Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Loads

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- **Appendix II:** LSPC Watershed Model Development for Simulation of Loadings to the Los Angeles/Long Beach Harbors (LSPC Model Report)
- **Appendix III** Supplemental Technical Information for TMDLs for Toxic Pollutants in Dominguez Channel and Greater Los Angeles and Long Beach Harbor Water

LIST OF ACRONYMS

µg/g	Micrograms per Gram
µg/kg	Micrograms per Kilogram
µg/L	Micrograms per Liter
BPTCP	Bay Protection and Toxic Cleanup Program
Caltrans	California Department of Transportation
CEQA	California Environmental Quality Act
City BOS	City of Los Angeles Bureau of Sanitation
CFR	Code of Federal Regulations
COMM	Commercial and Sport Fishing
CTR	California Toxics Rule
CWA	Clean Water Act
DDT	dichlorodiphenyltrichloroethane
DL	Detection Limit
EMCs	Event Mean Concentrations
ERL	Effects Range-Low
ERM	Effects Range-Median
EST	Estuarine Habitat
FR	Federal Register
kg	Kilograms
LACDPW	Los Angeles County Department of Public Works
LARWQCB	Los Angeles Regional Water Quality Control Board
LACSD	Los Angeles County Sanitation District
LAR	Los Angeles River
LSPC	Loading Simulation Program in C++
MAR	Marine Habitat
mg/kg	Milligrams per Kilogram
MS4	Municipal Separate Storm Sewer System
MTRL	Maximum Tissue Residue Level
NAV	Navigation
ng/L	Nanograms per Liter
NPDES	National Pollutant Discharge Elimination System
OEHHA	Office of Environmental Health Hazard Assessment
PAHs	Polyaromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PEL	Probable Effects Level
POLA	Port of Los Angeles
POLB	Port of Long Beach
pg/L	Picograms per Liter
ppb	Parts per Billion
ppt	Parts per Thousand
RARE	Rare, Threatened, or Endangered Species
REC1	Water Contact Recreation
REC2	Non-Contact Water Recreation
SGR	San Gabriel River
SHELL	Shellfish Harvesting

SQOs	Sediment Quality Objectives
TEL	Threshold Effects Level
TMDL	Total Maximum Daily Load
TSMP	Toxic Substances Monitoring Program
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
WDRs	Waste Discharge Requirements
WILD	Wildlife Habitat
WLAs	Waste Load Allocations
WQA	Water Quality Assessment
WQOs	Water Quality Objectives

1 INTRODUCTION AND REGULATORY BACKGROUND

The waters of the Dominguez Channel and the Ports of Los Angeles and Long Beach in the San Pedro Bay have enormous economic, recreational and habitat value and fail to meet water quality standards. The California Regional Water Quality Control Board, Los Angeles Region (Regional Board) has developed this total maximum daily load (TMDL) to attain the water quality standards for the Dominguez Channel and greater Los Angeles and Long Beach Harbors waters. The TMDL has been prepared pursuant to state and federal requirements.

The California Water Quality Control Plan, Los Angeles Region (Basin Plan) sets standards for surface waters and ground waters in the Coastal Watersheds of Los Angeles and Ventura Counties. These standards are comprised of designated beneficial uses for surface and ground water, numeric and narrative objectives necessary to support beneficial uses, and the state's antidegradation policy. Such standards are mandated for all waterbodies within the state under the Porter-Cologne Water Quality Act and the Federal Clean Water Act. In addition, the Basin Plan describes implementation programs to protect all waters in the region. The Basin Plan implements the Porter-Cologne Water Quality Act (also known as the "California Water Code") and serves as the State Water Quality Control Plan as required pursuant to the federal Clean Water Act (CWA).

Section 305(b) of the CWA mandates biennial assessment of the nation's water resources, and these water quality assessments are used to identify and list impaired waters. CWA requires that each State "shall identify those waters within its boundaries for which the effluent limitations are not stringent enough to implement any water quality objective applicable to such waters." The resulting list is referred to as the 303(d) list. The CWA also requires states to establish a priority ranking for impaired waters and to develop and implement Total Maximum Daily Loads (TMDL). A TMDL specifies the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and allocates pollutant loadings to point and non-point sources. The elements of a TMDL are described in 40 CFR 130.2 and 130.7 and Section 303(d) of the CWA, as well as in the USEPA guidance (USEPA, 2000a). A TMDL is also required to account for seasonal variations and include a margin of safety to address uncertainty in the analysis (USEPA, 2000a).

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

A consent decree between the USEPA, the Santa Monica BayKeeper and Heal the Bay Inc., represented by the Natural Resources Defense Council (NRDC), was signed on March 22, 1999 (consent decree). This consent decree requires that all TMDLs, as required by the 1998 303(d) list, for the Los Angeles Region be adopted within 13 years. For the purpose of scheduling TMDL development, the consent decree combined the more than 700 water body-pollutant combinations into 92 TMDL analytical units and also prescribed schedules for certain TMDLs.

Specific water body-pollutant combinations for Dominguez Channel and greater Los Angeles and Long Beach Harbor waters were identified as impaired on the 1996, 1998, 2002, 2006 and 2008/2010 California 303(d) lists (LA RWQCB, 1996, 1998, 2002, 2007, 2010). The final 2008/2010 list of impaired water body-pollutant combinations for Dominguez Channel and greater Los Angeles and Long Beach Harbor waters is contained in Table 2-7.

On Sept. 2, 2010, the U.S. District Court approved a modification to the consent decree which added and removed certain pollutants from certain Analytical Units from the consent decree-required TMDLs for the Harbor waters. Analytical units (AU) 73, 74, 75 and 78 are addressed via these Harbor Toxics TMDLs. However, parts of two AUs are not addressed in this TMDL project - Copper and lead in Wilmington Drain which is part of AU 75 and Chlordane, DDT and PCBs in Machado Lake which is part of AU 73. A separate TMDL for Chlordane, DDT and PCBs in Machado Lake was approved by the Regional Board in September of 2010. The September 2010 modification of the consent decree included a finding of non-impairment for copper and lead in Wilmington Drain; these impairments will also be removed from the 303(d) list when sufficient data is available to de-list in accordance with the State Listing Policy.

The TMDLs for Dominguez Channel and greater Los Angeles/Long Beach Harbor waters will be established in a Basin Plan Amendment and are therefore subject to Public Resources Code Section 21083.9 that requires California Environmental Quality Act (CEQA) Scoping and Analysis to be conducted for Regional Projects. CEQA Scoping involves identifying a range of project/program related actions, alternatives, mitigation measures, and significant effects to be analyzed in an EIR or its Substitute Environmental Documents (SEDs). On September 21, 2006 a CEQA Scoping meeting was held to present and discuss the foreseeable potential environmental impacts of compliance with the TMDLs for Dominguez Channel and greater Los Angeles/Long Beach Harbor waters at the Los Angeles Regional Water Quality Control Board. Input from all stakeholders and interested parties were solicited for consideration in the development of the CEQA environmental analysis.

Metals TMDLs have already been completed for Los Angeles River, San Gabriel River and Los Cerritos Channel; therefore, metal pollutant allocations have been defined to restore beneficial uses in these watersheds. These three watersheds also contribute freshwater to the greater LA/LB Harbor waters, primarily the LA River Estuary and eastern San Pedro Bay.

2 Problem Statement

The waters of Dominguez Channel, Dominguez Channel estuary, Torrance Lateral Channel (sometimes referred to as Torrance Carson Channel), Los Angeles and Long Beach Harbors (including Inner and Outer Harbor, Main Channel, Consolidated Slip, Southwest Slip, Fish

Harbor, Cabrillo Marina, Inner Cabrillo Beach), San Pedro Bay and Los Angeles River Estuary are impaired by heavy metals and organic pollutants. More specifically, each of these water bodies are included on the 303(d) list for one or more of the following pollutants: cadmium, chromium, copper, mercury, lead, zinc, chlordane, dieldrin, toxaphene, DDT, PCBs, and certain PAH compounds. These impairments may exist in one or more environmental media—water, sediments or tissue. This section provides an overview of water quality criteria and guidelines applicable to the above waterbodies and reviews the fish tissue, and sediment and water quality data compiled for the purpose of these TMDLs.

2.1 Environmental Setting

This report addresses water quality in Dominguez Channel and waters associated with greater Los Angeles and Long Beach Harbor ("greater Los Angeles and Long Beach Harbor waters"). Specifically, the greater Los Angeles/Long Beach Harbor waters include Inner and Outer Harbor, Consolidated Slip, Fish Harbor, Cabrillo Marina, Inner Cabrillo Beach, Los Angeles River estuary, and San Pedro Bay (Figure 2-1). Dominguez Channel includes the Dominguez Channel Estuary and Torrance Lateral Channel (Figure 2-2).

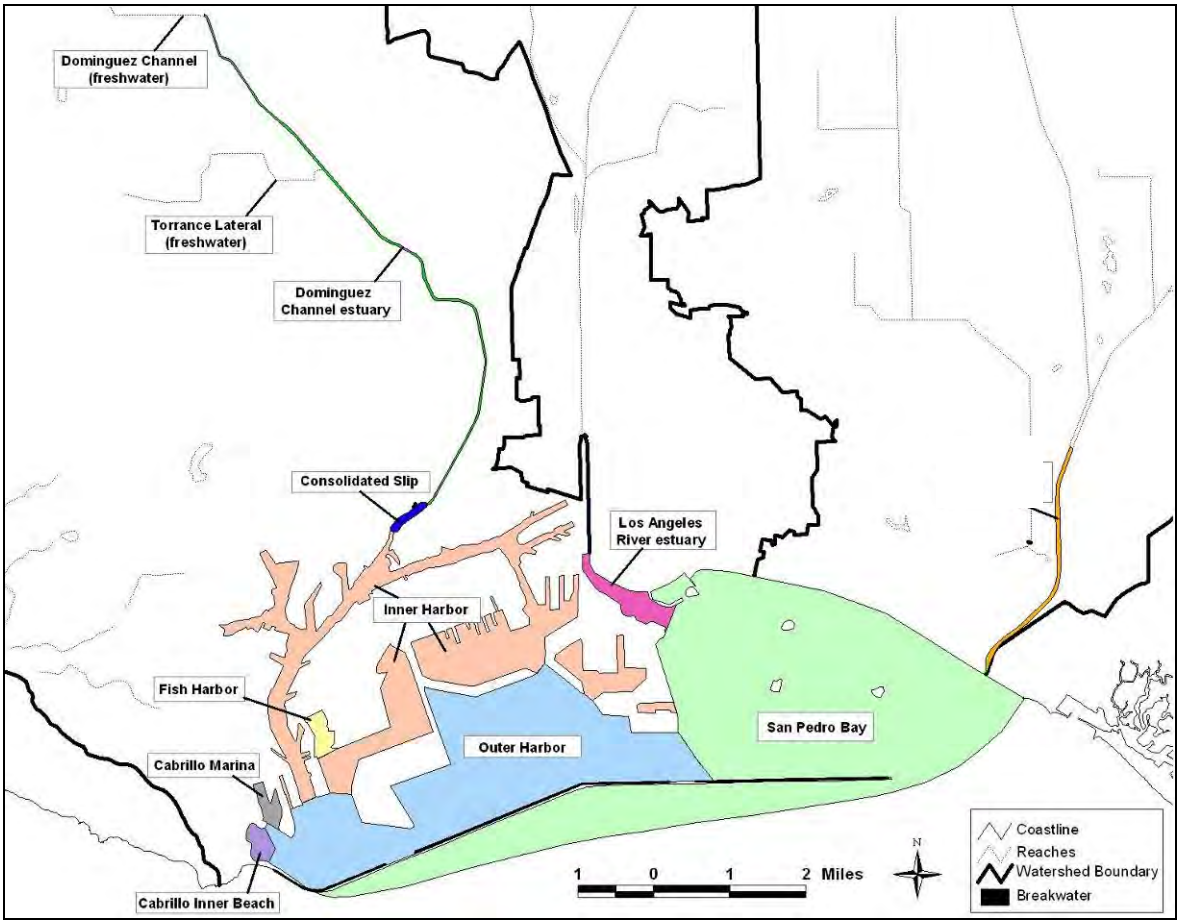


Figure 2-1. Dominguez Channel and greater Los Angeles and Long Beach Harbor waters.

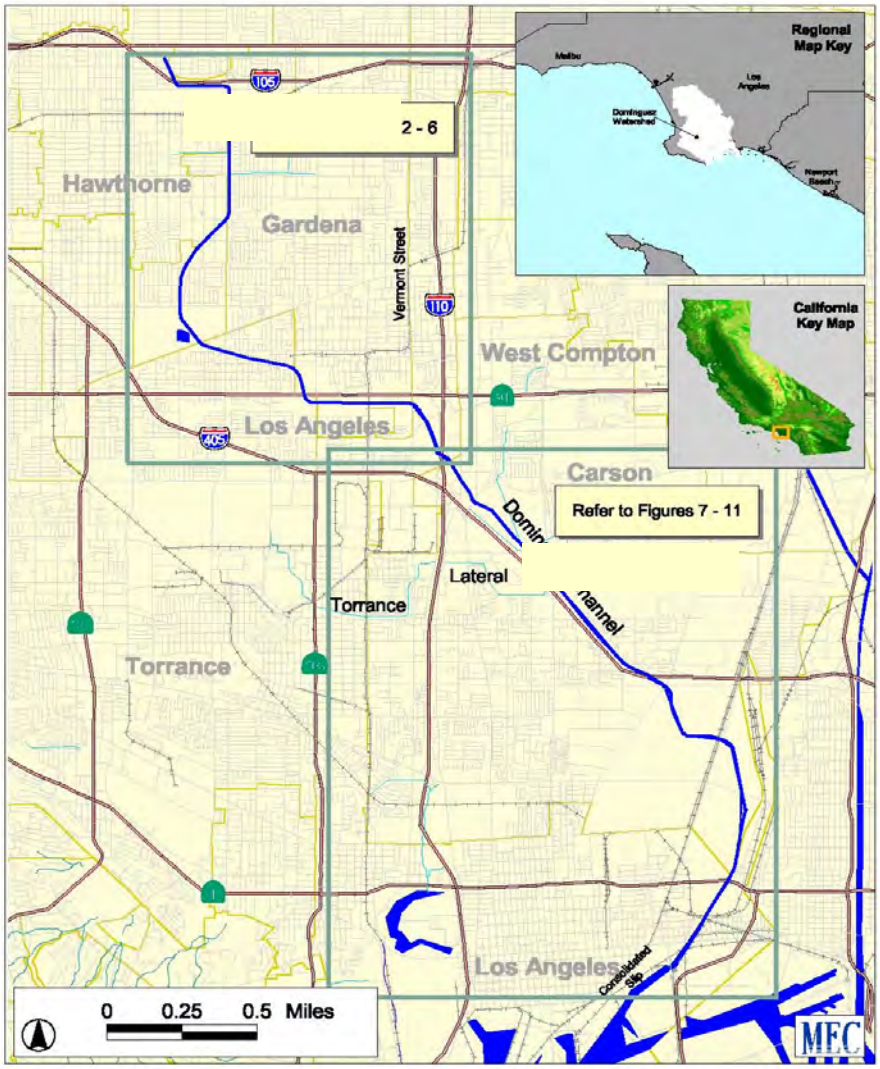


Figure 1. Dominguez Channel Vicinity Map.

Figure 2-2. Dominguez Channel sub-watershed areas
(Source: MEC Analytical; note: boxes in the figure refer to additional figures within the original MEC Analytical report)

2.1.1 Watersheds and Land Use

The watershed of the Dominguez Channel and the Los Angeles and Long Beach Harbors is an important industrial, commercial and residential area with unique and important historical and environmental resources. The area includes 21 municipalities within and including Los Angeles County and roughly 1 million residents. Prior to its development, the area was largely marshland and now almost no wetland or original coastline exists. Water quality decreased with increased

development in the 1970s. Since then, the water quality has improved but there are still significant water quality and sediment quality challenges.

The ports of Los Angeles and Long Beach occupy over 10,500 acres of land and water. The Inner Harbors contain piers for ship loading and unloading and several marinas. The outer part of both harbors (the greater San Pedro Bay) has been less disrupted than the inner areas and supports a great diversity of marine life. It is open to the ocean at its eastern end and receives much greater ocean flushing than inner harbor areas.

San Pedro Bay receives the discharges of the Dominguez Channel, Los Angeles and San Gabriel Rivers, although the latter two watersheds are not the focus of these TMDLs. (Machado Lake also may contribute intermittent flows to the Inner Harbor and is also not a focus of this TMDL.) The Los Angeles River is largely treated wastewater flow and the watershed is 834 square miles, 66% developed. The San Gabriel River is 689 square miles (including the Los Cerritos Channel and Alamitos Bay) and is largely developed in the downstream end.

The Dominguez Channel Watershed drains an area of approximately 133 square miles in southwestern Los Angeles. The watershed is composed of two hydrologic subunits. The two subunits drain primarily via an extensive network of underground storm drains. The northern subunit drains into the Dominguez Channel while the southern subunit drains directly into the Los Angeles and Long Beach Harbor Area. The headwaters of the Dominguez Channel consist of an underground storm drain system which daylights approximately 0.25 miles north of the Hawthorne Municipal Airport. The Dominguez Channel drains approximately 62 percent of the watershed before discharging to Los Angeles Harbor. Land use for Dominguez Channel is shown in Table 2-1.

As documented in the Los Angeles County Department of Public and Work (LA Co DPW) Integrated Report (1994-2005), the Dominguez Channel watershed is dominated by urban land uses such as residential, industrial, commercial and transportation, which comprise as much as 85% of the land area. Very little vacant and open space areas are present in the watershed. The watershed is approximately 60% impervious based on assumptions of impervious areas in each land use type. The highest population density in the watershed appears to be in communities of Inglewood and Hawthorne.

The Dominguez Channel and the Los Angeles and Long Beach Harbors watershed has a Mediterranean climate with an average of approximately 14 inches of rain per year, most of it during the winter season. LA Co DPW maintains a water sampling mass emission station, S28, in the Dominguez Channel near the center of the watershed area. At this station in 2004-2005 all daily rainfall totals were below 2.5 inches. The wettest period was in late December and early January.

There are many permitted discharges to the watershed. There are approximately 60 active, individual NPDES permitted discharges to the Dominguez Channel and to the Los Angeles and Long Beach Harbors. These include four refineries that discharge to the Dominguez Channel, two generating stations that discharge to the inner harbor areas and the Terminal Island Water Reclamation Plant (TIWRP). The Terminal Island Treatment Plant discharges secondary-treated

effluent to the Outer Harbor and this POTW is under a time schedule order to eliminate their discharge into surface waters. In addition, there are approximately 50 active, general NPDES permitted discharges to the watershed.

Table 2-1. Land Use by Subwatershed Area for Dominguez Channel Watershed

Land Use Type*	Area
Agricultural	1%
Industrial	17%
Mixed Use	1%
Open Space/Recreation	3%
Residential	41%
Retail/Commercial	14%
Transportation	13%
Vacant	4%
Water	6%
Total	100%

* source: LACDPW integrated 1994-2005 report.

Habitats:
A number of fresh and marine habitat types are included in the TMDL area.

The Freshwater habitat areas of Upper Dominguez Channel are concrete lined and offer minimal habitat value at this time. The Torrance Lateral and other tributary channels, 132nd and 135th Street Drains, Del Amo Laterals, and Victoria Creek, are also freshwater and concrete-lined.

From Vermont Street downstream to Los Angeles Harbor, Dominguez Channel has a soft-bottom with riprap banks, and is estuarine.

Within the Harbor areas and San Pedro Bay the habitats are marine and include shallow water habitat, deeper habitat, some beach areas and small wetland areas. A small, man-made wetland (approx. 5 acres), “Salinas de San Pedro” extends about 650 feet north along waterfront on northern Cabrillo Beach.

Shallow water habitat, some man-made during 1999-2000 as part of the Port of Los Angeles’ Outer Harbor Channel Deepening and Pier 400 Construction Project occurs within the outer harbor and supports some kelp habitat. The Harbors also include extensive soft bottom areas and eelgrass beds. The ship channels in the Harbors are deeper and maintained by dredging.

Birds:
Over 100 species of birds occupy habitats in the Port of Los Angeles and Port of Long Beach, including three species that are listed as Threatened or Endangered by either the State or federal government [California least tern (*Sterna antillerum browni*), Western Snowy Plover (*Charadrius alexandrinus nivosus*) and Peregrine Falcon (*Falco pereginus anatum*)]. At least 18 bird species nest in the Port area. Birds that use Inner Cabrillo Beach include gulls and pigeons

as well as seasonal snowy plovers, Caspian terns, least terns, black skimmers, Forster's terns, brown pelicans, great blue herons, sanderlings, western and least sandpipers, willets western, Clark's, and eared grebes, cormorants, occasional loons and ducks (S. Vogel, Cabrillo Marine Aquarium, personal communication).

Fish:
Over 70 species of fish have been noted in the Harbor. From 1993 to 2001 trawls for fish in the Los Angeles Harbor by the City of Los Angeles Environmental Monitoring Division, typically found 20 or 30 fish species, dominated by white croaker (*Genyonemus lineatus*), queenfish (*Seriphus politus*), California tonguefish (*Symphurus atricauda*), and Pacific sanddab (*Citharichthys stigmaeus*) (City of Los Angeles, 2002; 2001; 2000; 1999a; 1998; 1997; 1996). Ports Biological Baseline Study (2000) reported the following fish by mass abundance: Northern anchovy, white croaker, queenfish, topsmelt, specklefin midshipman, speckled sanddab, Pacific sardine, shiner surfperch, white surfperch, and salema. California halibut and barred sandbass had moderate abundance. In beach seines on Inner Cabrillo Beach, commonly caught fish include surfperch, topsmelt, jacksmelt, pipefish and flatfish. In addition, there are grunion runs on the Inner and Outer Cabrillo Beaches from March through July (S. Vogel, Cabrillo Marine Aquarium, personal communication).

Invertebrates:
Over 400 species of invertebrates have been noted in the Harbor. From 1993 to 2001 trawls for invertebrates in the Los Angeles Harbor by the City of Los Angeles Environmental Monitoring Division, were dominated by blackspotted bay shrimp (*Crangdon nigromaculata*), American spider crab (*Pyromaia tuberculata*) and New Zealand cephlaspidian (*Philine auriformis*) (City of Los Angeles, 2002; 2001; 2000; 1999a; 1998; 1997; 1996).

Mammals:
Los Angeles Harbor is used by California sea lions (*Zalophus californianus*) and occasionally harbor seals, elephant seals, dolphins and gray whale calves (S. Vogel, Cabrillo Marine Aquarium, personal communication).

2.2 Water Quality Standards

California state water quality standards consist of the following elements: 1) beneficial uses; 2) narrative and/or numeric water quality objective (WQOs); and 3) an antidegradation policy. In California, beneficial uses are defined by the Regional Boards in the Water Quality Control Plans (Basin Plans). Numeric and narrative objectives are also specified in each region's Basin Plan. The objectives are set to be protective of the beneficial uses in each water body in the region and/or to protect against degradation. Numeric objectives for toxics in water can be found in the California Toxics Rule (40 CFR §131.38).

2.2.1 Beneficial Uses

The first part of California water quality standards is beneficial uses. The Basin Plan for the Los Angeles Regional Board (1994) defines beneficial uses for Dominguez Channel and greater Los Angeles/Long Beach Harbor waters (Table 2-2).

Table 2-2. Beneficial Uses of Dominguez Channel and greater Los Angeles/Long Beach Harbor waters (LARWQCB, 1994)

303(d) list waterbody	Basin Plan waterbody (Hydo # 405.12)	MUN	NAV	IND	REC1	REC2	COMM	WARM	EST	MAR	WILD	RARE	MIGR	SPWN	SHELL	WET
Dominguez Channel fresh Torrance Lateral	Dominguez Channel to Estuary	P			Ps	E		P			P	E				
Dominguez Channel Estuary	Dominguez Channel Estuary		P		Es	E	E		E	E	E	Ee	Ef	Ef		
Consolidated Slip Inner Harbor Fish Harbor	Los Angeles Long Beach Harbor All Other Inner areas		E	E	E	E	E			E		Ee			P	
Cabrillo Marina	Los Angeles Long Beach Harbor Marinas		E	E	E	E	E			E		E			P	
Inner Cabrillo Beach	Los Angeles Long Beach Harbor Public Beach areas		E		E	E	E			E	E	E		E	E	
Los Angeles River Estuary	Los Angeles River Estuary		E	E	E	E	E		E	E	E	Ee	Ef	Ef	P	E
Outer Harbor San Pedro Bay	Los Angeles Long Beach Harbor Outer Harbor		E		E	E	E			E		E			P	

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

Greater Los Angeles and Long Beach Harbor waters have designated uses to protect aquatic life including the marine (MAR) and rare, threatened or endangered species habitat (RARE). There are also beneficial uses associated with human use of these waters, including recreational use for water contact (REC1), non-contact water recreation (REC2), navigation (NAV), industrial service supply (IND), commercial and sport fishing (COMM), and shellfish harvesting (SHELL). The estuaries (EST) are recognized as areas for spawning, reproduction and/or early development (SPWN), migration of aquatic organisms (MIGR) and wildlife habitat (WILD). Dominguez Channel also has an existing designated use of warm freshwater habitat (WARM) and the Los Angeles River estuary has the designated use of wetland habitat (WET).

2.2.2 Water Quality Objectives (WQOs)

The second part of California water quality standards is water quality objectives. As stated in the Basin Plan, water quality objectives (WQOs) are intended to protect the public health and welfare and to maintain or enhance water quality in relation to the designated existing and potential beneficial uses of the water. The Basin Plan specifies both narrative and numeric water quality objectives. The following narrative water quality objectives are the most pertinent to this TMDL. These narrative WQOs may be applied to both the water column and the sediments.

> Chemical Constituents: *Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.*
>
> Bioaccumulation: *Toxic pollutants shall not be present at levels that will bioaccumulate in aquatic life to levels, which are harmful to aquatic life or human health.*
>
> Pesticides: *No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. There shall be no increase in pesticide concentrations found in bottom sediments or aquatic life.*
>
> Toxicity: *All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.*

The Regional Board's narrative toxicity objective reflects and implements national policy set by Congress. The Clean Water Act states that, "it is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited." (33 U.S.C. 1251(a)(3).) In 2000, USEPA established numeric water quality objectives for several pollutants addressed in this TMDL in the California Toxics Rule (CTR) (USEPA, 2000b). The CTR establishes numeric aquatic life criteria for 23 priority toxic pollutants and numeric human health criteria for 92 priority toxic pollutants. These criteria are established to protect human health and the environment and are applicable to inland surface waters, enclosed bays and estuaries.

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

In the CTR, freshwater and saltwater criteria for metals are expressed in terms of the dissolved fraction of the metal in the water column. These criteria were calculated based on methods in USEPA's *Summary of Revisions to Guidelines for Deriving Numerical National Water Quality*

dCriteria for the Protection of Aquatic Organisms and Their Uses (50 FR 30792, July 29, 1985), developed under Section 304(a) of the CWA. This methodology is used to calculate the total recoverable fraction of metals in the water column and then appropriate conversion factors, included in the CTR are applied, to calculate the dissolved criteria.

The human health criteria are established to protect the general population from priority toxic pollutants regulated as carcinogens (cancer-causing substances) and are based on the consumption of water and aquatic organisms or aquatic organisms only, assuming a typical consumption of 6.5 grams per day of fish and shellfish and drinking 2.0 liters per day of water. Table 2-3 summarizes the aquatic life, and human health criteria for metals and organic constituents, covered under this TMDL.

Table 2-3. Water quality standards established in the CTR for metals and organic compounds

Pollutant	Criteria for the Protection of Aquatic Life		Criteria for the Protection of Human Health	
	Saltwater			
	Acute (µg/L)	Chronic (µg/L)	Water & Organisms (µg/L)	Organisms only (µg/L)
Cadmium	42	9.3		
Copper	4.8	3.1	1300	
Chromium VI	1100	50		
Lead	210	8.1		
Nickel	74	8.2	610	4600
Selenium	290	71		
Silver	1.9	n/a		
Zinc	90	81		
Chlordane	0.09	0.004	0.00057	0.00059
Dieldrin	0.71	0.0019	0.00014	0.00014
4,4'-DDT[1]	0.13	0.001	0.00059	0.00059
Total PCBs[2]		0.014	0.00017	0.00017
Benzo[a]pyrene			0.0044	0.049

[1]Based on total DDT, the sum of all isomer analyses.
[2]Based on total PCBs, the sum of all congener or isomer or homolog or aroclor analyses.

For PCBs, the aquatic life values in the Basin Plan are the same as in the CTR. For PCBs, the human health values are not the same. The Basin Plan human health value for PCBs is based only on the sum of Aroclor analyses; however the CTR human health value (0.17 ng/L) is for total PCBs and is applicable and more stringent since it is calculated as sum of all congener, or isomer, or homolog or Aroclor analyses.

There are no numeric standards for fish tissue in the Basin Plan or CTR. However, the human health criteria in the CTR were developed to ensure that bioaccumulative substances do not concentrate in fish tissue at levels that could impact human health.

There are no sediment quality objectives in the Basin Plan or CTR. The Regional Board applied best professional judgment to define elevated values for metals in sediment during the water

quality assessments conducted in 1996, 1998, and 2002. During the water quality assessments for 2006, assessments of sediments for metals and organics followed the sediment quality guidelines in the Functional Equivalent Document for the California Listing policy "Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List." These guidelines were also used in the assessment of sediment quality for this TMDL (Table 2-4).

Table 2-4. Sediment quality guidelines used for determination of impairment for metals and organic compounds

Pollutant	Marine and Estuarine Sediments			Freshwater Sediments
	Effects Range Median[1]	Probable Effects Level[2]	Other Sediment Quality Guideline	Probable Effect Concentration[3]
METALS				
Cadmium		4.21 µg/g dw		4.98 mg/kg dw
Copper	270 µg/g dw			149 mg/kg dw
Chromium	370 µg/g dw			111 mg/kg dw
Lead		112.18 µg/g dw		128 mg/kg dw
Nickel				48.6 mg/kg dw
Selenium				
Silver		1.77 µg/g dw		
Zinc	410 µg/g dw			459 mg/kg dw
ORGANICS				
Chlordane	6 ng/g dw[4]			17.6 µg/kg dw
Dieldrin	8 ng/g dw			61.8 µg/kg dw
Total DDT			590*	572 µg/kg dw
Total PCBs	180 ng/g dw		400 ng/g[5]	676 µg/kg dw
Total PAHs			180,000(µg/kg)[8]	22,800(µg/kg)
Benzo[a]pyrene		763.22 ng/g		1450 µg/kg dw
2-methyl-napthalene		201.28 ng/g dw		
Phenanthrene		543.53 ng/g dw		1170 ug/kg dw
Lo MW PAHs		1442 ng/g dw		
Benza[a]anthracene		692.53 ng/g dw		1050 ug/kg dw

[1]Long et al. 1995 dw = Dry Weight
[2]MacDonald et al., 1996
[3]MacDonald et al., 2000a
[4]Long and Morgan, 1990
[5]MacDonald et al., 2000b
[8]Fairey et al., 2001
Freshwater and saltwater SQG values from CA listing policy, FED pg. 122-123
*marine DDT value from EPA Superfund Risk Assessment (1994)

The California Water Quality Control Board has set a State policy, *The State Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality* (SQO Part 1), for evaluation of sediments by the interpretation and integration of multiple lines of evidence called the sediment "triad": Application of the SQO Part 1 results in assessed sediments being categorized as Unimpacted, Likely Unimpacted, Inconclusive, Possibly Impacted, Likely

Impacted, or Clearly Impacted. The sediment categories of **Unimpacted** and **Likely Unimpacted** are the protective conditions and meet the narrative objective.

2.2.3 Antidegradation

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

2.3 Impairments Identified in 303(d) lists

The waters of the Dominguez Channel and the Ports of Los Angeles and Long Beach in the San Pedro Bay, addressed by this TMDL, are impaired due to a variety of toxic pollutants, including metals, organic compounds, and sediment toxicity. In addition, certain waterbodies show impairment to the benthic community.

This section reviews the 303(d) lists issued by the State of California and USEPA in 1998 (the list to which the consent decree refers) (Table 2-5), 2002, 2006 (Table 2-6) and 2008/2010 (Table 2-7) which establish the impairments.

The consent decree provides that TMDLs need not be completed for specific water body by pollutant combinations if the State or EPA determines that TMDLs are not needed for these combinations, consistent with the requirements of Section 303(d). The consent decree provides that this determination may be made either through a formal decision to remove a combination from the State Section 303(d) list or through a separate determination that the specific TMDLs are not needed. The September 2010 modification of the consent decree included a finding of non-impairment for copper and lead in Wilmington Drain; these impairments will also be removed from the 303(d) list when sufficient data is available to de-list in accordance with the State Listing Policy

For the 2006 303(d) list, the State of California made several changes in water body-pollutant listings for water in Dominguez Channel and greater Los Angeles and Long Beach Harbor waters. Clarification was provided such that individual PAH compounds were listed as opposed to the general category of polyaromatic hydrocarbons (PAHs). Some areas changes also occurred. In addition, EPA proposed some additions to the State's 2006 list. Table 2-6 provides the waterbody-pollutant combinations for the 2006 list.

Table 2-5. 1998 303(d) list of metal and organic compound impairments, shown here by analytical units as defined in consent decree.

Water body name	Tissue	Sediment
Analytical Unit #73		
Dominguez Channel freshwater	Aldrin*, Chem A* Chlordane*, Dieldrin* DDT*, PCBs*	
Dominguez Channel estuary	Aldrin*, Chem A* Chlordane, Dieldrin DDT, PCBs	Benthic community effects
Consolidated Slip	Chlordane, Dieldrin DDT, PCBs,	Toxicity, benthic community effects
Inner Harbor	DDT, PCBs	Toxicity
Main Channel	DDT, PCBs	Toxicity
SouthWest Slip	DDT, PCBs	Toxicity
Fish Harbor	DDT, PCBs	Toxicity
Long Beach Harbor	DDT, PCBs	Toxicity, benthic community effects
Cabrillo Beach-Inner	DDT, PCBs	Toxicity
San Pedro Bay	DDT, PCBs	Toxicity
Los Angeles River Estuary	DDT, PCBs	Toxicity
Machado Lake **	DDT, PCBs	
Analytical Unit #74		
Dominguez Channel freshwater		PAHs
Dominguez Channel estuary		PAHs
Consolidated Slip		PAHs
Inner Harbor		PAHs
Main Channel		PAHs
Fish Harbor		PAHs
Long Beach Harbor		PAHs
San Pedro Bay		PAHs
Analytical Unit #75		
Torrance Lateral Channel		Cu, Pb
Wilmington Drain *		Cu, Pb
Dominguez Channel freshwater		Cr, Cu, Pb, Zn
Dominguez Channel estuary		Cr, Cu, Pb, Zn
Consolidated Slip		Cr, Pb, Zn
Inner Harbor		Cu, Zn
Main Channel		Cu, Zn
Fish Harbor		Cu, Zn
Analytical Unit #78		
San Pedro Bay		Cr*, Cu*, Zn*

* Pollutants marked are removed from the 303(d) list. Therefore, this TMDL will not address these.
** Machado Lake and Wilmington Drain will not be addressed in these TMDLs.

Table 2-6. 2006 final 303(d) list of individual pollutant impairments by water body.

Water body name	Tissue	Sediment
Dominguez Channel freshwater	Pb, Dieldrin	Zn, Cu Toxicity
Torrance Lateral		Cu, Pb
Dominguez Channel estuary	Chlordane, Dieldrin DDT, Pb	DDT, PCBs, Zn benthic community effects Benzo[a]anthracene, Benzo[a]pyrene, Chrysene, Phenanthrene, Pyrene
Consolidated Slip	Chlordane, Dieldrin DDT, PCBs, toxaphene	Chlordane, DDT, PCBs Cd, Cr, Cu, Hg, Pb, Zn Toxicity, benthic community effects Benzo[a]anthracene, Benzo[a]pyrene, Chrysene, Phenanthrene, Pyrene, 2-methylnaphthalene
Inner Harbor*	DDT, PCBs	Cu, Zn, Toxicity, benthic community effects
Fish Harbor	DDT, PCBs	Cu, Hg, Pb, Zn Chlordane, DDT, PCBs Benzo[a]anthracene, Benzo[a]pyrene Chrysene, Dibenz[a,h]anthracene, Phenanthrene, Pyrene, PAHs, Toxicity
LA Harbor—Cabrillo Marina	DDT, PCBs	
LA Harbor—Inner Cabrillo Beach	DDT, PCBs	Cu
Outer Harbor*	DDT, PCBs	Toxicity
San Pedro Bay	DDT, PCBs	Chlordane, PAHs, Cr, Cu, Zn, Toxicity
Los Angeles River Estuary	--	Chlordane, toxicity DDT, PCBs, Pb, Zn

*Inner Harbor area changes made in 2006, includes Southwest Slip and portions of Main Channel, as well as portions of Los Angeles and Long Beach Harbor. Also Long Beach Harbor area changes were made in 2006, redefined into Inner and Outer Harbor (see Figure 2-1).

The final 2008/2010 303(d) list was approved by EPA on November 12, 2010. Several additional additions and deletions were made based on newer data. Table 2-7 provides the waterbody-pollutant combinations for the 2008/2010 list.

Table 2-7. 2008/10 final 303(d) list of individual pollutant impairments by water body.

Water body name	Tissue	Sediment
Dominguez Channel freshwater		Cu, Pb, Zn Diazinon
Torrance Lateral		Cu, Pb
Dominguez Channel Estuary	Chlordane, Dieldrin DDT, Pb	DDT, PCBs, Zn, benthic community effects Benzo[a]anthracene Benzo(a)pyrene Chrysene Phenanthrene Pyrene Toxicity
Consolidated Slip	Chlordane, Dieldrin DDT, PCBs Toxaphene	Chlordane DDT PCBs Cd, Cr, Cu, Hg, Pb, Zn, Toxicity, Benthic Community Effects Benzo[a]anthracene Benzo(a)pyrene Chrysene Phenanthrene Pyrene 2-Methylnapthalene
Inner Harbor	DDT, PCBs	Cu, Zn, Toxicity Benthic Community Effects Benzo(a)pyrene Chrysene
Fish Harbor	DDT, PCBs	Cu, Hg, Pb, Zn Chlordane, DDT, PCBs Benzo[a]anthracene Benzo(a)pyrene Chrysene Dibenz[a,h]anthracene Phenanthrene *PAHs (Polycyclic Aromatic Hydrocarbons)* Phenanthrene Pyrene, Toxicity
Los Angeles Harbor – Cabrillo Marina	DDT, PCBs	Benzo(a)pyrene
Los Angeles Harbor –Inner Cabrillo Beach	DDT, PCBs	
Outer Harbor	DDT, PCBs	toxicity
San Pedro Bay Near/Off Shore Zones	DDT, PCBs	Chlordane Toxicity
Los Angeles River Estuary		Chlordane, Toxicity, DDT, PCBs

2.4 Data Review/Impairments identified for this TMDL

This section summarizes available monitoring data for Dominguez Channel and greater Los Angeles and Long Beach Harbor waters for the listed pollutants in water, fish and sediments. This section includes more recent data than the listing data, in some instances, and provides more detail in terms of whether impairments are in water, tissue or sediment. The summary includes water quality, fish tissue, and sediment quality data from various monitoring sources, for the period of 1992 to 2010. Thus, the assessment and problem statement sections of this document more accurately reflect current water quality conditions in Dominguez Channel and greater Los Angeles and Long Beach Harbor waters.

2.4.1 Assessment methodology

In general, the protocols used for this assessment are consistent with those outlined in the State's 303(d) listing policy (SWRCB 2004). The benchmarks used in this assessment are consistent with those identified in the policy's supporting Functional Equivalency Document (FED) document. The state's policy was developed by the State for purposes of water quality assessments, and the State applied this policy to develop its decisions for the 2006 and 2008/2010 303(d) lists. In addition, EPA added waterbodies and pollutants to the State's list in 2006.

This assessment builds on the data record evaluated by the State and compiled in the 2006 and 2008/2010 303(d) list factsheets; it also includes more recent information. This more detailed analysis is consistent with procedures provided in the State's Impaired Waters Guidance (SWRCB, 2005) to produce an assessment more accurately reflecting current water conditions.

As described above, this assessment is generally consistent with protocols and benchmarks provided in the State's 303(d) listing policy and supporting (FED) document. For example, this assessment used the same benchmarks for comparison to determine exceedences; e.g., water quality objectives from CTR, sediment quality guideline values and OEHHA fish tissue screening values from the policy's FED. One exception (discussed below) is that this assessment used a sediment chemistry benchmark for DDT, whereas the listing policy did not include a media-pollutant specific value.

Important sources of new data include: Bight 2003 study, recent Los Angeles County MS4 monitoring, City of Los Angeles (TIWRP) Harbor monitoring, Port of Los Angeles (POLA) Prop 13 studies, Port of Long Beach (POLB) water monitoring and POLA/POLB TMDL monitoring of 2006 and some SCCWRP studies. The complete list of data reviewed is provided in Table 2-8. All recent data are final and have received some QA/QC review, thus data are viable for assessment.

Table 2-8. Water Quality, sediment and fish data reviewed for this assessment.

ID	Data Source	Data record	Spatial scope	Sample media
5	POLA/POLB Sediment survey	2006	Greater Los Angeles/Long Beach Harbor waters	Sediment, porewater, overlying water
3	POLB water data	2006	Inner Harbor	Water
8	SCCWRP	2006	Consolidated Slip	Sediment, porewater, overlying water
		2006	Dominguez Channel estuary	Air
4	POLA Prop. 13 POLA water data	2004—2006	Dominguez Channel estuary, Consolidated Slip, Inner Harbor	Water
		2004—2006	Consolidated Slip, Inner Harbor	Water
11	Bight '03	2003	greater Los Angeles/Long Beach Harbor waters	Sediment
21	LA RWQCB SWAMP	2003	Dominguez Channel freshwater	Water
7	SCCWRP DDE Inventory	2003	So. Calif. Bight and LA Harbor	Water
18	SCCWRP	2002-03	Dominguez Channel freshwater	Water
10	POLA/AMEC	2002	Consolidated Slip	Fish
13	USEPA Superfund Montrose site	2002 and 1994	Stormwater pathway from site downstream to Consolidated Slip	Sediment DDT
17	POLA Biological baseline	2002 and 2008	Inner & Outer Harbor; San Pedro Bay	Biology
1	LACDPW NPDES MS4	2002—2010	Dominguez Channel freshwater	Water
19	ACTA 2001	2000-01	Dominguez Channel estuary	Mussels
6	City of LA BOS TIWRP	1999-2004	Outer Harbor	Sediment, Fish; Water in 2002-03
16	Oil Refineries NPDES	1998-2004	Dominguez Channel estuary	Sediment
2	POLB stormwater NPDES data	1996—2005	LB Harbor	Water
20	LACSD	1995—2004	San Gabriel River Estuary	Water, Sediments
9	CSTF sediment database	1988-2001	greater Los Angeles/Long Beach Harbor waters	Sediment, Fish
14	NOAA status & trends data	1986—1998	Outer Harbor and San Pedro Bay	Mussels
15	TSMP	1978—2000	Dominguez Channel estuary	Fish
14	SMW	1977—2000	Inner & Outer Harbor	Mussels
12	OEHHA	1991	So. Calif. Bight	Fish
	OEHHA/CFCP	1999 & 2000	San Pedro Bay, Belmont Pier	Fish

note: numbered data sources are discussed further below.
POLA – Port of Los Angeles, POLB – Port of Long Beach

2.4.2 Water Column

2.4.2.1 1. LACDPW NPDES MS4 Los Angeles County Department of Public Works - Freshwater Dominguez Channel

Los Angeles County Department of Public Works (LACDPW) collects samples at the Dominguez Channel mass emissions monitoring station (S28), which is above tidal influence. The upper portion of Dominguez Channel contains freshwater down to Artesia Blvd. S28 is in a concrete-lined, rectangular channel. LACDPW monitoring results from this site provides data for both wet and dry weather.

Metals data was reviewed for both wet and dry weather. All metal data were compared to sample-specific hardness adjusted CTR standards. From 2002 to 2010, CTR criteria for dissolved metals were exceeded in wet weather for copper, lead and zinc: Cu, 29 exceedances out of 35wet weather samples; Pb: 16 exceedances of 35 and Zn: 27 exceedances out of 35. While pre-2005 Pb results contain some uncertainty because the lab reporting limit (5 ug/L) was occasionally above the hardness specific Pb criteria, Pb results as of 2004 -2010 were reliably assessed, since the method detection limit was lowered to 0.5 ug/L at that time. In dry weather, no dissolved exceedences were observed for these three metals. In addition, no exceedences were observed for dissolved cadmium, chromium, mercury, nickel, selenium and silver in wet or dry weather.

Also, water column toxicity was repeatedly observed at S28 monitoring station from 2002 to 2010. Chronic *Ceriodaphnia dubia* tests showed inhibited survival during wet weather events in 2002, 2003 and 2005. *C. dubia* tests also showed inhibited reproductive success in the same timeframe. Toxic responses occurred in 6 of 14 wet weather sampling events during this timeframe. Dry weather results showed only one toxic result in 14 sampling events. Few water toxicity identification evaluation (TIE) studies have been performed to identify the category of causative agent(s). TIEs in 2003-04 indicated some volatile organic compounds may have caused toxicity; whereas 2002-03 TIEs indicated toxicity may be due to one or more non-polar organic compounds, cationic metals, and/or metabolically-activated organophosphates.

Five of 21 samples collected as part of the Los Angeles County Stormwater monitoring program exceeded the chronic DFG fresh water hazard assessment criteria for diazinon (three of which also exceeded the acute criteria) for the protection of aquatic life. Trend analysis of sample results collected over 8 years, showed that diazinon levels were below the DFG criteria after 2005, this is concurrent with EPA's deadline to ban on urban use of this pesticide. While toxicity is apparent in Dominguez Channel freshwater after 2005, it does not appear attributable to elevated diazinon.

Torrance Lateral

Torrance Lateral is a sub-watershed within the larger Dominguez Channel watershed that flows directly into Dominguez Channel Estuary (approx. 2 miles below S28). Recently Los Angeles County DPW completed more monitoring within Torrance Lateral as part of the Dominguez Channel tributary study (LAC DPW, 2009; 2010). Torrance Lateral refers to waters upstream of confluence with Dominguez Channel, consistent with LAC DPW sampling site TS19. Available

water column results (2008 & 2009) reveal exceedences of dissolved copper (8 of 10) and zinc (9 of 10) CTR criteria during wet weather conditions. Dissolved lead was below the criteria in wet weather conditions and no dry weather exceedences occurred for any of these three metals. Currently there is no flow gauge associated with stream flows within Torrance Lateral, thus the daily storm volume or load duration approach can not apply.

2.4.2.2 2. POLB stormwater NPDES data Port of Long Beach—Inner Harbor (mid-water column)

Port of Long Beach has collected ambient samples from one site (3RW) within Long Beach Harbor. Available data from 1996 to 2005, include only total recoverable metals. Careful review of these ambient results, revealed some possible QA/QC concerns that require further clarification prior to assessment. Most notably, results from dates prior to and including 2002 are much higher than those reported from 2003 to present. These results will not be included in the assessment of Inner Harbor waters until the QA issues have been resolved.

2.4.2.3 3. POLB water data

In 2006, POLB performed one sampling event with numerous sites within the Inner Harbor. All samples were below criteria. Results are summarized in Table 2-9.

Table 2-9. Water column dissolved metal results from Port of Long Beach—Inner Harbor (2006).

Pollutant	Detection Limit	# of detections	Conc. Range (ug/L)	CTR chronic saltwater objective (ug/L)
Cadmium	0.005	14	0.01 – 0.06	9.3
Copper	0.01	14	0.28 – 1.41	3.1
Lead	0.005	14	0.10 – 0.07	8.1
Mercury	0.005	14	<0.01	0.05¥
Nickel	0.005	14	0.19 – 0.39	8.2
Silver	0.02	14	<0.02	1.9*
Zinc	0.005	14	0.58 – 3.81	81

*silver value is acute criterion; ¥mercury value is human health criterion

2.4.2.4 4. POLA water data Port of Los Angeles—various Harbor waters (mid-water column)

Port of Los Angeles (POLA) currently has a monitoring program which obtains monthly samples for conventional parameters (DO, pH, TSS) at fixed stations which began in 2003. In 2005, POLA collected extra samples for an enhanced suite of analytes; i.e., metals and priority organics during two sampling events. Waterbodies sampled included Inner and Outer Harbor, Fish Harbor, Consolidated Slip, Cabrillo Marina and Inner Cabrillo Beach. Results for the two enhanced suite events are presented in Table 2-10 and compared with CTR chronic criteria.

Table 2-10. Water column data (2005) for POLA Inner, Fish and Outer Harbor.

Pollutant	Detection Limit	# of sites	Conc. Range (ug/L)	CTR chronic saltwater objective (ug/L)
Cadmium*	0.005	22	0.015 – 0.104	9.3
Copper*	0.01	22	0.28 – 3.16	3.1
Lead*	0.005	22	0.02 – 0.834	8.1
Mercury*	0.005	22	0.0005 – 0.0046	0.05¥
Nickel*	0.005	22	0.27 – 0.71	8.2
Silver *	0.02	22	0.007 – 0.11	1.9*
Zinc*	0.005	22	3.28 – 58.8	81
totDDT	0.01	22	ND	0.001
totPAHs	0.01	22	0.09 – 0.28	0.049**
totPCBs	0.01	22	ND	0.03

*silver value is acute criterion; ¥mercury value is human health criterion;
** total PAHs CTR criterion is for benzo[a]pyrene, protection of human health (consumption of organisms only).
Dissolved results for metals; unfiltered total results for organics.

POLA has also collected freshwater samples in Dominguez Channel at Artesia, the same site as the mass emission station (S28) maintained by LACDPW. Pollutograph samples were collected by capturing samples at distinct time intervals to evaluate concentration changes over short time frame such as one day. POLA has also collected some Dominguez Channel estuary water samples during wet and dry weather to support hydrodynamic and water quality modeling for the estuary. Results are pending.

2.4.2.5 5. POLA/POLB Sediment survey Ports of Long Beach and Los Angeles—Inner and Outer Harbor (waters overlying sediments)

In fall 2006, POLB and POLA performed a joint monitoring survey of sediments and overlying waters at 60 sites within greater Los Angeles/Long Beach Harbor waters. More description of this survey is provided in the section describing sediment monitoring results. Analytical results for total, unfiltered samples of waters overlying the sediment are summarized in Table 2-11.

Table 2-11. Overlying Water data (2006) for Ports—Inner and Outer Harbor.

Pollutant	Detection Limit	# of detections	Conc. Range (ug/L)	CTR chronic saltwater objective (ug/L)
Cadmium*	0.005	43		9.3
Copper*	0.01	43	0.3 – 3.9	3.1
Lead*	0.005	43	<0.005 – 1	8.1
Mercury*	0.005	43	<0.005	0.05¥
Silver *	0.02	43	<0.02	1.9*
Zinc*	0.005	43	0.4 – 7.1	81
totDDT		43	ND— 0.0043	0.001
totPAHs		43	0.0046 – 0.42	
totPCBs		43	ND	0.03

*silver value is acute criterion; ¥mercury value is human health criterion
All results are total unfiltered samples collected one foot above sediment-water interface.

2.4.2.6 6. City of LA BOS TIWRP- Outer Harbor

City of Los Angeles, Bureau of Sanitation, collects ambient samples in compliance with an NPDES permit for TIWRP. Some water samples were collected as part of the Interim Monitoring Program (IMP) in 2002-03, from station HW50 in the Outer Harbor. The vast majority of these water column results are below the detection limits, however, the detection limits are above the water quality criteria. The metal results have some detections for (presumably) total recoverable metal analytes. Some exceedences of water quality criteria are noted for copper (5-31.5 ppb), lead (11-58 ppb) and silver (6.7-11.6 ppb).
NOTE: These results may require additional investigation regarding appropriate QA/QC for saltwater matrices and potential confounding interferences for accurate instrumental analysis.

2.4.2.7 7. SCCWRP DDE Inventory SCCWRP – Inner & Outer Harbor, San Pedro Bay

SCCWRP has utilized special analytical techniques to obtain measurements of priority organics in the water column at various sites along the Southern California Bight. Special, highly sensitive, solid phase microextraction (SPME) devices were deployed into the water column for sufficient time periods as to yield actual ambient results for DDT and PCBs with extremely low detection levels (sub-ng/L). The initial research efforts measured dissolved phase DDE (metabolite form of parent DDT compound) throughout the Bight (Zeng et al. 2005). Results from four stations within Inner and Outer Harbor waters show elevated levels of DDE in comparison to CTR human health numeric criteria. Total PCB measurements also exceed the CTR human health numeric criteria at these stations. Concentrations of DDE and total PCBs were higher at surface (2 m sub-surface) than those measured in water overlying (2m above) contaminated sediments.

2.4.2.8 8. SCCWRP – Consolidated Slip

In fall 2006, SCCWRP performed repeated sampling at one site in Consolidated Slip. The sampling was designed to obtain chemical measurements of priority organics from sediment, porewater and overlying water to characterize the sediment flux values for the pollutants of concern in the Consolidated Slip. During each of three sampling events, the overlying waters were sampled via in-situ high volume pump to obtain high sample volumes (e.g., 1000+ L) for chemical extraction via PUF methods and to generate lower detection limits. Average results showed elevated levels of total DDT (0.47 ng/L) and total PCBs (0.45 ng/L) in comparison to CTR human health criteria (10^{-6}) for consumption of organisms only. Measured concentration ranges for listed organic compounds are provided in Table 2-12, along with CTR human health criteria.

Table 2-12. SCCWRP (2006) overlying water data for Consolidated Slip.

Pollutant	Detection Limit	# of detections	Conc. Range (ng/L)	CTR Human health (ng/L)
Chlordane total	0.010	3	0.055 – 0.07	0.59
Dieldrin	0.020	3	<0.020	0.59
p,p-DDE*	0.050	3	0.15 – 0.23	0.59
DDT total	0.050	3	0.41 – 0.47	0.59¥
PCBs total	0.020	3	0.37 – 0.43	0.17
Benzo[a]pyrene	0.020	3	0.147 – 0.827	49
Benzo[a]anthracene	0.050	3	0.743 – 1.006	49
Chrysene	0.050	3	0.747 – 1.319	49
Phenanthrene	0.050	3	5.772 – 12.169	n/a
Pyrene	0.050	3	8.670 – 11.173	11,000

2.4.3 Sediment

Several sources provide sediment results for both sediment chemistry as well as sediment toxicity. Data were compiled through the Contaminated Sediments Task Force (CSTF), representing the data record from 1992 to 2001. For Consolidated Slip, there are also sediment results from the EPA Superfund sampling event in 2002, with added analyses by AMEC in contract with the Port of Los Angeles. In addition, for Dominguez Channel freshwater, NPDES-collected data from LA County DPW were analyzed and for Dominguez Channel estuary NPDES-collected data from oil refineries were analyzed.

To assess impacts to sediments, sediment results from the 2006 303(d) list as well as more recent additional data for the waterbodies of concern in these TMDLs were reviewed. The more recent data includes: Bight 2003 study, TIWRP NPDES samples, Los Angeles and Long Beach Harbor's 2006 survey and the SCCWRP sediment flux study in 2006. Below is a brief discussion of each sediment data set to provide general spatial and temporal information.

2.4.3.1 Consolidated Sediment Task Force database (CSTF)

Numerous sediment results have been compiled by SCCWRP into one database (CSTF 2001). The database contains records from numerous sampling events by various monitoring groups/studies. Records from 1992 to 2001, including results from Bay Protection Toxic Cleanup Program (1992, 1994, 1996, 1997), Bight 1998, Western EMAP 1999 and dredge studies were reviewed.

2.4.3.2 Refineries (NPDES)

Oil refineries that discharge process waters into Dominguez Channel are required to collect receiving water samples from within the Channel as part of their NPDES permits. Most years, however, the refineries do not discharge. Sampling sites are located within Dominguez Channel estuary. From 1994 to 2004, sampling frequency has decreased and now occurs only in years when there is a discharge, such as 2005. Analytical detection limits for DDT, PCBs and PAHs were not sufficiently sensitive to allow assessment in comparison to sediment quality guidelines.

For example, results for individual PAH compounds in sediments were expressed as "<0.8mg/kg" in 2003; whereas the State's Listing Policy has identified sediment quality guidelines values (all in dry wt.) for 2-methylnaphthalene (201 µg/kg), phenanthrene (543.5 µg/kg), benzo[a]pryrene (763.2 µg/kg), benzo[a]anthracene (692.5 µg/kg), chrysene (845.9 µg/kg), pyrene (1397.4 µg/kg). Future monitoring efforts will benefit significantly from lower detection limits for comparison with these and other relevant sediment quality guidelines.

2.4.3.3 Terminal Island Water Reclamation Plant (NPDES)

City of Los Angeles Terminal Island Water Reclamation Plant monitors sediment in five locations in Outer Harbor. Sediment chemistry results from 1999-2004 were reviewed.

2.4.3.4 Bight 03—Southern California Bight Regional Monitoring Project

Bight 03 provides an integrated assessment of Southern California coastal estuaries (SCCWRP 2004, 2006). Multiple agencies coordinated to collect samples in summer 2003 which were analyzed for sediment chemistry, toxicity, and benthic community response. The sediment toxicity and bulk chemistry results for stations in the greater Harbor waterbodies have been included in this assessment report relevant to these TMDLs. These sediment chemistry results supplement the sediment data record provided by CSTF and provide review of more recent ambient sediment concentrations.

2.4.3.5 PORTs (POLB & POLA)—sediment survey 2006

In fall 2006, the Ports of Los Angeles and Long Beach performed a monitoring survey of 60 sites in greater Los Angeles/Long Beach Harbor waters. The sampling approach was discussed by both Ports, Regional Board staff, USEPA, SCCWRP and Weston Solutions, and agreed upon as part of a more comprehensive data collection plan to support the TMDL development process. One goal was to characterize contaminant concentrations in sediment, porewater and overlying water. Physical parameters, such as grain size and percent moisture, were also measured to provide ancillary data. Another goal was to reduce uncertainty associated with spatial variability thus sampling occurred at 30 randomly selected sites within each of the Port's jurisdictional areas. A complementary study by SCCWRP (see immediately below) provided additional data at co-located sites. These studies were designed to help characterize site-specific sediment-water flux rates within these greater Los Angeles/Long Beach Harbor waters. To ensure compatibility of all data, both Weston and SCCWRP used the same analytical laboratory, therefore analytical methods and method detection limits were consistent across both programs.

2.4.3.6 SCCWRP—Sediment flux study 2006

In fall 2006, SCCWRP, under separate contract with the Regional Board, performed complementary monitoring to the Port's study described above. One goal was to perform similar matrix sampling of sediment, porewater, overlying waters at one site in the Consolidated Slip and to collect samples at three different times to evaluate individual site variability. Another goal was to co-locate solid phase microextraction (SPME) devices at 11 stations with the Ports' sites to measure organics in waters overlying sediments via a different analytical approach. As mentioned above, the overall goal was to obtain site-specific data for generating sediment-water flux estimates of organochlorines and PAHs at the Consolidated Slip site and then extrapolate

this information to other Harbor sites using other chemical data collected by Ports at the 60 other sites.

2.4.4 Fish and Shellfish Tissue

While fish tissue data are limited, analysis of fish tissue for chemical contaminants provides a good measure of water quality since this media represents a long term integrator of bioaccumulation of pollutants and more reliable indication of water quality impacts. The following summary discusses the existing fish advisory and then presents more recent results along with some older data for perspective.

2.4.4.1 OEHHA—LA Harbor, Cabrillo Marina, Inner Cabrillo Beach, San Pedro Bay

In 1991, OEHHA issued a fish consumption advisory for various waters along the coastline between Point Dume and Dana Point, including waters in the Harbor area. High levels of DDT and PCBs were measured in sportfish representing a human health risk. Samples collected inside the Harbor breakwater, at Pier J and at Belmont Pier clearly showed elevated total DDT and PCBs in comparison to risk-based values. Total chlordane levels (ranged from 0 to 53 ppb) in these same samples were not above risk values so chlordane was not included in the advisory.

As part of the Coastal Fish Contamination Project (CFCP), OEHHA collected more fish tissue samples off Belmont Pier in 1999 and 2000. Results are summarized in Table 2-13.

Table 2-13. Fish tissue composite results from OEHHA/CFCP (1999 & 2000) (µg/kg, wet weight).

Pollutant	White Croaker (n=2)	Queenfish (n=1)	Spotted Turbot (n=1)	Total # of exceedences	OEHHA screening value
Chlordane	5.4 – 17.5	12.4	2.3	0	30
DDT total	92.4 – 254.0	396.6	104.0	3	100
PCBs total	98.0 – 294	207	116	4	20

Composite results shown for filets only, organics reported for skin-on filets

2.4.4.2 Terminal Island Water Reclamation Plant–LA Harbor

City of Los Angeles Terminal Island Water Reclamation Plant monitoring program has also collected fish tissue samples within the Outer Harbor. Results for 2000-2004 are summarized in Table 2-14. These results indicate non-impairment of fish tissue for arsenic, cadmium, mercury, selenium and chlordane, based on samples lower than Listing Policy screening values. The continued presence of high DDT and PCB levels indicates these pollutants are still creating adverse impacts and provide corroborating evidence for the consumption advisory in these waters.

Table 2-14. Fish tissue data from Terminal Island Water Reclamation Plant (1999-2004) (ppb = ug/kg, wet weight).

Pollutant	Count	Fish Tissue (conc. range)	Total # of exceedences	OEHHA screening value
As	30	0.46 – 1.14	1	1.0
Cd	30	<0.4	0	3.0
Hg	30	0.01 – 0.11	0	0.3
Se	30	0.10 – 0.46	0	1*
Chlordane	30	0.30 – <3.0	0	30
DDT total	40	22 – 6514	36	100
PCBs total	40	19 – 1000	36	20

*Se tissue value from USFWS for protecting birds. Dieldrin in fish tissue was not reported.

2.4.4.3 USEPA Superfund (and POLA)

In 2002, USEPA Superfund Division collected fish samples via separate projects in various waters of concern to these TMDLs. The Consolidated Slip was sampled to determine DDT levels in fish tissue. POLA coordinated with EPA to have these samples analyzed by AMEC for other parameters. Two fish species were collected and four individuals of each species (halibut and white croaker) were analyzed. Various sample preparation methods were used and yielded different analytical results consistent with each approach. Analytical results for fish filets are presented in Table 2-15 below. In general, tissue levels were below Listing Policy tissue screening values for arsenic, cadmium, mercury, selenium and chlordane. DDT and PCB total levels exceeded Listing Policy values in several samples indicating impairment due to these pollutants.

Table 2-15. Fish tissue data from Consolidated Slip (ppb = ug/kg, wet weight; EPA Superfund & POLA/AMEC).

Pollutant	White Croaker (n=4)	Halibut (n=4)	Total # of exceedences	OEHHA screening value
	Conc. Range	Conc. Range		
As	0.42—0.63	0.19—0.56	0	1.0
Cd	0.01	0.01—0.07	0	3.0
Hg	0.08—0.13	0.05—0.11	0	0.3
Se	0.31—1	0.23—0.41	1	1*
Chlordane	1—8.2	1	0	30
Dieldrin	n/a	n/a	--	2.0
DDT total	399—569	6—15	4	100
PCBs total	131—888	47	3	20

Metals reported for filets only, organics reported for skin-on filets
*Se value from USFWS (not OEHHA) for protecting birds

As part of Montrose Settlement Restoration Program, USEPA (Superfund Division) and other federal agencies collected fish samples from Point Dume to Dana Pt. in 2002. The objective of this project was to measure DDT and PCB contamination in fish tissue. Over 1000 individual fish from 123 species were collected in Santa Monica Bay, around Palos Verde peninsula, San

Pedro Bay, Huntington Harbor, Newport Harbor, etc. Tissue results from three "segments" are pertinent to waterbodies within the scope of these TMDLs (EPA 2007). These segments are all inside the San Pedro Bay breakwater ranging from Cabrillo fishing pier in the west (segment #16) to Pier J/Finger Piers (segment #17) to Belmont Pier/Seaport Village in the east (segment #18). Fish tissue results for these segments are summarized in Table 2-16 below.

Table 2-16. Individual Fish tissue results from inside breakwater of Outer Harbor and eastern San Pedro Bay. (EPA /NMFS/OEHHA, 2002) (ppb = µg/kg, wet weight).

	Cabrillo Pier-inside bkwtr (Segment 16)		Pier J/Fingers Pier (Segment 17)		Belmont Pier/Seaport Village (Segment 18)	
Pollutant	**Conc. range**	**# exceeds/total**	**Conc. range**	**# exceeds/total**	**Conc. range**	**# exceeds/total**
Chlordane	3 – 23	0 / 80	2 – 63	5 / 68	3 – 33	3 / 69
Dieldrin	0.4 – 1.4	0 / 74	0.4 – 7.9	8 / 65	0.5 – 1.5	0 / 69
DDT total	9 – 2522	27 / 80	0.4 – 764	13 / 68	1.4 – 206	12 / 69
PCBs total	0.5 – 278	50 / 80	46 – 188	46 / 68	4.1 – 190	50 / 69

organics reported for skin-on filets

In 1994, to demonstrate DDT contamination in the stormwater pathway coming off the Montrose Chemical plant site, USEPA Superfund Division collected biota samples in waterbodies downstream of the Montrose site in the Dominguez Channel watershed and into Consolidated Slip. Various tissue samples were obtained ranging from mosquito fish (in freshwater Torrance Lateral) to mussels, whole crabs and mallard eggs (in Dominguez Channel estuary) to whole topsmelt and black surfperch filets (in Consolidated Slip). Total DDT results for majority of these samples exceeded the OEHHA screening value (100 ppb wet wt.). No chlordane, dieldrin or PCB results were determined for these samples.

2.4.4.4 Mussel Watch data—greater Los Angeles/Long Beach Harbor waters

Both NOAA and SWRCB have monitoring programs of mussels in bay, harbor and coastal waters. Given the nature of this program which is to transplant mussels to specific sites on annual basis, these analytical results can be used for evaluating long term trends. State Mussel Watch (SMW) results for Consolidated Slip in 1982-2000 showed declining trends for chlordane, DDT, and PCBs. SMW chlordane results did not exceed the OEHHA value, and DDT results were often below the corresponding OEHHA value, whereas, PCB results were never below the OEHHA PCB value. SMW results for dieldrin and toxaphene were the basis for listing Consolidated Slip in 1996; dieldrin had one exceedence (1/20) above the OEHHA value, whereas toxaphene had more exceedences, (5/10) in ten years.

2.4.4.5 CSTF database—Inner Harbor, Outer Harbor, Inner Cabrillo Beach, San Pedro Bay

The CSTF database contains fish tissue results from BPTCP 1997 and Bight 1998. Composite results were presented for whole fish, mostly small forage species such as goby. No metal results were reported in the database. There were exceedances of Listing Policy tissue guidelines for DDT and PCBs: total DDT = 4 exceedance of 18 detections, and total PCBs = 7 exceedances of 18 detections. Chlordane, detected 13 times, showed no exceedances.

2.4.4.6 Toxic Substances Monitoring Program—Dominguez Channel

In 1992, Toxic Substances Monitoring Program (TSMP) collected one fish sample (white croaker) in Dominguez Channel. The 1998 and 2002 303(d) lists utilized this data to indicate the freshwater portion of Dominguez Channel as impaired due to high levels of organics in fish tissue. For the 2006 303(d) list, the State of California concluded that the conclusion of impairment within Dominguez Channel freshwater segment were inaccurate because the actual sampling site for the one fish was collected in the estuary. The 2006 303(d) list analysis stated the TSMP sampling report verifies that the white croaker was caught downstream of Vermont Ave., in the estuary segment of Dominguez Channel. Thus there is no impairment due to dieldrin within Dominguez Channel; no TMDL will be developed for this specific waterbody-pollutant combination. Table 2-17 is a summary of the TSMP data.

Table 2-17. Fish tissue data (1992) from Dominguez Channel estuary (ppb, wet weight).

Program	TSMP	SWRCB	SWRCB
Date	1992	Maximum Tissue Residue Level (MTRL)	Screening Value (µg/kg)
Species	White Croaker (n=1)		
Cd	n/d	--	3
Hg	0.09	--	0.3
Se	0.68	--	1*
Chlordane	164	8.3	30
Dieldrin	5.3	0.7	2.0
Total DDTs	6487	--	100
Total PCBs	1780	5.3	20

Note: MTRLs are not used for assessment purposes , but provided for perspective.
*Se value from USFWS for protecting birds

2.5 Summary of data on pollutant basis

2.5.1 Metals

Copper, lead and zinc were most commonly above numeric criteria for various waterbodies. Elevated levels of these three metals were observed in the freshwaters of Dominguez Channel, and Torrance Lateral. Dissolved copper occasionally exceeds in Inner and Fish Harbor. Elevated copper, lead and zinc levels in sediments were evident within Dominguez Channel estuary, Consolidated Slip, Inner Harbor, and Fish Harbor. Cadmium and chromium were elevated in sediments of Consolidated Slip or Dominguez Channel estuary but do not exceed in sediments elsewhere in the watershed or receiving waters. Mercury levels in fish tissue were not above Listing Policy screening values for any water body. Mercury sediment levels were high only in Consolidated Slip and Fish Harbor. Some water bodies appeared to show non-impairment for metals, Cabrillo Beach, Outer Harbor, Los Angeles River estuary and San Pedro Bay. Arsenic did not exceed water or sediment numeric criteria in any waters.

2.5.2 PAHs

Individual PAH results exceeded numeric sediment guidelines most frequently in Dominguez Channel estuary, Consolidated Slip, Inner Harbor and Fish Harbor. A few sediment exceedences for benzo[a]pyrene were also observed in Cabrillo Marina and Los Angeles River Estuary. Measurements of PAH compounds in water were not reliable for assessment due to inadequate method detection limits in comparison to numeric criteria. Fish tissue results for PAHs were either non-existent or do not provide sufficient information to be utilized for assessment with screening values.

2.5.3 Organochlorines

Chlordane sediment levels were observed above sediment guidelines in Dominguez Channel estuary, Consolidated Slip, Fish Harbor and Los Angeles River Estuary. The vast majority of fish tissue results of chlordane were below Listing Policy screening values in all waterbodies. Mussel results show declining trend for chlordane at two locations in receiving waters.

Dieldrin tissue and sediment results were elevated and isolated to Dominguez Channel estuary and Consolidated Slip. Toxaphene is elevated in tissue in Consolidated Slip only.

DDT and PCB fish results were elevated above Listing Policy screening values in nearly all receiving waters. This does not include Dominguez Channel freshwater; although DDT has been detected in stormwater samples collected in Torrance Lateral (SCCWRP 2002-03). The more recent (1999-2004) tissue results corroborated the previously established consumption advisory in these greater Los Angeles/Long Beach Harbor waters (OEHHA 1991; 2009). Sediment results for DDT and PCBs were elevated in transitional waters; e.g., Dominguez Channel estuary, Consolidated Slip and Los Angeles River Estuary.

2.5.4 Sediment Toxicity

Water toxicity was repeatedly observed in Dominguez Channel freshwaters. Sediment toxicity was observed in Dominguez Channel estuary, Consolidated Slip, Inner and Outer Harbor, Fish Harbor, Los Angeles River estuary and San Pablo Bay. The Bight 03 and Ports' 2008 BioBaseline studies provided the most recent sediment toxicity results.

2.5.5 Benthic Community Effects

The Dominguez Channel estuary, Consolidated Slip and Inner Harbor were previously listed for degraded benthic communities (infauna population and species composition). The recent survey of benthic infauna (Bight 2003; Ports' 2006 and 2008) provided results in more current conditions; whereas previous studies provided historical information (BPTCP 1992-97, Bight 1998). While certain areas in the Inner Harbor have shown dramatic improvement, most notably the Cabrillo and Pier 400 Shallow Water Habitat areas, the 2003-08 results did not change the overall assessment conclusion of impairment for three waterbodies mentioned above.

2.6 Assessment Findings for each water body

2.6.1 Dominquez Channel freshwaters

Dissolved copper, lead and zinc exceeded numeric hardness-specific CTR criteria during wet weather events. No exceedences for these three metals occurred during dry weather conditions. Results for other metals or organochlorine compounds did not exceed criteria or detection limits were too high for adequate assessment determinations. Water toxicity has been repeatedly observed in the freshwater at the mass emissions station during wet weather conditions, only one exceedence was observed during dry conditions. Whereas elevated diazinon levels had been observed concurrently with toxicity in 2002-2005 wet weather samples and therefore diazinon was presumed to be contributing to adverse toxicity results; post-2005 results show no diazinon concentrations above the freshwater guideline. Therefore, it is appropriate to develop freshwater metals and toxicity TMDLs for wet weather; however, the more recent toxicity results are not attributable to diazinon and therefore no diazinon TMDLs have been developed for Dominguez Channel.

2.6.2 Torrance Lateral

Torrance Lateral contains freshwater and is currently included on the State's 2008/2010 CWA 303(d) list as impaired due to copper and lead. Sediment results for copper and lead were above the State listing policy sediment quality values for these heavy metals (POLA/AMEC 2002). Recently Los Angeles County DPW completed water column monitoring within Torrance Lateral as part of the Dominguez Channel tributary study (LAC DPW, 2009; 2010). Available water column results reveal exceedences of dissolved copper (8 of 10) and zinc (9 of 10) CTR criteria during wet weather conditions. Dissolved lead was below the criteria in wet weather conditions and no dry weather exceedences occurred for any of these three metals. Based on this information, we conclude water column impairments for copper and zinc.

2.6.3 Dominquez Channel estuary

Sediment toxicity has been observed in 4 of 7 results, including 3 of 6 highly toxic results in Bight 03. In recent sediment triad studies, bulk levels of Cd, Cu, Pb and Zn were above sediment guidelines (Bight 03). Historical sediment results showed elevated levels of these metals, also. PAH sediment data showed levels of five individual compounds were above guidelines and maybe contributing to sediment toxicity. Elevated DDT and PCBs occurred in fish tissue and some sediment samples. Chlordane was elevated in recent sediment samples and historical fish tissue results. Dieldrin was not measured in sediments and was observed at slightly elevated levels in the individual fish sample reported in 1992. Degraded benthic community effects were observed in BPTCP 96 & 97 and confirmed in Bight 03 (3 of 5 in poor condition).

2.6.4 Los Angeles Harbor - Consolidated Slip

Water results showed elevated levels of DDT and PCBs (SCCWRP, 2006). Sediment toxicity has been observed in 12 of 13 historical samples, including one highly toxic result in Bight 03. In recent sediment triad studies, bulk levels of Hg, Pb and Zn were above sediment guidelines (Bight 03). Historical sediment results showed elevated levels of these metals and Cd, Cr, Cu, also. PAH sediment data showed that levels of six individual compounds were above guidelines

and may be contributing to sediment toxicity. Chlordane and dieldrin have not been measured in recent sediment samples. Tissue results were mixed. Elevated DDT and PCBs occurred in fish tissue and nearly all sediment samples. Toxaphene was originally listed due to elevated levels in mussels and remains impaired until new data shows significant decreases. Benthic community effects were observed in BPTCP 96 & 97 and moderate degradation observed in the Bight 03 results.

2.6.5 Los Angeles and Long Beach Inner Harbor

A fish consumption advisory for certain DDT and PCBs in certain fish species is currently in place and is corroborated by recent fish tissue results (OEHHA 2009).

Sediment toxicity has been observed in 10 of 23 samples, including 3 of 8 toxicity samples in Bight 03. Historical sediment data (pre- 1996) showed elevated levels of metals, PAHs and PCBs. In sediment triad studies, individual PAH levels were above PAH sediment guidelines (BPTCP 96 & 97, Bight 98). PAH sediment data showed sufficient exceedences of benzo[a]pyrene and chrysene (8/80) as to be impaired. There are fewer exceedences of benzo[a]anthracene, pyrene and phenanthrene (2/72) so these PAH compounds appear to not contributing to sediment toxicity. PCB sediment results from two older studies were also above sediment guidelines (BPTCP 96 & 97, Bight 98). More recent triad studies did not show such elevated (nor threatening) levels of PCBs; however, Pb and Zn were above guidelines (Bight 03). There are some reliable measurements of metals in water and only copper exceedences were evident (POLA 2005-06, Ports 2006). DDT and PCBs in water column have been detected via solid phase microextraction (SPME) devices; DDE results showed exceedences of CTR human health criteria (Zeng, et al. 2005). Benthic community effects were observed in BPTCP 96 & 97, Bight 98 & 03 and a few in Biobaseline 08.

2.6.6 Outer Harbor

A fish consumption advisory for DDT and PCBs in certain fish species is currently in place and is corroborated by recent fish tissue results (OEHHA 2009). Additional support is provided by 2004 -06 fish tissue results (TIWRP). Sediment toxicity has been observed in 7 of 26 samples, including 3 of 7 moderately toxic samples in Bight 03. No individual contaminants were above sediment guidelines in more recent studies (Bight 98, WEMAP 99, Bight 03). Individual PAH levels were above pollutant sediment guidelines only in historical results; e.g., BPTCP 1997 and earlier. Trend analyses of NOAA mussel data for PAHs were inconclusive. There are a few reliable measurements of metals, PAHs, DDT and PCBs in the water column. DDE measured in water column showed 2 of 4 exceedences of CTR criteria (Zeng, et al. 2005). Benthic community effects were observed in Bight 98 & 03 and a few in Biobaseline 08.

2.6.7 Los Angeles Fish Harbor

A fish consumption advisory for DDT and PCBs in certain fish species is currently in place and is corroborated by recent fish tissue results (OEHHA 2009). Sediment toxicity has been observed in 2 of 4 results, including 1 of 1 moderate toxicity result in Bight 03. In recent sediment triad studies, bulk levels of Cu, Pb and Zn were above sediment guidelines (Bight 03). Historical

sediment results showed elevated levels of chlordane, mercury, and six individual PAH compounds. There are a few reliable measurements of aqueous metals or organics in this waterbody.

2.6.8 Cabrillo Marina

A fish consumption advisory for DDT and PCBs in certain fish species is currently in place and is corroborated by recent fish tissue results (OEHHA 2009). Only one sediment toxicity result (Bight 03) exists and showed moderate to high toxicity, with corresponding and repeatedly elevated results for benzo[a]pyrene (5 of 26 exceedences of sediment quality guideline). Historical sediment results showed elevated levels of chlordane and chrysene in comparison to sediment guidelines, yet these do not correspond with sediment toxicity results, so impairment is not associated with these two compounds. Sediment results did not show elevated levels of metals or other organic compounds. There are a few reliable measurements of aqueous metals or organics exist in this waterbody; no exceedences have been recorded.

2.6.9 Cabrillo Beach - Inner

A fish consumption advisory for DDT and PCBs in certain fish species is currently in place and is corroborated by recent fish tissue results (OEHHA 2009). Only historical sediment toxicity results exist for this segment; however no corresponding elevated levels of individual PAHs, total PAHs or organochlorine compounds were associated with the one toxic result. Sediment metal results are not elevated values relative to sediment quality guidelines, except for copper (2 of 16 in BPTCP 1994). More recent sediment results do not show any exceedences for any metal or organic compounds (PORTs 2006). There are a few reliable measurements of aqueous metals or organics exist in this waterbody; no exceedences have been recorded, including copper 0 of 4 dissolved (POLA 2005-06). Based on available data in this pre-TMDL assessment, this waterbody is not impaired for copper, although it is on 2006 303(d) list.

2.6.10 Los Angeles River Estuary

A fish consumption advisory for DDT and PCBs in certain fish species is currently in place and extends into the estuary based on recent fish results collected at Pier J/Fingers Pier, both near the estuary mouth (OEHHA 2009). Sediment toxicity has been observed in 4 of 7 results, including 2 of 5 moderate toxicity results in Bight 03. Historical sediment results showed elevated levels of chlordane. In recent sediment triad studies, bulk levels of chlordane, PCBs, and benzo[a]pyrene were above sediment guidelines (Bight 03). A few reliable measurements of aqueous metals or organics exist in this waterbody; no exceedences have been recorded. Based on available data in this pre-TMDL assessment, this waterbody is not impaired for lead and zinc.

2.6.11 San Pedro Bay

A fish consumption advisory for DDT and PCBs in certain fish species is currently in place and is corroborated by recent fish tissue results (OEHHA 2009). Chlordane in fish tissue did not appear to be elevated above OEHHA screening values. Sediment toxicity has been observed in 4 of 18 results, including 1 of 2 moderate toxicity results in Bight 03. Elevated levels of chlordane have been repeatedly occurring (6 of 19) and are associated with sediment toxicity. Other

sediment results do not show exceedences for metals nor PCBs, nor other organics. A few reliable measurements of aqueous metals or organics exist in this waterbody (Ports 2006, SCCWRP 2006). Based on available data, this waterbody is not impaired for chromium, copper, zinc, and total PAHs and these listings have been removed from the 2008/2010 303(d) list.

2.7 Assessment changes

2.7.1 New findings of impairment

In the course of this assessment, some waterbodies were identified as impaired due to pollutants not identified on previous 303d lists. Please note that previous "PAHs" listings have been clarified, where feasible, for individual PAH compounds; these may be construed as new listings.

- Dominguez Channel for water toxicity.
- Dominguez Channel Estuary for cadmium and copper.
- Torrance Lateral for zinc.

2.7.2 Assessment findings of non-impairment

This assessment has identified some water body-pollutant combinations as non-impaired. Even though this combination is on the 2010 303(d) list, based on review of available data, the pollutant levels are not elevated relative to water quality benchmarks, therefore, the assessment conclusion yields the water body is attaining standards for this particular pollutant.

- Dominguez Channel for Diazinon

2.8 Conclusions

Based on review of available data, including information with 2008-2010 303(d) list factsheets and more recent monitoring information, the water-quality limited segments are identified in Table 2-18 below. Each waterbody-pollutant combination will require TMDL development.

Using available sediment triad results (Bight 98, 03; WEMAP 99,05; BioBaseline 2008), we performed an assessment for each saline waterbody using SQO Part I-Direct Effects methodology. An exceedence of SQO Part I was considered for Possibly Impacted, Likely Impacted or Clearly Impacted at each station. Following the CA 303(d) Listing Policy procedures, including those outlined in Table 3-1 of that document, two or more exceedences per waterbody was interpreted as impaired. These assessment results confirmed impairment within the estuaries and and greater LA/LB Harbor waters identified in Table 2-18. See Appendix III.9 for sediment triad results compiled per waterbody.

Table 2-18. Assessment Findings for each water body

Waterbody	Metals	PAHs	PCBs, DDT, etc	Toxicity	Benthic Community	SQO Impaired
Dominguez Channel fresh	Cu, Pb, Zn			**Water (diazinon)**		
Torrance Lateral	Cu, Pb, **Zn**					
Dominguez Channel estuary	**Cd**, Cu, Pb, Zn	Benzo[a]anthracene, Benzo[a]pyrene, Chrysene, Pyrene, Phenanthrene	DDT, PCBs, Chlordane, Dieldrin	sediment	X	X
Consolidated Slip	Cd, Cr, **Cu**, Hg, Pb, Zn	Benzo[a]anthracene, Benzo[a]pyrene, Chrysene, Pyrene, Phenanthrene, 2-methylnapthalene	DDT, PCBs, Chlordane, Dieldrin, Toxaphene	sediment	X	X
Inner Harbor	Cu, Zn	Benzo[a]pyrene, Chrysene	DDT, PCBs	sediment	X	X
Outer Harbor			DDT, PCBs	sediment		X
Fish Harbor	Cu, Pb, Zn, Hg	Benzo[a]anthracene, Benzo[a]pyrene, Chrysene, Pyrene, Phenanthrene, Dibenzoanthracene	DDT, PCBs, Chlordane	sediment		X
Cabrillo Marina		Benzo[a]pyrene,	DDT, PCBs,			X
Inner Cabrillo Beach			DDT, PCBs			
LA River Estuary			DDT, PCBs, Chlordane	sediment		X
San Pedro Bay			DDT, PCBs, Chlordane	sediment		X

Bold indicates impairment although not included on 2008/2010 303(d) list
No impairment due to diazinon in freshwaters of Dominguez Channel

3 NUMERIC TARGETS

Numeric targets were developed for all toxic pollutants identified in Section 2, above. Metal, chlordane and individual PAH compound target values are provided for water and sediment (Tables 3-1 and 3-7). DDT and PCBs and toxaphene targets are provided for water and sediment (Tables 3-1 and 3-7) as well as for fish tissue and tissue residues (Table 3-8 and 3-9). Also, ambient water toxicity and sediment toxicity targets are included since TMDLs will be developed for these impairments, which may not be alleviated by attainment of water quality

standards for metals, PAHs, or organochlorine compounds. Both freshwater and saltwater targets are provided in this section.

3.1 Water

Numeric water targets are established in this TMDL for metals, organics and toxicity. Water targets are guided by the Basin Plan and the California Toxics Rule (CTR).

3.1.1 Water: Metals and Organics

Numeric water targets for metals and organics, consistent with CTR water quality criteria for protecting aquatic life, are established in Table 3-1. All metal water targets are for dissolved forms of the metals and are hardness dependent, except mercury which is for total mercury and is not hardness dependent.

The human health target was determined using the "organism only" values from the CTR versus the "organism and water" values because the waters of the Harbors are not drinking waters.

Table 3-1. Water quality criteria established in CTR for metals and organics.

Pollutant	Criteria for the Protection of Aquatic Life				Human Health
	Freshwater		Saltwater		Organism only
	Acute (µg/L)	Chronic (µg/L)	Acute (µg/L)	Chronic (µg/L)	(ug/L)
Copper	6.99*	4.95*	4.8	3.1	n/a
Lead	30.14*	1.17*	210	8.1	n/a
Zinc	65.13*	65.66*	90	81	n/a
Mercury	n/a	n/a	n/a	n/a	0.051
Chlordane	2.4	0.0043	0.09	0.004	0.00059
Dieldrin	0.24	0.056	0.71	0.0019	0.00014
4,4'-DDT	1.1	0.001	0.13	0.001	0.00059
Total PCBs	n/a	0.014	n/a	0.03	0.00017
Benzo[a]pyrene	n/a	n/a	n/a	n/a	0.049**

* Freshwater aquatic life criteria for Cd, Cu, Pb, Zn are expressed as a function of total hardness (mg/L) in the water body. Values presented correspond to average hardness from/to 2002-2010 of 50 mg/L (n=35).

****** CTR criteria for individual PAH of benzo(a)anthracene, benzo(a)pyrene, and chrysene equals 0.049 µg/L. CTR criteria for pyrene is 11,000 ug/L.

n/a = no criteria available in CTR

3.1.2 Water: Total metals

Wet weather monitoring results were evaluated for the potential use of site-specific wet-weather factors to converting the acute CTR criteria from dissolved metals concentrations to total recoverable concentrations. LAC DPW stormwater data collected at Vermont Ave (MES site# S28, 2002 to 2010), included hardness, TSS, dissolved and total metals.

Staff used EPA Guidance *The Metals Translator: Guidance For Calculating A Total Recoverable Permit Limit From A Dissolved Criterion* (USEPA, 1996) on developing metal translators, to evaluate the potential for site-specific wet weather conversion factors for copper,

lead and zinc. CTR identifies default translators which were compared to the USEPA guidance on three options for deriving a site-specific translator:

- Direct Measurement - Assuming no Relationship to Total Suspended Solids (TSS), uses descriptive statistics and may be developed directly as the ratio of dissolved to total recoverable metal;
- Direct Measurement - Based upon Relationship to TSS, uses regression equations to evaluate correlations and yield r^2 values, which indicate the strength of the relationship with TSS and fraction of particulate metals;
- Partition coefficient – Based on relationship to TSS and is functionally related to the number of metal binding sites on the particulate surfaces in the water column (i.e., concentrations of TSS, TOC, or humic substances), and r^2 values also indicate the strength of the relationships and the conversion factor (fraction of particulate metals).

Option 1 ("percentile method") was selected as viable for estimating site-specific wet weather hardness specific conversion factors for each metal (Table 3-2). For translation of acute metals criteria, the 90% value was determined, which is consistent with the State's Implementation Policy (SIP) for CTR (SWRCB, 2005). Analysis via Options 2 and 3 revealed a very poor correlation of particulate metals fractions with TSS (r^2 values ranged from 0.345 - 0.378). Without any reliable relationship with TSS, translators derived from Options 2 and 3 were disregarded.

Table 3-2. Freshwater wet weather dissolved/total metals targets (ug/L) – using different translators

Metal	Diss. CTR Criteria*	CTR default translator	Total metals w/ CTR	Site specific Conv. Factor*	Total metals w/ Site Sp. Conv. Factor
Copper	6.99	0.96	7.3	0.722	9.7
Lead	30.14	0.895	33.8	0.706	42.7
Zinc	65.13	0.978	66.6	0.935	69.7

*LAC DPW results at S28, data record 2002-2010, median hardness – 50 mg/L; sample size = 35

3.1.3 Water: Toxicity

The Basin Plan includes a narrative toxicity objective which states, in part: "All Waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in, human, plant, animal, or aquatic life." This objective does not allow acute toxicity in any receiving waters or chronic toxicity outside designated mixing zones.

A numeric toxicity target of 1 chronic toxicity unit (1 TUc) is established for this TMDL to allow evaluation of the narrative toxicity objective. The 1 TUc target maybe replaced by an equivalent toxicity target based upon any Statewide Toxicity Policy. A chronic toxicity target was selected because it addresses the potential adverse effects of long term exposure to lower concentrations of a pollutant and is therefore more protective than an acute toxicity target that may not address potential effects of longer term exposures. Equation 1 describes the calculation of a TUc.

Equation 1 TU_c = Toxicity Unit Chronic = 100/NOEC (no observable effects concentration).

Or: TUc = 100% ÷ the sample concentration, derived using hypothesis testing, to cause no observable effect, with the sample concentration expressed as a percentage.

The numeric toxicity target is set at no observable toxicity with water samples defined as toxic by toxicity testing if the following two criteria are met: 1) there is a significant difference ($p<0.05$) in mean organism response (e.g., percent survival) between a sample and the control as determined using a separate-variance t-test, and 2) the mean organism response in the toxicity test (expressed as a percent of the laboratory control) was less than the threshold based on the 90th percentile Minimum Significant Difference (MSD) value expressed as a percent of the control value.

The 90th percentile MSD value is specific for each specific toxicity test protocol and is determined by identifying the magnitude of difference that can be detected 90% of the time by a specific test method. The following is a description of MSDs and how a toxic effect would be identified (SWRCB, 1996): "In toxicity tests, the MSD represents the smallest difference between the control mean and a treatment mean (the effect size) that leads to the statistical rejection of the null hypothesis (H^o: no difference). Any effect size equal to or larger than the MSD would result in a finding of statistically significant difference. For example, if the control mean for mysid growth were 80 ug/mysid and the MSD were 20, any treatment with mean mysid weight less than or equal to 60 ug would be significantly different from the control and considered toxic."

3.2 Sediment

Numeric sediment targets are established in this TMDL for metals, PAHs, and some priority organic compounds. Sediment targets are guided by the Basin Plan and the State Board Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality (SQO Part 1) which include descriptive narrative goals and methods for integrating sediment triad results. The numeric sediment quality guidelines of Long and MacDonald (Long et al., 1995; MacDonald et al., 2000) are recommended by the State Listing Policy. In this section, the Sediment Quality Plan is discussed first, as it guides sediment conditions for restoration and protection of benthic infauna (or sediment dwelling organisms) Consistent with SQO Part I, the sediment quality condition for direct effects is based on interpreting multiple lines of evidence using sediment triad results. Later, Section 3.3 presents sediment targets related to fish tissue values using an indirect effects approach.

3.2.1 Sediment: Applicability of the State Board Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality

California recently adopted the Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality (SQO Part 1) which applies to sediments within enclosed bays and estuaries. EPA approved the Sediment Quality Plan on September 25, 2009. Part 1 of the Sediment Quality Plan establishes a method to assess sediment quality which integrates chemical and biological measures to determine if the aquatic life within ambient sediment are protected or degraded by exposure to toxic pollutants in sediment. The Sediment Quality Plan establishes

sediment quality objectives (SQO) based on three lines of evidence including sediment chemistry, sediment toxicity and benthic community condition. These three lines of evidence are referred to as the sediment triad.

