branch, California Department of Fish and Game. www.dfg.ca.gov/biogeodata/cnddb/. Accessed July 2009.

Boyd, G.R., J.M. Palmeri, S. Zhang, and D.A. Grimm. 2004. Pharmaceuticals and personal care products (PPCPs) and endocrine disrupting chemicals (EDCs) in storm water canals and Bayou St. John in New Orleans, Louisiana, USA. *Science of the Total Environment* 333:137–148.

Bozó, L., J. Alcarno, J. Bartnicki, and K. Olendrzyriski. 1991. *Heavy Metals Contamination in Eastern Europe: Background Load from the Atmosphere*. International Institute for Applied Systems Analysis, Laxenburg, Austria. WP-91-46.

Bradsher, K., and D. Barboza. 2006. Pollution from Chinese coal casts a global shadow. *The New York Times.* June 11, 2006.

Buffleben, M.S., K. Zayeed, D. Kimbrough, M.K. Stenstrom, and I.H. Suffett. 2002. Evaluation of urban non-point source runoff of hazardous metals entering Santa Monica Bay, California. *Water Science and Technology* 45(9):263–268.

Caltrans (California Department of Transportation). 2003. *A Review of Contaminants and Toxicity Associated With Particles in Stormwater Runoff*. California Department of Transportation, Sacramento, CA.

CASQA (California Stormwater Quality Association). 2003a. *Stormwater Best Management Practice Handbook: Industrial and Commercial*. www.cabmphandbooks.com/documents/Industrial/IndustrialCommercial.pdf. Accessed September 20, 2009.

CASQA (California Stormwater Quality Association). 2003b. *Stormwater Best Management Practice Handbook: Construction*. www.cabmphandbooks.com/Documents/Construction/Construction.pdf. Accessed September 20, 2009.

Center for Watershed Protection. 2006a. *Research in Support of an Interim Pollutant Removal Rate for Street Sweeping and Storm Drain Cleanout Activities*. Technical Memorandum 1 – Literature Review: Final Draft. Center for Watershed Protection, Ellicott City, MD.

Center for Watershed Protection. 2006b. *Research in Support of an Interim Pollutant Removal Rate for Street Sweeping and Storm Drain Cleanout Activities*. Technical Memorandum 2 – Summary of Municipal Practices Survey. Center for Watershed Protection, Ellicott City, MD.

Center for Watershed Protection. 2008. *Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping and Storm Drain Cleanout Programs in the Chesapeake Bay Basin*. Center for Watershed Protection, Ellicott City, MD.

Chea, T. 2006. China's air pollution reaches California; U.S. estimates that on some days 25% of L.A.'s smog is traceable to country. *The Washington Post.* October 8, 2006.

County of Los Angeles. 2000. *Development Planning for Storm Water Management: A Manual for the Standard Urban Storm Water Mitigation Plan (SUSMP).* www.ladpw.com/wmd/NPDES/SUSMP_MANUAL.pdf. Accessed July 2009.

County of Los Angeles. 2009a. *Title 12 Environmental Protection*. Accessed July 2009. http://ordlink.com/codes/lacounty/_DATA/TITLE12/. Accessed September 20, 2009.

County of Los Angeles. 2009b. *Low Impact Development Standards Manual*. January 2009. http://dpw.lacounty.gov/bsd/lib/fp/Drainage%20and%20Grading/dg_gd~~-LA%20County%20LID%20Manual%20(1-26-2009).pdf. Accessed September 20, 2009.

Daggupaty, S.M., C.M. Banic, P. Cheung, and J. Ma. 2006. Numerical simulation of air concentration and deposition of particulate metals around a copper smelter in northern Québec, Canada. *Geochemistry: Exploration, Environment, Analysis* 6(2–3):139–146.

Davis A.P., M. Shokouhian, and S. Ni. 2001. Loading estimates of lead, copper, cadmium, and zinc in urban runoff from specific sources. *Chemosphere 2001 44*: 997–1009.

Ellis, J.B., and D.M. Revitt. 1982. Incidence of heavy metals in street surface sediments—solubility and grain size studies. *Water, Air, and Soil Pollution 17*: 87–100.

Gleick, P.H., D. Haasz, C. Henges-Jeck, V. Srinivasan, G. Wolff, K.K. Cushing, and A. Mann. 2003. Waste not, Want Not: The Potential for Urban Water Conservation in California. Pacific Institute for Studies in Development, Environment, and Security. ISBN No. 1-893790-09-6. Oakland, California. www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf. Accessed July 3, 2009.

Helfert, Erich A. 1997. *Techniques of Financial Analysis*. 9th ed. McGraw-Hill, New York.

Hoffman, E., J. Latimer, G. Mills, and J. Quinn. 1982. Petroleum Hydrocarbons in Urban Runoff from a Commercial Land Use Area. *Journal WPCF* 54(11).

Hotz, R.L. 2007. Huge Dust Plumes from China Cause Changes in Climate. *The Wall Street Journal.* July 20, 2007. p B1.

Jassby, A.D., J.E. Reuter, R.P. Axler, C.R. Goldman, and S.H. Hackley. 1994. Atmospheric deposition of nitrogen and phosphorus in the annual nutrient load of Lake Tahoe (California-Nevada). *Water Resources Research* 30(7):2207–2216.

Katznelson, R., and T. Mumley. 1997. *Diazinon in Surface Waters in the San Francisco Bay Area: Occurrence and Potential Impact*. Prepared for The California State Water Resources Control Board. June 30, 1997.

LACDPW (Los Angeles County Department of Public Works). 2003. *Dry Weather Discharge Treatment Feasibility Study*. Los Angeles County Department of Public Works, Los Angeles, CA.

LACDPW (Los Angeles County Department of Public Works). 2007. *Construction Site Best Management Practices (BMPs) Manual*. Los Angeles County Department of Public Works, Alhambra, CA.

LACDPW (Los Angeles County Department of Public Works). 2008a. *Ballona Creek Watershed MS4 Water Quality Assessment*. Prepared for LACDPW by Weston.

LACDPW (Los Angeles County Department of Public Works). 2008b. *Identification of Pollutant Source and Watershed Management Categories*. Prepared for the County of Los Angeles Department of Public Works and the U.S. Environmental Protection Agency Region 9, by Tetra Tech, Inc., San Diego, CA.

LACDPW (Los Angeles County Department of Public Works). 2009. *Stormwater Best Management Practice Design and Maintenance Manual for Publicly Maintained Storm Drain Systems*. Los Angeles County Department of Public Works, Alhambra, CA.

LARWQCB (Los Angeles Regional Water Quality Control Board) and USEPA (U.S. Environmental Protection Agency). 2005a. *Total Maximum Daily Loads for Metals in Ballona Creek*. California Regional Water Quality Control Board, Los Angeles Region and U.S. Environmental Protection Agency, Region 9. Los Angeles, CA.

LARWQCB (Los Angeles Regional Water Quality Control Board) and USEPA (U.S. Environmental Protection Agency). 2005b. *Total Maximum Daily Loads for Toxic Pollutants in Ballona Creek Estuary*. California Regional Water Quality Control Board, Los Angeles Region and U.S. Environmental Protection Agency, Region 9. Los Angeles, CA.

LARWQCB (Los Angeles Regional Water Quality Control Board) and USEPA (U.S. Environmental Protection Agency). 2005c. *Total Maximum Daily Loads for Toxic Pollutants in Ballona Creek Estuary*. California Regional Water Quality Control Board, Los Angeles Region and U.S. Environmental Protection Agency, Region 9. Los Angeles, CA.

LARWQCB (Los Angeles Regional Water Quality Control Board). 2003. *Total Maximum Daily Loads for Nitrogen Compounds and Related Effects, Los Angeles River and Tributaries – Draft*. California Regional Water Quality Control Board-Los Angeles Region, Los Angeles, CA.

LARWQCB (Los Angeles Regional Water Quality Control Board). 2007. Order No. 01-182, Los Angeles County Municipal Storm Water National Pollutant Discharge Elimination System (NPDES) Permit as Amended by Regional Board Order R4-2007-0042 on August 9, 2007 (Board Order 01-182; NPDES Permit No. CAS004001). www.swrcb.ca.gov/rwqcb4/water_issues/programs/stormwater/municipal/ms4_permits/los_angeles/2001-2007/LA_MS4_Permit2001-2007.pdf. Last updated August 23, 2007. Accessed August 19, 2009.