The Sediment Quality Plan-Part 1 describes a method of using the three lines of evidence to categorize a sediment as "Unimpacted," "Likely unimpacted," "Inconclusive," "Possibly impacted," Likely impacted," or "Clearly impacted." The categories -"Unimpacted," and "Likely unimpacted" - are considered as achieving the protective condition for aquatic life in ambient sediment; these categories integrate three lines of evidence to define the TMDL targets for impaired sediments. Possibly Impacted, Likely Impacted and Clearly Impacted indicate impaired conditions; while Inconclusive is not impaired. T hese target conditions - "Unimpacted," and "Likely unimpacted" are the goal conditions, however TMDLs and allocations need to be numeric according to federal regulations. Both the narrative and numeric target are described in more detail below.

The SQOs for the protection of aquatic life and human health are described below:

a. Aquatic Life – Benthic Community Protection

   Pollutants in sediments shall not be present in quantities that, alone or in combination, are toxic to benthic communities in bays and estuaries of California. This narrative objective shall be implemented using the integration of multiple lines of evidence. The assessment of sediment quality consists of the measurement and integration of three lines of evidence (LOE). The LOE are:

- Sediment Toxicity: Sediment toxicity is a measure of the response of invertebrates exposed to surficial sediments under controlled laboratory conditions. The sediment toxicity LOE is used to assess both pollutant related biological effects and exposure. Sediment toxicity tests are of short durations and may not duplicate exposure conditions in natural systems. This LOE provides a measure of exposure to all pollutants present, including non-traditional or unmeasured chemicals.
- Benthic Community Condition: Benthic community condition is a measure of the species composition, abundance and diversity of the sediment-dwelling invertebrates inhabiting surficial sediments. The benthic community LOE is used to assess impacts to the primary receptors targeted for protection of aquatic life. Benthic community composition is a measure of the biological effects of both natural and anthropogenic stressors.
- Sediment Chemistry: Sediment chemistry is the measurement of the concentration of chemicals of concern in surficial sediments. The chemistry LOE is used to assess the potential risk to benthic organisms from toxic pollutants in surficial sediments. The sediment chemistry LOE is intended only to evaluate overall exposure risk from chemical pollutants. This LOE does not establish causality associated with specific chemicals.

b. Human Health

> Pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health. The narrative human health objective shall be implemented on a case-by-case basis, based upon a human health risk assessment. In conducting a risk assessment, the Water Boards shall consider any applicable and relevant information, including California Environmental Protection Agency's (Cal/EPA), Office of Environmental Health Hazard Assessment (OEHHA) policies for fish consumption and risk assessment, Cal/EPA's Department of Toxic Substances Control (DTSC) Risk Assessment, and USEPA Human Health Risk Assessment policies.

Each line of evidence produces specific information that, when integrated with the other lines of evidence provides a more confident assessment of sediment quality relative to sediment chemistry alone. When the exposure (chemistry) and effects (toxicity and benthic community assessment) are integrated, the approach can quantify protection through effects measures and also provide predictive capability through the exposure measure.

3.2.2 Benthic community effects

This TMDL establishes benthic community targets based on the Sediment Quality Plan. Benthic community condition is a measure of the species composition, abundance and diversity of the sediment-dwelling invertebrates inhabiting surficial sediments. The narrative SQOs in the Sediment Quality Plan are designed to protect the biological organisms within marine sediments and provide a direct measure of impact to these communities.

The Sediment Quality Plan identifies methods to evaluate a waterbody's benthic community condition and its alteration from reference conditions. Four different benthic indices are provided in the Sediment Quality Plan each using the same benthic community data: the Benthic Response Index (BRI); the Index of Biological Integrity as adapted for California bays and estuaries (IBI); the Relative Benthic Index (RBI); and the River Invertebrate Prediction and Classification System (RIVPACS) which was adapted for use in California bays and estuaries.

Categorical thresholds for each of the four biological indices (BRI, IBI, RBI, RIVPACS) were developed based in comparison to reference condition and categorized into four levels of biological disturbance:

> Reference: Equivalent to least affected or unaffected site
> Low Disturbance: Some indication of stress is present, but within measurement error of unaffected condition
> Moderate Disturbance: clear evidence of stress
> High Disturbance: high magnitude of stress

The combination of the four benthic indices provides more information than any single index (Ranasinghe, et al., 2007). These benthic-response categories are integrated by taking the median value, rounding up when the median falls midway between two benthic-response categories.

Because the SQOs were developed in part based on a local reference condition specific to Southern California marine bays, benthic assessments can rely on these published indices in a weight of evidence approach. The target for benthic community effects are either reference or low disturbance condition for any of the four biological indices included in the SQOs (Table 3-3, shaded boxes).

Table 3-3. Benthic Index Categorization Values (Recreated from Sediment Quality Plan Part 1 Table 5)

Index	1. Reference	2. Low Disturbance	3. Moderate Disturbance	4. High Disturbance
Southern California Marine Bays				
BRI	**<39.96**	**39.96 to 49.14**	**49.15 to 73.26**	**>73.26**
IBI	**0**	**1**	**2**	**3 or 4**
RBI	**>0.27**	**0.17 to 0.27**	**0.09 to 0.16**	**<0.09**
RIVPACS	**>0.90 to <1.10**	**0.75 to 0.90 or 1.10 to 1.25**	**0.33 to 0.74 or >1.25**	**<0.33**

3.2.3 Sediment toxicity

This TMDL establishes sediment toxicity targets based on the Sediment Quality Plan. Sediment toxicity is a measure of the response of invertebrates exposed to surficial sediments under controlled laboratory conditions. This provides a measure of exposure to all pollutants present in the sediment, including non-traditional or unmeasured chemicals.

Application of SQOs per the Sediment Quality Plan requires a minimum of two sediment toxicity tests—at least one short-term survival test and at least one sub-lethal test.

For the short-term survival tests, the acceptable species are all amphipods species (*Eohaustorius estuarius, Leptocheirus plumulosus, and Rhepoxynius abronius*). For these species, toxicity is defined by tests that are statistically significant (from reference sediment sample) and exhibit more than 10% mortality. Thus the target conditions for short-term survival tests are less than or equal to 10% toxicity in comparison to a reference sediment sample. The thresholds established in the Sediment Quality Plan are based on statistical significance and magnitude of the toxic effect. Acceptable test organisms and methods are summarized in Table 3-4.

Table 3-4. Acceptable Short Term Survival Sediment Toxicity Test Methods.

Test Organism	Exposure Type	Duration	Endpoint
Eohaustorius estuarius	Whole Sediment	10 days	Survival
Leptocheirus plumulosus	Whole Sediment	10 days	Survival
Rhepoxynius abronius	Whole Sediment	10 days	Survival

The sub-lethal sediment toxicity tests, growth or development tests are required by the SQOs. For the acute sub-lethal tests, the selection of test organisms is constrained to two organisms—Neanthes for juvenile growth or Mytillus embryo for reproductive development. The target conditions for sub-lethal sediment toxicity tests are less than or equal to 10% toxicity for juvenile growth and 20% for reproductive development in comparison to a reference sediment sample. Acceptable test organisms and methods are summarized in Table 3-5.

Table 3-5. Acceptable Sublethal Sediment Toxicity Test Methods.

Test Organism	Exposure Type	Duration	Endpoint
Neanthes arenaceodentata	Whole Sediment	28 days	Growth
Mytilus gallopprovincialis	Sediment-water Interface	48 hours	Embryo Development

Because the SQOs require both toxicity tests, the desired condition for a waterbody is a non-toxic category from each type of toxicity test as shaded in Table 3-6, Disturbance Category 1.

Table 3-6. Sediment toxicity categorization values (Sediment Quality Plan Part 1. Table 4).

Test Species/ Endpoint	Statistical Significance	Score (Disturbance Category)			
		1 Nontoxic (Percent)	2 Low Toxicity (Percent of Control)	3 Moderate toxicity (Percent of Control)	4 High Toxicity (Percent of Control)
Eohaustorius Survival	Significant	90 to 100	82 to 89	59 to 81	<59
Eohaustorius Survival	Not Significant	82 to 100	59 to 81		<59
Leptocheirus Survival	Significant	90 to 100	78 to 89	56 to 77	<56
Leptocheirus Survival	Not Significant	78 to 100	56 to 77		<56
Rhepoxynius Survival	Significant	90 to 100	83 to 89	70 to 82	<70
Rhepoxynius Survival	Not Significant	83 to 100	70 to 82		<70
Neanthes Growth	Significant	90 to 100*	68 to 90	46 to 67	<46
Neanthes Growth	Not Significant	68 to 100	46 to 67		<46
Mytilus Normal	Significant	80 to 100	77 to 79	42 to 76	<42
Mytilus Normal	Not Significant	77 to 79	42 to 76		<42

*Expressed as a percentage of the control

3.2.4 Sediment Chemistry: Metals and organics

Sediment targets are the desired surface sediment concentrations for specific toxic pollutants to protect human health, aquatic organisms and wildlife as well as to restore all beneficial uses. Sediment targets represent longer term goals than water quality targets.

This TMDL establishes numeric targets that are protective of aquatic life beneficial uses for organochlorine pesticides, PCBs, PAHs, and metals in sediments. While chlordane, dieldrin, toxaphene, DDT, and PCB impairments have been documented in fish tissue only, sediment targets are necessary as these fish tissue contaminants are directly associated with sediments which are the transport mechanism of these compounds to the fish.

The Sediment Quality Objectives (SQOs) established by the Sediment Quality Plan provide objectives based on multiple lines of evidence that can be applied to sediments but does not provide individual numeric targets for sediment chemistry. To develop a TMDL, it is necessary to translate the narrative objectives in the Basin Plan and the lines of evidences in the SQOs into numeric targets that identify the measurable endpoint or goal of the TMDL and represent attainment of applicable numeric and narrative sediment and water quality standards.

The sediment quality guidelines of Long and MacDonald (Long et al., 1995; MacDonald et al., 2000) provide applicable numeric sediment targets because the impairments and the 303(d) listings for PAHs, metals, toxicity and benthic community effects - are primarily based on sediment quality data for the Dominguez Channel estuary, Consolidated Slip, Fish Harbor, Inner and Outer Harbor, Cabrillo Beach-Inner, San Pedro Bay, and Los Angeles River Estuary. In addition, the pollutants being addressed have a high affinity for particles and the delivery of these pollutants is generally associated with the transport of suspended solids from the watershed or from sediments via porewater diffusion within the estuaries and greater Los Angeles/Long Beach Harbor waters.

The sediment quality guidelines of Effect Range Low (Long et al., 1995) and Threshold Effects Concentrations (MacDonald et al., 2000) are used to establish the numeric targets for freshwater sediment for Dominguez Channel, and marine sediment for the greater Los Angeles/Long Beach Harbor waters, as shown in Table 3-7. The State Board listing policy recommends the use of the Effect Range Medians (ERMs), Probable Effect Levels (PELs), and other sediment quality guidelines as a threshold for 303d listing decisions. ERM and PEL values are interpreted as levels above which the adverse biological effects are expected, which make them applicable in the determination of impairment. The Threshold Effects Concentration (TEC) for freshwater sediment and Effect Range Low (ERL) for marine sediment values, on the other hand, represent the levels below which adverse biological effects are not expected to occur, and are more applicable to the prevention of impairment. The goal of the TMDL is to remove impairment and to restore beneficial uses; therefore, the TEC for freshwater sediment and ERLs for marine sediment are selected as numeric targets over the ERMs and PELs to limit adverse effects to aquatic life.

Sediment targets must also be established at levels which will be protective of fish tissue contaminant levels. The organic pollutants addressed by this TMDL (e.g. Chlordane, Dieldrin, Toxaphene, DDT, and PCBs) have the potential to bioaccumulate. To account for bioaccumulation, these TMDLs will rely on the simplified assumption that reduced sediment pollutants will correspond to reduced fish tissue levels. This is reasonable based on the observation that white croaker is a bottom feeding fish and DDT and PCB levels in this fish species are contributing to the fish advisory throughout the greater Los Angeles/Long Beach Harbor waters. The Chlordane, Dieldrin, Toxaphene, DDT and PCBs sediment targets presented in section 3.2.1 may need to be revised in the future to attain the fish tissue targets. Assessment of indirect impacts of sediment contamination via bioaccumulation is currently under development by State Board and SCCWRP, as part of the State's Sediment Quality Plan –Part II. Scientific information from such studies, based on local fish species and biogeochemistry specific to Southern California will be helpful in evaluating possible revision of sediment quality targets.

Table 3-7. Targets for sediment chemistry in fresh and saline waters (conc. in dry wt.)

Metals	Freshwater Sediment (mg/kg)	Marine Sediment (mg/kg)
Cadmium	n/a	1.2
Chromium	n/a	81
Copper	31.6	34
Lead	35.8	46.7
Mercury	n/a	0.15
Zinc	121	150
Organics	**Marine Sediment (ug/kg)**	
Chlordane, total	0.5	
Dieldrin	0.02	
Toxaphene	0.10*	
Total PCBs	22.7	
Benzo[a]anthracene	261	
Benzo[a]pyrene	430	
Chrysene	384	
Pyrene	665	
2-methylnaphthalene	201	
Dibenz[a,h]anthracene	260	
Phenanthrene	240	
Hi MW PAHs	1700	
Lo MW PAHs	552	
Total PAHs	4,022	
Total DDT	1.58	

n/a = not applicable since target not needed for this pollutant in freshwater sediment
*Toxaphene value from New York DEP (1999), assumes 1% TOC

Sediment targets, defined in Table 3-7 or 3-8, are not intended to be used as ~~necessarily~~ 'clean-up standards' for navigational, capital or maintenance dredging or capping activities; rather they are long-term sediment concentrations that should be attained after reduction of external loads, targeted actions addressing internal reservoirs of contaminants, and environmental decay of contaminants in sediment.

3.3 Fish Tissue for the protection of Human Health

Fish tissue targets for DDT and PCBs are selected from "Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene", which are recently developed by OEHHA in June 2008 to assist other agencies to develop fish tissue-based criteria with a goal toward pollution mitigation or elimination and to protect humans from consumption of contaminated fish or other aquatic organisms (OEHHA 2008). Use of fish tissue targets is appropriate to account for uncertainty in the relationship between pollutant loadings and beneficial use effects (USEPA, 2002) and directly addresses potential human health impacts from consumption of contaminated fish or other aquatic organisms. Use of fish tissue targets also allows the TMDL analysis to more completely use site-specific data where limited water column data are available,

consistent with the provisions of 40 CFR 130.7(c)(1)(i). Thus, use of Fish Contaminant Goals (FCGs) provides an effective method for accurately quantifying achievement of the water quality objectives/standards (Table 3-8). Associated sediment targets are not provided for Dieldrin and PAHs because the relationship between sediment and fish tissue is not sufficiently well established to determine an associated sediment target.

Table 3-8. Targets for bioaccumulatives in fish tissue.

Pollutant	Fish Tissue target (ug/kg wet)	Associated sediment target (ug/kg dry)
Chlordane	**5.6**	**1.3** [b]
Dieldrin	**0.46**	**n/a**
Total DDT	**21**	**1.9** [b]
Total PCBs	**3.6**	**3.2** [c]
PAHs – total	**5.47**[a]	**n/a**
Toxaphene	**6.1**	**0.1** [d]

[a] PAHs –total in fish is EPA screening value (EPA 2000c)
[b] Chlordane and total DDT associated sediment values from Newport Bay Indirect Effects draft report (SFEI, 2007)
[c] PCBs-total associated sediment target from SF Bay bioaccumulation study (Gobas & Arnot, 2010)
[d] Toxaphene value from New York DEP (1999), assumes 1%TOC
n/a indicates that a target is not established in this TMDL for this constituent.

3.4 Tissue residues for the protection of Wildlife

Tissue residue goals are identified for protection of wildlife habitat (WILD) and preservation of rare and endangered species (RARE) can also be achieved through tissue/residue levels for DDT and PCBs (Table 3-9). Reducing pollutant loads to attain human health targets will yield progress toward restoring all beneficial uses, yet additional wildlife specific goals must be considered to address possible impairments to reproductive success (birds) or immune system suppression (seals).

Table 3-9. Goals for DDT and PCBs in tissue residues for protecting wildlife habitat and rare and endangered species.

Pollutant	Birds	Harbor Seals
Total DDT	n/a	0.3 ug/g lipid*
Total PCBs	2.2 ug/g in eggs**	5.2 ug/g lipid*

*Barron et al (2003; citations therein) no-effect level for total DDT and total PCBs in harbor seals from Europe.
**Muir et al (1999) no-effect level for total PCBs in Forster's Tern eggs.

4 SOURCE ASSESSMENT

This section identifies the potential sources of OC Pesticides, PCBs, sediment toxicity, PAHs and metals compounds to Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters including discharges directly to these waterbodies and also through the Los Angeles River above the estuary (Los Angeles River estuary, itself, is included in "Greater Los Angeles and Long Beach Harbor Waters") and the San Gabriel River and estuary. As introduced in Section 2, Environmental Setting, the Los Angeles River Watershed and San Gabriel River

watershed are not focus of these TMDLs. Detailed discussion of sources of OC Pesticides, PCBs, sediment toxicity, PAHs and metals *within* the Los Angeles and San Gabriel River watershed will not be provided in this section. However, a discussion of the Los Angeles River above the estuary and the San Gabriel River and estuary as a source to the Harbors on the whole, is included.

Briefly, there are two categories of pollutant sources to the waters of concern in these TMDLs. Point source discharges are regulated through National Pollutant Discharge Elimination System (NPDES) permits. Point sources include stormwater and urban runoff (MS4) and other NPDES discharges, including but not limited to the Terminal Island Water Reclamation Plant, refineries (5), and power generating plants (2), etc. Non-point sources, by definition, include pollutants that reach waters from a number of diffuse land uses and are not regulated through NPDES permits. Non-point sources include existing contaminated sediments within these waters and direct (air) deposition to the waterbody surface.

Metals and PAHs are currently generated or deposited in the watersheds and are then washed into storm drains and channels that discharge to the Dominguez Channel and greater Harbor waters. PCBs, DDT, dieldrin, toxaphene, and chlordane are legacy pollutants for the most part, yet, they remain ubiquitous in the environment, bound to fine-grained particles. When these particles become waterborne, the chemicals are often transported downstream and deposited within estuarine or marine waters. Urban runoff and rainfall higher in the watersheds mobilize the particles, which are then washed into storm drains and channels that discharge to the Dominguez Channel and greater Harbor waters.

Monitoring data from NPDES discharges, land use runoff coefficients, and air deposition studies were used to estimate the magnitude of metals, organo-chlorine pesticides, PCBs, and PAHs loads to Dominguez Channel and Greater Los Angeles and Long Beach Harbor waters.

4.1 **Point Sources**

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

The NPDES permits in the Dominguez Channel watershed, Los Angeles River Watershed, San Gabriel Watershed, and Greater Los Angeles and Long Beach Harbor Waters include the MS4 and Caltrans Storm Water Permits, general construction storm water permits, general industrial storm water permits, individual NPDES permits, minor NPDES permits, and general NPDES permits (Table 4-1).

Table 4-1. Summary of Active NPDES Permits in the Dominguez Channel and Greater Harbor Waters and the Los Angeles River, and San Gabriel River (Summer 2010)

Order Title	Number of Permits		
	Dominguez Channel and Greater Harbor Waters	Los Angeles River	San Gabriel River
Municipal Stormwater Permits:			
▪ Municipal Stormwater Permit (number of municipalities in the Los Angeles County MS4)	24	32	34
▪ California Department of Transportation Storm Water	1	1	1
▪ Municipal Storm Water Permit for the City of Long Beach	1	1	1
Individual NPDES Permits			
Individual NPDES Permits (Major including POTW, refineries, and generating stations)	6	3	8
Individual NPDES Permits (Minors)	12	13	16
General Permits:			
▪ Statewide Industrial storm water permits	207		
▪ Statewide Construction storm water permits	90		
▪ Statewide Discharges of Aquatic Pesticides for Vector and Aquatic Weed Control permits		2	
▪ Statewide Permit for discharges from utility vaults and underground structures		3	
▪ Specified discharges to groundwater in Santa Clara River and Los Angeles River Basins		1	
▪ Treated Groundwater from Construction and Project Dewatering to Surface Waters		2	
▪ Groundwater from Construction and Project Dewatering to Surface Waters		2	
▪ Waste Discharge Requirements for discharges of groundwater from potable water supply wells to surface waters	13	33	26
▪ Waste Discharge Requirements for discharges of nonprocess wastewater to surface waters in coastal watersheds	1	8	3
▪ Waste Discharge Requirements for discharges of low threat hydrostatic test water to surface waters in coastal waters	2	12	3
▪ Waste Discharge Requirements for discharges of groundwater from construction and project dewatering to surface waters in coastal watersheds	1	32	12
▪ Waste Discharge Requirements for treated groundwater and other wastewaters from investigation and/or cleanup of petroleum fuel-contaminated sites to surface waters in coastal watersheds		2	2
▪ Waste Discharge Requirements for discharges of treated groundwater from investigation and/or cleanup of volatile organic compound Contaminated-sites to surface waters in coastal watersheds		5	5
Total	**358**	**155**	**110**

4.1.1 Stormwater Permits in Dominguez Channel Watershed and Greater Harbor Waters Nearshore Watershed

Storm water runoff in the Dominguez Channel watershed and in the nearshore watershed to the greater harbor waters is regulated through a number of permits including:

1) The municipal separate storm sewer system (MS4) permit issued to the County of Los Angeles and the incorporated jurisdictions therein (except the City of Long Beach);
2) The municipal separate storm sewer system (MS4) permit issued to the City of Long Beach;
3) A separate statewide storm water permit specifically for the California Department of Transportation (Caltrans);
4) The statewide Construction Activities Storm Water General Permit; and
5) The statewide Industrial Activities Storm Water General Permit.

These discharges are point sources because the storm water discharges from the end of a storm water conveyance system.

4.1.1.1 MS4 Storm Water Permits

A. Regulation under MS4 Permit

Federal regulations for controlling pollutants in storm water discharges were issued by the USEPA on November 16, 1990 (40 Code of Federal Regulations [CFR] Parts 122, 123, and 124). As part of these regulations, USEPA developed rules establishing Phase I of the 'Municipal Separate Storm Sewer System' storm water program, designed to prevent harmful pollutants from being washed by storm water runoff into MS4s (or from being discharged directly into the MS4s) and then discharged from the MS4s into local waterbodies. Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or more) to implement a storm water management program as a means to control polluted discharges from the MS4s. (Phase II of the MS4 program will focuses on smaller municipalities.) Approved storm water management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipally owned operations, and hazardous waste treatment. Large and medium MS4 operators are required to develop and implement Storm Water Management Plans that address, at a minimum, the following elements:

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

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

The municipalities in Los Angeles County are covered by Phase I MS4 permits. The current County of Los Angeles MS4 permit was issued to the Los Angeles County Flood Control District, County of Los Angeles, and 84 incorporated cities on December 13, 2001 (Order No. 01-182, NPDES No. CAS004001) and was amended on amended on September 14, 2006 by Order R4-2006-0074, on August 9, 2007 by Order R4-2007-0042, on December 10, 2009 by Order No. R4-2009-0130, and on October 19, 2010, pursuant to a Preemptory Writ of Mandate.

The permittees in the Dominguez Channel or Greater Harbors waters watersheds include the following:

- City of Bellflower
- City of Carson
- City of Compton
- City of El Segundo
- City of Gardena
- City of Hawthorne
- City of Inglewood
- City of Lakewood
- City of Lawndale
- City of Long Beach
- ~~City of Lomita~~
- City of Los Angeles
- City of Manhattan Beach
- City of Paramount
- City of Rancho Palos Verdes
- City of Redondo Beach
- City of Rolling Hills
- City of Rolling Hills Estates
- City of Signal Hill
- City of Torrance
- County of Los Angeles
- County of Los Angeles, Flood Control District

The current City of Long Beach MS4 Permit was issued on June 30, 1999 (Order No. 99-060, NPDES No. CAS004003).

Both the County of Los Angeles and City of Long Beach MS4 permits were scheduled to expire five years after they were issued but remain in effect until new MS4 permits are issued and these rescinded.

B. Summary of Los Angeles County MS4 Stormwater Monitoring

As part of the Los Angeles County MS4 Permit Core Monitoring Program, flow and water quality are measured in Dominguez Channel at station, S28 (mass emission station) which is located near the center of the watershed. Data from the mass emission station has been used for flow data in Dominguez Channel.

In addition, as part of the Los Angeles County MS4 Permit Core Monitoring Program, tributary monitoring is conducted in specific subwatersheds each year. Tributary monitoring was conducted at six locations in the Dominguez Channel watershed in 2008-2009. Automatic flow weighted composite samples and grab samples were taken from each tributary location; five wet-weather and three dry-weather events were monitored for each location. The samples were analyzed for OC pesticides and PCBs, although only non-detect results were reported (Los Angeles County Stormwater Monitoring Report, 2008-09). Based on insufficient sensitivity of analytical methods and difficulty with accurately interpreting these results, current stormwater discharge from the Dominguez Channel watershed appears to be an uncertain load of contaminants to the Dominguez Channel and Greater Harbor Waters. However, detections have been measured by other parties within these waters (SCCWRP, 2003), thus it is possible for small amounts of contaminated sediment to transport downstream, become bioavailable and accumulate in tissue to levels that cause impairment.

4.1.1.2 Caltrans Storm Water Permit

Caltrans is regulated by a statewide storm water discharge permit that covers all municipal storm water activities and construction activities (State Board Order No. 99-06-DWQ, NPDES No. CAS000003). The Caltrans storm water permit authorizes storm water discharges from Caltrans properties such as the state highway system, park and ride facilities, and maintenance yards.

The storm water discharges from most of these Caltrans properties and facilities eventually end up in either a city or county storm drain. The metals loading specifically from Caltrans properties have not been determined in the Greater Harbors and Dominguez Channel watershed. A conservative estimate of the percentage of the Greater Harbors and Dominguez Channel watershed covered by state highways is 2.4% (approximately 618 acres). This area represents Caltrans' right-of-way that drains to Dominguez Channel. This percentage does not represent all the watershed area that Caltrans is responsible for under the storm water permit. For example, the park and ride facilities and the maintenance yards were not included in the estimate.

4.1.1.3 General Storm Water Permits

The federal Phase I stormwater regulations for controlling pollutants in storm water issued by the USEPA in 1990, require operators of facilities where discharges of storm water associated with industrial activity occur to obtain an NPDES permit and to implement Best Available Technology Economically Achievable (BAT) to reduce or prevent pollutants associated with industrial activity in storm water discharges and authorized non-storm discharges. The regulations also require discharges of storm water associated with construction activity including clearing, grading, and excavation activities (except operations that result in disturbance of less than five acres of total land area) to obtain an NPDES permit and to implement BAT to reduce or eliminate storm water pollution.

The federal Phase II stormwater rules promulgated by USEPA on December 8, 1999, (40CFR Parts 122, 123, and 124) expanded the NPDES storm water program to include storm water discharges from construction sites that resulted in land disturbances equal to or greater than one acre but less than five acres. Now, under Phase II, any construction site that is greater than one acre must obtain a storm water permit.

On April 17, 1997, State Board issued a statewide general NPDES permit for Discharges of Storm Water Associated with Industrial Activities Excluding Construction Activities Permit (Order No. 97-03-DWQ). This Order regulates storm water discharges and authorized non-storm water discharges from ten specific categories of industrial facilities, including but not limited to manufacturing facilities, oil and gas mining facilities, landfills, and transportation facilities. Under Order No. 97-03-DWQ, non-storm water discharges are authorized only when they do not contain significant quantities of pollutants, where BMPs are in place to minimize contact with significant materials and to reduce flow, and when they are in compliance with Regional Board and local agency requirements.

As of summer 2010, there are 207 discharges enrolled under the general industrial storm water permit within the Dominguez Channel watershed and Greater Harbor Waters.

Potential pollutants from an industrial site will depend on the type of facility and operations that take place at that facility. There is a potential for metals loadings from these types of facilities, especially transportation, recycling and manufacturing facilities. During wet weather, runoff from industrial sites has the potential to contribute metals loadings to the Dominguez channel. This finding is supported by Stenstrom et al. in their final report (2005) on the industrial storm water monitoring program under the existing general permit. In the summary of existing data, the report found that although the data collected by the monitoring program were highly variable, the mean values for copper, lead and zinc were 1010, 2960, and 4960 µg/L, respectively (Stenstrom et al., 2005). During dry weather, the potential contribution of metals loadings from industrial storm water is low.

On August 19, 1999, State Board issued a statewide general NPDES permit for Discharges of Storm Water Runoff Associated with Construction Activities (Order No. 99-08-DQW, NPDES NO. CAS000002). On September 2, 2009 the State Board updated the permit (Order No. 2009-009-DWQ). There are 90 construction sites enrolled under the general construction storm water permit within the Dominguez Channel watershed and Greater Harbor Waters.

Potential pollutants from construction sites include sediment, which may contain metals as well as metals from construction materials and the heavy equipment used on construction sites. During wet weather, runoff from construction sites has the potential to contribute metals loadings to the channel. During dry weather, the potential contribution of metals loadings is low. Under Order No. 99-08-DWQ, discharges of non-storm water are authorized only where they do not cause or contribute to a violation of any water quality standard and are controlled through implementation of appropriate BMPs for elimination or reduction of pollutants.

4.1.2 Other General and Individual NPDES Permits

An individual NPDES permit may be classified as either a major or a minor permit. The discharge flows associated with minor individual NPDES permits and general NPDES permits are typically less than 1 million gallons per day (MGD). There are six major NPDES discharges in Dominguez Channel watershed: one POTW, two generating stations, and three refineries. Other than the major NPDES discharges, there are total of 12 minor NPDES discharges and 17 discharges covered by general NPDES permits. General NPDES permits often regulate episodic discharges (e.g. dewatering operations) rather than continuous flows. The minor NPDES permits issued within the Dominguez Channel watershed are also for episodic discharges.

- Major and Minor Individual NPDES Permits

  Terminal Island Water Reclamation Plant (TIWRP) (NPDES No. CA005386) is the only Publically-Owned Treatment Works (POTW) that discharges to Dominguez Channel watershed or Greater Harbor Waters. The TIWRP discharges tertiary-treated effluent to the Outer Harbor and is under a time schedule order to remove the discharge. The discharger's plan consists of achieving full reclamation (mostly for industrial reuse purposes) by 2020 which would eliminate the effluent discharge completely.

  The Harbor Generating Station and Long Beach Generating Station discharge to the Inner Harbor area. Several oil refineries discharge to Dominguez Channel Estuary. Exxon Mobil discharges to Torrance Lateral.

Facility	**NPDES NO.**	**Regional Board Order No.**
Conoco Phillips (Los Angeles Refinery)	CA0000051	R4-2006-0082
BP Carson Refinery	CA0000680	R4-2007-0015
Tesoro (Los Angeles Refinery)	CA0003778	R4-2010-0179
Exxon Mobil Torrance Refinery	CA0055387	R4-2007-0049
Shell/Equilon Carson Terminal	CA0000809	R4-2007-0026
Long Beach Generating Station	CA0001171	R4-2009-0112
Harbor Generating Station	CA000361	R4-2003-0101

  Many smaller, non-process waste discharges also occur into the harbors.

- General NPDES Permits

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

  The general NPDES permit for Discharges of Groundwater from Potable Water Supply Wells to Surface Waters (Order No. R4-2003-0108) covers discharges of groundwater from potable supply wells generated during well purging, well rehabilitation and redevelopment,

and well drilling, construction and development. As of summer 2010, there are 13 dischargers enrolled under this Order in the Dominguez Channel watershed for a combined total discharge flow of 21.7 MGD.

The general NPDES permit for Discharges of Nonprocess Wastewater to Surface Waters (Order No. R4-2004-0058) covers waste discharges, including but not limited to, noncontact cooling water, boiler blowdown, air conditioning condensate, water treatment plant filter backwash, filter backwash, swimming pool drainage, and/or groundwater seepage. Currently, there is only one discharger enrolled under this Order. The facility discharges only up to 5,000 gallons per day of wastewater into a nearby storm drain that flows into Dominguez Channel.

The general NPDES permits for Discharges of Low Threat Hydrostatic Test Water to Surface Waters (Order No. R4-2009-0068) covers waste discharges from hydrostatic testing of pipes, tanks, and storage vessels using domestic/potable water. Currently, there is only one discharger enrolled under this Order in the Dominguez Channel watershed with design flow of 2.5 MGD.

The general NPDES permit for Discharges of groundwater from construction and project dewatering to surface waters in coastal watersheds of Los Angeles and Ventura Counties (Order No. R4-2008-0032) covers wastewater discharges, including but not limited to, treated or untreated groundwater generated from permanent or temporary dewatering operations. Currently, there is one discharger enrolled under this Order in the Dominguez Channel watershed with design flow of 0.6 MGD.

4.1.3 Superfund Sites within Torrance Lateral subwatershed

Two Superfund sites are located in the watershed: the Montrose Superfund site (DDT) and the Del Amo Superfund site (benzene). Montrose Superfund site includes multiple operable units, which are identified as investigation areas potentially contributing site-related contamination. Both sites are located in the Kenwood Drain subwatershed, which discharges stormwater into Torrance Lateral and flows downstream into saline waters of Dominguez Channel Estuary and Consolidated Slip. Torrance Lateral, Dominguez Channel Estuary and Consolidated Slp (OU2) contain sediments contaminated with multiple pollutants including DDT (potentially from various sources). In 1994 and 2002, USEPA performed a sediment transect study by measuring DDT levels in sediments at numerous sites throughout OU2. Individual grab samples were collected at each site and a comparative analysis was performed on 1994 vs. 2002 results at each site. Briefly, average DDT levels within Kenwood Drain were considerably lower in 2002 when compared to 1994 levels. DDT levels in Consolidated Slip were somewhat higher in 2002 than 1994. Given the ‘snapshot’ nature of these results, one might infer that DDT contaminated sediments in waters of OU2 have moved to more downstream locations in this stormwater pathway (CH2M Hill, 2003).

4.1.4 Point Sources Summary

Dominguez Channel drains a highly industrialized area and also contains remnants of persistent legacy pesticides as well as PCBs which results in poor sediment quality both within the Channel

and in adjacent Inner Harbor areas. The total loading of OC pesticides, PCBs, PAHs, and metals reflects the sum of inputs from urban runoff and multiple NPDES permits within the watershed (Table 4-2). In the Dominguez Channel Watershed storm water discharges are regulated under the MS4 permit, the Caltrans permit, the general industrial storm water permit and the general construction storm water permit.

Table 4-2. Summary of permits in Dominguez Channel Watershed

Type of NPDES Permit	Number of Permits	Permitted Volume (MGD)	Screening for pollutants?	Potential for significant contribution?
Municipal Storm Water	24	NA	Yes	High
Caltrans Storm Water	1	NA	Yes	High
Municipal Storm Water Permit for the City of Long Beach	1	NA	Yes	High
General Construction Storm Water	90	NA	Yes	High
General Industrial Storm Water	207	NA	Yes	High
POTW	1	16	Yes	Medium
Individual NPDES Permits (majors) (incl refineries)	6	24.8	Yes	Medium
Individual NPDES Permits (minors)	12	4.1	Yes	Medium
General Permits	17	24.3	Yes	Low

"Potential for significant contribution" is based on professional judgment on type of discharges and associated potential pollutants maybe carried by the discharges."

4.2 Non-point Sources

A nonpoint source is a source that discharges to water of the US or State via sheet flow or natural processes. Surface water runoff within the watershed occurs as sheet flow near the shores. Additional non-point sources include air deposition and contaminant fluxes from existing sediments within the receiving waters into porewater and overlying water.

4.2.1 Air Deposition

Nonpoint source inputs not only occur from the runoff of precipitation, but also from precipitation falling directly onto the land surface or the harbors. Precipitation occurs as wet deposition of rain droplets, and dry deposition of particulate matter. In the atmosphere, the mixture of gases, water vapor, particulate matter, and wind currents form a dynamic environment in which changes in chemical composition of precipitation can frequently occur. Precipitation can carry significant amounts of inorganic contaminants and sediments to the harbors. Atmospheric deposition is a nonpoint source of metals to the watershed through both direct deposition onto waterbody surface and indirect deposition onto land and then urban runoff carries into the waterbody.

Atmospheric Deposition Loads of Metals in Los Angeles Area Study (Atmospheric Deposition Report) completed by the Regional Board in 2009, summarizes the findings of previous studies

on the air deposition loads of metals resulting from direct sources of major facilities in Los Angeles area including Los Angeles River watershed, San Gabriel River watershed, Dominguez Channel and Los Angeles and Long Beach Harbors Watershed, Santa Monica Bay Watershed, and Ballona Creek Watershed. The study also uses the existing information of the previous studies to estimate the indirect atmospheric deposition loads of metals in the Los Angeles area. The study is referenced in this section to provide estimated loadings from direct and indirect atmospheric deposition.

Direct atmospheric deposition of metals to Los Angeles River, San Gabriel River, and Dominguez Channel watersheds was calculated using monitoring data. The estimates are shown in Table 4-3. In general, direct atmospheric deposition from Los Angeles River and San Gabriel River watersheds is smaller in comparison to the deposition from Dominguez Channel and Harbors watershed because the actual surface area of the river systems themselves are smaller than surface areas of the Harbors and Dominguez Channel.

Table 4-3 Direct Atmospheric Deposition of Metals Provided by Dischargers

Constituent	Direct Source	Los Angeles River Watershed	San Gabriel River Watershed	Dominguez Channel and LA/LB Harbors Watershed
Copper (g/year)				
	WSPA			43
	Rangers Die Casting	21,909		
	Total	**21,909**		**43**
Lead (g/year)				
	WSPA			32
	Exide Tech	11,340		
	Trojan Battery		83	
	Total	**11,340**	**83**	**32**
Zinc (g/year)				
	WSPA			490
	Bandag Licensing	454		
	Quemetco		222	
	US Borax			3,112
	Western Tube and Conduit	907		454
	Total	**1,361**	**222**	**4,056**

Direct atmospheric deposition rates used in this TMDL are based on the most recent study performed by the Southern California Coastal Water Research Project (SCCWRP): *Metals Dry Deposition Rates along a Coastal Transect in Southern California study* performed by Sabin et al. in 2007. Differences in metal dry deposition flux rates observed between sites were dominated by proximity to urban areas and/or other nearby sources, with the highest metal fluxes observed near the Los Angeles Harbor and San Diego Bay sites. Compared with data from the 1970s, lead fluxes were typically one to two orders of magnitude lower in the present study (2007), indicating atmospheric sources of these metals have decreased over the past three decades. The median dry deposition fluxes for all metals measured at the Los Angeles Harbor

site were comparable to measurements in other studies in Los Angeles and Chicago and provided in Table 4-4.

Table 4-4. Comparison of metal dry deposition flux rates (Sabin et al. 2007)

Air Deposition Study	Constituents (µg/m^2-day)			
	Chromium	Copper	Lead	Zinc
Lim et al., 2006 **Urban Sites in Los Angeles and Orange County, CA USA**				
Los Angeles River -1	6	21	15	130
Los Angeles River -2	2.3	30	31	160
Los Angeles River -3	9	16	32	110
Ballona Creek	2.7	18	20	77
Dominguez Channel	3.3	12	11	74
Santa Ana River	4.3	30	10	180
Yi et al., 2001				
Chicago, IL USA	5.7	63	38	120
South Haven, MI USA	0.7	31	23	51
Sleeping Bear Dunes, MI USA	1.6	79	35	68
Sabin et al., 2007				
Santa Barbara	0.34	2.0	1.3	14
Oxnard	0.23	0.89	0.52	4.8
Malibu	0.29	1.9	1.0	12
Hyperion	0.39	3.9	1.0	16
Los Angeles Harbor (a.k.a Wilmington)	3.6	22	14	160
Newport	0.64	5.1	1.8	22
Oceanside	0.48	4.2	1.4	40
San Diego Bay	0.99	29	3.3	63

Note: Shaded rows indicate inland monitoring sites

The SCCWRP study (2006) collected air deposition samples at a Los Angeles Harbor air monitoring site, also known as 'Wilmington' site, (located 3 km inland) and these results are more comparable to other inland sites (shaded sites in Table 4-4). Therefore, the deposition rate for LA Harbor is applied to calculate the estimated current air deposition loads for certain waterbodies: Dominguez Channel Estuary, Consolidated Slip, Inner Harbor and LA River Estuary. The average of six coastal site values (underlined in table immediately above) are applied to the following waterbodies: Fish Harbor, Cabrillo Marina, Inner Cabrillo Beach, Outer Harbor and San Pedro Bay. The estimates of copper, lead, zinc, DDT, and PAHs loading from atmospheric deposition are presented in Table 4-5. See also Appendix III, Part 6.

Table 4-5. Estimated Atmospheric Deposition of Copper, Lead, Zinc, and PAHs in Dominguez Channel Estuary and Greater Harbor Waters based on monitoring results from Sabin & Schiff (2007).

		Wilmington site (µg/m^2-day)			Coastal sites (n= 6) (µg/m^2-day)			(ng/m^2-day)
		Cu	Pb	Zn	Cu	Pb	Zn	PAHs
Water Bodies	**Area (m^2)**	**22**	**14**	**160**	**3**	**1.17**	**18.1**	**244**
Dominguez Channel	567,900	4.56	2.90	33.2				0.051
Consolidated Slip	147,103	1.18	0.75	8.59				0.013
Inner Harbor	12,154,560	97.6	62.1	709.8				1.08
LA River Estuary	837,873	6.73	4.28	48.93				0.075
Fish Harbor	368,524				0.40	0.16	2.43	0.033
Cabrillo Marina	310,259				0.34	0.13	2.05	0.028
Cabrillo Inner Beach	331,799				0.36	0.14	2.19	0.03
Outer Harbor	16,358,366				17.9	6.99	108.1	1.46
San Pedro Bay	33,073,517				36.2	14.1	218.5	2.95

Shaded rows indicate monitoring results from Wilmington (inland) site; other rows based on average of six coastal sites from Sabin et al., 2007 in Table 4-4 above.

Indirect deposition of metals is generally associated with the accumulation and wash-off of metals on the land surface during rain events. Metals washed off the land surface are delivered to the river through creeks and stormwater collection systems. As such, indirect loading varies depending on the amount of rainfall and size of storms in a given year.

Indirect atmospheric deposition is the amount of airborne metals deposited on land surface that may be washed into a water body during storm events. The amount of deposited metals available for transport to Los Angeles area (i.e., not infiltrated) is unknown.

Indirect atmospheric deposition reflects the process by which metals deposited on the land surface may be washed off during rain events and be delivered to the river and tributaries. Not all the metals deposited on the land from the atmosphere are loaded to the river. Estimates of metals deposited on land are much higher than estimates of loadings to the river system. The loadings of metals associated with indirect atmospheric deposition are accounted for in the estimates of the stormwater loadings.

4.3 Model Estimated Loads from Point and Non Point Sources

4.3.1 Existing Loads within Dominguez Channel freshwater

Current loads of metals into Dominguez Channel freshwater were estimated using Loading Simulation Program in C++ (LSPC) model output from simulated flows for 1995-2005. Monitoring data from NPDES discharges and land use runoff coefficients were analyzed along with Channel stream flow rates to estimate the magnitude of metal loadings. The PAH loads were calculated using simulated flow and PAH Event Mean Concentrations (EMC), while the DDT and PBC loads were calculated by applying observed sediment concentrations to the LSPC simulated sediment concentrations (see Appendix II). In recognition of the wide variety of stream flow rates generated by various rainfall conditions, flow duration curves were utilized to analyze the metals loading during wet weather.

The LSPC model was also updated for freshwater inputs from Los Angeles River and San Gabriel River. These models were previously developed by Tetra Tech to support metals TMDLs in those watersheds. The nearshore areas were also modeled using LSPC. These nearshore areas refer to freshwater inputs that discharge either directly into the saline TMDL receiving waters or to the Channels, Rivers, or Bays that ultimately discharge to the saline TMDL receiving waters. More discussion of the LSPC model and results are provided in the Linkage Analysis section of this document. Additional information is provided in Appendix II and III.

4.3.2 Existing Pollutants in in Dominguez Channel Estuary and Greater Harbor Waters

A variety of activities in the past decades in Dominguez Estuary, Los Angeles and Long Beach Harbors, and surrounding areas contributed to contamination of existing sediment bed. The sediment bed is represented by multiple layers with internal transport of contaminants by pore water advection and diffusion. Sediment and water is exchanged between the water column and bed by deposition, erosion and re-suspension, with corresponding exchange of adsorbed and dissolved contaminants. Re-suspension may occur via natural processes and/or anthropogenic activities including (ship) propeller wash. Dissolved phase contaminants are also exchanged by diffusion between bed pore water and the overlying water column. Sediment bed conditions are persistent with changes in bed sediment composition and contamination levels occurring slowly at annual scales and longer. Sediment conditions influence both sediment transport dynamics and the phase distribution and mobility of contaminants in the bed.

Existing sediment loading for metals, PAHs, DDT, and PCBs for Dominguez Channel Estuary and greater Harbor waters were estimated via Environment Fluid Dynamics Code (EFDC) model for 2002-2005. (Summary information for the EFDC model used for these TMDLs are included in Linkage Analysis, Section 5. Detailed model reports are included in Appendices I, II and III.) This involved using the existing average sediment concentration predicted by the EFDC model for 2002-2005 in the top 5 cm and the total sediment deposition rate per waterbody (see Appendix III, Part 1). Table 4-6 presents the modeled existing sediment bed pollutant loads in Dominguez Channel Estuary and Greater Harbor waters.

Table 4-6. Estimated pollutant loadings in existing sediment bed based on average EFDC model output for 2002-2005 (deposition rate * existing concentration in top 5 cm = total existing load).

Waterbody	Pollutants (g/yr)					
	Cu	Pb	Zn	DDT	PAH	PCB
Dominguez Channel Estuary	327,600	457,905	1,799,038	54	28,082	57
Consolidated Slip	92,143	127,260	398,941	49	11,510	84
Inner Harbor	178,444	105,916	542,093	22	3,524	30
Outer Harbor	118,991	66,725	403,429	31	626	35
Fish Harbor	1,434	600	4,209	0.17	3	0.08
Los Angeles River Estuary	1,611,961	2,641,274	20,096,108	232	8,722	402
Cabrillo Inner Beach	2,980	655	4,518	1.0	24	0.3
Cabrillo Marina	9,164	2,307	9,144	1.7	236	1.1
San Pedro Bay	1,250,794	1,737,044	8,166,507	205	3,634	111

4.4 Sources Summary

Dominguez Channel freshwater waters: The major pollutant sources of metals into Dominguez Channel and Torrance Lateral freshwaters are stormwater and urban runoff discharges. Nonpoint sources include atmospheric deposition.

Current loads of metals into Dominguez Channel were estimated using Loading Simulation Program in C++ (LSPC) model output from simulated flows for 1995-2005. Monitoring data from NPDES discharges and land use runoff coefficients were analyzed along with Channel stream flow rates to estimate the magnitude of metal loadings. In recognition of the wide variety of stream flow rates generated by various rainfall conditions, flow duration curves were utilized to analyze the metals loading during wet weather.

Dominguez Channel Estuary and Greater Los Angeles and Long Beach Harbor waters: A variety of activities over the past decades in the four contributing watersheds (Dominguez Channel, Los Angeles River, San Gabriel River and the nearshore watershed) and in the Harbors themselves have contributed to the sediment contamination. The contaminated sediments are a reservoir of historically deposited pollutants. Stormwater runoff from manufacturing, military facilities, fish processing plants, wastewater treatment plants, oil production facilities, and shipbuilding or repair yards in both Ports discharged untreated or partially treated wastes into Harbor waters. Current activities also contribute pollutants to Harbor sediments including, stormwater runoff from upstream sources and port sources, commercial vessels (ocean going vessels and harbor craft), recreational vessels, and the re-suspension of contaminated sediments from propeller wash within Ports' slips and unmaintained areas also contributes to transport of pollutants within the Harbors. Loadings from the four contributing watersheds and intermittent overflows from Machado Lake are also potential sources of metals, pesticides, PCBs, and PAHs to the Harbors.

The pollutants of concern in Machado Lake (a.k.a. Harbor Lake) are similar to those in this TMDL. Some intermittent overflows from Machado Lake reach LA Inner Harbor via storm channel; however, there is a paucity of available data and information for chemical concentrations and flow rates from Machado Lake overflows. For this TMDL, the freshwater hydrologic model incorporated pollutant loads into Machado Lake, treating it as a sink, but we did not have sufficient data to quantify loadings that may occur in intermittent overflows reaching the Inner Harbor. (See Appendix II for additional discussion.) A Toxics TMDL has been developed and approved for Machado Lake and implementation is planned (and funded) to occur through Prop O project which includes dredging contaminated sediment in the Lake.

Another nonpoint source of pesticides and PCBs to the greater Harbor waters are fluxes from currently contaminated sediments into the overlying water. The re-suspension of these sediments as well as desorption of pollutants into the water column contributes to the fish tissue impairments. In addition, atmospheric deposition appears to be a potentially significant nonpoint source of metals, DDT and PAHs to the watershed, through either direct deposition or indirect deposition.

Current loading of metals, PAHs, DDT and PCBs to the Dominguez Channel Estuary and Greater Harbor waters were calculated by adding the stormwater runoff and other point source contributions (including TIWRP into Outer Harbor) and the nonpoint sources – existing sediment loads and direct deposition to each waterbody surface. The total current load for each water body-pollutant combination is included in Section 6, Tables 6-9 and 6-11 along with required percent reductions.

5 LINKAGE ANALYSIS

The linkage analysis connects pollutant loads to the numeric targets and protection of beneficial uses of the listed waterbodies. The numeric targets selected for pollutants in fish tissue, water, and sediments define acceptable levels to restore habitat conditions and protect benthic infauna, other aquatic organisms including fish and marine mammals, wildlife and human health.

For direct effects, the linkage between pollutants and sediment dwelling organisms is presented in Figure 5-1. Benthic organisms are exposed to pollutants via ingestion of sediment, intake of sediment porewater or overlying water, and possible consumption of other bottom dwelling organisms, algae or detritus. Furthermore benthic organisms reside in these sediments and are relatively immobile so they endure continual exposure to pollutants in sediments, porewater or overlying water.

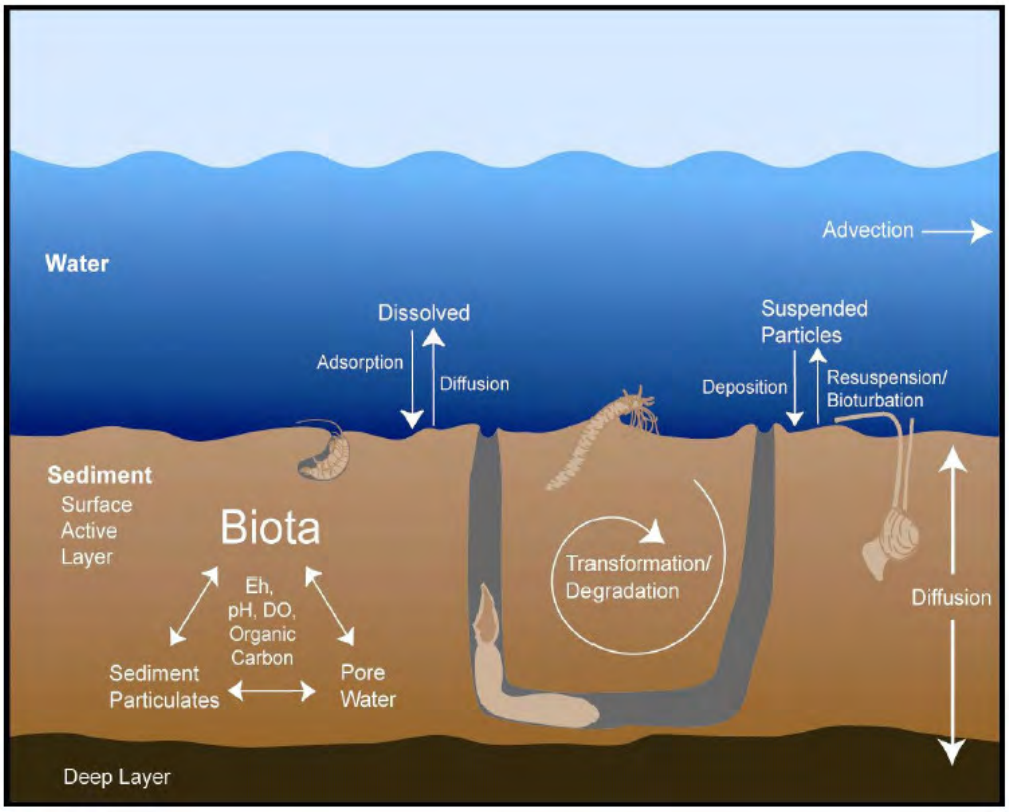


Figure 5-1. Sediment processes affecting the distribution and form of contaminants to benthic and aquatic organisms. (Source: SWRCB, 2008; Figure 2-2)

A food web diagram is presented in Figure 5-2 to describe linkage between bioaccumulative pollutants in water and sediment and transfer across trophic levels. This conceptual model represents organisms in various trophic levels or guilds in the San Francisco Bay food web bioaccumulation model (Gobas and Arnot 2010). The organisms and pollutant transfer pathways closely resemble those within greater Harbor waters, namely: phytoplankton and algae; zooplankton; filter-feeding invertebrates (bivalves and amphipods); sediment detritovores (shrimp and mysids); juvenile and adult fish; fish-eating birds; juvenile and adult marine mammals and humans (not shown). The biological species with empirical data used in S.F Bay bioaccumulation study are also residents of greater Harbor waters, including Pacific oysters, California mussels, shiner surfperch, jack smelt, white croaker, double-crested cormorant and harbor seals. The Newport Bay bioaccumulation study has similar trophic guilds and has included many fish species that also reside in greater Harbor waters, e.g., striped anchovy, topsmelt, halibut, sandbass, corbina and croaker. Again, once such studies are completed in local waters with corresponding empirical data to revise food web models, then site-specific sediment and tissue targets may be reconsidered.

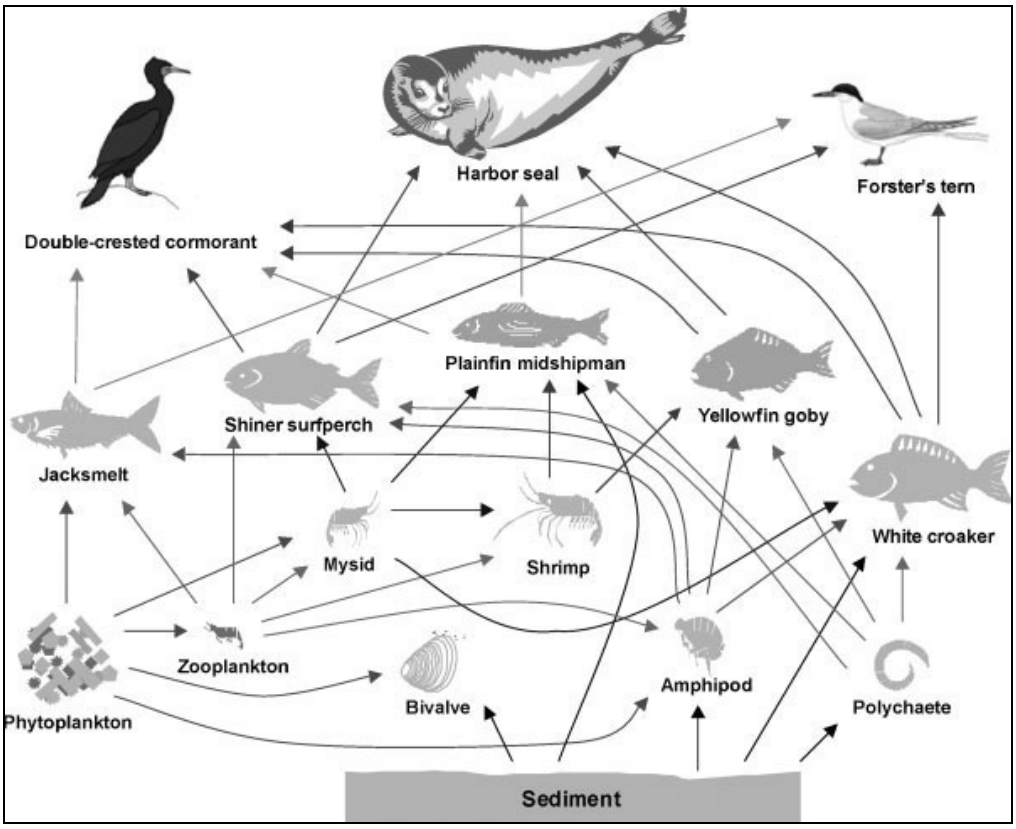
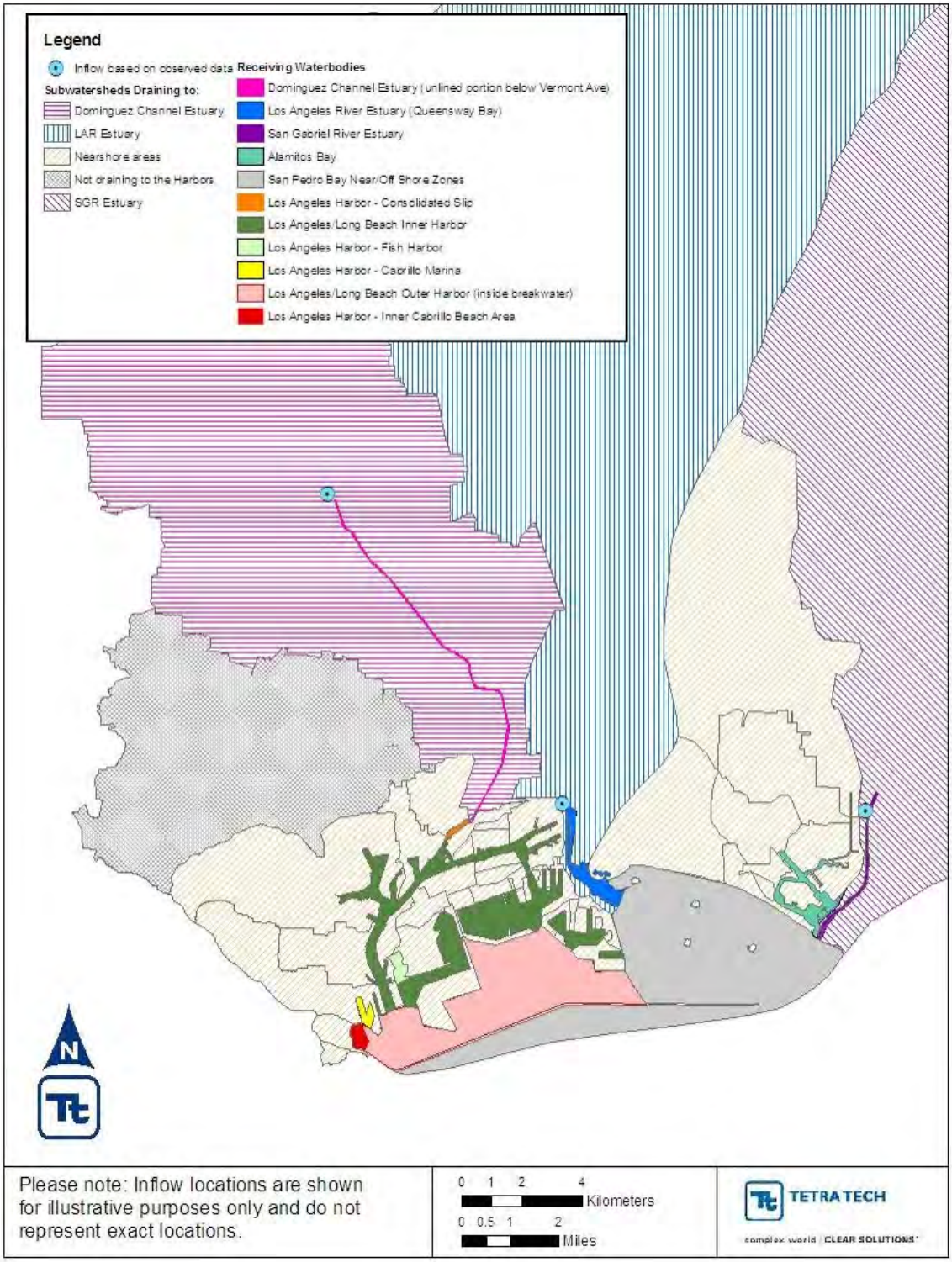


Figure 5-2. Conceptual model of food web in S.F Bay bioaccumulation study, used for this TMDL to set sediment PCBs targets. (Reproduced from Gobas and Arnot, 2010).

5.1 Model Development

This section will also describe model development for use in the area of the Los Angeles and Long Beach Harbors and San Pedro Bay, including their tributaries, the Los Angeles and San Gabriel Rivers and Dominguez Channel (Figure 5-3), which will be used to evaluate the results of different input scenarios for the TMDL allocation plan in the following Section.

To represent the linkage between source contributions and in receiving water response, a dynamic water quality model was developed to simulate source loadings and transport of the listed pollutants in the greater harbor water area. Hydrodynamic and sediment and contaminant transport models provide an important tool to evaluate existing conditions, including identifying point and non-point source load contributions, source controls, and TMDL allocation alternatives. A modeling system that includes hydrodynamic, sediment transport, and contaminant transport and fate is necessary to estimate current conditions and potential load reduction scenarios for the listed waterbodies.



5.2 **Figure 5-3. Watershed associated with each receiving waterbody.**

Three appendices are included with the Staff Report to fully document the modeling approach.

Appendix I, *The Los Angeles-Long Beach Harbors and San Pedro Bay Hydrodynamic and Sediment- Contaminant Transport Model Report* describes the estimation of metals and organic pollutant concentrations using Environmental Fluid Dynamics Code (EFDC) in the Dominguez Channel Estuary and Greater Los Angeles and Long Beach Harbor Waters. Appendix I gives a complete description of the hydrodynamic, water quality, and sediment transport developed to simulate the dynamic interactions in saline waters of the greater harbor system.

Appendix II, *The Watershed Model Development for Simulation of Loadings to the Los Angeles/Long Beach Harbors Report* describes the approach used to estimate metals and organic pollutant loads from the Los Angeles River, the San Gabriel River, and nearshore watershed areas. These models, based on the Loading Simulation Program in C++ (LSPC) watershed model, and in addition to the Dominguez Channel model, were used to determine the pollutant loadings into Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters.

Appendix III includes additional material developed by Tetra Tech including: TMDL Loading Calculations for Saltwater Waterbodies; Dominguez Channel Freshwater Loading Calculations; Initial Conditions for EFDC Model; Applicable Maps; SCCWRP Flux Monitoring Study; Metals Aerial Deposition Rates; Justification for Addition of Waterbody-Pollutant Combinations (in addition to 2006 303(d) list); Tetra Tech Memo on TMDL Scenarios.

Dominguez Channel and other freshwater

The LSPC model was used to estimate freshwater loadings of total metals and totals of PAHs, DDT, and PCBs from the four contributing watersheds (Dominguez Channel, Los Angeles River (LAR) , San Gabriel River (SGR), and the nearshore watersheds) (see Appendix II for more information). An LSPC model developed for the Dominguez Channel watershed was based on information initially provided by SCCWRP. LAR and SGR models were updated from earlier versions used for metals TMDLs in those two watersheds. The nearshore watershed was analyzed and modeled using LSPC by breaking it into 67 subwatersheds that discharge directly to the Greater Los Angeles and Long Beach Harbor waters. These sub-watersheds were then aggregated by receiving waterbody; e.g. nearshore contributions to Inner Harbor consisted of stormdrains and surface (sheet) flows that discharge directly into the Inner Harbor. See Figure 5-5 at the end of this section for nearshore watersheds and associated neighboring waters.

Model development throughout Los Angeles waters relies on regionally-calibrated metals parameters, stormwater event mean concentrations (EMCs) for PAHs, predicted sediment loads and receiving water sediment concentrations for DDT and PCBs as well as simulated (and LAR hourly observed) flows to estimate pollutant loadings. The simulation time frames for the LSPC watershed model were expanded to 1995-2005 to generate temporally consistent model output from each contributing watershed. A separate approach was used to estimate dry weather loads, as described in Appendix II, Section 2. These were combined with the wet weather loads and the resulting loads from all contributing watersheds were applied to the estuarine and marine receiving waters.

Detailed model results are presented in Appendix II. This modeling approach relied on a regional modeling approach using regionally-calibrated parameter values, consistent with other TMDLs in the Los Angeles Region. While the watershed model results did not always predict the

observed values, they generally captured the range of observations; however, deviations from the observed values did occur (see Appendix II). Given the limited data available for model calibration and validation, there were not enough data to justify refinement of the calibrated and validated parameter values associated with the regional modeling approach (which were developed using significantly larger datasets). Overall, the TMDL model made use of the best available data at the time of modeling.

Table 5-1 below shows total loads from the four contributing watersheds to the Greater Harbor waters by comparing them to one another. Overall, the Los Angeles River is the largest freshwater contributor of pollutants to the greater Harbor waters; LA River flows primarily impact water quality in eastern San Pedro Bay. The Inner Harbor receives the bulk of the loading from the nearshore watershed, which is expected since this waterbody has the largest nearshore drainage areas and acts as a pollutant sink. See Table 5-2. For Dominguez Channel, Los Angeles River, and San Gabriel River, all of their loadings are directly received by their downstream estuaries (Dominguez Channel Estuary, Los Angeles River Estuary, and San Gabriel River Estuary, respectively).

Table 5-1. Comparative Watershed Loadings to Greater Harbor Waters.

Contaminant	LSPC Modeled Existing Loading by Watershed (1995-2005)							
	Dominguez Channel		Los Angeles River		San Gabriel River		Nearshore Watershed	
	Percent of Total Loading	Average Daily Load (kg/day)	Percent of Total Loading	Average Daily Load (kg/day)	Percent of Total Loading	Average Daily Load (kg/day)	Percent of Total Loading	Average Daily Load (kg/day)
Wet Conditions								
Sediment	5.6%	1.88E+05	72.0%	2.79E+06	20.4%	4.90E+05	1.9%	6.54E+04
Total Copper	4.3%	3.58E+01	81.1%	7.85E+02	12.5%	7.51E+01	2.1%	1.78E+01
Total Lead	3.0%	2.08E+01	71.5%	5.67E+02	23.3%	1.15E+02	2.2%	1.53E+01
Total Zinc	5.0%	3.56E+02	72.2%	5.89E+03	20.2%	1.02E+03	2.6%	1.84E+02
Total DDT	9.2%	2.20E-02	89.5%	2.46E-01	0.7%	1.15E-03	0.7%	1.59E-03
Total PAH	8.0%	2.04E+00	70.2%	2.07E+01	16.1%	2.95E+00	5.8%	1.50E+00
Total PCB	2.3%	1.38E-02	97.5%	6.86E-01	0.1%	3.11E-04	0.2%	9.92E-04
Dry Conditions								
Sediment	0.7%	8.57E+01	19.0%	2.27E+03	80.1%	1.01E+04	0.1%	1.54E+01
Total Copper	2.6%	2.56E-01	48.7%	4.69E+00	40.8%	4.18E+00	8.0%	7.78E-01
Total Lead	0.9%	3.48E-02	19.8%	7.86E-01	72.9%	3.07E+00	6.5%	2.59E-01
Total Zinc	0.9%	5.65E-01	30.4%	1.90E+01	62.6%	4.15E+01	6.2%	3.89E+00
Total DDT	7.7%	1.90E-05	83.0%	2.01E-04	9.3%	2.38E-05	0.0%	2.88E-10
Total PAH	6.8%	7.06E-02	62.7%	6.39E-01	30.4%	3.29E-01	0.0%	4.18E-05
Total PCB	1.8%	1.06E-05	97.1%	5.59E-04	1.1%	6.43E-06	0.0%	1.45E-10

Table 5-2. Receiving Waterbody and Contaminant Loading from the Near Shore Watershed (based on LSPC model output).

Contaminant		Alamitos Bay	Los Angeles Harbor - Cabrillo Marina	Los Angeles Harbor - Consolidated Slip	Los Angeles Harbor - Fish Harbor	Los Angeles Harbor - Inner Cabrillo Beach Area	Los Angeles River Estuary	Los Angeles/Long Beach Inner Harbor	Los Angeles/ Long Beach Outer Harbor (inside breakwater)	San Pedro Bay Near/Off Shore Zones
Total Copper	Percent of Total Loading	54.9%	3.1%	0.1%	1.2%	0.8%	0.6%	28.2%	4.9%	6.2%
	Average Daily Load (kg/day)	1.36E+00	7.74E-02	1.50E-03	3.04E-02	1.97E-02	1.52E-02	6.97E-01	1.21E-01	1.54E-01
Total Lead	Percent of Total Loading	59.9%	2.8%	0.1%	1.1%	0.7%	0.5%	25.0%	4.0%	5.9%
	Average Daily Load (kg/day)	1.05E+00	4.95E-02	9.29E-04	2.02E-02	1.20E-02	9.03E-03	4.39E-01	7.12E-02	1.04E-01
Total Zinc	Percent of Total Loading	59.5%	2.7%	0.1%	1.0%	0.6%	0.6%	25.2%	4.3%	5.9%
	Average Daily Load (kg/day)	1.30E+01	6.00E-01	1.23E-02	2.28E-01	1.40E-01	1.31E-01	5.51E+00	9.41E-01	1.30E+00
Total DDT	Percent of Total Loading	15.5%	3.0%	0.1%	2.2%	0.7%	2.4%	66.9%	7.3%	2.0%
	Average Daily Load (kg/day)	2.46E-05	4.81E-06	9.93E-08	3.43E-06	1.11E-06	3.78E-06	1.06E-04	1.16E-05	3.25E-06
Total PAH	Percent of Total Loading	53.5%	2.9%	0.1%	1.3%	0.7%	0.6%	29.1%	4.2%	7.6%
	Average Daily Load (kg/day)	8.04E-02	4.32E-03	1.32E-04	1.97E-03	1.13E-03	9.16E-04	4.37E-02	6.27E-03	1.14E-02
Total PCB	Percent of Total Loading	11.0%	2.5%	0.0%	2.5%	0.6%	2.7%	71.4%	7.7%	1.5%
	Average Daily Load (kg/day)	1.10E-05	2.45E-06	4.46E-08	2.47E-06	5.69E-07	2.68E-06	7.08E-05	7.68E-06	1.53E-06

Dominguez Channel Estuary and Greater Los Angeles and Long Beach Harbor waters
The EFDC model was used to simulate hydrodynamics and water and sediment quality of Dominguez Channel Estuary and the Greater LA/LB Harbor waters (see Appendix I for more details). The EFDC model applied a simulated time period of 2002-2005. The model was calibrated with numerous sediment monitoring studies, and it benefitted significantly from POLA/POLB sediment characterization study (2006) which yielded sediment, porewater and overlying water concentrations as well as results from highly sensitive monitoring (SPME) devices for detecting DDT, PCBs, and PAHs in the water column (SCCWRP 2007). The EFDC model also considered ocean water (outside breakwater) conditions as well as fine and course sediment transport and deposition within this hydrologically connected system of fresh and saline waters. While a grid was used to represent Dominguez Channel Estuary and the Greater LA/LB Harbor waters, it is important to note that the grid was not modeled as a closed system. Specifically, water, sediment, and associated pollutant loads can be exchanged both in and out of the model grid through the open ocean boundary.

Ultimately the EFDC model was integrated with LSPC output – hourly for three watersheds, daily for nearshore watersheds – to model total metals, PAHs, PCBs, and DDT (total) concentrations in the receiving waters. The EFDC model was used to quantify fine and coarse

sediment deposition rates associated with each waterbody. These rates were summed, yielding the total deposition rate for each waterbody multiplied by the corresponding average modeled existing sediment concentration (in the top 5 cm of active sediment layer) or the target concentration to estimate the existing and target pollutant loads, respectively, within each waterbody (Table 5-3). The sediment flux is dependent on watershed inputs as well as tidal movements between waterbodies.

Table 5-3. Sediment Deposition Rates per Waterbody

Waterbody Name	TMDL Zone	Area (acres)[1]	Area (m^2)[1]	Total Deposition (kg/yr)[2]
Dominguez Channel Estuary	01	140	567,900	2,470,201
Consolidated Slip	02	36	147,103	355,560
Inner Harbor - POLA	03	1,539	6,228,431	1,580,809
Inner Harbor - POLB	08	1,464	5,926,130	674,604
Fish Harbor	04	91	368,524	30,593
Cabrillo Marina	05	77	310,259	38,859
Cabrillo Beach	06	82	331,799	27,089
Outer Harbor - POLA	07	1,454	5,885,626	572,349
Outer Harbor - POLB	09	2,588	10,472,741	1,828,407
Los Angeles River Estuary	10	207	837,873	21,610,283
San Pedro Bay	11	8,173	33,073,517	19,056,271

[1] Area obtained from GIS layer of the 2006 303(d) list. Available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/303d_lists2006_gis.shtml

[2] Sediment deposition rates were calculated by approximating the average mass of total sediment (fine and coarse particles) deposited in each waterbody annually based on 2002-2005 EFDC output. Sediment flux for each grid cell, which is dependent on watershed inputs as well as tidal movements between waterbodies, was obtained from the EFDC model output. These values were summarized across each TMDL zone, resulting in the average deposition of both sediment fines and sand by waterbody. The total deposition rate is simply the sum of the rates for fines and sand and this value is the waterbody-specific average annual (clean) sediment deposition rate.

EFDC is a multidimensional (i.e., 1-D, 2-D, or 3-D) hydrodynamic and water quality model that has been used by EPA for TMDL development in river, lake, estuary, wetland, and coastal regions throughout the United States. The model has three primary components (hydrodynamics, sediment-toxic transport and fate, and water quality) integrated into a single model. The hydrodynamic component is dynamically coupled to salinity and temperature transport as well as to sediment-toxic transport and water quality components.

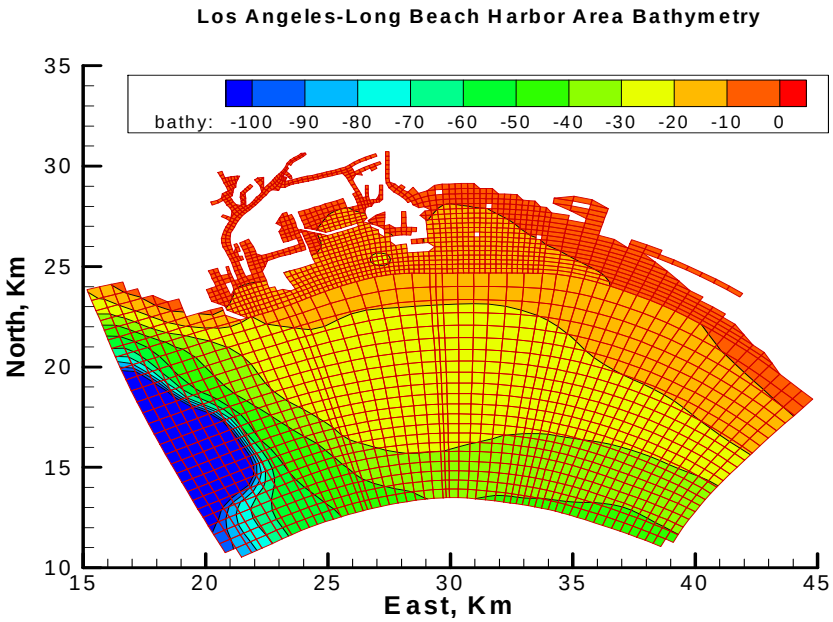
The water quality component of EFDC simulates eutrophication and sediment biogeochemical (diagenesis) processes. The eutrophication kinetics and sediment processes are similar to those in the USACE CE-QUAL-ICM or Chesapeake Bay water quality model. EFDC can simulate multiple classes of sediment such as suspended loads and bed loads as well as sediment deposition and re-suspension. The sediment transport is linked to toxic or contaminant transport and fate components. EFDC is capable of simulating any number of contaminants, including metals and hydrophobic organics, adsorbed to any sediment size class.

A brief overview of the hydrodynamic simulation model including grid set-up and model parameters are presented in the next section (additional details are provided in Appendix I).

5.2.1 Hydrodynamic Model

Computational Grid Setup and Boundary Conditions

A multi-resolution, curvilinear spatial grid of the greater Los Angeles and Long Beach Harbor waters and San Pedro Bay was constructed using the Visual Orthogonal Grid Generation (VOGG) grid generation system (Tetra Tech, 2002). Shoreline boundaries for the grid were based on the NOAA/NOS electronic navigation charts in GIS format. The Dominguez Channel grid from a previous study was incorporated into the model (Everest, 2006). The grid system uses a multi-domain mapping, unique to the EFDC model, which allow a course resolution outside the breakwater in San Pedro Bay and a finer resolution in the harbors system. Bathymetric data were interpolated on to the model grid using an average of the bathymetric data points falling within a cell. The primary bathymetric data set used was the NOAA High Resolution Coastal Relief Data, which has a horizontal resolution of approximately 90 meters. Model grid and bathymetry are shown in Figure 5-4, except the Dominguez Channel estuary area.



Note: Elevation in meters relative to local mean sea level.
The portion of the grid in Dominguez Channel extending to Vermont Avenue is not shown. The grid for this area was represented by a previous study (Everest, 2006)

Figure 5-4. EFDC Model Grid System and bathymetry for Los Angeles-Long Beach Harbor and San Pedro Bay.

Boundary conditions for velocity and water elevations were specified for every grid cell in the model region. Salinity and temperature open boundary conditions were specified as spatially constant and temporally varying along the open boundary. The hydrodynamic and transport model was configured for a four-year historical simulation period from January 2002 through December 2005, since this period encompasses the greatest amount of observational data for

model calibration and overlaps with the available watershed model output (see Appendix I for more details).

5.2.2 Sediment and Contaminant Transport Model

Sediment and Contaminant Transport Model Parameters

The EFDC model simulates transport and fate in both the water column and sediment bed. Both fine, cohesive behaving sediment and noncohesive sand were simulated. Particulate organic material was assumed to be associated with the fine sediment class. Contaminants modeled included three metals; copper, lead, and zinc and three organics; DDT, PAH, and PCB. See Appendix I for more EFDC details). Two-phase equilibrium partitioning was used to represent for the Los Angeles and Long Beach Harbor adsorption of the metals and organics to the fine sediment class.

Water column transport included advection, diffusion, and settling for sediment and sediment adsorbed contaminates. The sediment bed was represented by multiple layers with internal transport of contaminants by pore water advection and diffusion. Sediment and water was exchanged between the water column and bed by deposition and erosion, with corresponding exchange of adsorbed and dissolved contaminants. Dissolved phase contaminants were also exchanged by diffusion between bed pore water and the overlying water column.

Initial water column conditions, based on available monitoring results were integrated into the model. However it is important to note that aqueous pollutant concentrations often wash out or rapidly respond to external sources and open boundary conditions. In contrast, initial bed sediment conditions are persistent and contamination levels change more slowly at annual scales and longer. Parameters used for hydrodynamic model development included salinity and bathymetry to reproduce observed water elevation and velocity patterns and magnitudes.

Equilibrium partition coefficients for three metals based on the 2006 POLA-POLB sediment and overlying water data are listed in Table 5-4. Both sets of values are within the literature range summarized by USEPA (2005). Water column partition coefficients for metal adsorption to dilute sediment (concentrations in the 1 to 100's mg/L) are typically larger than bed values.

Table 5-4. Sediment Bed and Water Column Equilibrium Partition Coefficients and Particulate to Dissolved Concentration Ratios for Metals.

Contaminant	Average Bed Partition Coefficient Based on Total Solids (L/mg)[1]	Visual Best Fit Bed Partition Coefficient Based on Total Solids (L/mg)[1]	Water Column Particulate to Dissolved Concentration Ratio[2]	Estimated Water Column Partition Coefficient, 5 Times Column 3 (L/mg)[3]
Copper	0.09	0.05	0.51	0.25
Lead	0.54	0.25	7.12	1.25
Zinc	0.02	0.01	0.20	0.05

[1] Based on POLA/POLB 2006 sediment bed and overlying water data.

[2] Based on POLA 2005 and 2006 mid-water data.

[3] Calculated based on POLA/POLB 2006 sediment bed and overlying water data.

Sediment initial conditions influence both sediment transport dynamics and the phase distribution and mobility of contaminants in the bed. Physical parameters for setting sediment initial conditions included: porosity, density, and grain size from numerous studies in the greater Los Angeles and Long Beach Harbor waters (Bight 98, WEMAP 99, Bight 03 and various POLA and POLB sediment analysis post-1997, n= 200). Available sediment bed grain size data suggested that a mean sand diameter between 0.125 and 0.250 mm would be appropriate. Sediment contaminant concentrations as well as particulate or total organic carbon (POC or TOC) data were interpolated into the model based on post 2000 available sediment chemistry results. See Appendix III.3 for monitoring results used to set up EFDC model initial conditions.

Equilibrium partition coefficients based on the 2006 POLA-POLB data for DDT, PAH, and PCB, as a function of bed sediment concentration and bed total organic carbon concentration. Since no functional dependence of the partition coefficients on sediment concentration and organic carbon is observed, average values were estimated for use in the modeling. Table 5-5 summarizes the estimated average equilibrium partition coefficients for the three organic contaminants based on the data.

Table 5-5. Sediment Bed Equilibrium Partition Coefficients for Organics.

Contaminant	Bed Solids Based (L/mg)[1]	Bed TOC Based (L/mg)[1]	TOC Based Low Range (L/mg)[2]	TOC Based High Range (L/mg)[2]
DDT	0.0002	0.02	0.0002	0.2
PAH	0.0004	0.04	0.01	2.0
PCB	0.0002	0.02	0.005	0.5

[1] Based on POLA-POLB 2006 sediment bed and overlying water data.

[2] Based on Chapra, 1997.

5.3 EFDC Model Calibration

5.3.1 Calibration of the Hydrodynamic Model

After the model was set-up or configured, model calibration was performed. This is generally a two-phase process, with hydrodynamic calibration completed before repeating the process for water quality. Upon completion of the calibration at selected locations, a calibrated dataset containing parameter values (salinity, etc.) was developed.

Hydrodynamics was the first model calibration component because simulation of water quality loading relies heavily on flow prediction. The hydrodynamic calibration involves a comparison of model results to water elevation and velocity observations at selected locations. After comparing the results, key hydrodynamic parameters were adjusted and additional model simulations were performed. This iterative process was repeated until the simulated results closely represented the system and reproduced observed water elevation and velocity patterns and magnitudes.

The parameters that need to be calibrated for tidal elevation and velocity were the amplitude and phase of the incoming tidal constituent waves along the open boundary. The amplitude and phase along the three open boundaries were determined using a proprietary optimization

procedure to minimize the difference between the observed and predicted complex amplitudes (cosine and sine amplitudes). Figure 5-5 shows a visual comparison of tidal frequency water surface elevation at the NOAA Gauge. As shown in this figure, agreement between observed and predicted tidal water surface elevations is reasonably good for the NOAA tide gauge station (note: additional details are provided in Appendix I).

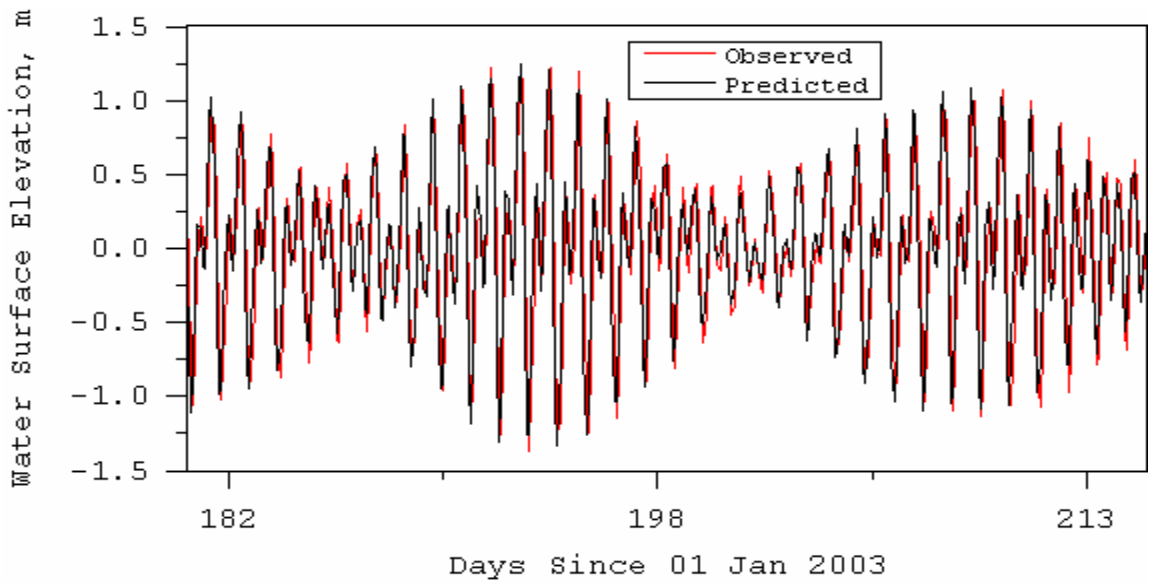


Figure 5-5. Tidal water surface elevation comparison at NOAA tide gauge in Los Angeles Harbor

Figure 5-6 shows a scatter plot comparing predicted and observed data for the 20 station locations for four sampling times from December 2004 to March 2005. The surface and bottom notation corresponds to averages over the upper and lower halves of the water column. Predicted salinities over the lower half of the water column agree reasonably well with observations although there are clusters of over and under prediction. Predicted salinities for the upper half of the water column agree reasonably well at most stations although the model tends to under predict surface salinity which the exception of a number of stations having over prediction. The solid lines represent linear regression fits. The lower range of variability of the bottom values yields a slope that is overly influenced by extreme values. The fit for the surface values yields a near unity slope.

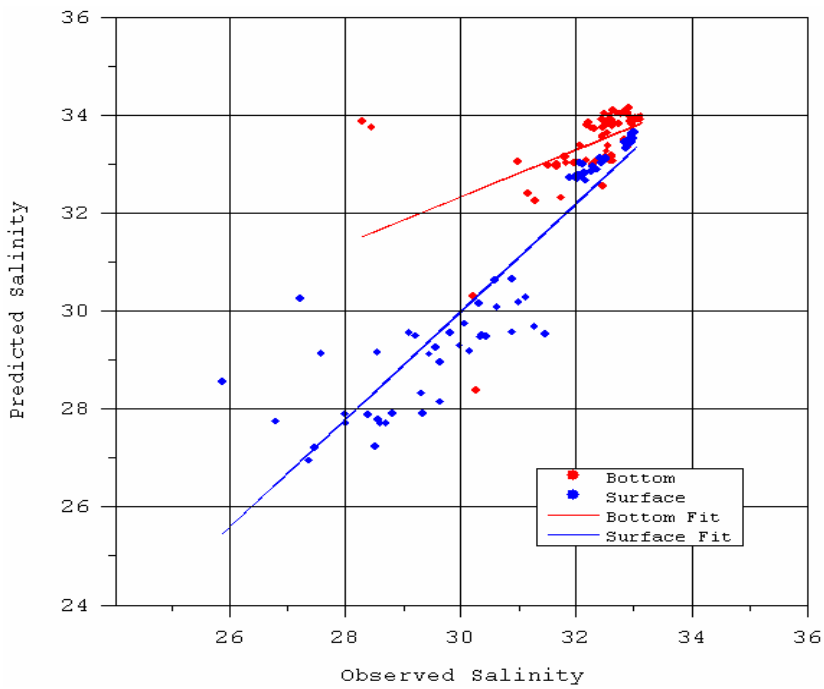


Figure 5-6. Comparison of EFDC predicted and observed salinity at 20 stations for four sampling times during the December 2004 to March 2005 period using NOAA Port wind fields

As can be seen from the comparisons indicated in the above figures, the hydrodynamic model provides a good foundation for the simulation of sediment and contaminant transport modeling in the greater harbor water system (see Appendix I for more details, especially Appendix A embedded within Appendix I, which presents time series plots of the modeled and observed salinity illustrating the model's response to high freshwater inflows).

5.3.2 Calibration of the Sediment and Contaminant Transport Model

The observational data available for sediment and contaminant transport model calibration and validation is sparse. Due to these data limitations, only a calibration effort was undertaken, as an independent set of data was not available to perform model validation. As mentioned in the preceding section, observational data defining conditions in the sediment bed were used for model initialization and are not appropriate for use in calibration. The calibration approach taken in this study was to use observational data in the water column for model calibration. Observational data in the water column included sediment and contaminant concentrations measured near the bottom of the water column during fall 2006.

The degree of calibration of the sediment and contaminant transport model is evaluated using sediment and contaminant concentrations at the 60 fall 2006 overlying water sites and the 2005 and fall 2006 mid-water column sites. As previously noted, the mid-water column sites only have data for the three metals. Overlying water sites failed to provide detectable concentrations of PCB, resulting in no calibration results being presented for PCB other than confirmation that the model predicted water column PCB levels were below detection limits. As was done for the sediment comparison, contaminant concentrations were averaged over the six-month dry season period from May to October 2005 for comparison with instantaneous observations taken during

dry fall conditions (mostly in 2006). Results for copper simulations are shown as an example (Figure 5-7). Appendix I provides additional details and calibrations results associated with the EFDC model.

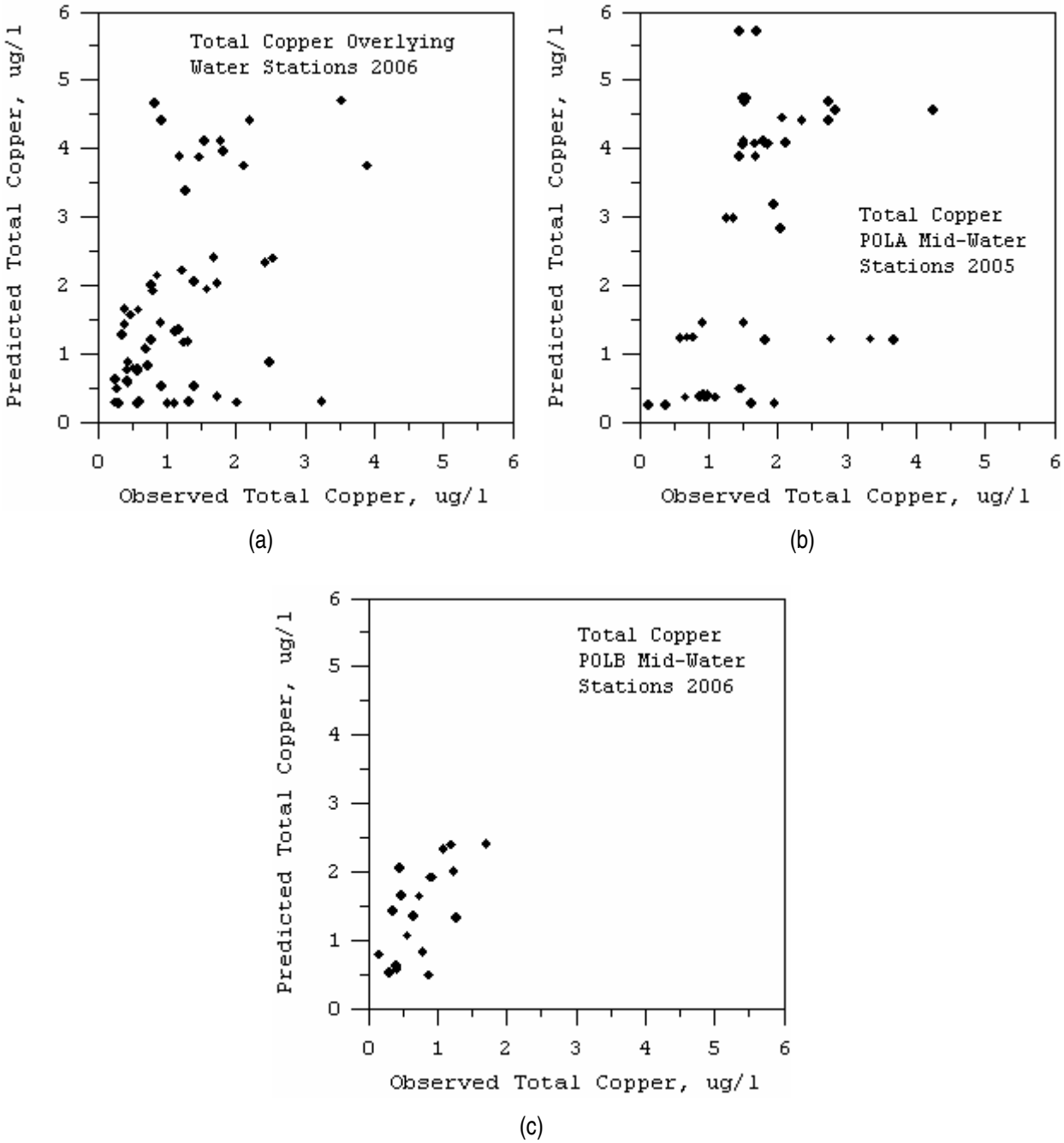


Figure 5-7. Comparison of model predicted and observed copper concentration at the overlying water and mid-water column sites (Appendix I, Figure 43)

Overall, there were extremely limited data available for model calibration and the best available data and information were incorporated into the models. While the model results did not always match the observed values, it generally captured the range of observations using the data and

information available at the time of model development. Appendix I provides extensive detail on the model calibration efforts and results.