LARWQCB (Los Angeles Regional Water Quality Control Board). 2004. *Trash Total Maximum Daily Loads for the Ballona Creek and Wetland*. California Regional Water Quality Control Board-Los Angeles Region. Los Angeles, CA.

LARWQCB (Los Angeles Regional Water Quality Control Board). 2006. *Total Maximum Daily Loads for Bacterial Indicator Densities in Ballona Creek, Ballona Estuary, & Sepulveda Channel*. California Regional Water Quality Control Board-Los Angeles Region, Los Angeles, CA.

LARWQCB (Los Angeles Regional Water Quality Control Board). 2007. Order No. 01-182, Los Angeles County Municipal Storm Water National Pollutant Discharge Elimination System (NPDES) Permit as Amended by Regional Board Order R4-2007-0042 on August 9, 2007 (Board Order 01-182; NPDES Permit No. CAS004001). www.swrcb.ca.gov/rwqcb4/water_issues/programs/stormwater/municipal/ms4_permits/los_angeles/2001-2007/LA_MS4_Permit2001-2007.pdf. Last updated August 23, 2007. Accessed August 19, 2009.

LARWQCB (Los Angeles Regional Water Quality Control Board). 2008. Machado Lake Eutrophic, Algae, Ammonia, and Odors (Nutrient) TMDL (Revised Draft), California Regional Water Quality Control Board, Los Angeles Region, Los Angeles, CA.

Lau, S.-L., Y. Han, J.-H. Kang, M. Kayhanian, and M.K. Stenstrom. 2009. Characteristics of highway stormwater runoff in Los Angeles: metals and polycyclic aromatic hydrocarbons. *Water Environment Research* 81(3):308–318.

Lau, S., and M. Stenstrom. 2005. Metals and PAHs Adsorbed to Street Particles. *Water Research* 39 (2005):4083–4092.

LeNoir, J.S., L.L. McConnell, G.M. Fellers, T.M. Cahill, and J.N. Seiber. 1999. Summertime transport of current-use pesticides from California's Central Valley to the Sierra Nevada Mountain Range, USA. *Environmental Toxicology and Chemistry* 18(22):2715–2722.

Longanathan, B., K. Irvine, K. Kannan, V. Pragatheeswaran, and K. Sajwan. 1997. Distribution of Selected PCB Congeners in the Babcock Street Sewer District: A Multimedia Approach to Identify PCB Sources in the Combined Sewer Overflows (CSOs) Discharging to the Buffalo River, New York. Archives of Environmental Contamination and Toxicology, 33, 130-140.

Lu, R., K. Schiff, S. Solzenbach, and D. Keith. 2004. *Nitrogen Deposition on Coastal Watersheds in the Los Angeles Region*. Southern California Coastal Water Research Project Annual Report. 2003-2004. pp. 73–81.

Lu, R., R.P. Turco, K.D. Stolzenbach, S.K. Freidlander, C. Xiong, K. Schiff, L.L. Tiefenthaler and G. Wang. 2003. Dry deposition of airborne trace metals on the Los Angeles Basin and adjacent coastal waters. *Journal of Geophysical Research* 108: 4074.

McPherson, T.N., S.J. Burian, H.J. Turin, M.K. Stenstrom, and I.H. Suffet. 2002. Comparison of the pollutant loads in dry and wet weather runoff in a Southern California urban watershed. *Water Science and Technology* 45(9):255–261.

McPherson, T.N., S.J. Burian, M.K. Stenstrom, H.J. Turin, M.J. Brown, and I.H. Suffet. 2005. Trace metal pollutant load in urban runoff from a Southern California Watershed. (Ballona Creek) *Journal of Environmental Engineering* 131(7):1073–1080.

Morgan, R.A., F.G. Edwards, K.R. Brye, and S.J. Burian. 2005. An Evaluation of the urban Stormwater Pollutant Removal Efficiency of Catch Basin Inserts. *Water Environment Research* 77(5):500–510.