5.4 Summary of Linkage Analysis

The LSPC model was developed and applied to TSS and pollutant loads from freshwaters, including Dominguez Channel, Los Angeles River, San Gabriel River and nearshore areas. Comparison of LSPC model output based on 1995-2005 simulation period, shows the Los Angeles River contains the highest pollutant load of any of the four fresh watersheds. Output (2002-2005) from these watersheds was integrated into the EFDC receiving water model. Figure 5-8 below illustrates the TMDL zones simulated by EFDC as well as the nearshore watersheds draining to those zones.

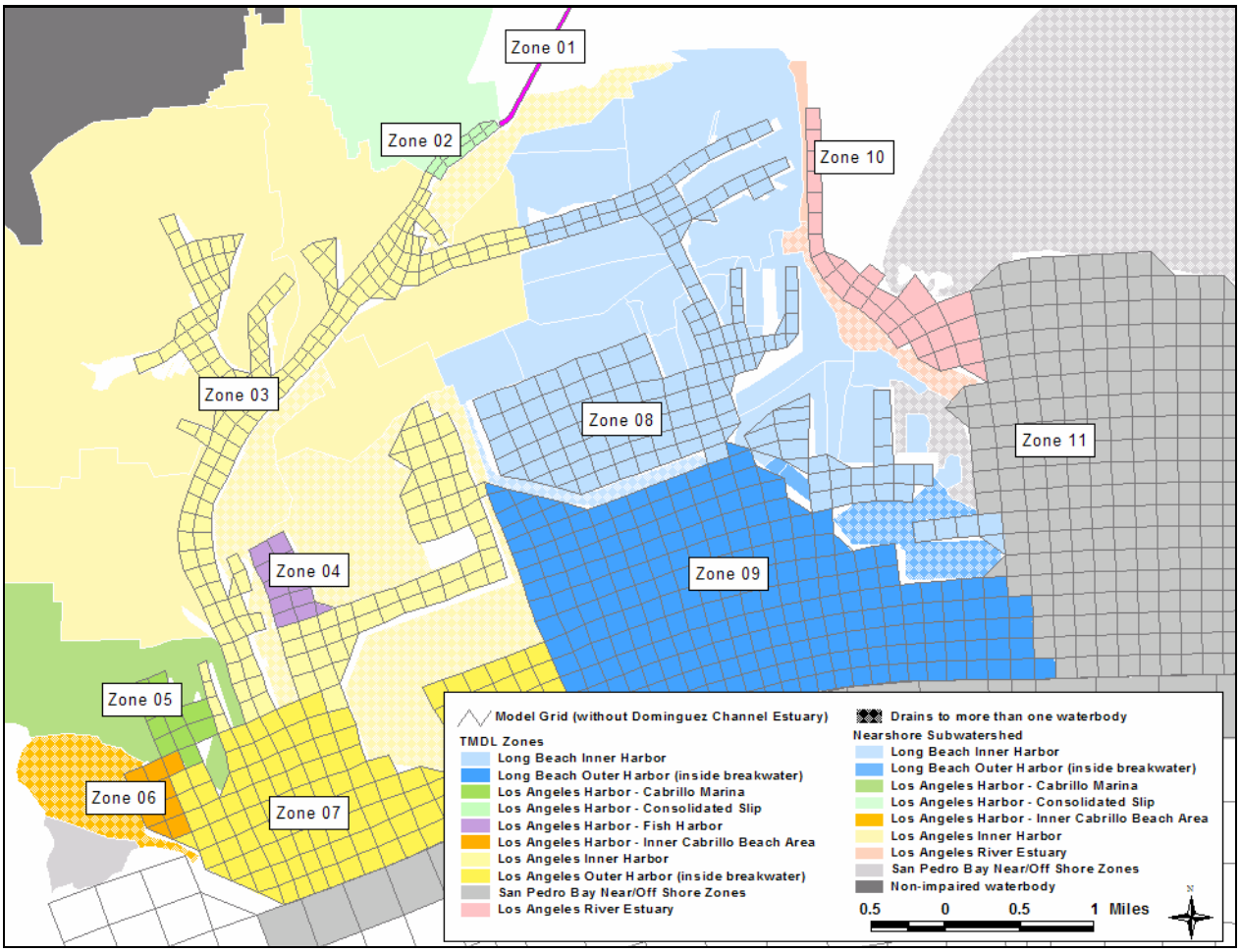


Figure 5-8. Nearshore subwatersheds (LSPC model) associated with TMDL (EFDC) model zones

The EFDC based hydrodynamic, sediment transport, and contaminant transport and fate model for the greater Los Angeles and Long Beach Harbors and adjacent region of San Pedro Bay has been calibrated and demonstrated to be suitable for use in TMDL development.

The EFDC model was used to generate a baseline as well as several other management scenarios and to evaluate relative contributions from various inputs to support water quality management decisions in these waters. The baseline scenario started with the initial conditions and then simulated four years ahead to determine average water and sediment conditions if no implementation occurs (see Appendix III, section 8) to characterize existing contaminant loads. Pollutant load reduction scenarios were performed to support allocation analyses and implementation alternatives. Appendix III, Part 8 provides details on all of these scenarios. The "no upland sources" scenario, which simulates conditions assuming no upland (watershed) contaminant loads, was used to support allocation of the TMDL loads.

Results of the "no upland sources" scenario were compared with results from the baseline scenario to quantify the relative contributions from the watersheds. Specifically, the model was run for 2002-2005 for these two scenarios and the resulting average sediment bed concentrations in each waterbody were quantified. The waterbody-specific values from each scenario were compared and the difference between them was represented as a percentage. This percentage was interpreted as the waterbody-specific percent contribution of the contaminant to the bed sediments from the upstream watersheds. These percentages were ultimately applied to both the TMDLs and the existing conditions to determine the wasteload allocation and existing load, respectively, associated with watershed inputs. The resulting WLAs were further distributed among MS4 permits based on the area draining to each waterbody (see Appendix III, Part 1).

Preliminary results for these two scenarios indicate that reducing freshwater input loads may not be sufficient to achieve target concentrations in water and sediments; thus decreasing contaminated pollutant levels in bed sediments may be required.

6 TMDLS AND ALLOCATIONS

This section explains the development of the loading capacities (i.e., TMDLs) and allocations for toxicants in the Dominguez Channel watershed and greater Harbor waters. EPA regulations require that a TMDL include waste load allocations (WLAs), which identify the portion of the loading capacity allocated to existing and future point sources (40 CFR 130.2(h)) and load allocations (LAs), which identify the portion of the loading capacity allocated to nonpoint sources (40 CFR 130.2(g)). As appropriate waste load allocations are assigned to point sources, such as wastewater treatment plants, storm water discharges, power generating stations, and other NPDES discharges. Load allocations are assigned to existing sediments and atmospheric deposition. As discussed in previous sections, the flows, sources, and the relative magnitude of inputs vary between pollutant types as well as seasonal conditions. Separate TMDLs have been developed for freshwaters in Dominguez Channel and Torrance Lateral; these apply during wet weather conditions only. TMDLs for impaired sediment chemistry, sediment quality conditions (benthic communities) and bioaccumulation (elevated fish tissue levels) apply year-round in Dominguez Channel Estuary and all other greater Harbor waterbodies.

Interim WLA and LA are to not allow any decrease in current facility performance. Interim allocations shall be met upon the effective date of the TMDL. As allocation-specific data are collected, interim targets for other pollutants and waterbodies may be identified.

6.1 Freshwater toxicity TMDLs in Dominguez Channel

The Basin Plan narrative toxicity objective does not allow acute or chronic toxicity in any receiving waters. To meet the narrative toxicity objective, a numeric toxicity target of 1 chronic toxicity unit (1 TUc) is established. Equation 1 describes the calculation of a TUc.

TUc – Toxicity Unit Chronic = 100/NOEC (no observable effects concentration) (Eq. 1)

To calculate the TUc: TUc = 100% divided by the sample concentration, derived using hypothesis testing, to cause no observable effect, with the sample concentration expressed as a percentage. For example, if the NOEC is estimated to 25% using hypothesis testing, then the TUc equals 100/25 = 4 toxic units.

An updated Toxicity Policy is now in development by the State Water Resources Control Board and may establish new toxicity criteria. Targets that are based on new criteria that achieve the narrative objective of Chapter 3 of the Basin Plan may substitute for the TUc of 1, when those new criteria are adopted and in effect.

As discussed in the Problem Statement section, whereas toxicity results are re-occurring (6 of 14 over 7 years), diazinon does not appear to be elevated and thus is probably not the causative agent. Recent City of Los Angeles monitoring data show diazinon exceedences from 2002-2005, but none from 2006-2010 (zero of 34 samples). This timing is consistent with the EPA ban on urban use of diazinon, effective Dec. 31, 2005. Based on available monitoring results, no diazinon TMDLs have been developed at this time. The Regional Board may revisit the potential for diazinon TMDLs in the future or if the data record continues to show no exceedences the Board may pursue delisting this pollutant in future 303(d) Listing cycles.

6.1.1 Toxicity Allocations – Wasteload and Load Allocation

To address toxicity occurring in freshwaters of Dominguez Channel, the allocations will equal the numeric target and loading capacity. Therefore the allocation of 1 TUc applies to each source, including all point sources and non-point sources (Table 6-1). Similar toxicity allocations have been applied to other freshwater TMDLs including Calleguas Creek Watershed Toxicity TMDL. The fresh water interim allocation shall be implemented as a trigger for initiation of the TRE/TIE process as outlined in USEPA's "Understanding and Accounting for Method Variability in Whole Effluent Toxicity Applications Under the National Pollutant Discharge Elimination System Program" (2000) and current NPDES permits. The fresh water interim allocation shall be implemented in accordance with US EPA, State Board and Regional Board resolutions, guidance and policy at the time of permit issuance, modification or renewal.

Table 6-1. Wasteload and Load Allocations for dischargers into Dominguez Channel freshwaters.

Allocations	Interim*	Final
Waste load Allocations		
MS4 – LA County	2 TUc	1 TUc
CalTrans	2 TUc	1 TUc
Other permittees**	2 TUc	1 TUc
Load Allocations		
non-point sources	2 TUc	1 TUc

* LACDPW results are currently <2 TUc so this interim should be easily achieved.

** 'Other permittees' includes General Construction and General Industrial permittees as well as minor permittees with irregular discharges during wet weather.

6.1.2 Freshwater Toxicity – Margin of Safety

An implicit margin of safety is included in these toxicity TMDLs. Chronic Toxicity unit allocations will be protective of both acute and chronic exposures. No explicit margin of safety is required as meeting the final allocation will attain the applicable narrative objective; i.e., "no toxics in toxic amounts."

6.2 Freshwater wet weather metals TMDLs in Dominguez Channel

Freshwater metals TMDLs within Dominguez Channel are based on repeated exceedences of CTR criteria for dissolved copper, lead and zinc in wet weather. No exceedence has been observed in dry weather; therefore no dry weather metals TMDLs are required for this waterbody. These freshwater metal TMDLs utilize a similar approach to other Regional Board metals TMDLs; that it, the targets are set for acute conditions, hardness dependent, and expressed in total metals concentrations. See Table 3-2 to review total metal targets.

Mass-based WLAs have been developed for combined stormwater sources, that is, MS4, Caltrans sources, and flow data will rely on approximate daily storm volume.

Concentration-based WLAs have been developed for General Construction and General Industrial; (and) non-stormwater discharges; e.g., minor, general and future minor NPDES permits.

6.2.1 Wet Weather TMDLs

Wet-weather TMDLs apply when the maximum daily flow in the Dominguez Channel is equal to or greater than 63 cfs as measured at LACDPW flow gauge S-28. This gauge is located in Dominguez Channel at Vermont Ave. and represents only freshwater flows.

During wet weather, the allowable load is a function of the volume of water in the Channel and the total metal target concentration. See Equation 2. Given the variability in wet-weather flows, the concept of a single critical flow is not justified. Instead, a load duration curve approach was used to establish the wet-weather loading capacity. In brief, a load duration curve is developed by multiplying the wet-weather flows by the in-stream numeric target. The result is a curve,

which identifies the allowable load for any given flow. The wet-weather loading capacity applies to any day when the maximum daily flow measured at a location within the Dominguez Channel is equal to or greater than 62.7 cfs, which is the 90th percentile of annual flow rates from the estimated modeled flow rates. The wet-weather freshwater metals TMDLs were defined by these load-duration curves and are presented in Table 6-2.

TMDL (g/day) = loading capacity = daily storm volume (liters) X numeric target (µg/L) / 1,000,000 (Eq. 2)

Table 6-2. Wet-weather loading capacities (TMDLs) for metals (total recoverable metals).

Reach	Copper (kg/day)	Lead (kg/day)	Zinc (kg/day)
Dominguez Channel (freshwater)	Daily storm volume x 9.7 g/L	Daily storm volume x 42.7 g/L	Daily storm volume x 69.7 g/L

The daily storm volume is equal to the total daily flow in Dominguez Channel measured at site S28.
Metal specific values are hardness dependent (50 mg/L) and site-specific conversion factors are applied.

The LSPC model was used to simulate flows and metals concentrations in Dominguez Channel from 1995-2005, providing daily flow volume and estimates of existing metals loads during wet days. By including all storm flows over the 1995-2005 period (an eleven-year period), analysis of critical conditions was included. Allowable loads were calculated by multiplying the daily flow volume (when Dominguez Channel maximum streamflow rate is greater than or equal to 62.7 cfs) by the appropriate numeric water quality target.

Based on modeling of the average annual loading capacity for each metal during only wet weather days, Table 6-3 compares the annual predicted existing load to the allowable load determined using the numeric targets. (Source: Tetra Tech spreadsheet, April 2011). The loads presented in Table 6-3 are based the load duration curves; therefore, the numbers used in these calculations are from the bars in the load duration curves presented for each metal or the total loads under the loading capacity curves (Appendix III, Figures III.2-2 to III.2-4).

Specifically, for the existing loads, the loads associated with all bars in the load duration curves are summed, but for the average annual allowable loads, the total possible loads below the loading capacity curve are summed. These total existing loads or total allowable loads (which are based solely on wet days over the eleven-year modeling period) were divided by eleven to yield average annual wet weather loads. It is important to note that these “annual” loads are only based on the wet days. If they are converted to average daily loads for comparison with the TMDL loads in Table 6-4, they should be divided by an average of 28 wet days per year (in the eleven-year simulation period, there were a total of 307 wet days). The percent reductions in Table 6-3 are estimates to provide readers with an approximate level of pollutant reductions during wet weather on daily basis.

Table 6-3. Dominguez Channel freshwater model-predicted average annual loads (kg) and percent reduction required.

Metal[1]	Allowable load (kg)	Existing load (kg)	Percent reduction required
Total Copper[2]	245	776	72.0%
Total Lead[3]	1080	440	3.1%
Total Zinc[2]	1763	6747	76.4%

[1] The numeric targets presented in Table 3-2 (based on CTR) were used to determine allowable loads for all three metals in the watershed model.
[2] Copper and zinc average annual and daily existing loads were consistently above the allowable load (based on wet days in the eleven-year modeling period), requiring 72% and 76% reductions, respectively.
[3] Although the average annual existing load of Pb is below the average annual allowable load (based on wet days in the eleven-year modeling period), there are a few exceedances of the allowable daily load in the modeled Load Duration Curve, thus a small percent reduction is required.

Wet-weather load-duration curves for each metal, along with the 1995-2005 wet weather modeled existing loads are presented in Appendix III, Part - 2. For practical purposes of comparing stormwater data to the TMDLs, the wet-weather load for a day is calculated based on the stormwater event mean concentration (EMC) from a flow-weighted composite.

Model results for lead are different from results for copper and zinc since the average annual existing lead loads are less than the average annual allowable load (based on wet days in the eleven-year modeling period). Given that this is an average condition; some daily loads are expected to be above this load, while others will fall below, as illustrated by the lead load duration curves in Appendix III.2 (Figure III.2-3). When comparing the sum of the daily exceedance loads with the sum of the total lead existing loads in the load duration curves, a 3.1 percent load reduction is required to achieve the loading capacity.

6.2.2 Wet-weather Allocations

Wet-weather allocations are assigned to all upstream reaches and tributaries of Dominguez Channel (above Vermont Avenue) because they potentially drain to these impaired freshwater reaches during wet weather. Allocations are assigned to both point (WLA) and nonpoint sources (LA). A mass-based LA has been developed for direct atmospheric deposition. A mass-based waste load allocation (WLA) is divided between the MS4 permittees and Caltrans under its NPDES stormwater permit by subtracting the other stormwater or NPDES waste load allocations, air deposition and the margin of safety from the total loading capacity. Individual MS4 waste load allocations are further defined for Los Angeles County MS4 Permittees and Caltrans based on land use percentages within the Dominguez Channel watershed. Concentration-based WLAs are assigned for the other point sources including but not limited to General Construction, General Industrial, Power Generating stations, minor permits and irregular dischargers, and other NPDES dischargers.

6.2.2.1 Wet-Weather Load Allocations

An estimate of direct atmospheric deposition is developed based on the percent area of surface water in the watershed. Approximately 0.3% of the watershed area draining to the freshwater portion of Dominguez Channel is comprised of surface water. The load allocation (LA) for atmospheric deposition is calculated by multiplying this percentage by the difference of total loading capacity (TMDL) and margin of safety (MOS), according to the following equation:

$$LA_{\text{Direct Atmospheric Deposition}} = 0.03 \times (TMDL - MOS)$$

6.2.2.2 Wet-Weather Waste Load Allocation for Stormwater

Wet-weather waste load allocations for the LA County and CalTrans stormwater permittees are calculated in the same manner as other metals TMDLs in Los Angeles region. Since the direct atmospheric deposition is calculated as a percentage of the TMDL, the equation becomes:

$$WLA_{\text{Stormwater permittees}} = TMDL - MOS - LA_{\text{Direct Atmospheric Deposition}}$$

Wet weather mass-based allocations for direct air deposition and stormwater permittees are presented in Table 6-4.

6.2.2.3 Wet-Weather Waste Load Allocation for other NPDES Permits

Concentration-based waste load allocations are established for General Construction and General Industrial stormwater and other minor NPDES permittees that discharge to Dominguez Channel to ensure that these point sources do not contribute to exceedances of the CTR criteria. The concentration-based waste load allocations are equal to the wet-weather numeric targets for each total recoverable metal expressed as an average daily concentration, identified as "other stormwater/NPDES" in Table 6-4. Any future minor NPDES permits or enrollees under a general non-stormwater NPDES permit will also be subject to the concentration-based waste load allocations.

Table 6-4. Wet-weather TMDLs and Allocations for copper, lead and zinc (g/d) in Dominguez Channel. Allocation values presented here are based on daily volume associated with stream flow rate = 62.7 cfs at monitoring station S28.

Dominguez Channel	Percent area	Total Copper	Total Lead	Total Zinc
TMDL	100%	1485.1	6548.8	10,685.5
Waste Load Allocations				
Municipal Stormwater	97.3%	1300.3	5733.7	9355.5
CalTrans Stormwater	2.4%	32.3	142.6	232.6
Other stormwater/NPDES	N/A	[9.7 µg/L]	[42.7 µg/L]	[69.7 µg/L]
Load Allocations				
Air Deposition	0.3%	4.0	17.7	28.9
Margin of Safety				
MOS (10%)	N/A	148.5	654.9	1069.6

Mass-based stormwater values were based on total recoverable metal targets, a hardness of 50 mg/L and a flow of 62.7 cfs (daily volume = 1.5×10^8 liters).
Recalculated mass-based allocations using ambient hardness and flow rate at the time of sampling are considered consistent with the assumptions and requirements of these waste load allocations. In addition, samples collected during flow conditions less than the 90th percentile of annual flow rates must demonstrate that the acute and chronic hardness dependent water quality criteria provided in the CTR are achieved. Other Stormwater/NPDES allocations are shown in total recoverable concentration.

Interim water allocations are assigned to stormwater dischargers, (MS4, general construction and general industrial stormwater dischargers) and other NPDES dischargers. Interim water allocations listed in Table 6-5 are based on the 95th percentile of total metals concentrations collected from January 2006 to January 2010 using a log-normal distribution. The use of 95th percentile values to develop interim allocations is consistent with NPDES permitting methodology. Regardless of the interim allocations below, permitted dischargers shall ensure that effluent concentrations and mass discharges do not exceed levels that can be attained by performance of the facility's treatment technologies existing at the time of permit issuance, reissuance or modification.

Table 6-5. Wet-weather Concentration-based Dominguez Channel and Torrance Lateral freshwater interim metal allocations (ug/L)

Allocation	Copper	Lead	Zinc
Interim water allocation	207.5	122.9	898.9

Based on hardness of 50 mg/L.
Recalculated concentration-based allocations using ambient hardness at the time of sampling are considered consistent with the assumptions and requirements of these waste load allocations. In addition, samples collected during flow conditions less than the 90th percentile of annual flow rates must demonstrate that the acute and chronic hardness dependent water quality criteria provided in the CTR are achieved.

6.2.3 Margin of Safety-Dominguez Channel freshwater

The federal statute and regulations require that TMDLs include a margin of safety (MOS) to account for any lack of knowledge concerning the relationships between effluent limitations and water quality. To account for any additional uncertainty in the wet-weather freshwater TMDLs, an explicit MOS equal to 10% of the loading capacity or existing load available for wet-weather allocations has been included. The 10% MOS was subtracted from the loading capacity or existing load, whichever is smaller. Applying an explicit margin of safety is reasonable because a number of uncertain estimates are offset by the explicit margin of safety. While the observed dissolved-to-total metals ratios are not similar to CTR default conversion values, there appears to be very poor correlation between the fraction of particulate metals and TSS. Also, there is added uncertainty of stream flow rates during wet weather conditions, when the highest metal loads occur, thus an explicit margin of safety is justified.

6.3 Freshwater wet weather metals TMDLs in Torrance Lateral

Torrance Lateral is a sub-watershed within the larger Dominguez Channel watershed that flows directly into Dominguez Channel Estuary (approx. 2 miles below S28). Torrance Lateral refers to waters upstream of confluence with Dominguez Channel Estuary, consistent with LAC DPW sampling site TS19. Currently there is no flow gauge associated with stream flows within Torrance Lateral, thus the daily storm volume or load duration approach can not be applied.

6.3.1 Wet weather metals TMDLs in Torrance Lateral

Recent monitoring results provide only 10 wet weather samples and no flow data within Torrance Lateral, thus the TMDL approach has been modified from that taken for freshwater metals in Dominguez Channel. For Torrance Lateral freshwaters, concentration-based TMDLs

and allocations for the water column were developed; these are consistent with total metal targets identified for Dominguez Channel freshwaters. To address impaired sediments, sediment waste load allocations are assigned to all other dischargers to Torrance Lateral equal to the concentration-based sediment targets.

6.3.2 Wet-weather Allocations

Until more robust results exist for waters sampled within the Torrance Lateral sub-watershed, the water column allocations are set equal to total metal concentration-based targets provided for Dominguez Channel. See Table 6-6. These allocations apply during all wet weather conditions; i.e., no base flow level has been identified. If future studies within Torrance Lateral provide sufficient flow data, then water column allocations maybe refined to apply above a designated stream flow rate.

These allocations apply to Los Angeles County MS4 Permittees. Non-point sources do not exist within this sub-watershed. Sediment concentration-based allocations are included here.

Table 6-6. Water and Sediment Allocations for Torrance Lateral sub-watershed.

Media	Copper	Lead	Zinc
Water (unfiltered)	9.7 µg/L	42.7 µg/L	69.7 µg/L
Sediment (TECs)	31.6 mg/kg dry	35.8 mg/kg dry	121 mg/kg dry

Hardness = 50 mg/L based on Dominguez Channel monitoring site S28.
Recalculated concentration-based allocations using ambient hardness at the time of sampling are considered consistent with the assumptions and requirements of these waste load allocations. In addition, samples collected during flow conditions less than the 90th percentile of annual flow rates must demonstrate that the acute and chronic hardness dependent water quality criteria provided in the CTR are achieved. Other Stormwater/NPDES allocations are shown in total recoverable concentration.

6.3.2.1 Wet weather wasteload allocations for ExxonMobil Refinery

Exxon Mobil retains stormwater for its facility and part of the City of Torrance. Typically this stormwater is retained on-site and then preferentially diverted to a local wastewater treatment system; however there are rare times when the facility must discharge stormwater into Torrance Lateral. ExxonMobil has provided monitoring results and flow data, from 2000-2010, for two discharge events during this timeframe, both occurred during water year 2005 (very large rainfall year). These allocations assume that Refinery stormwater discharges will continue to be rare in the future; that is, these facilities will continue to maximize storage and divert large stormwater volumes into POTWs prior to discharging into Torrance Lateral or Dominguez Channel Estuary. ExxonMobil anticipates discharging stormwater once every seven years on average (ExxonMobil 2007). If, due to an increase in discharge frequency or volumes, it appears that the allocations are not supportive of the TMDL, these allocations may be revised. Based on this information as well as the total recoverable metals targets, the mass-based allocations for copper, lead and zinc for stormwater discharges from this NPDES permittee are shown in Table 6-7. No explicit allocations for PAHs are identified for ExxonMobil; however, discharges should not exceed existing water quality criteria for these individual compounds and continued monitoring should occur.

Table 6-7. Waste Load Allocations for ExxonMobil refinery into Torrance Lateral.

Media	Copper	Lead	Zinc
Water (unfiltered)	1.36 kg/yr	5.98 kg/yr	9.75 kg/yr

Values are based on Q = 3.7 MGD for 7 days/year and total metal targets; assumes discharge events are irregular; e.g., once every seven years on average.

Compliance with the freshwater metals allocations for Dominguez Channel and Torrance Lateral may be demonstrated via any one of three different means:

a. Final allocations are met.
b. CTR total metals criteria are met instream.
c. CTR total metals criteria are met in the discharge.

6.3.3 Margin of Safety-Torrance Lateral

An implicit margin of safety exists in the final wasteload allocations. The implicit margin of safety is based on multiple targets (for water and sediment). Currently no explicit margin of safety is applied to these TMDLs to address impaired conditions within the sediments; however, if any chemical-specific freshwater sediment quality value(s) is revised or updated contingent on future sediment quality studies, then an explicit margin of safety may be considered and may be applied.

6.4 Impaired Sediment Quality Objective – Direct Effects TMDLs in Dominguez Channel Estuary and Greater Harbor waters

Based on monitoring studies with sediment triad results, impaired sediment conditions exist and TMDLs are required for the following waterbodies: Dominguez Channel Estuary, Consolidated Slip, Inner, Outer and Fish Harbors, Los Angeles River estuary, eastern San Pedro Bay and Cabrillo Marina. The goal is to restore the beneficial uses of aquatic life within sediments of these waterbodies.

The categories designated in the State Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality (SQO Part 1) as Unimpacted and Likely Unimpacted by the interpretation of multiple lines of evidence shall be considered as the protective narrative objective. Evaluation of achieving these desired categories relies on multiple lines of evidence, integrating sediment chemistry, sediment toxicity and benthic community index results. Numeric TMDLs and allocations are presented below and are expected to attain the narrative objective.

6.4.1 Interim Allocations for Sediment

Interim sediment allocations are assigned to stormwater dischargers, (MS4, general construction and general industrial stormwater dischargers) and other NPDES dischargers. Interim sediment allocations are based on the 95th percentile of sediment data collected from 1998-2006 (Table 6-8). The use of 95th percentile values to develop interim allocations is consistent with NPDES permitting methodology. For waterbodies where the 95th percentile value has been equal to, or lower than, the numeric target, then the interim allocation is set equal to the final allocation. Regardless of the allocation, permitted dischargers shall ensure that effluent concentrations and

mass discharges do not exceed levels that can be attained by performance of the facility's treatment technologies existing at the time of permit issuance, reissuance or modification.

Compliance with the interim concentration-based sediment allocations may be demonstrated via any one of three different means:

1. Demonstrate that the sediment quality condition of **Unimpacted** or **Likely Unimpacted** via the interpretation and integration of multiple lines of evidence as defined in the SQO Part 1, is met; or
2. Meet the interim allocations in bed sediment over a three-year averaging period; or
3. Meet the interim allocations in the discharge over a three-year averaging period.

Table 6-8. Sediment, Interim Concentration-based Allocations

Waterbody	Pollutant (mg/kg sediment)					
	Copper	**Lead**	**Zinc**	**DDT**	**PAHs**	**PCBs**
Dominguez Channel Estuary	220.0	510.0	789.0	1.727	31.60	1.490
Long Beach Inner Harbor	142.3	50.4	240.6	0.070	4.58	0.060
Los Angeles Inner Harbor	154.1	145.5	362.0	0.341	90.30	2.107
Long Beach Outer Harbor (inside breakwater)	67.3	**46.7**	**150**	0.075	**4.022**	0.248
Los Angeles Outer Harbor (inside breakwater)	104.1	**46.7**	**150**	0.097	**4.022**	0.310
Los Angeles River Estuary	53.0	**46.7**	183.5	0.254	4.36	0.683
San Pedro Bay Near/Off Shore Zones	76.9	66.6	263.1	0.057	**4.022**	0.193
Los Angeles Harbor - Cabrillo Marina	367.6	72.6	281.8	0.186	36.12	0.199
Los Angeles Harbor - Consolidated Slip	1470.0	1100.0	1705.0	1.724	386.00	1.920
Los Angeles Harbor - Inner Cabrillo Beach Area	129.7	**46.7**	163.1	0.145	**4.022**	0.033
Fish Harbor	558.6	116.5	430.5	40.5	2102.7	36.6

Numbers in **bold** are also the final allocation.

6.4.2 TMDL – Direct Effects

The narrative objective provides two qualitative conditions that satisfy the support of aquatic life in sediments. These two qualitative conditions are either 'unimpacted' or 'likely unimpacted' which must be interpreted via evaluation multiple lines of evidence as described above. For

these TMDLs, an alternative, quantitative expression, defined as meeting the sediment quality value (SQV) for each chemical[1] identified within the applicable Sediment Quality Plan, Part I – Direct Effects is included. The SQV for each chemical is initially set equal to the chemical-specific ERL values. However, the SQV may be modified or replaced based on future sediment quality studies, such as site-specific (toxicity or benthic impact) studies or stressor identification studies. Such special sediment studies may test for sediment toxicity (survival and sub-lethal effects) as well as benthic community response index. Also, plans for sediment special studies will be reviewed by the Regional Board and EPA in order to provide the basis for replacing an ERL as the SQV.

Attainment of the narrative sediment quality objective may occur either through demonstrating the waterbody has achieved the desired qualitative condition [clearly unimpacted or likely unimpacted] or the quantitative condition; i.e., if the ambient sediment chemistry levels within a waterbody are equal to or below the sediment quality values.

The direct effects TMDLs were calculated using annual average sediment deposition rates (Table 5-3) from the EFDC model output for each TMDL zone. These deposition rates were multiplied by the applicable numeric targets and a conversion factor to determine the loading capacities for each pollutant in each TMDL waterbody. See Appendix III, Part 1 for more information on the TMDL calculations. The loading capacities are presented in Table 6-10. This table also includes estimates of existing loads, which are consistent with the values presented in Table 4-6 and are based on the total deposition rate multiplied by the applicable existing sediment concentration and a conversion factor (the existing sediment concentrations are based on the average simulated sediment concentration from 2002-2005 in the top 5 cm of sediment).

6.4.3 Allocations – Direct Effects

These allocations apply to pollutant sources discharging into the waterbody as well as to existing sediments within each waterbody. To comply with Federal Regulations, wasteload and load allocations must be express in numeric form within TMDLs. See 40 C.F.R. § 130.2(h) & (i). For these TMDLs, the allocations are based on chemical specific sediment quality value (SQV), referring to the chemical concentration in the bulk sediments. The initial SQV value is equal to the ERL value. As described below, mass-based allocations were defined for some sources where sufficient data was available, whereas concentration-based allocations were identified for others.

6.4.3.1 Waste Load Allocations – Direct Effects

Wasteload Allocations are provided by waterbody and source-type in Table 6-9 and 6-10. Mass-based WLAs are identified for TIWRP and other point sources that have provided discharge flow data. (Refineries which have provided discharge flow data along with monitoring results receive mass-based allocations, whereas other refineries receive concentration-based allocations because no discharge flow data has been provided to Regional Board staff.) Stormwater sources,

[1] Sediment Quality Plan, Part I identifies the following specific contaminants of concern: Cu, Pb, Hg, Zn, PAHs (18 compounds), Dieldrin, Chlordane (3 isomers), DDT (6 isomers), total PCBs (18 congeners), TOC, % fines. Here the approach is simplified by developing TMDLs for total PAHs, total Chlordane, total DDT and total PCBs.

including Los Angeles County MS4 Permittees, City of Long Beach and Caltrans, have received individual, mass-based allocations by permit within each watershed. Stormwater discharges from the Port of Los Angeles (POLA) and Port of Long Beach (POLB) are grouped with the MS4 dischargers. Mass-based WLAs are applied as annual limits. Individual mass-based WLAs for an individual MS4 Permittee will be calculated based on its share, on an area basis, of the mass-based WLA or other approved approach available at the time final mass-based WLAs are in effect and incorporated into the permit.

As described above in Section 5.3, the relative difference between the baseline and "no upland sources" scenarios were interpreted as the waterbody-specific percent contribution of the contaminant to the bed sediments from the upstream watersheds. These percentages were applied to the TMDLs to determine the mass-based WLAs for the stormwater sources. These overall WLAs were further divided to individual, mass-based allocations by permit based on the percent area draining to each waterbody (see Appendix III, Part 1).

Concentration-based WLAs are identified for other sources, such as General Construction, General Industrial, Power Generating stations, minor permits and irregular dischargers into Dominguez Channel Estuary. Any future minor NPDES permits or enrollees under a general non-stormwater NPDES permit will also be subject to the concentration-based waste load allocations. Concentration-based limits are applied as daily limits.

Non-MS4 point sources such as General Construction, General Industrial, individual industrial permittees, including power generating stations, minor permits and irregular dischargers into Dominguez Channel Estuary and greater Harbor waters are assigned concentration-based allocations. Any future minor NPDES permits or enrollees under a general NPDES permit are also assigned the concentration-based waste load allocations. The allocations are set equal to the saltwater targets for metals and equal to the human health targets for the organic compounds in CTR. The averaging period for the concentration-based WLAs shall be consistent with that specified in the regulation establishing the criterion or objective or relevant implementation guidance published by the establishing agency.

Table 6-9. Receiving (salt) Water Column Concentration-Based Waste Load Allocations

Constituents	Copper* (µg/L)	Lead* (µg/L)	Zinc* (µg/L)	PAHs (µg/L)	Chlordane (µg/L)	4,4'-DDT (µg/L)	Dieldrin (µg/L)	Total PCBs (µg/L)
Dominguez Channel Estuary	3.73	8.52	85.6	0.049**	0.00059	0.00059	0.00014	0.00017
Inner Harbor	3.73	8.52	85.6			0.00059		0.00017

***** Total Concentration-based WLAs for metals are converted from saltwater dissolved CTR criteria using CTR saltwater default translators.

****** CTR human health criteria were not established for total PAHs. Therefore, the CTR criteria for individual PAHs of 0.049 µg/L are applied individually to benzo[a]anthracene, benzo[a]pyrene, and chrysene. The CTR criterion for pyrene of 11,000 µg/L is assigned as an individual WLA. Other PAHs compounds in the CTR shall be screened as part of the TMDL monitoring.

Calculations for the allocations shown here include MS4 discharges from the Seal Beach area (Orange County) to San Pedro Bay. The Orange County MS4 is issued by the Santa Ana Regional Board. Allocations for the Orange County MS4 will not be assigned in the Basin Plan

Amendment. If later monitoring demonstrates that the Seal Beach MS4 discharges do not support the goals of the TMDL, a revision to this TMDL in conjunction with the Sana Ana Region may be developed.

TIWRP discharges into Outer Harbor. Effluent flow from 1988 to 2009 showed the following range of average annual discharge rates – 21.0 to 16.0 MGD, with general declining trend. The target pollutant concentrations multiplied by 15.6 MGD (annual average flow rate in 2009) was used to calculate mass-based allocations for this point source. This yields allocation quantities for metals and bioaccumulatives that exceed the loading capacity. A reduction in the flow from TIWRP is planned and may allow for a revision of the WLA in future TMDL re-considerations.

6.4.3.2 Load Allocations – Direct Effects

Load Allocations apply to non-point sources; e.g., existing sediments and direct air deposition, and are also presented in Table 6-10. Direct air deposition allocations are included for Cu, Zn and PAHs based on estimates of current atmospheric loading rates presented in Source Analysis section, Table 4-6 based on monitoring results cited by Sabin & Schiff (2007) or Sabin et al., (2010). Future changes to Cu, Zn and PAH air quality criteria, other regulation such as brake pad requirements, or other improvement in air quality may allow for re-calculations of air deposition allocations in future revisions to the TMDL. Mass-based LAs are applied as annual limits.

For Lead (Pb), the direct air deposition allocation was calculated using information from EPA's revision to the National Ambient Air Quality Standard (EPA, 2008) as well as recent rule making by South Coast Air Quality Management District (SCAQMD, 2010). SCAQMD will be implementing EPA's Pb ambient air standard (0.15 ug/m^3) in forthcoming years. The load allocation for direct deposition of Pb onto surface waters is based on this revised air quality standard and the surface area of each waterbody, converted to mass/year. These mass-based direct air deposition allocations apply as annual limits.

Air deposition allocations for copper and zinc are based on existing loads; assuming no direct deposition reductions this consumes or partially consumes the available loading capacity. Copper and zinc load allocations for bed sediments are negative values, in Inner and Outer Harbor, indicating that copper and zinc loads must be reduced. (Each negative copper and zinc bed sediment allocation may alternatively be interpreted as zero, or not adversely affecting benthic organisms.) The amount of copper and zinc load reduction may be revised based on future monitoring results. For example, if future air deposition studies show lower existing air deposition copper and zinc loads or, if future copper and zinc sediment characterization studies show lower existing bed sediment copper and zinc loads, then copper and zinc allocations may be adjusted (presumably higher).

If, at some point in the future, a non-point source is considered subject to NPDES or WDR regulations, then the corresponding load allocation (numeric value) may switch to wasteload allocation columns.

6.4.3.3 Allocations for other sediment pollutants

Consolidated Slip and Fish Harbor are impaired for mercury in sediments and the average sediment concentration (1.1 mg/kg dry) is significantly higher than the target concentration (0.15 mg/kg dry). Consolidated Slip is also impaired for cadmium and chromium in sediments. Dominguez Channel Estuary is impaired for cadmium in sediments. While mercury is a compound that often bioaccumulates, there are no associated tissue listings for mercury in these waters, so it does not appear to be bioaccumulating to excessive levels and no fish tissue-supporting sediment target or allocation is assigned. See Table 6-11 for applicable WLAs.

6.4.4 Margin of Safety – Direct Effects

An implicit margin of safety exists in the final allocations. Implicit margin of safety is based on the selection of multiple numeric targets, including targets for water, fish tissue and sediment. Currently no explicit margin of safety is applied to these TMDLs to address impaired conditions within the sediments; however, an explicit margin of safety must be considered and may be applied if any chemical-specific sediment quality value is revised or updated contingent on future sediment quality studies.

Table 6-10. TMDLs and Allocations (kg/yr) – Metals and PAHs Compounds by waterbody/source. Sediment values are based on active sediment layer = 5cm depth.

Waterbody/source	*Total Cu*	*Total Pb*	*Total Zn*	*PAHs total*
DomCh Estuary - TMDL	84	115.4	370.5	9.94
WLAs				
MS4- LA County et al.	22.4	54.2	271.8	0.134
MS4- City of Long Beach	0.6	1.52	7.6	0.0038
MS4- CalTrans	0.384	0.93	4.7	0.0023
LAs				
Air deposition	4.6	0.031	33.2	0.051
Bed sediments	56.0	58.7	53.3	9.7
Current Load (Table 4-6)	327.6	457.9	1799.0	28.1
Overall reduction	74%	75%	79%	65%
Consolidated Slip - TMDL	12.1	16.6	53.3	1.43
WLAs				
MS4- LA County et al	2.73	3.63	28.7	0.0058
MS4 CalTrans	0.043	0.058	0.5	0.00009
LAs				
Air deposition	1.2	0.008	8.6	0.013
Bed sediments	8.13	12.9	15.57	1.41
Current Load (Table 4-6)	92.1	127.3	398.9	11.5
Overall reduction	***87%***	***87%***	***87%***	***88%***
Inner Harbor - TMDL	76.7	105.3	338.3	9.1
WLAs				
MS4- LA County et al	1.7	34.0	115.9	0.088

Waterbody/source	*Total Cu*	*Total Pb*	*Total Zn*	*PAHs total*
MS4 City of Long Beach	0.463	9.31	31.71	0.024
MS4 CalTrans	0.032	0.641	2.18	0.0017
LAs				
Air deposition ***Bed sediments***	97.6 (23.1)	0.67 60.7	710 (521.3)	1.08 7.88
Current Load (Table 4-6)	178.4	105.9	542.1	3.524
Overall reduction	57%	1%	38%	0%
Outer Harbor - TMDL	81.6	112.1	360.1	9.7
WLAs				
MS4- LA County et al	0.91	26.1	81.5	0.105
MS4 City of Long Beach	0.63	18.1	56.4	0.073
MS4 CalTrans	0.0018	0.052	0.162	0.00021
TIWRP = POTW (CTR & MGD)***	80.4	183.6	1845	1.056
LAs				
Air deposition ***Bed sediments***	17.9 (18.2)	0.9 (116)	108.1 (1731)	1.5 6.964
Current Load (Table 4-6)	119.0	66.7	403.4	0.626
Overall reduction	31%	0%	11%	0%
Fish Harbor - TMDL	1.04	1.43	4.59	0.123
WLAs				
MS4- LA County et al (POLA)	0.00017	0.54	1.62	0.007
MS4 CalTrans	0.0000005	0.00175	0.0053	0.000021
LAs				
Air deposition ***Bed sediments***	0.4 0.636	0.02 0.87	2.4 0.5	0.033 0.084
Current Load (Table 4-6)	1.43	0.60	4.2	0.003
Overall reduction	27%	0%	0%	0%
Cabrillo Marina -TMDL	1.32	1.81	5.8	0.156
WLAs				
MS4- LA County et al (POLA)	0.0196	0.289	0.74	0.00016
MS4 CalTrans	0.00019	0.0028	0.007	0.0000016
LAs				
Air deposition ***Bed sediments***	0.34 1.0	0.017 1.506	2.05 3.03	0.028 0.1285
Current Load (Table 4-6)	9.2	2.3	9.14	0.236
Overall reduction	86%	21%	36%	34%
San Pedro Bay - TMDL	648	890	2858	76.6
WLAs				

Waterbody/source	*Total Cu*	*Total Pb*	*Total Zn*	*PAHs total*
MS4- LA County et al	20.3	54.7	213.1	1.76
MS4 City of Long Beach	137.9	372.2	1449.7	12.0
MS4 CalTrans	0.88	2.39	9.29	0.077
MS4 Orange County**	*9.8*	*26.4*	*102.9*	*0.85*
LAs				
Air deposition	36	1.8	219	2.9
Bed sediments	442.9	432	865	59.0
Current Load (Table 4-6)	1251	1737	8167	3.63
Overall reduction	48%	49%	65%	0%
LA River Estuary - TMDL	735	1009	3242	86.9
WLAs				
LAR Estuary dischargers*	[Cu SQV]	[Pb SQV]	[Zn SQV]	[PAH SQV]
MS4- LA County et al	35.3	65.7	242.0	2.31
MS4 City of Long Beach	375.8	698.9	2572.7	24.56
MS4 CalTrans	5.1	9.5	34.8	0.333
LAs				
Air deposition	6.7	0.046	48.9	0.075
Bed sediments	311.8	235.0	343.0	59.6
Current Load (Table 4-6)	1612	2641	20096	8.72
Overall reduction	54%	62%	84%	0%

Note: Cu, Zn & PAHs air dep allocation = existing load, no reductions anticipated. MS4 and bed sediments are expected to reduce loads. Negative values for bed sediments indicates loads are expected to be reduced – the amount of reduction may be revised with additional monitoring results. See discussion in Section 6.4.3.2.
Individual MS4 permits based on land percentage within that individual watershed.
Pb air dep allocation = reduction based on new SCAQMD ambient air standard proposed November 2010.
*SQV values are currently set at ERLs as discussed in section 6.4.1.
**Orange County MS4 permit is issued by the Santa Ana Regional Board. The allocations included, here, for the Seal Beach nearshore area, are for TMDL calculation purposes only, and an allocation is not assigned in the Basin Plan Amendment.
***For TIWRP, the discharge volume at the time of permit modification or reissuance shall be used to calculate the mass-based effluent limitations consistent with the assumptions and requirements of these WLAs. Studies may be conducted to determine the portion of the discharged pollutants that is deposited on bedded sediment. The results of any such Executive Officer approved studies shall be evaluated at the TMDL reconsideration to modify these WLAs as appropriate.

Table 6-11. Final Concentration-Based Sediment WLAs for metals.

Concentration-based Sediment WLAs (mg/kg dry sediment)		
Cadmium	**Chromium**	**Mercury**
1.2	81	0.15

Mercury applies to both Consolidated Slip and Fish Harbor; Cd applies to Dominguez Estuary and Consolidated Slip; Cr applies to Consolidated Slip only.

6.4.5 Compliance with TMDL – Direct Effects

These TMDLs are designed to protect the benthic organisms in sediments of these waterbodies. Attainment of these Direct Effects TMDLs may be achieved any one of three different means:

- Meet final sediment allocations in Table 6-10, are met.
- The qualitative sediment condition of Unimpacted or Likely Unimpacted via the interpretation and integration of multiple lines of evidence as defined in the SQO Part 1 is met, with exception of Cr which is not included in SQO Part 1.
- Sediment numeric targets are met in bed sediments over a three-year averaging period.

Compliance with mass-based limits will be measured at designated discharge points. Compliance with concentration-based WLA for existing sediment shall be determined by pollutant concentrations in ambient sediment in each waterbody. The average ambient bulk sediment level within a waterbody at or below the sediment quality value is considered attainment with these TMDLs. Implementation Section 7.5 provides more details on compliance for these Direct Effects TMDLs.

Interim WLAs are based on the 95th percentile of sediment data collected from 1998-2006. The use of 95th percentile values to develop interim limits is consistent with NPDES permitting methodology. If the 95th percentile is equal to or lower than the numeric target, then the interim limit is equal to the final WLA. Interim and final WLAs will be included in MS4 permits in accordance with NPDES regulations and guidance (40 CFR 144.22(d)(1)(vii)(B); US EPA Memorandum "Revisions to the November 22, 2002 Memorandum 'Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs'" (November 12, 2010)).

The allocations were designed to achieve the following specific goals:

1 Reduction of sediment toxicity (as measured by both lethal and sub-lethal tests),

2 Improvement of benthic organism communities,

3 Minimization of the negative impact of sediment chemicals,

4 Reduction of pollutant loads.

Whereas certain chemicals are identified in these TMDLs as pollutants of concern, future site specific studies may yield results that point to other toxicants as causative agents. The SQO – Direct Effects Policy provides for sediment stressor ID studies, which may be pursued as long as stakeholders/responsible parties are concurrently pursuing activities supporting these TMDLs and the goals defined above. Demonstrable improvement in the SQO lines of evidence must be provided along with progress in stressor ID studies. Progress solely in stressor ID studies is not an acceptable substitute; thus sediment quality improvements must be concurrent.

6.5 Bioaccumulative/Organochlorine compounds TMDLs in Dominguez Channel Estuary and greater Harbor waters

6.5.1 TMDL – Bioaccumulatives[2]

[2] Total DDT, total PCBs, total chlordane, dieldrin, and toxaphene.

Fish tissue levels of certain bioaccumulative compounds are above desired numeric targets (OEHHA Fish Contaminant Goals). DDT and PCBs (total) apply to all estuarine and marine waters in greater Harbor area, including Cabrillo Beach Inner, Los Angeles River estuary and eastern San Pedro Bay. Chlordane TMDLs apply to Dominguez Channel estuary, Consolidated Slip, Fish Harbors, Los Angeles River estuary and eastern San Pedro Bay. Dieldrin applies to Dominguez Channel estuary and Consolidated Slip. Toxaphene applies to Consolidated Slip only.

To address these impairments, the TMDLs have been designed to reduce contaminated sediment levels which will result in lower corresponding pollutant levels in fish tissue. This approach has been utilized in other Los Angeles Region TMDLs. (Ballona Estuary TMDLs, 2007, Calleguas Creek Organochlorine Compounds TMDLs, 2005). Here, the active sediment layer approach to quantify the mass of allowable sediment-bound loads has been used. More specifically, the average mass of total sediment (fine and coarse particles) deposited in each waterbody annually based on average EFDC model output (using water years 2002-2005) was approximated. This value is the average annual (clean) sediment deposition rate per waterbody (Table 5-3). Then the more protective sediment quality value of either ERLs or biota-sediment accumulation factor (BSAF) was selected to determine desired sediment concentrations to attain specific fish tissue levels. The loading capacity of contaminated sediments within each waterbody was calculated from multiplying the sediment quality target by the average annual sediment deposition rate (Equation 3; See also Appendix III, Part 1).

TMDL = total sediment deposition rate x SQV or BSAF; (Eq. 3)

where sediment deposition rate = average annual mass of sediment deposited per waterbody

The loading capacities are presented in Table 6-12. This table also includes estimates of existing loads, which are consistent with the values presented in Table 4-6 and are based on the total deposition rate multiplied by the applicable existing sediment concentration and a conversion factor (the existing sediment concentrations are based on the average simulated sediment concentration from 2002-2005 in the top 5 cm of sediment).

The biota-sediment accumulation factor (BSAF) accounts for the sediment concentration, the associated food web and the desired fish tissue level to protect wildlife or human health consumption. The Basin Plan does not contain BSAFs, nor has State Board have approved any; however, the current development of Sediment Quality Plan,Part 2 – Indirect Effects is using a foodweb spreadsheet model to determine sediment concentrations (BSAFs) that correspond to specific fish tissue levels. As described above the more protective value between BSAF or ERL was used for determining TMDLs for bioaccumulative compounds. For chlordane and dieldrin, the ERL value is lower and more protective than BSAF values. The DDT sediment values are nearly equal (ERL = 1.58, BSAF = 1.9); the more stringent one was used for calculation. The PCBs sediment value associated with fish tissue is more stringent than the ERL sediment value for PCBs (3.2 vs. 22.7).

The active sediment layer is a generic term for the depth of contaminated sediments that benthic infauna consume or mix up via their physical movements. The sediment volume is

approximately equal to the product of waterbody surface area and active sediment layer or depth. The issue of active sediment layer is contingent on the burrowing depth of benthic organisms within the bioaccumulation foodweb. Studies of benthic infauna in sediment show that 95% of benthic organisms exist within top 5 cm, yet some benthic organisms (such as ghost shrimp) burrow deeper down (~ 20 cm) and are also contained within the bioaccumulative foodweb. Here the active sediment layer is defined as 5 cm depth[3].

Chlordane, Dieldrin and Toxaphene TMDLs and allocations are concentration-based for all sources. Available monitoring data for these particular bioaccumulative pollutants does not provide sufficient detection levels to adequately estimate the current loads. Some detections of chlordane has been reported for a few waterbodies, however it is highly erratic and less frequent for Dieldrin and Toxaphene. To simplify, allocations for these pollutants within the impaired waters are concentration-based.

6.5.2 Allocations – Bioaccumulatives

6.5.2.1 Wasteload Allocations – Bioaccumulatives

Wasteload Allocations are provided by waterbody and source-type in Table 6-9 or 6-12. Mass-based WLAs were developed for TIWRP and other point sources that have provided discharge flow data. (Refineries that have provided discharge flow data along with monitoring results receive mass-based allocations, where as other refineries receive concentration-based allocations because no discharge flow data has been provided to Regional Board staff.) Stormwater sources, including Los Angeles County MS4 Permittees, City of Long Beach and Caltrans, have received individual mass-based allocations, by permitted land area. Mass-based WLAs are applied as annual limits. Individual mass-based WLAs for an individual MS4 Permittee will be calculated based on its share, on an area basis, of the mass based WLA or other approved approach available at the time final mass-based WLAs are in effect and incorporated into the permit.

As described above in Section 5.3, the relative difference between the baseline and "no upland sources" scenarios were interpreted as the waterbody-specific percent contribution of the contaminant to the bed sediments from the upstream watersheds. These percentages were applied to the TMDLs to determine the mass-based WLAs for the stormwater sources. These overall WLAs were further divided to individual, mass-based allocations by permit based on the percent area draining to each waterbody (see Appendix III, Part 1).

Concentration-based WLAs are identified for other sources, such as General Construction, General Industrial, Power Generating stations, minor permits and irregular dischargers into Dominguez Channel Estuary. Any future minor NPDES permits or enrollees under a general non-stormwater NPDES permit will also be subject to the concentration-based waste load allocations. Concentration-based limits are applied as daily limits.

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[3] The Sediment Quality Plan – Direct Effects describes 5 cm for monitoring purposes however it does not intend to constrain or limit the sediment depth of applicability (person. commun., C. Beegan, SWRCB). Sediment Quality Plan –Indirect Effects is still in development and has not indicated a definite number for active sediment layer.

The calculations for the allocations shown here included MS4 discharges from the Seal Beach area (Orange County) to San Pedro Bay. The Orange County MS4 is issued by the Santa Ana Regional Board. Allocations for the Orange County MS4 will not be assigned in the Basin Plan Amendment. If later monitoring demonstrates that the Seal Beach MS4 discharges do not support the goals of the TMDL, a revision to this TMDL in conjunction with the Sana Ana Region may be developed.

6.5.2.2 Load Allocations – Bioaccumulatives

Load Allocations are provided by waterbody and source-type in Table 6-12. Mass-based LAs are identified for non-point sources, existing sediments and direct air deposition. Direct air deposition allocations are included for total DDT based on atmospheric monitoring results collected close to Los Angeles/Long Beach Harbor at SCAQMD Wilmington station in 2006 (SCCWRP presentation, 2007). Chemical-specific air deposition values (DDT = 29 ng/m^2/day) were multiplied by the surface area of each waterbody to produce direct deposition allocations. Direct deposition allocations for PCBs are not included since air deposition (air to water) has been measured to be less than water to air fluxes. Chlordane and dieldrin were not measured in the 2006 air deposition study. Mass-based WLAs will be applied as annual limits.

Air deposition allocations for DDT are based on existing loads; with no reductions anticipated this consumes the available loading capacity. DDT load allocations for bed sediments are negative values, with exception of those for the Los Angeles River Estuary, indicating that DDT loads must be reduced. (Each negative DDT bed sediment allocation may alternatively be interpreted as zero, or interpreted as minimal bioaccumulation into the food web.) The amount of DDT load reduction may be revised based on future monitoring results. For example, if future air deposition studies show lower existing air deposition DDT loads or, if future DDT sediment characterization studies show lower existing bed sediment DDT loads, then DDT allocations may be adjusted.

Note: If, at some point in the future, a non-point source is considered subject to NPDES or WDR regulations, then the corresponding load allocation (numeric value) may switch to wasteload allocation columns.

Table 6-12. TMDLs and Allocations (g/yr) – Bioaccumulative Compounds by waterbody/source. Sediment values are based on active sediment layer = 5cm depth.

Waterbody/source	***DDT total***	***PCBs total***
DomCh Estuary – TMDL	3.90	7.90
WLAs		
MS4- LA County et al	0.250	0.207
MS4 City of Long Beach	0.007	0.006
MS4 CalTrans	0.004	0.004
LAs		
Air deposition	6.01	n/a
Bed sediments	(2.4)	7.7

Waterbody/source	***DDT total***	***PCBs total***
Current Load (Table 4-6)	54.0	57.5
Overall reduction	93%	86%
Consolidated Slip - TMDL	0.56	1.14
WLAs		
MS4- LA County et al	0.009	0.004
MS4 CalTrans	0.00014	0.00006
LAs		
Air deposition ***Bed sediments***	1.56 (1.00)	n/a 1.13
Current Load (Table 4-6)	49.0	83.9
Overall reduction	99%	99%
Inner Harbor - TMDL	3.56	7.22
WLAs		
MS4- LA County et al	0.051	0.059
MS4 City of Long Beach	0.014	0.016
MS4 CalTrans	0.0010	0.0011
LAs		
Air deposition ***Bed sediments***	129 (125)	n/a 7.14
Current Load (Table 4-6)	21.67	29.51
Overall reduction	84%	76%
Outer Harbor - TMDL	3.79	7.68
WLAs		
MS4- LA County et al	0.005	0.020
MS4 City of Long Beach	0.004	0.014
MS4 CalTrans	0.000010	0.00004
TIWRP = POTW (CTR & MGD)***	12.7	0.37
LAs		
Air deposition ***Bed sediments***	173 (182)	n/a 7.28
Current Load (Table 4-6)	30.8	34.7
Overall reduction	88%	78%
Fish Harbor - TMDL	0.048	0.098
WLAs		
MS4- LA County et al	0.0003	0.0019
MS4 CalTrans	0.0000010	0.000006
LAs		
Air deposition	3.9	n/a

Waterbody/source	***DDT total***	***PCBs total***
Bed sediments	(3.85)	0.10
Current Load (Table 4-6)	0.168	0.075
Overall reduction	71%	0%
Cabrillo Marina -TMDL	0.061	0.124
WLAs		
MS4 LAC DPW	0.000028	0.000025
MS4 CalTrans	0.00000028	0.00000024
LAs		
Air deposition ***Bed sediments***	3.3 (3.22)	n/a 0.12
Current Load (Table 4-6)	1.66	1.06
Overall reduction	96%	88%
Inner Cabrillo Beach - TMDL	0.04	0.09
WLAs		
MS4- LA County et al	0.0001	0.0003
LAs		
Air deposition ***Bed sediments***	3.5 (3.5)	n/a 0.09
Current Load (Table 4-6)	0.98	0.31
Overall reduction	96%	72%
San Pedro Bay - TMDL	30.1	61.0
WLAs		
MS4- LA County et al	0.049	0.44
MS4 City of Long Beach	0.333	3.01
MS4 CalTrans	0.002	0.019
MS4 Orange County**	0.024	0.213
LAs		
Air deposition ***Bed sediments***	350 (320)	n/a 57.3
Current Load (Table 4-6)	205.2	110.7
Overall reduction	85%	45%
LA River Estuary - TMDL	34.1	69.2
WLAs		
MS4- LA County et al	0.100	0.324
MS4 City of Long Beach	1.067	3.441
MS4 CalTrans	0.014	0.047
LAR Estuary dischargers*	[DDT SQV]	[PCB SQV]
LAs		

Waterbody/source	*DDT total*	*PCBs total*
Air deposition	8.9	n/a
Bed sediments	24.09	65.3
Current Load (Table 4-6)	231.6	402.2
Overall reduction	85%	83%

Note: DDT air dep allocation = existing load, no reductions anticipated. Negative values for bed sediments indicate DDT loads are expected to be reduced-the amount of reduction may be revised with additional monitoring results. See discussion in Section 6.5.2.2.
Individual MS4's based on land percentage within that individual watershed.
PCBs air dep value n/a since monitoring results show flux from water to air.
*SQV values are currently set at the more protective of ERLs or BSAFs as discussed in section 6.5.1.
**Orange County MS4 is issued by the Santa Ana Regional Board. The allocations included, here, for the Seal Beach nearshore area, are for TMDL calculation purposes, only and an allocation is not assigned in Basin Plan Amendment.
***For TIWRP, the discharge volume at the time of permit modification or reissuance shall be used to calculate the mass-based effluent limitations consistent with the assumptions and requirements of these WLAs. Studies may be conducted to determine the portion of the discharged pollutants that is deposited on bedded sediment. The results of any such Executive Officer approved studies shall be evaluated at the TMDL reconsideration to modify these WLAs as appropriate.

Bed sediment concentration-based allocations are assigned for chlordane in Dominguez Channel Estuary, Consolidated Slip, Fish Harbor, Los Angeles River Estuary and Eastern San Pedro Bay. Bed sediment concentration-based allocations are also assigned for dieldrin in Dominguez Channel Estuary and Consolidated Slip. Bed sediment concentration allocations are also assigned for toxaphene in Consolidated Slip. The TMDLs and allocations are set at target sediment concentrations; see Table 6-13.

Table 6-13. Final Concentration-Based Sediment WLAs for other bioaccumulative compounds.

Concentration-based Sediment WLAs (µg/kg dry sediment)		
Chlordane	**Dieldrin**	**Toxaphene**
0.5	0.02	0.10

6.5.3 MOS – Bioaccumulatives

An implicit margin of safety exists in the final allocations to Dominguez Channel estuary and greater Harbor waters. The implicit margin of safety is based on the selection of multiple numeric targets, including targets for water, fish tissue and sediment among other conservative assumptions. An explicit margin of safety must be considered and may be applied if any chemical-specific sediment quality value is revised or updated contingent on future sediment quality studies. That is, there may be uncertainty associated with revised sediment quality values that may warrant including an explicit margin of safety.

6.5.4 Compliance with TMDL – Bioaccumulatives

Compliance with these bioaccumulative TMDLs may be achieved via any of four different means:

- Fish tissue targets are met in species resident to the TMDL waterbodies[4].
- Final sediment allocations, presented in Table 6-12, are met.
- Sediment numeric targets to protect fish tissue are met in bed sediment over a three-year averaging period.
- Demonstrate that the sediment quality objective protective of fish tissue is achieved per the Statewide Enclosed Bays and Estuaries Plan, as amended to address contaminants in finfish and wildlife.

Implementation Section 7.5 provides more details on compliance for these bioaccumulative TMDLs.

6.6 Summary of TMDLs

The freshwater TMDLs within Dominguez Channel are based on water column pollutants. The loading capacity is based on meeting CTR criteria for metals in freshwaters for both Dominguez Channel and Torrance Lateral. For downstream saline receiving waters – Dominguez Estuary and greater Harbor waters, the loading capacity for metals, organochlorine and PAH TMDLs are based on an estimate of annual pollutant loads that can be delivered to sediments and still meet the sediment targets. These TMDLs acknowledge that pollutant load reductions are required by watershed (stormwater) sources as well as existing bed sediments to attain the allowable loading capacity. Water column concentration-based allocations are also included for receiving waters; these allocations are equal to existing CTR criteria for protection of aquatic life or human health. Reductions in air deposition are expected only for Pb, otherwise load allocations for the other pollutants are equal to current estimates of direct deposition. As a general rule of thumb, reductions necessary to meet target Cu levels will also attain Pb, Zn and PAHs allocations. Necessary copper reductions range from 25 – 87%. Likewise, necessary reductions to meet DDT or PCB levels, up to 99%, will also attain the other bioaccumulative compound allocations.

Direct Effects targets are presented in flexible manner; that is, future stressor identification site-specific studies may yield different sediment quality values that correlate with desired sediment toxicity and benthic community goals. These TMDLs will need to be revisited and modified if toxic pollutants outside the scope of these TMDLs are identified as causative agents. Bioaccumulative compound TMDLs are designed to achieve fish tissue targets through contaminated sediment reductions and meeting saltwater column criteria.

6.7 Critical Condition

TMDLs must include consideration of critical conditions and seasonal factors. Pesticides, PCBs, PAHs, and metals are a concern in Dominguez Channel Estuary and Greater Harbor waters due to long-term loading and bioaccumulation effects. Wet weather events are likely to transport sediments and therefore produce extensive sediment redistribution into the harbors. In concert with aqueous pollutant transfer and contaminant diffusion properties the CTR-based water column targets are protective of this condition. This would be considered the critical condition

[4] A site-specific study to determine resident species shall be submitted to the Executive Officer for approval.

for loading. The effects of pollutants in sediment and fish tissue are manifested over long time periods. As an example, the half-life of PCBs in some sediment is estimated to be 20 years, whereas the PCBs half-life in fish is closer to 100 days, according to Gobas & Arnot (2010) and references therein. For this reason, short term variations (e.g., annual wet and dry seasons) in pollutant loadings are not likely to cause significant variations in impairment in fish tissue or sediments. In addition, no correlation with flow or seasonality (wet vs. dry season) was found to exist in sediment or tissue data. Given that allocations for this TMDL are expressed in terms of pesticides, PCBs, PAHs, and metals levels in sediment, a critical condition is not identified based upon flow or seasonality.

7 IMPLEMENTATION

California Water Code section 13360 precludes the Regional Board from specifying the method of compliance with waste discharge requirements; however California Water Code section 13242 requires that the Basin Plan include an implementation plan to describe the nature of actions to be taken to achieve water quality objectives and a time schedule for action. This section describes the proposed implementation plan to meet numeric targets for toxic pollutants in the Dominguez Channel and greater Los Angeles and Long Beach Harbor Waters.

Compliance with the TMDL for metals and PAHs is based on achieving the load and waste load allocations and/or demonstrating attainment of the sediment quality objectives (SQO Part 1) as multiple lines of evidence. Compliance with the TMDLs for bioaccumulative compounds shall be based on achieving the assigned loads and waste load allocations or, alternatively, by meeting fish tissue targets. Compliance will require the elimination of toxic pollutants being loaded into Dominguez Channel and the harbors, and clean up of contaminated sediments lying at the bottom of greater Los Angeles and Long Beach Harbors. Dischargers and responsible parties may implement structural and or non-structural BMPs and work collaboratively to achieve the numeric targets and allocations.

As discussed in the source analysis and allocations section of this TMDL, in most areas of the harbors, contaminant concentrations in sediment are above numeric targets for sediment. WLAs and LAs may not be attainable without reducing loadings from storm water discharges, near-shore and on water discharges, and river influences, and removal of contaminated sediment within hotspots of the Dominguez Channel Estuary and the Los Angeles and Long Beach Harbors. SWRCB (1999b, 2003) has prioritized hotspots in these waters, including: Consolidated Slip, and areas of Inner and Outer Harbors. This implementation section includes discussion of implementation actions to address these TMDLs. The implementation section describes the following implementation processes.

1. Implement (and evaluate effectiveness of) best management practices (BMPs) and source control in conjunction with the remediation actions to remove contaminated sediment as necessary;
2. Evaluate effectiveness of controlling sediment loading from Los Angeles River, San Gabriel River, and Machado Lake through implementation of effective TMDLs.
3. Conduct monitoring to evaluate compliance with targets during implementation and after

implementation actions are in place.

4. Determine if reductions in loadings from controllable sources from Los Angeles River and San Gabriel River will be required and addressed through revision of the TMDL.
5. Re-evaluate the WLAs and LAs, if necessary.

This implementation section also includes a schedule for conducting the activities listed above, a discussion of monitoring activities, and consideration of an economic analysis.

7.1 Regulation by the Regional Board

The Porter-Cologne Water Quality Control Act provides that "All discharges of waste into the waters of the State are privileges, not rights." Furthermore, all discharges are subject to regulation under the Porter-Cologne Act including both point and nonpoint source discharges.[5] In obligating the State Board and Regional Boards to address all discharges of waste that can affect water quality, the legislature provided the State Board and Regional Boards with authority in the form of administrative tools (waste discharge requirements (WDRs), waivers of WDRs, and Basin Plan waste discharge prohibitions) to address ongoing and proposed waste discharges. Hence, all current and proposed discharges must be regulated under WDRs, waivers of WDRs, a prohibition, or some combination of these or other administrative tools (e.g. Statewide Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program). Since the USEPA delegated responsibility to the State and Regional Boards for implementation of the National Pollutant Discharge Elimination System (NPDES) program, WDRs for discharges to surface waters also serve as NPDES permits

The regulatory mechanisms to implement the TMDL include, but are not limited to, general NPDES permits, individual NPDES permits, MS4 Permits covering jurisdictions and flood control districts within these waters, the Statewide Industrial Storm Water General Permit, the Statewide Construction Activity Storm Water General Permit, the Statewide Stormwater Permit for Caltrans Activities, and the authority contained in Sections 13263, 13267 and 13383 of the Cal. Water Code. For each discharger assigned a WLA, the appropriate Regional Board Order shall be reopened or amended when the order is reissued, in accordance with applicable laws, to incorporate the applicable WLA(s) as a permit requirement consistent with federal regulation and related guidance (40 CFR 144.22(d)(1)(vii)(B); US EPA Memorandum "Revisions to the November 22, 2002 Memorandum 'Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs'" (November 12, 2010)).

The MS4 Permits, Caltrans Storm Water Permit, general NPDES permits, general industrial storm water permits, general construction storm water permits, and minor NPDES permits shall be allowed a phased implementation schedule to achieve the waste load allocations. A phased implementation approach, using a combination of non-structural and structural BMPs could be

[5] See CWC sections 13260 and 13376.

used to achieve compliance with the waste load allocations. The administrative record and the fact sheets for the permits must provide reasonable assurance that the BMPs selected will be sufficient to implement the WLAs in the TMDL.

MS4 permittees, Caltrans, and other NPDES dischargers will be required to meet the WLAs at the designated compliance locations as defined in the TMDL monitoring plan. To achieve the necessary reductions to meet the allowable waste load allocations, permittees could balance short-term capital investments directed to addressing this and other TMDLs in the Dominguez Channel watershed and greater Los Angeles and Long Beach Harbor waters with long-term planning activities for stormwater management in the region as a whole. It should be emphasized that the potential implementation strategies discussed below may contribute to the implementation of other TMDL for Dominguez Channel watershed and greater Los Angeles and Long Beach Harbor waters. Likewise, implementation of other TMDLs in the watershed may contribute to the implementation of this TMDL.

Implementation by assigned responsible parties is required in three waterbody areas:

1. Dominguez Channel, Torrance Lateral, and Dominguez Channel Estuary
2. Greater Los Angeles and Long Beach Harbor waters (including Consolidated Slip)
3. Los Angeles River and San Gabriel River

The sediment targets are not intended to be used as ~~necessarily~~ 'clean-up standards' for navigational, capital or maintenance or dredging or capping activities; rather they are long-term sediment concentrations that should be attained after reduction of external loads, targeted actions addressing internal reservoirs of contaminants, and environmental decay of contaminants in sediment. Sediment remediation or dredging activities are reviewed in different regulatory processes (e.g., CWA Section 404; Marine Protection, Research, and Sanctuaries Act; Rivers and Harbors Act) and often take into account numerous factors, including yet not limited to: depth and volume of dredge materials, cost, disposal options, navigation and potential redistribution.

7.2 Responsible Parties and Potential Implementation Strategy

TMDL implementation will be carried out by responsible parties including, but not limited to:

1. Dominguez Channel Responsible Parties

- Dominguez Channel, Torrance Lateral, and Dominguez Channel Estuary MS4 Permittees
  - Los Angeles County
  - Los Angeles County Flood Control District
  - Caltrans
  - City of Carson
  - City of Compton
  - City of El Segundo
  - City of Gardena
  - City of Hawthorne
  - City of Inglewood
  - City of Lawndale
  - ~~City of Lomita~~

    - City of Long Beach
    - City of Los Angeles
    - City of Manhattan Beach
    - City of Redondo Beach
    - City of Torrance
- Individual and General Stormwater Permit Enrollees
- Other Non-stormwater Permittees
- Dominguez Channel Estuary Subgroup for bed sediment and fish:
    - Los Angeles County
    - Los Angeles County Flood Control District
    - Caltrans
    - City of Carson
    - City of Compton
    - City of Gardena
    - City of Los Angeles
    - City of Long Beach
    - City of Torrance

2. Greater Los Angeles and Long Beach Harbors Waters Responsible Parties

- Greater Los Angeles and Long Beach Harbor Waters MS4 Permittees
    - Los Angeles County
    - Los Angeles County Flood Control District
    - Caltrans
    - City of Bellflower
    - City of Lakewood
    - City of Long Beach
    - City of Los Angeles
    - City of Paramount
    - City of Signal Hill
    - City of Rolling Hills
    - City of Rolling Hills Estates
    - City of Rancho Palos Verdes
- City of Los Angeles (including the Port of Los Angeles)
- City of Long Beach (including the Port of Long Beach)
- State Lands Commission
- Individual and General Stormwater Permit Enrollees
- Other Non-stormwater Permittees, including City of Los Angeles (TIWRP)
- <u>Los Angeles River Estuary Subgroup for bed sediment and fish:</u>
    - Los Angeles County
    - Los Angeles County Flood Control District
    - City of Long Beach
    - City of Los Angeles
    - City of Signal Hill
    - Caltrans
- Consolidated Slip Responsible Parties subgroup
    - Consolidated Slip MS4 Permittees[6]

[6] US EPA is the regulatory oversight agency pursuant to CERCLA with respect to the Superfund site within the Dominguez Channel Estuary and Consolidated Slip subarea, but is not identified as a Responsible Party under the TMDL. As the regulatory oversight agency, US EPA is

- Los Angeles County
- Los Angeles County Flood Control District
- City of Los Angeles

3. Los Angeles River and San Gabriel River Watershed TMDLs Responsible Parties
   - Los Angeles River and San Gabriel River metals TMDLs responsible parties

7.3 Phased Implementation by Waterbody Area

The implementation actions described in this implementation section represent a range of activities that could be conducted to achieve final allocations. The specific actions taken to achieve the final allocations may vary to some degree from the elements presented here based on this evaluation and future analyses of the most cost effective and beneficial mechanisms for achieving the final allocations. To the extent possible, all ideas being considered as mechanisms for implementing the TMDL have been included in this implementation plan. Future considerations may result in other actions being implemented rather than the options presented.

Reductions to be achieved by each BMP will be documented and sufficient monitoring will be put in place to verify that the required reductions are achieved. When permits for responsible parties are revised, the permits should provide mechanisms to make adjustments to the required BMPs as necessary to ensure their adequate performance. If proposed structural and non-structural BMPs adequately implement the waste load allocations then additional controls will not be necessary. Alternatively, if the proposed structural and non-structural BMPs selected prove to be inadequate then additional structural and non-structural BMPs or additional controls may be required.

Implementation actions to achieve WLA and LA will be implemented via an iterative process, whereby information from each phase being used to inform the implementation of the next phase. The project will be adjusted as necessary based on information gained during each implementation phase.

Phase I Implementation includes elements to reduce the amount of sediment transport from point sources that directly or indirectly discharge to Dominguez Channel and the harbors. An important component of Phase I will be to secure the relationships and agreements between cooperating parties and to develop a detailed scope of work with priorities.

Phase I includes the following elements:

- Incorporate interim limits into WDRs and NPDES permits
- Implementation of Structural and Non-Structural BMPs throughout Dominguez Watershed and nearshore areas of greater LA/LB Harbor waters
- Implementation of effective TMDLs in Los Angeles River, San Gabriel River, and Machado Lake

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responsible for choosing an appropriate remedy for these sites. Furthermore, under CERCLA, US EPA is responsible for assuring that the CERCLA PRPs clean up the site in compliance with CERCLA and applicable or relevant and appropriate requirements (ARARs) (CERCLA section 121(d))

- Develop and initiate monitoring program

Phase II will include the implementation of site-specific cleanup actions for areas identified as high-priority in Phase I according to prioritization assessment completed by responsible parties and approved by the Regional Board in Phase I. Phase II will also include implementation of additional BMPs and site remedial actions upstream and in the Los Angeles and Long Beach Harbors, as determined to be effective based on the success of upstream source control, TMDL monitoring data evaluations, and WRAP and Sediment Management Plan-directed activities implemented during Phase I. Responsible parties will develop, prioritize, and implement Phase II elements based on data from the TMDL monitoring program and other information from special studies. Possible actions include additional structural and non-structural BMPs throughout the watershed by municipalities, counties, Caltrans, and others. It is expected that Phase II will include the majority of any necessary sediment removal activities.

Phase II should be designed by responsible parties to achieve all allocations by the end of Phase II. Phase III is provided to allow for any necessary follow-on activities due to the scope and complexity of the TMDL goals.

Phase III will includes implementation of secondary and addition remediation actions as necessary to be incompliance with final load allocations by end of implementation period.

7.3.1 Dominguez Channel, Torrance Lateral, and Dominguez Channel Estuary

Responsible parties can implement a variety of implementation strategies to meet the required WLAs and LAs, such as non-structural and structural BMPs, diversion and treatment to reduce sediment transport from the watershed to Dominguez Channel and Greater Harbor waters, and sediment removal activities.

Nonpoint source elements include legacy sediments and air deposition across Dominguez Channel and Harbor waters. The sediment load allocations for the contaminated bed sediments are assigned to the Cities of Long Beach and Los Angeles and the State Lands Commission, which have responsibility for remediation of the contaminated sediments.

- Phase I

  The purpose of the Phase I implementation is to reduce the amount of sediment transport from point sources that directly or indirectly discharge to Dominguez Channel and the Harbor waters. Phase I should include watershed-wide implementation actions. Important components of Phase I should be to secure the relationships and agreements between cooperating parties and to develop a detailed scope of work with priorities.

  Potential watershed-wide non-structural BMPs include more frequent and appropriately timed storm drain catch basin cleaning, improved street cleaning by upgrading to vacuum type sweepers, and educating residents and industries about good housekeeping practices. Structural BMPs may include the placement of stormwater treatment devices designed to reduce sediment loading, such as infiltration trenches, vegetated swales, and/or filter strips at critical points in the watershed. Structural BMPs may also include diversion and treatment

facilities to divert runoff directly, or provide capture and storage of runoff and then diversion to a location for treatment. Treatment options to reduce sediment could include sand or media filters.

The Los Angeles County Flood Control District (District) owns and operates Dominguez Channel; therefore, the District and the cities that discharge to Dominguez Channel shall each be responsible for conducting implementation actions to address contaminated sediments in Dominguez Channel. Responsible parties in Dominguez Channel shall develop a Sediment Management Plan to address contaminated sediment in Dominguez Channel and Dominguez Channel Estuary.

Sediment conditions shall be evaluated through the Sediment Quality Objective (SQO) process detailed in the SQO Part 1. If chemicals within sediments are contributing to an impaired benthic community or toxicity, then causative agent(s) shall be determined using SQO recommended procedures, SQO Part 1 (VII.F.). Impacted sediments shall be included in the list of sites to be managed.

- Phase II

Phase II should include the implementation of additional BMPs and site remedial actions, as determined to be effective based on the success of upstream source control, evaluation of TMDL monitoring data collected during Phase I, and targeted source reduction activities as identified in Phase I. Regional responsible parties should develop, prioritize, and implement Phase II elements based on data from the TMDL monitoring program and other available information from special studies. Possible actions include implementation of additional structural and non-structural BMPs throughout the watershed by municipalities, LA County, Caltrans, and others. Phase II should include the implementation of site-specific cleanup actions for areas identified as high priority in the Dominguez Channel Estuary and in accordance with the Sediment Management Plan.

- As management actions are planned for a contaminated site, site-specific cleanup criteria should be determined following protocols that are consistent with state and national guidance. The site improvements should be confirmed through a sediment monitoring program.
- There are two Superfund sites located within Dominguez Channel Watershed: the Montrose Superfund Site and the Del Amo Superfund Site. The US EPA has not yet reached a final remedial decision with respect to certain of the Montrose Superfund Site Operable Units (OUs) that remain contaminated with DDT, including the on- and near-property soils (OU1), the current storm water pathway (OU2), and the "Neighborhood Areas" (OU4 and OU6). The TMDL, its waste load and load allocations, and other regulatory provisions of this TMDL may be applicable or relevant and appropriate requirements (ARARs) as set forth in Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S.C. §§ 9621(d)) for those OUs. The TMDL for DDT should be taken into account in the course of the remedial decision-making process. The City of Los Angeles and/or Los Angeles County, should they decide to take action that impacts

one of the OUs, shall consult with US EPA's Superfund Division in advance of such action.

Detection of DDT compounds in water or sediment samples collected within Torrance Lateral shall trigger additional monitoring, by parties to be determined by the Executive Officer, in coordination with EPA, to evaluate potential contribution from contaminated soils related to upstream Montrose operable units discharging via the Kenwood storm drain. Upon reconsideration of the TMDL, all monitoring results for DDT compounds collected by responsible parties or other entities shall be considered as part of source analysis and to determine potential future allocation(s) that may be necessary to minimize impacts to downstream waters and restore beneficial uses in TMDL waterbodies.

- Phase III

Phase III should include implementation of secondary and additional remediation actions as necessary to be in compliance with final allocations by the end of the implementation period. TMDLs to allocate additional contaminant loads between dischargers in the Dominguez Channel, Torrance Lateral and Dominguez Channel Estuary subwatersheds may also be developed, if necessary.

7.3.2 Greater Los Angeles and Long Beach Harbor Waters (including Consolidated Slip)

Responsible parties can implement a variety of implementation strategies to meet the required WLAs, such as non-structural and structural BMPs, and/or diversion and treatment to reduce sediment transport from the nearshore watershed to the Greater Harbor waters.

- Phase I

The purpose of Phase I implementation is to reduce the amount of sediment transport from point sources that directly or indirectly discharge to the Harbor waters. Phase I should include actions to be implemented throughout the nearshore watershed and specific implementation actions at the Ports. Important components of Phase I should be to secure the relationships and agreements between cooperating parties and to develop a detailed scope of work with priorities.

Potential watershed-wide non-structural BMPs include more frequent and appropriately timed storm drain catch basin cleaning, improved street cleaning by upgrading to vacuum type sweepers, and educating residents and industries about good housekeeping practices. Structural BMPs may include the placement of stormwater treatment devices designed to reduce sediment loading, such as infiltration trenches, vegetated swales, and/or filter strips at critical points in the watershed. Structural BMPs may also include diversion and treatment facilities to divert runoff directly, or provide capture and storage of runoff and then diversion to a location for treatment. Treatment options to reduce sediment could include sand or media filters.

Implementation actions at the Ports should be developed to address different sources that contribute loading to the Harbors such as Port-wide activities and associated control measures for water and sediment, control measures to reduce the discharges from various land uses in the Harbors, nearshore discharges, and on-water discharges. The implementation actions described in the *Water Resources Action Plan* (WRAP) adopted by the Port of Los Angeles and the Port of Long Beach represent a range of activities that could be conducted to control discharges of polluted stormwater and contaminated sediments to the Harbors.

To meet necessary reductions in sediment bed loads, a Sediment Management Plan shall be developed by the dischargers assigned a sediment bed load LA, the Cities of Los Angeles and Long Beach and the State Lands Commission. Phase I implementation elements for the improvement of the Harbors' sediment quality should be conducted through the continuation of source reduction, source control, and sediment management. Below are proposed implementations actions that may be implemented in Phase I or Phase II to improve sediment quality at the ports:

- *Removal of Contaminated Sediment within Areas of Known Concern*. Planned removal programs are in place for IR Site 7 (former Navy facility in the Port of Long Beach) and Berth 240 (former Southwest Marine facility in the Port of Los Angeles). Contaminated sediment will be removed by Port of Long Beach and Port of Los Angeles.

- *Sediment Management Plan, Prioritization Assessment for Contaminated Sediment Management.* Sediment will be evaluated through the Sediment Quality Objective (SQO) process detailed in the Enclosed Bays and Estuaries Plan (i.e., SQO Part 1 as amended). If chemicals within sediments are contributing to an impaired benthic community or toxicity or fish tissue, then causative agent(s) will be determined using SQO recommended procedures, including SQO Part I (VII. F.). Impacted sediments will be included in the list of sites to be managed. The sites to be managed by the responsible parties will be prioritized for management and coupled with other planned projects when feasible. Prioritized sites shall include known hot spots, including but not limited to Consolidated Slip and Fish Harbor. For these prioritized sites, the sediment management plan shall include concrete actions and milestones, including numeric estimate of load reductions or removal, to remediate the priority areas and shall demonstrate the atcitons to address prioritized hot spots will be initiated and completed as early as possible during the 20-year TMDL implementation period. This process will prioritize management efforts on sites that have the greatest impact to the overall health of the benthic community and fish tissue and allow sites with lower risks to be addressed in later phases when opportunities can be coupled to capital projects. As management actions are planned for a contaminated site, site-specific cleanup criteria will be determined following established protocols that are consistent with state and national policy and guidance. The site will then be managed and the improvements confirmed through a sediment monitoring program. A flow chart showing a potential sediment monitoring and priority assessment program is included in Figure 7-1.

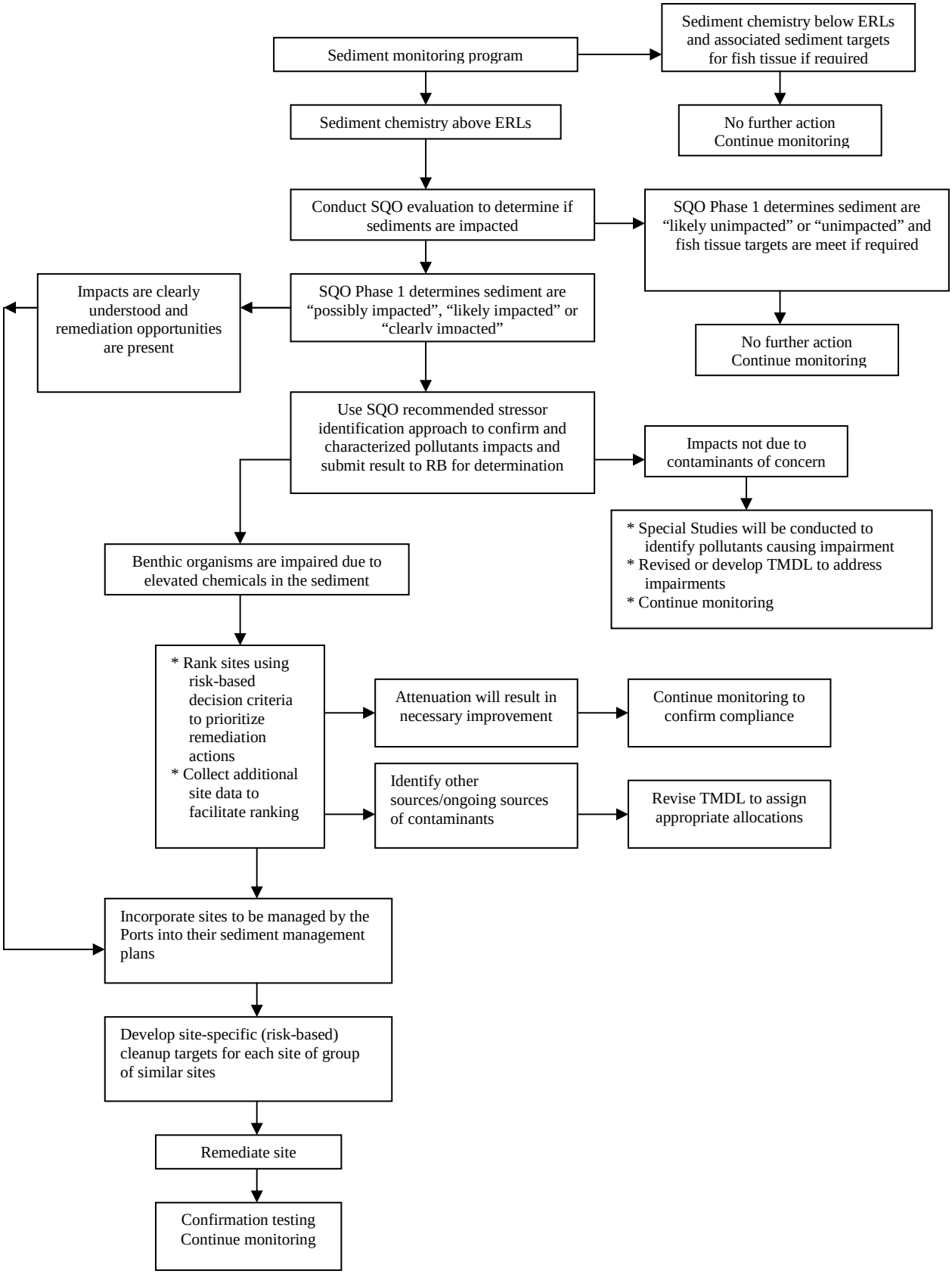

Figure 7-1. Proposed Sediment Monitoring Program and Priority Assessment Flowchart.

- *Superfund Sites.* Two Superfund sites are located in Dominguez Channel Watershed: the Montrose Superfund Site (DDT) and the Del Amo Superfund Site (benzene). Montrose Superfund Site includes multiple operable units (OUs), which are identified as investigation areas potentially containing site-related contamination. These Superfund Sites are located in a community known as Harbor Gateway, which is situated mostly in the City of Los Angeles and partially in unincorporated land in Los Angeles County. Harbor Gateway lies within the Kenwood Drain subwatershed, which discharges stormwater into Torrance Lateral which flows downstream into saline waters of Dominguez Channel Estuary and Consolidated Slip. The Torrance Lateral, Dominguez Channel Estuary and Consolidated Slip (OU2) contain sediments contaminated with multiple pollutants including DDT (potentially from various sources). The US Environmental Protection Agency (US EPA) has been working with other government agencies and local agencies including the City of Los Angeles and Los Angeles County to ensure the protection of both the environment and public health in the areas surrounding these Superfund sites.

  The US EPA has not yet reached a final remedial decision with respect to certain of the Montrose Superfund Site Operable Units (OUs) that remain contaminated with DDT, including the on- and near-property soils (OU1), the current storm water pathway (OU2), and the "Neighborhood Areas" (OU4 and OU6). The TMDL, its waste load and load allocations, and other regulatory provisions of this TMDL may be applicable or relevant and appropriate requirements (ARARs) as set forth in Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S.C. §§ 9621(d)) for those OUs. The TMDL for DDT should be taken into account in the course of the remedial decision-making process.

  In August 1999, USEPA and the State of California, which includes the Regional Board, entered into a consent decree concerning the Montrose Superfund site in a case entitled *United States of America and State of California v. Montrose Chemical Corporation of California, et al.*, United States District Court Central District of California, Case No. CV 90-3122-AAH (JRx)."

  Also, US EPA Superfund does not need to make a remedial decision prior to individual or collective action (by City of LA and/or County of LA) to clean up sediments within the OU2 stormwater pathway. The City of Los Angeles and/or Los Angeles County, should they decide to take action that impacts one of the OUs, shall consult with US EPA's Superfund Division in advance of such action. The goal of consultation is to ensure the proposed sediment cleanup will not aggravate the situation or further interfere with the site. The Montrose surrounding area is shown in Figure 7-2.

  Detection of DDT compounds in water or sediment samples collected within Torrance Lateral shall trigger additional monitoring, by parties to be determined by the Executive Officer, in coordination with EPA, to evaluate potential contribution from contaminated soils related to upstream Montrose operable units discharging via the Kenwood storm drain. Upon reconsideration of the TMDL, all monitoring results for DDT compounds collected by responsible parties or other entities shall be considered as part of source

analysis and to determine potential future allocation(s) that may be necessary to minimize impacts to downstream waters and restore beneficial uses in TMDL waterbodies.

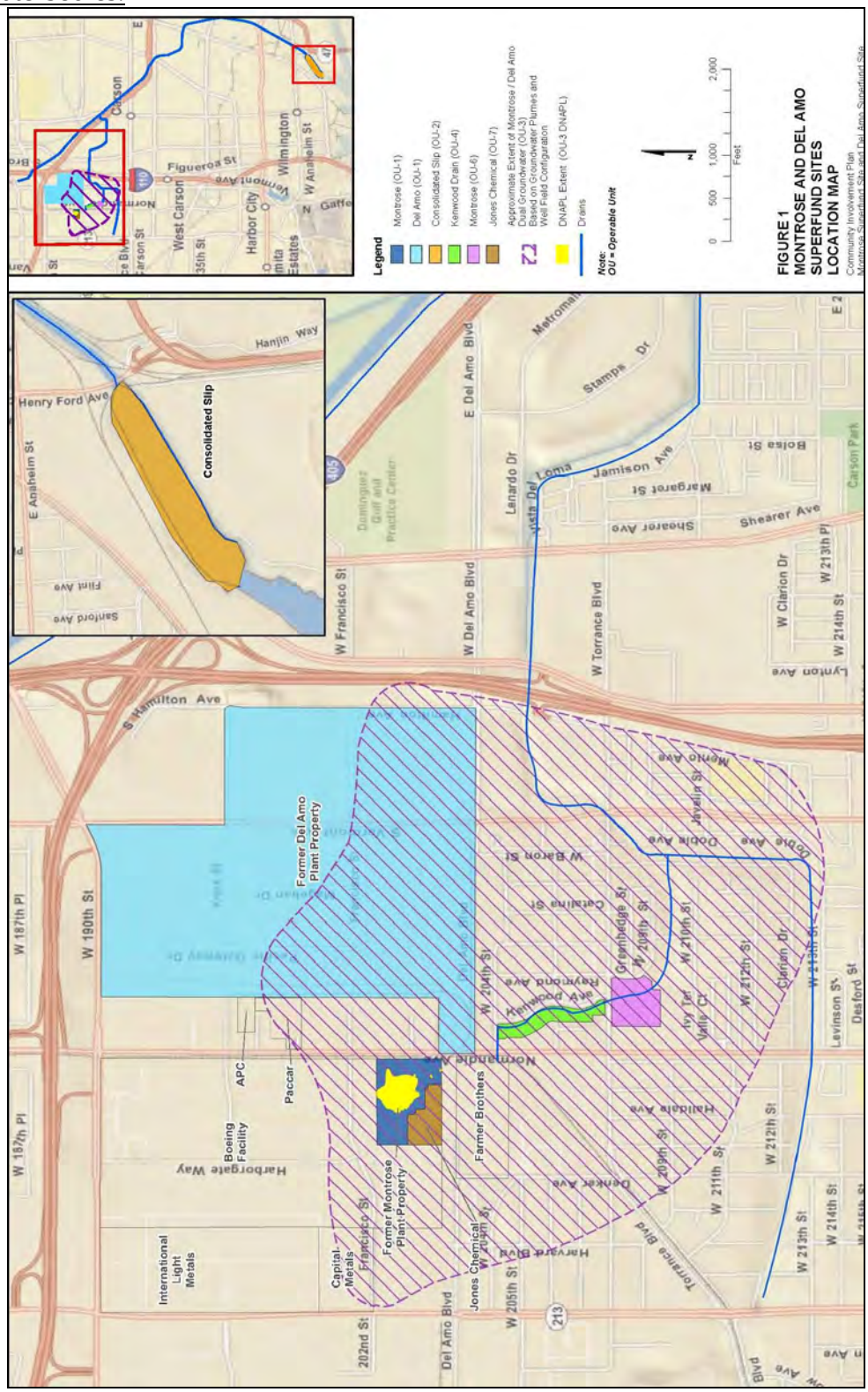

Figure 7-2 Montrose Superfund Site and the Del Amo Superfund Site Area Map

- Phase II

Phase II should include the implementation of additional BMPs and site remedial actions including sediment removal in the nearshore watershed and in the Harbors, as determined to be effective based on the success of upstream source control, TMDL monitoring data evaluations, WRAP activities implemented during Phase I, and targeted source reduction activities as identified in Phase I. Responsible parties should develop, prioritize, and implement Phase II elements based on data from the TMDL monitoring program and other available information from special studies. Possible actions include additional structural and non-structural BMPs throughout the watershed.

Phase II should include the implementation of site-specific cleanup actions for areas identified as high priority in the Harbor waters and per the Sediment Management Plan.

- Phase III

The purpose of Phase III is to implement secondary and additional remediation actions as necessary to be in compliance with final waste load and load allocations by the end of the TMDL implementation period.

7.3.3 Los Angeles River and San Gabriel River

Responsible parties in these watersheds are implementing other TMDLs, which will directly or indirectly support the goals of this TMDL.

- Phase I

Responsible parties for each watershed shall submit a Report of Implementation to describe how current activities support the downstream TMDL.

- Phases II and III

Implementation actions may be developed and required in Phases II and III as necessary to meet the targets in the Greater Harbor waters. TMDLs to allocate contaminant loads between dischargers in the Los Angeles and San Gabriel Rivers watersheds may also be developed, if necessary.

7.4 Special Studies and Reconsiderations

Special studies may be used to refine source assessments, assign appropriate allocation based on updated information from the results of implementation actions and monitoring program, and help focus implementation efforts. Regional Board staff also recognize that the TMDL targets, allocations, and proposed implementation actions to reach those targets and allocations will change due to changes in policies anticipated SQO Part II. In addition, improved air deposition studies may be used to refine air deposition allocations. The results of special studies submitted to the Regional Board's EO will be considered during subsequent TMDL reopeners. In addition,

it may be necessary to make adjustments to the TMDL to be responsive to new State policies including, but not limited to, SQO Part II; toxicity policy; possible changes to air quality criteria and other regulations affecting air quality.

If appropriate, the TMDL will be reconsidered by the Regional Board at the end of Phase I to consider completed special studies or policy changes. As allocation-specific data are collected, interim targets for the end of Phase II may be identified.

Below is list of potential optional special studies that may be conducted by responsible parties:

- **Optional Special Study - Stressor Identification Studies**
  Outlined in the Phase I SQOs is a stressor identification (stressor ID) process that is intended to be completed in order to identify the specific constituents causing sediment quality impairments. Given the recent adoption of the Phase I SQOs, stressor IDs have not been completed within the waterbodies addressed by the Harbors TMDLs. As a stressor ID process has not been completed, no individual constituent has been identified as directly causing or contributing to impairment in a manner consistent with the State's sediment quality objectives.

  A stressor ID study consists of the development and implementation of a work plan to: (1) confirm and characterize pollutant-related impacts; (2) identify specific pollutants; and (3) identify pollutant sources. The stressor ID process outlined in Section VII.F of the Phase I SQOs and the NPDES receiving water and effluent limit process outlined in Section VI.B of the Phase I SQOs provide the scientific basis and an approved regulatory process for identifying and addressing specific constituents causing sediment quality impairments. Work plans consistent with the Phase I SQOs stressor ID study approach must be submitted for Regional Board EO approval. The results of this special studies will submitted to the Regional Board and maybe used to revised the targets and allocation if determine by the Regional Board to be sufficient and appropriate.

- **Optional Special Study – Further characterization of direct air deposition loadings for heavy metals and legacy pesticides**
  Allocations of certain pollutants in certain waterbodies are confounded by preliminary estimates of pollutant loading via direct deposition onto waterbody surface area. Additional monitoring of these pollutants at air sampling sites more closely resembling the respective waterbody will help characterize these loadings. Limited data exist for dry deposition so this could be extended over longer timeframes. Measurements of wet deposition for each pollutant may also be appropriate to estimate air deposition more completely. Results could provide data to reconsider pollutant-specific allocations in this TMDL.

  <u>Detection of DDT compounds in water or sediment samples collected within Torrance Lateral shall trigger additional monitoring, by parties to be determined by the Executive Officer, in coordination with EPA, to evaluate potential contribution from contaminated soils related to upstream Montrose operable units discharging via the Kenwood storm drain. Upon reconsideration of the TMDL, all monitoring results for DDT compounds collected by responsible parties or other entities shall be considered as part of source analysis and to</u>

determine potential future allocation(s) that may be necessary to minimize impacts to downstream waters and restore beneficial uses in TMDL waterbodies.

- **Optional Special Study - Evaluation of Los Angeles River and San Gabriel River Loadings to the Harbors**
  This special study will evaluate whether or not the loading from Los Angeles River and San Gabriel have the potential to re-contaminate the Harbors and the results from this study will be used to determine if reductions in loadings from controllable sources from Los Angeles River and San Gabriel River will be required and addressed through revision of the TMDL.

- **Optional Special Study - Sediment and Fish Tissue Linkage Studies**
  A relationship between sediment pollutant concentrations, depth of sediment contamination and fish tissue pollutant concentrations exists; however, the quantification of that relationship (i.e., what concentrations in sediment lead to levels of concern in fish) is not well understood in the waterbodies addressed in the Harbors TMDLs. Performing special studies to develop a more comprehensive understanding of the link between sediment constituent concentrations and fish constituent concentrations may affect allocations associated with bioaccumulative pollutants addressed in the TMDL. Additionally, determining the range and habitat of specific fish populations within the receiving waterbodies can help guide implementation actions and the attainment of targets. That is, if a specific fish populations' range and habitats are known, then the fish tissue quality can be compared to the sediment quality for areas within the fish populations' range and habitats. These investigations may also be based on applying Phase II SQOs (currently being developed) for an understanding of the continuing level of impairment.

  Completion of studies linking sediment pollutant concentrations with fish tissue pollutant concentrations and evaluating the range and habitat of specific fish populations may be used to evaluate the attainment of targets, guide future implementation actions, and may lead to changes in TMDL targets, WLAs and LAs. Work plans to complete such studies must be submitted for Regional Board EO approval.

- **Optional Special Study – Additional monitoring results within Dominguez Channel and greater Harbor waters**
  Any additional monitoring data or information may be used to refine the existing watershed and/or receiving water models relevant to the TMDL.

7.5 Compliance with Allocations and Attainment of Numeric Targets

The goal of the TMDL is to restore all of the beneficial uses of Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters through attainment of water and sediment quality objectives.

Compliance with the TMDL shall be determined through water, sediment, and fish tissue monitoring and comparison with the TMDL waste load and load allocations and numeric targets. Compliance with the sediment TMDL for metals and PAH compounds shall be based on

achieving the loads and waste load allocations or, alternatively, demonstrating attainment of the SQO Part 1 through the sediment triad/multiple lines of evidence approach outlined therein. Compliance with the TMDLs for bioaccumulative compounds shall be based on achieving the assigned loads and waste load allocations in water and sediment or, alternatively, by meeting fish tissue targets. If at any point during the implementation plan, monitoring data or special studies indicate that WLAs or LAs will be attained but fish tissue targets may not be achieved, the Regional Board shall reconsider the TMDL to modify WLAs and LAs to ensure that the fish tissue targets are attained.

The compliance point for the stormwater WLAs shall be at the storm drain outfall of the permittee's drainage area. Alternatively, if stormwater dischargers select a coordinated compliance monitoring option, the compliance point for the stormwater WLA may be at storm drain outfalls or at a point in the receiving water, which suitably represents the combined discharge of cooperating parties discharging to Dominguez Channel and Greater Los Angeles and Long Beach Harbor waters. Depending on potential BMPs implemented, alternative stormwater compliance points may be proposed by responsible parties subject to approval by the Regional Board Executive Officer. The compliance point(s) for responsible parties receiving load allocations shall be in the receiving waters or the bed sediments of the Dominguez Channel and the Greater Los Angeles and Long Beach waters.

7.6 **Monitoring**

Monitoring is required to measure the progress of pollutant load reductions and improvements in water and sediment quality and fish tissue. The information presented in this section is intended to be a brief overview of the goals of the monitoring. Special studies may be planned to improve understanding of key aspects related to achievement of WLAs and LAs, restore the beneficial uses, and to assist in the modification of structural and non-structural BMPs if necessary. The goals of monitoring include:

- To determine compliance with the assigned waste load and load allocations.
- To monitor the effect of implementation actions proposed by responsible parties to improve water and sediment quality including proposed structural and non-structural BMP to reduce storm water run-off and sediment loading, and remediation actions to remove contaminated sediment.
- To monitor contaminated sediment level in the harbors and determine if additional implementation action should be required.
- To implement the monitoring in a manner consistent with other TMDL implementation plans and regulatory actions within the Dominguez Channel watershed.

Monitoring by assigned responsible parties is required in three waterbody areas:

1. Dominguez Channel, Torrance Lateral, and Dominguez Channel Estuary
2. Greater Los Angeles and Long Beach Harbor Waters (including Consolidated Slip)

3. Los Angeles River and San Gabriel River

Monitoring shall be conducted under technically appropriate Monitoring and Reporting Plans (MRPs) and Quality Assurance Project Plans (QAPPs). The MRPs shall include a requirement that the responsible parties report compliance and non-compliance with waste load and load allocations as part of annual reports submitted to the Regional Board. The QAPPs shall include protocols for sample collection, standard analytical procedures, and laboratory certification. All samples shall be collected in accordance with SWAMP protocols. Monitoring Plans shall be submitted twenty (20) months after the effective date of the TMDL for public review and, subsequently, Executive Officer approval.

Monitoring shall begin six months after the monitoring plan is approved by the Executive Officer. Responsible parties assigned both WLAs and LAs may submit one document that addresses the monitoring requirements (as described below) and implementation activities for both WLAs and LAs. Responsible parties shall submit annual monitoring reports.

The Regional Board Executive Officer may reduce, increase, or modify monitoring and reporting requirements, as necessary, based on the results of the TMDL monitoring program. Currently, several of the constituents of concern have numeric targets that are lower than the readily available detection limits. As analytical methods and detection limits continue to improve (i.e., development of lower detection limits) and become more environmentally relevant, responsible parties shall incorporate new method detection limits in the MRP and QAPP.

7.6.1 Dominguez Channel Freshwater, Torrance Lateral, and Dominguez Channel Estuary Compliance Monitoring Program

For Dominguez Channel, Dominguez Channel Estuary, and Torrance Lateral, water and total suspended solids samples shall be collected at the outlet of the storm drains discharging to the channel and the estuary. Fish tissue samples shall be collected in receiving waters of the Dominguez Channel Estuary. Sediment samples shall be collected in the estuary.

Responsible parties listed above for Dominguez Channel, Torrance Lateral, and Dominguez Channel Estuary are each responsible for conducting water, sediment, and fish tissue monitoring. However, they are encouraged to collaborate or coordinate their efforts to avoid duplication and reduce associated costs. Stormwater dischargers may coordinate compliance with the TMDL. Compliance with the TMDL may be based on a coordinated MRP. Dischargers interested in coordinated compliance shall submit a coordinated MRP that identifies stormwater BMPs and monitoring to be implemented by the responsible parties. Under the coordinated compliance option, the compliance point for the stormwater WLAs shall be storm drain outfalls which suitably represent the combined discharge of cooperating parties.

Water samples and total suspended solids samples will be collected during two wet weather and one dry weather events each year. The first large storm event of the season shall be included as one of the wet weather monitoring events. Water samples and total suspended solid samples will be analyzed for metals, DDT, PCBs, Benzo[a]anthrancene, Benzo[a]pyrene, Chrysene, Phenanthrene, and Pyrene. Sampling shall be designed to collected sufficient volumes of suspended solids to allow for analysis of the listed pollutants in the bulk sediment.

In addition to TMDL constituents, general water chemistry (temperature, dissolved oxygen, pH, and electrical conductivity) and a flow measurement will be required at each sampling event. General chemistry measurements may be taken in the laboratory immediately following sample collection, if auto samplers are used for sample collection or if weather conditions are unsuitable for field measurements.

Sediment monitoring program shall be developed in agreement with the selected method for compliance and all samples shall be collected in accordance with SWAMP protocols.

a) If ERLs compliance method is selected, sediment chemistry samples will be collected every two years for analysis of general sediment quality constituent and full chemical suite as specified in SQO Part 1. In addition, benthic community effects shall be assessed in the Dominguez Channel estuary.

b) If SQO compliance method is selected, sediment chemistry samples shall also be collected every five years (in addition to, and in between, the sediment triad sampling events as described below), beginning after the first sediment triad event to evaluate trends in general sediment quality constituents and listed constituents relative to sediment quality targets. Chemistry data without accompanying sediment triad data shall be used to assess sediment chemistry trends and shall not be used to determine compliance.

Sediment quality objective evaluation as detailed in the SQO Part 1 (sediment triad sampling) shall be performed every five years in coordination with the Biological Baseline and Bight regional monitoring programs, if possible. Sampling and analysis for the full chemical suite, two toxicity tests and four benthic indices as specified in SQO Part 1 shall be conducted and evaluated. If moderate toxicity as defined in the SQO Part 1 is observed, results shall be highlighted in annual reports and further analysis and evaluation to determine causes and remedies shall be required in accordance with the EO approved monitoring plan. Locations for sediment triad assessment and the methodology for combining result from sampling locations to determine sediment conditions shall be specified in the MRP to be approved by the Executive Officer. The sampling design shall be in compliance with the SQO Part 1 Sediment Monitoring section (VII.E.).

Fish tissue samples will be collected every two years and analyzed for chlordane, dieldrin, toxaphene, DDT, and PCBs. The target species in the Dominguez Channel estuary shall be selected based on the local abundance and fish size at the time of field collection. Tissues analyzed will be based on most common preparation for the selected fish species.

7.6.2 Greater Harbor Waters Compliance Monitoring Program

Responsible parties listed above for Greater Harbor Waters, Eastern San Pedro Bay are jointly responsible for implementing the monitoring program. At a minimum, monitoring shall be conducted at the locations and constituents listed in Table 7-1 for water column, total suspended solid, and sediment. The exact location of monitoring sites shall be specified in the monitoring plan to be approved by the Executive Officer. During aspects of the remedial action(s) for the Montrose Superfund Site that may mobilize sediments and associated pollutants from the on- or

near-property soils or "Neighborhood Areas", it is recommended that US EPA, as the regulatory oversight agency, require that Potentially Responsible Parties (PRP) implement monitoring to evaluate pollutant loads and concentrations leaving the site and surrounding area, as well as pollutant concentrations in the bed sediments of Dominguez Channel Estuary and Consolidated Slip and coordinate such monitoring with other TMDL compliance monitoring.

Sediment quality objective evaluation as detailed in the SQO Part 1 (sediment triad sampling) will be performed every five years for compliance; concurrently with the Biological Baseline and Bight programs. Full chemical suite, two toxicity tests and four benthic indices will be conducted and evaluated. If moderate toxicity as defined in the SQO Part 1 is observed, results shall be highlighted in annual reports and further analysis and evaluation to determine causes and remedies shall be required in accordance with the EO approved monitoring plan. Locations for sediment triad assessment and the methodology for combining results from sampling locations to determine sediment conditions in the waterbody shall be specified in the MRP to be approved by the EO. The sampling design shall be in compliance with the SQO Part I Sediment Monitoring section (VII.E).

Sediment chemistry samples will also be collected in between every five year of the sediment quality objective evaluation for analysis of general sediment quality constituents (GSQC) and listed constituents in Table 7-1. The chemistry analysis shall be used to assess sediment chemistry trend and will not be used to determine compliance. All samples will be collected in accordance with SWAMP protocols.

Water samples and total suspended solids samples will be collected during two wet weather and one dry weather event each year. The first large storm event of the season shall be included as one of the wet weather monitoring events. General water chemistry (temperature, dissolved oxygen, pH, and electrical conductivity), flow measurement, and listed constituent in Table 7-1 will be required at each sampling event.

Table 7-1. List of Constituents for Analysis and Required Monitoring Sites and for Water Column and Sediment Chemistry

Water Body Name	Station Id	Station Location	Sample Media	
			WATER/TSS	SEDIMENT
Consolidated Slip	01	Center of Consolidated Slip	Metals, PCBs, DDT	Metals, Chlordane, DDT PCBs, Benzo[a]anthracene, Benzo[a]pyrene, Chrysene, Phenanthrene, Pyrene, 2-methylnaphthalene
Los Angeles Inner Harbor	02	East Turning Basin	Metals, PCBs, DDT	Metals, Toxicity, Benthic Community Effect
	03	Center of the POLA West Basin	Metals, PCBs, DDT	
	04	Main Turning Basin north of Vincent Thomas Bridge	Metals, PCBs, DDT	
	05	Between Pier 300 and Pier 400	Metals, PCBs, DDT	Metals, Toxicity, Benthic Community Effect

Water Body Name	Station Id	Station Location	Sample Media	
			WATER/TSS	SEDIMENT
	06	Main Channel south of Port O'Call	Metals, PCBs, DDT	Metals, Toxicity, Benthic Community Effect
Fish Harbor	07	Center of inner portion of Fish Harbor	Metals, PCBs, DDT	Metals, Toxicity, PCBs, DDT, Chlordane, Benzo[a]anthracene, Benzo[a]pyrene, Chrysene, Dibenz[a,h]anthracene, Phenanthrene, Pyrene
Los Angeles Outer Harbor	08	Los Angeles Outer Harbor between Pier 400 and middle breakwater	Metals, PCBs, DDT	Toxicity
	09	Los Angeles Outer Harbor between the southern end of the reservation point and the San Pedro breakwater	Metals, PCBs, DDT	Toxicity
Cabrillo Marina	10	Center of west Channel	Metals, PCBs, DDT	
Inner Cabrillo Beach	11	Center of Inner Cabrillo Beach	Metals, PCBs, DDT	Metals
Long Beach Inner Harbor	12	Cerritos Channel between the Heim Bridge and the Turning Basin	Metals, PCBs, DDT	Metals, Toxicity, Benthic Community Effect
	13	Back Channel between Turning Basin and West Basin	Metals, PCBs, DDT	Metals, Toxicity, Benthic Community Effect
	14	Center of West Basin	Metals, PCBs, DDT	Metals, Toxicity, Benthic Community Effect
	15	Center of Southeast Basin	Metals, PCBs, DDT	Metals, Toxicity, Benthic Community Effect
Long Beach Outer Harbor	16	Center of Long Beach Outer Harbor	Metals, PCBs, DDT	Toxicity
	17	Between the southern end of Pier J and the Queens Gate	Metals, PCBs, DDT	Toxicity
San Pedro Bay	18	Northwest of San Pedro Bay near Los Angeles River Estuary	Metals, PCBs, DDT	Metals, Chlordane, PAHs, Toxicity
	19	East of San Pedro Bay	Metals, PCBs, DDT	Metals, Chlordane, PAHs, Toxicity
	20	South of San Pedro Bay inside breakwater	Metals, PCBs, DDT	Metals, Chlordane, PAHs, Toxicity
Los Angeles River Estuary	21	Los Angeles River Estuary Queensway	Metals, PCBs, DDT	Metals, Chlordane, DDT, PCBs

Water Body Name	Station Id	Station Location	Sample Media	
			WATER/TSS	SEDIMENT
		Bay		
	22	Los Angeles River Estuary	Metals, PCBs, DDT	Metals, Chlordane, DDT, PCBs

Fish tissue samples will be collected annually in San Pedro Bay, Los Angeles Harbor, and Long Beach Harbor, and analyzed for Chlordane, Dieldrin, Toxaphene, DDT, PCBs. Fish targeted to evaluate potential impacts to human health will be limited to species more commonly consumed by humans. White croaker, a sport fish, and a prey fish shall be collected and analyze to capture contaminant concentrations in species that pose the biggest risk to human health if consumed.

7.7 Implementation Schedule

The TMDL Implementation Schedule (Table 7-2) is designed to provide responsible parties flexibility to implement BMPs and management strategies to address toxicity pollutant impairments in Dominguez Channel and Greater Harbor waters. Implementation consists of development of monitoring/management plans by responsible parties, implementation of BMPs to address contaminant loading to the Dominguez Channel and Greater Harbor waters, and the ports management activities to remediate the sediment contamination and protect aquatic life.

Table 7-2. Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants TMDL: Implementation Schedule

Task Number	Task	Responsible Party	Deadline
1	Interim allocations are met.	All Responsible Parties	Effective date of the TMDL
2	Submit a Monitoring Plan to the Los Angeles Regional Board for Executive Officer approval.	Dominguez Channel Responsible parties; Greater Harbors Responsible Parties; Consolidated Slip Responsible Parties subgroup; Los Angeles and San Gabriel River Responsible Parties	20 months after effective date of the TMDL
3	Implement Monitoring Plan	Dominguez Channel Responsible parties; Greater Harbors Responsible Parties; Consolidated Slip Responsible Parties subgroup; Los Angeles and San Gabriel River Responsible Parties	6 months after monitoring plan approved by Executive Officer.
4	Submit annual monitoring reports to the Los Angeles Regional Board.	All Responsible parties	15 months after monitoring starts and annually thereafter
5	Submit an Implementation Plan and Contaminated Sediment Management Plan (CSMP). The Implementation Plan and CSMP shall be circulated for public review for 30 days. The CSMP shall include concrete milestones with numeric estimates of load reductions or removal, including milestones for remediating hot spots, including but no limited to Dominguez Channel Estuary, Consolidated Slip and Fish Harbor, for Executive Officer approval. The Executive Officer shall consider the consent decree for the Montrose Superfund site in determining whether to approve the CSMPs.	Dominguez Channel Responsible parties; Greater Harbors Responsible Parties; Consolidated Slip Responsible Parties subgroup	2 years after effective date of the TMDL
6	Submit Report of Implementation to the Los Angeles Regional Board for Executive Officer approval.	Los Angeles and San Gabriel River Responsible Parties	2 years after effective date of the TMDL
7	Submit annual implementation reports to the Los Angeles Regional Board. Report on implementation progress and demonstrate progress toward meeting the assigned LAs and WLAs.	All Responsible parties	3 years after effective date of the TMDL and annually thereafter
8	Complete Phase I of TMDL Implementation Plan and Sediment Management Plan.	Dominguez Channel Responsible parties; Greater Harbors Responsible Parties; Consolidated Slip Responsible Parties subgroup	5 years after effective date of the TMDL
9	Submit updated Implementation Plan and	Dominguez Channel	5 years after

Task Number	Task	Responsible Party	Deadline
	Contaminated Sediment Management Plan.	Responsible parties; Greater Harbors Responsible Parties; Consolidated Slip Responsible Parties subgroup	effective date of the TMDL
10	Regional Board will reconsider targets, WLAs, and LAs based on new policies, data or special studies. Regional Board will consider requirements for additional implementation or TMDLs for Los Angeles and San Gabriel Rivers and interim targets and allocations for the end of Phase II.	Regional Board	6 years after the effective date of the TMDL
11	Report on status of implementation and scope and schedule of remaining Phase II implementation actions to Regional Board	All responsible parties	10 years after the effective date of the TMDL.
12	Complete Phase II of TMDL Implementation Plan and Sediment Management Plan.	Dominguez Channel Responsible parties; Greater Harbors Responsible Parties; Consolidated Slip Responsible Parties subgroup	15 years after effective date of the TMDL
13	Complete Phase III of TMDL Implementation Plan and Sediment Management Plan.	Dominguez Channel Responsible parties; Greater Harbors Responsible Parties; Consolidated Slip Responsible Parties subgroup	20 years after effective date of the TMDL
14	~~Final LAs and WLAs are achieved~~. Demonstrate attainment of WLAs and LAs using the mean identified under WLAs and LAs in Table 7-40.1 in the Basin Plan.	All Responsible parties	20 years after effective date of the TMDL

7.8 Cost Consideration

Porter-Cologne Section 13241(d) requires staff to consider costs associated with the establishment of water quality objectives. This TMDL does not establish water quality objectives, but is merely a plan for achieving existing water quality objectives. Therefore, cost considerations required in Section 13241 are not required for this TMDL.

The purpose of this cost analysis is to provide the Regional Board with information concerning the potential cost of implementing this TMDL, and to address concerns about costs that may be raised by responsible parties. An evaluation of the costs of implementing this toxic pollutant TMDL amounts to evaluating the costs of remediating toxic pollutant levels in the Dominguez Channel and Los Angeles and Long Beach Harbors and preventing toxic pollutant loading to these waters from stormwater discharge. This section provides an overview of the costs associated with the typical toxic pollutant cleanup and toxic pollutant reduction implementation methods.

7.8.1 Cost of Implementing Toxic Pollutant TMDL

The cost of implementing this TMDL will range widely, depending on methods that the responsible parties select to meet the Waste Load and Load Allocations. Based on the implementation measures discussed previously, approaches can be categorized as Harbor management and stormwater treatment prior to discharging into Harbor. Harbor management strategies may be relatively more effective in reducing toxic pollutant concentrations in harbors, since some methods can remove the long accumulated sediment, which is a large source of toxic pollutants. Attainment of the WLA and LA in Harbor by only treating incoming stormwater would require more time. However, stakeholders may determine the compliance approach by considering the possible time needed in conjunction with the expense.

7.8.1.1 Harbor Management Implementation Options

Sediment Removal/Dredging

The depth of Harbor ranges from 30 to 60 feet (10-20 meters) with shallower bottom near outlet of Dominguez Channel and inner side of Pier 300 at Port of Los Angeles (< 20 feet), and deeper water at the entrance to Port of Long Beach (> 60 feet). Both Los Angeles and Long Beach Harbors are dredged periodically for navigation purposes. Staff finds it may be feasible to dredge Harbors for contaminated sediment removal as part of the existing practices.

Factors that possibly influence the dredging cost include dredging methodology, depth to the bottom of harbor, distance from shoreline, composition (silt, clay, sands with different grain sizes) of the sediments, transport of dredged materials, disposal methods and locations, and subaqueous capping for off-shore disposal. Based on a feasibility study conducted in 1998 for sediment contamination mitigation at the mouth of Ballona Creek and Marina del Rey, the dredging cost ranges from $10.95 per cubic yard ($yd^3$) to $74.4 per cubic yard (Moffatt & Nichol Engineers, 1998). The less expensive estimate was the results of choosing off-shore disposal, and economic capping. Since most of cost driving factors are undetermined, the average of estimates is used to predict the most probable dredging unit cost of $42.68 per cubic yard (1998 dollars). Assuming an inflation rate of 3% each year, the unit cost adjusted to the current value (year 2010) becomes $60.84 per cubic yard. This cost includes delivery of equipment, setup, operating equipment, pumping, dewatering process or sludge/sediment management, cleaning, labor associated with the above activities, and transporting waste.

Based on the draft memorandum to Regional Board staff on December 10, 2010, prepared by Ports of Long Beach and Los Angeles, and its associated discussion, areas where dredging activities may be necessary to remove contaminated sediment to fulfill requirements of Effect Range Low (ERL) or Sediment Quality Objective (SQO) were analyzed. Multiple literatures including Southern California Bight Monitoring (1998, 2003 and 2008) and the Ports Biobaseline Monitoring in 2008, indicated that the sediments at five primary locations which are Fish Harbor, Cabrillo Marina, Consolidated Slip, and Inner Cabrillo Beach of Los Angeles Harbor, Inner and Outer Harbors of Los Angeles/Long Beach have concentrations exceeding ERLs, and may have caused or contributed to benthic community impairment.

In accordance with the SQO procedure, multiple lines of evidences for sediment chemistry, toxicity, and benthic community may be used to determine the levels of impact which indirectly

may interpolate the areas and depth of necessary dredging activities. Approximately 1889 acres where classified either possible, likely or clearly impacted, with varying depths with a range of 2-8 feet may be dredged. Table 7-3 summarizes the total volume of dredged materials that may fulfill requirements of SQO and ERLs.

Table 7-3. Estimated volume of dredged materials with respect to SQO and ERL, prepared by Anchor QEA for Port of Los Angeles and Long Beach December 2010.

	Estimated Volume of Dredged materials Cubic Yard (yd^3)	
Waterbody	**SQO**	**ERL**
Fish Harbor	1,120	1,111,701
Los Angeles Harbor Cabrillo Marina	1,156,131	1,159,768
Los Angeles Harbor Consolidated Slip	475,910	478,294
Los Angeles Harbor Inner Cabrillo Beach Area	196,560	238,138
Los Angeles Harbor Beach Inner Harbor	6,692,551	21,864,948
Los Angeles Harbor Beach Outer Harbor	2,645,954	10,669,544
San Pedro Bay outside Harbors Outlet of Los Angeles River*	4,840*	4,840*
Total	11,173,066	35,527,233

*Additional estimate provided by Regional Board Staff.

The memo referenced above did not address any areas outside of Los Angeles and Long Beach Harbors. Based on a study conducted by Southern California Coast Water Research Project (SCCWRP) in 2008 and Regional Board staff's analysis, several locations with total area of 73 acres were identified as impacted. By the typical protocol of dredging, the minimal dredging depths are in a range of 2-3 feet. Therefore, the total volume to be dredged per SQO is approximately 11,173,066 cubic yards.

The total cost to dredging at Harbors is estimated $679.8 million dollars. Given a compliance schedule of 20 years, and the annual interest rate of 6%, the amortized cost for each year would be $59.3 million dollars (Table 7-4).

Table 7-4. Summary of estimated cost for dredging

	Volume (cubic yards)	Unit Cost	Total Cost
Dredging	11,173,066	$60.84/cubic yard	$679,788,860
Amortized over 20 years (6% interest rate)			$59,277,589 per year

(Wastewater Engineering Treatment, disposal and Reuse, 3rd edition, Chap 12, Metcalf & Eddy).

7.8.1.2 Stormwater Treatment Implementation Options

Sand/Organic Filters

A typical sand/organic filter system contains two or more chambers. The first is the sedimentation chamber for removing floatables and heavy sediments. The second is the filtration chamber, which removes additional pollutants by filtering the runoff through a sand bed. Properly designed sand/organic filters are effective methods to remove suspended solids, biochemical oxygen demand (BOD), total phosphorus, fecal coliform bacteria, metals and toxic pollutants from stormwater. The effectiveness of a sand/organic filter system is greatly influenced by the pollutant loadings, and the characteristics of the drainage areas.

The construction cost of a sand/organic filter system depends on the drainage areas, expected efficiency and other design parameters. Case studies conducted in 1997 indicate cost ranges from $2,360 dollars/acre for areas greater than 30 acres to $18,500 dollars per acre (EPA, 1999). With considerations of inflation rate of 3% to bring the monetary value to current, and the vast areas, the unit price of constructing filter system is assumed $3,000 dollars per acre. The Dominguez Channel subwatershed is approximately 75,144 acres, which results in the overall cost of $ 225 million dollars for sand/organic filter system construction (Table 7-5). Amortized with interest rate of 6% annually and into 20 years based on the implementation schedule, and with the average annual maintenance rate of 5%, the total cost is 20.64 million dollars.

Table 7-5. Summary of estimated cost for stormwater treatment filters

Items	Unit Price	Total Cost
Construction cost	$3,000/acre of drainage area Total 75,144 acres in the Dominguez Channel Subwatershed.	$225,432,000 $19.6 million annually if amortized with an interest rate of 6% for 20 years.
Maintenance	5% of the construction cost, annually	$982,884 annually
Total Cost		$20,640,554 annually

Vegetated Swales

Vegetated swales are constructed along drainage ways where stormwater runoff conveyed. Vegetation in swales and strips allows for the filtering of pollutants, and infiltration of runoff into groundwater. Densely vegetated swales can be designed to add visual interest to a site or to

screen unsightly views. They reduce runoff velocities, which allow sediment and other pollutants to settle out.

The effectiveness of vegetated swales depends on slopes of swales, soil permeability, grass cover density, contact time of stormwater runoff and intensity of storm events. Vegetated swales, based on case studies, are capable of managing runoff from small drainage areas with approximate sizes of 10 acres.

Construction of swales begins with site clearing, grubbing, excavation, leveling and tilling, thereafter followed with seeding and vegetation planting. The cost of developing a swale unit is estimated in the range of $6,000 to $17,000 (CASQA, 2003). Routine maintenance activities include keeping up the hydraulic and removal efficiency of the channel, periodic mowing, weed control, watering, reseeding and clearing of debris and blockages for a dense, healthy grass cover.

With considerations of inflation rate of 3% to bring the monetary value to current, and the vast areas, the unit price of constructing a vegetated swale is assumed to be $7,200 dollars each. Acreage of the Dominguez Channel subwatershed requires approximately 7,514 units of vegetated swales, which results in the overall cost of $54.1 million dollars (Table 7-6). Amortized with interest rate of 6% annually and into 20 years based on the implementation schedule, and with the average annual maintenance rate of 5%, the total cost is $4.95 million dollars.

Table 7-6. Summary of estimated cost for vegetative swales

Items	Unit Cost	Total cost
Construction	$7,200 per unit swale for each 10-acre drainage area	$54,103,680 $4.7 million annually if amortized with an interest rate of 6% for 20 years.
Maintenance	5% of construction cost annually	$235,892 annually
Total Cost		$4,953,733 annually

7.8.1.3 Cost Comparison

Water quality improvement at the Harbors can be achieved through harbor management which mitigates the toxic pollutant problem in harbors water and by reducing toxic pollutant loading from stormwater discharge. The following table summarizes the estimated total costs as results of implementing this TMDL (Table 7-7). The overall project costs arising from dredging the contaminated sediment in harbors and pollutant loading reduction in stormwater could be in a range of 733 million dollars to 905 million dollars. With consideration of the maintenance cost to structural BMPs such as infiltration system and vegetated swales, this overall cost may amortized, at a interest rate of 6%, to become as low as 64 million dollars per year during implementation of this TMDL.

Both the Port of Los Angeles and Port of Long Beach dredge the harbors and channels periodically or upon request to maintain proper navigation. The quantity of dredged materials

for purposes other than removing contaminated sediment was not accounted, and may further reduce the cost for implementing this TMDL.

Table 7-7. Cost summary for stormwater treatment implementation alternatives

Implementation Alternatives	Harbor Dredging and Sand/Organic Filters	Harbor Dredging and Vegetated Swale
Total Project Cost (current value)	$905,220,860	$733,892,540
Amortized annual Cost (Interest rate 6% over 20 years)	$79,918,143	$64,231,322

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Appendix I:

Los Angeles-Long Beach Harbors and San Pedro Bay Hydrodynamic and Sediment-Contaminant Transport Model Report

May 2011

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Appendix I Summary

The *Los Angeles-Long Beach Harbors and San Pedro Bay Hydrodynamic and Sediment-Contaminant Transport Model Report* describes the estimation of metals and organic pollutant concentrations in the Dominguez Channel Estuary and Greater Los Angeles and Long Beach Harbor Waters using the EFDC receiving water model. Key findings of the report include:

- Pollutants of interest include metals such as copper, lead, and zinc, and several organic pollutants (PAHs, DDT, and PCBs), which were simulated over a four-year period.
- Model configuration (Sections 4 and 7), included representation of the model grid, bathymetry, topography, open boundary hydrodynamic forcing, salinity open boundaries, wind and atmospheric forcing, freshwater inflows, sediment bed initial conditions, sediment parameters, equilibrium partition coefficients, and external loads and open boundary associated with sediment and contaminants. This information is presented in various formats in the document (text, maps, graphs, and tables).
- Model calibration was performed for hydrodynamics (tidal frequency water surface elevation, low frequency water surface elevation, tidal frequency currents; Section 5), transport (Section 6), and sediment and contaminant transport (Section 8). Similar to the model configuration information, details are provided in the discussion as well with maps, graphs, and tables.
- Model inputs associated with the pollutants of concern include sediment initial conditions based on observed physical and sediment concentration data (see Appendix III.3 and Section 7.1) and loading from the LSPC watershed models (see Appendix II and Section 7.4).
- Sensitivity analyses were performed for both dry season conditions (Appendix C) as well as long-term load reductions (Appendix D).
- Model output associated with sediment deposition and average sediment concentrations (over a four-year simulation period) were used to calculate TMDLs and existing loads. In addition, the calibrated model was used to perform several scenarios to support TMDL calculations.

Los Angeles-Long Beach Harbors and San Pedro Bay Hydrodynamic and Sediment-Contaminant Transport Model Report

FINAL

May 2011

Prepared for:
USEPA Region 9
Los Angeles Regional Water Quality Control Board

Prepared by:
Tetra Tech, Inc.

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1. Introduction

This report summarizes the development and calibration of the hydrodynamic and sediment transport model components of a coupled hydrodynamic and water quality modeling system under development to support TMDLs in the greater Los Angeles and Long Beach Harbors, including the Los Angeles River estuary and San Pedro Bay. The report presents the overall modeling framework to support TMDL development, observational data to support the hydrodynamic and sediment transport model configuration and calibration, and calibration results.

Areas of the Los Angeles and Long Beach (LA/LB) Harbors and San Pedro Bay, including their tributaries, the Los Angeles and San Gabriel Rivers and Dominguez Channel, are currently on the State of California's 303(d) list of impaired waters. A variety of toxic inorganic and organic contaminants contribute to benthic effects and sediment toxicity impairments. Specific inorganic metal contaminants on the list include cadmium, chromium, copper, lead, mercury, nickel, and zinc. Organic contaminants listed include chlordane, DDT, dieldrin, PAHs, PCBs, and toxaphene. The fate and transport of metals and organic contaminants in surface water systems is strongly coupled with the fate and transport of organic and inorganic sediments and dissolved organic material due to their affinity to adsorb to sediment particles and bond with dissolved organic carbon to form complexes.

Hydrodynamic and water quality models provide an important tool to evaluate existing conditions, including identifying non-point source load contributions, source controls, and TMDL allocation alternatives. A modeling system that includes hydrodynamic, sediment transport, and contaminant transport and fate is necessary to assess current conditions and potential load reduction scenarios for the listed waterbodies. This report provides an update on the status of the development of the hydrodynamic component of this modeling system, including calibration results (Section 5, Section 6, and Appendix A), and describes the sediment transport and contaminant transport and fate components. The report is organized as follows:

- *Modeling Framework*. Summarizes the overall modeling framework including model selection and the sequence of steps leading to the decision support modeling system for TMDL development.
- *Observational Data for Model Configuration and Calibration*. Summarizes available observational data for configuration and calibration of the hydrodynamic model component.
- *Hydrodynamic Model Configuration*. Describes general and hydrodynamic configuration of the model for the greater Los Angeles and Long Beach Harbors system.
- *Hydrodynamic Calibration*. Outlines the approach used and presents results for the hydrodynamic and transport calibration.

- *Sediment and Contaminant Transport Configuration.* Describes the configuration of the sediment and contaminant transport and fate components of the modeling including analysis of field observations.
- *Sediment and Contaminant Transport Calibration*. Outlines the approach used and presents calibration results.
- *Summary and Recommendations*. Summarizes the status of the calibration and makes recommendations for use of the model for TMDL development.
- *Appendix A*. Provides time series plots of the salinity calibration.
- *Appendix B*. Describes the model performance measures used to compare model output and observed data during model calibration.
- *Appendix C.* Presents dry season model sensitivity analyses.
- *Appendix D*. Presents model sensitivity to long-term load reductions.
- *Appendix E.* Provides analyses of additional water column data.

2. Modeling Framework

A modeling system to support TMDL development for metals and hydrophobic organic compounds in the greater Los Angeles and Long Beach Harbors system requires three primary components: hydrodynamic, sediment transport, and contaminant transport and fate. The U. S. Army Corps of Engineers (ACOE) has conducted numerous hydrodynamic and eutrophication modeling studies in the greater LA/LB Harbor area (Seabergh and Outlaw, 1984; Seabergh, 1985; CERC, 1990; Hall, 1990; Hall, 1995; Wang et al., 1995; Miller et al., 1998; Bunch, et al., 2000, 2002, 2003) using the proprietary CH3D hydrodynamic and CE-QAUL-IC water quality models. No previous modeling efforts have addressed the fate and transport of sediment adsorbed toxic metals and organic compounds in the greater LA/LB Harbor waters.

The Environmental Fluid Dynamics Code (EFDC) (Hamrick, 1992; Hamrick and Wu; 1997; Park et al., 1995) was selected for this study for a number of reasons. The EFDC model includes all required model components (hydrodynamic, sediment transport, and contaminant transport and fate) and is in the public domain, as well as being supported by the U. S. Environmental Protection Agency (EPA). The EFDC model has been used for more than 100 surface water modeling applications including nutrient TMDL development (Wool et al., 2003; Zou et al., 2006) and metals and organic contaminant fate and transport at conventional (Ji et al., 2002; King County, 1999) and superfund sites (U. S. EPA, Region 1, 2006; U. S. EPA Region 10, 2006). An EFDC model was developed by the Port of Los Angeles for the Dominguez Channel estuary and the Consolidated Slip (Dominguez Channel Estuary Model [DCEM] study).

The EFDC modeling framework to support TMDL development in the greater LA/LB Harbor waters was undertaken in a sequence of steps. The first step was configuration and calibration of the model hydrodynamic component, including

salinity transport. This step was followed by the configuration and calibration of the sediment transport and contaminant fate and transport components. Both of these steps utilized results from two complimentary studies. Fresh water inflow and associated sediment and contaminant loads were provided by LSPC models of the near shore watersheds and the three larger watersheds (Dominguez Channel, Los Angeles River, and San Gabriel River watersheds) (SCCWRP, unpublished report; Tetra Tech, 2010). The EFDC model had previously been applied to simulate sediment and metals transport in the tidal region of Dominguez Channel (Everest, 2006). The model grid used in the Dominguez study was adopted for this study. Field observations collected during that study were also used for model calibration and validation in this current effort. These data included dry weather water elevation, current, salinity, and other water quality data (note: the DCEM study also included data associated with a dye study and a wet weather event in February 2006, which was outside of the 2002-2005 TMDL model period and therefore not used). This report summarizes the configuration and calibration of the hydrodynamic, sediment transport, and contaminant transport and fate components of this modeling system.

3. Observational Data for Model Configuration and Calibration

Observational data for the hydrodynamic model falls within two general classes: data used for model configuration and data used for model calibration. Model configuration data includes the water body shoreline, bathymetry, data used for specifying hydrodynamic and salinity boundary conditions, atmospheric wind and thermal forcing, and inflows. Calibration data includes observations of hydrodynamic variables predicted by the modeling including water surface elevation, horizontal currents, and salinity.

Table 1 summarizes the observational data currently used for hydrodynamic model configuration and calibration. Data listed in Table 1 and used for the hydrodynamic model configuration and calibration are discussed later in this report. It is useful to summarize that the available observational data for hydrodynamic model configuration are very adequate, while the data for model calibration could be judged as less adequate. The available data being used for calibration are limited to one tide gauge, four current meters within the breakwater (which also recorded water surface elevation), six current meters outside the breakwater in San Pedro Bay, and approximately 120 salinity and temperature monitoring stations.

The adequacy of the data for calibration relates strongly to the hydrodynamic characteristics of the greater LA/LB Harbor waters. Previous modeling studies by the ACOE indicated that water surface elevation amplitude and phase vary insignificantly in the system and that the long-term NOAA tide gauge record is representative of the entire system. Recent current meter observations within the breakwater (POLA Prop 13, Table 1) have been confined to the inner regions

of Los Angeles Harbor. Current meter observations outside the breakwater (LSCSD Palos Verde Shelf, Table 1) were useful in developing boundary conditions, but are far removed from the primary area of interest.

Table 1. Data Used for Hydrodynamic Model Configuration and Calibration

Data Type	Use	Source
Shoreline, Breakwaters and Fairways	Model Grid Generation	NOAA Electronic Navigation Charts
Bathymetry	Primary Model Bathymetry Configuration	NOAA High Resolution Coastal Relief Bathymetric Data Set
Bathymetry	Local Model Bathymetry Configuration	NOAA Electronic Navigation Charts
Bathymetry	Local Model Bathymetry Configuration	Port of Los Angeles
Tide Gauge Record at Port of Los Angeles	Development of Tidal Boundary Conditions and Tidal Elevation Calibration	NOAA Center for Operational Oceanographic Products and Services
Port of Los Angeles Prop 13 Current Meter Record	Tidal Elevation Calibration	Electronic Data Provided to US EPA by Study Contractor
LACSD Palos Verde Shelf Study Current Meter and CTD Records	Development of Tidal and Temperature Boundary Conditions and Tidal Current Calibration	Electronic Data Provided to US EPA by Study Contractor (SAIC, 2004)
Port of Los Angeles Prop 13 Current Meter Record	Tidal Current Calibration	Electronic Data Provided to US EPA by Study Contractor
Stream Flow Records	Dominguez Channel Los Angeles and San Gabriel River Inflows	County of Los Angeles, Department of Public Works
WWTP Discharge Record	Terminal Island Treatment Plant Discharge	City of Los Angeles
Wind Speed and Direction Records	Wind Forcing	NOAA National Climate Data Center LAX Airport Station
Wind Speed and Direction Records	Wind Forcing	California Irrigation Management System, Long Beach and Santa Monica Station
Wind Speed and Direction Records	Wind Forcing	NOAA National Data Buoy Center Stations 46025, 46086
Wind Speed and Direction Records	Wind Forcing	NOAA PORTS observational sites (October 2004-April 2005)
Atmospheric Temperature, Relative Humidity, Solar Radiation and Cloud Cover Records	Atmospheric Thermal Forcing	NOAA National Climate Data Center LAX Airport Station
Atmospheric Temperature, Relative Humidity, Solar Radiation and Cloud Cover Records	Atmospheric Thermal Forcing	California Irrigation Management System, Long Beach and Santa Monica Stations
Salinity Monitoring Data	Transport Calibration	City of Los Angeles
Salinity Monitoring Data	Transport Calibration	Harbor Generating Station
Salinity Monitoring Data	Transport Calibration	Port of Los Angeles
Salinity Monitoring Data	Transport Calibration	Port of Los Angeles & Port of Long Beach Biological Baseline Study
Port of Los Angeles Prop 13 Salinity Data	Transport Calibration	Electronic Data Provided to US EPA by Study Contractor
Salinity Monitoring Data (Bight 03 data on stormwater runoff and dispersion)	Transport Calibration	SCCWRP and others

Table 1 lists a number of discrete salinity monitoring studies, representing approximately 120 stations. The adequacy of the salinity observations in these monitoring data sets is very limited. This is due to the climate and hydrology of the area that results in significant salinity variability being associated with episodic freshwater inflow events. Of the 120 monitoring stations, only 20 have observations corresponding to times when the salinity is significantly less than the 32 to 33 ppt level characteristic of the greater LA/LB Harbor waters. Further, at these 20 stations, there are only three observations per station showing depressed salinity. Wet weather data were provided associated with the DCEM study; however, these data were for a storm in February 2006, which is outside of the TMDL model study period (2002-2005). Hence these additional wet weather data could not be used for calibration or validation.

Table 2 summarizes data used for sediment transport and contaminant fate and transport configuration and calibration. These data are described in detail throughout sections 7 and 8 and their associated appendices. Similar to the salinity data, dry and wet weather data were provided associated with the DCEM study. The wet weather data were collected outside of the TMDL model study period (2002-2005) and could therefore not be used. While some dry weather data were collected during overlapping time periods, they were excluded from the TMDL model. Since the TMDL model used the previous Dominguez Channel model upstream of the Consolidated Slip, it was determined that there was no need to repeat the comparison presented in the DCEM report (Everest, 2006).

Table 2. Data Used for Sediment and Contaminant Model Configuration and Calibration

Data Description	Use	Source
POLA/POLB – Sediment bed physical data (2006)	Sediment Bed Physical Model Initialization	Electronic Data Provided to US EPA by Study Contractor
Bight 03 – Sediment bed physical data (2003)	Sediment Bed Physical Model Initialization	Electronic Data Provided by SCCWRP
Bight 94 – Sediment bed physical data (1994)	Sediment Bed Physical Model Initialization	Contaminated Sediments Task Force Database
Bight 98 – Sediment bed physical data (1998)	Sediment Bed Physical Model Initialization	Contaminated Sediments Task Force Database
POLA/POLB Biological Baseline Study – Sediment bed physical data (2000)	Sediment Bed Physical Model Initialization	Electronic Reports Provided to US EPA
Bay Protection and Toxic Cleanup – Sediment bed physical data (1997)	Sediment Bed Physical Model Initialization	Contaminated Sediments Task Force Database
Western EMAP – Sediment bed physical data (1999)	Sediment Bed Physical Model Initialization	Contaminated Sediments Task Force Database
POLA/POLB Special Studies (1998-2001) POLA Berth 100 Final Report POLA Berth 121, 122-124 Final Rprt 2/2 POLA Berth 240B Final Report POLA Berths 148-151 Sed Test POLA Berths 167-169 Sed Tests POLA Berths 212-215 Sed Tests POLA Berths 263-264 Sed Tests POLA Slip 5 Sed Tests POLA West Ch B40-44 Sed Testing POLB Contract HD5951 POLB Pier J, East Channel Dredge	Sediment Bed Physical Model Initialization	Contaminated Sediments Task Force Database

Data Description	Use	Source
POLB Pier S Dredging, Final Report POLB West Basin, 8/98 Sed Testing		
Harbor Generating Station - Sediment chemistry data (2001-2003)	Sediment Bed Chemistry Model Initialization	Electronic Data Provided to US EPA by Contractor during 303(d) data compilation efforts
Terminal Island Treatment Plant - Sediment chemistry data (2001-2003)	Sediment Bed Chemistry Model Initialization	Electronic Data Provided to US EPA by City of Los Angeles, Environmental Monitoring Division
EPA/POLA/AMEC - Sediment chemistry data (2002)	Sediment Bed Chemistry Model Initialization	Electronic Data Provided to US EPA by Study Contractor
Bight 03 – Sediment chemistry data (2003)	Sediment Bed Chemistry Model Initialization	Electronic Data Provided by SCCWRP
POLA/POLB – Sediment chemistry data (2006)	Sediment Bed Chemistry Model Initialization	Electronic Data Provided to US EPA by Study Contractor
POLA/POLB – Overlying water chemistry data (2006)	Water Column Chemistry Calibration	Electronic Data Provided to US EPA by Study Contractor
POLA/POLB – Mid-column water chemistry data at POLB stations (2006)	Water Column Chemistry Calibration	Electronic Data Provided to US EPA by Study Contractor
POLA - Mid-column water chemistry data at POLA stations (2005)	Water Column Chemistry Calibration	Electronic Data Provided to US EPA by Port of Los Angeles

4. Model Configuration

The following subsections outline the steps conducted to configure the EFDC hydrodynamic model.

4.1. Model Grid System

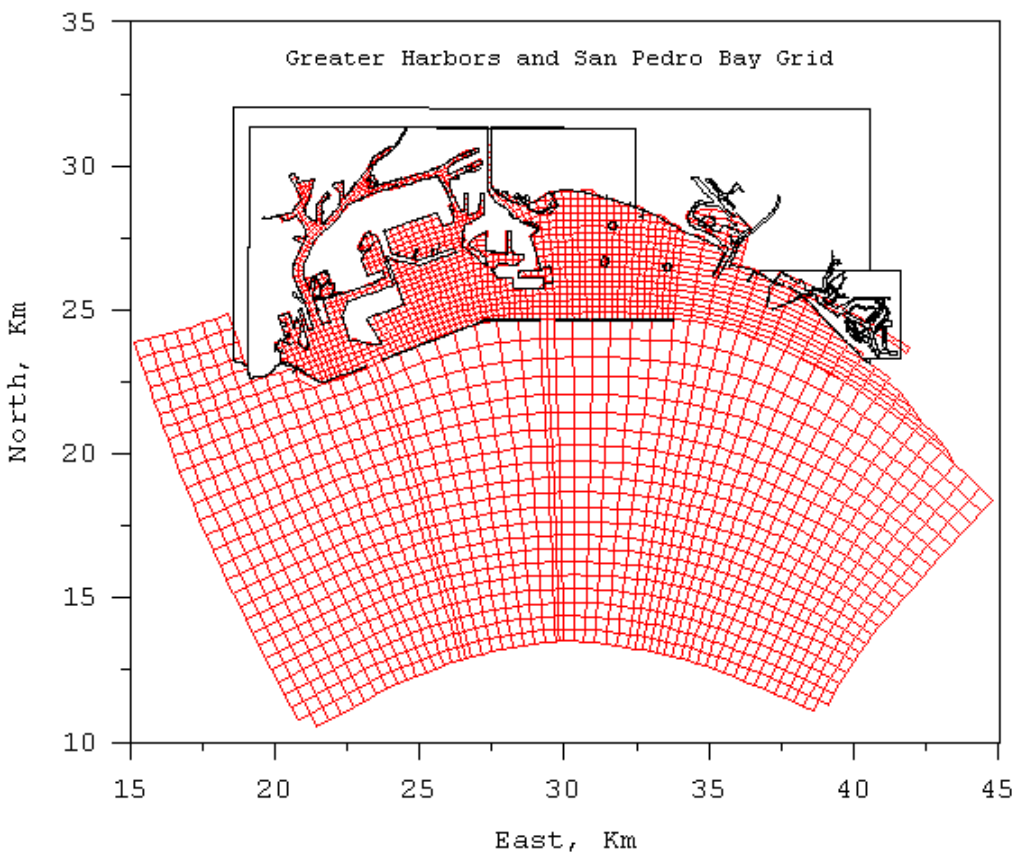
A multi-resolution, curvilinear spatial grid of the greater LA/LB Harbor waters and San Pedro Bay was constructed using the using the Visual Orthogonal Grid Generation (VOGG) grid generation system (Tetra Tech, 2002). Shoreline boundaries for the grid were based on the NOAA/NOS electronic navigation charts in GIS format. The grid and shoreline, with the exception of the Dominguez Channel area, are shown in Figure 1. The Dominguez Channel grid from a previous study was incorporated into the model (Everest, 2006). The grid system uses a multi-domain mapping, unique to the EFDC model, which allow a course resolution outside the breakwater in San Pedro Bay and a finer resolution in the harbors system. The individual grid cell sizes varied; however, the cells in the eastern portion of San Pedro Bay were 2-3 times the size as those within the harbors system, while the cells outside the breakwater were even larger. The grid has 2,568 horizontal cells. In the vertical, the number of sigma layers is readily changed to allow for use of an optimum number of layers to represent hydrodynamic and transport processes. For this study four vertical layers were used. While a grid is used to represent the LA/LB Harbor waters, it is important to note that the grid is not modeled as a closed system. Specifically, water, sediment, and associated pollutant loads can be exchanged both in and out of the model grid through the open ocean boundary.

4.2. Bathymetry and Topography

Bathymetric data were interpolated on to the model grid using an average of the bathymetric data points falling within a cell. The primary bathymetric data set used was the NOAA High Resolution Coastal Relief Data, which has a horizontal resolution of approximately 90 meters. This dataset was supplemented by recent bathymetric data provided by the Port of Los Angeles. Additional bathymetry adjustments were made by visual comparison of gridded bathymetry with NOAA/NOS electronic navigation charts. Model bathymetry is shown in Figure 2.

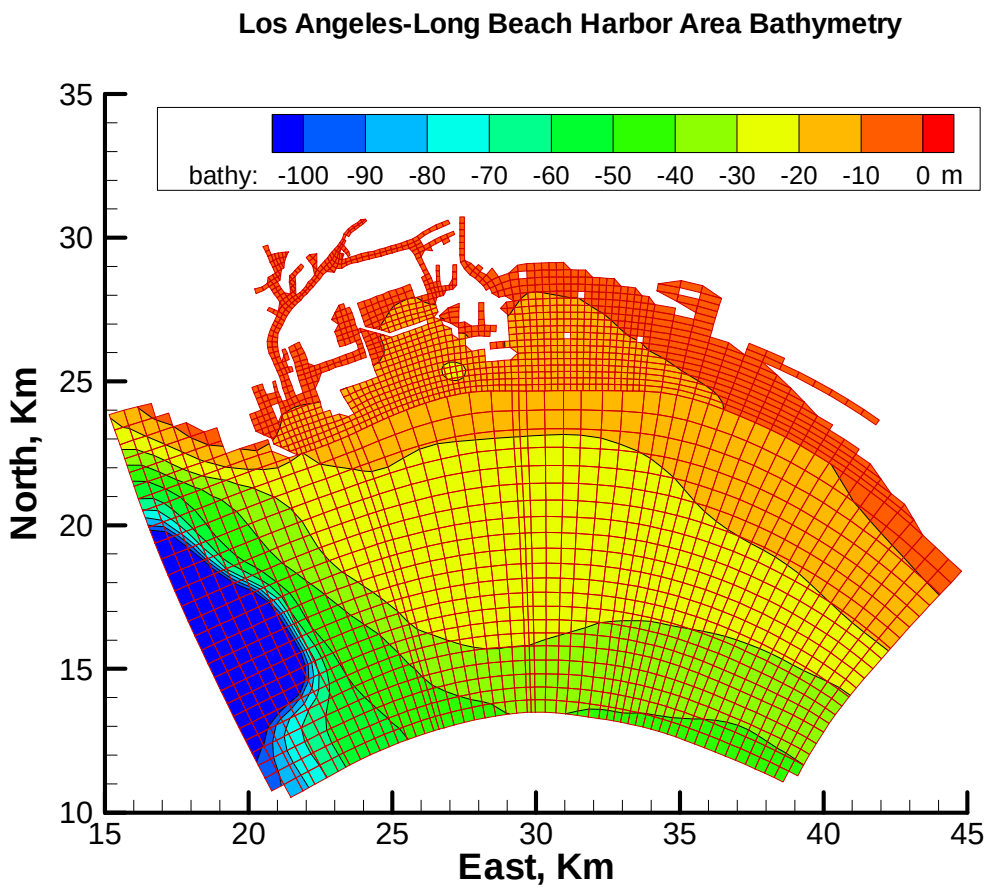
4.3. Selection of Temporal Simulation Period

The hydrodynamic and transport model was configured for a four-year historical simulation period from January 2002 through December 2005, since this period encompasses the greatest density of observational data for model calibration.



Note: The portion of the grid in Dominguez Channel extending to Vermont Avenue is not shown. The grid for this area was represented by a previous study (Everest, 2006).

Figure 1. Greater LA/LB Harbor waters and San Pedro Bay grid



Note: Elevation in meters relative to local mean sea level.

Figure 2. Los Angeles-Long Beach Harbor area bathymetry

4.4. Open Boundary Hydrodynamic Forcing

Circulation in the greater LA/LB Harbor waters is forced by water surface elevation and transport along the grid boundaries in San Pedro Bay. The hydrodynamic boundary condition used along the three open boundaries is a radiation separation condition of the form

$$\zeta - \frac{\mathbf{n} \cdot \mathbf{u} H}{\sqrt{gH}} = 2\zeta_R \qquad (1)$$

where ζ is the water surface elevation relative to a sea-level data, **n** is the outward normal vector to the boundary, **u** is the horizontal barotropic velocity vector, H is the water depth, and ζ_R is the equivalent progressive wave amplitude.

Along the open boundaries, the water surface elevation is composed of periodic tidal components and a transient or low frequency component in the sub-tidal frequency spectrum. The equivalent incoming wave boundary condition (1) was specified as the sum of a low frequency component and harmonic components, described by equation (2):

$$\zeta_R = \zeta_{LF} + \sum_{m=1}^{M} \left(\zeta_{RCm} \cos(\omega_m t) + \zeta_{RSm} \sin(\omega_m t) \right) \qquad (2)$$

where M is the number of tidal constituents, ζ_{RCm} and ζ_{RSm} are cosine and sine amplitudes at frequency ω_m. Six harmonics constituents (M2, S2, N2, K1, O1, and P1) were used. Since observational data were not available along the open boundaries, the tidal frequency components of the incoming wave open boundary condition were estimated by an optimization based inverse procedure to obtain a best fit prediction of water surface elevation and current meter observations within the model domain shown in Figure 3.

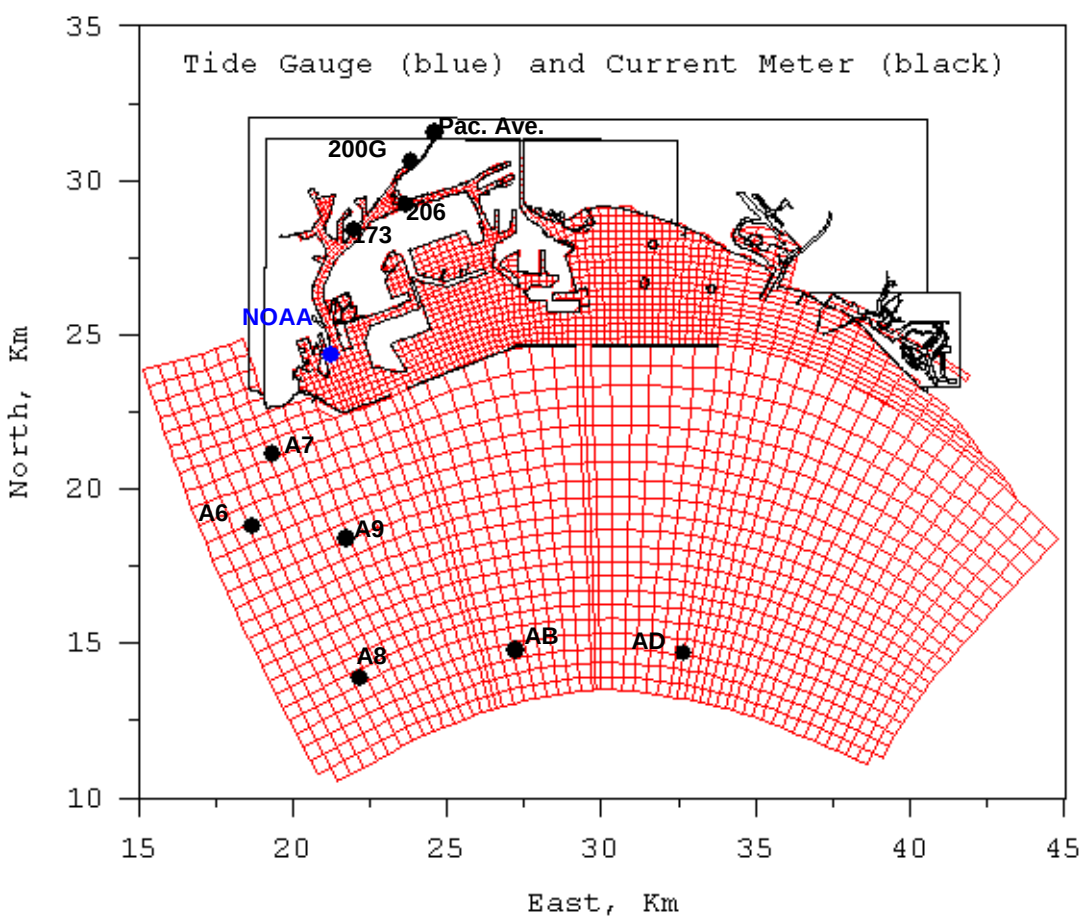


Figure 3. Location of Tide Gauge (blue) and Current Meters (black)

4.5. Salinity Open Boundary Conditions

Salinity open boundary conditions were specified as spatially constant and temporally varying along the open boundary. There is no significant variation in off shore salinity in San Pedro Bay based on a review of available data. Figure 7 (in Section 6.1) illustrates the Bight 03 salinity sampling stations in San Pedro Bay, which were reviewed to represent the open boundary condition. Salinity did not vary significantly between these stations, thus a constant salinity boundary condition was used. Because the salinity did not vary at these stations, they were used to help identify the constant boundary condition and no adjustment factors were calibrated to represent the salinity open boundary condition. It is important to note that these stations were not used for subsequent salinity calibration (Figure 6 in Section 6.1 illustrates the interior stations used for salinity calibration, which do not include the Bight 03 stations in San Pedro Bay).

4.6. Wind and Atmospheric Forcing

Wind speed and direction and atmospheric thermal conditions including air temperature, relative humidity, rainfall, solar short wave radiation, and cloud cover data were obtained from the NOAA National Climate Data Center for Los Angeles International Airport (LAX). These data were supplemented by California Irrigation Management Information System observational data for Long Beach and Santa Monica and NOAA National Data Buoy Center observational data for off shore stations 46025 and 46086. Wind data from the seven NOAA Ports observational sites for Los Angeles and Long Beach Harbors was also utilized for October 2004 through April 2005. The resulting model wind forcing is a spatially variable weighted average taking into account regional topographic conditions except for the period between October 2004 and April 2005 when the spatially variable Ports wind data is used. LAX wind data were used to represent modeling periods before and after these dates. The atmospheric thermal forcing is spatially uniform and based on a composite of the various data sets.

4.7. Fresh Water Inflow

Fresh water inflow along the boundaries of the model domain is introduced for Dominguez Channel, the Los Angeles River, and the San Gabriel River. For the Los Angeles River, observed inflows data provided by the Los Angeles County Department of Public Works were used (Figure 4). Hourly observed flows were preferentially used during periods when they were available. For Dominguez Channel and the San Gabriel River, hourly watershed model output was used (Tetra Tech, 2010). Terminal Island Treatment Plant Discharges, provided by the City of Los Angeles, were introduced into the interior model grid cell at the corresponding diffuser location. Non-point source freshwater inflows corresponding to 67 local near shore watersheds were based on daily model

output from the LSPC watershed model (Tetra Tech, 2010). Daily output rather than hourly output were used for the nearshore areas to reduce the size for the 67 time series files since the overall loading associated with the nearshore watersheds is significantly smaller than the Los Angeles River, San Gabriel River, and Dominguez Channel watersheds.

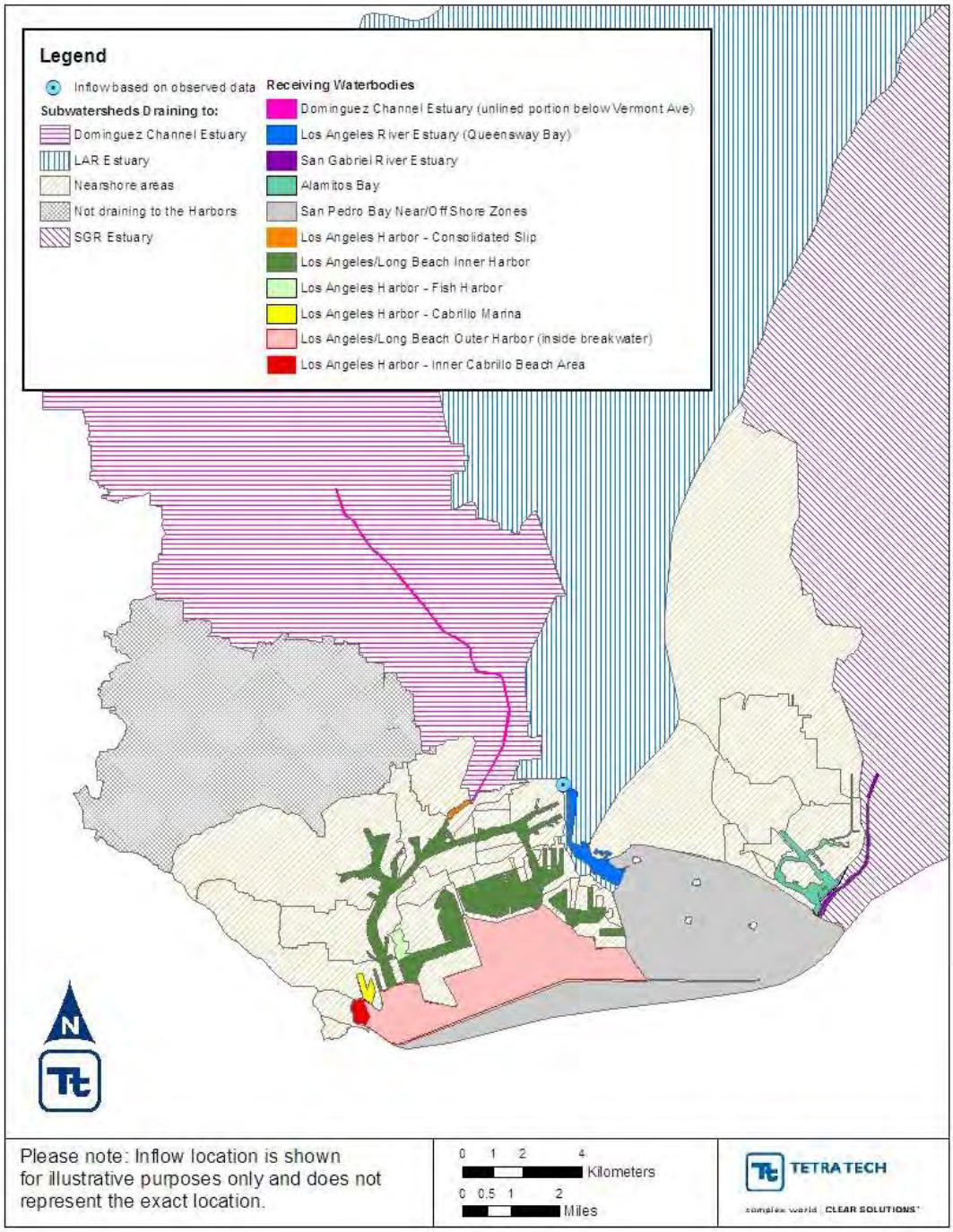


Figure 4. Watershed areas draining to the greater LA/LB Harbor waters

5. Hydrodynamic Calibration

Hydrodynamic model calibration involved the adjustment of open boundary forcing, bottom roughness, and bottom elevations to obtain a general best agreement between model predictions and observations of water surface elevation and horizontal currents. Quantitative evaluation of the hydrodynamic calibration is based on comparison of observed and model predicted harmonic amplitudes and phases of tidal water surface elevation and currents and time series error analysis of observed and low frequency water surface elevation. The following subsections summarize the steps followed in the calibration process.

5.1. Tidal Frequency Water Surface Elevation

Tidal frequency water surface elevation calibration is based on comparison of observed and model predicted tidal constituent amplitudes and phases at the NOAA Los Angeles Harbor tide gauge shown in Figure 3 and water surface elevation records at four Los Angeles inner harbor current meter stations also shown in Figure 3. The comparison of observed and predicted tidal constituent harmonic amplitudes and phases for tidal components of water surface elevation are considered more rigorous than visual time series comparisons. Since the harmonic amplitudes and phases are time invariant, the model simulation period and the observation period do not have to be the same. Likewise small discrepancies in time origin between the observed and model predicted data, which can result in large errors in the time domain, do not influence harmonic comparison which is a frequency domain technique.

The parameters that were calibrated for tidal elevation and velocity were the amplitude and phase of the incoming tidal constituent waves along the open boundary. The amplitude and phase along the three open boundaries were determined using a proprietary optimization procedure to minimize the difference between the observed and predicted complex amplitudes (cosine and sine amplitudes).

Comparisons of amplitude and phase are shown in Tables 3-7 for the five stations (NOAA plus four inner harbor current meter stations). Specifically, for the NOAA gauge (Table 3) three of the six constituents have normalized amplitude errors less than 1 percent (0.01). Absolute phase error for the dominant M2 constituent is just over 1 minute. Agreement between observed and predicted constituent amplitudes and phases is reasonably good for inner harbor stations 206B (Table 4) 173 (Table 5, and 200G (Table 6),), which also indicates that there is little change in amplitude and phase throughout the system consistent with previous model study findings. For the Pacific Avenue station in Dominguez Channel (Table 7), the amplitude and phase errors are large for all constituents. The disagreement at Pacific Avenue (Table 7) is likely due to a large number of default entries in the data records. As will be shown in Section

5.3, model comparison with current meter data at these two stations is more reasonable. Figures 5 and 6 show visual comparisons of tidal frequency water surface elevation at the NOAA Gauge and Station 200G.

Table 3. Water Surface Elevation Tidal Constituents Comparison at NOAA Gauge

Tidal Constituent	Observed Amplitude (meters)	Modeled Amplitude (meters)	Amplitude Error (|Observed-Modeled|/Observed)	Observed Phase (seconds)	Modeled Phase (seconds)	Phase Error (Seconds)
M2	0.503	0.505	0.004	27434	27498	64
S2	0.203	0.202	0.005	31335	31149	186
N2	0.119	0.119	0.000	31824	31657	167
K1	0.371	0.364	0.019	19854	19095	759
O1	0.246	0.240	0.024	7829	7082	747
P1	0.107	0.102	0.047	22894	26560	3666

Table 4. Water Surface Elevation Tidal Constituents Comparison at 206B Gauge

Tidal Constituent	Observed Amplitude (meters)	Modeled Amplitude (meters)	Amplitude Error (|Observed-Modeled|/Observed)	Observed Phase (seconds)	Modeled Phase (seconds)	Phase Error (Seconds)
M2	0.500	0.508	0.016	27273	27489	216
S2	0.219	0.204	0.068	31102	31123	21
N2	0.120	0.119	0.008	31436	31664	228
K1	0.380	0.366	0.037	18958	19214	256
O1	0.254	0.241	0.051	8891	7136	1755
P1	0.102	0.103	0.010	22507	26241	3734

Table 5. Water Surface Elevation Tidal Constituents Comparison at 173 (Data File Borx) Gauge

Tidal Constituent	Observed Amplitude (meters)	Modeled Amplitude (meters)	Amplitude Error (|Observed-Modeled|/Observed)	Observed Phase (seconds)	Modeled Phase (seconds)	Phase Error (Seconds)
M2	0.575	0.508	0.116	27065	27502	437
S2	0.250	0.203	0.188	31921	31127	794
N2	0.135	0.119	0.118	32390	31667	723
K1	0.400	0.366	0.085	18089	19217	1128
O1	0.303	0.241	0.204	9299	7136	2163
P1	0.086	0.103	0.197	23452	26229	2777

Table 6. Water Surface Elevation Tidal Constituents Comparison at 200G (Data file Barg) Gauge

Tidal Constituent	Observed Amplitude (meters)	Modeled Amplitude (meters)	Amplitude Error (|Observed-Modeled|/Observed)	Observed Phase (seconds)	Modeled Phase (seconds)	Phase Error (Seconds)
M2	0.563	0.508	0.097	27773	27503	270
S2	0.266	0.204	0.233	31119	31129	10
N2	0.151	0.119	0.212	31478	31670	192
K1	0.454	0.366	0.194	14209	19217	5008
O1	0.300	0.241	0.197	6443	7138	695
P1	0.067	0.103	0.537	27921	26251	1670

Table 7. Water Surface Elevation Tidal Constituents Comparison at DC Pacific Avenue Gauge

Tidal Constituent	Observed Amplitude (meters)	Modeled Amplitude (meters)	Amplitude Error (|Observed-Modeled|/Observed)	Observed Phase (seconds)	Modeled Phase (seconds)	Phase Error (Seconds)
M2	0.897	0.510	0.431	39765	27705	12060
S2	0.378	0.204	0.460	18710	31333	12623
N2	0.245	0.119	0.510	44224	31909	12315
K1	0.361	0.370	0.025	39878	19428	20450
O1	0.225	0.242	0.076	30302	7349	22953
P1	0.148	0.102	0.310	45411	26159	19252

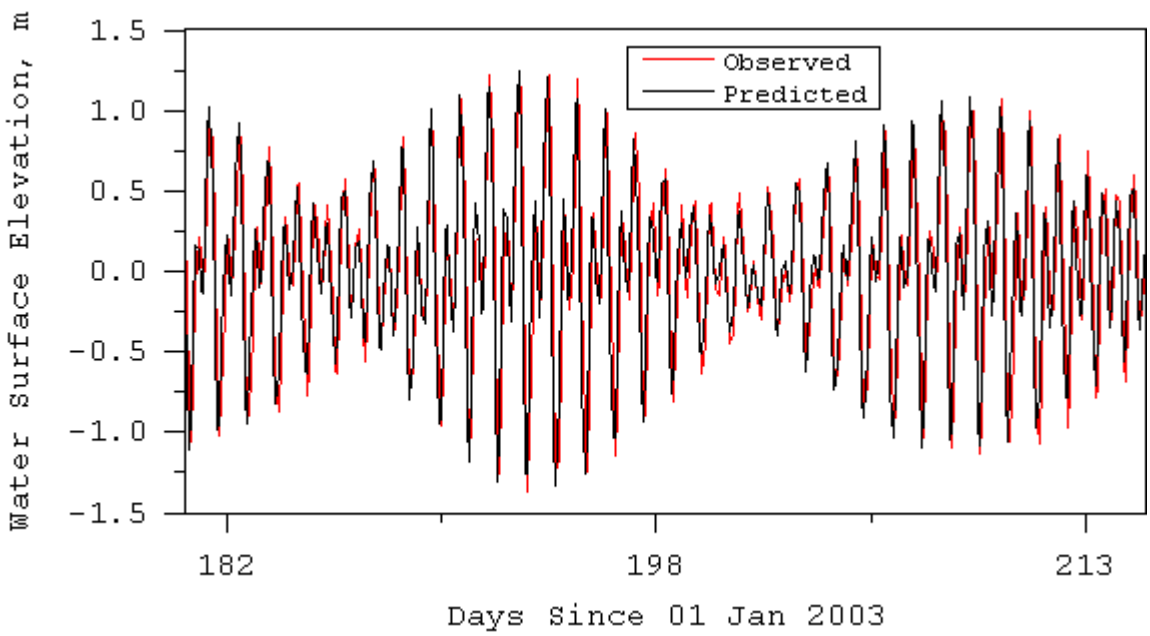


Figure 5. Tidal frequency sea level comparison at NOAA tide gauge in Los Angeles Harbor

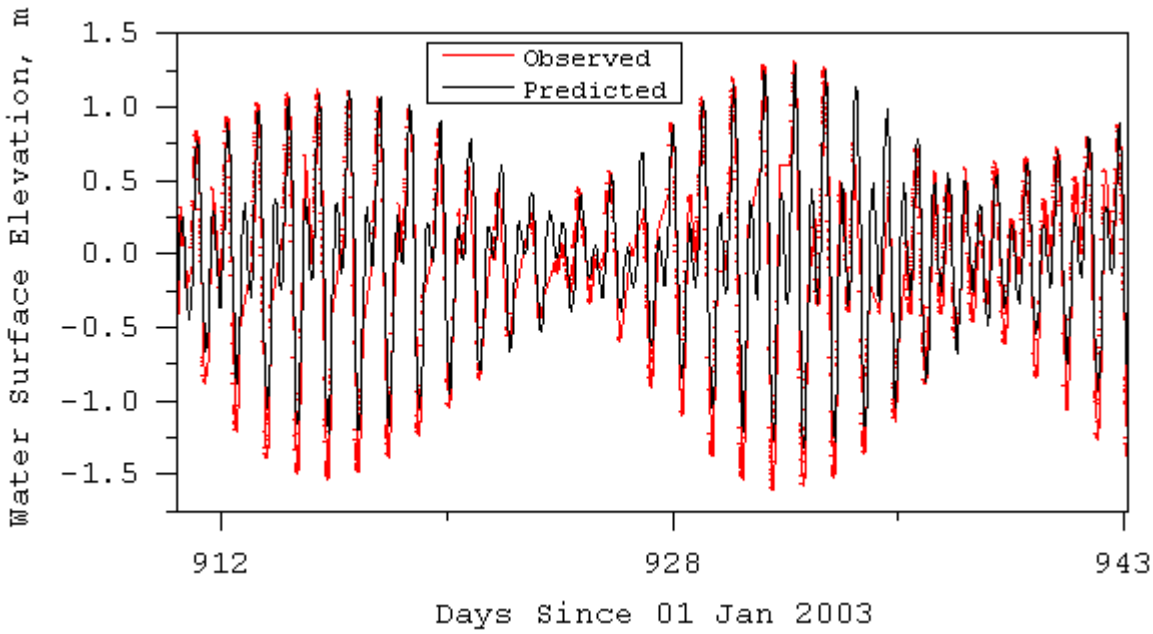


Figure 6. Tidal frequency sea level comparison at LA Harbor-Dominguez Channel station 200G.

5.2. Low Frequency Water Surface Elevation

Low frequency or sub-tidal water surface elevation in the greater LA/LB Harbor waters responds to low-frequency sea level variability in San Pedro Bay with negligible amplitude and phase variation. Figure 7 shows a comparison of model predicted and observed low frequency sea level at the Los Angeles Harbor NOAA Tide Gauge. Time series error analyses for the observed and predicted low frequency sea level are summarized in Table 8. These, and other, model performance measures are described in Appendix B.

Table 8. Instantaneous and Low Frequency Water Surface Elevation Statistical Comparison at NOAA Gauge

Statistical Measure	Instantaneous	Low Frequency
Mean Error (meters)	0.001	0.001
Absolute Mean Error (meters)	0.122	0.003
Maximum Absolute Error (meters)	0.670	0.047
RMS Error (meters)	0.168	0.004
RMS Error/RMS Observed	0.324	0.058
Linear Regression Intercept (meters)	0.001	0.001
Linear Regression Slope	0.959	0.993
Correlation Coefficient	0.986	0.997
Skill (0 to 1, 1 being perfect)	0.973	0.999

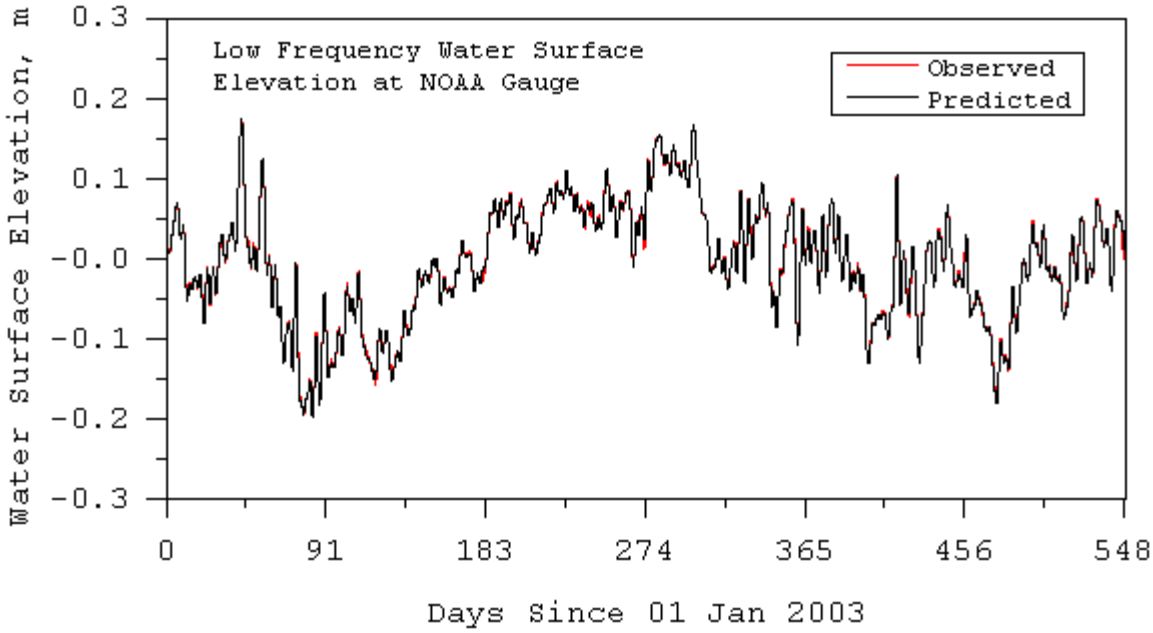


Figure 7. Low frequency sea level comparison at NOAA tide gauge in Los Angeles Harbor

5.3. Tidal Frequency Currents

Horizontal current comparisons using the tidal ellipse form of vector harmonic analysis were made for four current meter deployments during the Dominguez Channel study and six current meters deployed in San Pedro Bay (Science Applications International Corp., 2004). Results for these comparisons are provided in Tables 9-20. The ellipse form of vector least squares harmonic analysis is particularly useful in that the comparison of major axis amplitudes is insensitive to errors in current direction as well as time origin discrepancies.

Table 9 through Table 14 summarize the comparison of horizontal tidal current major axis amplitudes, phases, and orientation angles at six Palos Verde Shelf current meter locations for the six primary tidal constituents. The locations correspond to the six current meter locations outside the breakwater shown in Figure 3. Both the absolute quantitative agreement between the observations and model predictions and the qualitative agreement are reasonably good in that current magnitudes are similar and phases are consistent. Predicted major axis orientations are generally good having angular errors of less than 20 degrees.

Tables 15 through 20 summarize the comparison of horizontal tidal current major axis amplitudes, phases, and orientation angles at the four Los Angeles Inner Harbor current meter locations shown in Figure 3. Tidal currents are weak at the 173, 200G, and 206B stations and on the order of 2 cm/sec or less for all constituents. However, the model predicted major axis amplitudes and phases compare reasonably well at these three stations and directions. The Pacific

Avenue station in Dominguez Channel has much stronger currents and the model predicted major axis amplitudes, phase, and directions compare well with the observations. The strong agreement between model predicted currents at the Pacific Avenue station tends to support the conclusion that water surface elevation observations at this station are compromised. Figures 8 through 11 compare the observed and predicted tidal frequency currents along the principal axis of the current oscillation. The agreement is generally good and differences can be attributed to lateral averaging effects of the across channel looking ADCP observations and the depth average model predictions.