Morton, R.L., W.A. Yanko, D.W. Graham, and R.G. Arnold. 1991. Relationships between Metal Concentrations and Crown Corrosion in Los Angeles County Sewers. *Research Journal of the Water Pollution Control Federation* 63(5):789–798.

Nixon, H., & Saphores, J.D. (2007). Impacts of motor vehicle operation on water quality: Clean-up costs and policies. *Transportation Research Part D: Transport and Environment 12*(8): 564-576.

Pitt, R. 1985. *Characterizing and Controlling Urban Runoff Through Street and Sewerage Cleaning*. EPA/600/S2-85/038. U.S. Environmental Protection Agency, Water Engineering Research Laboratory. Cincinnati, OH. http://cfpub.epa.gov/ols/catalog/catalog_display.cfm?&FIELD4=CALLNUM&INPUT4=600%20s2%2085%20038&item_count=1. Accessed October 1, 2009.

R.S. Means. 2009. *Means Site Work and Landscape Cost Data*. Robert Snow Means Company, Inc., Kingston, MA.

Raskin, L., M.J. Singer and A. DePaoli. 2004. Final Report to the State Water Resources Control Board Agreement number 01-269-250.

Sabin, L.D., K. Schiff, J.H. Lim, and K.D. Stolzenbach. 2004. Atmospheric concentrations of PAH, pesticides, and other semi-volatile organic compounds in the Los Angeles coastal region. pp. 61-72 in S.B. Weisberg and D. Elmore (eds.), *Southern California Coastal Water Research Project 2003-04 Biennial Report*. Southern California Coastal Water Research Project, Westminster, CA.

Santa Clara Valley Nonpoint Source Control Program. 1992. *Source Identification and Control Report*. Woodward Clyde Consultants. 96 pp.

SCAG (Southern California Association of Governments). 2005. 2005 Land Use Data. Obtained directly from the Southern California Association of Governments (SCAG). www.scag.ca.gov/mappingGIS.htm. Accessed May 19, 2008.

SCCWRP (Southern California Coast Water Research Project). 2008. SCCWRP Website available at: http://sccwrp.org/. Direct links referenced: *Research Area: Atmospheric Deposition* at http://sccwrp.org/view.php?id=52; *Project: Atmospheric Deposition of Trace Metals* at http://sccwrp.org/view.php?id=270; *Project: Atmospheric Nutrient Deposition* at http://sccwrp.org/view.php?id=486

Schiff, K., and M. Sutula. 2001. *Organonphosphorous Pesticides in Storm water Runoff from Southern California*. Technical Report #356. Southern California Coastal Water Research Project, Westminster, CA.

Schueler, T.R. 2009. Cars are leading source of metal loads in California. Center for Watershed Protection. *Watershed Protection Techniques* 1(1):28.

Schueler, T., and H.K. Holland. 2000. *The Practice of Watershed Protection*. Center for Watershed Protection, Ellicott City, Maryland.

Southern Nevada Water Authority. 2009. *Water Smart Landscapes Rebate. Southern Nevada Water Authority*. www.snwa.com/html/cons_wsl.html. Accessed September 2009.

State Water Resources Control Board. 1997. Waste Discharge Requirements for Discharges of Storm Water Associated With Industrial Activities Excluding Construction Activities. State Water Resources Control Board Water Quality Order No. 97-03-DWQ, National Pollutant Discharge Elimination System General Permit No. CAS000001. www.swrcb.ca.gov/water_issues/programs/stormwater/docs/induspmt.pdf. Accessed August 31, 2009.

Stein, E.D., and D. Ackerman. 2007. Dry weather water quality loadings in arid, urban watersheds of the Los Angeles Basin, California, USA. *JAWRA* 43(2):398–413.

Stein, E.D., and L.L. Tiefenthaler. 2005. Dry weather metals and bacteria loading in an arid, urban watershed: Ballona Creek, California. *Water, Air, and Soil Pollution* 164:367–382.

Stein, E.D., L.L. Tiefenthaler, and K. Schiff. 2006. Watershed-based sources of polycyclic aromatic hydrocarbons in urban storm water. *Environmental Toxicology and Chemistry* 25(2):373–385.