Table 9. Horizontal Current M2 Major Axis Amplitude, Orientation and Phase Comparison at Palo Verde Shelf Current Meter Stations

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
PV A6	0.053	0.023	9126	8091	160	170
PV A7	0.096	0.047	10840	9709	179	180
PV A8	0.047	0.060	5084	4326	145	152
PV A9	0.069	0.059	7843	9190	171	15 (195)
PV AB	0.053	0.077	2731	5080	141	161
PV AD	0.052	0.050	21788	3125	126	117

Table 10. Horizontal Current S2 Major Axis Amplitude, Orientation and Phase Comparison at Palo Verde Shelf Current Meter Stations

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
PV A6	0.027	0.014	17329	17372	175	178
PV A7	0.050	0.028	18703	17986	2	0
PV A8	0.024	0.031	13561	14130	131	155
PV A9	0.032	0.033	16132	17200	174	15 (195)
PV AB	0.028	0.043	10211	14209	151	169
PV AD	0.021	0.022	7372	12358	136	127

Table 11. Horizontal Current N2 Major Axis Amplitude, Orientation and Phase Comparison at Palo Verde Shelf Current Meter Stations

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
PV A6	0.012	0.007	14608	12120	166	166
PV A7	0.025	0.013	14521	13794	0 (180)	179
PV A8	0.009	0.017	8373	8419	121	155
PV A9	0.016	0.015	12077	13427	152	15
PV AB	0.012	0.021	6201	9430	145	162
PV AD	0.012	0.013	827	8026	105	112

Table 12. Horizontal Current K1 Major Axis Amplitude, Orientation and Phase Comparison at Palo Verde Shelf Current Meter Stations

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
PV A6	0.034	0.024	4924	7573	129	82
PV A7	0.048	0.031	42864	32391	162	4 (184)
PV A8	0.032	0.056	2027	11750	104	152
PV A9	0.046	0.056	2086	29650	131	17
PV AB	0.036	0.058	39852	19312	125	154
PV AD	0.031	0.043	42692	42053	141	21

Table 13. Horizontal Current O1 Major Axis Amplitude, Orientation and Phase Comparison at Palo Verde Shelf Current Meter Stations

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
PV A6	0.026	0.019	37240	40430	143	74
PV A7	0.034	0.022	38133	22097	170	3 (183)
PV A8	0.014	0.036	39197	91780	110	154
PV A9	0.025	0.040	36670	17039	149	16
PV AB	0.018	0.039	34854	6872	138	152
PV AD	0.017	0.027	33163	26160	140	0 (180)

Table 14. Horizontal Current P1 Major Axis Amplitude, Orientation and Phase Comparison at Palo Verde Shelf Current Meter Stations

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
PV A6	0.006	0.007	6472	15643	116	77
PV A7	0.005	0.009	3839	39296	112	0 (180)
PV A8	0.008	0.015	42175	19610	134	153
PV A9	0.007	0.015	41014	36314	39	16
PV AB	0.010	0.017	39484	26896	51	153
PV AD	0.010	0.012	1007	3990	99	13

Table 15. Horizontal Current M2 Major Axis Amplitude, Orientation and Phase Comparison at Los Angeles Inner Harbor Current Meter Stations

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
206 B	0.021	0.017	19382	21780	1	14
200G	0.023	0.019	15881	14407	57	29
173	0.020	0.026	10989	12645	59	53
DC PA	0.365	0.317	17542	17306	64	60

Table 16. Horizontal Current S2 Major Axis Amplitude, Orientation and Phase Comparison at Los Angeles Inner Harbor Current Meter Stations

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
206 B	0.005	0.007	2543	6861	4	14
200G	0.010	0.008	20890	17170	54	26
173	0.008	0.014	19476	16920	60	53
DC PA	0.156	0.119	21958	21340	64	60

Table 17. Horizontal Current N2 Major Axis Amplitude, Orientation and Phase Comparison at Los Angeles Inner Harbor Current Meter Stations

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
206 B	0.005	0.004	21792	25047	7	14
200G	0.004	0.004	22337	18580	54	26
173	0.005	0.006	15018	16930	62	53
DC PA	0.082	0.072	22027	21350	64	60

Table 18. Horizontal Current K1 Major Axis Amplitude, Orientation and Phase Comparison at Los Angeles Inner Harbor Current Meter Stations

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
206B	0.008	0.004	42848	27923	1	14
200G	0.008	0.005	468	24060	61	29
173	0.002	0.014	1353	38330	62	52
DC PA	0.138	0.125	41512	40890	64	60

Table 19. Horizontal Current O1 Major Axis Amplitude, Orientation and Phase Comparison at Los Angeles Inner Harbor Current Meter Stations

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
206B	0.007	0.004	27528	39638	-2	14
200G	0.004	0.006	32331	9203	66	26
173	0.002	0.006	38429	20710	60	53
DC PA	0.086	0.075	32783	31020	63	60

Table 20. Horizontal Current P1 Major Axis Amplitude, Orientation and Phase Comparison at Los Angeles Inner Harbor Current Meter Stations

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
206B	0.005	0.005	15789	24410	-4	14
200G	0.003	0.001	3300	8369	54	26
173	0.003	0.007	28868	37500	65	53
DC PA	0.004	0.025	2950	3126	61	60

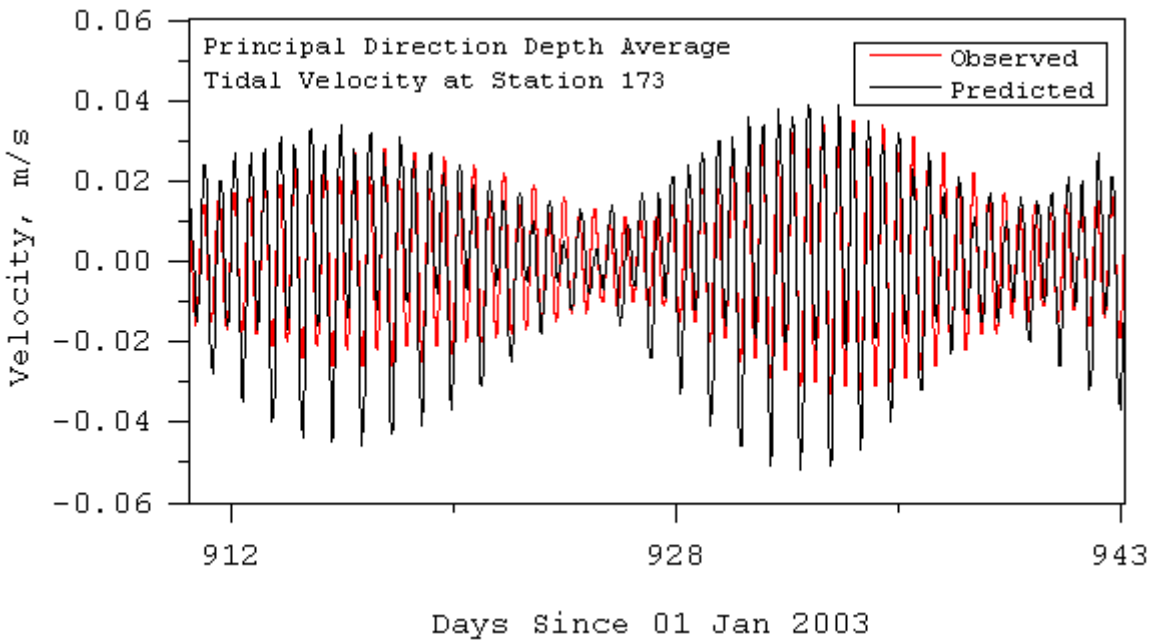


Figure 8. Comparison of principal direction, depth averaged tidal frequency current comparison at station 173

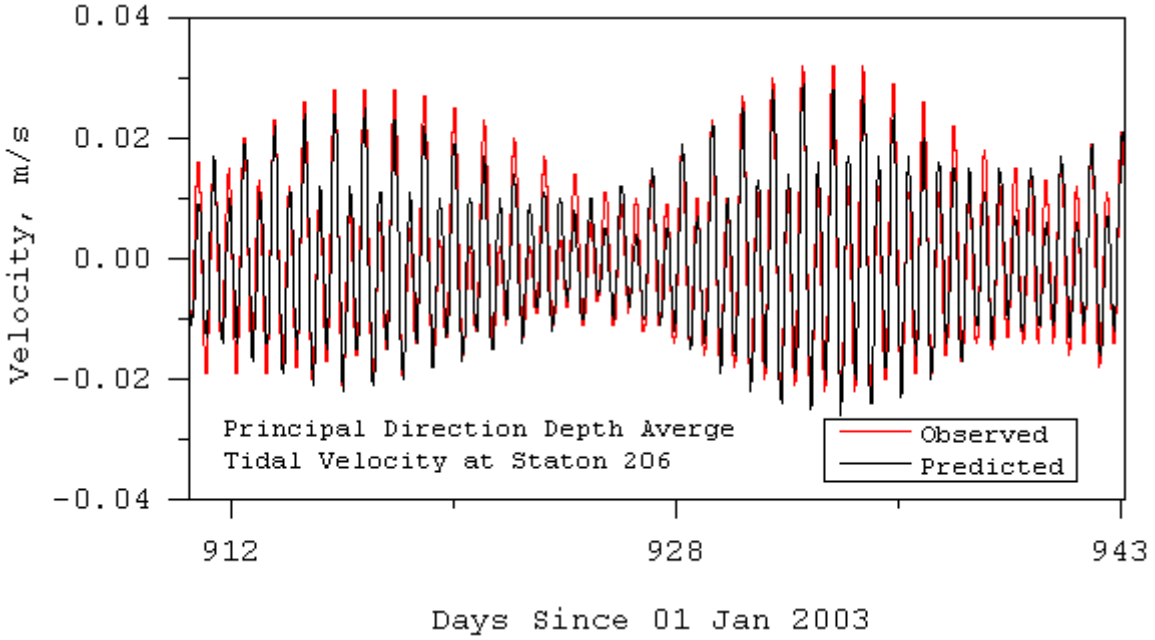


Figure 9. Comparison of principal direction, depth averaged tidal frequency current comparison at station 206B

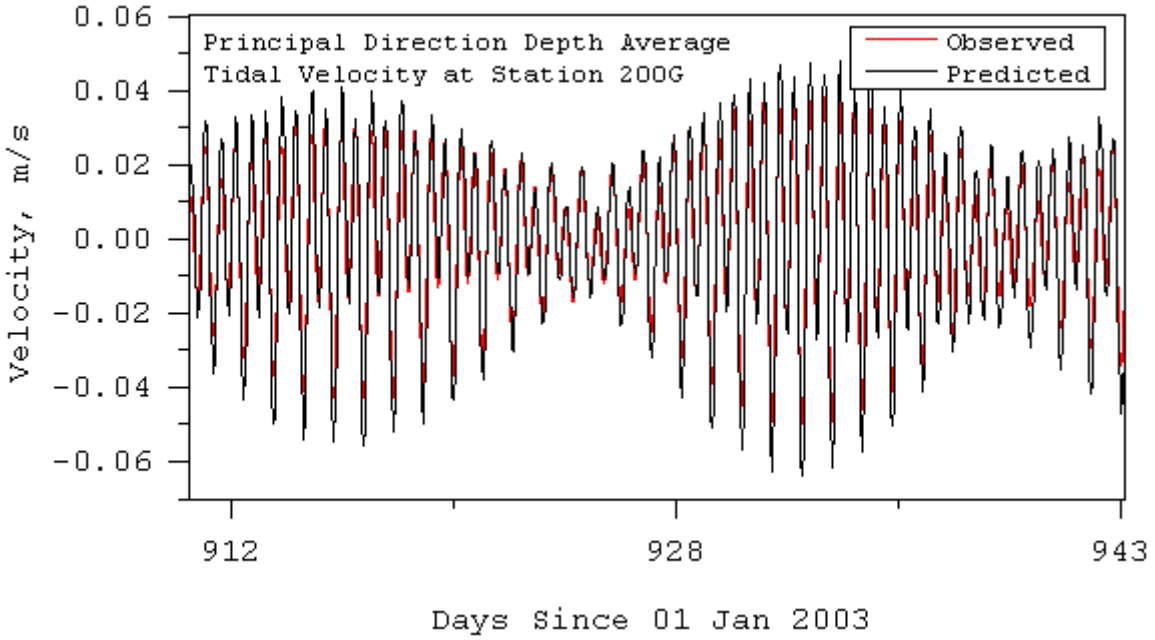


Figure 10. Comparison of principal direction, depth averaged tidal frequency current comparison at station 200G

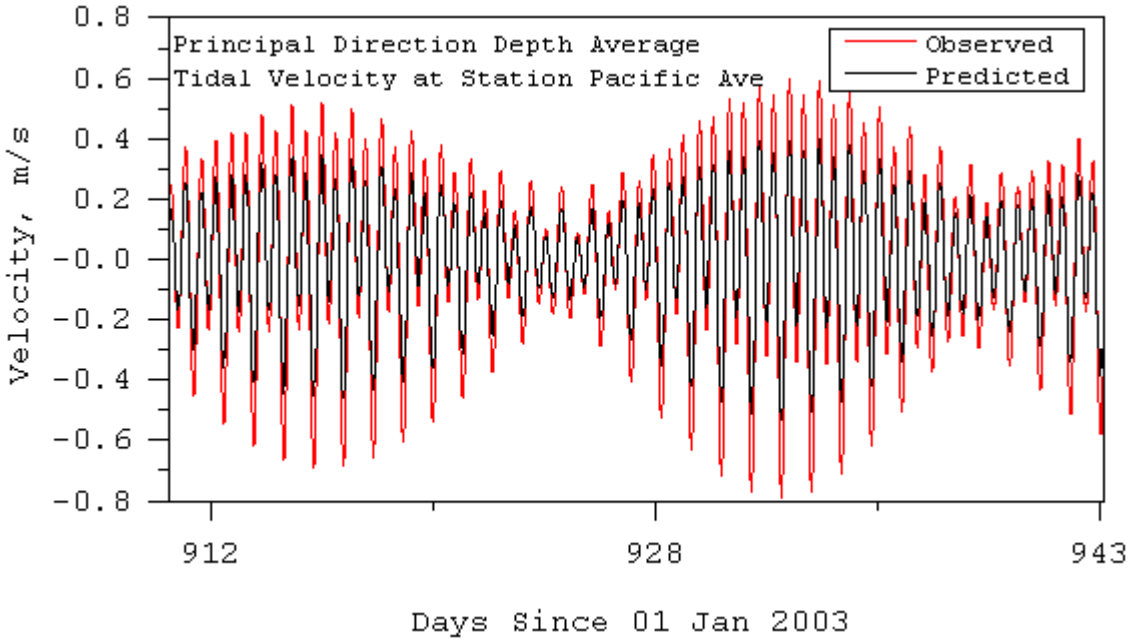


Figure 11. Comparison of principal direction, depth averaged tidal frequency current comparison at station Pacific Avenue

6. Transport Calibration

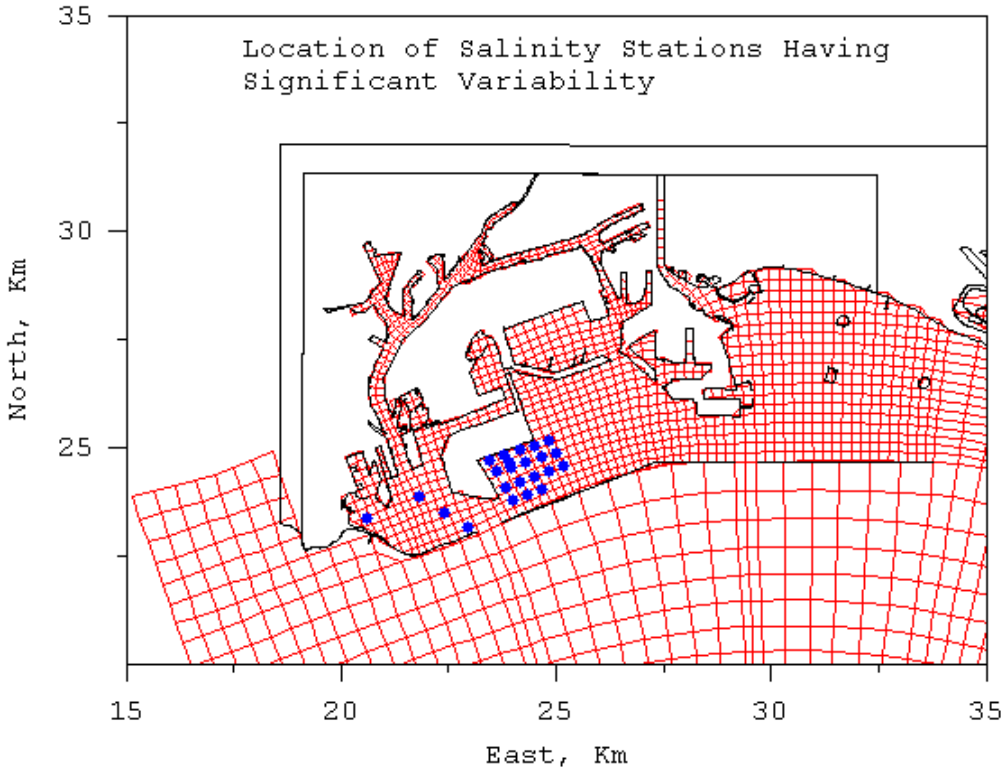
Transport calibration involves the quantitative comparison of model predicted and observed concentrations of dissolved and suspended material in the water column. For freshwater influenced estuarine and coastal waterbodies, salinity transport calibration provides an additional level of confidence in model predictive ability, particularly in the absence of extensive current meter observations. Model prediction of temperature is generally more sensitive to wind and atmospheric thermal forcing rather than hydrodynamic transport, the exception being situations that have large thermal loads from power plants. In the absence of significant salinity variability, simulation of other tracers, including dye, is also an important means of transport calibration. This section presents the results of model calibration for salinity. Temperature simulation is typically not conducted for modeling applications directed at simulating sediment and contaminant transport and fate, unless temperature stratification and thermal buoyancy induced current contribute significantly to transport processes. Evaluation of temperature observations in the greater LA/LB Harbor waters indicates that this is not the case and temperature is not simulated. Model configuration and calibration for sediment and adsorptive contaminant transport calibration are presented in sections 7 and 8, respectively.

6.1. Salinity Calibration

Salinity calibration involves the adjustment of salinity open boundary conditions and possibly freshwater inflows if there is significant uncertainty associated with the inflows. Although there are approximately120 salinity monitoring stations, only 20 of those stations, whose locations are shown in Figure 12, have significant salinity variability (when the salinity is significantly less than the 32 to 34 ppt level characteristic of the greater LA/LB Harbor waters). Bight 03 event stations in San Pedro Bay (Figure 13) did not show salinity variations significant enough for comparison with model predictions. Figure 14 shows a scatter plot comparing predicted and observed data for the 20 station locations shown in Figure 12 for four sampling times from December 2004 to March 2005. The surface and bottom notation corresponds to averages over the upper and lower halves of the water column. Predicted salinities over the lower half of the water column agree reasonably well with observations although there are clusters of over and under prediction. Predicted salinities for the upper half of the water column agree reasonably well at most stations (Figure 14) although the model tends to under predict surface salinity which the exception of a number of stations having over prediction. The solid lines in Figure 14 represent linear regression fits. The lower range of variability of the bottom values yields a slope that is overly influenced by extreme values. The fit for the surface values yields a near unity slope.

To examine the effect using the spatially varying NOAA Ports wind during the December 2004 to March 2005 period, a second simulation was conducted using LAX wind for the same period with the results shown in Figure 15. These results are also reasonable although the fitted slope of the surface values is further from unity. The results do suggest that the LAX wind is a reasonable alternative for use during periods when the NOAA Ports wind observations are not available. In summary, when available NOAA Ports wind data were used in the model (November 2004 to April 2005); however, to conduct longer-term simulations for dates without the Ports data, LAX wind data were used (i.e., to address the periods January 2002 through October 2004 and May 2005 through December 2005).

Due to the extreme scatter of the data, lumped error statistics are not particularly meaningful. The salinity response of the model is better represented by time series plots of continuous model simulations of salinity observations at each of the twenty stations. These plots correspond to the comparison in Figure 14 and are presented in Figures A-1 through A-20 of Appendix A. Although point wise agreement is not always good, the model does represent the general response to the high freshwater inflow events represented by the observations. The model tends to predict observed stratification reasonably well in response to high inflow events during the seven-month simulation period.



Note: Stations illustrated are where the salinity during the simulation period is significantly less than the 32 to 33 ppt level characteristic of the greater LA/LB Harbor waters.

Figure 12. Location of salinity stations having significant variability

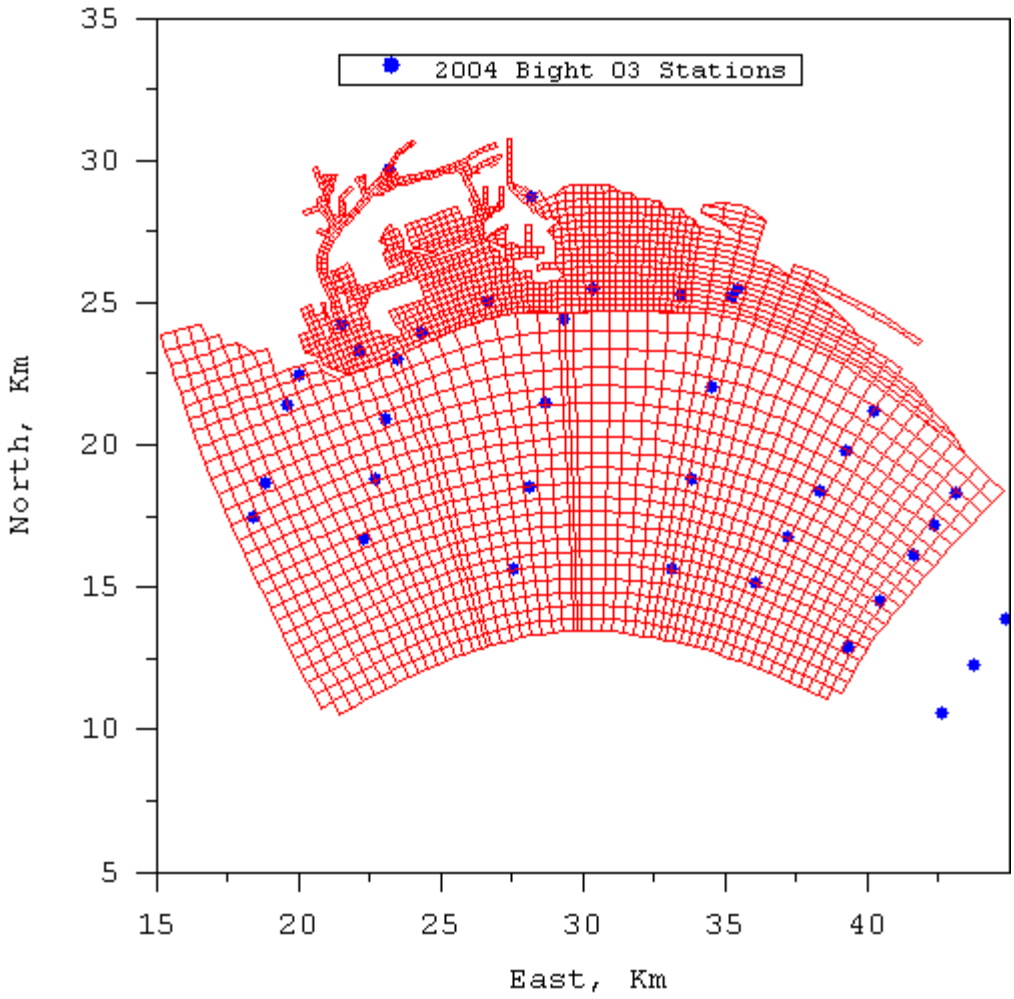


Figure 13. Location of Bight 03 salinity sampling stations

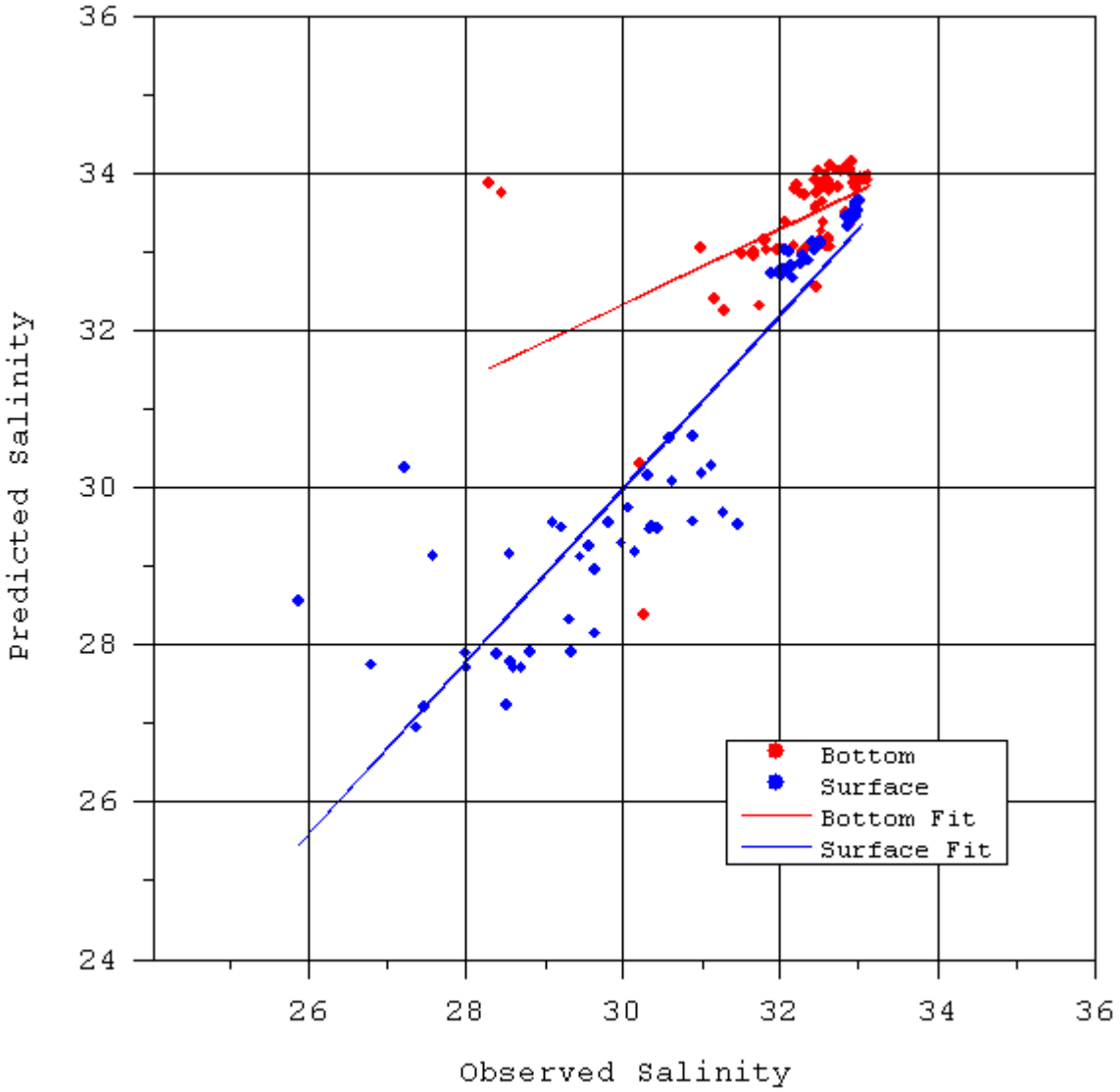


Figure 14. Comparison of predicted and observed salinity at 20 stations for four sampling times during the December 2004 to March 2005 period using NOAA Port wind fields

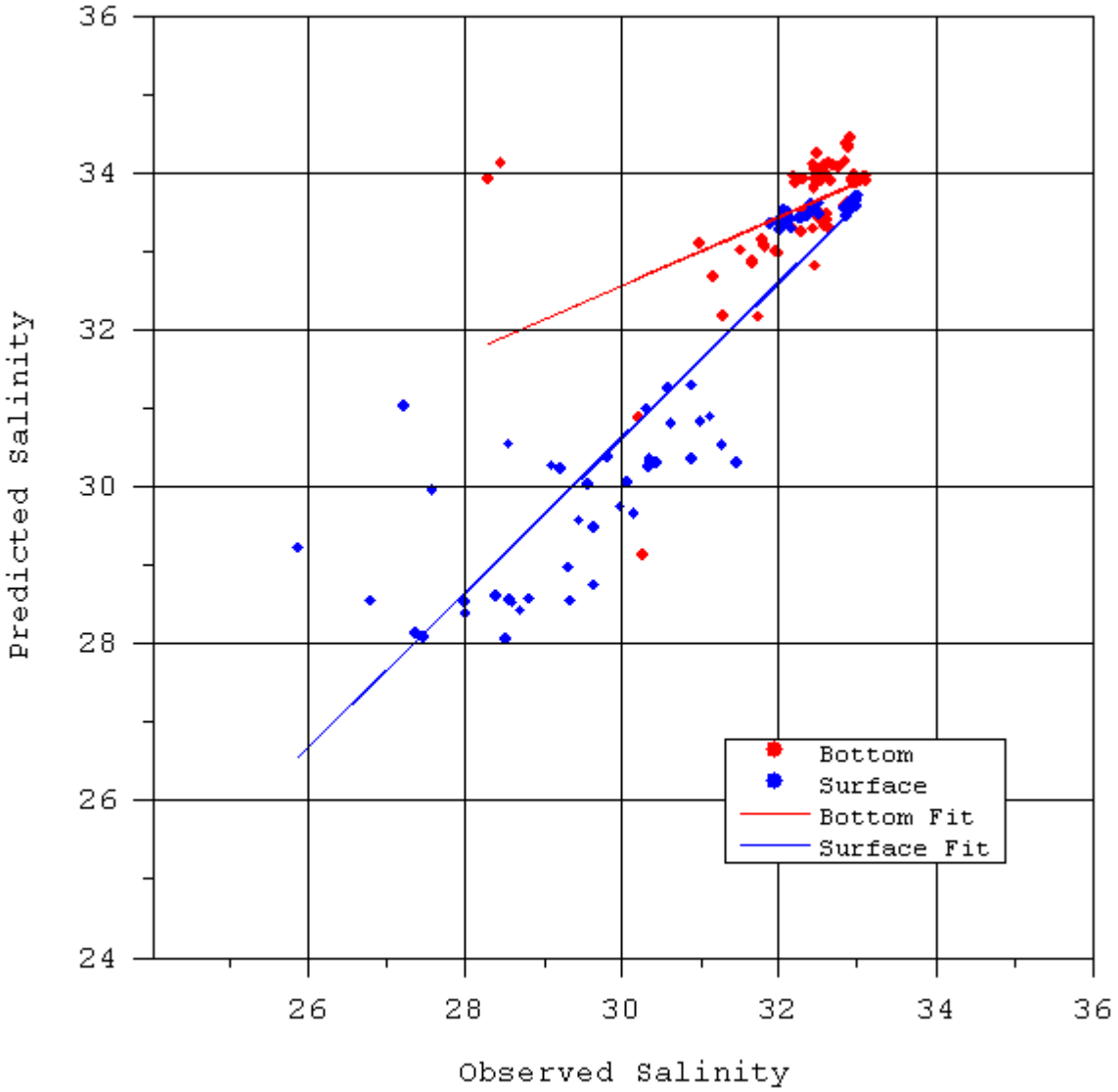


Figure 15. Comparison of predicted and observed salinity at 20 stations for four sampling times during December 2004 to March 2005 using LAX wind fields

7. Sediment and Contaminant Transport Model Configuration

This section describes the configuration of the EFDC based greater LA/LB Harbor waters model for the simulation of sediment and adsorptive contaminant transport simulation. Sediment and contaminant transport formulations in the EFDC model are documented by Tetra Tech (2007). Both fine, cohesive behaving sediment and noncohesive sand are simulated. Particulate organic material is assumed to be associated with the fine sediment class. Contaminants modeled include three metals; copper, lead, and zinc and three organics; DDT, PAH, and PCB. Two-phase equilibrium partitioning is used to represent

adsorption of the metals and organics to the fine sediment class. The EFDC model simulates transport and fate in both the water column and sediment bed. Water column transport includes advection, diffusion, and settling for sediment and sediment adsorbed contaminates. The sediment bed is represented by multiple layers with internal transport of contaminants by pore water advection and diffusion. Sediment and water is exchanged between the water column and bed by deposition and erosion, with corresponding exchange of adsorbed and dissolved contaminants. Dissolved phase contaminants are also exchanged by diffusion between bed pore water and the overlying water column. The following subsections describe specific aspects of model configuration including: establishment of spatially varying initial conditions in the sediment bed, specification of sediment erosion potential, specification of contaminant partition coefficients, and external loadings and boundary conditions.

7.1. Sediment Bed Initial Conditions

Inter-annual scale simulation of sediment adsorbed contaminants requires establishment of sediment bed initial conditions to the highest possible level of accuracy because the bed can be a significant source and/or sink of contaminants with respect to the water column as well as a reservoir for exposure and subsequent transport up the aquatic food chain. In contrast to water column initial conditions that wash out or rapidly respond to external sources and open boundary conditions, bed initial conditions are persistent with changes in bed sediment composition and contamination levels occurring slowly at annual scales and longer. Initial conditions are required for both sediments and contaminants. Sediment initial conditions influence both sediment transport dynamics and the phase distribution and mobility of contaminants in the bed. Required model initial conditions include sediment size class fractional distribution and a measure of water content such as porosity or void ratio. Organic material composition as specified by particulate or total organic carbon (POC or TOC) is also desirable.

Numerous studies in the greater LA/LB Harbor waters have collected sediment bed physical data. However the data sets are quite heterogeneous in that they include near surface samples, composite cores, and depth varying sub-cores having data ranging from fraction of fine sediment to detailed grain size distributions. To achieve the widest spatial coverage, approximately 200 data points were selected, which are distributed among the datasets described in Table 2. Data inside the breakwaters prior to 1997 were excluded (except for one Bight 1994 station) while all data outside the break water were used. Sediment bed physical data prior to 1997 were excluded from the initial conditions to ensure that data associated with areas that had subsequently been dredged were not included (Note: Time period for physical data extends back before the chemical data associated with the contaminants, described below. Given that the physical data were somewhat limited and several studies with useful physical data were available prior to 2000, the time period was extended

to 1997. Individual stations that were known to have been dredged were excluded). Grain size information was reduced to two classes, fines composed of silt and clay, and sand and coarser particles, using 0.063 mm as the class size boundary. Water content measures were all converted to porosity. Figure 16 shows the location of 200 data sites having bed sediment size information, while Figure 17 shows a zoom of the most recent sub-set of these data.

Since many of the sites had no information on water content as defined by porosity, correlations between porosity and fine sediment fractions were developed using sites having data for both (Figure 18). The average of these two correlations was used to estimate porosity at sites having no data. Due to lack of quantitative data in San Pedro Bay, sediment composition near the open boundaries was assumed to be 25 percent fine with a porosity of 0.5. The fine sediment fraction and porosity data including assumed values along the open boundaries in San Pedro Bay were interpolated to the model grid (Figure 1) using a Laplacian scheme which is equivalent to bi-linear interpolation with the exception that interpolation over land is prohibited. Figures 19 and 20 show the bed initial conditions for fine sediment fraction and porosity. The sediment bed was also configured to have five layers: a 5 cm thick layer on top, followed by a 15 cm layer, and then three 20 cm thick layers on the bottom. Sediment size class fractions, porosity, and contaminant concentrations are assumed uniform over the depth of the sediment bed at each horizontal location.

The procedure for establishing initial conditions for contaminants in the sediment bed follows that for sediment physical properties. To again achieve the widest spatial coverage, approximately 250 to 300 data points were selected for each contaminant, which are distributed among the datasets shown in Table 2. Data inside the breakwaters prior to 2000 were excluded while all data outside the breakwater were used. Contaminant concentration data inside the breakwater collected prior to 2000 were excluded from the initial conditions to ensure that data associated with areas that had subsequently been dredged were not included. The Ports of Los Angeles and Long Beach provided maps to help identify dredged areas and associated dredging dates. Figure 21 shows the location of all contaminant bed concentration data sites, while Figure 22 shows the location of sites recently sampled in fall 2006. The bed data for sites shown in Figure 22 were used to initialize metals and organics concentrations, while the overlying water data at these stations were used for calibration of sediment and contaminant transport. Since data in San Pedro Bay were extremely limited, bed solid phase concentrations near the open boundaries were estimated to be 10, 10, and 50 mg/kg for copper, lead, and zinc, and 0.01, 0.1, and 0.01 mg/kg for DDT, PAH, and PCB. Figures 23 through 28 show the spatial distribution of total sediment-normalized bed initial conditions for six contaminants using logarithmic concentration scales. For clarification of the logarithmic concentration scales, the log of the pollutant-specific sediment quality guidelines are identified in the figure captions as well as on the concentration legends. The distribution of initial concentrations in Figures 23 through 28 were based on the observed data.

Specifically, observed concentrations were used to represent the grid cell at their specific location and the concentrations between the individual data points were estimated by interpolating between the known concentrations.

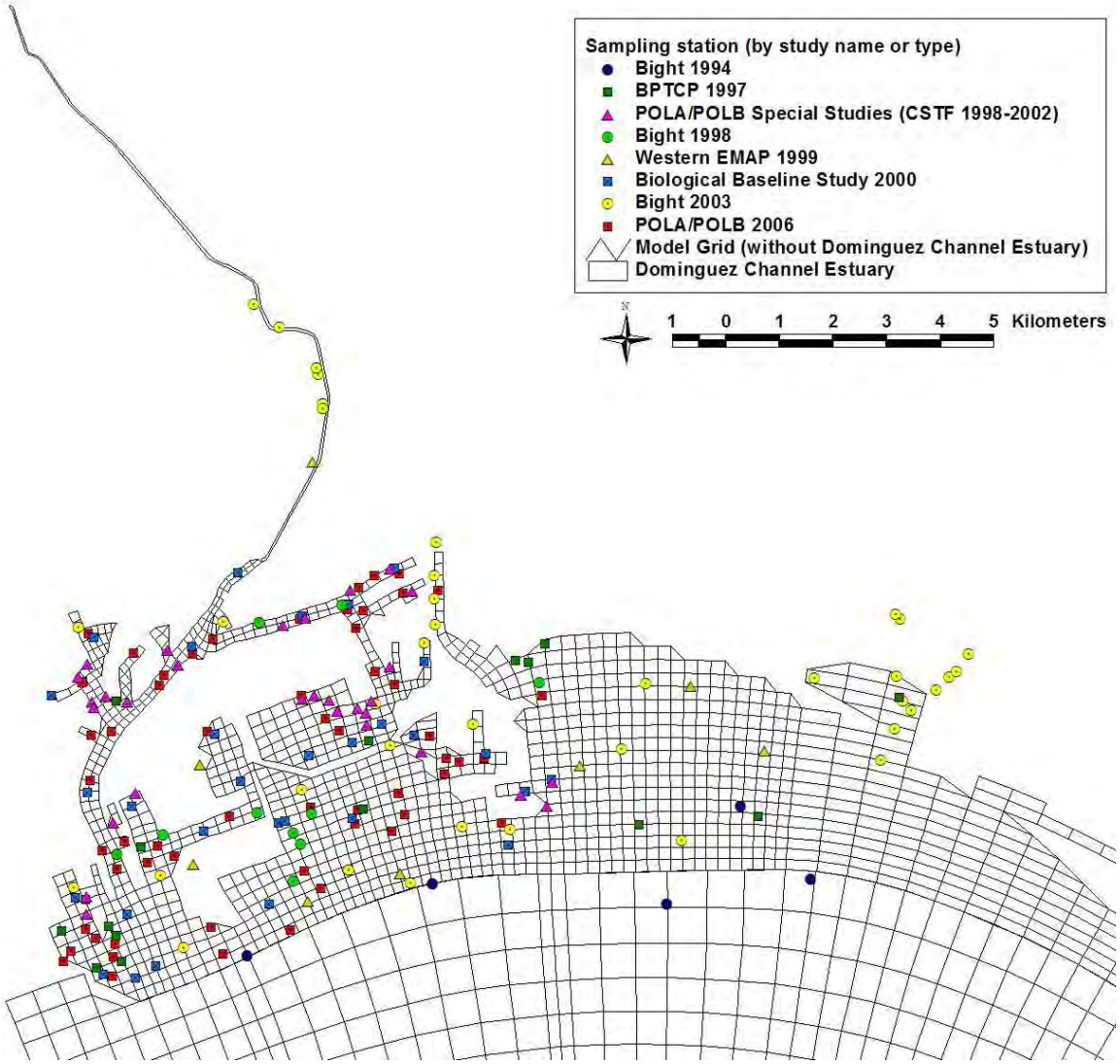
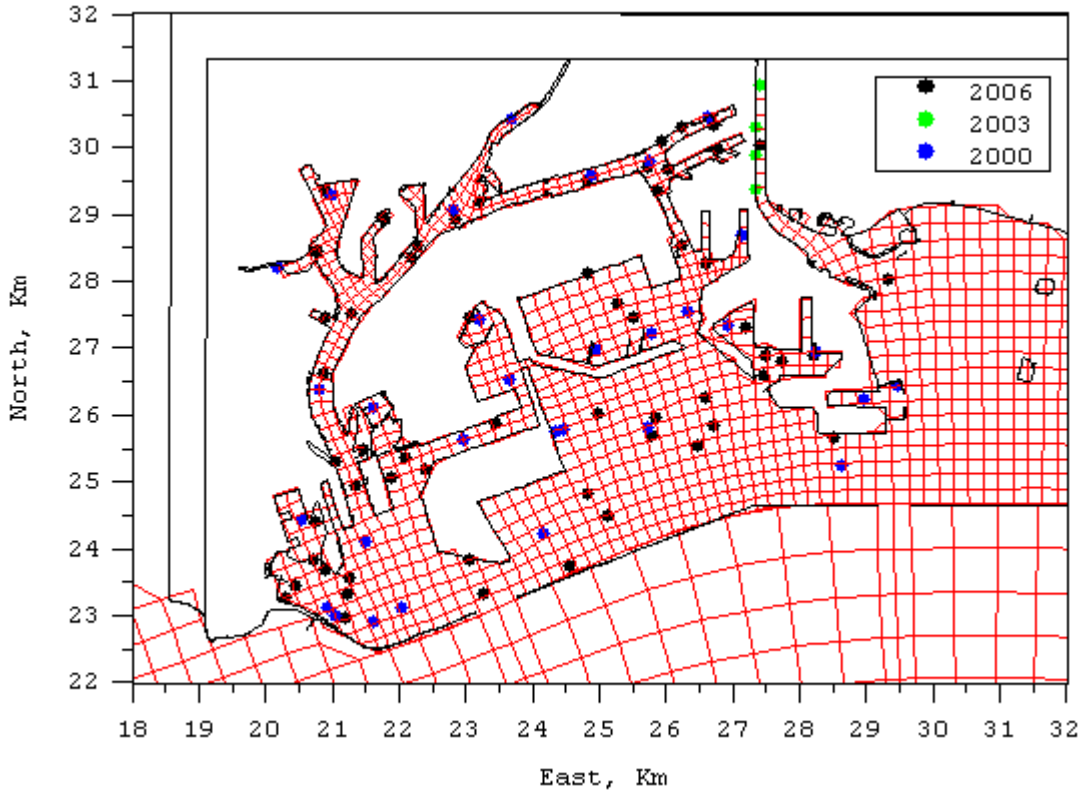


Figure 16. Location of 200 data sites used to initialize sediment bed physical properties



Note: 2006 data points refer to the POLA/POLB fall 2006 sampling; Bight 03 samples are represented by the 2003 points; 2000 data points refer to the POLA/POLB Biological Baseline Study conducted in 2000.

Figure 17. Most recent sediment bed physical data sites inside the breakwater

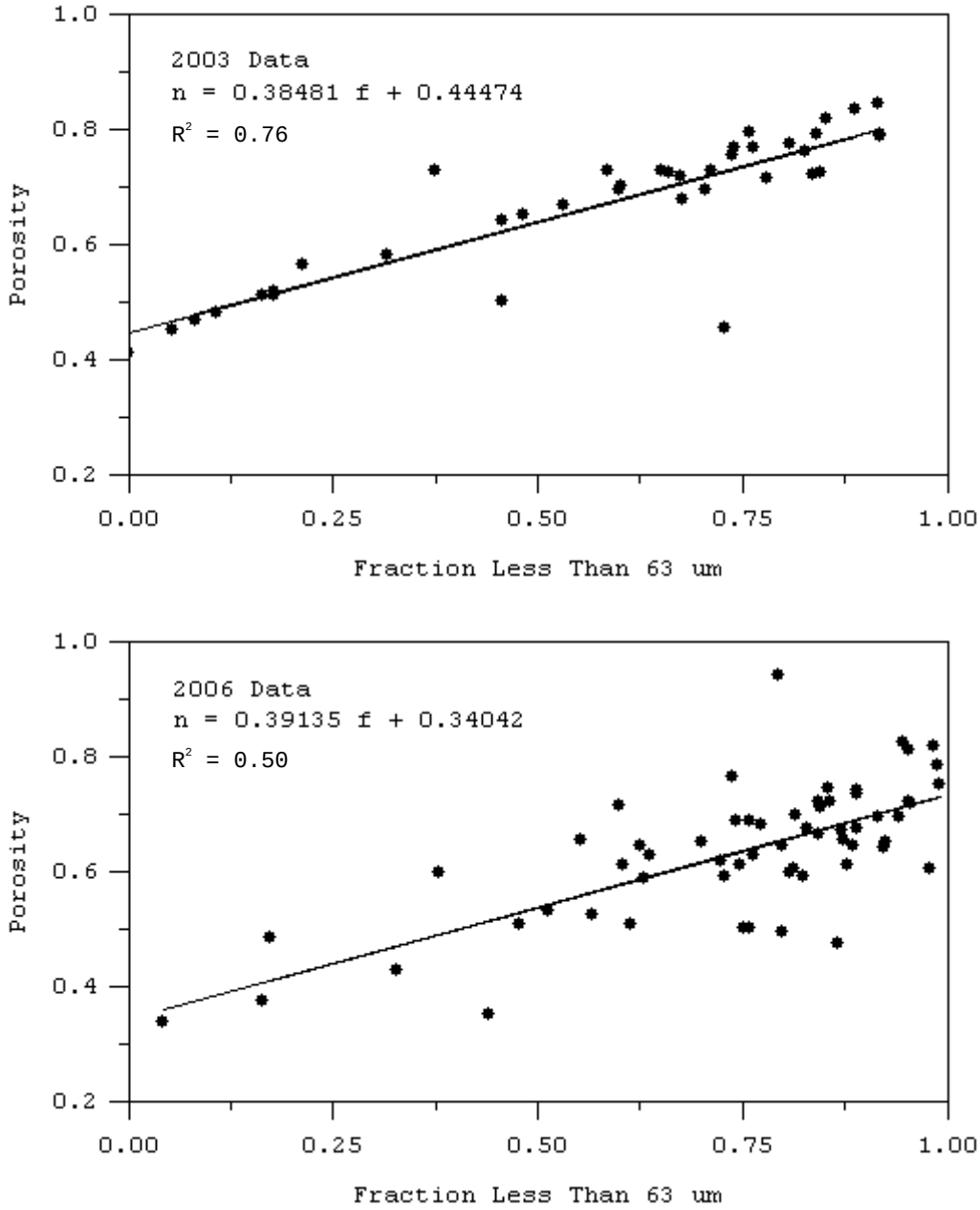


Figure 18. Porosity as a function of fine sediment fraction

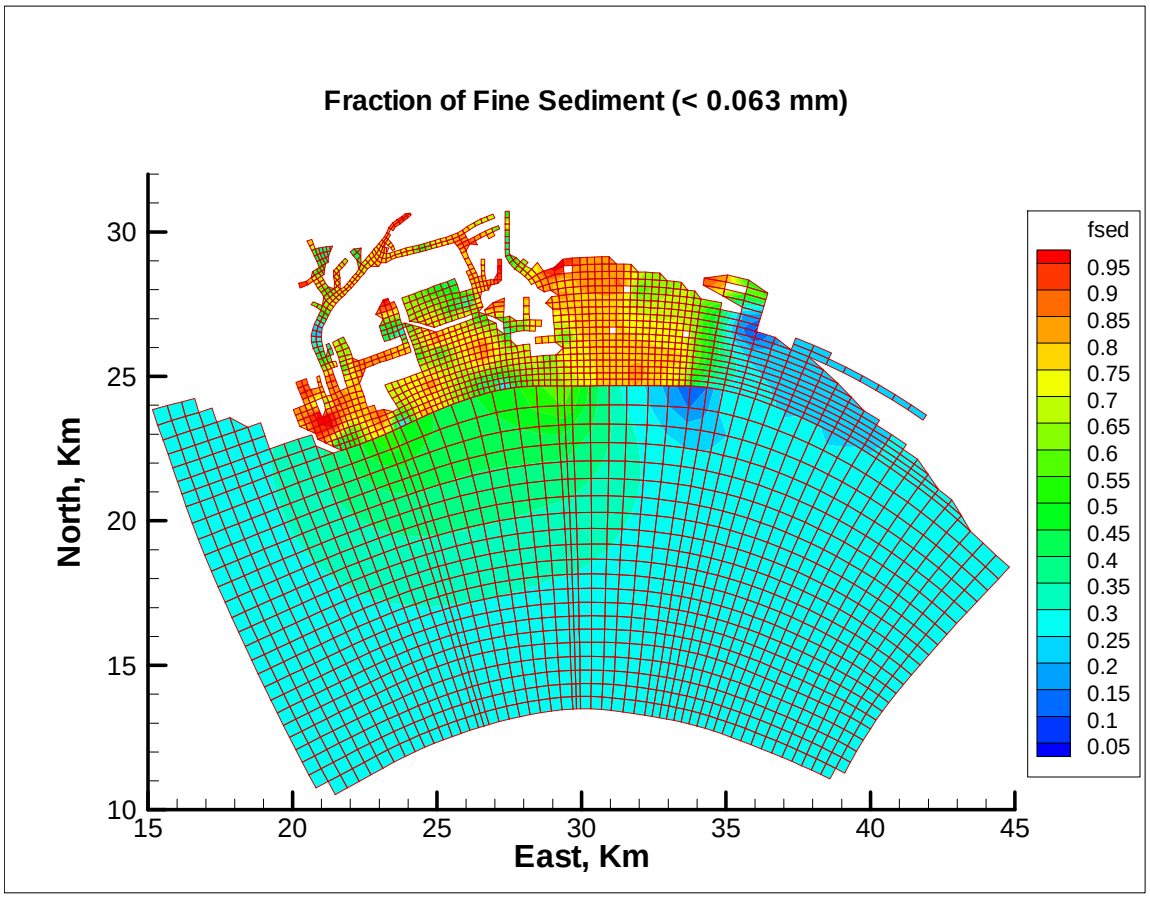


Figure 19. Fraction of fine sediment (< 0.063 mm) in the sediment bed used for model initialization

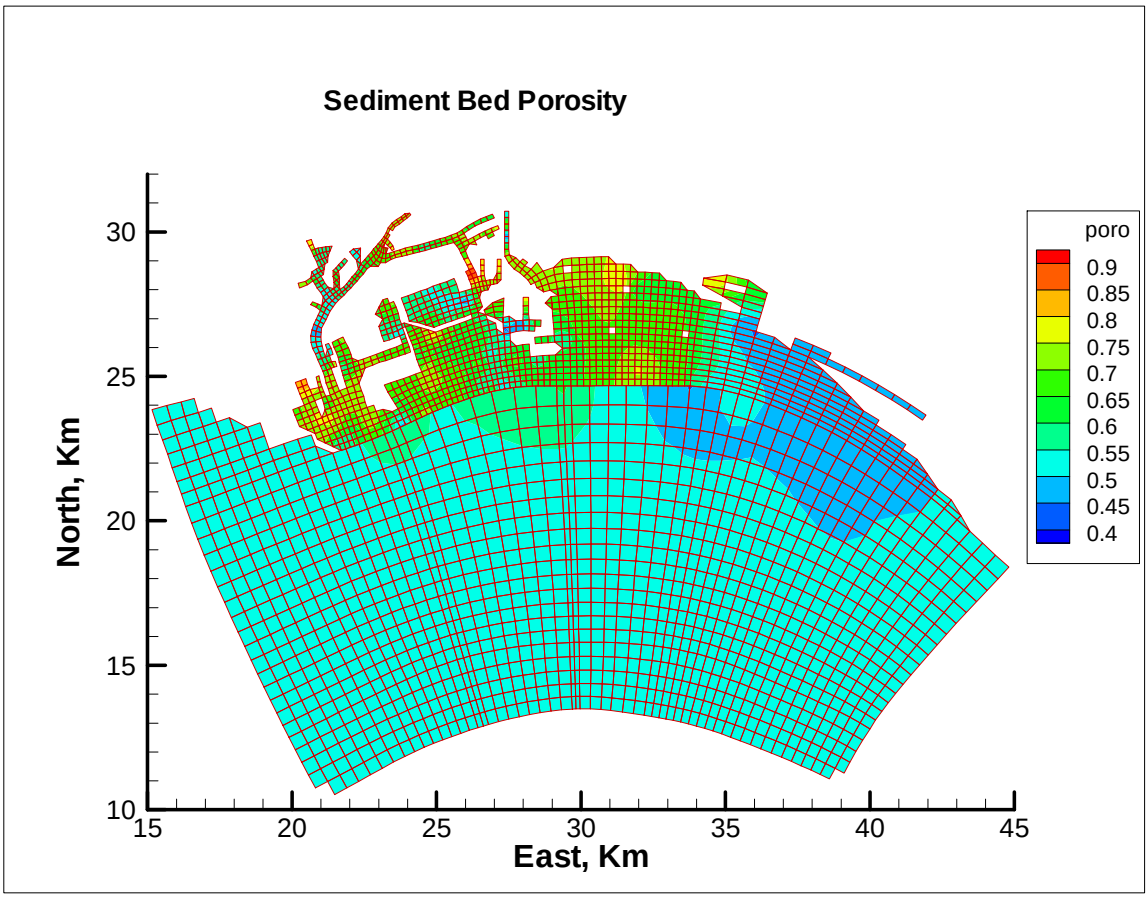


Figure 20. Sediment bed porosity used for model initialization

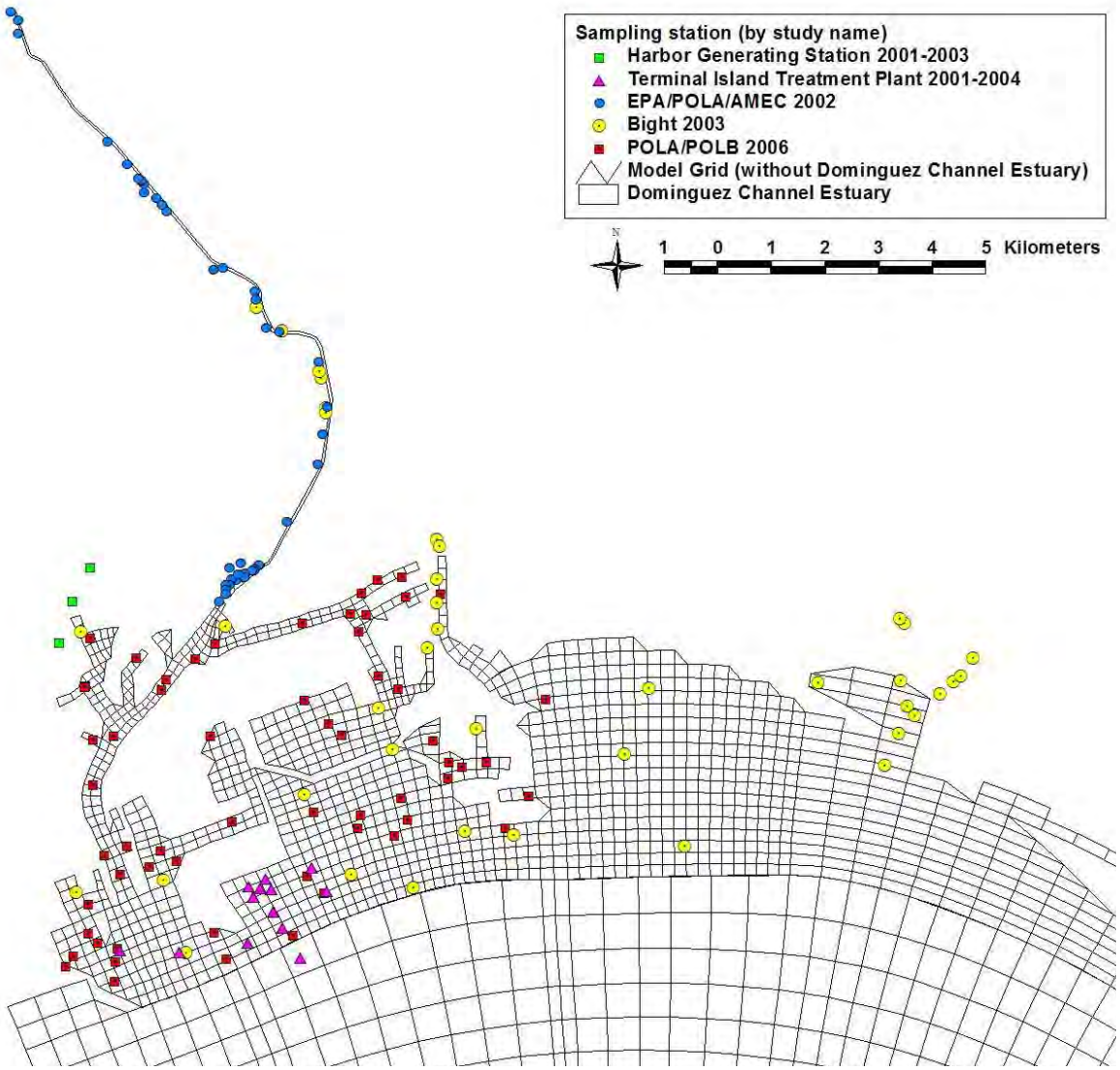
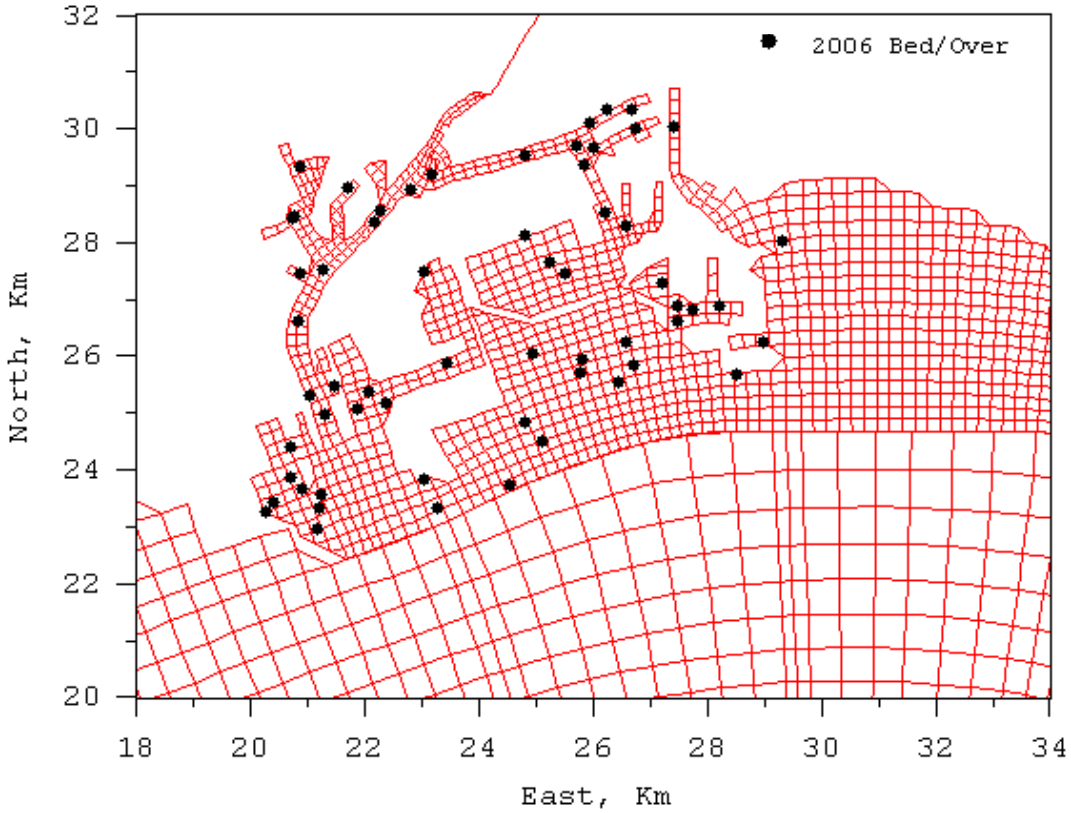
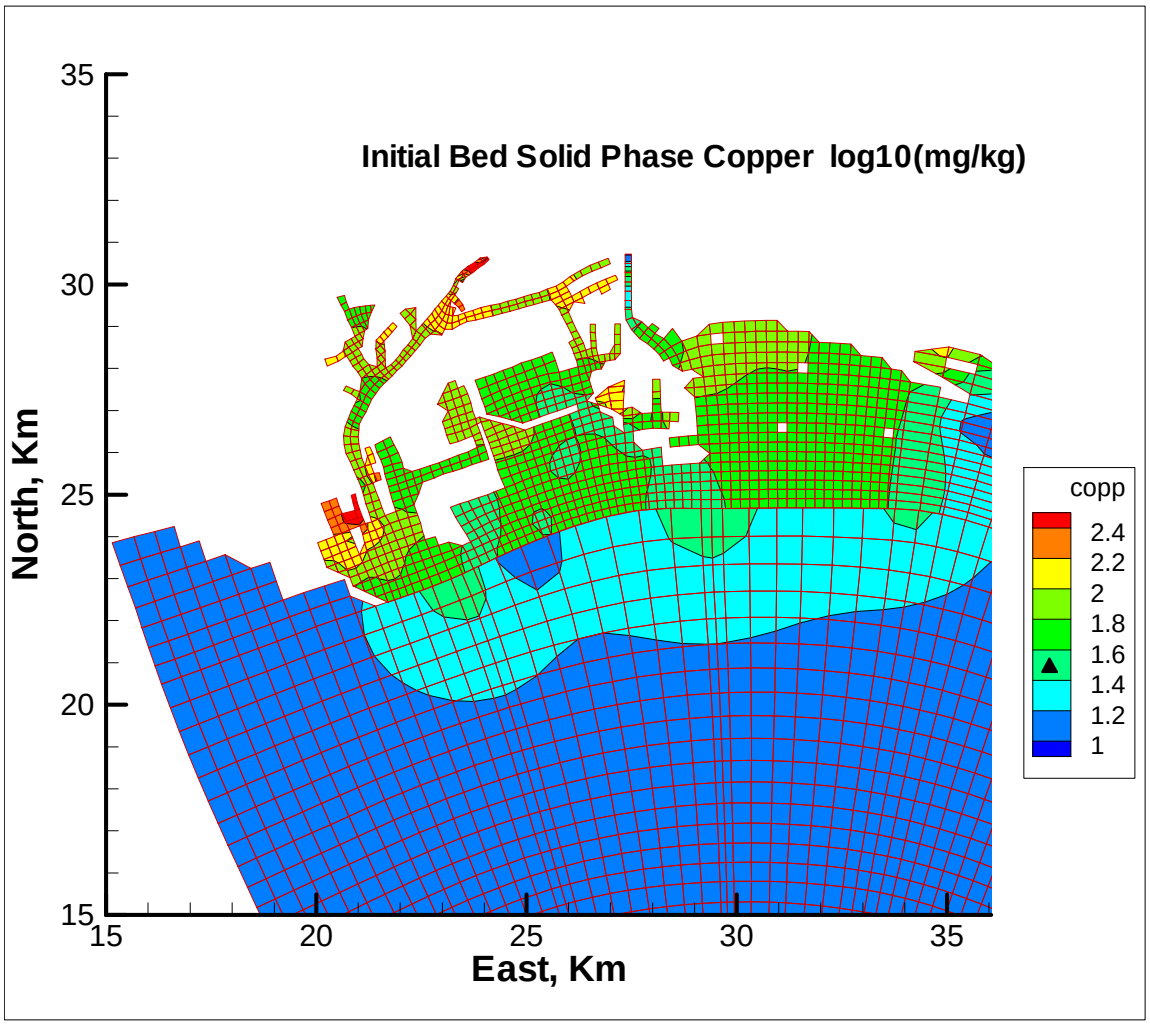


Figure 21. All sites used to initialize sediment bed metals, and organics concentrations



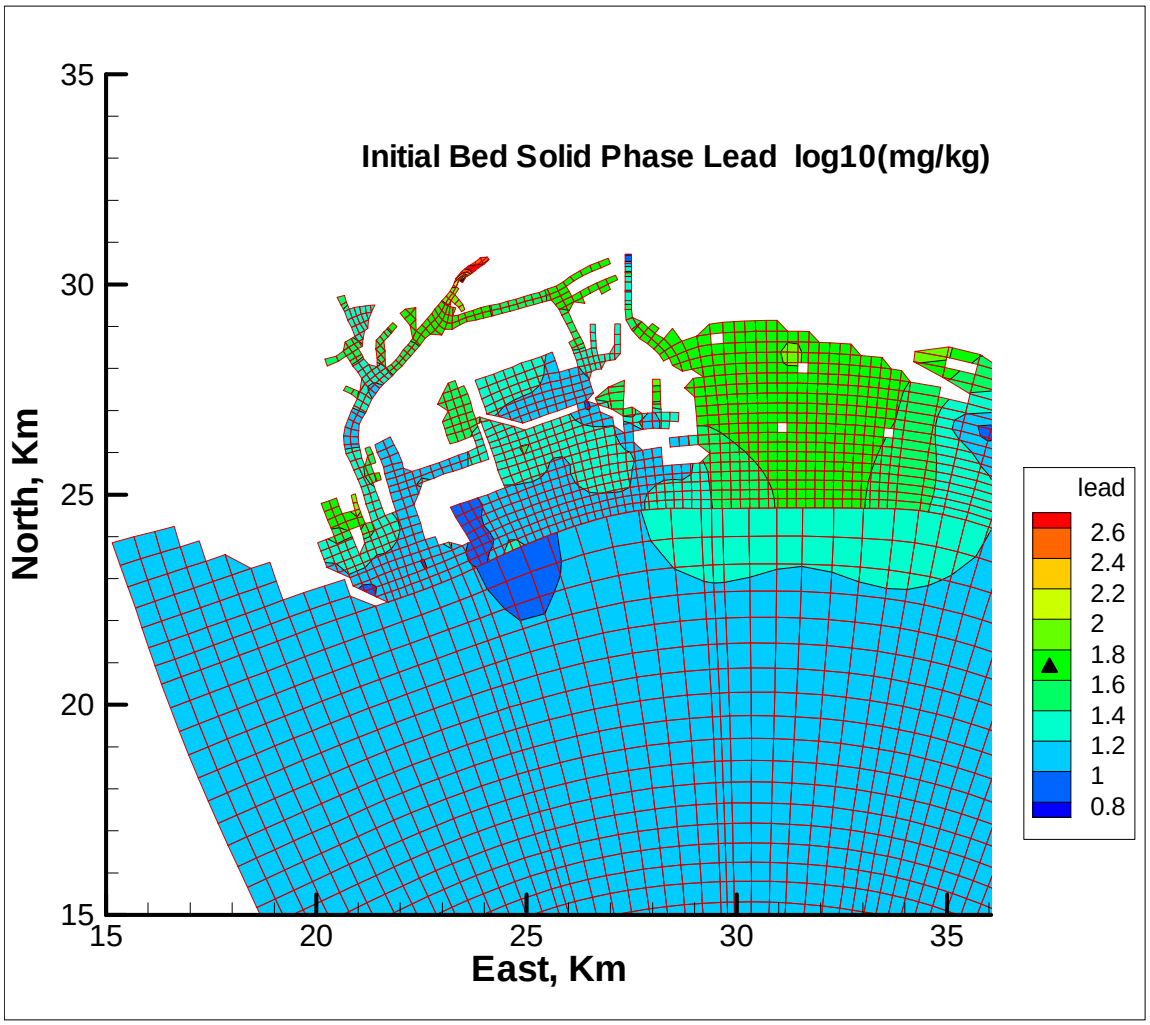
Note: These stations are the recently sampled locations in the greater LA/LB Harbor waters used for model configuration and calibration (POLA/POLB 2006). They are a subset of the stations presented in Figure 21. Bed data used to initialize sediment, metals, and organics concentrations. Overlying water data used for sediment and contaminant transport calibration.

Figure 22. Fall 2006 bed and overlying water column sample sites



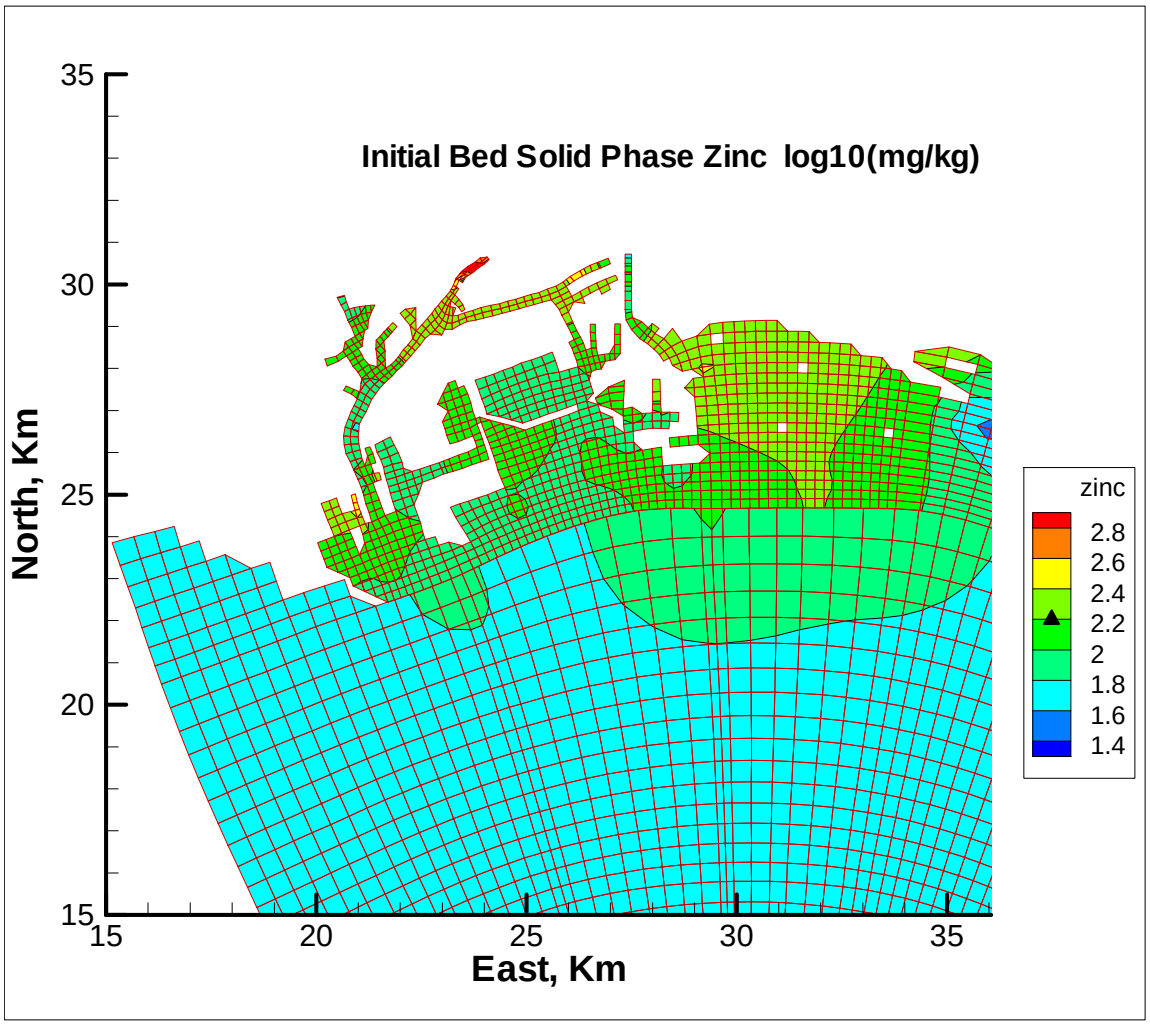
Note: Copper sediment quality guideline is 34 ppm (or mg/kg dry weight). Log(34) = 1.5 (represented by a black triangle in the concentration legend).

Figure 23. Initial bed solid phase copper concentration



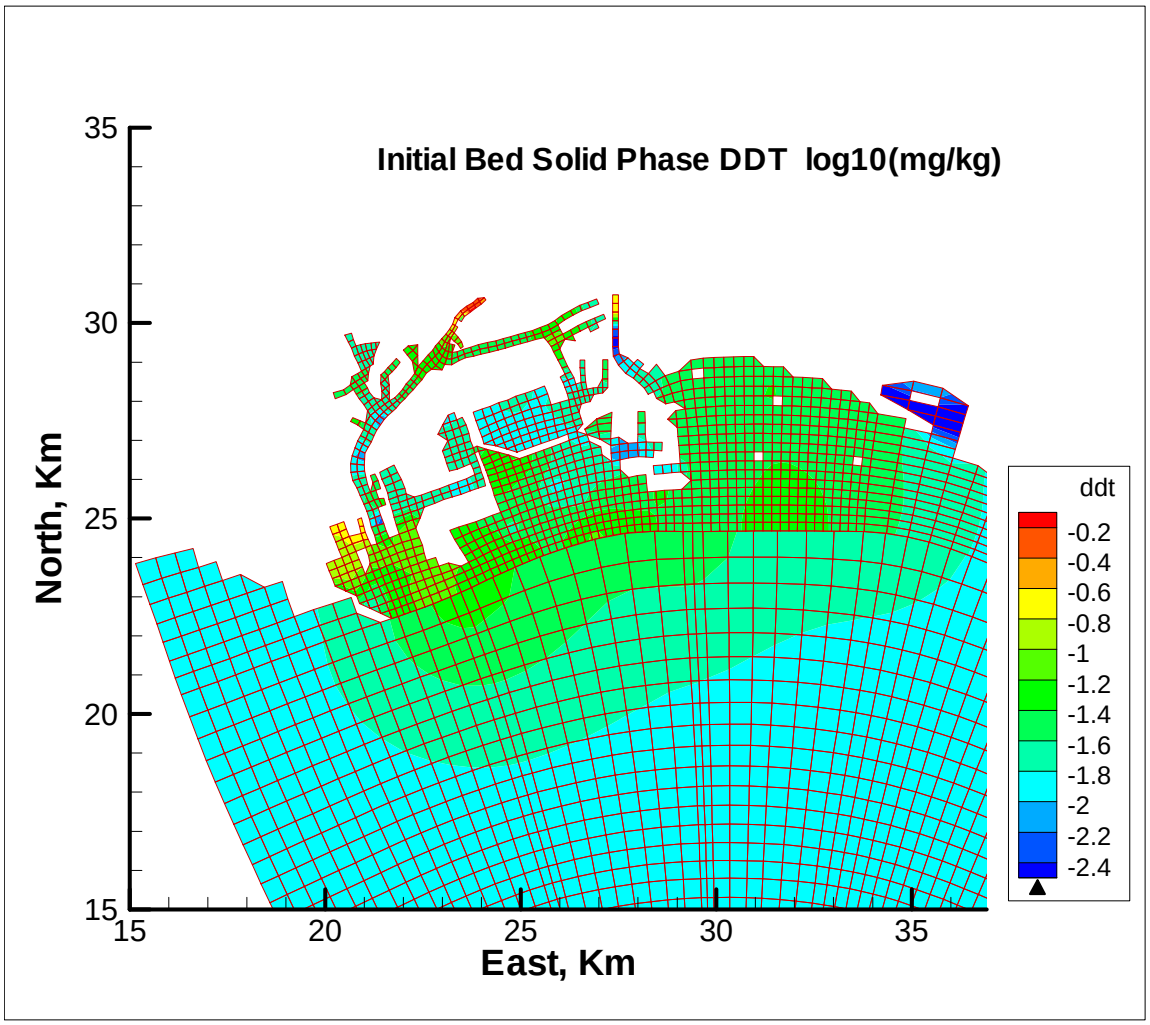
Note: Lead sediment quality guideline is 46.7 ppm (or mg/kg dry weight). Log(46.7) = 1.7 (represented by a black triangle in the concentration legend).

Figure 24. Initial bed solid phase lead concentration



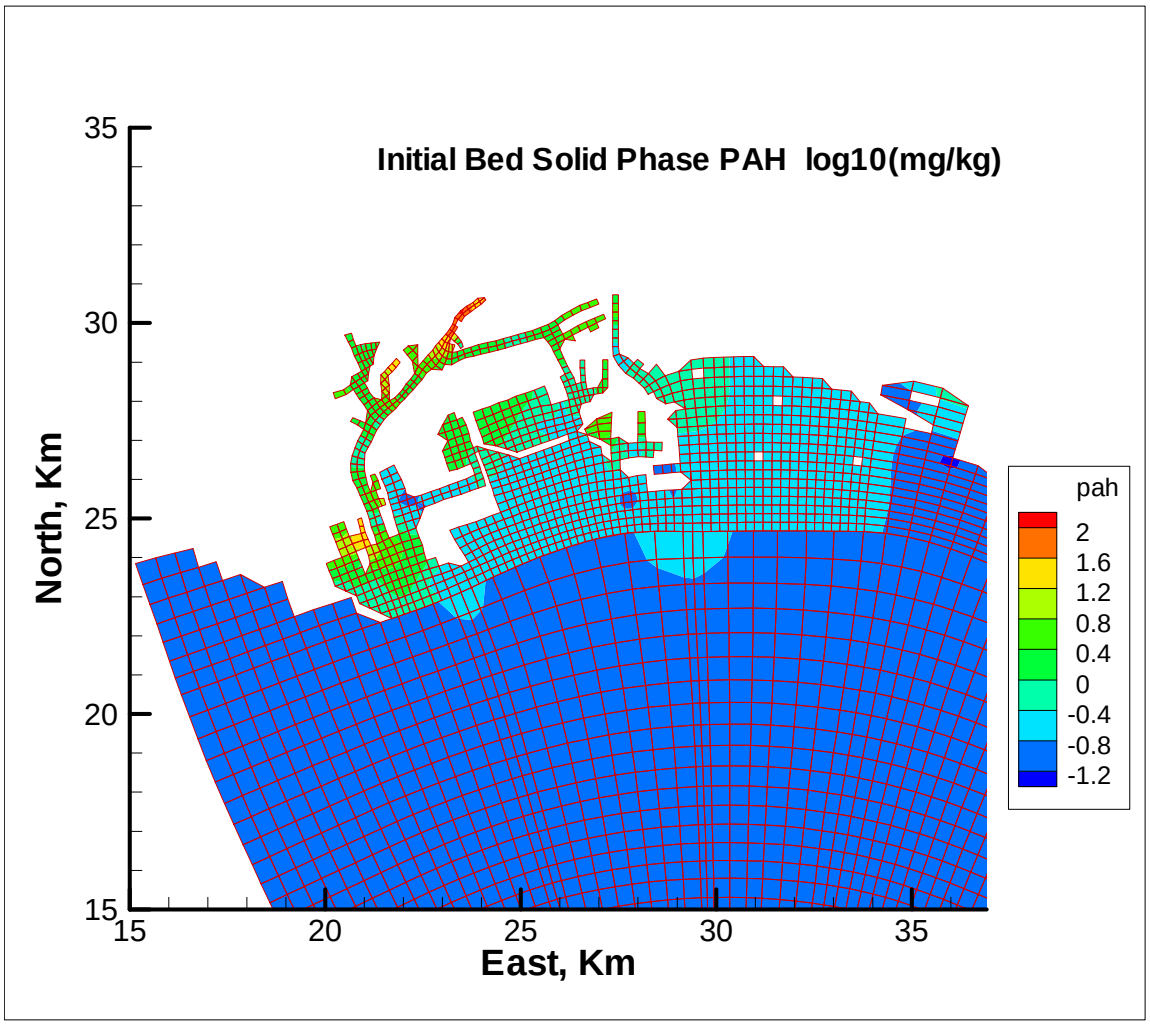
Note: Zinc sediment quality guideline is 150 ppm (or mg/kg dry weight). Log(150) = 2.2 (represented by a black triangle in the concentration legend).

Figure 25. Initial bed phase zinc concentration



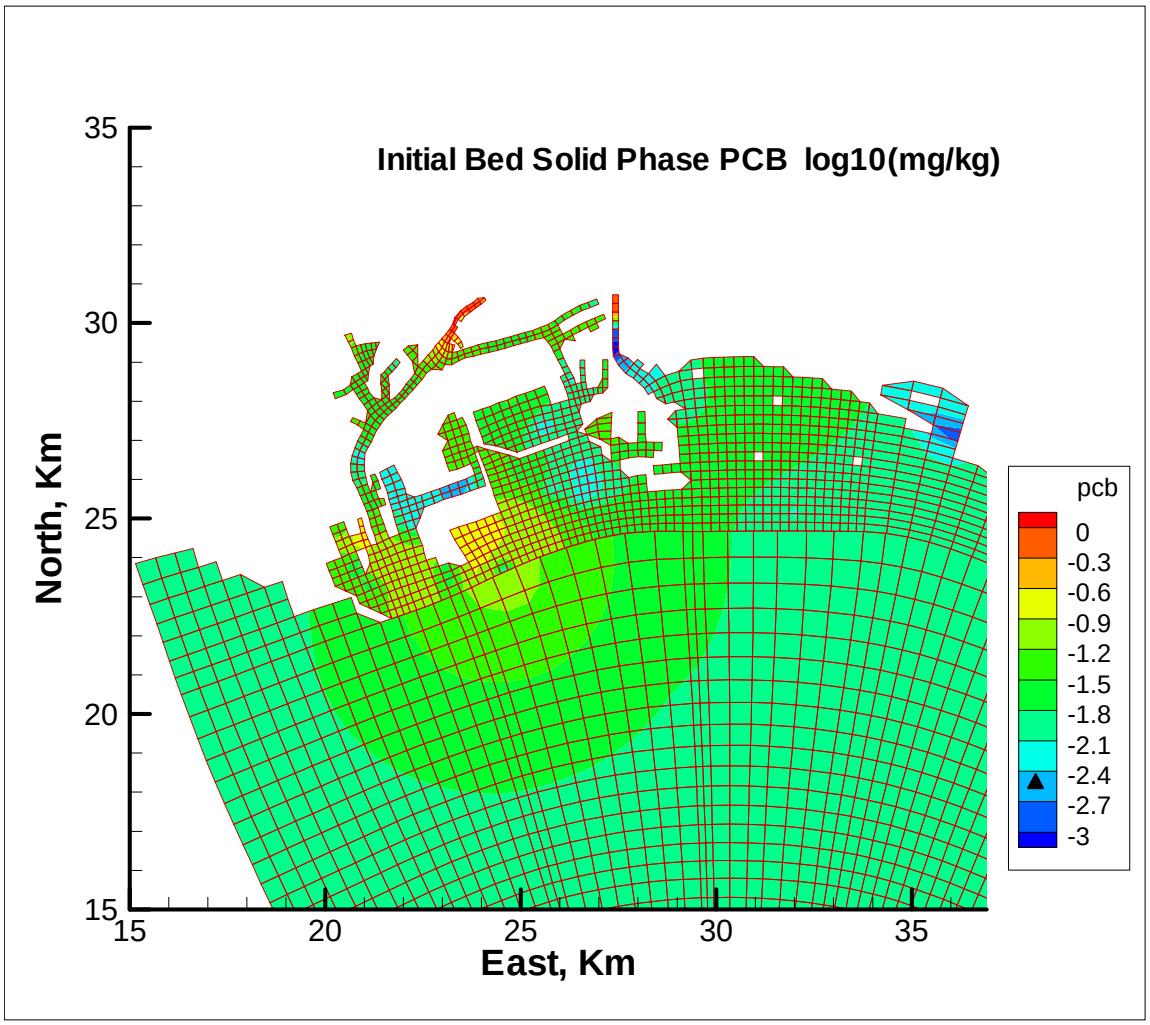
Note: DDT sediment quality guideline is 1.58 ppb or 0.00158 ppm (or mg/kg dry weight). Log(0.00158) = -2.8 (represented by a black triangle in the concentration legend).

Figure 26. Initial bed solid phase DDT concentration



Note: Data presented are normalized to total solids.

Figure 27. Initial bed solid phase PAH concentration



Note: PCB sediment quality guideline is 3.2 ppb or 0.0032 ppm (or mg/kg dry weight). Log(0.0032) = -2.5 (represented by a black triangle in the concentration legend).

Figure 28. Initial bed solid phase PCB concentration

7.2. Sediment Settling, Deposition and Erosion Parameters

The sediment transport model requires specification of various sediment settling, deposition and erosion parameters. For the noncohesive sand sediment class, settling velocity is determined internally in the model based on input mean sand size. Erosion and deposition of sand associated with suspended and bed load transport is also internally parameterized in the model based on size class diameter and user choices of a number of widely accepted suspended and bed transport formulas (Tetra Tech, 2007). Available sediment bed grain size data suggest that a mean sand diameter between 0.125 and 0.250 mm would be appropriate and could be further refined during calibration.

The settling, deposition and erosion of fine cohesive-behaving silt and clay tends to be highly site specific and influenced by water ionic chemistry, organic content, sediment mineralogy and the state of bed consolidation. Site specific information requires settling column analyses and either in-situ or laboratory sediment erosion potential analyses. For environments having relatively low suspended sediment concentration, settling column analyses are not feasible and the fine sediment settling velocity is generally assigned an appropriate fresh or salt water value, in this case 0.0001 m/s, which can be adjusted during calibration as necessary.

A laboratory study of sediment erosion was conducted by Jepson et al. (1997) using intact field cores and cores reconstituted from field samples taken near Queen's Way and Queen's Gate in Long Beach Harbor. Grain size analysis of the material sampled near Queen's Gate and used to form four reconstituted cores indicated approximately 30 percent of the material to be cohesive silt and clay and the remaining 70 percent to be fine sand with a mean diameter of approximately 0.120 mm. The four reconstituted cores were allowed to consolidate for 2, 6, 20, and 60 days before their erosion potential was measured with the sedflume devise, described in Jepson et al. (1997). Consolidation of the cores allowed the degree of consolidation, represented by the void ratio, to be considered as a factor in determining erosion potential. The resulting sedflume measurements provided data to parameterize erosion as a function of applied shear stress and sediment bulk density using

$$\frac{E}{V} = \alpha \left(\frac{\tau}{V^2} \right)^{\beta} \exp\left(\frac{\gamma}{1+\varepsilon} \right) \qquad (3)$$

$$\alpha = 0.237 \quad \beta = 2.18$$

$$\gamma = -32.05$$

$$V = (\nu g)^{1/3} = 0.02\ m/s$$

for the erosion velocity, E, and

$$\frac{M}{\rho_s V} = \alpha \left(\frac{f}{1+\varepsilon} \right) \left(\frac{\tau}{V^2} \right)^{\beta} \exp\left(\frac{\gamma}{1+\varepsilon} \right) \qquad (4)$$

for the mass erosion rate M. In equations (3) and (4), ρ_s is the sediment particle density, V is a velocity scale, f is the fine fraction, τ is the kinematic shear stress, and ε is the void ratio. The coefficients α, β, and γ are based on a log-linear least squares fit of equation (3). Figure 29 compares observed erosion velocities with those predicted by equation (3).

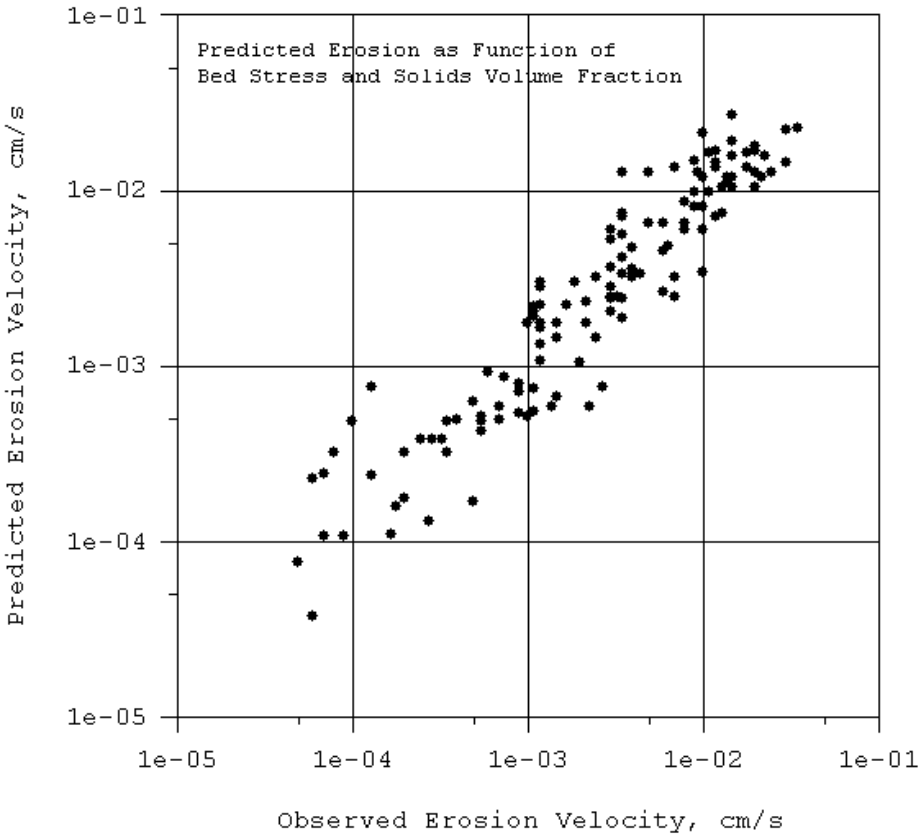


Figure 29. Erosion velocity predicted by equation (3) versus erosion velocity observed during sedflume erosion potential measurements

7.3. Equilibrium Partition Coefficients

The phase distribution of adsorptive contaminants, including metals and hydrophobic organic compounds, is an important determinant in their transport and fate. Although arguments and evidence can be presented to question the utility of equilibrium partitioning to represent phase distribution, the equilibrium approach is accepted by US EPA for regulatory modeling studies associated with TMDL development and Remedial Investigation/Feasibility studies (RI/FS) at Superfund sites. Literature values are available for use when site specific information is not available. Site specific information, when available, is preferred to estimate equilibrium partition coefficients, in conjunction with comparison to literature values to identify unreasonable estimates. The EFDC model supports three phase equilibrium partitioning into free dissolved, adsorbed to dissolved organic carbon, and particulate adsorbed, with further particulate phase options based on sediment size class, fraction of organic carbon and particulate organic carbon. Data available in the greater LA/LB Harbor waters do not support three phase partitioning; therefore, the following two phase formulation was used:

$$C_d = \left(\frac{n}{n + K_p \bullet P} \right) C = dissolved \;\; per\ total\ volume \qquad (5a)$$

$$C_p = \left(\frac{P \bullet K_p}{n + K_p \bullet P} \right) C = particulate \;\; per\ total\ volume \qquad (5b)$$

$$C = contaminant\ concentration\ \ per\ total\ volume$$

$$n = porosity$$

$$P = particulate\ adsorption\ site\ concentration\ \ per\ total\ volume$$

$$K_p = \frac{C_p}{P} \bullet \frac{n}{C_d} = partition\ coefficient \qquad (5c)$$

The particulate adsorption site can be defined as the concentration of the fine sediment size class or as the concentration of particulate organic carbon (POC). The concentration of particulate organic carbon can in turn be defined as the product of a POC fraction and fine sediment concentration.

A field study in fall 2006 collected both sediment and contaminant data at approximately 60 sediment bed and overlying water sites (Figure 22). Bed data were sufficient to estimate partition coefficients using equation (5c) since both the particulate and dissolved phase contaminants were measured as total solids and organic carbon concentrations. The overlying water was sampled only for total concentration and total suspended solids. For the three metals, partition coefficients were defined in terms of fine sediment concentration. For the three organic compounds, partition coefficients were defined in terms of both the fine sediment and particulate organic carbon concentrations. Since organic carbon data were not available for all samples, a relationship between total bed solids concentration and total bed organic carbon was developed (Figure 30).

Equilibrium partition coefficients as a function of bed sediment concentration for the three metals are shown in Figure 31. Corresponding average and visual best estimates based on the 2006 sediment bed and overlying water data (Figure 22) are listed in Table 21. The visual best estimates are based on clustering and are lower than the averages by a factor of approximately two since the averages are influenced by a few large values. Both sets for values are within the literature range summarized by USEPA (2005). Water column partition coefficients for metal adsorption to dilute sediment (concentrations on the order of 1 to 100's mg/L) are typically larger than bed values. For suspended sediment concentrations in the range of a few mg/L, the water column partition coefficients would be five to ten times larger than those for the bed values (USEPA, 2005). For initial metals configuration, the visual best fit bed partition coefficients (column three) were used to set water column values five times the bed values (column five). This is supported by the particulate to dissolved ratios (column 4) which can also be used to estimate partition coefficients by dividing them by

suspended sediment concentration (not recorded in the laboratory analysis). Using a range of 1 to 10 mg/l gives ranges, which bound the estimates in column 5 of Table 21. Subsequent to conducting the model simulations, additional data became available. These data, presented in Appendix E, further substantiate the use of the metals partition coefficients in column 5.

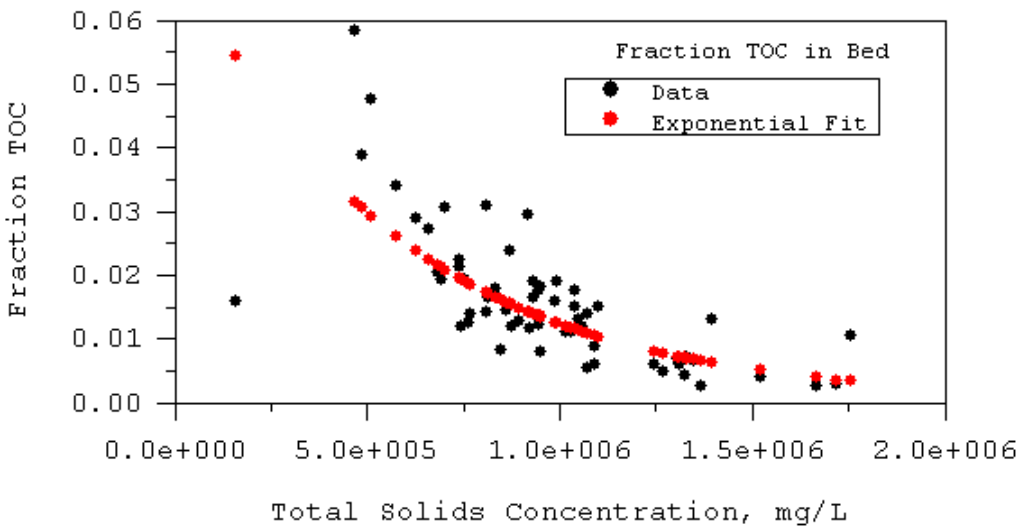


Figure 30. Total organic carbon fraction as a function of total solids concentration, based on 2006 sediment bed data

Table 21. Sediment Bed and Water Column Equilibrium Partition Coefficients and Particulate to Dissolved Concentration Ratios for Metals

Contaminant	Average Bed Partition Coefficient Based on Total Solids (L/mg)[1]	Visual Best Fit Bed Partition Coefficient Based on Total Solids (L/mg)[1]	Water Column Particulate to Dissolved Concentration Ratio[2]	Estimated Water Column Partition Coefficient, 5 Times Column 3 (L/mg)[3]
Copper	0.09	0.05	0.51	0.25
Lead	0.54	0.25	7.12	1.25
Zinc	0.02	0.01	0.20	0.05

[1] Based on POLA/POLB 2006 sediment bed and overlying water data.

[2] Based on POLA 2005 and 2006 mid-water data.

[3] Calculated based on POLA/POLB 2006 sediment bed and overlying water data.

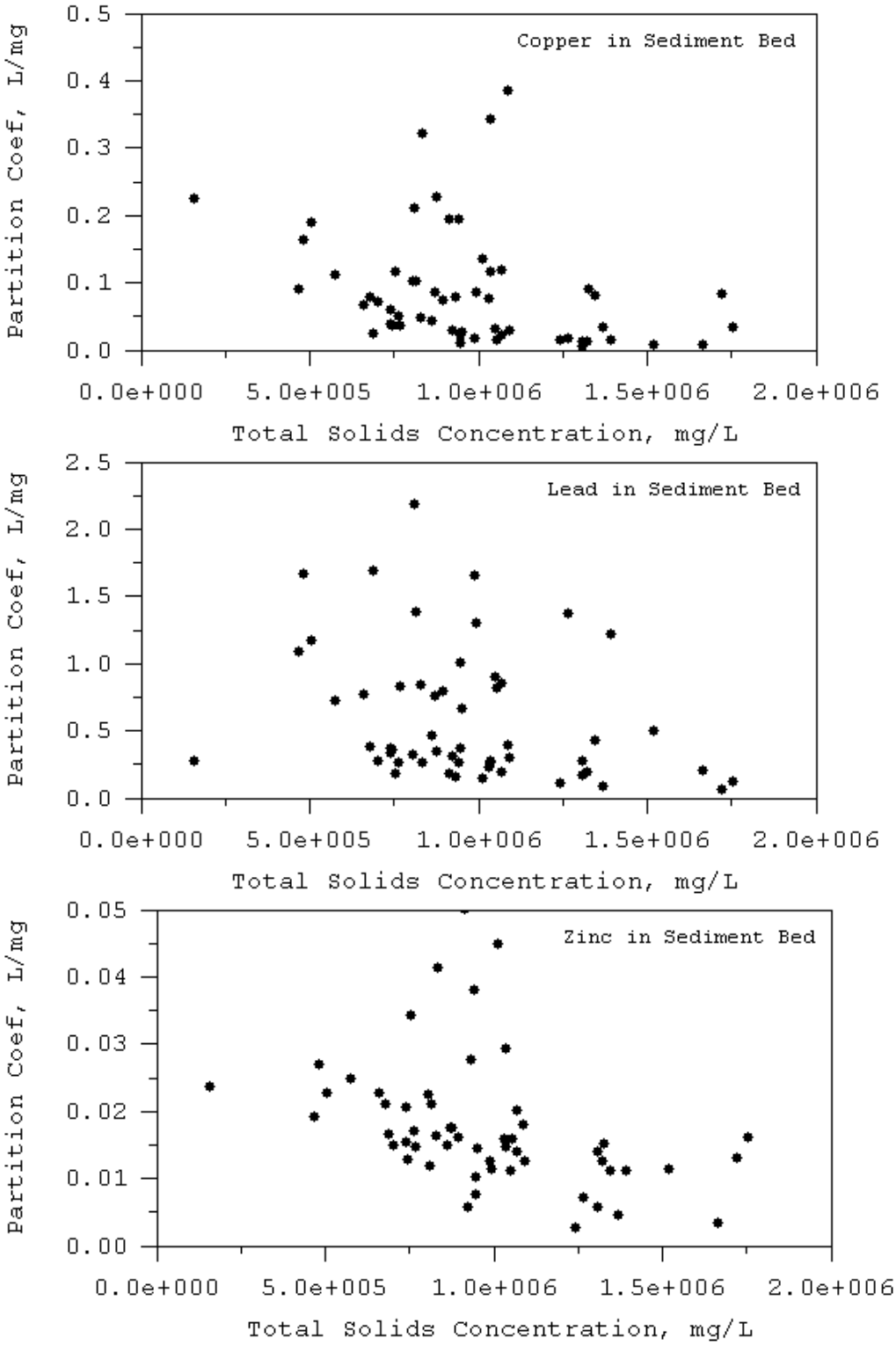
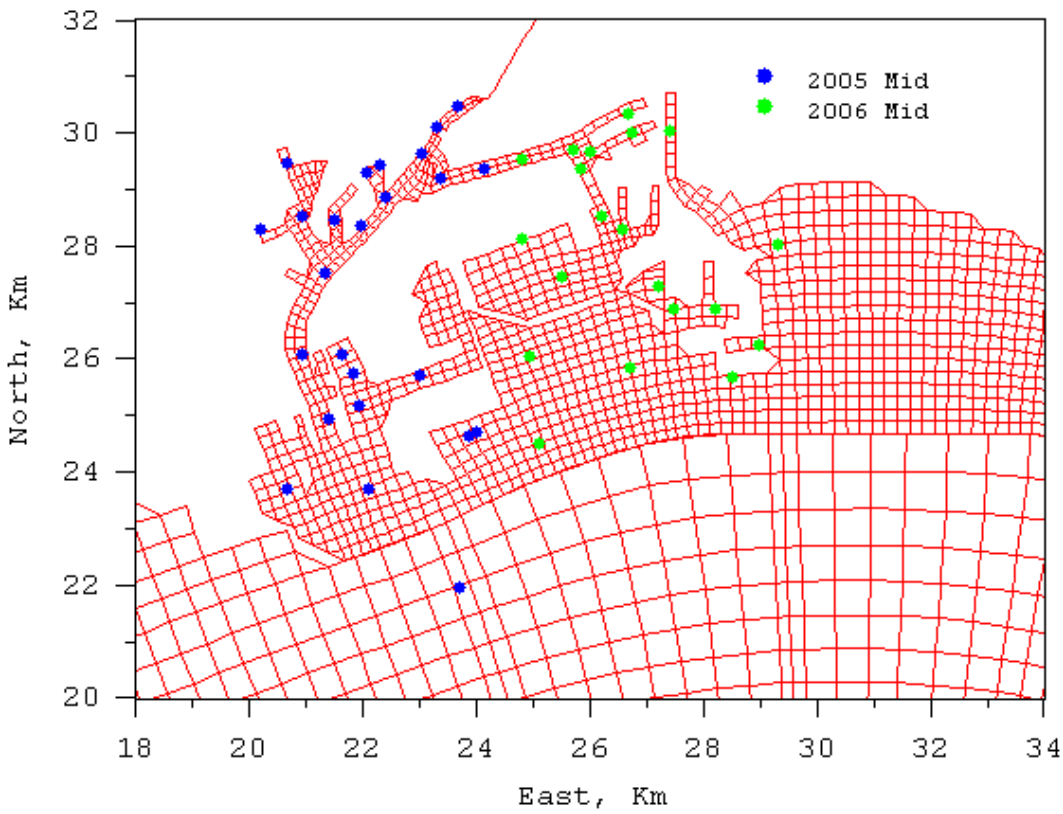


Figure 31. Equilibrium partition coefficients for copper, lead, and zinc based on bed total solids concentration.

Thomann and Mueller (1987) suggest that the product of the partition coefficient and sediment concentration, given by,

$$K_p \bullet P = \frac{C_p}{C_d} \qquad (6)$$

is approximately constant. Mid-water column metals samples collected during 2005 and 2006 (Figure 32) provide dissolved and particulate concentrations allowing the quantity defined in equation (6) to be determined. Sediment concentrations were erroneously not recorded. Figure 33 shows this product for the 2005-2006 mid-water data (Figure 32) for copper, lead, and zinc with average values tabulated in Table 21. The range of average ratios for the copper and zinc data is consistent with the value of 0.25 suggested by Thomann and Mueller (1987) while the lead value is an order of magnitude higher.



Note: 2005 data collected by POLA; 2006 data collected at POLB stations as part of 2006 POLA/POLB study.

Figure 32. Mid-water column sample sites used for metals calibration

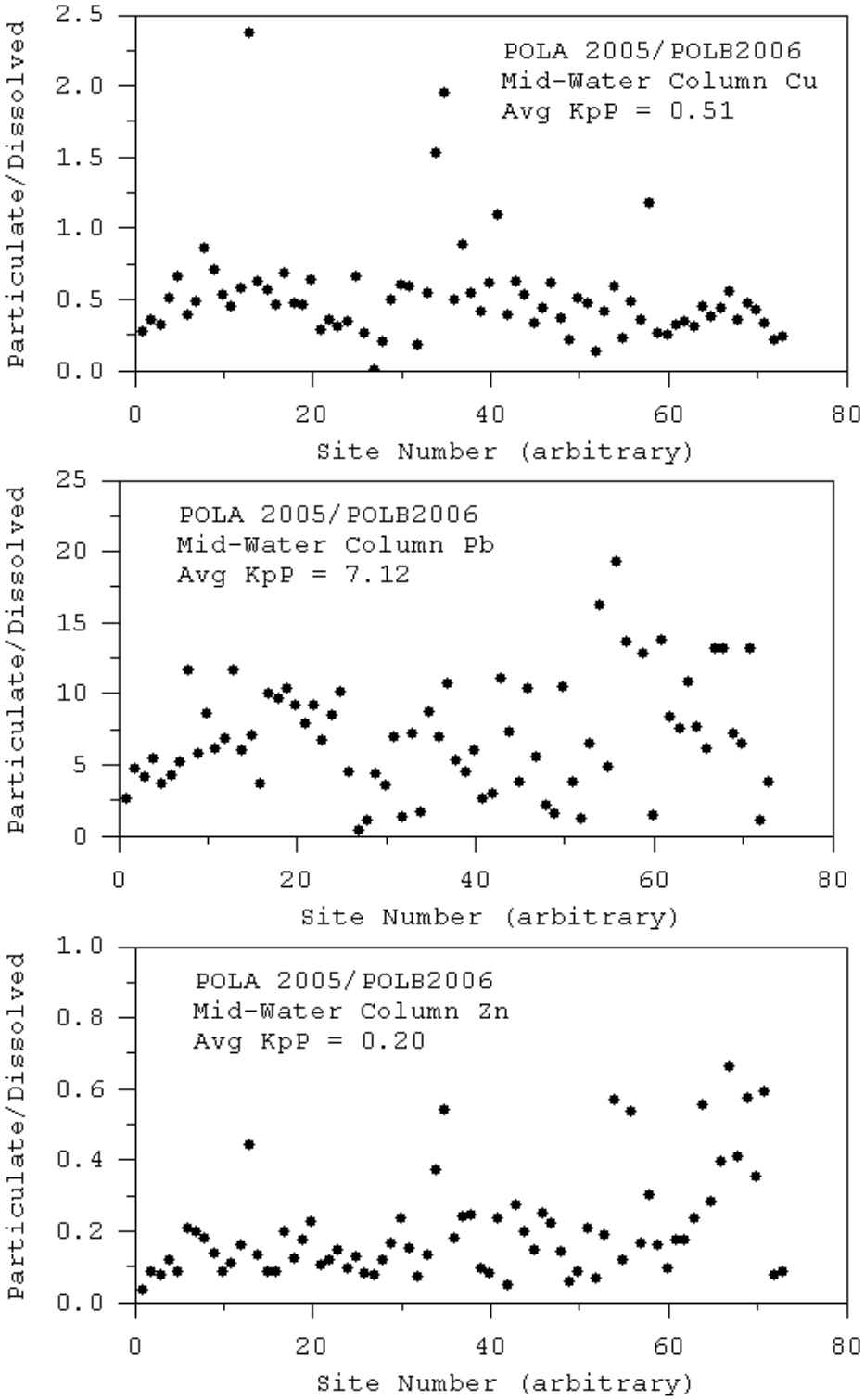


Figure 33. Particulate to dissolved concentration ratio (equal to product of partition coefficient and adsorption site particle concentration) for mid-water column metals concentrations

Subsequent to conducting the calibration and sensitivity simulations for metals, described in Chapter 8 and Appendix C, using water column partition coefficients in column 5 of Table 21, additional water column metals and sediment concentration data sets became available. These data sets include dissolved and total metals data collected during January and March 2006, and dissolved and total metals and suspended solids during January 2008 by POLA. The locations of these data sets correspond to the 2005 locations shown in Figure 32. An analysis and discussion of the significance of these additional data sets is provided in Appendix E.

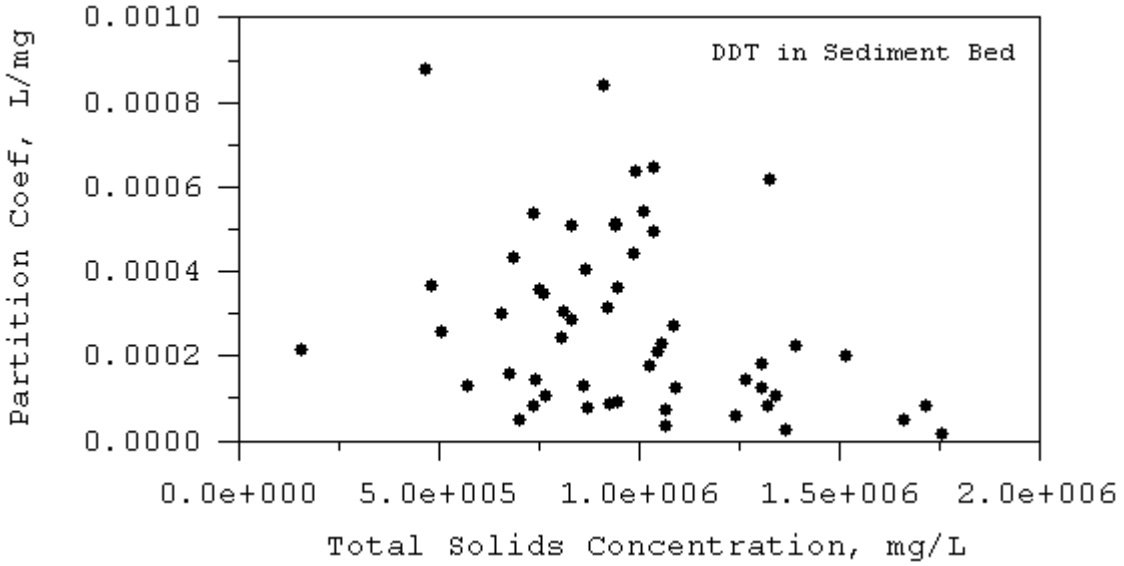
Equilibrium partition coefficients based on the 2006 POLA-POLB data (Figure 22) for DDT, PAH, and PCB, as a function of bed sediment concentration and bed total organic carbon concentration, are shown in Figures 34 through 36. Since no functional dependence of the partition coefficients on sediment concentration and organic carbon is observed, average values were estimated for use in the modeling. Table 22 summarizes the estimated average equilibrium partition coefficients for the three organic contaminants based on the data shown in Figures 34 through 36. Bed solids and bed TOC based values are consistent with the ranges reported in the literature (Chapra, 1997; Chiou, 2002). Low and high range values in Table 22 are based on the range of octanol-water partition coefficients for pesticides, PAHs, and PCBs reported in Chapra (1997). For these three contaminants, organic carbon-referenced bed values should be readily utilized in the water column and can be referenced to water column solids by dividing by the ratio of TOC to total solids. A limited number of the fall 2006 overlying water sites (Figure 22) had organic carbon samples, which are shown in Figure 37. At higher sediment concentrations, the ratio is approximately 0.01, which is approximately the ratio represented by the difference in solids and TOC normalized bed values (Table 22). This suggests that the bed solids referenced partition coefficients for the three organics can also be used in the water column.

Table 22. Sediment Bed Equilibrium Partition Coefficients for Organics

Contaminant	Bed Solids Based (L/mg)[1]	Bed TOC Based (L/mg)[1]	TOC Based Low Range (L/mg)[2]	TOC Based High Range (L/mg)[2]
DDT	0.0002	0.02	0.0002	0.2
PAH	0.0004	0.04	0.01	2.0
PCB	0.0002	0.02	0.005	0.5

[1] Based on POLA-POLB 2006 sediment bed and overlying water data.

[2] Based on Chapra, 1997.



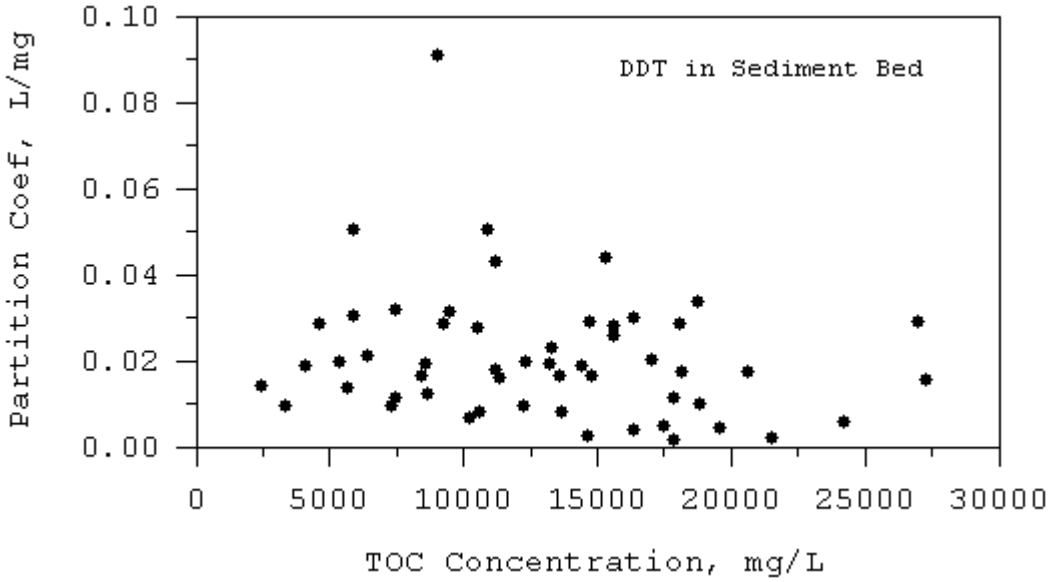
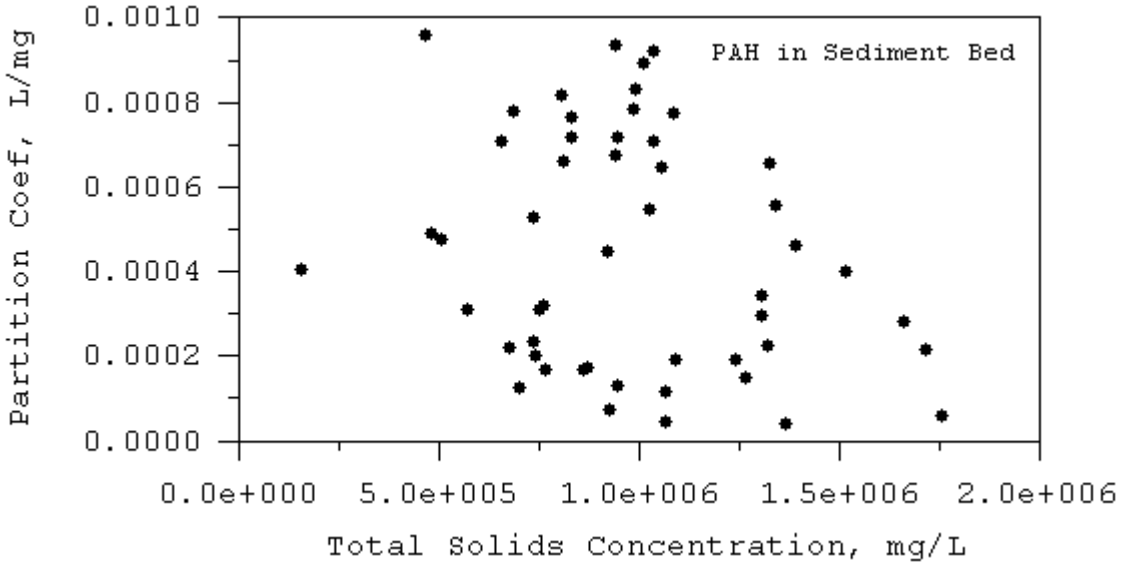


Figure 34. Equilibrium partition coefficient for DDT based on total solids (top panel) and total organic carbon (bottom panel) based on data collected in 2006



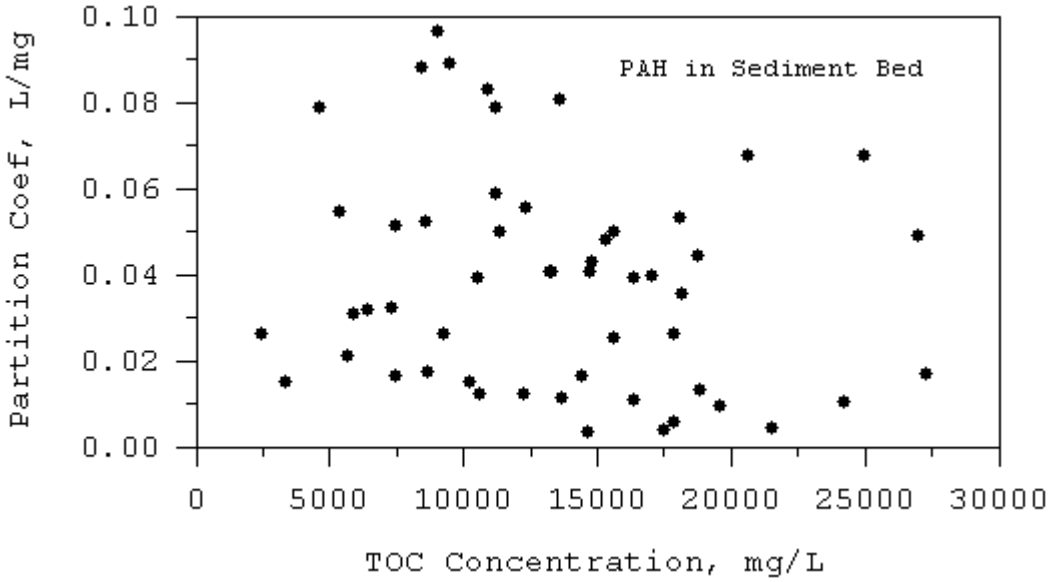
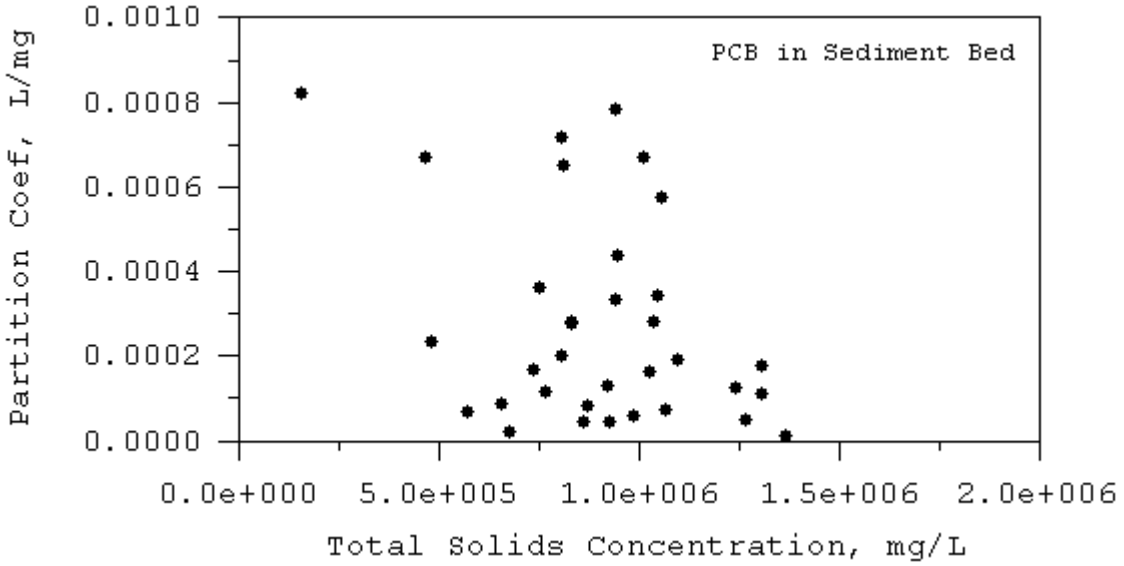


Figure 35. Equilibrium partition coefficient for PAH based on total solids (top panel) and total organic carbon (bottom panel) based on data collected in 2006



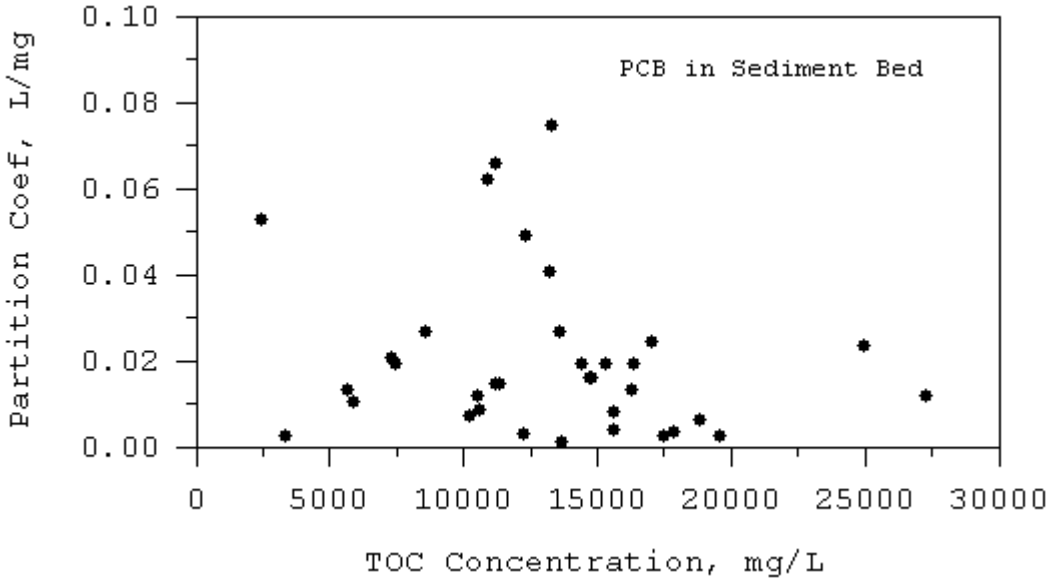


Figure 36. Equilibrium partition coefficient for PCB based on total solids (top panel) and total organic carbon (bottom panel) based on data collected in 2006

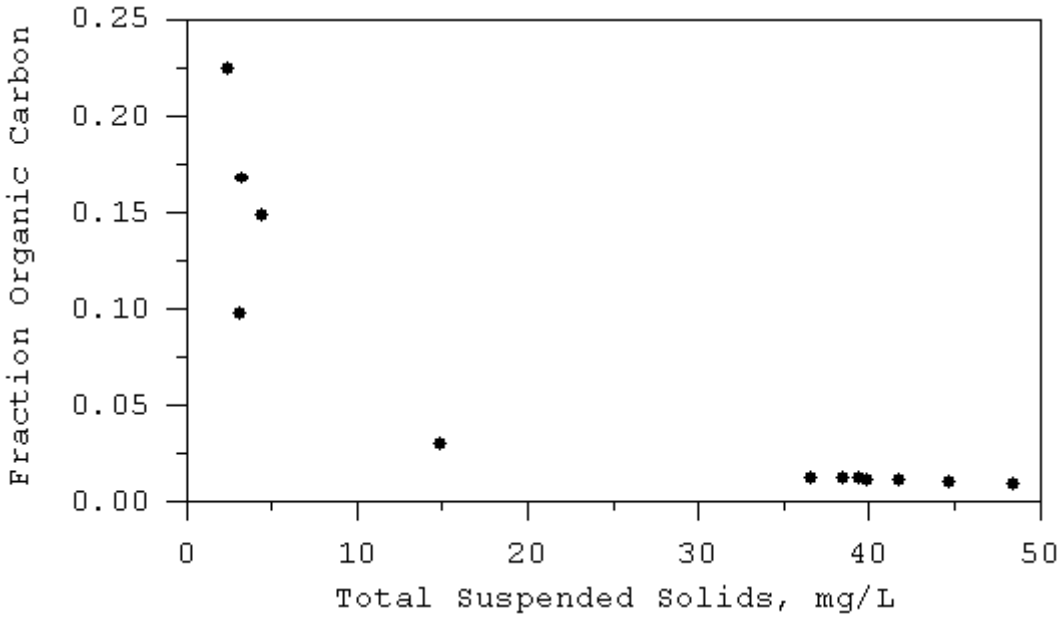


Figure 37. Fraction of organic carbon as function of total suspended solids concentration based on fall 2006 overlying water site data

7.4. External Loads and Open Boundary Conditions

External loads of sediment and contaminants are determined using point and non-point source inflows and corresponding sediment and contaminant concentrations. As noted in Section 4.7, hourly observed flows are preferentially used for the Los Angeles River with data gaps filled using flows simulated by the watershed model (Tetra Tech, 2010). Hourly watershed model flows were used exclusively for the Dominguez Channel and the San Gabriel River. In addition, daily non-point source flows from local near shore watersheds are provided by the watershed model (Tetra Tech, 2010). Since observational data for sediment and contaminant concentrations are not sufficient to combine with observed flows for the three major river inflows, hourly concentrations predicted by the watershed model are used for all watershed sources (Dominguez Channel, Los Angeles River, San Gabriel River, and near shore watersheds; Figure 4). Figure 38 shows an example of hourly inflow and inflowing sediment and copper concentrations for the Los Angeles River.

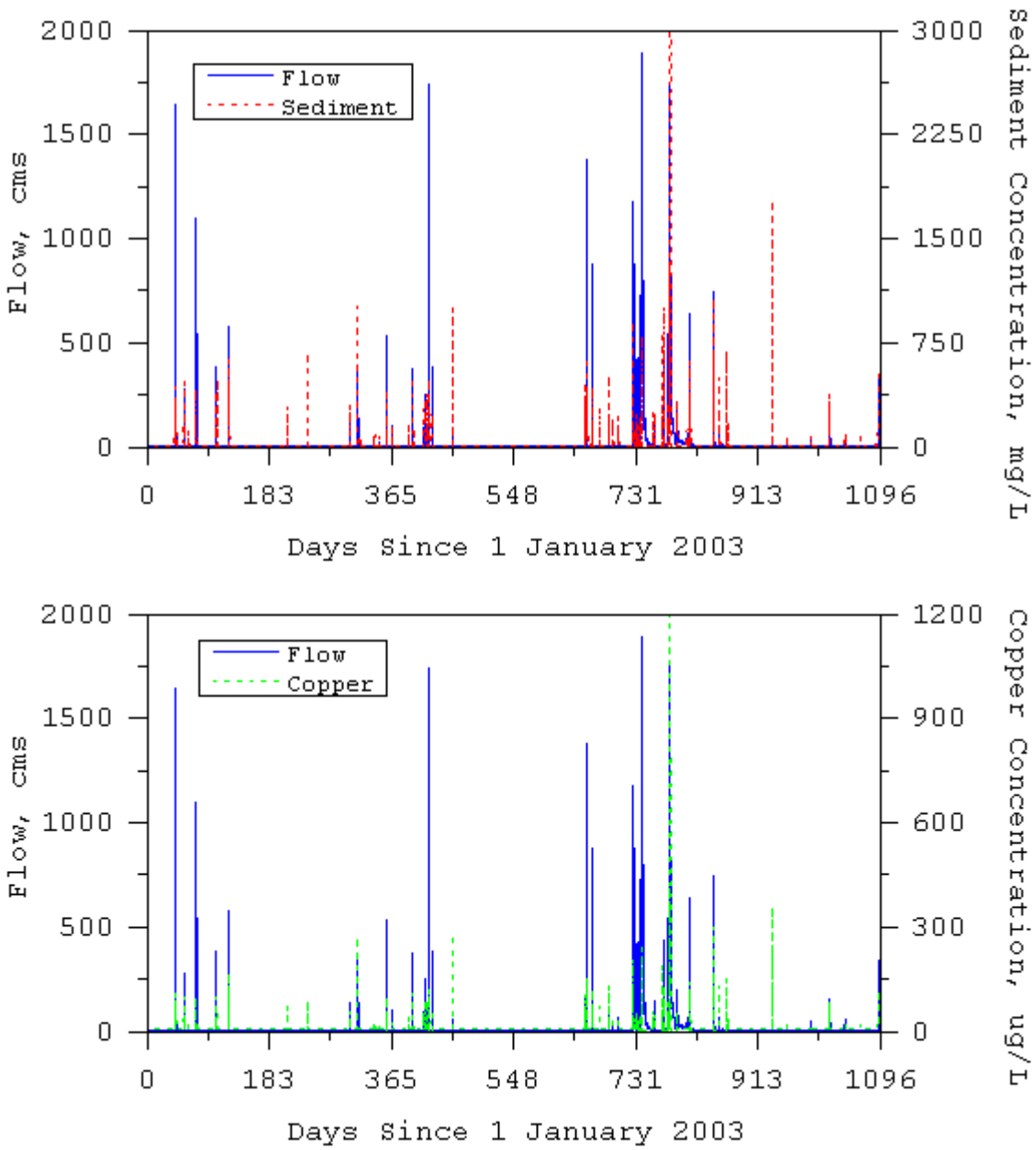


Figure 38. Examples of flow and inflowing sediment and copper concentration for the Los Angeles River

Table 23 presents the loadings by watershed for wet and dry conditions based on the watershed inputs to the EFDC model (presented as relative loading and average daily loads). These loadings were obtained from the observed flows and watershed model output. For metals, the concentrations were simulated directly using LSPC. The PAH concentrations were calculated using PAH EMCs, while the DDT and PBC concentrations were calculated by applying observed sediment concentrations to the LSPC simulated sediment concentrations (Tetra Tech, 2010). Sources of flow, which were multiplied by the concentrations to obtain watershed loads, varied by watershed, as described previously. Figure 4

illustrates the watersheds associated with each receiving waterbody. Loads for metals also included atmospheric dry deposition rates of 22, 14, and 160 µg/m^2-day, for copper, lead, and zinc, respectively (Sabin and Schiff, 2007).

Table 23. Sediment and Contaminant Loading by Watershed (based on LSPC model output)

	Loading by Watershed (1995-2005)							
	Dominguez Channel		Los Angeles River		San Gabriel River		Near Shore Watershed	
Contaminant	Percent of Total Loading	Average Daily Load (kg/day)	Percent of Total Loading	Average Daily Load (kg/day)	Percent of Total Loading	Average Daily Load (kg/day)	Percent of Total Loading	Average Daily Load (kg/day)
Wet Conditions								
Sediment	5.6%	1.88E+05	72.0%	2.79E+06	20.4%	4.90E+05	1.9%	6.54E+04
Copper	4.3%	3.58E+01	81.1%	7.85E+02	12.5%	7.51E+01	2.1%	1.78E+01
Lead	3.0%	2.08E+01	71.5%	5.67E+02	23.3%	1.15E+02	2.2%	1.53E+01
Zinc	5.0%	3.56E+02	72.2%	5.89E+03	20.2%	1.02E+03	2.6%	1.84E+02
DDT	9.2%	2.20E-02	89.5%	2.46E-01	0.7%	1.15E-03	0.7%	1.59E-03
PAH	8.0%	2.04E+00	70.2%	2.07E+01	16.1%	2.95E+00	5.8%	1.50E+00
PCB	2.3%	1.38E-02	97.5%	6.86E-01	0.1%	3.11E-04	0.2%	9.92E-04
Dry Conditions								
Sediment	0.7%	8.57E+01	19.0%	2.27E+03	80.1%	1.01E+04	0.1%	1.54E+01
Copper	2.6%	2.56E-01	48.7%	4.69E+00	40.8%	4.18E+00	8.0%	7.78E-01
Lead	0.9%	3.48E-02	19.8%	7.86E-01	72.9%	3.07E+00	6.5%	2.59E-01
Zinc	0.9%	5.65E-01	30.4%	1.90E+01	62.6%	4.15E+01	6.2%	3.89E+00
DDT	7.7%	1.90E-05	83.0%	2.01E-04	9.3%	2.38E-05	0.0%	2.88E-10
PAH	6.8%	7.06E-02	62.7%	6.39E-01	30.4%	3.29E-01	0.0%	4.18E-05
PCB	1.8%	1.06E-05	97.1%	5.59E-04	1.1%	6.43E-06	0.0%	1.45E-10

It is also important to consider the receiving waterbody associated with these watershed loadings. For Dominguez Channel, Los Angeles River, and San Gabriel River, all of their loadings (Table 23) are directly received by their downstream estuaries (Dominguez Channel Estuary, Los Angeles River Estuary, and San Gabriel River Estuary, respectively). The near shore watershed is more complicated because it consists of 67 subwatersheds. The loading from the individual subwatersheds was assigned to one or more adjacent shoreline grid cells in the EFDC model using weightings based on the adjacent shoreline length (Figure 39). (For example, the Inner Cabrillo Beach area is adjacent to only one near shore sub-watershed; whereas Inner Harbor is surrounded by numerous near shore inputs; see Figure 4 and Figure 39.) Loading to Cabrillo Marina is one exception to the load assignment methodology. Specifically, all of the loading from the upstream watershed is routed through the 22nd Street storm drain, directly to Cabrillo Marina (if the loads were assigned based on adjacent shoreline grid cells, the total load would be distributed among several waterbodies).

Table 24 presents the receiving waterbody and their loading for each pollutant from the near shore watershed (presented as relative loading and average daily loads). This table illustrates that Alamitos Bay and the Inner Harbor areas receive the bulk of the loading from the near shore watershed, which is expected since these two waterbodies have the largest near shore drainage areas. The relative inputs for a specific waterbody (such as Inner Harbor) from large or sub-watersheds will be evaluated in the future.

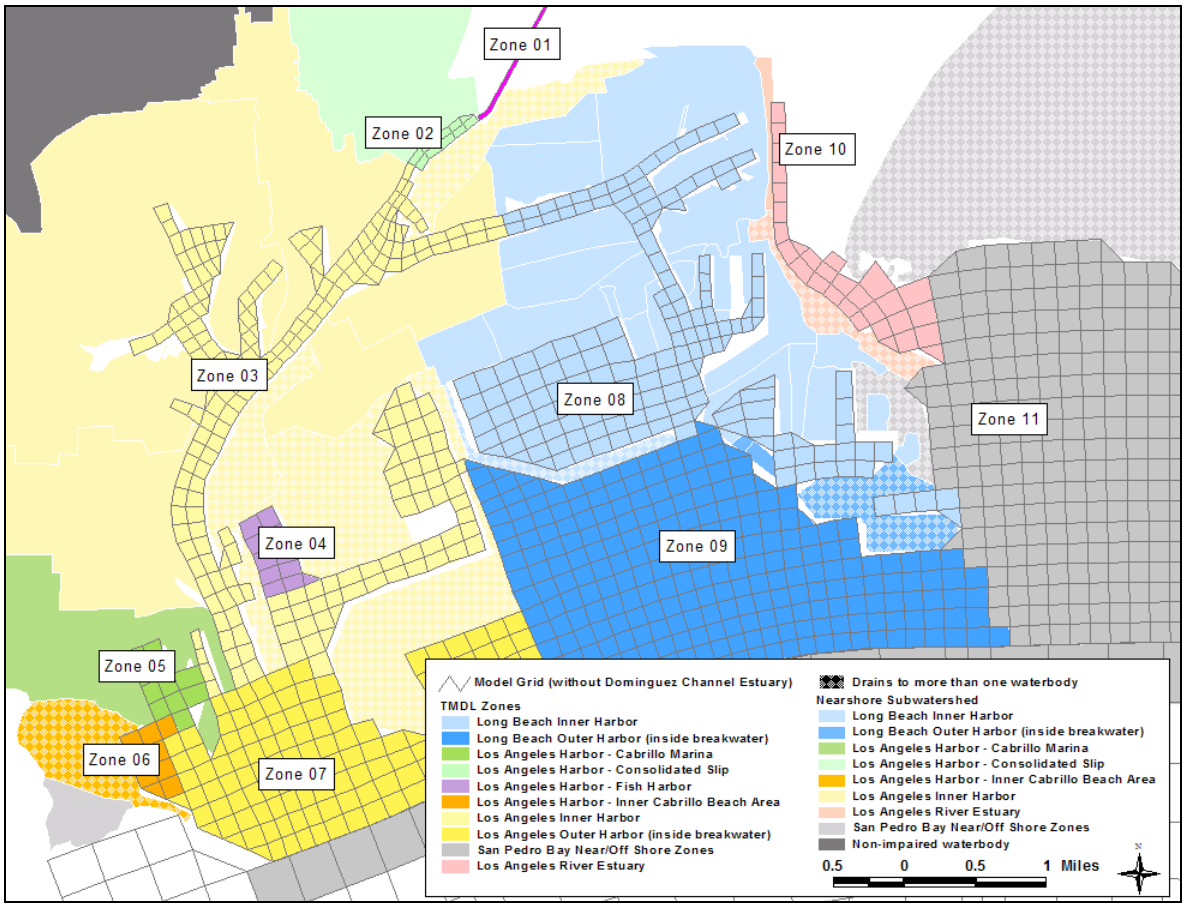


Figure 39. Nearshore Subwatersheds and Waterbody Designations

Table 24. Receiving Waterbody and Contaminant Loading from the Near Shore Watershed (based on LSPC model output)

Contaminant		Alamitos Bay	Los Angeles Harbor - Cabrillo Marina	Los Angeles Harbor - Consolidated Slip	Los Angeles Harbor - Fish Harbor	Los Angeles Harbor - Inner Cabrillo Beach Area	Los Angeles River Estuary	Los Angeles/Long Beach Inner Harbor	Los Angeles/ Long Beach Outer Harbor (inside breakwater)	San Pedro Bay Near/Off Shore Zones
Sediment	Percent of Total Loading	15.7%	1.5%	1.5%	0.5%	0.8%	7.3%	56.0%	6.7%	10.2%
	Average Daily Load (kg/day)	1.03E+03	9.80E+01	9.64E+01	2.98E+01	4.94E+01	4.76E+02	3.67E+03	4.37E+02	6.70E+02
Copper	Percent of Total Loading	54.9%	7.3%	0.1%	1.2%	0.4%	0.6%	26.1%	3.1%	6.2%
	Average Daily Load (kg/day)	1.36E+00	1.81E-01	1.50E-03	3.04E-02	1.11E-02	1.52E-02	6.46E-01	7.75E-02	1.54E-01
Lead	Percent of Total Loading	59.9%	6.6%	0.1%	1.1%	0.4%	0.5%	23.1%	2.5%	5.9%
	Average Daily Load (kg/day)	1.05E+00	1.16E-01	9.29E-04	2.02E-02	6.49E-03	9.03E-03	4.06E-01	4.37E-02	1.04E-01
Zinc	Percent of Total Loading	59.5%	6.4%	0.1%	1.0%	0.3%	0.6%	23.3%	2.8%	5.9%
	Average Daily Load (kg/day)	1.30E+01	1.40E+00	1.23E-02	2.28E-01	7.32E-02	1.31E-01	5.11E+00	6.08E-01	1.30E+00
DDT	Percent of Total Loading	15.5%	7.1%	0.1%	2.2%	0.4%	2.4%	64.8%	5.6%	2.0%
	Average Daily Load (kg/day)	2.46E-05	1.12E-05	9.93E-08	3.43E-06	5.77E-07	3.78E-06	1.03E-04	8.93E-06	3.25E-06
PAH	Percent of Total Loading	53.5%	6.7%	0.1%	1.3%	0.4%	0.6%	27.2%	2.6%	7.6%
	Average Daily Load (kg/day)	8.04E-02	1.01E-02	1.32E-04	1.97E-03	6.46E-04	9.16E-04	4.08E-02	3.87E-03	1.14E-02
PCB	Percent of Total Loading	11.0%	5.8%	0.0%	2.5%	0.3%	2.7%	69.7%	6.4%	1.5%
	Average Daily Load (kg/day)	1.10E-05	5.71E-06	4.46E-08	2.47E-06	2.97E-07	2.68E-06	6.92E-05	6.32E-06	1.53E-06

Suspended sediment and contaminant concentration must be specified on the model open boundaries in San Pedro Bay (Figure 1). Suspended sediment (TSS) concentrations on all three open boundaries were set to a value of 2.0 mg/L based on limited measurements during the Bight 03 study. Water column concentrations of copper, lead, and zinc were set to 0.10, 0.03, and 0.30 µg/L based on greater harbors observations during 2005 and 2006 taken near and immediately outside of the breakwater (Figure 32). Water column concentrations of DDT, PAH, and PCB were set to 0.25, 100.0, and 0.015 ng/L. Values for DDT and PCB were based on those reported by Zeng and Tran (2002) and Zeng, et al. (2005). Values for PAH were based on greater harbors observations during 2006 take near and immediately outside of the breakwater (Figure 32; 2006 sample locations only).

8. Sediment and Contaminant Transport Calibration

Model calibration involves the adjustment of selected model input parameters to achieve a best or targeted level of agreement between model predictions and observations. The level of agreement can be judged by combinations of qualitative methods, usually visual comparison, or quantitative methods, such as those discussed in Appendix B of this document. Subsequent validation of a calibrated model involves using the same procedures to judge the level of agreement between model predictions and a different set of observations not used for calibration. Preferably the observations used for validation should represent hydrodynamic and transport conditions different from those under which the calibration observations were obtained. In many situations, particularly when the cost of obtaining multiple observation data sets is prohibitive, calibration and validation cannot be unique activities and validation is often foregone or replaced by sensitivity analysis. Since the availability of water column sediment and contaminant data in the greater LA/LB Harbor waters precludes formal validation, sensitivity analysis was conducted (see Appendix C and Appendix D). Specifically, the dry weather sensitivity of water column sediment and contaminant concentration prediction to changes in river and watershed loads, open boundary conditions, and sediment erosion rates were analyzed (Appendix C). Long-term sensitivity was also evaluated by comparing water column and sediment bed concentration results from simulations using baseline conditions and a 50 percent reduction in river and watershed loading (Appendix D).

The observational data available for sediment and contaminant transport model calibration and validation is sparse to the extent that only a calibration effort can be undertaken. As discussed in the preceding section, observational data defining conditions in the sediment bed were used for model initialization and are not appropriate for use in calibration. Instead, the calibration approach taken in this study is to use observational data in the water column for model calibration. Observational data in the water column includes sediment and contaminant concentrations measured near the bottom of the water column during fall 2006. This data set is referred to as the overlying water observations since they were taken at the same locations as the in bed observations (Figure 22). Specifically, the data set includes total suspended sediment concentration and total concentration of the six contaminants sampled at one instance in time. Two additional water column data sets taken at mid-depth in the water column during 2005 and 2006 (Figure 32) provide observations of total and particulate concentrations of the three metals. Total suspended solids information, which would allow definition of phase distribution in these metal data sets, was not recorded. Subsequently, six of the sites sampled in 2005, were sampled for mid-water column total suspended solids in 2007. The following two sections further discuss the calibration approach and present results for sediment and contaminants.

8.1. Sediment Transport Calibration

The degree of calibration of the sediment transport model is evaluated using sediment concentrations at 59 fall 2006 overlying water sites (Figure 22; 59 of the 60 stations had TSS data for comparison) and six of the 2005 mid-water column sites (Figure 32) which were sampled for suspended sediment concentration in fall 2007. For comparison with the instantaneous observations, taken under dry fall conditions (many of which were from 2006-2007, which is outside of the modeling period, but used for comparison since dry conditions are expected to be relatively constant), model predictions were averaged over a six month dry season period. Figure 40 shows the continuous model predictions at a representative site with the instantaneous observation value shown as a dashed line. The early transient shown in this figure is due to suspended sediment remaining in the system after high flows in January through March 2005. The differences between observed and predicted values are less than approximately 5 mg/L and within a factor of two, which is considered a good fit. Model predicted (dry season in 2005) and observed sediment concentration at the 2006 overlying water sites and the 2007 mid-water column sites are shown in Figure 41 (note: some 2006 observed data with higher TSS concentrations were removed as they were not considered representative of dry weather concentrations and were assumed associated with navigational activities in the Ports). Model predicted concentrations are reasonable; however, a quantitative measure of agreement would be extremely low. The average predicted values show somewhat less variation than observations, although Figure 40 shows that instantaneous predictions can vary significantly about the mean. It is important to note that due to the lack of observed data during the modeling period, the model predicted results from 2005 were compared to data collected in 2006 and 2007. Given these different time periods, the model does well capturing the range of dry weather conditions.

Calibration parameters for suspended sediment traditionally include effective diameters for noncohesive size classes, settling velocity and erosion rate for the fine cohesive size class, loading relationships, and open boundary conditions. Best estimates for all of these parameters were used for model configuration. The primary adjustment made during calibration was setting the noncohesive sediment class diameter to 0.125 mm so that excess erosion did not occur in San Pedro Bay and override the observational based boundary conditions. For the fine cohesive sediment, which represented more than 90 percent of the model predicted water column sediment, sensitivity of predictions with respect to settling velocity were conducted. Lower and higher settling velocities increased disagreement between predictions and observations at most stations. Increasing and decreasing the base cohesive sediment erosion rate coefficient (α in equation 5) resulted in similar responses using lower and higher settling velocities. Ultimately, the settling velocity for the cohesive sediment class was adjusted based on extremely limited water column TSS data.

8.2. Contaminant Transport Calibration

The degree of calibration of the contaminant transport model is evaluated using contaminant concentrations at the 60 fall 2006 overlying water sites (Figure 22) and the 2005 and fall 2006 mid-water column sites (Figure 32). As previously noted, the mid-water column sites only have data for the three metals. Overlying water sites failed to provide detectable concentrations of PCB, resulting in no calibration results being presented for PCB other than confirmation that the model predicted water column PCB levels were below detection limits. As was done for the sediment comparison, contaminant concentrations were averaged over the six-month dry season period from May to October 2005 for comparison with instantaneous observations taken during dry fall conditions.

Figures 42 through 44 show comparisons of model predictions and observations for total copper, lead, and zinc. The comparisons show extensive scatter, but model predicted levels are within the range of observations. For copper, the model predictions have a similar level of variability as the observations. For lead, the model predicts a larger range of concentrations than the observational data. Zinc predictions show a greater range of predictions as well. Predicted copper, lead, and zinc concentrations are significantly larger than boundary conditions values of 0.01, 0.03, and 0.3 μg/L, respectively, suggesting that the boundary forcing is of secondary significance (which is supported by the sensitivity analyses presented in Appendix C). Figures 45 and 46 show comparisons of predicted and observed total concentrations of DDT and PAH. The range of DDT predictions is similar to the range of observations with both being at least four times the open boundary value of 0.25 ng/L. Predictions for PAH show more variability than observations and many are greater than the boundary condition value of 100 ng/L. The use of time invariant PAH input concentrations in excess of 1000 ng/L is likely the cause of these larger concentrations.

8.3. Dry Season Sensitivity Analysis

A dry season sensitivity analysis was conducted for May to October 2005 to determine the influence of open boundary concentrations, watershed loads, and sediment bed erosion rates on model predictions. These results are presented in Appendix C. Open boundary conditions, representing ambient or background concentrations in San Pedro Bay, result from much larger scale distributed sources than the greater LA/LB Harbor watersheds, and cannot be readily controlled with respect to a localized watershed-scale TMDL. In this respect, demonstration of low sensitivity to open boundary conditions is desirable. A moderate to high sensitivity with respect to river and watershed loads indicates that these sources are primarily responsible for observed levels of contamination. In water bodies having significant existing or legacy contaminant of the sediment bed, net flux of sediment, metals, and organics from the bed to the water column

due to erosion and slower diffusive flux can represent a significant source to the water column.

For the organics and, to a certain extent, zinc, the sensitivity analyses suggest that a reduction of land-derived loads may result in lower levels of water column contamination. In addition, sediment bed erosion was found to be a significant source of contamination. Pollutant load reductions may be achieved by implementation measures either individually or in combination. Such implementation measures may include, but are not limited to, reducing watershed and river inflows of contaminated sediments (but not necessarily clean sediment), localized capping or sediment removal, and gradual replacement of incoming contaminated sediment with clean sediment (to reduce contaminant flux from the sediment bed since the new deposited cleaner sediment would lower contamination levels).

8.4. Sensitivity to Long-Term Load Reductions

To compliment the dry season sensitivity analysis and demonstrate the application of the model to investigate load allocations, two long-term simulations were conducted (Appendix D). Both simulations examined several pollutants (copper, zinc, DDT, and PAHs) and spanned a four year period from 2002 through 2005. The first (or baseline) simulation used watershed model estimated sediment and contaminant loads (i.e., the baseline conditions from the calibrated model). The second (or load reduction) simulation used sediment and contaminant loads which were reduced by 50 percent for inputs from both the rivers and near shore watersheds. The sensitivity analysis results are presented in both time series graphs and maps illustrating changes in contaminant level over the four year period.

Results for both copper and zinc indicate decreases in water column concentrations during periods of high flow, when comparing the baseline conditions with the 50 percent load reduction scenario. In addition, after the four-year period, the copper and zinc sediment bed concentrations associated with the 50 percent load reduction scenario were lower than baseline. The spatial maps of copper and zinc indicate that a 50 percent reduction of incoming loads results in a system-wide reduction in sediment bed concentrations.

Similar to the metals, DDT and PAH concentrations in the water column decrease during periods of high flow when comparing the baseline conditions with the 50 percent load reduction scenario. Sediment bed contaminant concentration for both DDT and PAH showed a continual decrease for all stations and both scenarios, consistent with a net flux into the water column. Whereas the metals sediment bed concentrations do not show a continuous decrease, the flux of DDT and PAH is due to pore water diffusion from the top layer of the sediment bed into the water column. The pore water concentrations of DDT and

PAH are extremely high compared with dissolved phase water column concentration and provide a strong gradient to drive diffusive flux into the water column. This is also supported by the observation that during dry or low inflow periods, water column DDT and PAH concentrations are similar. As illustrated by the maps, the spatial pattern is somewhat similar for the two organics except near the Los Angeles River inflow. In contrast to the metals, the reduction of DDT and PAH loads do not show a wide spatial response, which is consistent with the model-predicted flux of dissolved phase DDT and PAH into the water column from the sediment pore water.

Overall, the simulations showed that water column contaminant concentrations were lower for the reduced load simulation during wet period events and that sediment bed contaminant levels were lower after the four year period for the reduced load simulation. These results suggest that the model could be used to evaluate spatially distributed and wet weather magnitude-based load reduction scenarios. Detailed discussion of the simulations are presented in Appendix D.

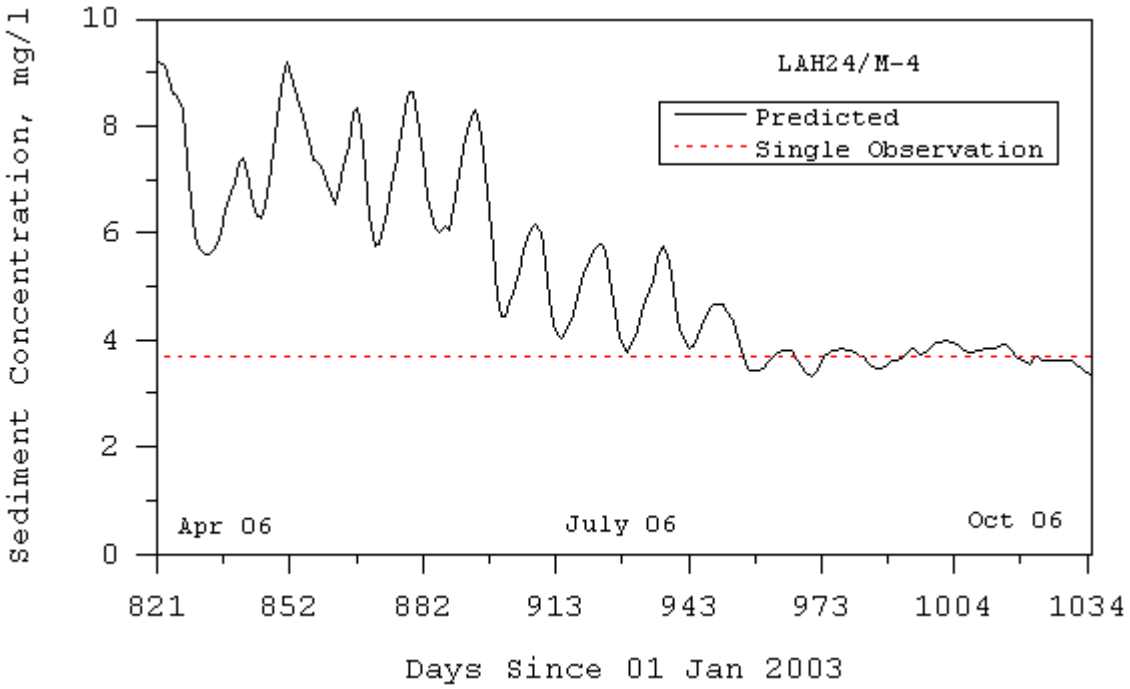
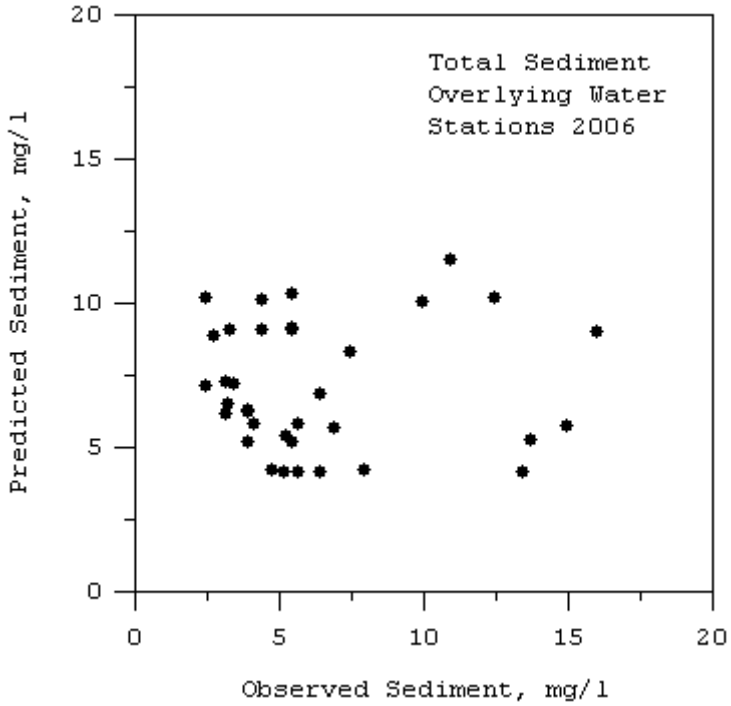


Figure 40. Comparison of model predicted and single observed sediment.



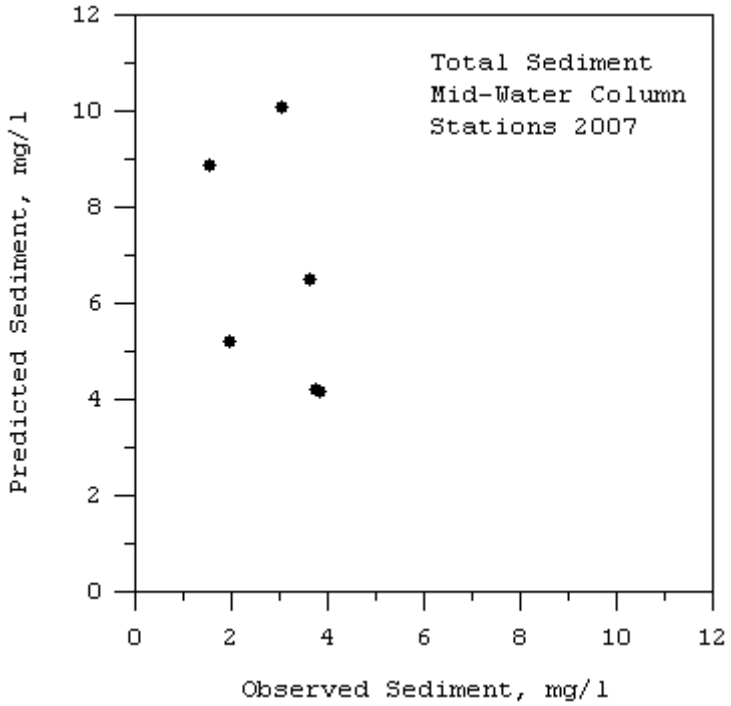
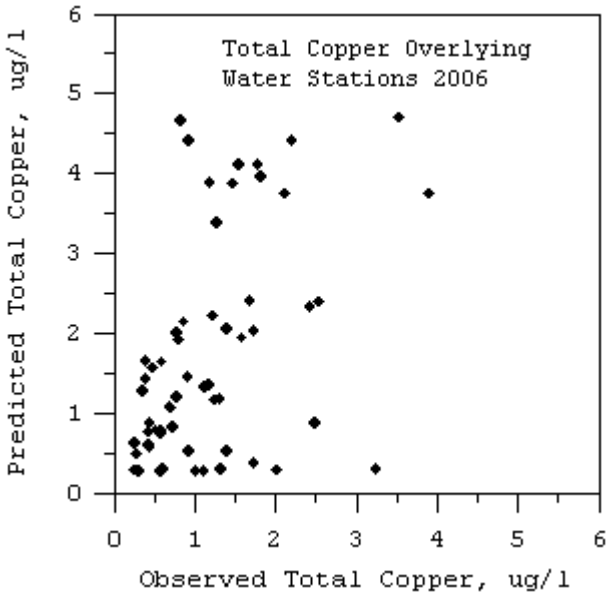
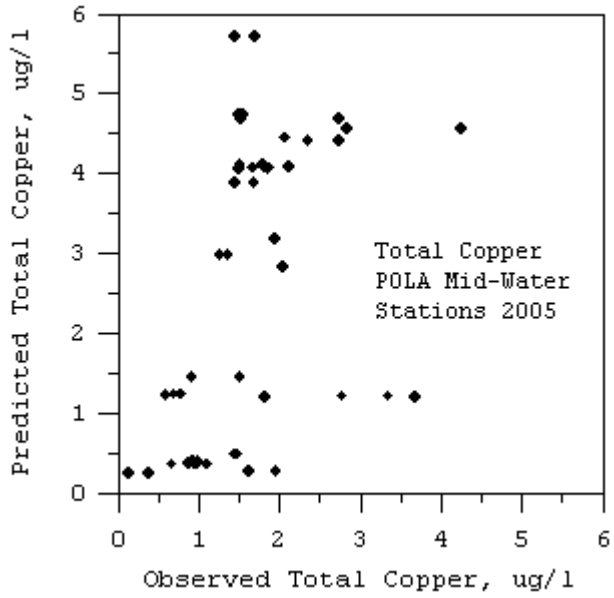


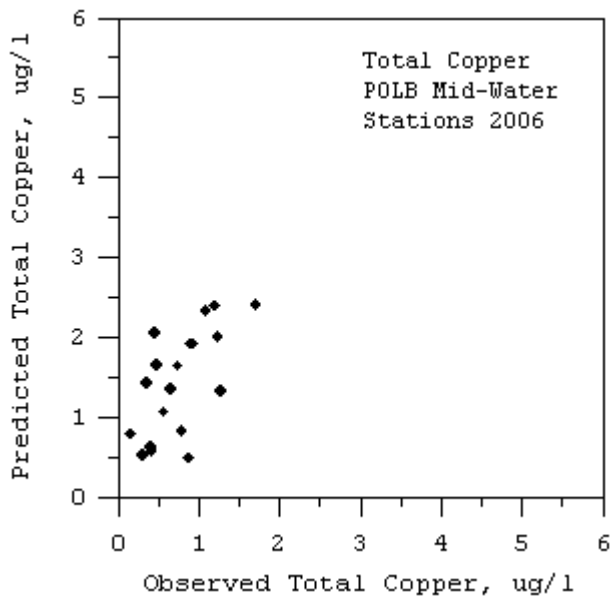
Figure 41. Comparison of model predicted and observed sediment concentration at the 2006 overlying water sites and 2007 mid-water column sites



(a)



(b)



(c)

Figure 42. Comparison of model predicted and observed copper concentration at the overlying water and mid-water column sites

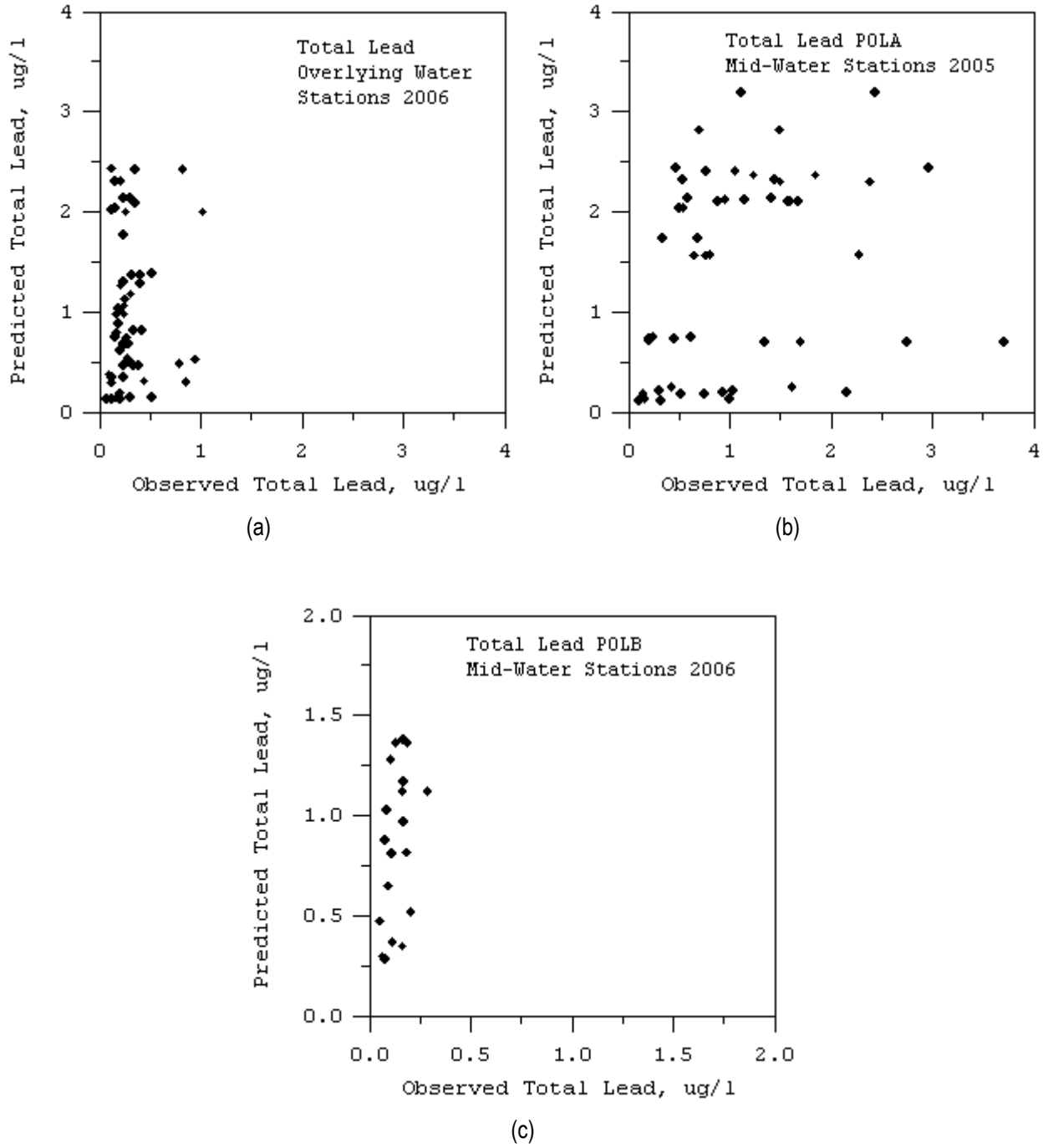


Figure 43. Comparison of model predicted and observed lead concentrations at the overlying water and mid-water column sites

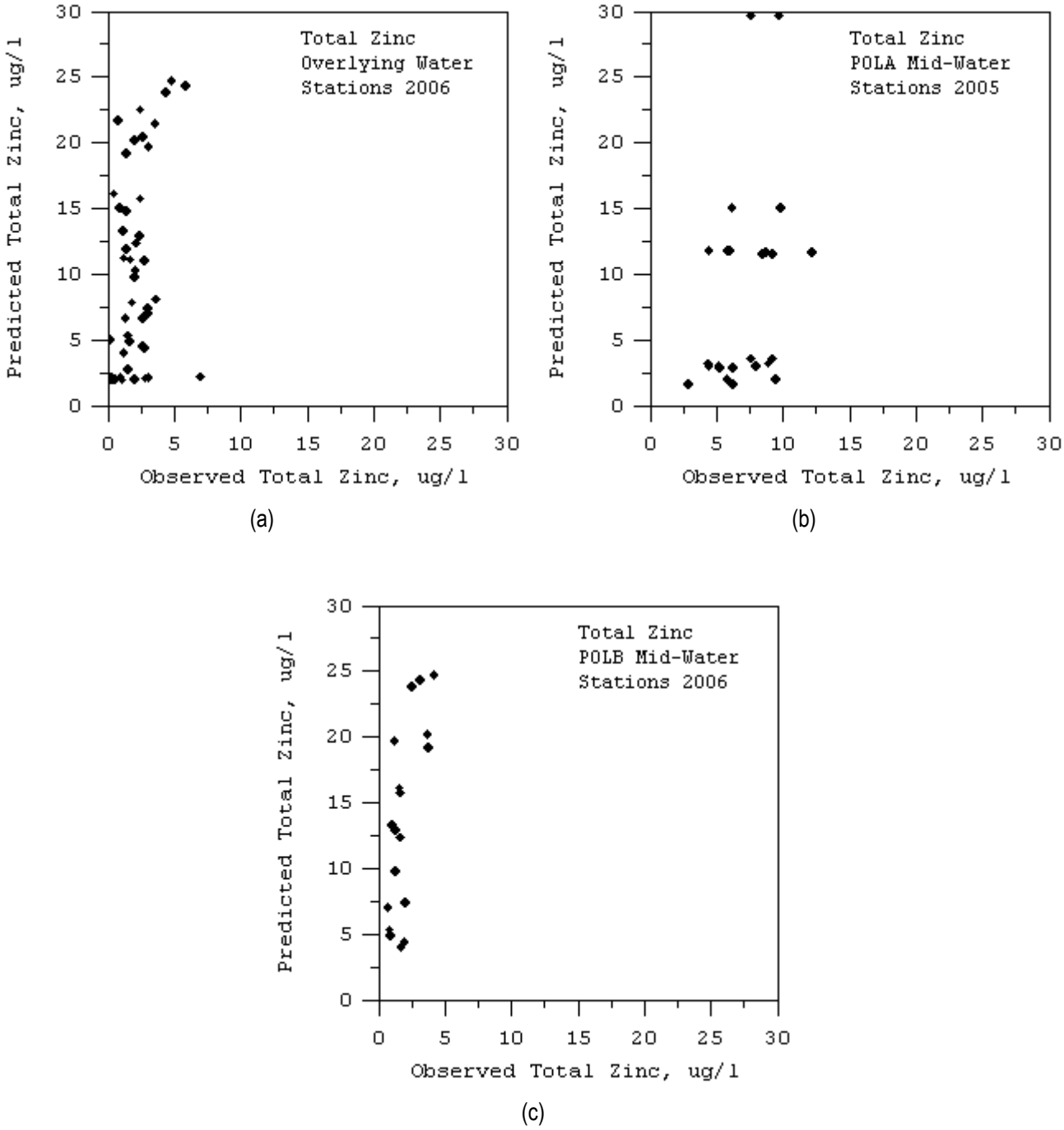


Figure 44. Comparison of model predicted and observed zinc concentration at the 2006 overlying water and mid-water column sites

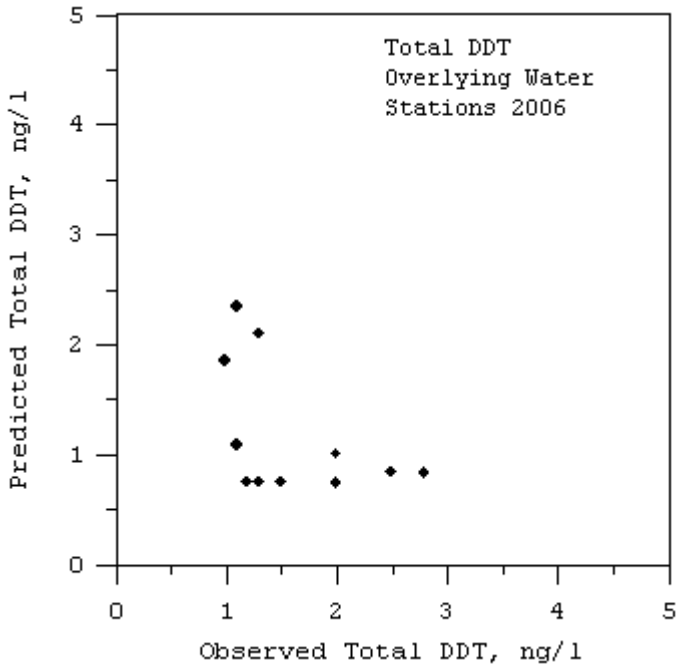


Figure 45. Comparison of model predicted and observed DDT concentration at the 2006 overlying water column sites

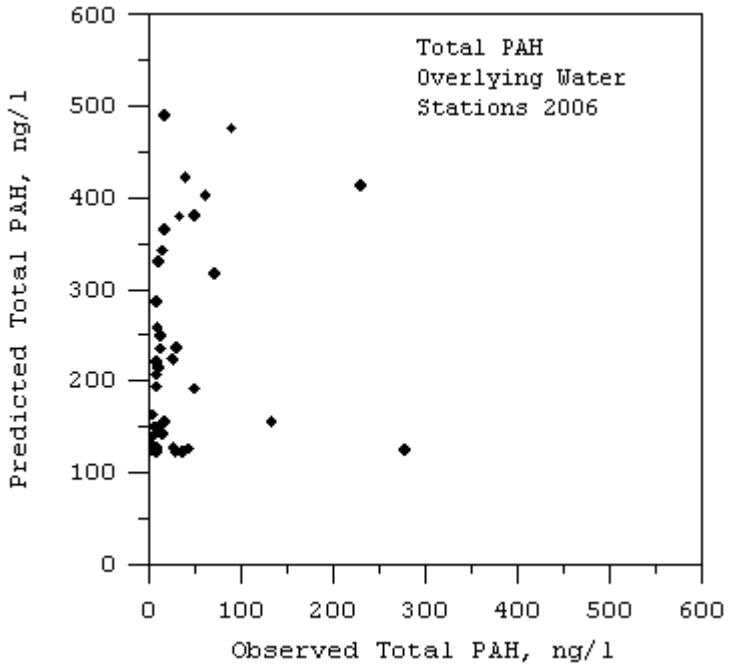


Figure 46. Comparison of model predicted and observed PAH concentration at the 2006 overlying water sites

9. Summary and Recommendations

This report summarizes the calibration of a fully coupled EFDC based hydrodynamic, sediment transport, and contaminant transport and fate model for the greater Los Angeles/Long Beach Harbors and adjacent region of San Pedro Bay. Observational data to support model configuration and calibration were reviewed and judged adequate to very adequate for model configuration. Tide gauge and current meter data were very adequate for hydrodynamic calibration and the level of calibration is consistent with other hydrodynamic modeling studies of similar scope. Due to the event-driven character of fresh water inflow into the greater LA/LB Harbor waters, salinity data sets lacked significant variability to fully evaluate salinity transport calibration as compared to studies in other estuaries and coastal harbors having continuous freshwater inflow.

Sediment and contaminant data were adequate for model configuration, which focused on establishing sediment bed initial conditions. Water column data for suspended sediment concentration are very limited and tend to constrain the level of calibration which can be achieved, although field observations during fall 2006 significantly enhanced the base of data. Water column data for metals concentration are more extensive, but metal calibration is still limited by the water column sediment transport calibration. Water column data for DDT and PAH are also limited and data for PCB indicate that levels are below detection limits. Dry weather sensitivity analyses were conducted to determine the influence of open boundary concentrations, watershed loads, and sediment bed erosion rates on water column, sediment, and contaminant concentration levels (Appendix C). Long-term sensitivity was also evaluated by comparing water column and sediment bed concentrations associated with baseline conditions and a 50 percent reduction in river and watershed loading (Appendix D). In contrast to hydrodynamic and eutrophication modeling studies in estuarine and coastal regions, extensive literature is not available for establishing what constitutes an acceptable level of calibration for sediment and contaminant transport modeling. However the calibration results presented herein demonstrate that use of available data combined with best estimates of required model parameters do yield model predictions well within the range of observations.

The EFDC based hydrodynamic, sediment transport, and contaminant transport and fate model for the greater Los Angeles/Long Beach Harbors and adjacent region of San Pedro Bay is judged suitable for use in TMDL development. Although the model does not always precisely predict individual observations, it has been demonstrated to respond appropriately to load reductions and is therefore considered useful for load reduction scenarios and implementation alternatives. As previously noted, the LA/LB Harbors grid is not modeled as a closed system; water, sediment, and associated pollutant loads can be exchanged both in and out of the model grid through the open ocean boundary.

The model provides a rigorous framework for contaminant response surface development with respect to the major sources including land-based loadings, net flux of legacy contaminants for the sediment bed, and open boundary driven loads. The attention given to the development of initial conditions for the sediment bed makes the modeling framework particularly useful in determining difficult to control source contributions from the sediment bed. Likewise the ease in model reconfiguration to adjust incoming contaminant levels on a sub-watershed scale will allow focused allocations to be developed.

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Appendix A: Salinity Time Series Calibration Plots

FINAL

May 2011

Prepared for:
USEPA Region 9
Los Angeles Regional Water Quality Control Board

Prepared by:
Tetra Tech, Inc.

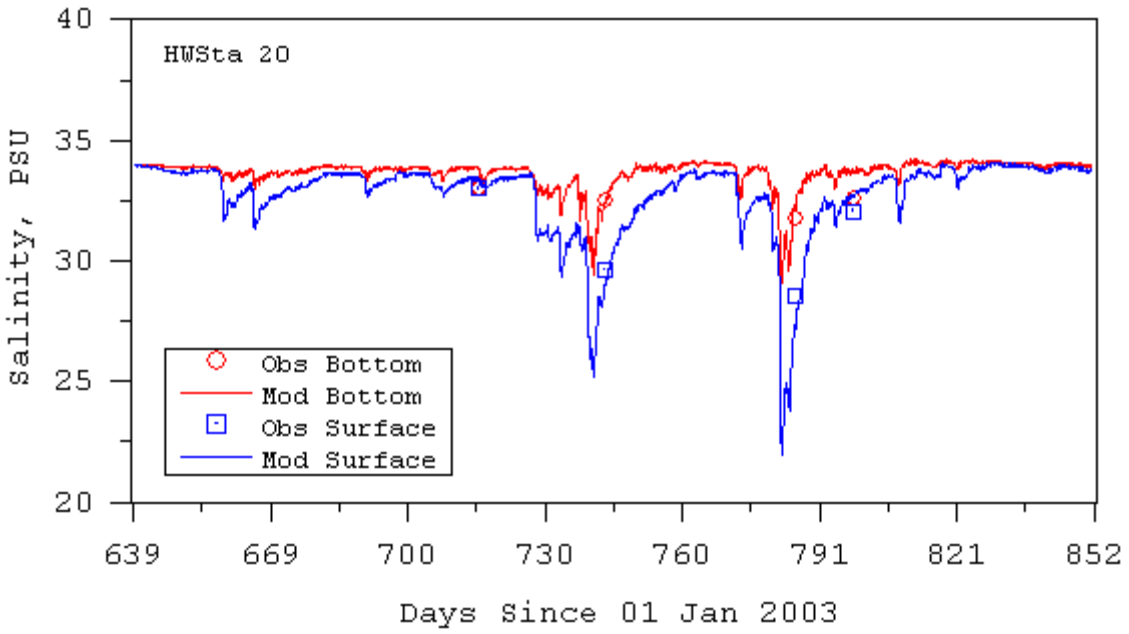

Figure A-1. Model Predicted and Observed Salinity at LAH Station 20

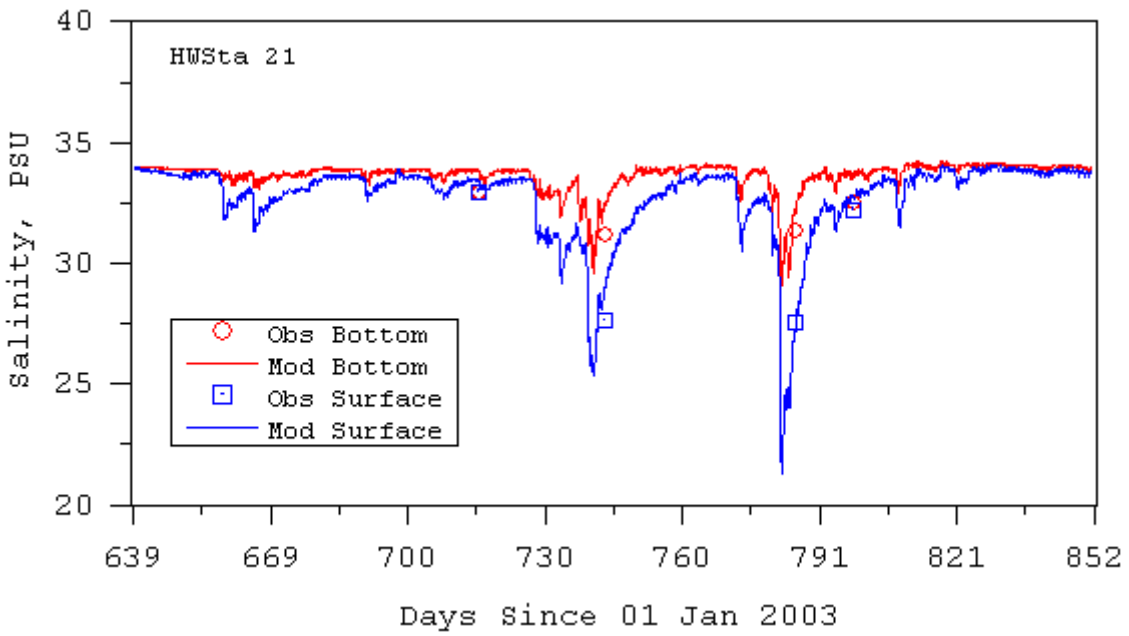

Figure A-2. Model Predicted and Observed Salinity at LAH Station 21

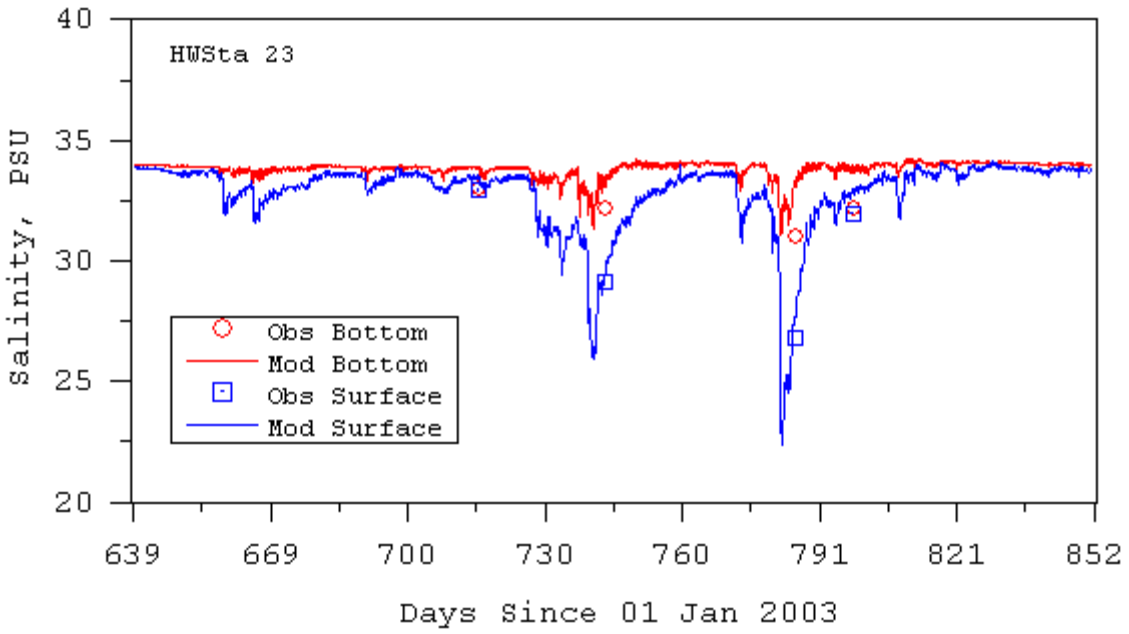

Figure A-3. Model Predicted and Observed Salinity at LAH Station 23

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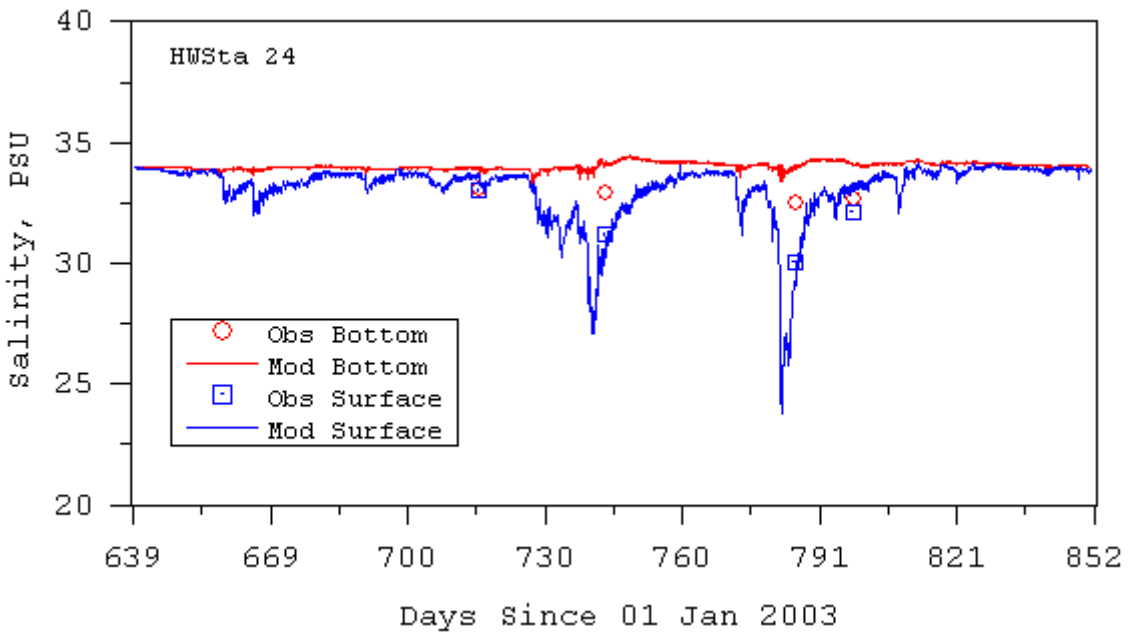

Figure A-4. Model Predicted and Observed Salinity at LAH Station 24

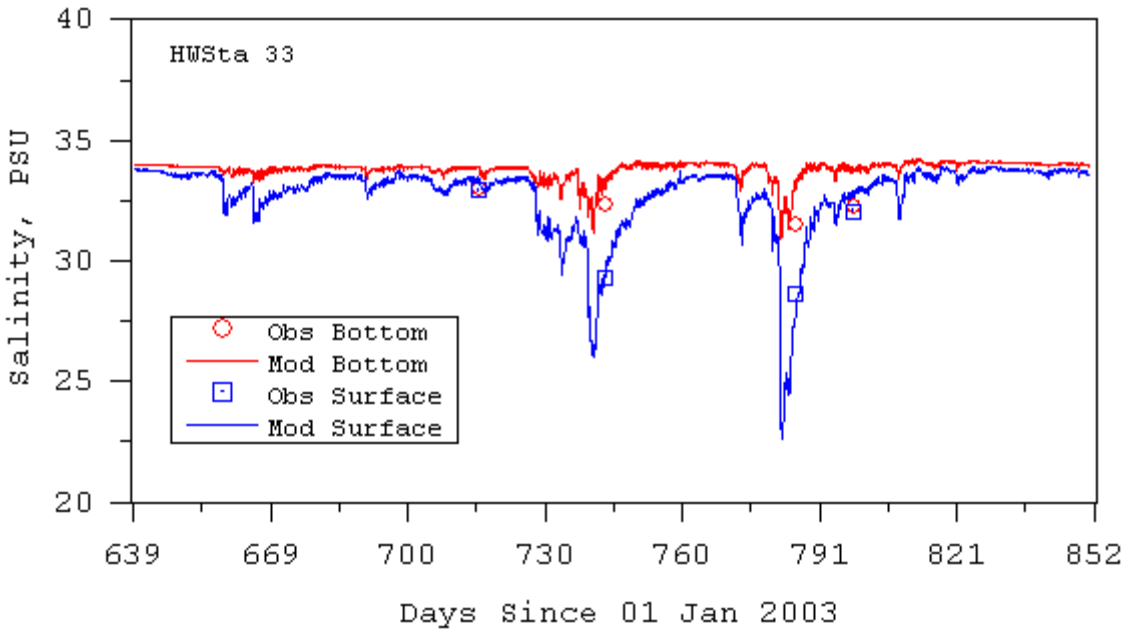

Figure A-5. Model Predicted and Observed Salinity at LAH Station 33

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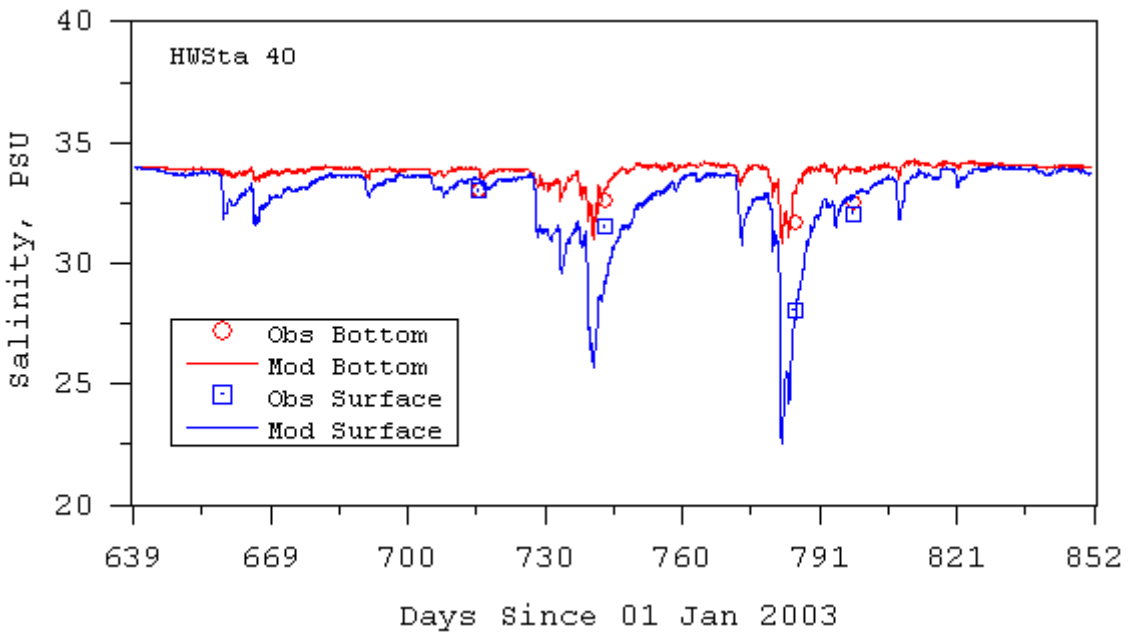