Stein, E.D., L.L. Tiefenthaler, and K. Schiff. 2008. Watershed-based sources of polycyclic aromatic hydrocarbons in urban storm water. *Environmental Toxicology and Chemistry* 25(2):373–385.

Stolzenbach, K.D. 2006. *Atmospheric Deposition Grades B+ to C-*. Southern California Environmental Report Card 2006. UCLA Institute of the Environment, Los Angeles, CA.

Stenstrom, M.K., S. Lau, and S.M. Bay. 1998. Toxicity of wet weather urban runoff. *Assessment of Storm Drain Sources of Contaminants to Santa Monica Bay*. Volume VI.

Stenstrom, M. K. and H. Lee. 2005. Final Report Industrial Storm Water Monitoring Program Existing Statewide Permit Utility and Proposed Modifications. Civil and Environmental Engineering Department, UCLA. Los Angeles, CA.

Sugden, R., and A. Williams. 1981. *Principles of Practical Cost Benefit Analysis*. Oxford University Press, Oxford, U.K.

SWRCB (State Water Resources Control Board). 1997. Waste Discharge Requirements for Discharges of Storm Water Associated With Industrial Activities Excluding Construction Activities. State Water Resources Control Board Water Quality Order No. 97-03-DWQ, National Pollutant Discharge Elimination System

General Permit No. CAS000001. www.swrcb.ca.gov/water_issues/programs/stormwater/docs/induspmt.pdf. Accessed August 31, 2009.

USEPA (U.S. Environmental Protection Agency). 2003a. Total Maximum Daily Loads for Bacteria in the Malibu Creek Watershed, US Environmental Protection Agency, Region 9.

USEPA (U.S. Environmental Protection Agency). 2003b. Total Maximum Daily Loads for Nutrients in the Malibu Creek Watershed, US Environmental Protection Agency, Region 9.

USEPA (U.S. Environmental Protection Agency). 2008. *Summary of the Resource Conservation and Recovery Act*. U.S. Environmental Protection Agency, Washington, DC. www.epa.gov/lawsregs/laws/rcra.html. Accessed July 2009.

USEPA (U.S. Environmental Protection Agency). 2009. *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs*. U.S. Environmental Protection Agency, Office of Wastewater Management. www.epa.gov/npdes/stormwater/menuofbmps. Accessed September 2009.

USEPA (U.S. Environmental Protection Agency) and LARWQCB (Los Angeles Regional Water Quality Control Board). 2006. *Watershed Model Development for Simulation of Loadings to the Los Angeles/Long Beach Harbors.* Prepared for U.S. Environmental Protection Agency Region 9 and Los Angeles Regional Water Quality Control Board, by Tetra Tech, San Diego, CA.

van Breemen A.J.H., and P.H.M. Vermij. 2007. Instruments to reduce the leaching of heavy metals from building materials in the Netherlands. *Water Science and Technology 55*: 79-85.

Van Metre, P.C., and B.J. Mahler. 2003. The contribution of particles washed from rooftops to contaminant loading to urban streams. *Chemosphere 52*: 1727-1741.

Walch, M. 2006. Monitoring of Contaminants in Delaware Street Sweeping Residuals and Evaluation of Recycling/Disposal Options. Presented at 21st Inter. Conf. on Solid Waste Technology and Management, Philadelphia, PA, March 26-29, 2006. http://www.deldot.gov/stormwater/pdfs/Walch_SolidWasteConf06.pdf.

Yunker, M., R. Macdonald, R. Vingarzan, R. Mitchell, D. Goyette, and S. Sylvestre. 2002. PAHs in the Frasier River Basin: A Critical Appraisal of PAH Ratios as Indicators of PAH Source and Composition. *Organic Geochemistry* 33(2002):489–515.

Zhang, L., P. De Schryvera, B. De Gussemea, W. De Muyncka, N. Boona and W. Verstraete. 2008. Chemical and biological technologies for hydrogen sulfide emission control in sewer systems: A review. *Water Research 42*(1-2): 1–12.

(This page intentionally left blank.)