Figure A-6. Model Predicted and Observed Salinity at LAH Station 40

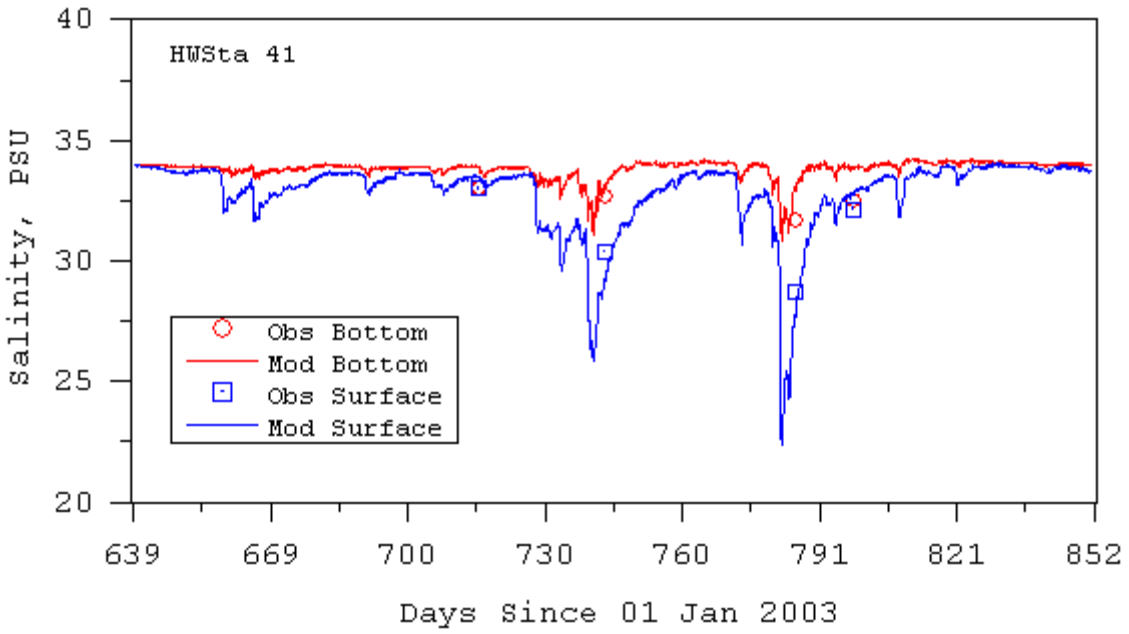


Figure A-7. Model Predicted and Observed Salinity at LAH Station 41

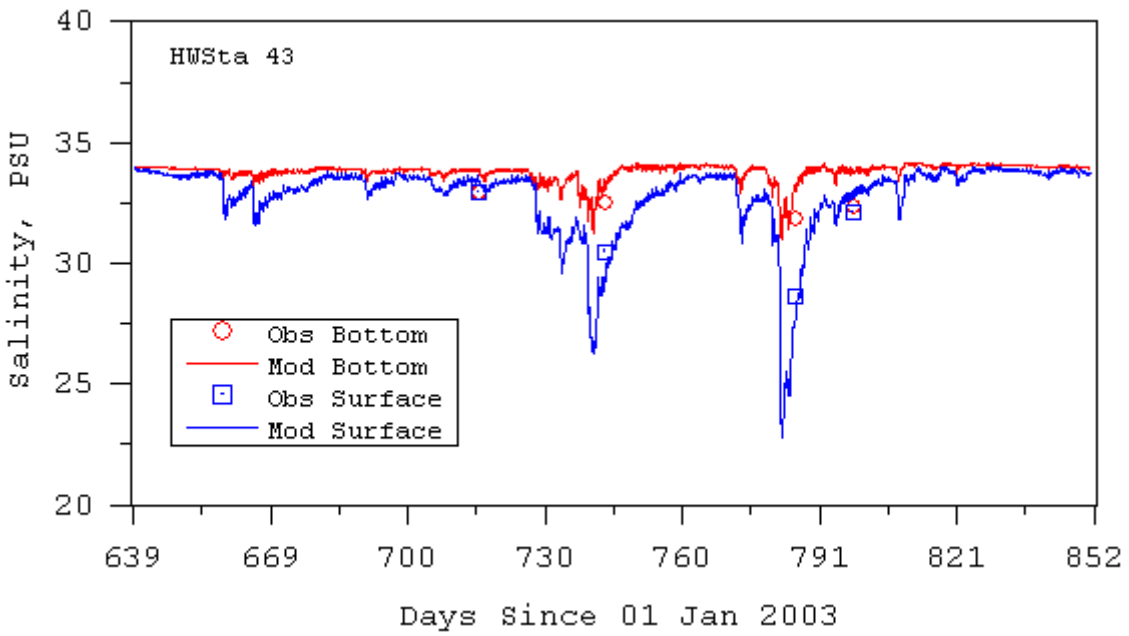


Figure A-8. Model Predicted and Observed Salinity at LAH Station 43

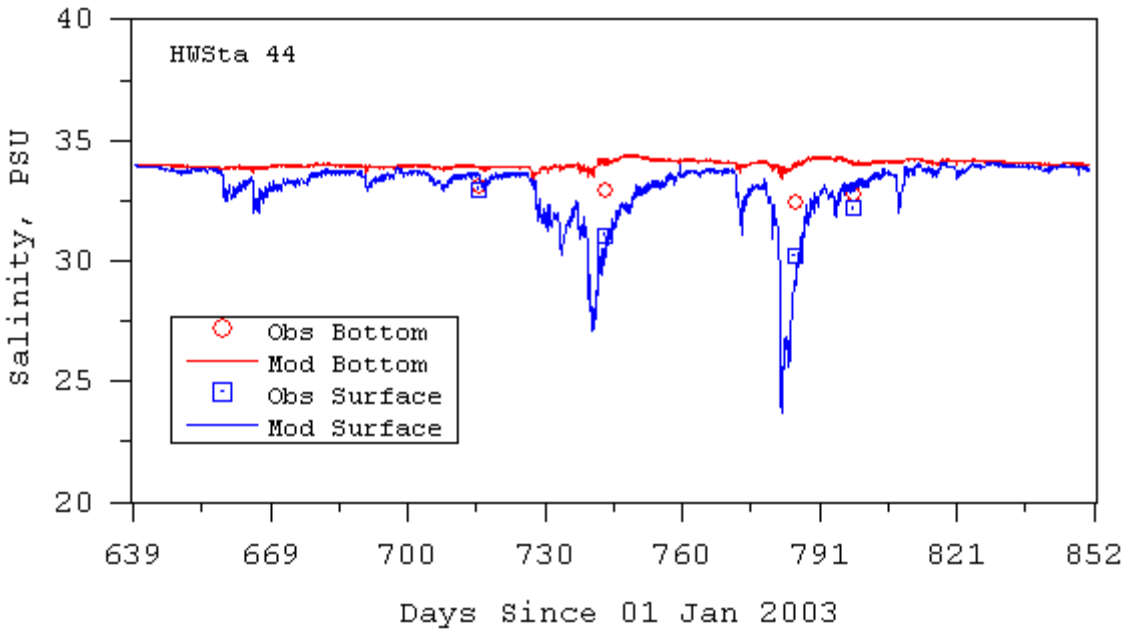
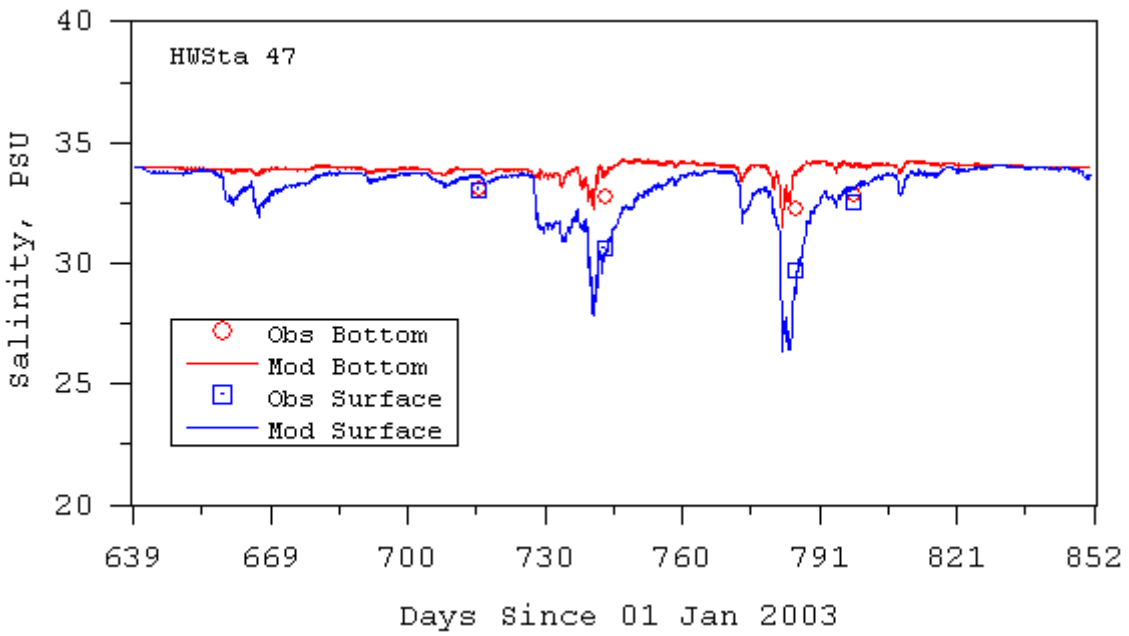


Figure A-9. Model Predicted and Observed Salinity at LAH Station 44



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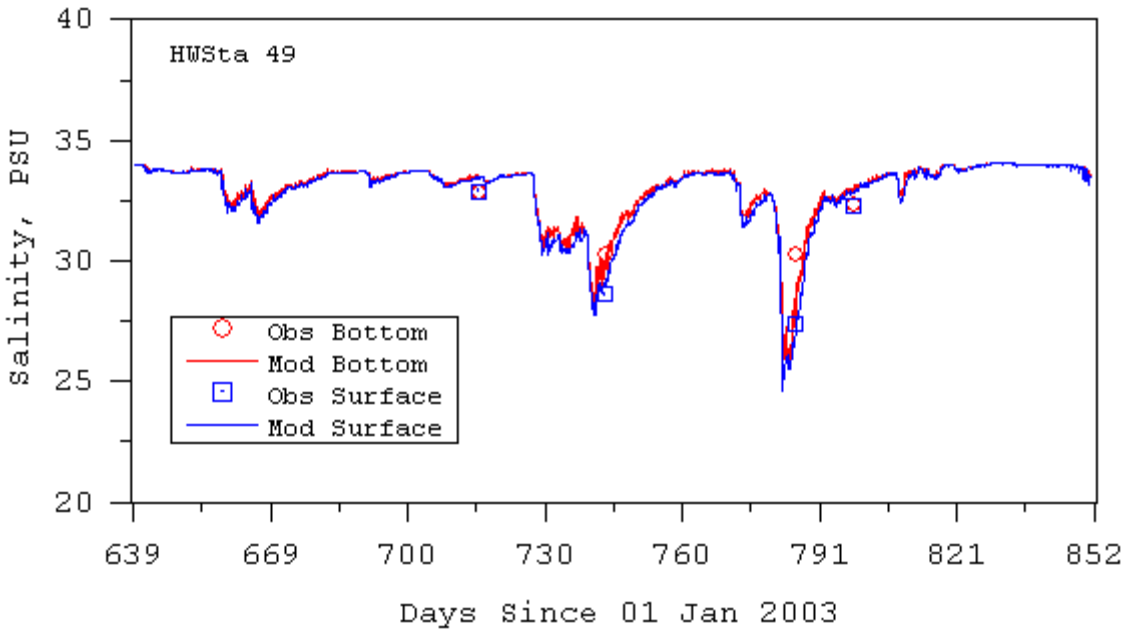

Figure A-11. Model Predicted and Observed Salinity at LAH Station 49

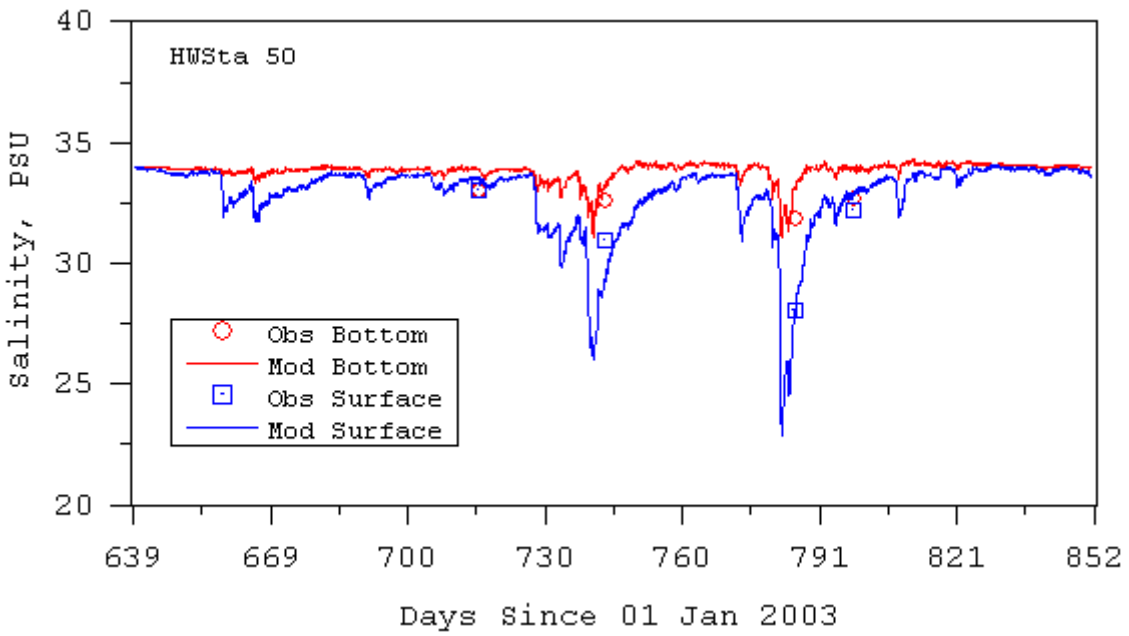

Figure A-12. Model Predicted and Observed Salinity at LAH Station 50

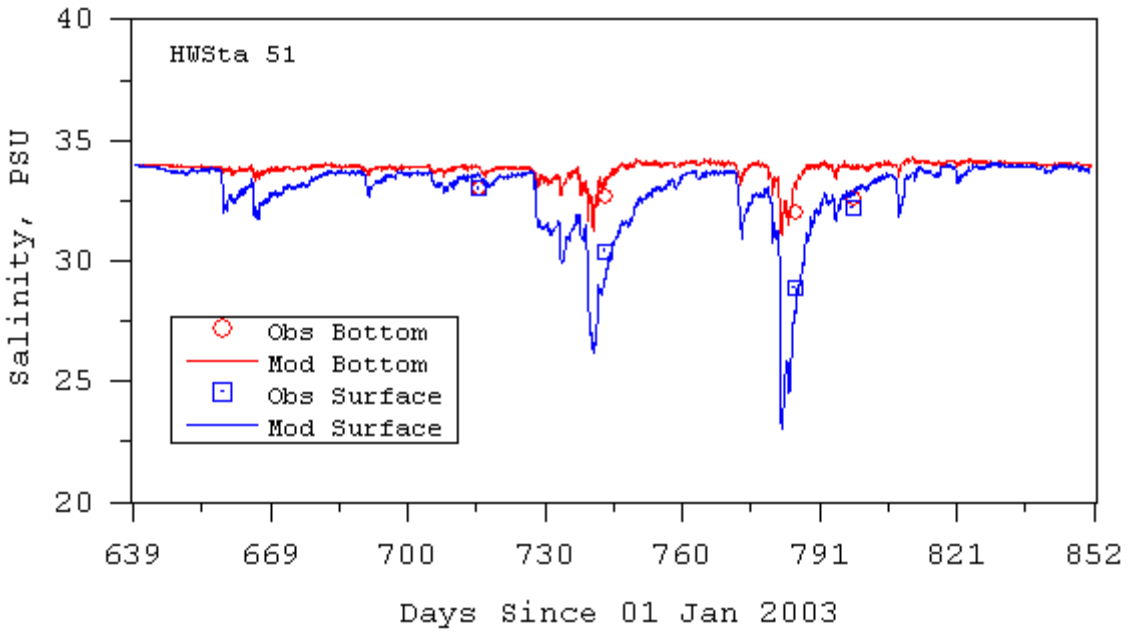

Figure A-13. Model Predicted and Observed Salinity at LAH Station 51

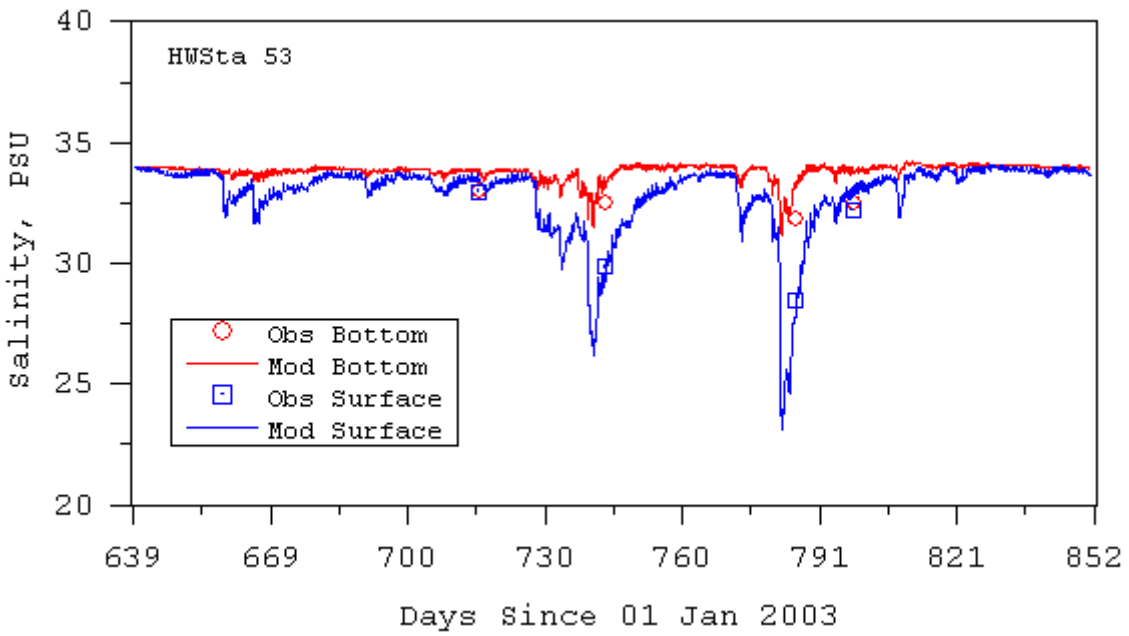

Figure A-14. Model Predicted and Observed Salinity at LAH Station 53

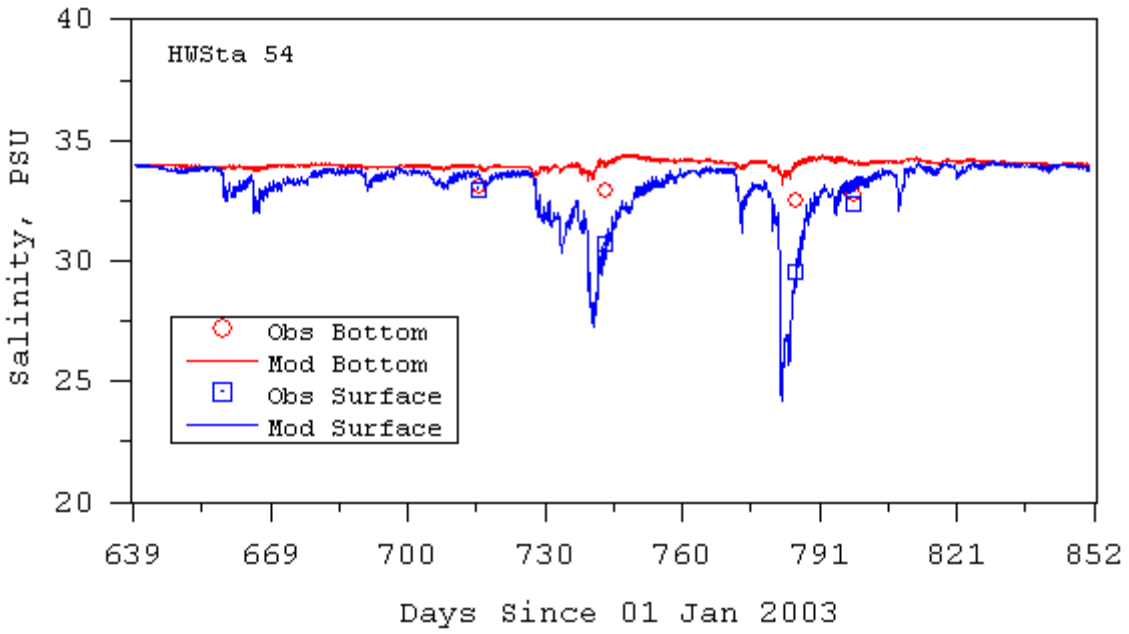

Figure A-15. Model Predicted and Observed Salinity at LAH Station 54

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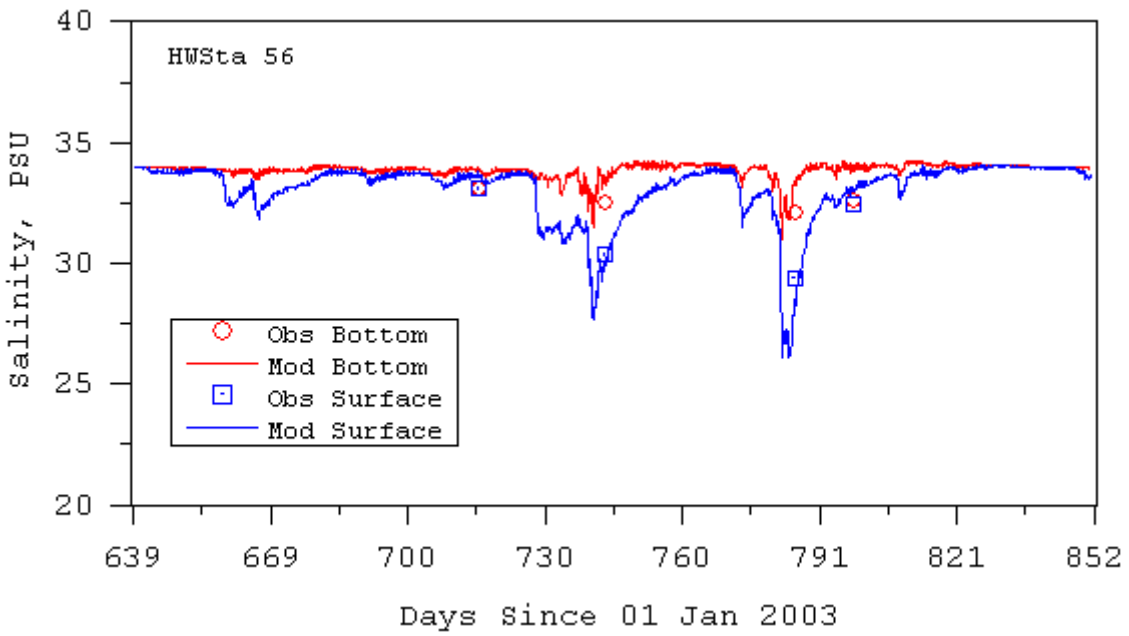


Figure A-16. Model Predicted and Observed Salinity at LAH Station 56

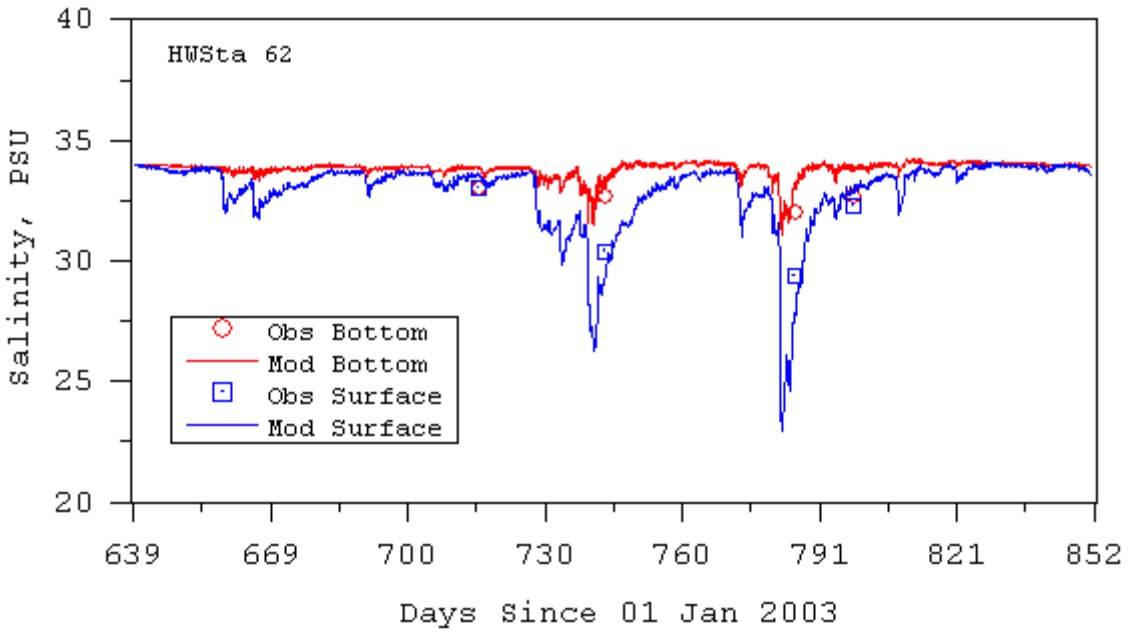


Figure A-17. Model Predicted and Observed Salinity at LAH Station 62

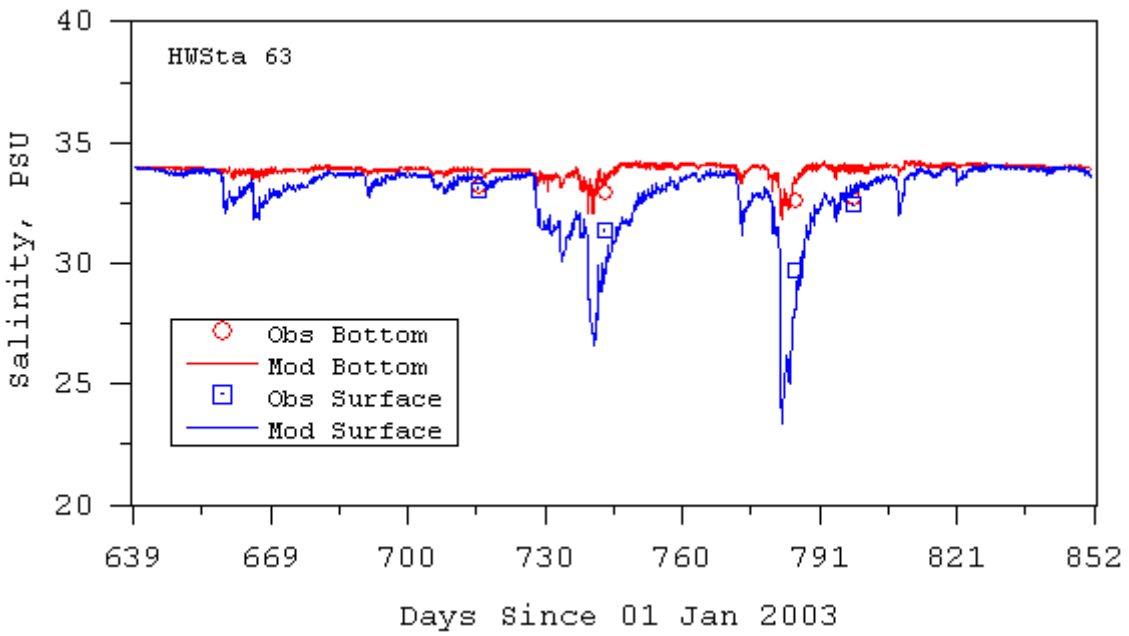


Figure A-18. Model Predicted and Observed Salinity at LAH Station 63

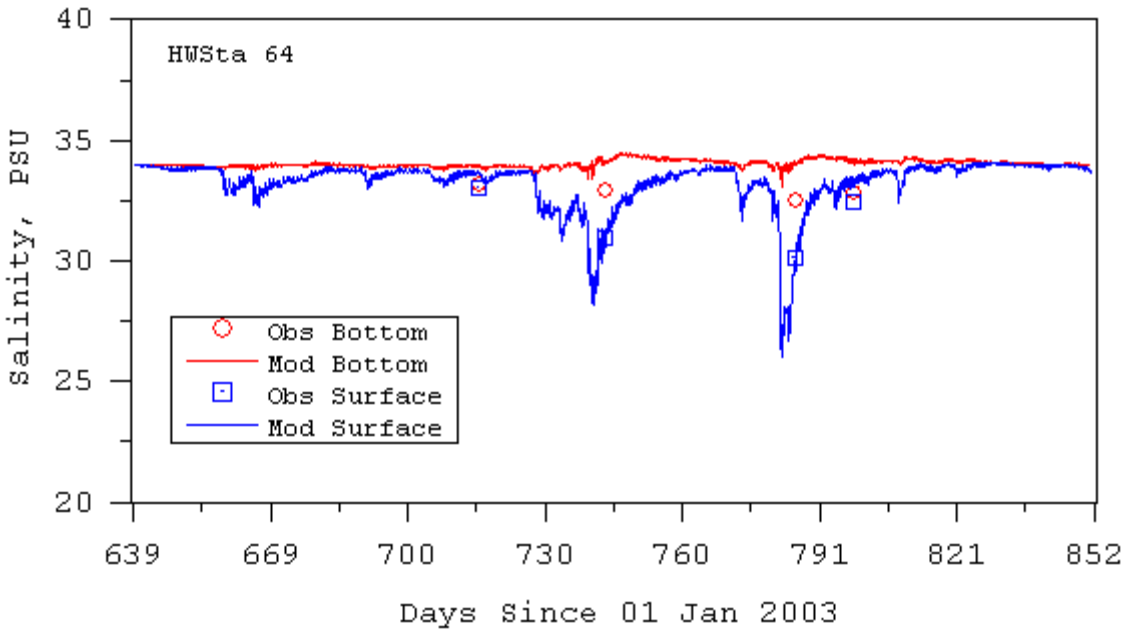


Figure A-19. Model Predicted and Observed Salinity at LAH Station 64

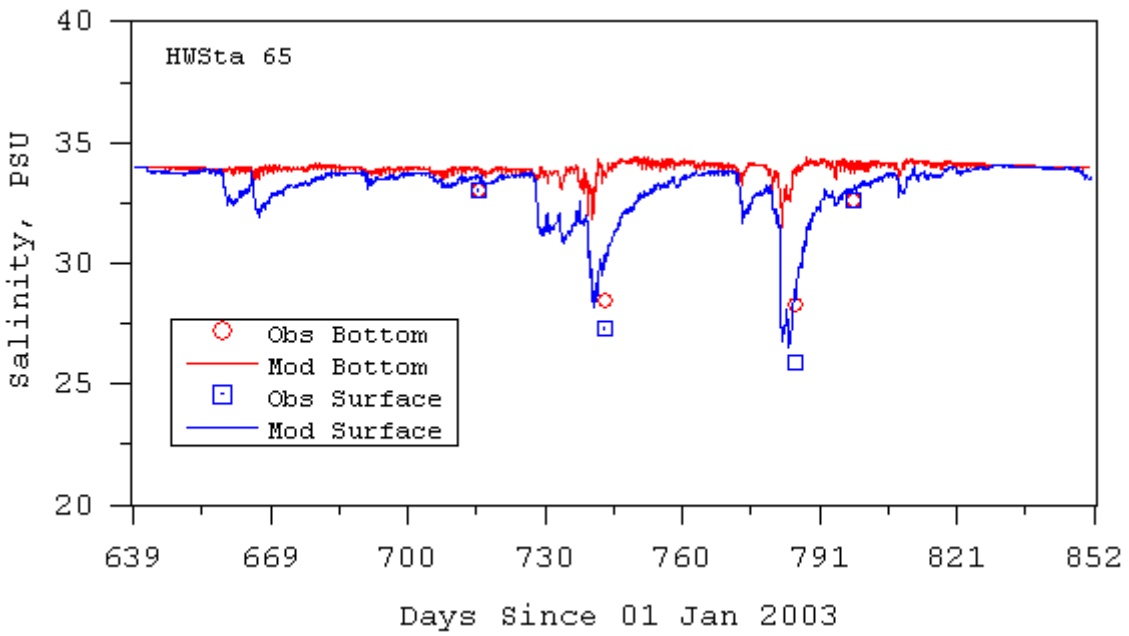


Figure A-20. Model Predicted and Observed Salinity at LAH Station 65

Appendix B: Model Performance Measures

FINAL

May 2011

Prepared for:
USEPA Region 9
Los Angeles Regional Water Quality Control Board

Prepared by:
Tetra Tech, Inc.

To quantify the EFDC model's prediction of water surface elevation, velocity, and concentration of suspended and dissolved water scalar state variables, a number of statistical tests and time series analyses are used. This section summarizes general test and analysis procedures.

The statistical test that can be used for evaluating model predictions includes the mean error, mean absolute error, root mean square error, maximum absolute error, relative mean error and relative absolute mean error (Thomann, 1982). Letting *O* and *P* denote observed and predicted values of a quantity at *N* observation times, the mean error is defined by

$$ME = \frac{1}{N}\sum_{n=1}^{N}\left(O_n - P_n\right) \tag{B.1}$$

Positive values of the mean error indicate that the model tends to under predict the observations whereas negative values indicate that the model tends to over predict observations. The mean absolute error is defined by

$$MAE = \frac{1}{N}\sum_{n=1}^{N}\left|O_n - P_n\right| \tag{B.2}$$

Although the mean absolute error provides no indication of over prediction or under prediction, it eliminates the canceling effects of positive and negative errors and can be viewed as a more extreme measure of observation-prediction agreement. The root mean square error is defined by

$$RMSE = \sqrt{\frac{1}{N}\sum_{n=1}^{N}\left(O_n - P_n\right)^2} \tag{B.3}$$

The root mean square error can be interpreted as a weighted equivalent to the mean absolute error with larger observation-prediction differences given larger weightings. The square root operation recovers the units of the data quantities. The rms error is generally viewed as the most rigorous absolute error test. The maximum absolute error is defined by

$$MAXE = \max\left|O_n - P_n\right| \quad : n = 1, N \tag{B.4}$$

and provides information on the largest discrepancy between corresponding values of observed and predicted quantities over an interval of *N* measurements.

Relative error measures can be used to eliminate data units and to provide a measure of error relative to the magnitude of the observational data. The relative mean error and the relative mean absolute error are defined by

$$RME = \frac{\frac{1}{N}\sum_{n=1}^{N}(O_n - P_n)}{\frac{1}{N}\sum_{n=1}^{N}O_n} \tag{B.5}$$

$$MAE = \frac{\frac{1}{N}\sum_{n=1}^{N}|O_n - P_n|}{\frac{1}{N}\sum_{n=1}^{N}O_n} \tag{B.6}$$

Caution should be employed in the use of these two relative error measures, particularly when observed and predicted quantities can have small values or values that have both positive and negative signs. An alternative relative error, hereafter referred to as the relative mean square error, is

$$RSE = \frac{\sum_{n=1}^{N}\left(O^{(n)} - P^{(n)}\right)^2}{\sum_{n=1}^{N}\left(\left(O^{(n)} - \overline{O}\right)^2 + \left(P^{(n)} - \overline{O}\right)^2\right)} \tag{B.7}$$

This error measure was proposed by Willmott (1982) and Willmont *et al.* (1982) and used by Blumberg and Goodrich (1990) to analyze the prediction skill of an estuarine model. The value of *RSE* always falls between zero and unity, with an increasing value corresponding to decreasing skill of the model.

Thomann (1982) suggested the use of linear regression for comparing model predictions with observations in the context of model calibration. Following Thomann, the linear equation relating observed and predicted values of the quantity is written as

$$O = \alpha + \beta P \tag{B.8}$$

where alpha and beta are determined by

$$\alpha = \frac{1}{N}\left(\sum_{n=1}^{N}O^{(n)} - \beta\sum_{n=1}^{N}P^{(n)}\right) \tag{B.9}$$

$$\beta = \frac{\sum_{n=1}^{N}\left(O^{(n)} - O^{(avg)}\right)\left(P^{(n)} - P^{(avg)}\right)}{\sum_{n=1}^{N}\left(P^{(n)} - P^{(avg)}\right)^2} \tag{B.10}$$

(Devore, 1982). The null hypothesis for the linear regression is alpha, the intercept, equal to zero, and beta, the slope, equal to one. Also useful in the regression analysis is the correlation coefficient

$$r = \frac{N\sum_{n=1}^{N} P^{(n)}O^{(n)} - \left(\sum_{n=1}^{N} P^{(n)}\right)\left(\sum_{n=1}^{N} O^{(n)}\right)}{\sqrt{N\sum_{n=1}^{N} P^{(n)}P^{(n)} - \left(\sum_{n=1}^{N} P^{(n)}\right)^2}\sqrt{N\sum_{n=1}^{N} O^{(n)}O^{(n)} - \left(\sum_{n=1}^{N} O^{(n)}\right)^2}} \tag{B.11}$$

For a good a fit or correlation between observations and predictions, the correlation coefficient should be near one. The square of the correlation coefficient equals the fractional proportion of variation of observations explained by the regression relationship between the observations and predictions (Devore, 1982).

Time series having deterministic periodic structure can be analyzed using least squares harmonic analysis. Consider a time series of the form

$$\phi(t) = a_0 + b_0 t + \sum_{m=1}^{M} a_n \cos\left(\frac{2\pi t}{T_m}\right) + \sum_{m=1}^{M} b_n \sin\left(\frac{2\pi t}{T_m}\right) \tag{B.12}$$

composed of a constant, a_0, a linear in time term $b_0 t$, and M periodic or harmonic components having periods T_m. Note that equation B.12 can also be written in the form

$$\phi(t) = a_0 + b_0 t + \sum_{m=1}^{M} A_m \cos\left(\frac{2\pi}{T_m}(t - \tau_m)\right) \tag{B.13}$$

$$A_m^2 = a_m^2 + b_m^2$$

$$\tau_m = \frac{T_m}{2\pi}\arctan\left(\frac{b_m}{a_m}\right)$$

where A_m and τ_m are the amplitude and phase of the mth periodic or harmonic component of the time series. The *a* and *b* coefficients representing the time series can be determined form discrete values of ϕ at *N* times by minimization of the least squares functional

$$E = \sum_{n=1}^{N}\left(\phi(t_n) - a_0 - b_0 t - \sum_{m=1}^{M} a_m \cos\left(\frac{2\pi t_n}{T_m}\right) - \sum_{m=1}^{M} b_m \sin\left(\frac{2\pi t_n}{T_m}\right)\right)^2 \tag{B.14}$$

with respect to the *a* and *b* coefficients. The minimization results in a system of *2N+1* equations for the *a* and *b* coefficients. For comparison of model

predictions with observations, harmonic coefficients are determined for both model-predicted and observed time series, and the amplitudes and phases appropriately compared for each harmonic component.

For two-dimensional vector time series, the vector components, *u* and *v*, are separately analyzed to determine the coefficients in the expansions

$$u(t) = u_0 + \sum_{m=1}^{M} uc_n \cos\left(\frac{2\pi t}{T_m}\right) + \sum_{m=1}^{M} us_n \sin\left(\frac{2\pi t}{T_m}\right) \tag{B.15a}$$

$$v(t) = v_0 + \sum_{m=1}^{M} vc_n \cos\left(\frac{2\pi t}{T_m}\right) + \sum_{m=1}^{M} vs_n \sin\left(\frac{2\pi t}{T_m}\right) \tag{B.15b}$$

The combined results can be cast in tidal velocity ellipse form with the major and minor axis amplitudes, the ellipse orientation, and the phase at which the velocity vector aligns with the major axis replacing the *uc*, *us*, *vc*, and *vs* coefficients for each constituent. The half-lengths, *ma* and *mi*, of the major and minor axes are given by

$$\begin{aligned} ma &= rp + rm \\ mi &= |rp - rm| \\ rp &= \sqrt{(uc + vs)^2 + (vc - us)^2} \\ rm &= \sqrt{(uc - vs)^2 + (vc + us)^2} \end{aligned} \tag{B.16}$$

for each constituent. The major axis orientation angle *ang*, in degrees counterclockwise from east, and the time phase *phe*, at which the velocity vector aligns with the major axis, are given by

$$\begin{aligned} ang &= \frac{90}{\pi}(ap + am) \\ phe &= \frac{T}{4\pi}(am - ap) \\ ap &= \tan^{-1}\left(\frac{vc - us}{uc + vs}\right) \\ am &= \tan^{-1}\left(\frac{vc + us}{uc - vs}\right) \end{aligned} \tag{B.17}$$

for each constituent.

An alternative method for comparing time series of observed and model predicted quantities is the use of spectral analysis techniques. Spectral analysis is particularly useful for comparing the frequency domain structure of observed and predicted responses to random external model forcings such as wind.

Spectral analysis can also be used for the analysis of time series composed of the sums of discrete harmonics and a random component. For a quantity s_k, observed or predicted at N discrete times $k\Delta t$ ($k = 0, N-1$) relative to a local time original, the discrete Fourier transform S_n is given by

$$S_n = \sum_{k=0}^{N-1} s_k \exp\left(\frac{2\pi ikn}{N}\right) \tag{B.18}$$

where i is the unit imaginary number. Note that the standard Fourier transform convention of defining N data points from indices 0 to $N-1$ is employed here (Press et al., 1992). The discrete transform is defined at discrete frequencies:

$$f_n = \frac{n}{N\Delta t} \quad ; \quad n = -\frac{N}{2}, \ldots 0 \ldots, \frac{N}{2} \tag{B.19}$$

with S_0 corresponding to the discrete 0 frequency, S_n ($n = 1, N/2-1$) corresponding to the first $N/2-1$ positive frequencies, and S_n ($n = N/2+1, N-1$) corresponding to the first $N/2-1$ negative frequencies in reverse order. At n equals $N/2$, S_n defines the value at both the positive and negative Nyquist critical frequencies,

$$f_c = f_{N/2} = \frac{1}{2\Delta t} \tag{B.20}$$

The inverse discrete transform is given by:

$$s_k = \frac{1}{N} \sum_{n=0}^{N-1} S_n \exp\left(\frac{2\pi ikn}{N}\right) \tag{B.21}$$

The power spectral density function, P_{ss}, of the quantity is defined, following Press et al. (1992), as

$$\begin{aligned} P_{ss}(0) &= P_{ss}(f_0) = \frac{1}{N^2}|S_0|^2 \\ P_{ss}(f_k) &= \frac{1}{N^2}\left(|S_k|^2 + |S_{N-k}|^2\right) \quad , \quad k = 1, \frac{N}{2} - 1 \\ P_{ss}(f_k) &= P_{ss}(f_{N/2}) = \frac{1}{N^2}|S_{N/2}|^2 \end{aligned} \tag{B.22}$$

for positive frequencies only and has the normalization property that its sum is equal to the mean square value of s.

$$\sum_{k=0}^{N/2} P_{ss}(f_k) = \frac{1}{N} \sum_{j=0}^{N-1} |s_j|^2 \tag{B.23}$$

When *s* is the water surface elevation, the summed spectral density function is readily identified as twice the mean potential energy divided by the acceleration for gravity:

$$\frac{2PE}{g} = \sum_{k=0}^{N/2} P_{\zeta\zeta}(f_k) \tag{B.24}$$

When *s* corresponds to velocity, the summed spectral density function is twice the component kinetic energy with the total kinetic energy defined by

$$2KE = \sum_{k=0}^{N/2} \left(P_{uu}(f_k) + P_{vv}(f_k)\right) \tag{B.25}$$

A useful measure of model performance is provided by the difference of observed and predicted power spectral density function of a particular quantity:

$$P_{dd}(f_k) = P_{oo}(f_k) - P_{pp}(f_k) \tag{B.26}$$

with *d*, *o*, and *p* denoting the difference, observed, and predict, quantities respectively.

Principal current direction

$$\theta_{PCD} = \frac{1}{2}\arctan\left(\frac{2\sum_{n=1}^{N}(u_n - \bar{u})(v_n - \bar{v})}{\sum_{n=1}^{N}(u_n - \bar{u})^2 - \sum_{n=1}^{N}(v_n - \bar{v})^2}\right) + m\frac{\pi}{2} \tag{B.27}$$

Where m is chosen to be 0 or 1, whichever maximizes

$$\begin{aligned} s^2 &= \cos^2\theta_{PCD}\sum_{n=1}^{N}(u_n - \bar{u})^2 + \sin^2\theta_{PCD}\sum_{n=1}^{N}(v_n - \bar{v})^2 \\ &+ \cos\theta_{PCD}\sin\theta_{PCD}\sum_{n=1}^{N}(u_n - \bar{u})(v_n - \bar{v}) \end{aligned} \tag{B.28}$$

Appendix C: Sediment and Contaminant Transport Model Dry Season Sensitivity Analysis

FINAL

May 2011

Prepared for:
USEPA Region 9
Los Angeles Regional Water Quality Control Board

Prepared by:
Tetra Tech, Inc.

Introduction

A preliminary, dry season sensitivity analysis (May to October 2005) for the sediment and contaminant transport model predictions was conducted with respect to three types of model forcing functions and process parameterizations representing sediment and contaminant sources and sinks. The three types of conditions included: open boundary concentration levels, river and watershed loads, and sediment erosion rates. These three sensitivity options represent the range of potentially controllable inputs to the model. For example, it is not practicable or feasible to control the open boundary concentration levels, representing ambient or background concentrations in San Pedro Bay. In this respect, demonstration of low sensitivity to open boundary concentration levels is desirable. In contrast, river and watershed loads are the primary controllable sediment and contaminant sources. A moderate to high sensitivity with respect to loads indicates that these sources are primarily responsible for observed levels of contamination. Another sensitivity analysis was performed to explore controlling sediment bed sources via sediment erosion rates. That is, lower erosion rates would reduce diffusive flux rates and minimize overall net flux of sediment, metals, and organics from the bed to the water column. This could be achieved via controlling sediment bed sources by either covering contaminated sediment with clean sediment from land source controlled inflow or remediation via active capping or removal at hot spots.

The approach utilized in the sensitivity analysis involved simple system wide perturbations in the three types of forcing functions. Since a primary objective of TMDL development is reduction in contamination levels, the perturbations were based on 50 percent reductions or halving of the forcing functions. The model calibration simulation was repeated for each of the three sensitivity cases. Sensitivity was evaluated by comparison of dry season average model calibration predictions with sensitivity simulation predictions at the sixty 2006 sediment and overlying water sites (Figure 16). These sites were chosen for comparison since their locations represent a random sampling within the greater LA/LB Harbor waters area of interest.

Sensitivity to Open Boundary Conditions

The open boundary of the model domain can be either a source or sink with net transport of material into or out of the model domain. To investigate sensitivity with respect to open boundary concentrations, the calibration open boundary concentrations were reduced by a factor of one-half (0.5). Dry season average concentration predictions corresponding to the full and half calibration boundary values were compared at the sixty 2006 sediment and overlying water sites and are shown in Figures C-1 through C-7. A diagonal or unit slope plot, Figure C-1 for example, of black dots indicates low sensitivity in that model predictions are not affected by halving the boundary condition. A slope of less than unity, Figure

C-6 for example, indicates sensitivity. The red dots indicate the difference between the full boundary concentration and the half boundary concentration and are measured on the y-axis.

With respect to halving boundary conditions values, PAH was the only variable showing sensitivity as noted in Table C-1. With reference to Figure C-6, sites with low concentrations tend to be highly sensitive with concentrations approximately halved. Higher concentration sites are moderately sensitive.

Sensitivity to River and Watershed Loads

In the absence of significant point source loads, river and watershed loads are the primary controllable sediment and contaminant sources. A simple global loading sensitivity analysis was conducted by halving the inflowing concentration of sediment and contaminants, which corresponds to a 50 percent load reduction. Dry season average concentration predictions corresponding to the full and half calibration sediment and contaminant loads are compared at the sixty 2006 sediment and overlying water sites and are shown in Figures C-8 through C-14. The results indicate that sediment, copper, lead, DDT, and PAH predictions are relatively insensitive to halving loads. Zinc exhibits moderate or medium level sensitivity in Figure C-11. Figure C-14 shows model predicted PCB concentrations to exhibit a medium to high sensitivity with a halving of loads yielding a corresponding reduction in PCB concentrations.

Sensitivity to Sediment Erosion Rates

Existing contamination of bed sediment can be a significant source of water column contamination due to sediment erosion and diffusion of contaminants dissolved in pore water. To gain insight into the relative importance of the sediment bed as a source of water column contamination, the base sediment erosion rate was halved. Although halving the erosion rate does not represent a feasible harbor wide control approach, it does directly reveal the relative importance of the sediment bed as a source. Alternatively, halving of the erosion rate could be viewed as analogous to wide scale capping of coarse material making the sediment more resistant to hydrodynamic forces responsible for erosion, or mixing clean sediment from the inflows such that net erosion flux of contaminants is reduced. As might be expected, the water column sediment concentrations were significantly reduced as shown in Figure C-15. The concentrations of the three metals in the water column were also reduced, Figures C-16 through C-18. Copper and lead, which have higher partition coefficients than zinc, showed corresponding higher sensitivities to erosion, as expected, due to their strong affinity for the particulate phase. The three organic contaminants showed a range of sensitivities to sediment erosion (Figures C-19 through C-21).

Summary

With respect to contaminated sediment TMDL development for the greater LA/LB Harbor waters, the sensitivity analysis suggests that a reduction of watershed and river inflows of contaminated sediments, but not necessarily clean sediment, provides a feasible pollution control strategy in combination with localized capping or sediment removal. For the organics and, to a certain extent, zinc, reduction of land-derived loads was shown to result in lower levels of water column contamination. Gradual replacement of incoming contaminated sediment with clean sediment would yield lower contaminant exposure levels to living organisms in either water column or bed sediments, since the new deposited cleaner sediment would ultimately reduce contaminant flux from the sediment bed.

Table C-1. Summary of Sensitivity Analysis

Contaminant	Sensitivity to Halving Open Boundary Conditions	Sensitivity to Halving River and Watershed Loads	Sensitivity to Halving Sediment Erosion Rate
Sediment	Low	Low	High
Copper	Low	Low	High
Lead	Low	Low	High
Zinc	Low	Medium	Medium
DDT	Low	Low	Medium
PAH	Low to Medium	Low	Medium to High
PCB	Low	Medium to High	Low to Medium

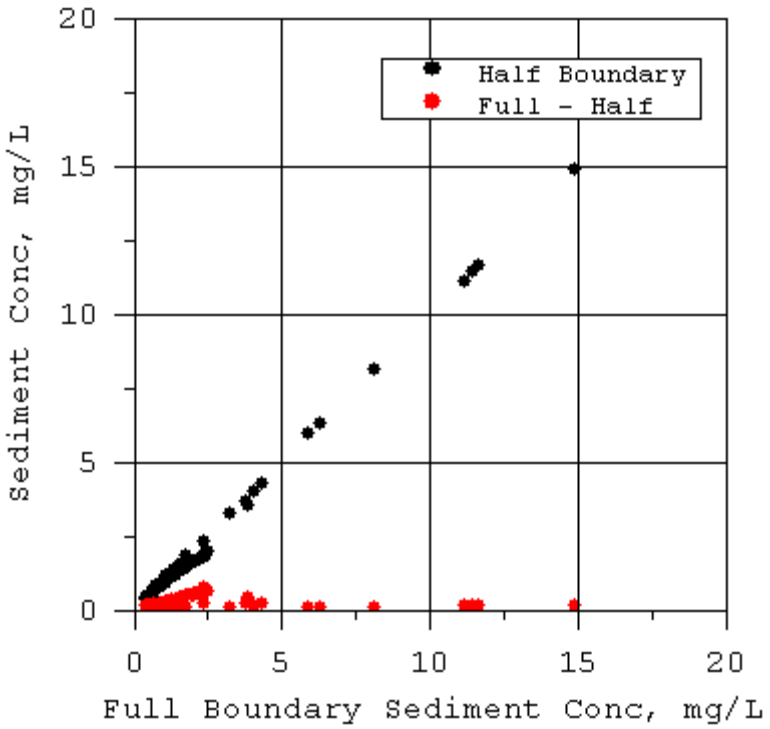


Figure C-1. Sensitivity of sediment concentration to halving sediment and contaminant open boundary conditions

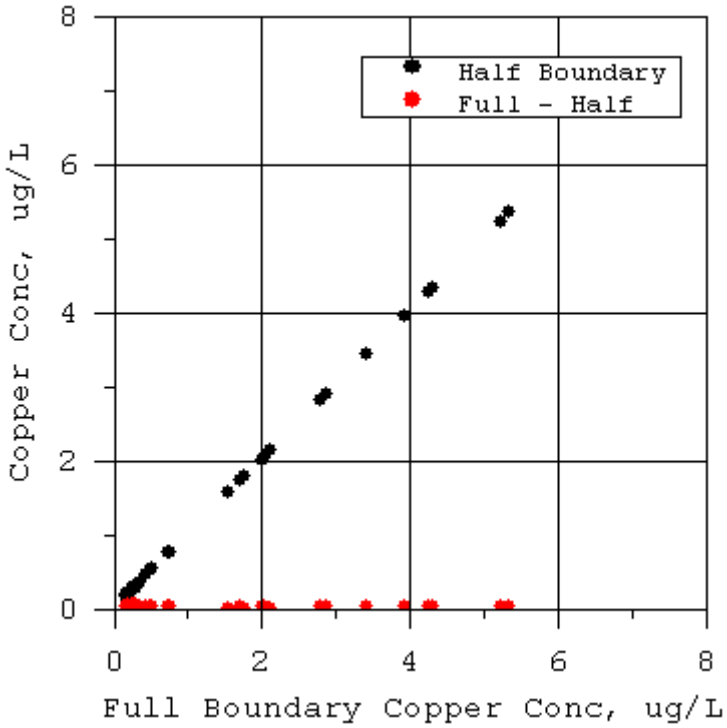


Figure C-2. Sensitivity of copper concentration to halving sediment and contaminant open boundary conditions

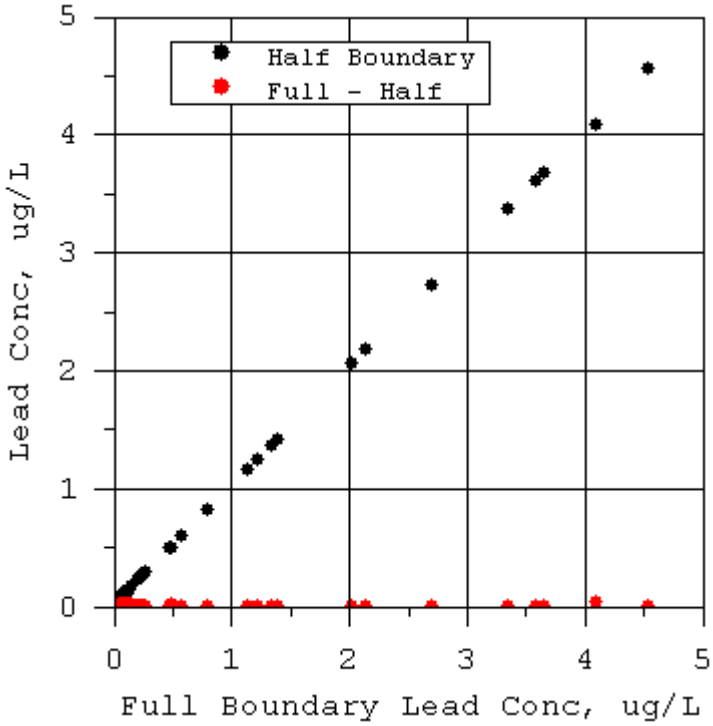


Figure C-3. Sensitivity of lead concentration to halving sediment and contaminant open boundary conditions

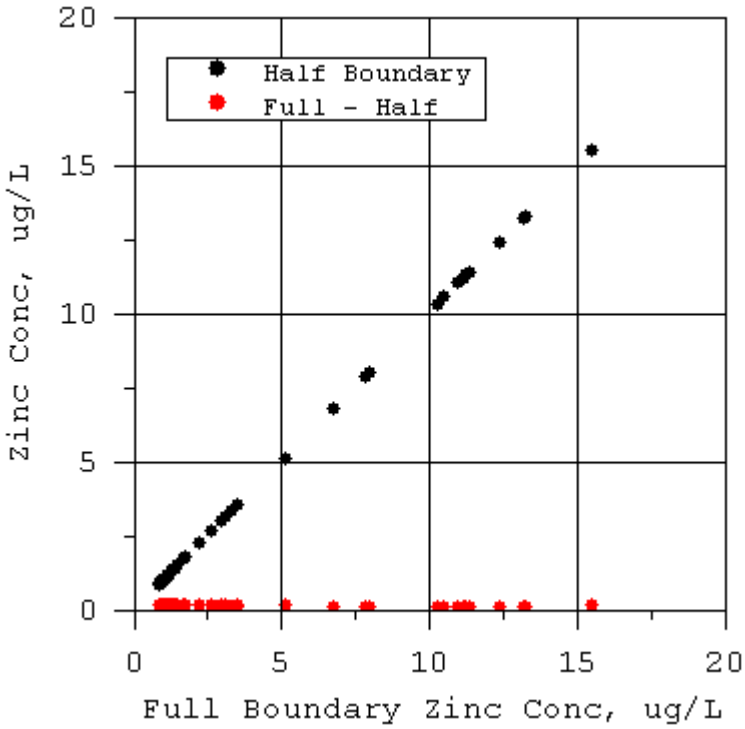


Figure C-4. Sensitivity of zinc concentration to halving sediment and contaminant open boundary conditions

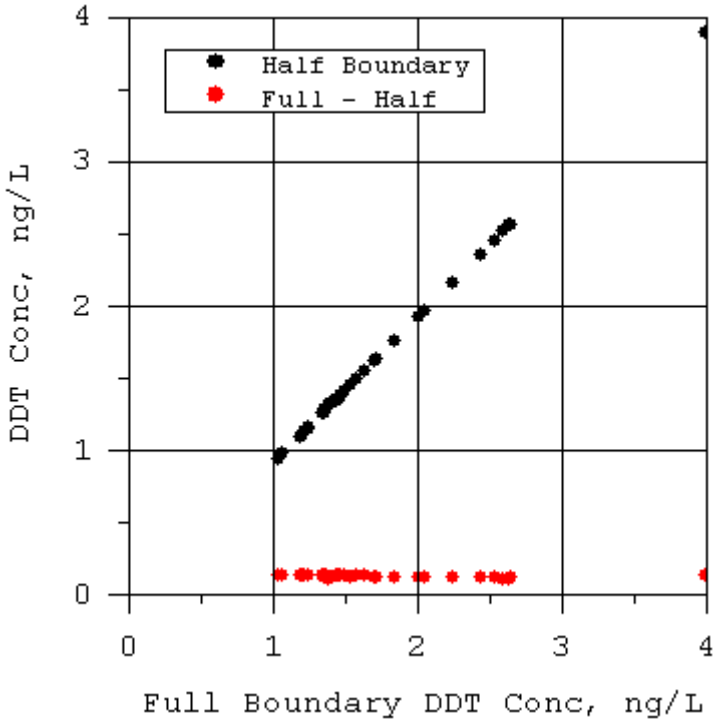


Figure C-5. Sensitivity of DDT concentration to halving sediment and contaminant open boundary conditions

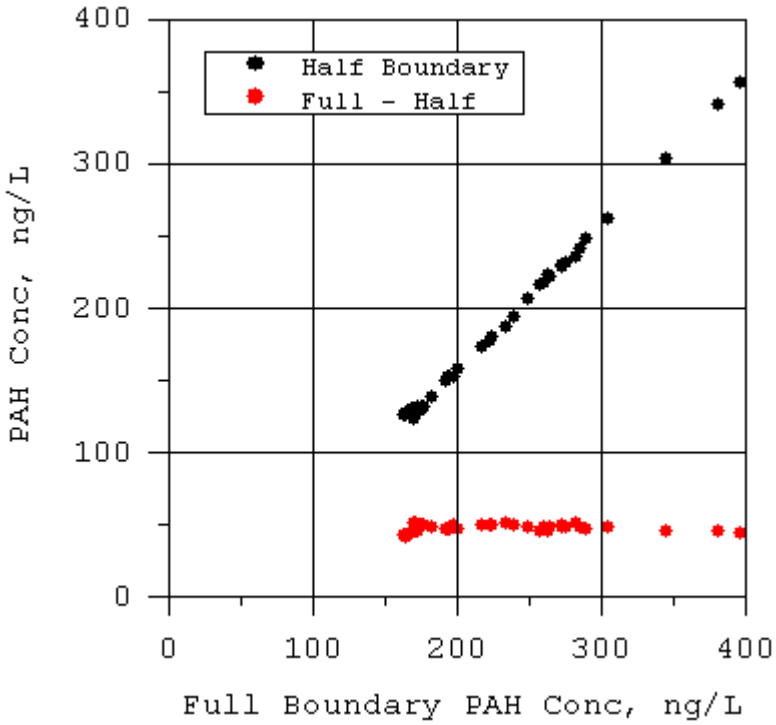


Figure C-6. Sensitivity of PAH concentration to halving sediment and contaminant open boundary conditions

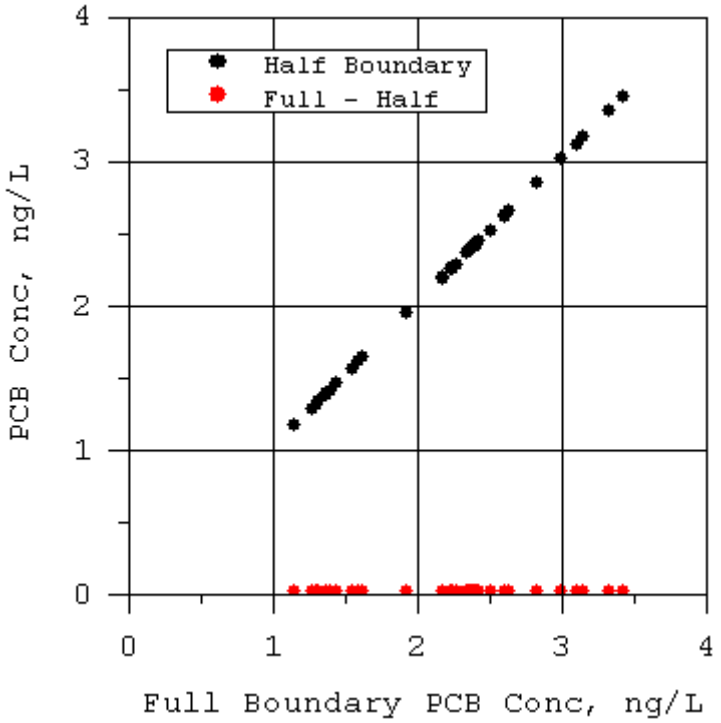


Figure C-7. Sensitivity of PCB concentration to halving sediment and contaminant open boundary conditions

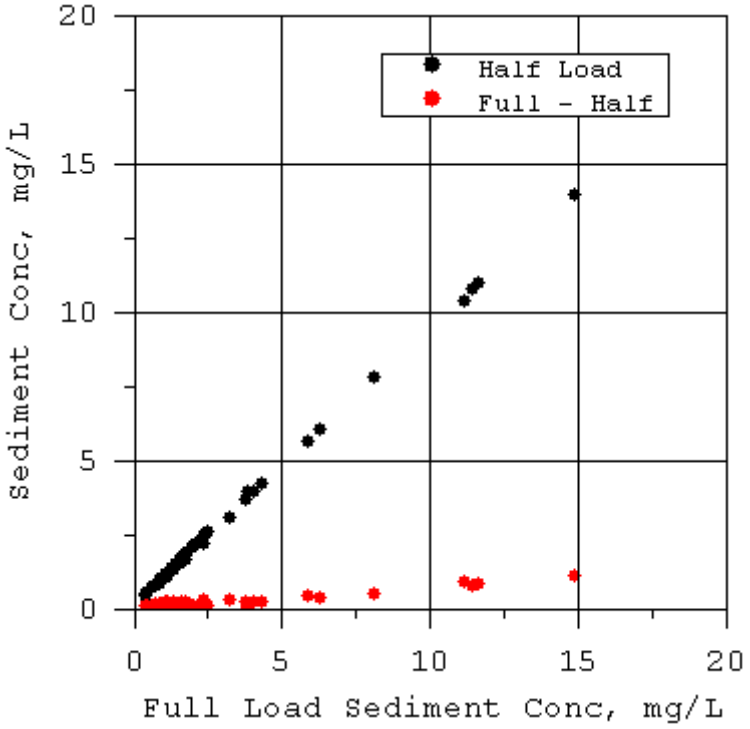


Figure C-8. Sensitivity of sediment concentration to halving sediment and contaminant loads

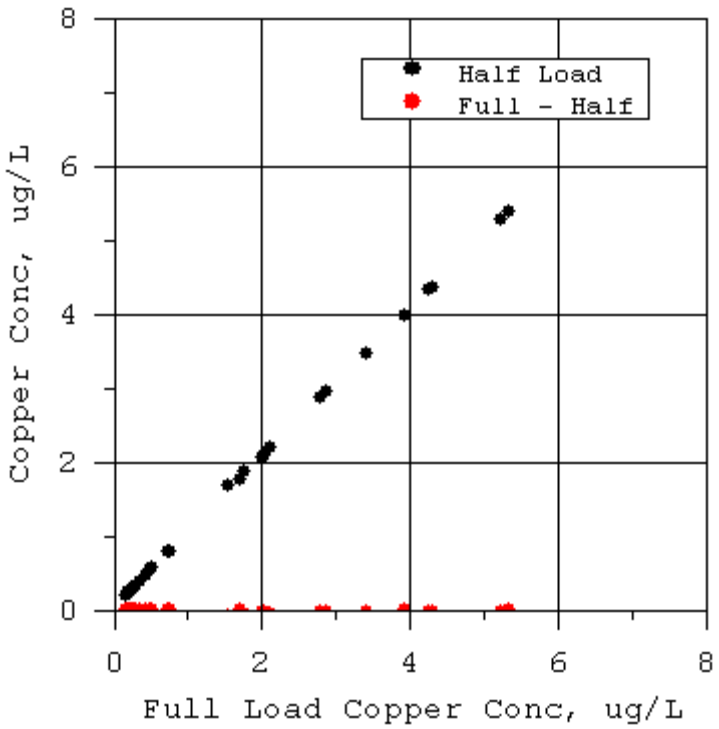


Figure C-9. Sensitivity of copper concentration to halving sediment and contaminant loads

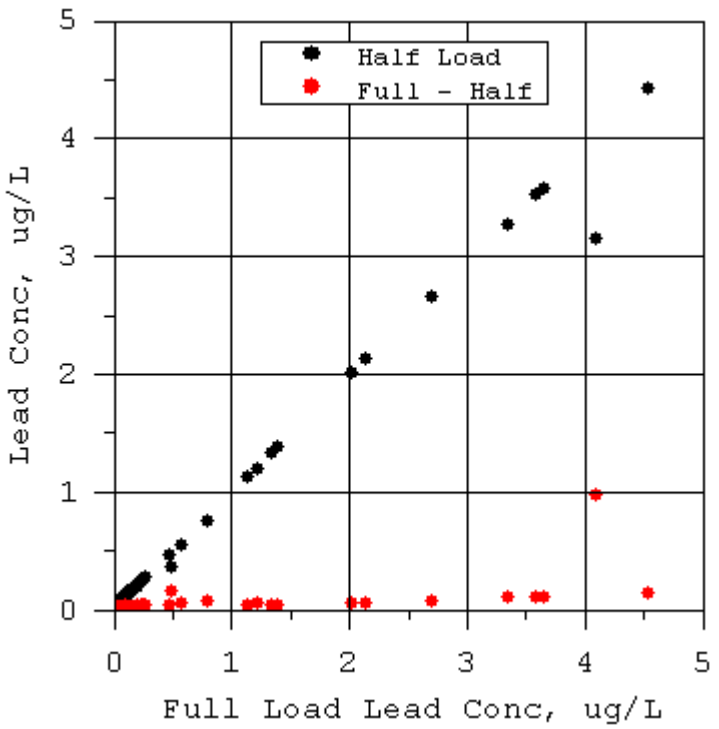


Figure C-10. Sensitivity of lead concentration to halving sediment and contaminant loads

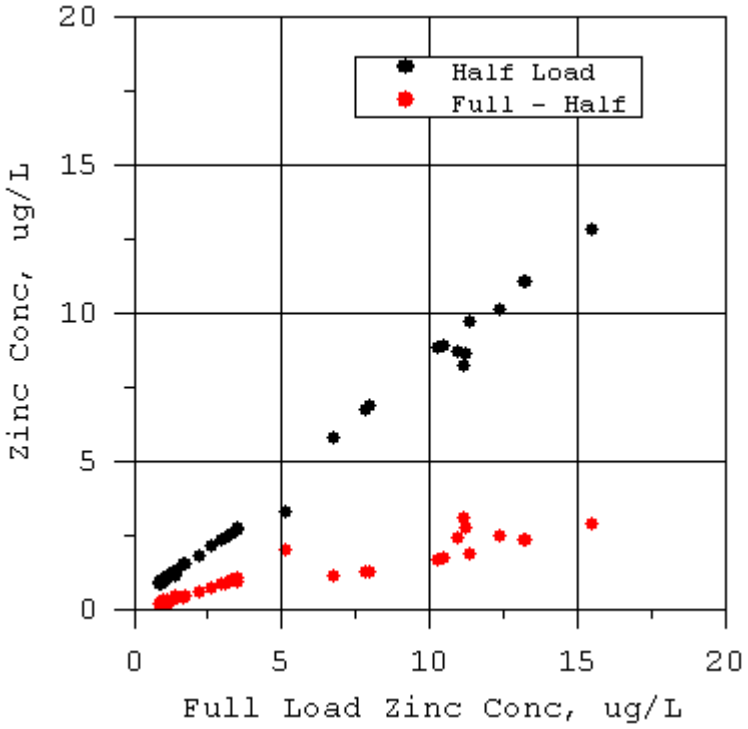


Figure C-11. Sensitivity of zinc concentration to halving sediment and contaminant loads

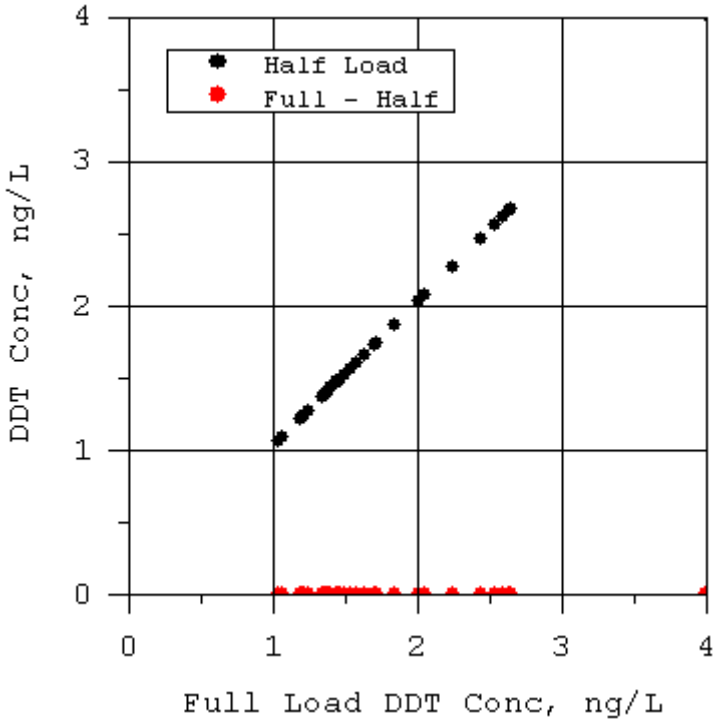


Figure C-12. Sensitivity of DDT concentration to halving sediment and contaminant loads

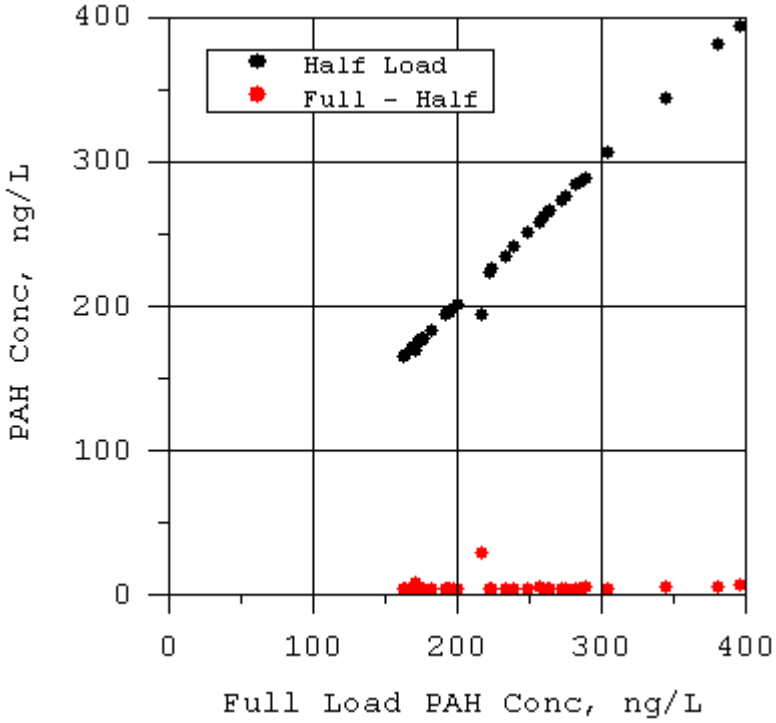


Figure C-13. Sensitivity of PAH concentration to halving sediment and contaminant loads

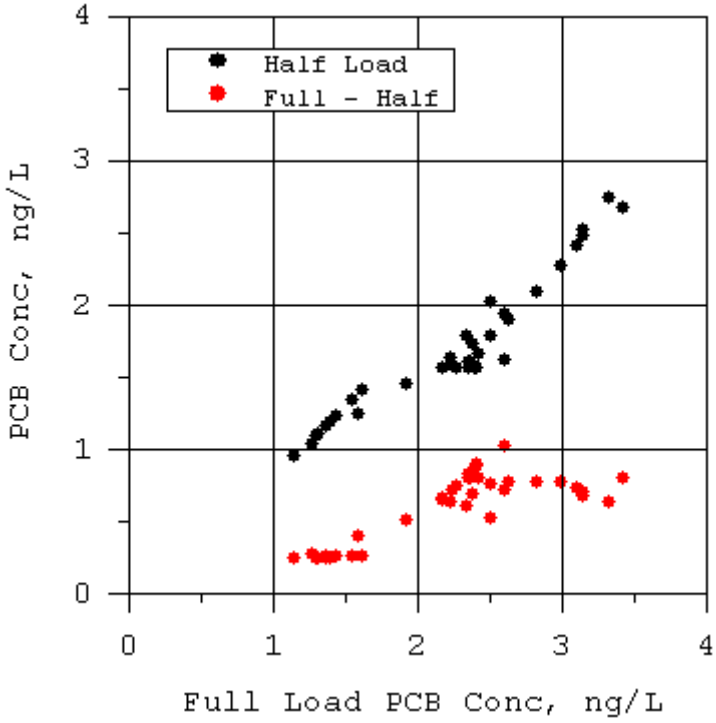


Figure C-14. Sensitivity of PCB concentration to halving sediment and contaminant loads

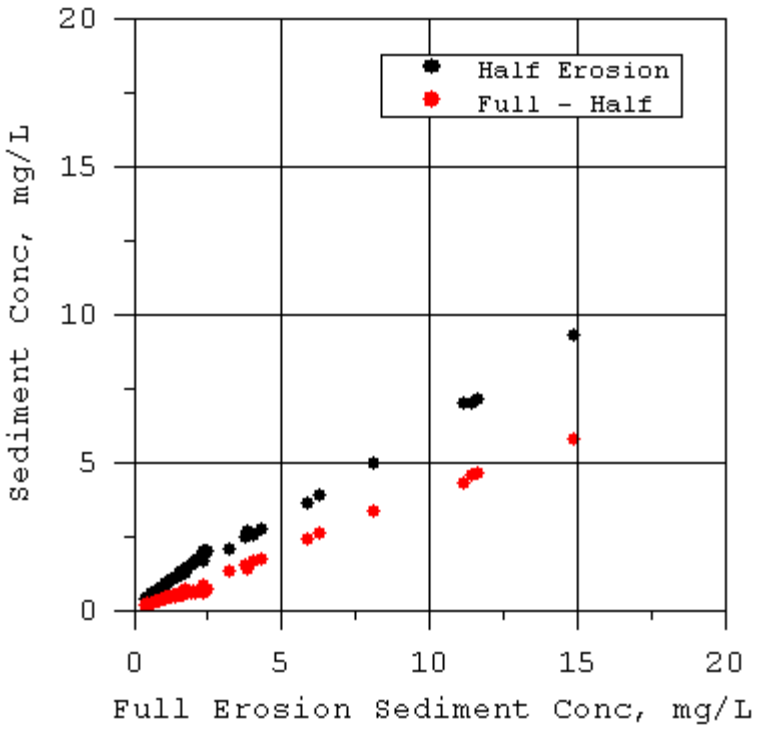


Figure C-15. Sensitivity of sediment concentration to halving sediment erosion rate

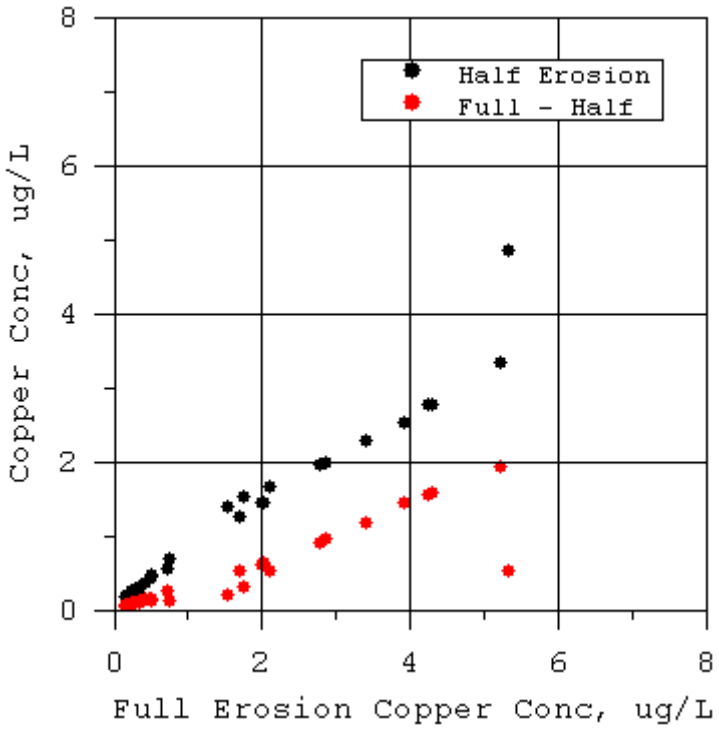


Figure C-16. Sensitivity of copper concentration to halving sediment erosion rate

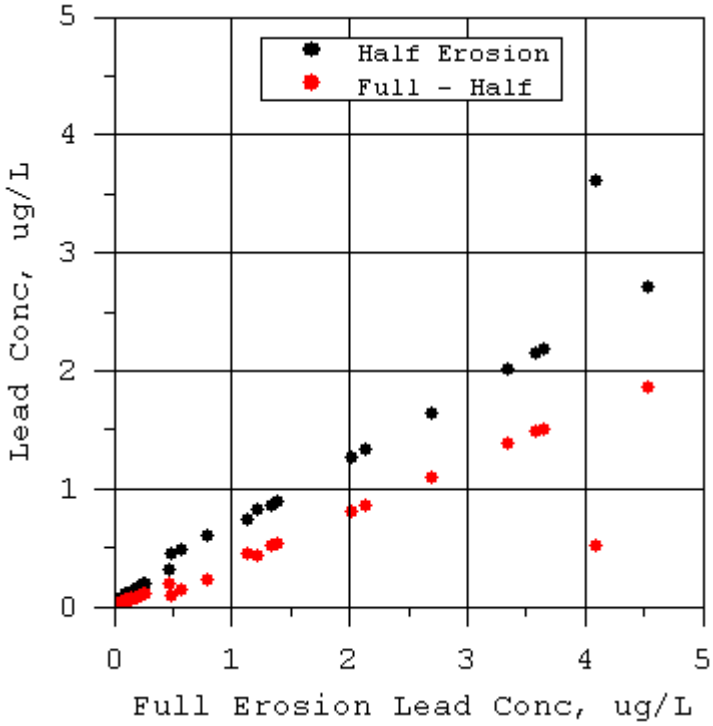


Figure C-17. Sensitivity of lead concentration to halving sediment erosion rate

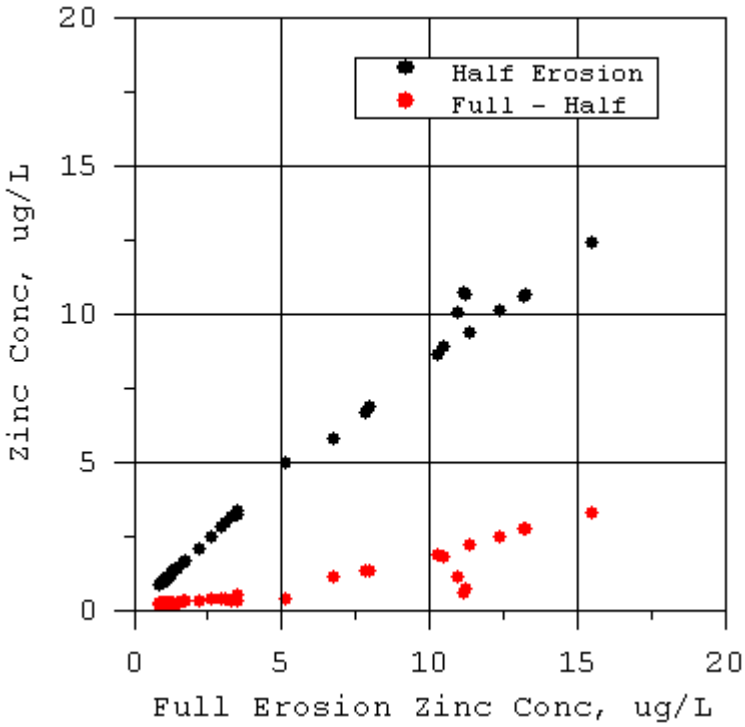


Figure C-18. Sensitivity of zinc concentration to halving sediment erosion rate

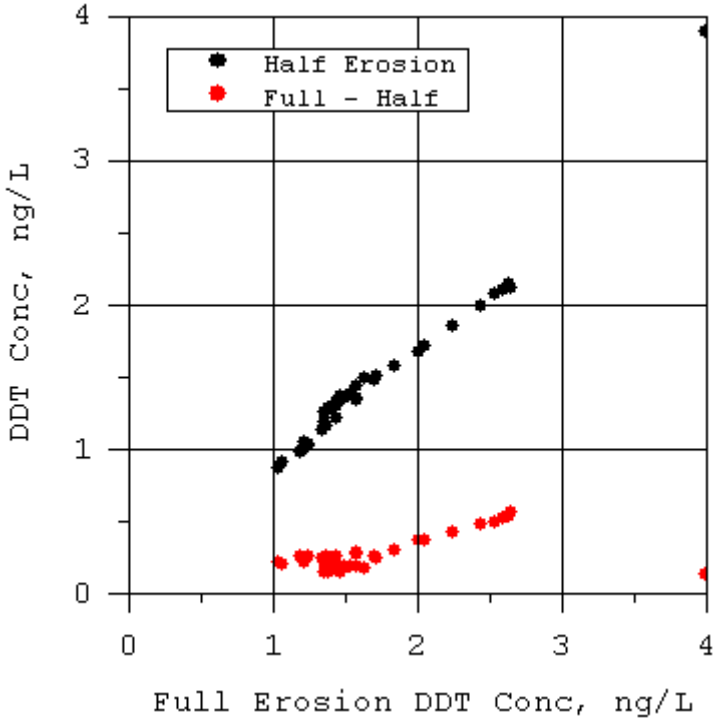


Figure C-19. Sensitivity of DDT concentration to halving sediment erosion rate

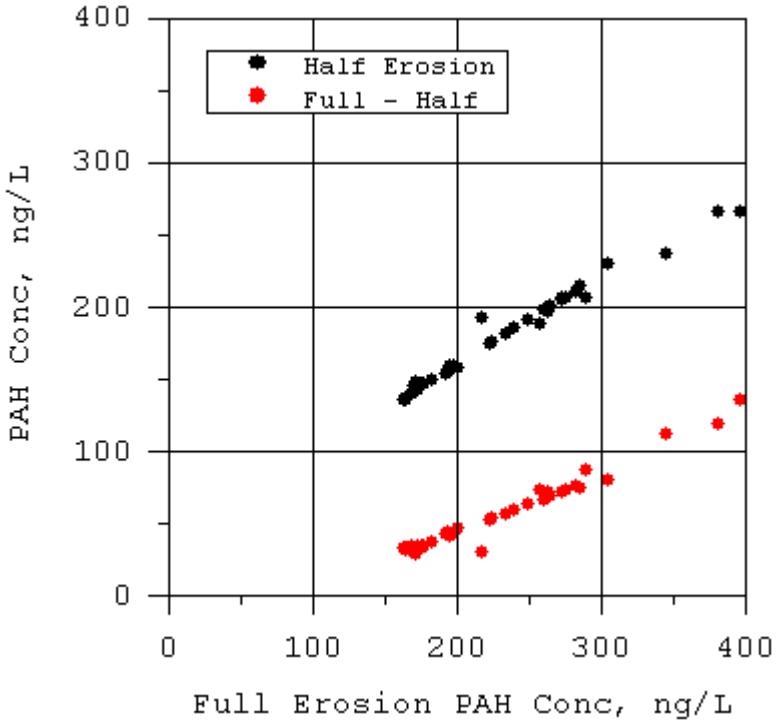


Figure C-20. Sensitivity of PAH concentration to halving sediment erosion rate

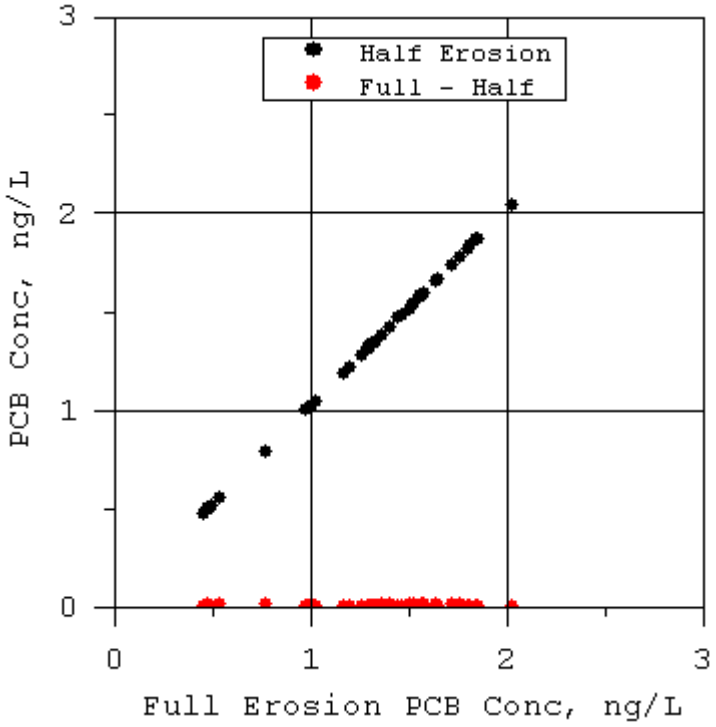


Figure C-21. Sensitivity of PCB concentration to halving sediment erosion rate

Appendix D: Sediment and Contaminant Transport Model Sensitivity to Long-Term Load Reductions

FINAL

May 2011

Prepared for:
USEPA Region 9
Los Angeles Regional Water Quality Control Board

Prepared by:
Tetra Tech, Inc.

Introduction

Two simulations were conducted to investigate the sensitivity of the sediment and contaminant model predictions to long-term load reductions. Both simulations spanned a four year period from 2002 through 2005. Hourly observed flows were used for Dominguez Channel and the Los Angeles and San Gabriel River, when available. Gaps in observations were filled with hourly watershed model predicted flows. This period includes significant wet season inflow events as illustrated by the Los Angeles River flow shown in Figure D-1. The first (or baseline) simulation used watershed model estimated sediment and contaminant concentrations to calculate loads. The second (or load reduction) simulation used sediment and contaminant concentrations which were reduced by 50 percent for both rivers and near shore watersheds. The sensitivity analysis results are presented in both time series graphs and maps illustrating changes in contaminant level over the four year period, as described below.

Time series of water column and sediment bed concentrations provide qualitative insight into the long-term response at three spatially diverse stations selected from the 60 sites visited in the Ports' 2006 study (Figure 16 and Figure D-2). Water column and sediment bed concentration time series for copper, zinc, DDT, and PAHs are shown for three stations: LA Inner Harbor (8); LB Inner Harbor (42) and Outer Harbor (54) (circled in blue on Figure D-2). These results also provide insight into water column and sediment bed concentration responses during wet weather inflow events. Concentrations in these graphs are defined as mass per unit volume (ug/L or ng/L) for both the water column and sediment bed surface. This provides a true measure of mass associated with the sediment bed and therefore illustrates the changes in total concentration.

Analysis of the simulation results focuses on the change in sediment bed surface contaminant levels over the four-year period. Three sets of spatial maps were generated to illustrate (1) the changes at the end of the four year simulations for the base and load reduction simulations and (2) the relative change for the load reduction simulation. The three maps presented for each contaminant are defined as:

> **Areal Concentration Change in Baseline Simulation Over Time** = Final Areal Concentration using Baseline Conditions in 2005 (after 4 years) – Initial Areal Concentration using Baseline Conditions in 2002 (beginning of simulation period)
>
> **Areal Concentration Change from Load Reduction Simulation** = Final Areal Base Simulation Concentration in 2005 – Final Areal Load Reduction Concentration in 2005 (based on 50 percent load reduction from the rivers and near shore watersheds)

Relative Change in Load Reduction Simulation = Relative Change in Load Reduction Change (normalized by initial top bed layer concentration)

Note: Areal concentration is the mass per unit area in top layer of sediment bed

The "Areal Concentration Change in Baseline Simulation" is presented for comparative purposes only. Specifically, the "Areal Concentration Change from Load Reduction Simulation" results can be compared with the "Areal Concentration Change in Baseline Simulation" to evaluate the impacts of reducing the watershed and river loads by 50 percent after a four year period.

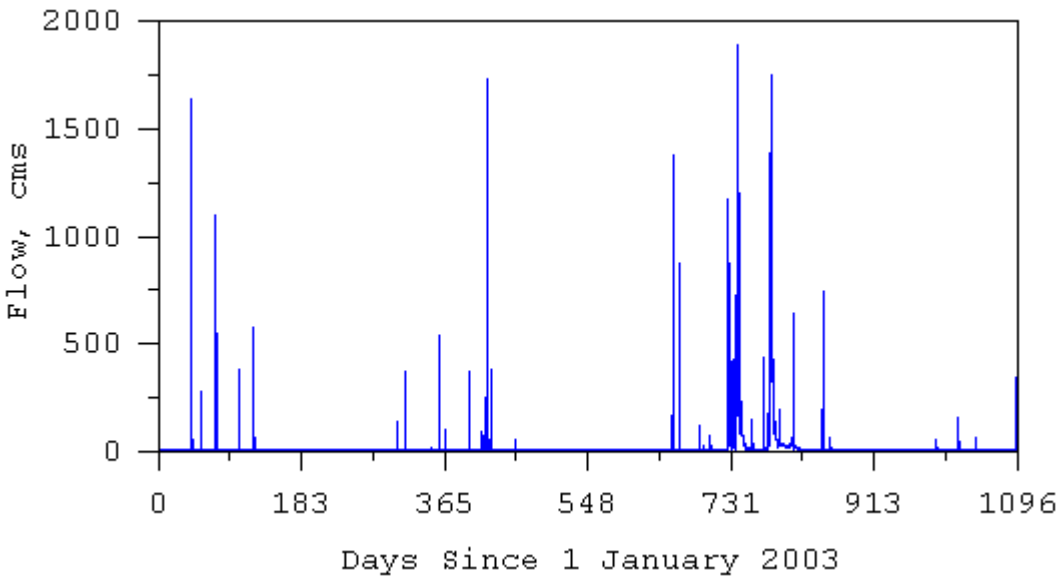
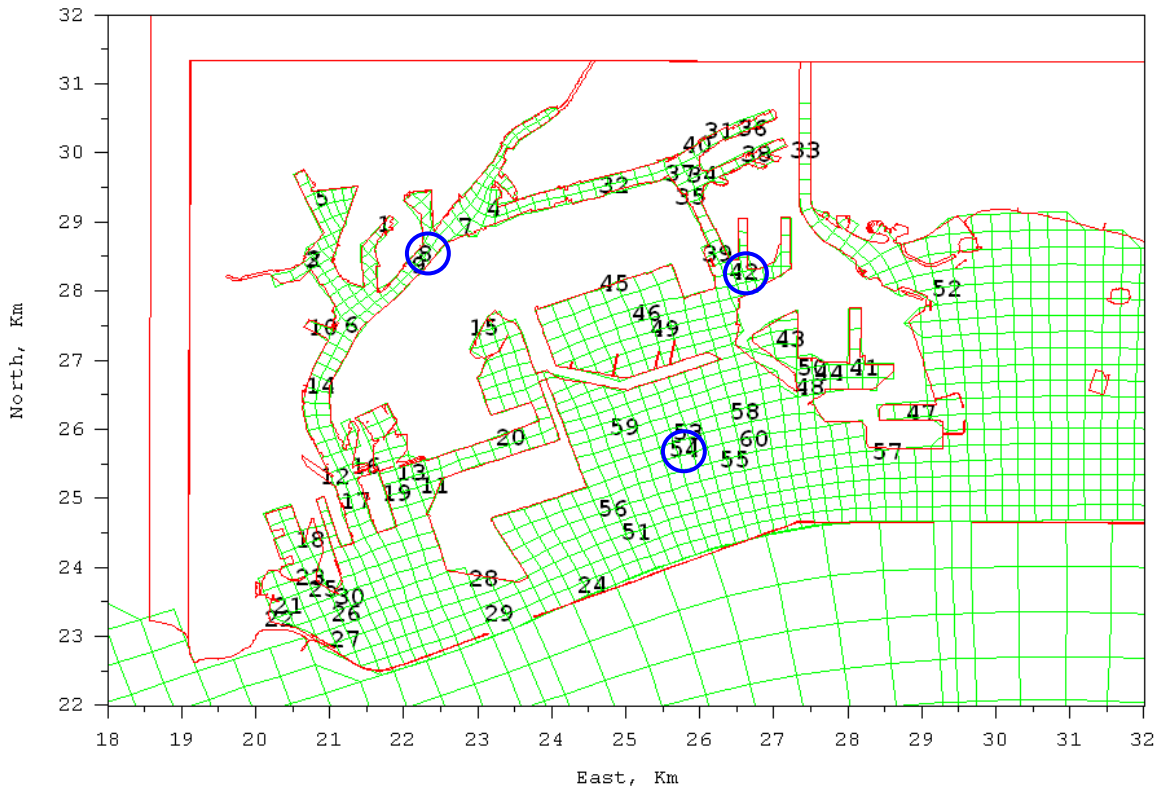


Figure D-1. Los Angeles River flow during long-term simulation period



Note: Long-term sensitivity results are presented for the three stations circled in blue.

Figure D-2. Location of 2006 sediment and overlying water sampling locations

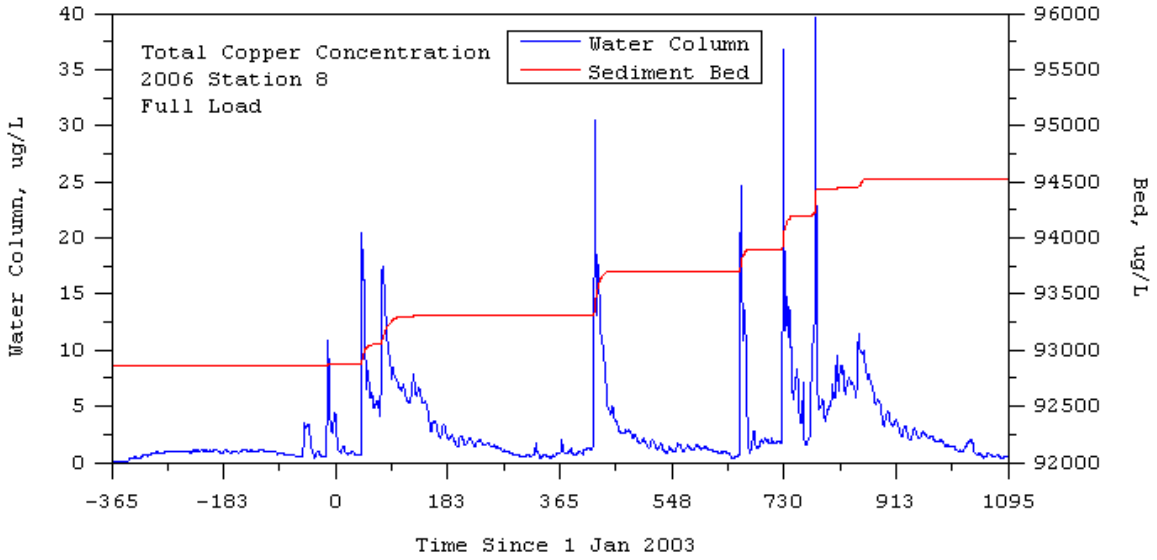
Copper and Zinc Results

Water column and sediment bed concentration time series for total copper are shown in Figures D-3 through D-5 for Stations 8, 42, and 54 (these stations are circled in blue on Figure D-2). Corresponding results for zinc are shown in Figures D-6 through D-8. The top panel of the time series figures shows the results for the Baseline Simulation (i.e., using baseline loads from the watersheds), while the lower panel illustrates the concentrations associated with the Load Reduction Simulation (i.e., river and near shore watershed loads were reduced by 50 percent). Results for both copper and zinc indicate decreases in water column concentrations during periods of high flow, when comparing the baseline conditions with the 50 percent load reduction scenario. Given the load reductions were 50 percent, there is corresponding similar ~50 percent reduction in water column concentrations.

In general, sediment bed contaminant concentrations tend to increase in response to high freshwater flows, which is expected since more sediments are transported by inflows from the watershed under high flow conditions. Over a four-year period, additional sediment is added to the system due to freshwater

inputs and other transport factors; therefore, there is an expected net increase in sediment bed contaminant concentrations (assuming no dredging or other pollutant-reduction activities have occurred). The net increases in sediment bed contaminant concentrations were compared between the Baseline Simulation and the Load Reduction Simulation. Overall, the net increase in copper and zinc concentrations over the four year period are substantially lower for the Load Reduction Simulation. Specifically, for stations 8 and 54 (Figures D-3 and D-5), the copper reductions observed at the end of the four-year period were greater than 1,000 ug/L and 500 ug/L, respectively (station 42 [Figure D-4] showed minimal change in copper concentrations). Sediment bed zinc concentrations at stations 8 and 54 (Figures D-6 and D-8) decreased by nearly 10,000 ug/L and 3,000 ug/L, respectively, after four years in the Load Reduction Simulation. Station 42 (Figure D-7) had a smaller zinc reduction at the end of the four-year period (approximately 500 ug/L).

Figures D-9 through D-11 present the three maps associated with sediment bed copper results, while Figures D-12 through D-14 present sediment bed zinc results. For comparative purposes, the Areal Concentration Change in Baseline Simulation results are shown first and exhibit a similar spatial pattern for the two metals (Figures D-9 and D-12). These results are followed by the maps of the Areal Concentration Change from Load Reduction Simulation. Overall, reduction of incoming loads by 50 percent results in a system-wide reduction in sediment bed copper and zinc concentrations (Figures D-10 and D-13, respectively). Recall that these figures represent the difference between the end of the simulation period under baseline conditions and the end of the simulation period for the load reduction scenario (not the change over time between the beginning and end of the load reduction simulation period). Therefore, all positive values indicate a reduction in copper and zinc sediment bed concentrations. Reductions in sediment bed copper concentrations due to the load reduction simulation ranged from over 1,000 mg/m^2 near the Consolidated Slip and Los Angeles River inflow to less than 100 mg/m^2 by the breakwater. Similarly, zinc reductions ranged from over 10,000 mg/m^2 near the Consolidated Slip and Los Angeles River inflow to less than 800 mg/m^2 by the breakwater. These correspond to relative copper reductions of approximately 30 percent (a factor of 0.30) in the Los Angeles River inflow region to nearly 1 percent (a factor of 0.01) in many of the other harbor areas (Figure D-11). Relative reductions associated with the load reduction simulations for zinc were even higher (Figure D-14), ranging from 40 percent (a factor of 0.4) to over 2 percent (a factor of 0.02) throughout most of the area inside the breakwater.



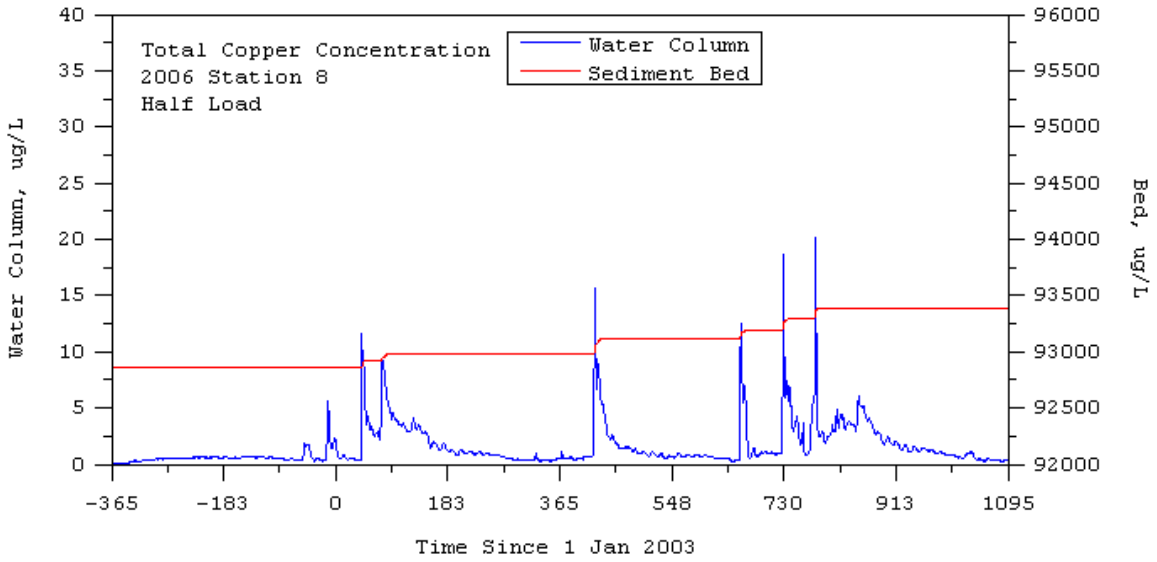
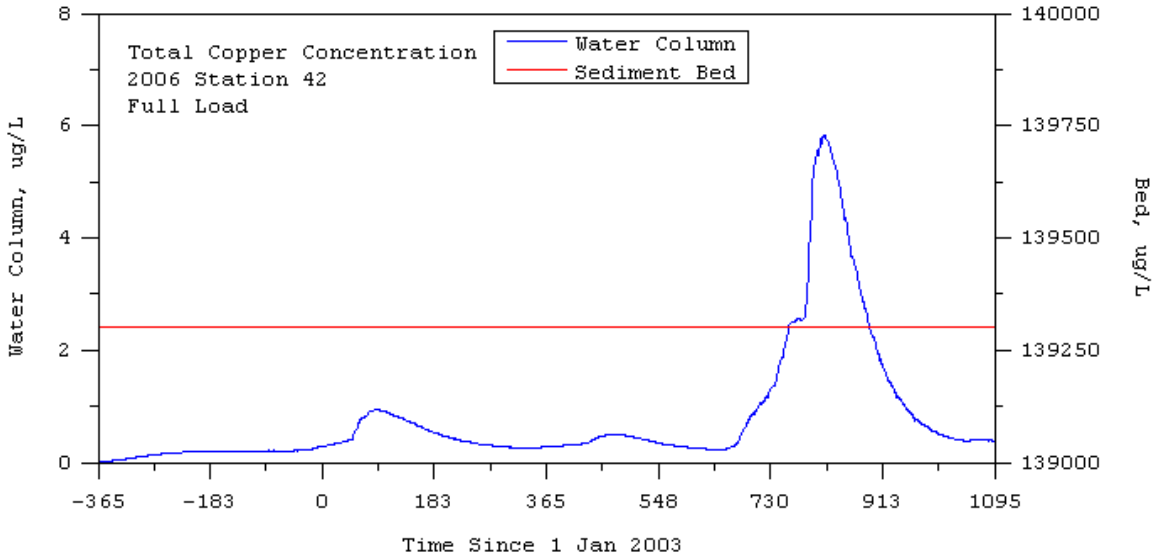


Figure D-3. Total copper concentration in water column and at sediment bed surface for Station 8 (see Figure D-2 for location)



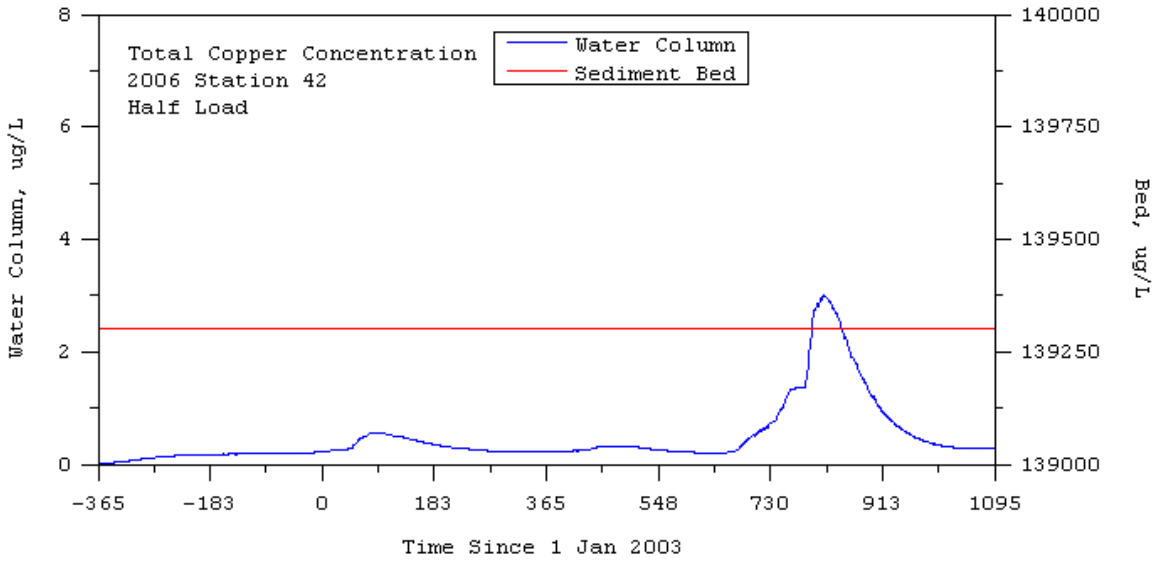


Figure D-4. Total copper concentration in water column and at sediment bed surface for Station 42 (see Figure D-2 for location)

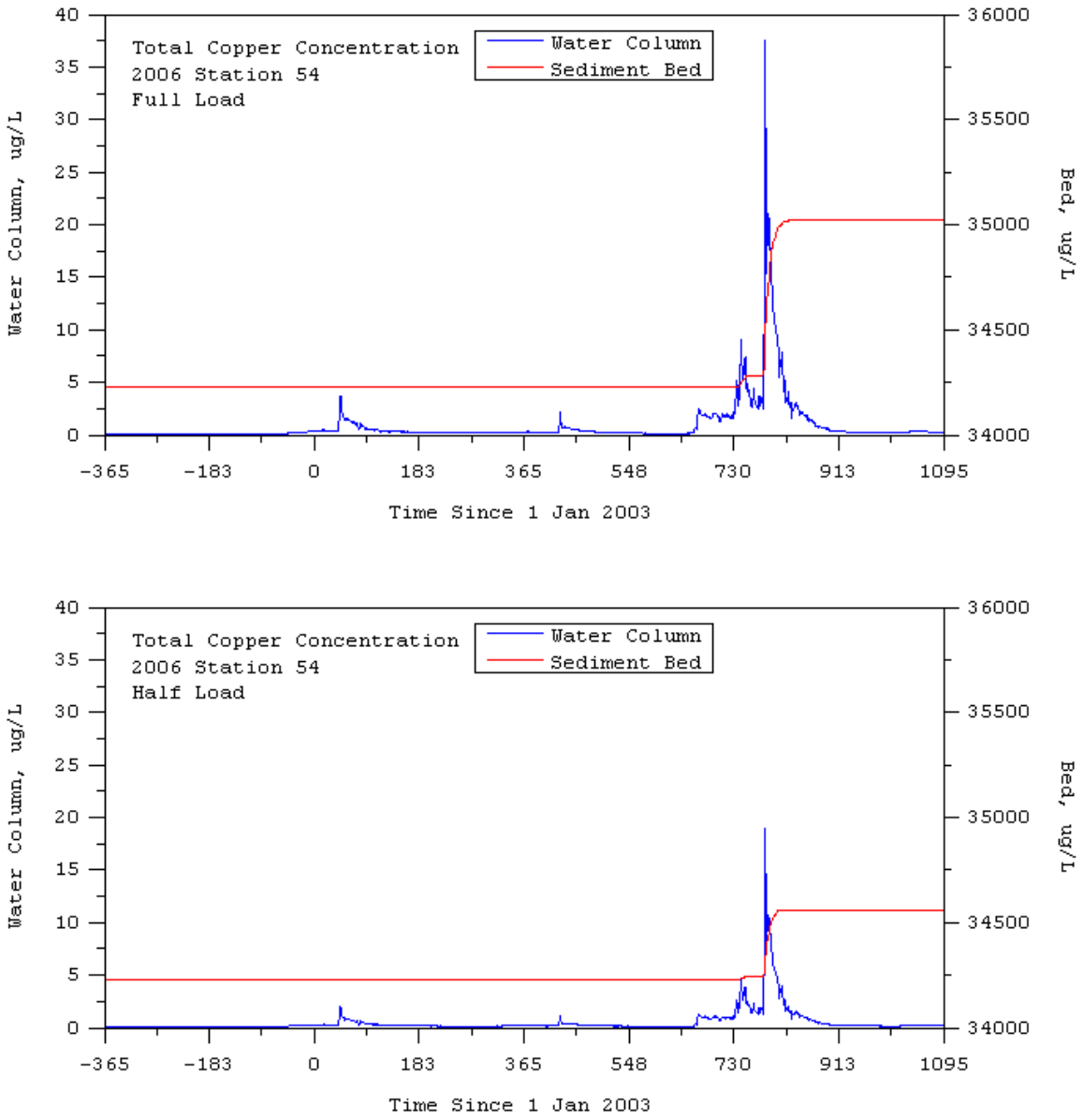


Figure D-5. Total copper concentration in water column and at sediment bed surface for Station 54 (see Figure D-2 for location)

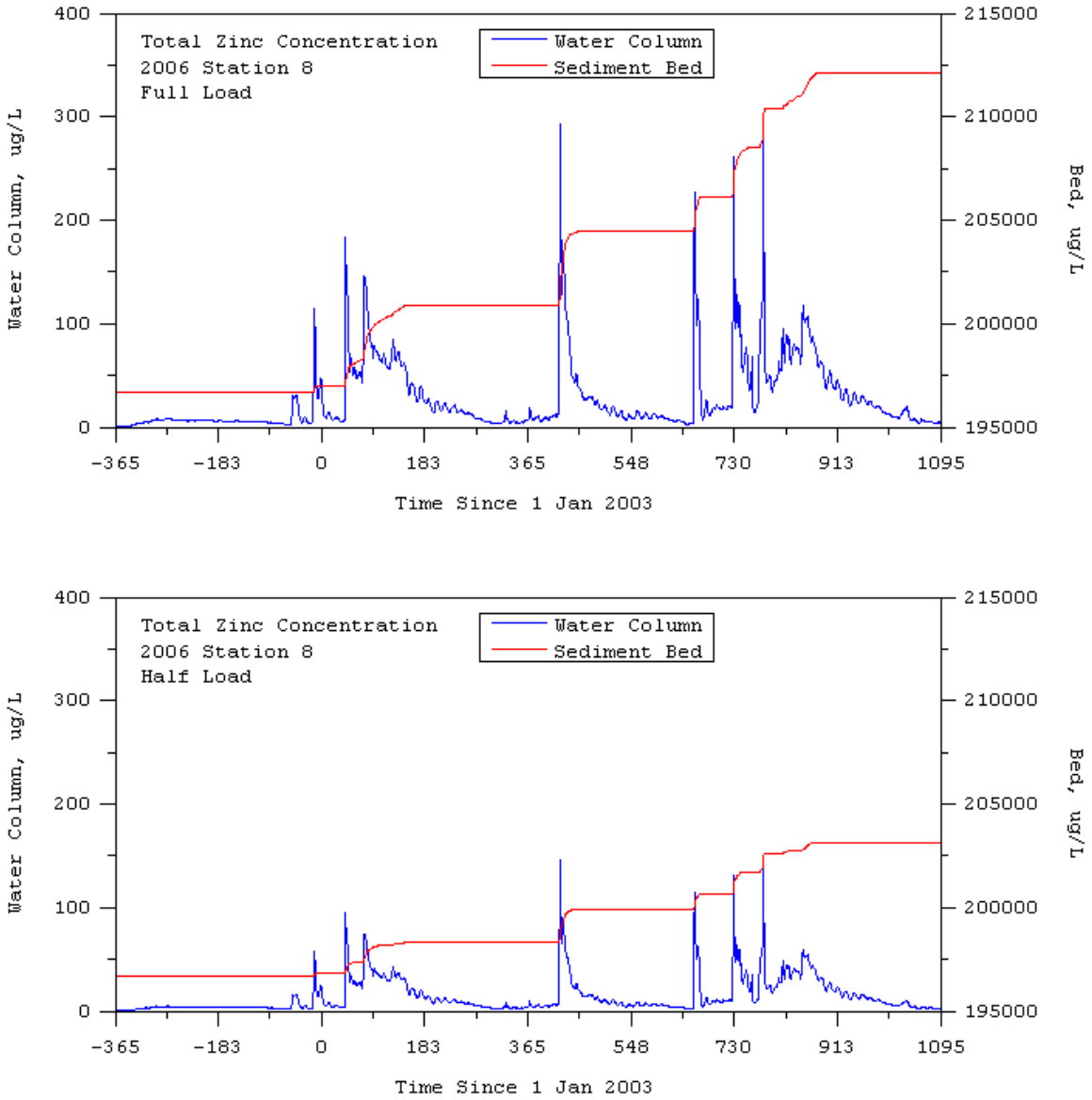


Figure D-6. Total zinc concentration in water column and at sediment bed surface for Station 8 (see Figure D-2 for location)

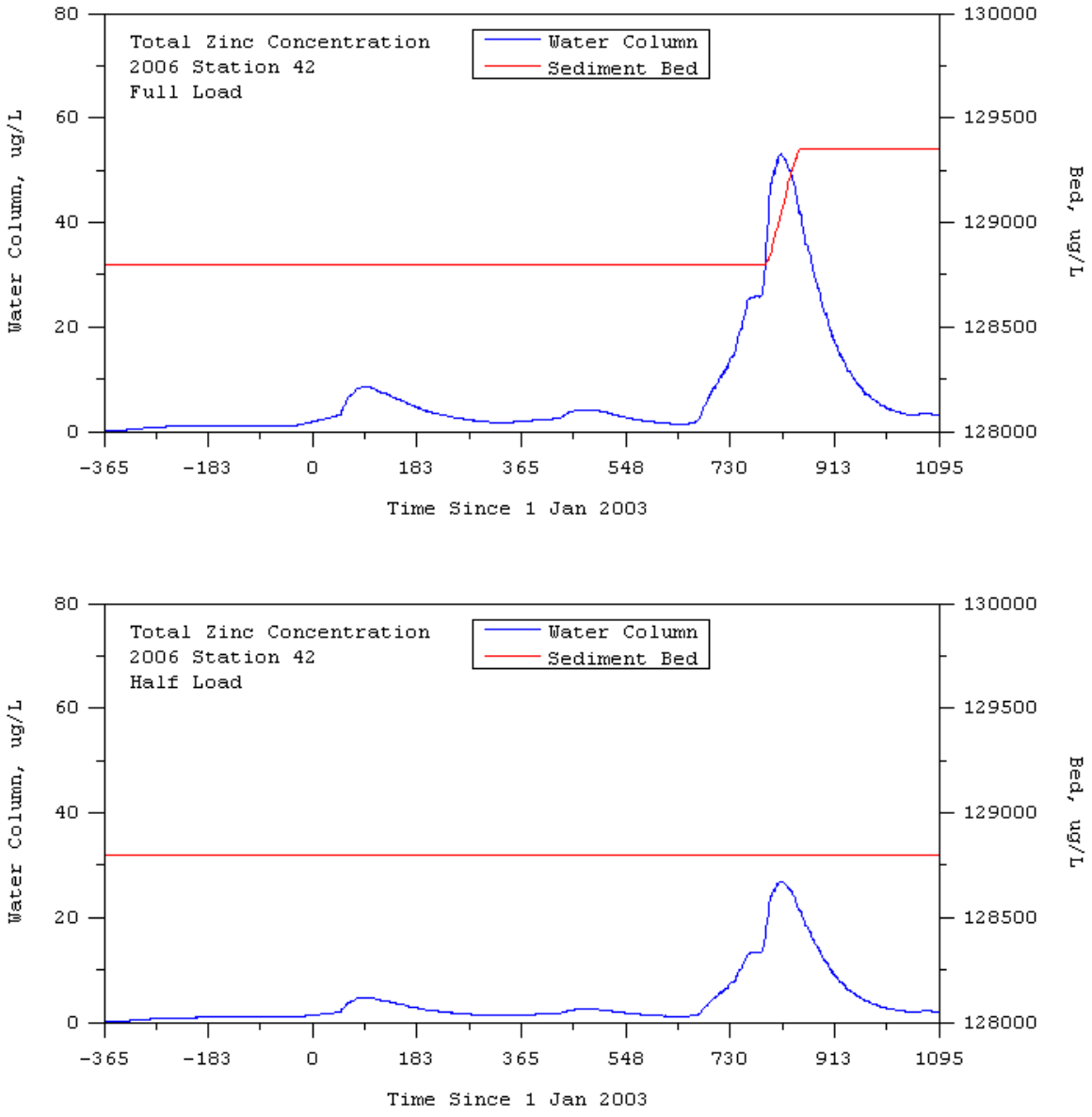
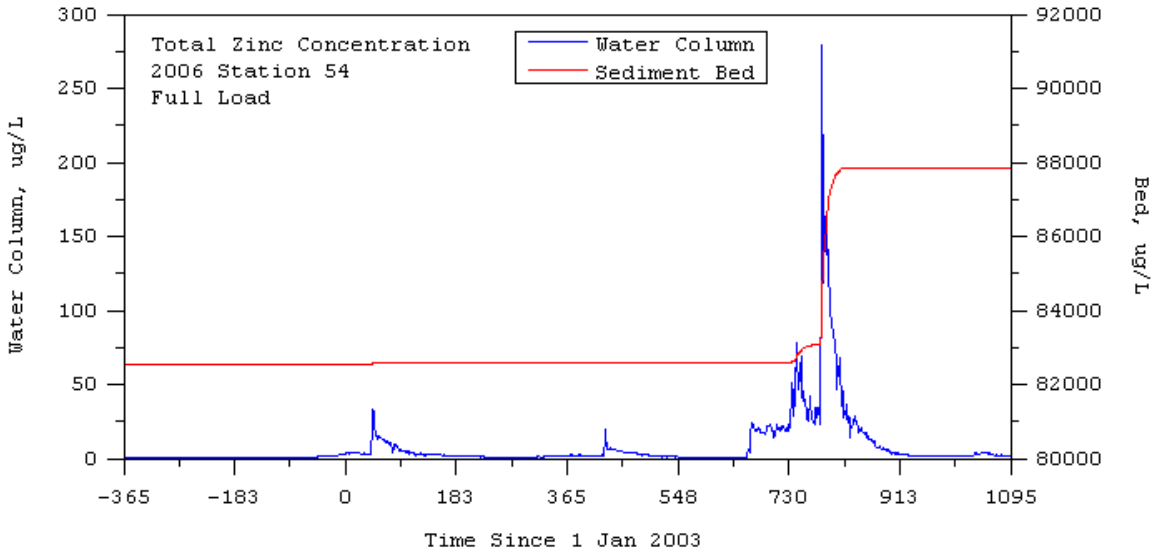


Figure D-7. Total zinc concentration in water column and at sediment bed surface for Station 42 (see Figure D-2 for location)



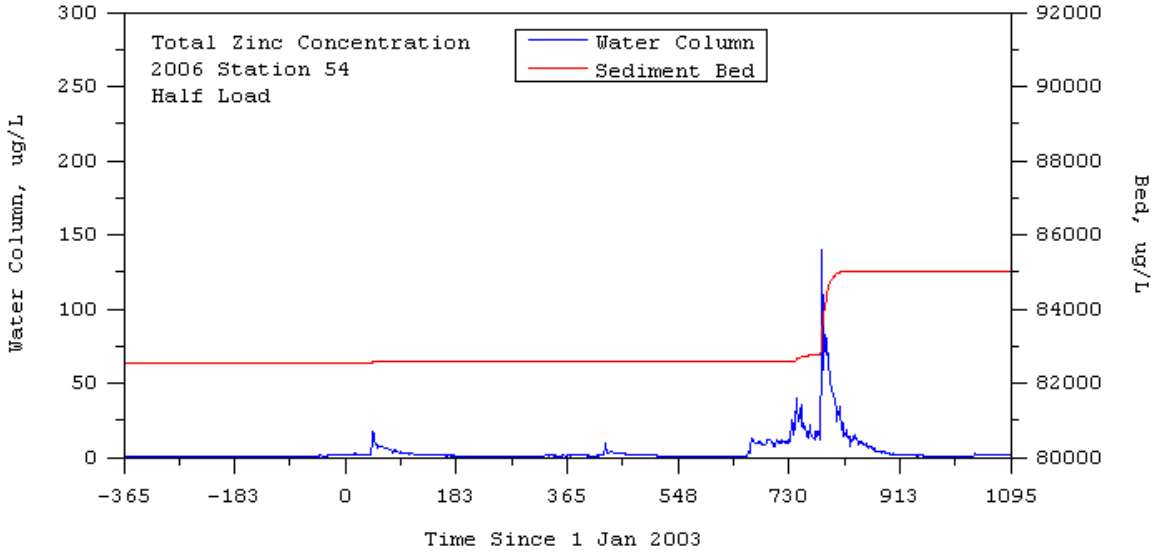
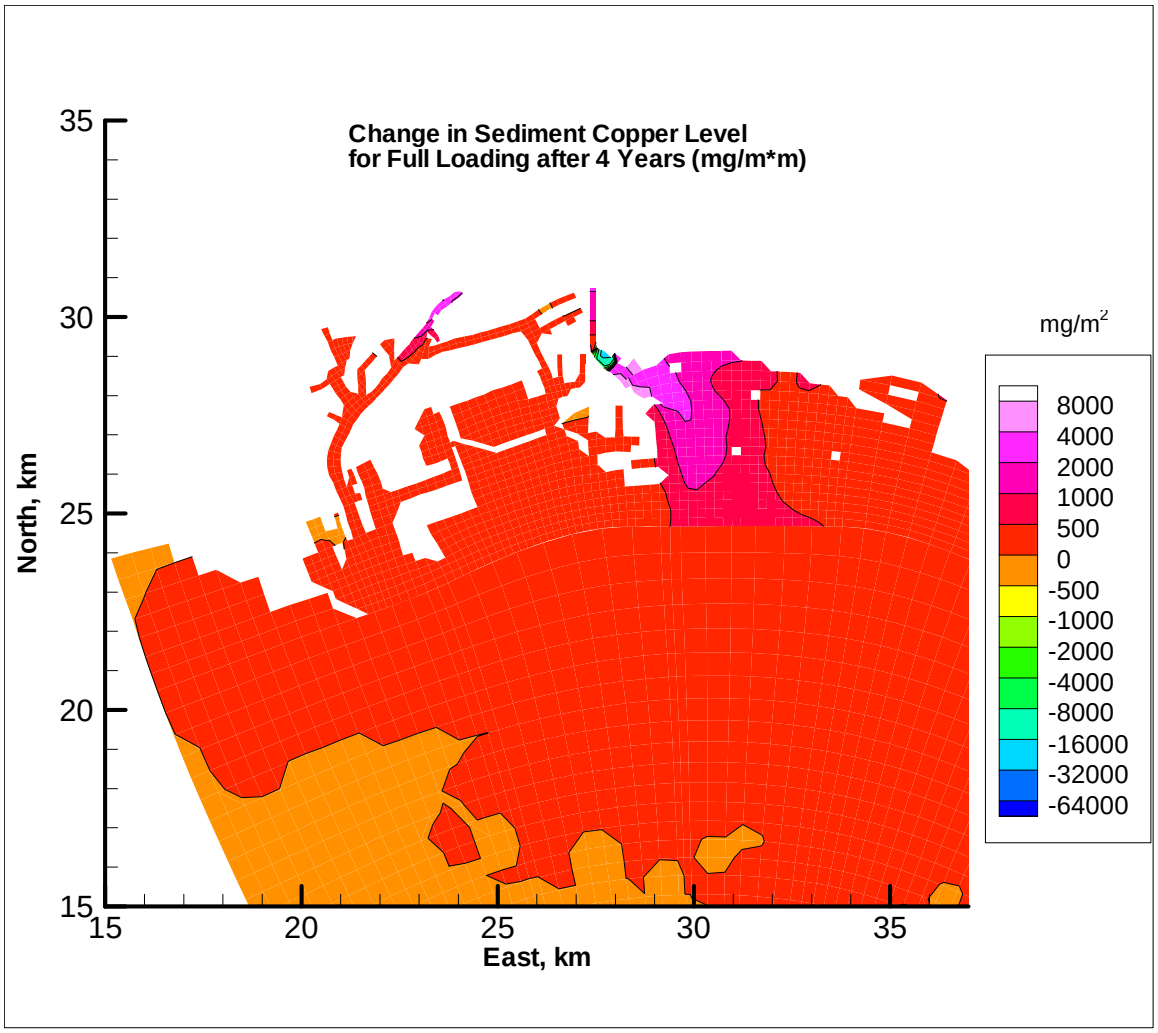
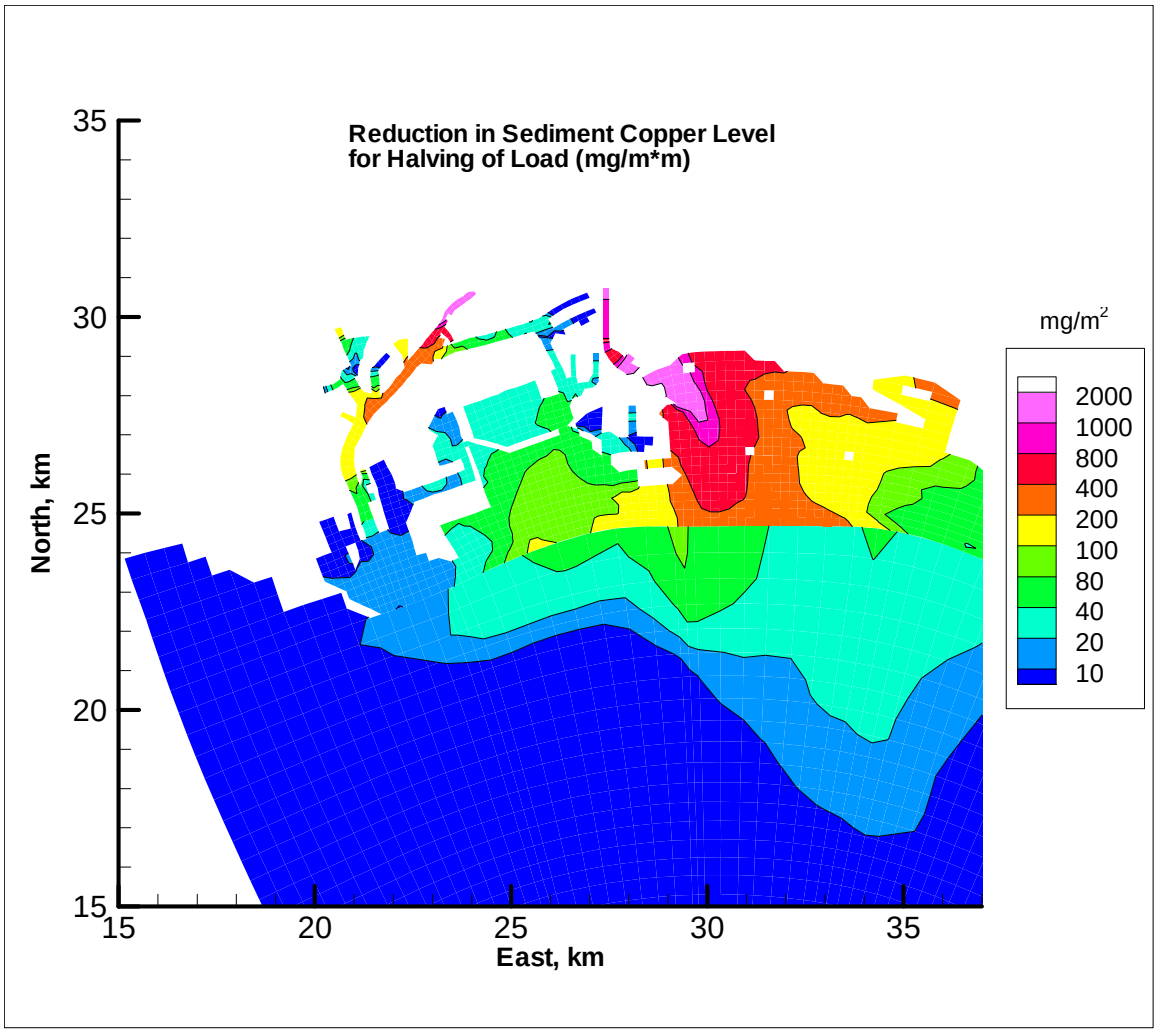


Figure D-8. Total zinc concentration in water column and at sediment bed surface for Station 54 (see Figure D-2 for location)



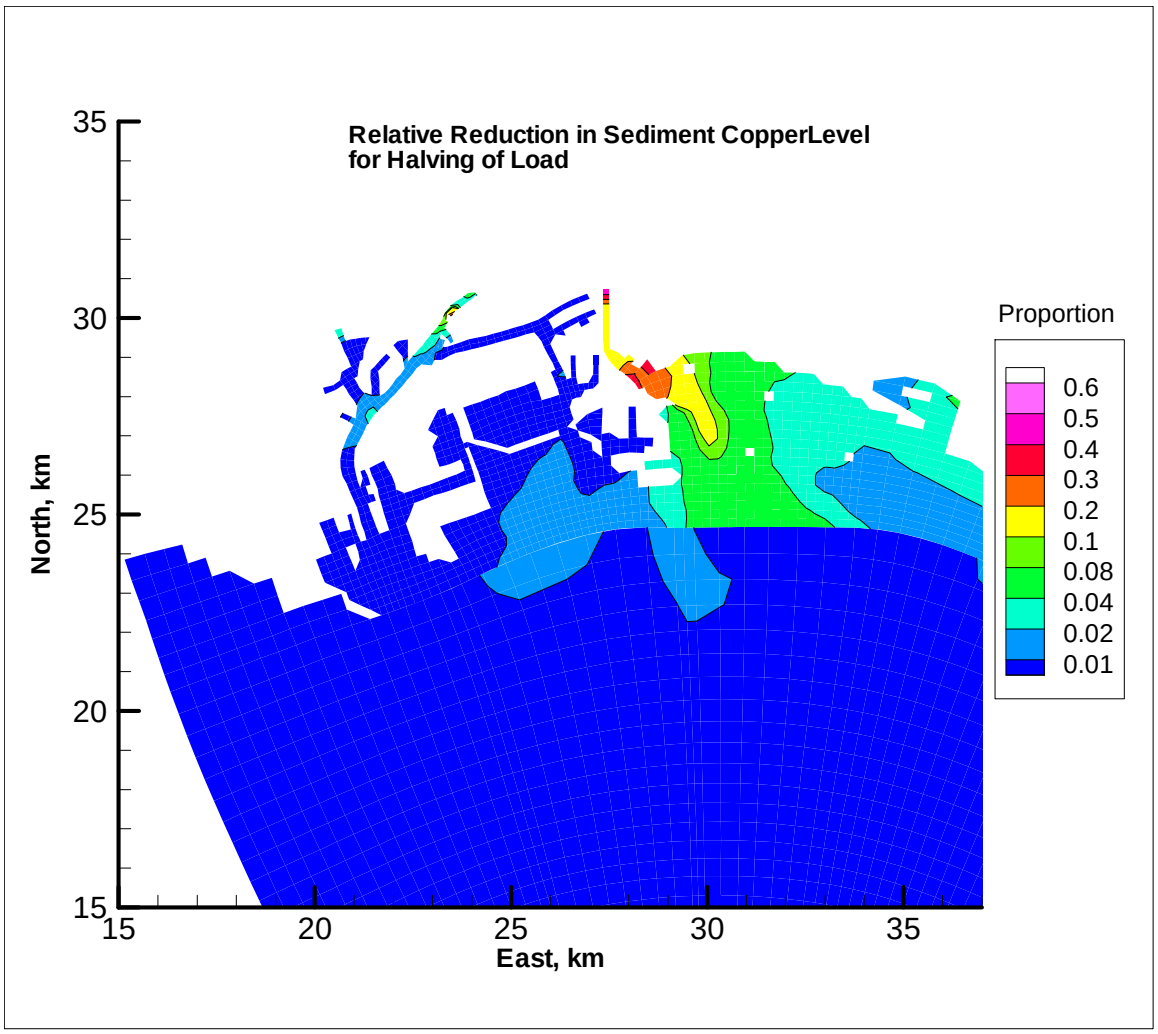
Note: Areal Concentration Change in Baseline Simulation Over Time = Final Areal Concentration using Baseline Conditions in 2005 (after 4 years) – Initial Areal Concentration using Baseline Conditions in 2002 (beginning of simulation period). Results are presented in mg/m^2.

Figure D-9. Areal concentration change in baseline simulation over time (after four years) – copper



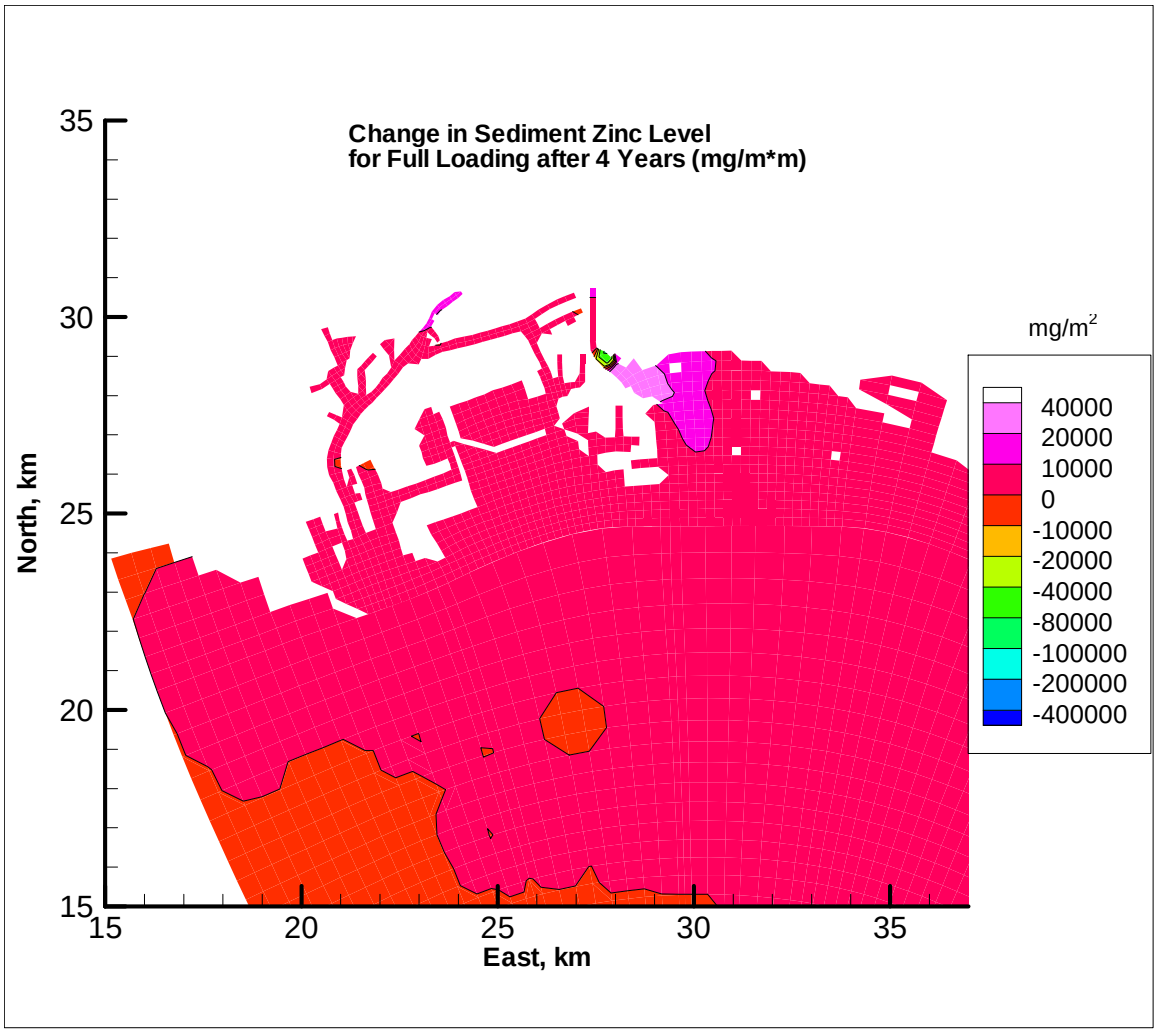
Note: Areal Concentration Change from Load Reduction Simulation = Final Areal Baseline Simulation Concentration in 2005 – Final Areal Load Reduction Concentration in 2005 (based on 50 percent load reduction from the rivers and near shore watersheds). Results are presented in mg/m^2.

Figure D-10. Areal concentration change from load reduction simulation – copper



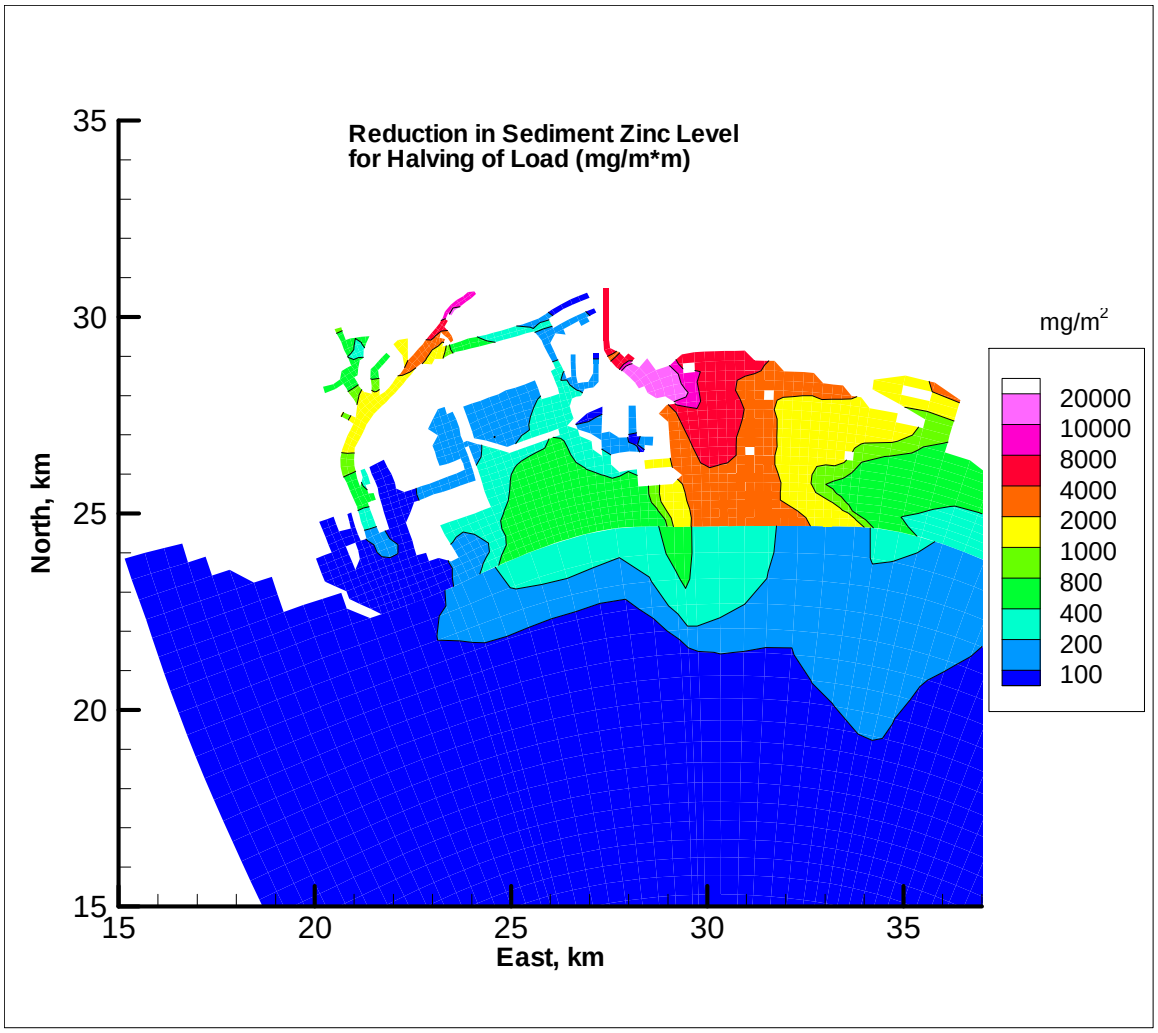
Note: Relative Change in Load Reduction Simulation = Relative Change in Load Reduction Change (normalized by initial top bed layer concentration). Results are proportions and can be multiplied by 100 to obtain percent.

Figure D-11. Relative change in load reduction simulation – copper



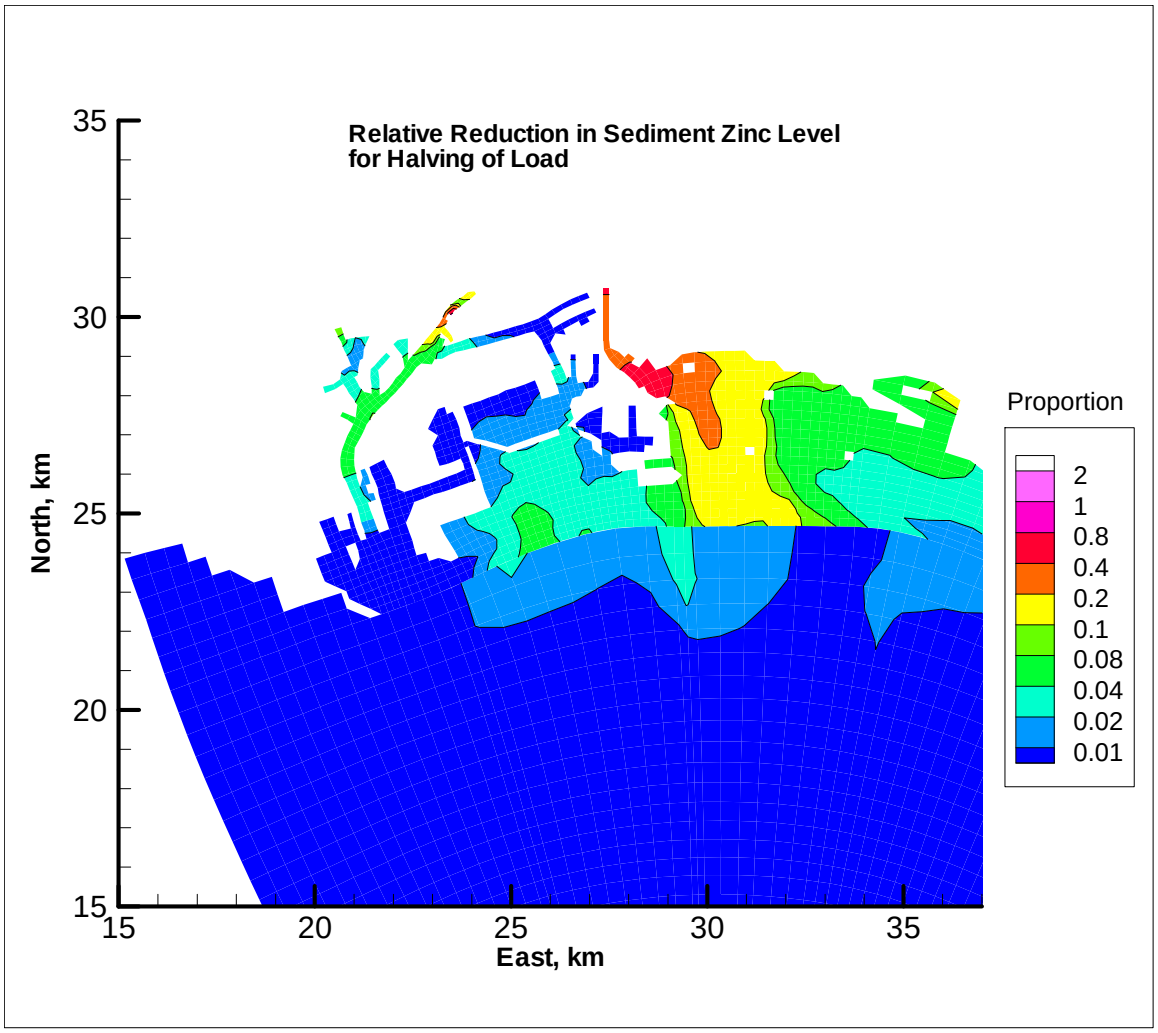
Note: Areal Concentration Change in Baseline Simulation Over Time = Final Areal Concentration using Baseline Conditions in 2005 (after 4 years) – Initial Areal Concentration using Baseline Conditions in 2002 (beginning of simulation period). Results are presented in mg/m^2.

Figure D-12. Areal concentration change in baseline simulation over time (after four years) – zinc



Note: Areal Concentration Change from Load Reduction Simulation = Final Areal Baseline Simulation Concentration in 2005 – Final Areal Load Reduction Concentration in 2005 (based on 50 percent load reduction from the rivers and near shore watersheds). Results are presented in mg/m^2.

Figure D-13. Areal concentration change from load reduction simulation – zinc



Note: Relative Change in Load Reduction Simulation = Relative Change in Load Reduction Change (normalized by initial top bed layer concentration). Results are proportions and can be multiplied by 100 to obtain percent.

Figure D-14. Relative change in load reduction simulation – zinc

DDT and PAH Results

Water column and sediment bed concentration time series for total DDT are shown for Stations 8, 42, and 54 (circled in blue on Figure D-2) in Figures D-15 through D-17. Corresponding results for PAH are shown in Figures D-18 through D-20. As described above for the metals, the top panel of the time series figures shows the results for the Baseline Simulation (i.e., using baseline loads from the watersheds), while the lower panel illustrates the concentrations associated with the Load Reduction Simulation (i.e., river and near shore watershed loads were reduced by 50 percent). The results indicate that DDT and PAH concentrations in the water column decrease during periods of high flow when comparing the baseline conditions with the 50 percent load reduction scenario, as was the case for the two metals.

Sediment bed contaminant concentration for both DDT and PAH show a continual decrease for all stations and both scenarios consistent with a net flux into the water column. Since the copper and zinc bed concentrations do not show a continuous decrease, the flux of DDT and PAH is attributed to pore water diffusion from the top layer of the sediment bed into the water column. This is also supported by the observation that during dry or low inflow periods, water column DDT and PAH concentrations behave in a similar manner. The flattening of the bed concentration curves over the four year period indicates that pore water and water column concentrations are coming into equilibrium and that the bed source of water column DDT and PAH diminishes with time.

Spatial maps associated with sediment bed DDT results are presented in Figures D-21 through D-23, while maps for PAH levels are illustrated in Figures D-24 through D-26. Similar to the metals, for comparative purposes, the Areal Concentration Change in Baseline Simulation results are shown first (Figures D-21 and D-24) and these results are followed by the maps of the Areal Concentration Change from Load Reduction Simulation (Figures D-22 and D-25). The Areal Concentration Change in Baseline Simulation maps illustrate the change in sediment bed concentrations over a four-year period using the baseline conditions. The spatial pattern is somewhat similar for the two pollutants, except near the Los Angeles River inflow (Figures D-21 and D-24). Review of the Load Reduction Simulation maps for DDT and PAH (i.e., the areal concentration change between the end of the simulation period under baseline conditions and the end of the simulation period for the load reduction scenario) indicates that the reduction of incoming loads by 50 percent results in a system-wide reduction in sediment bed DDT and PAH levels (Figures D-22 and D-25, respectively). These reductions are illustrated by the positive values in sediment bed concentrations. Reductions in areal sediment bed DDT concentrations due to the load reduction are quite small, and range from approximately 50 $\mu g/m^2$ near the Consolidated Slip and 25 $\mu g/m^2$ near the Los Angeles River to less than 1 $\mu g/m^2$ by the breakwater. PAH reductions ranged from approximately 6,400 $\mu g/m^2$ near the mouth of the Los Angeles River to less than 100 $\mu g/m^2$ by the

breakwater. These correspond to relative DDT reductions of approximately 1.6 percent (a factor of 0.016) in the Los Angeles River region to 0.1 percent (a factor of 0.001) throughout most of the area inside the breakwater (Figure D-23). Relative reductions associated with the load reduction simulations for PAH were higher (Figure D-26), ranging from 10 percent (a factor of 0.10) near the Los Angeles River to approximately 0.5 percent (a factor of 0.005) throughout large areas inside and outside of the breakwater.

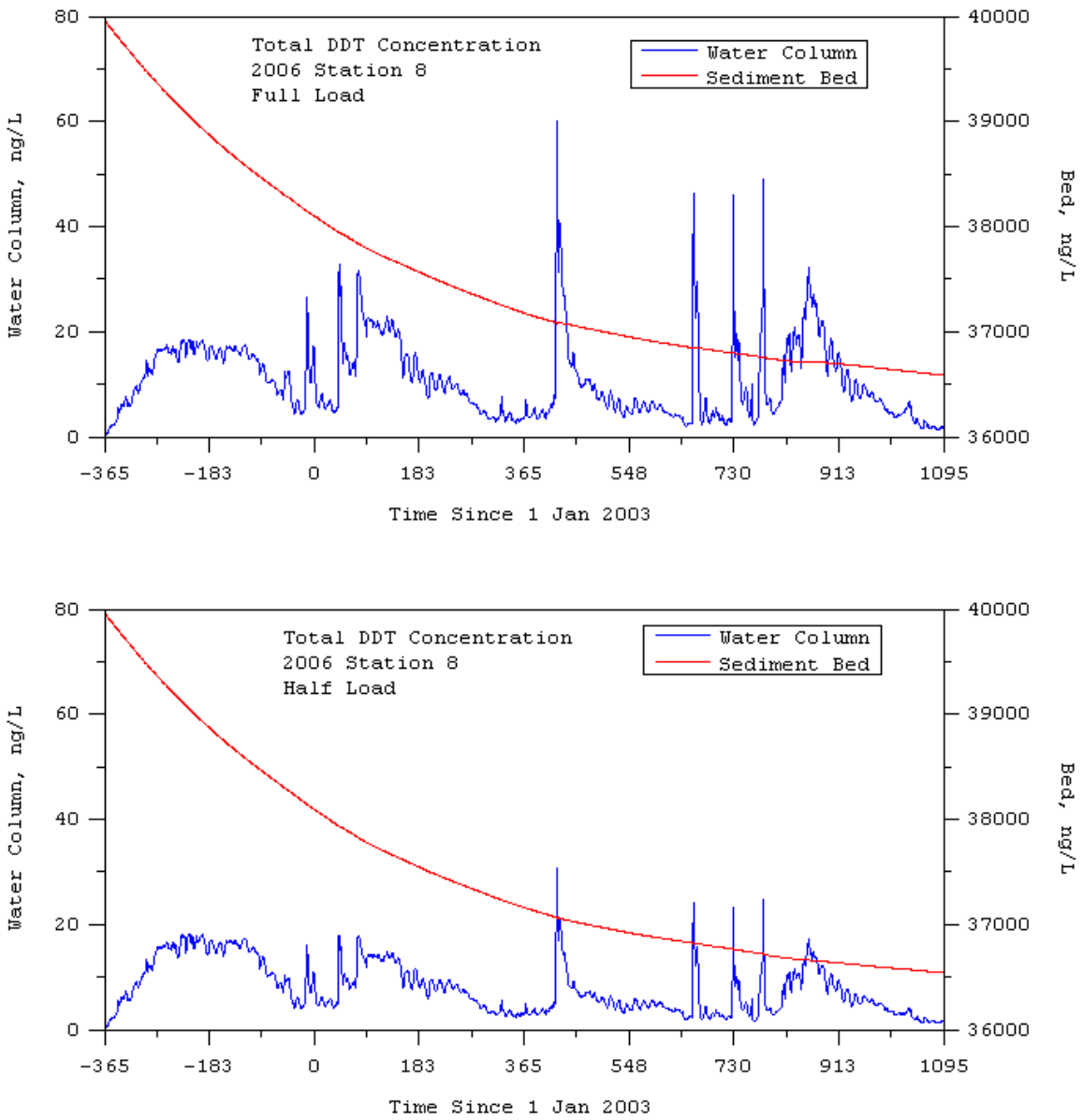


Figure D-15. Total DDT concentration in water column and at sediment bed surface for Station 8 (see Figure D-2 for location)

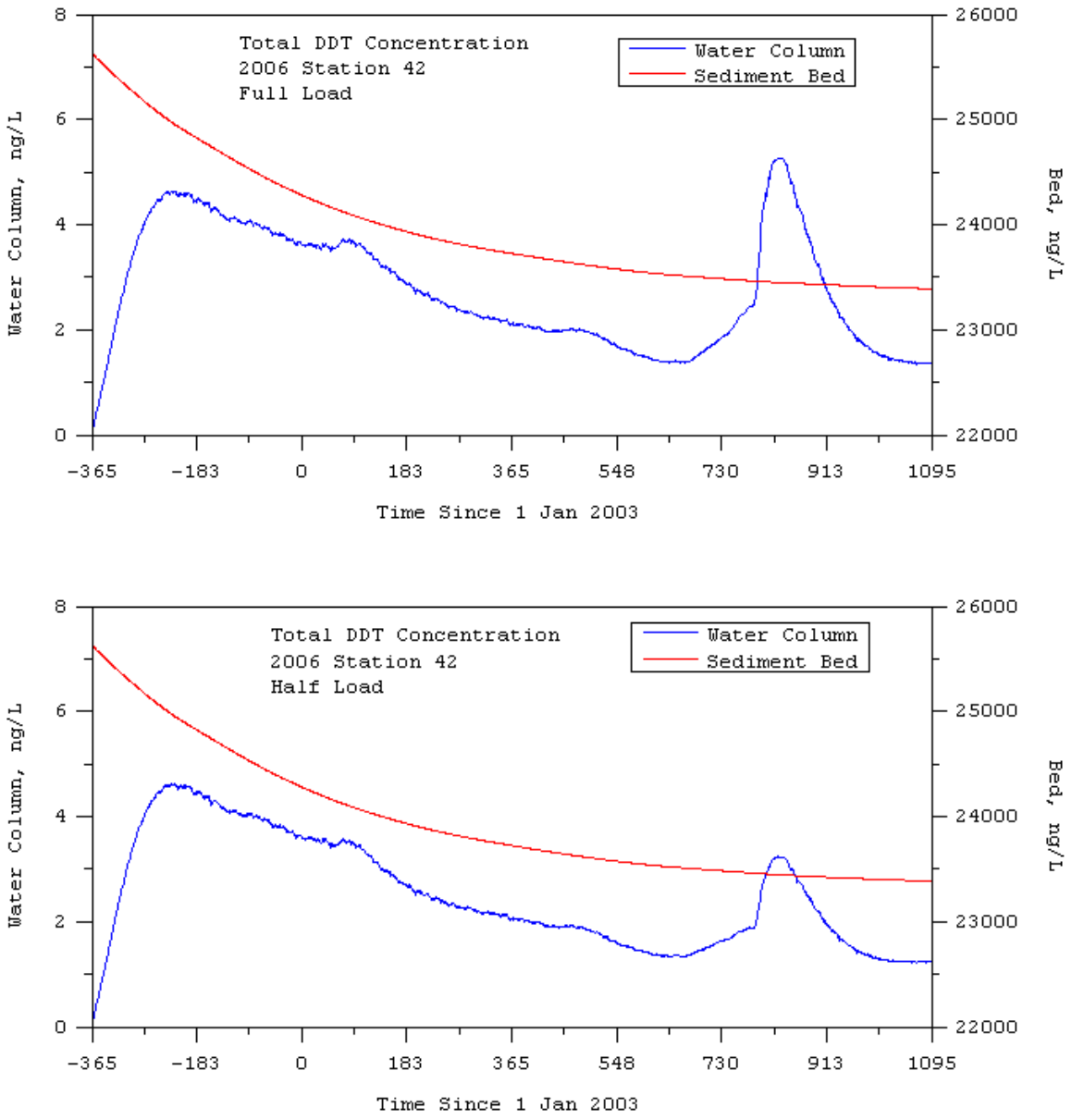
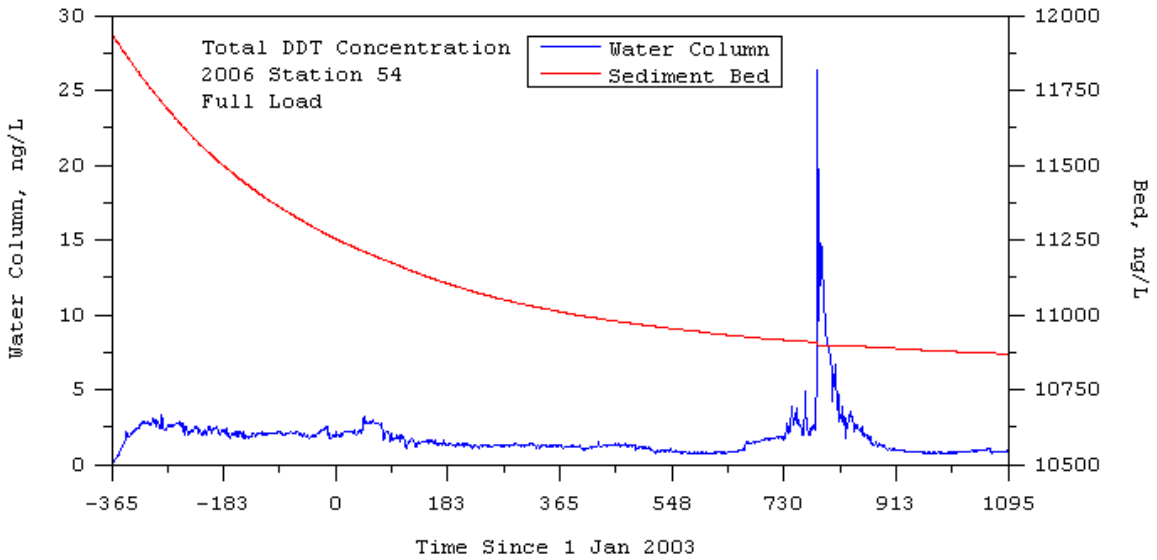


Figure D-16. Total DDT concentration in water column and at sediment bed surface for Station 42 (see Figure D-2 for location)



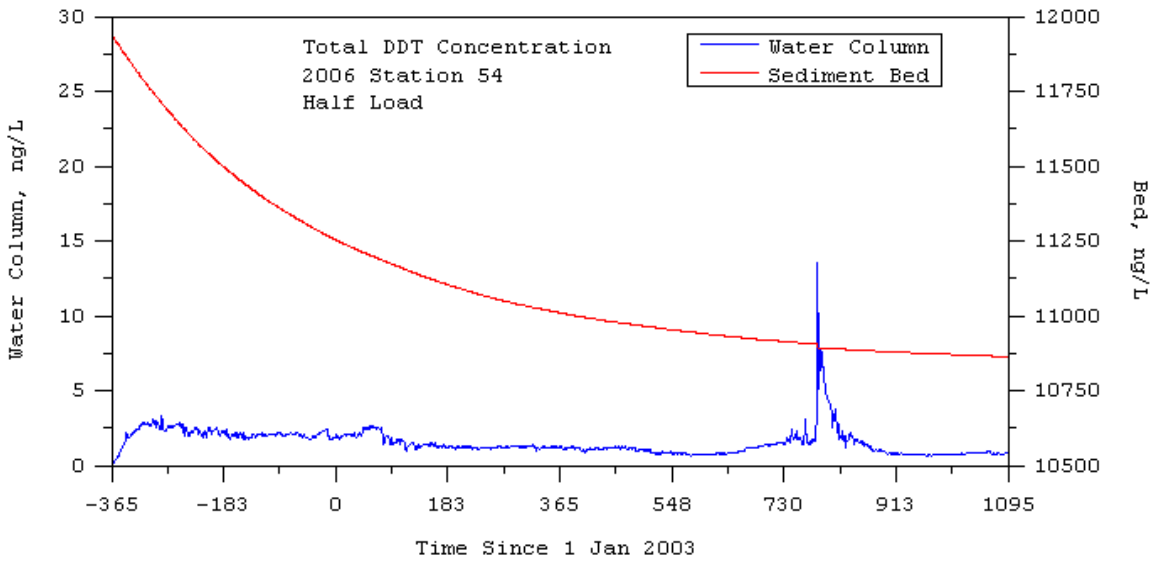
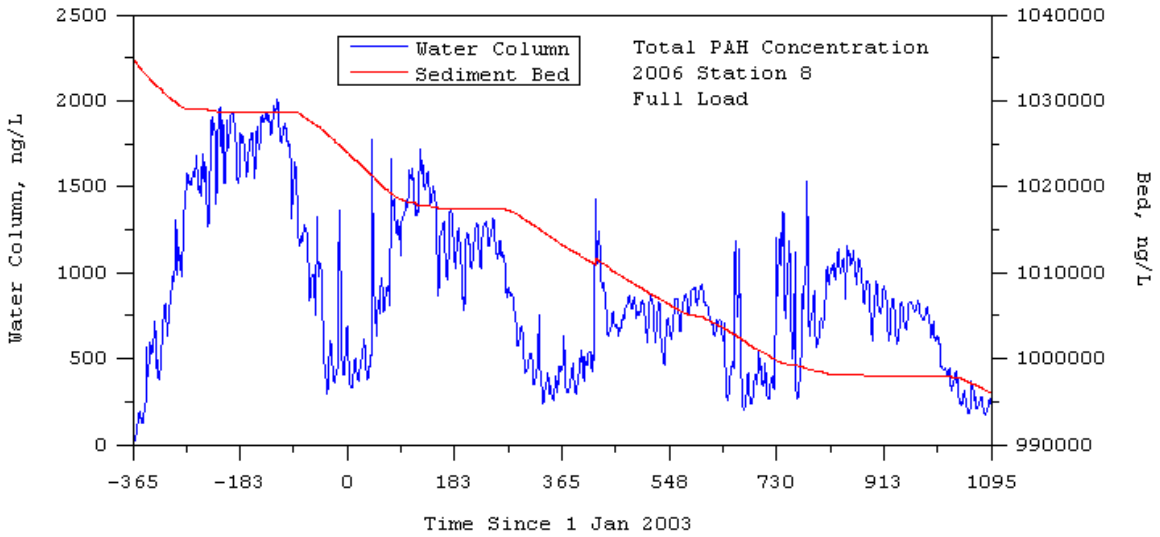


Figure D-17. Total DDT concentration in water column and at sediment bed surface for Station 54 (see Figure D-2 for location)



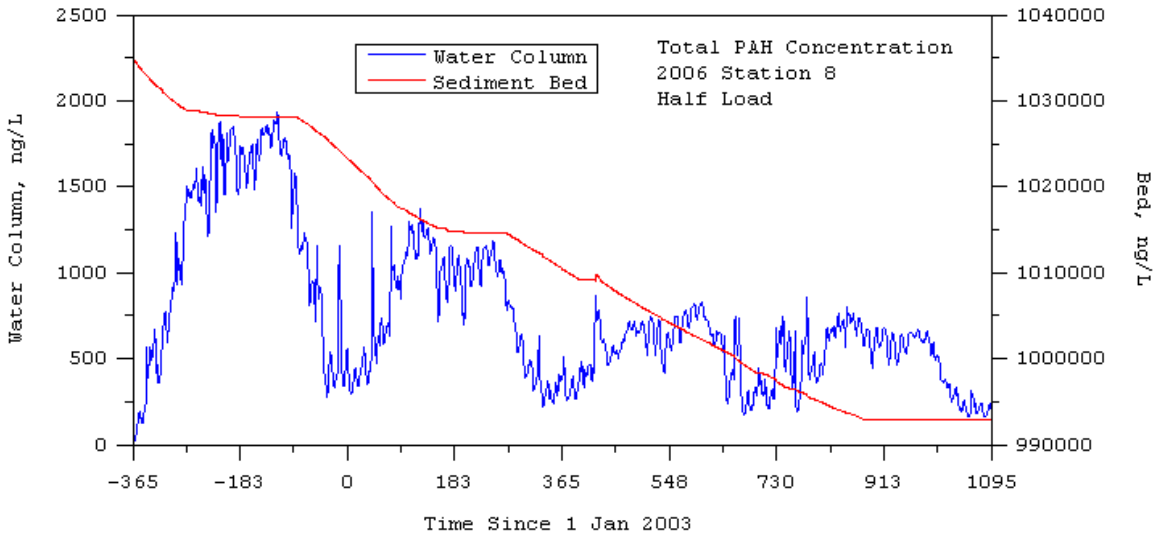
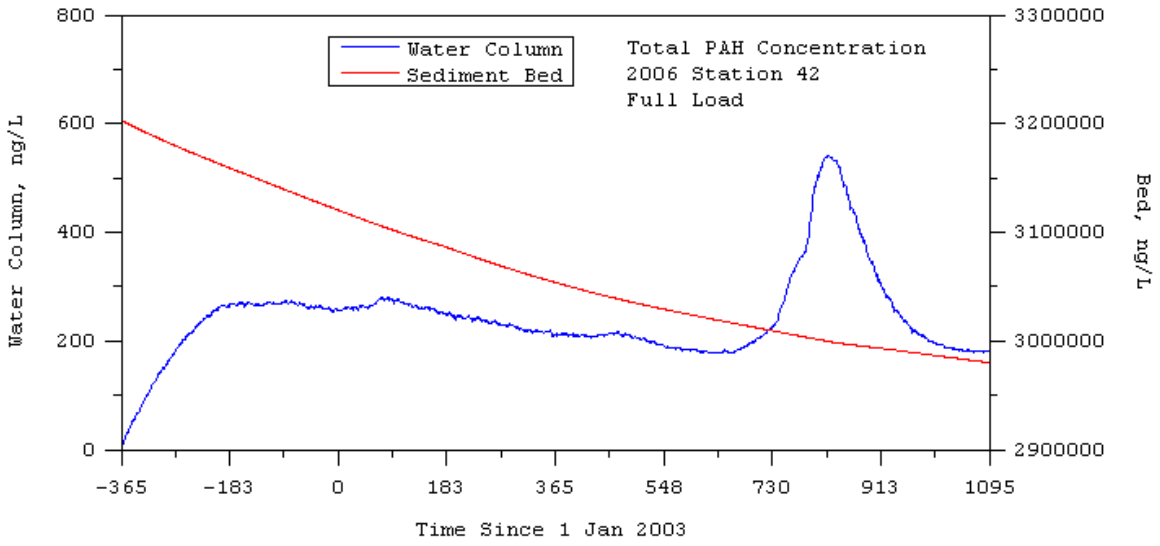


Figure D-18. Total PAH concentration in water column and at sediment bed surface for Station 8 (see Figure D-2 for location)



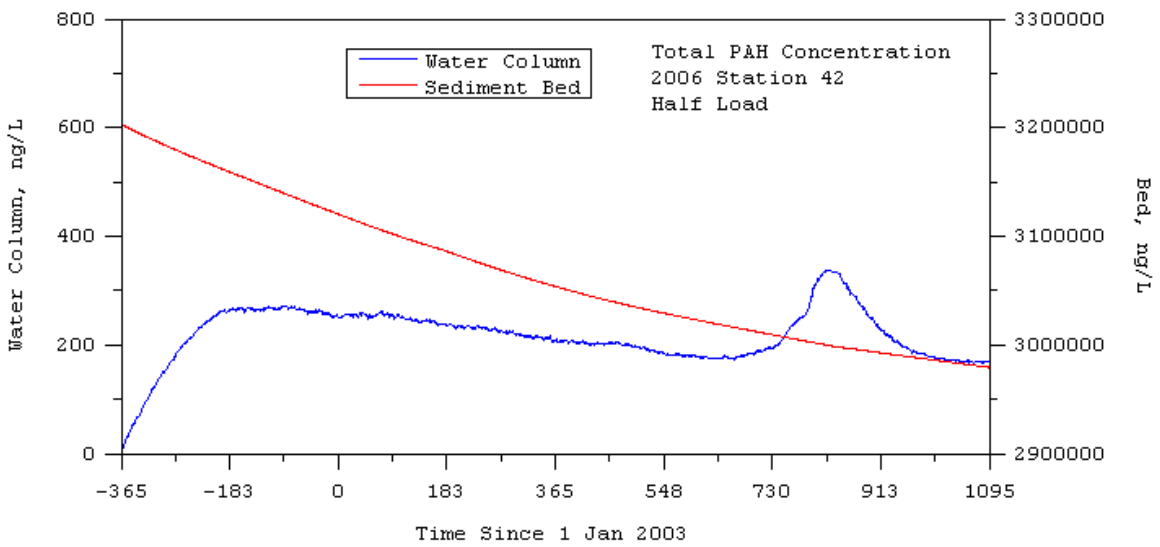


Figure D-19. Total PAH concentration in water column and at sediment bed surface for Station 42 (see Figure D-2 for location)

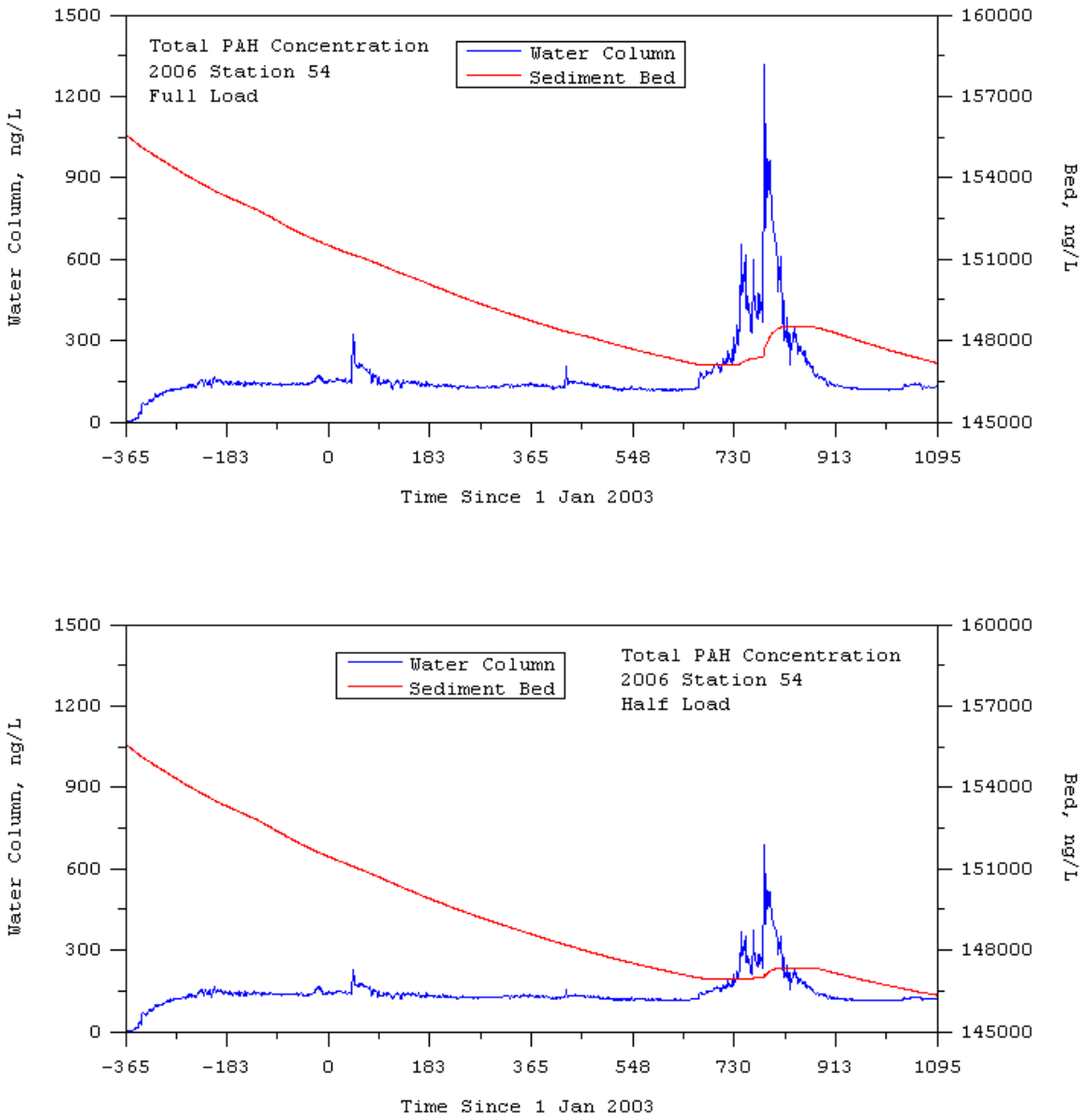
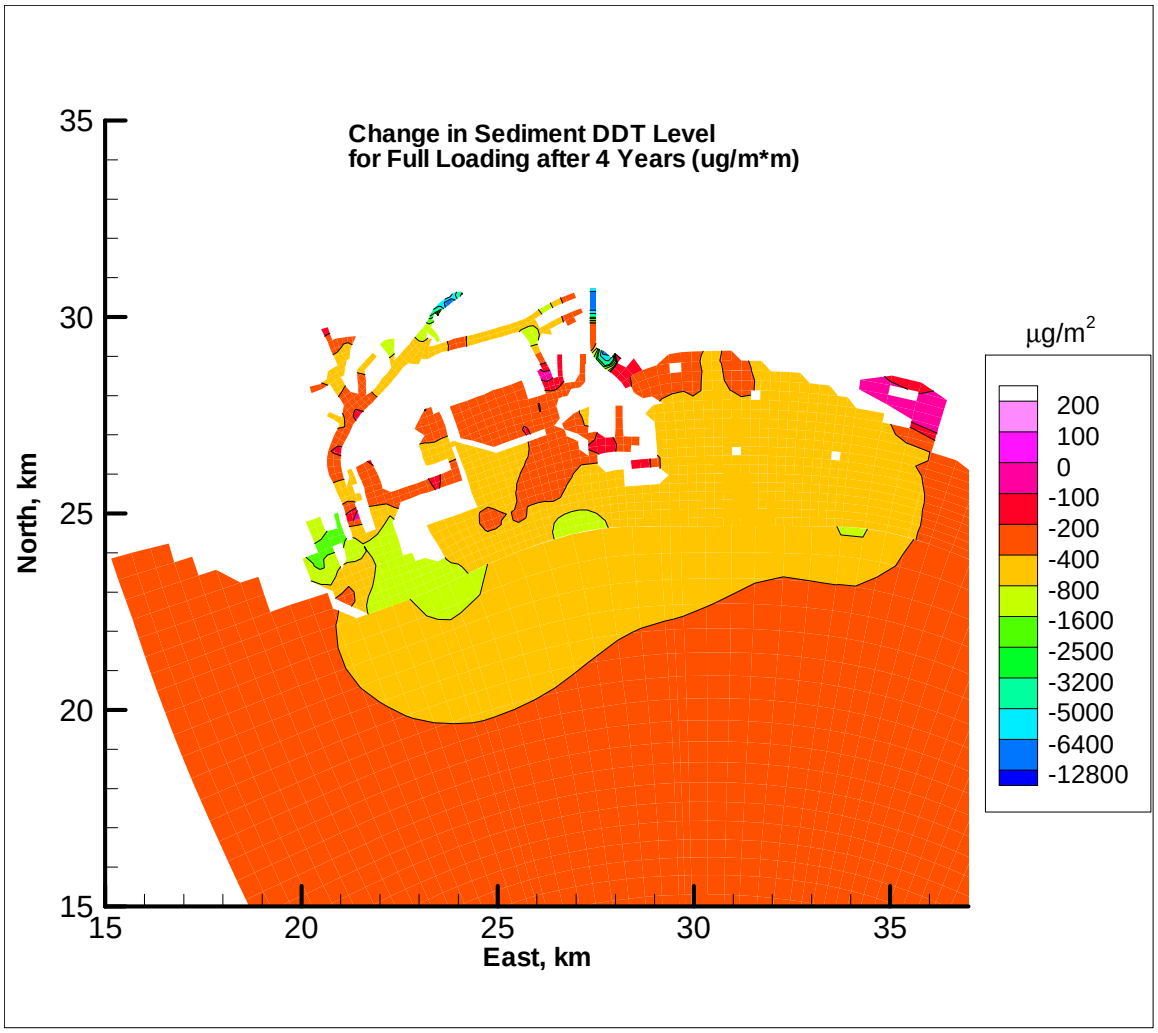
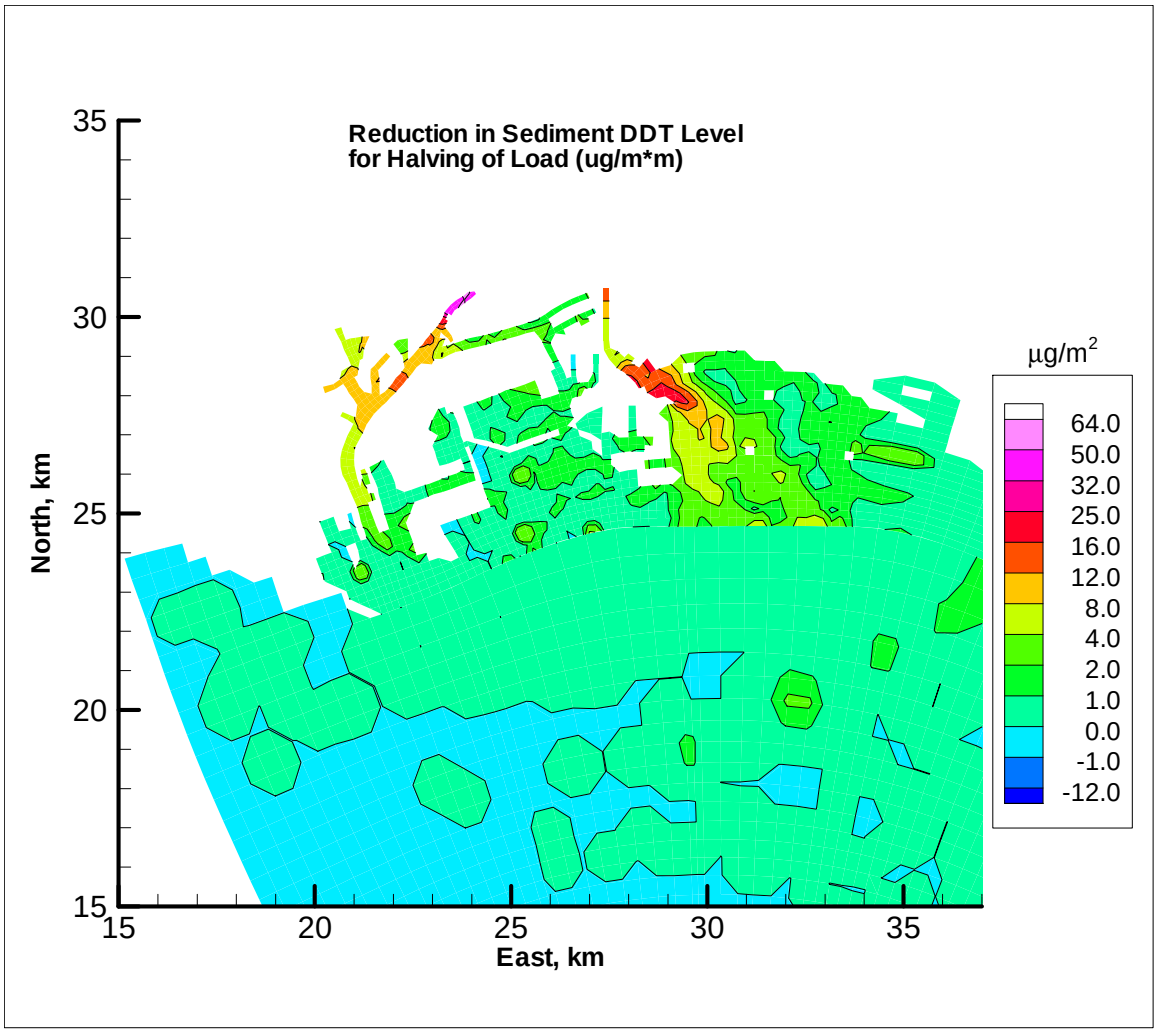


Figure D-20. Total PAH concentration in water column and at sediment bed surface for Station 54 (see Figure D-2 for location)



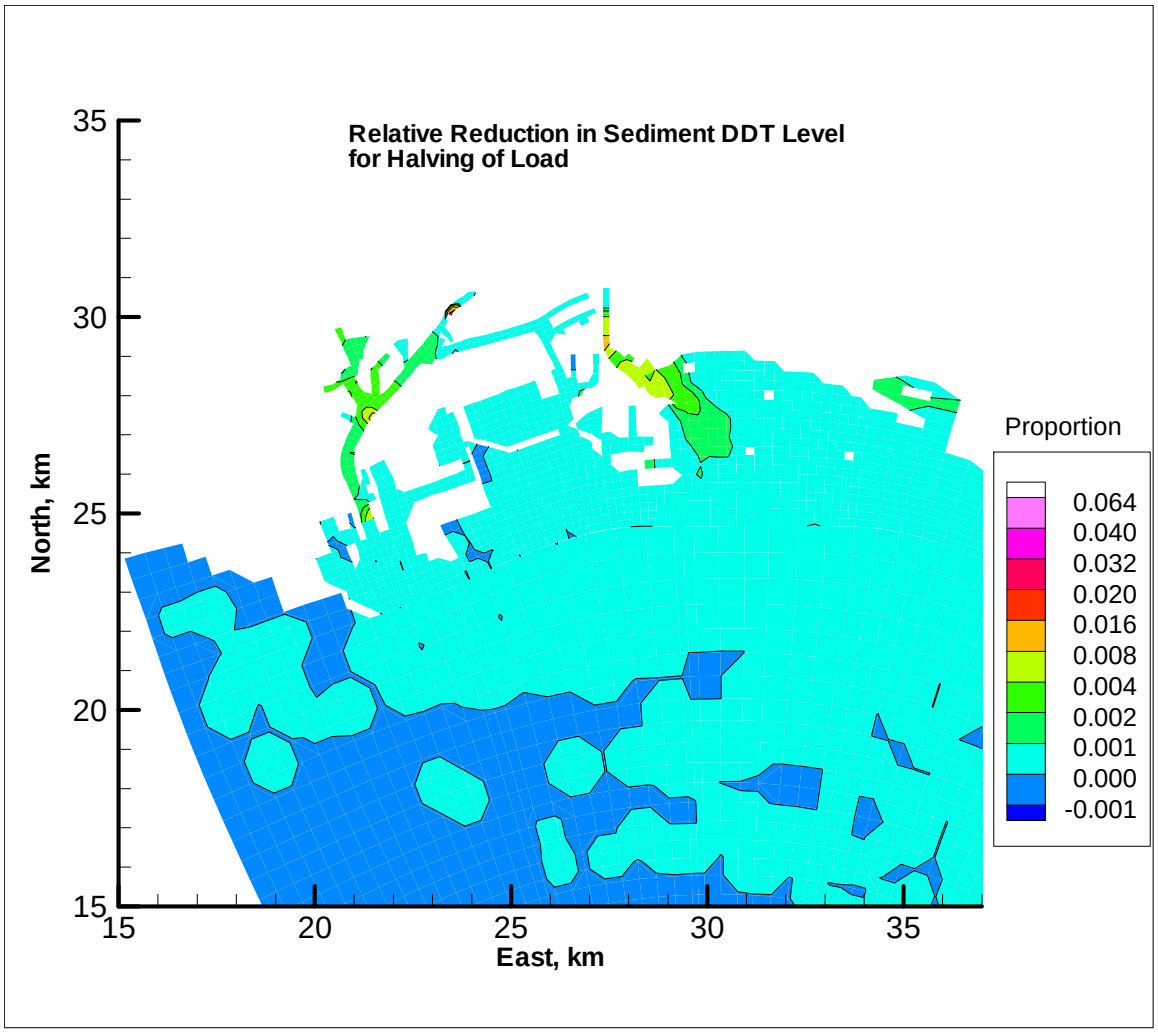
Note: Areal Concentration Change in Baseline Simulation Over Time = Final Areal Concentration using Baseline Conditions in 2005 (after 4 years) – Initial Areal Concentration using Baseline Conditions in 2002 (beginning of simulation period). Results are presented in $\mu g/m^2$.

Figure D-21. Areal concentration change in baseline simulation over time (after four years) – DDT



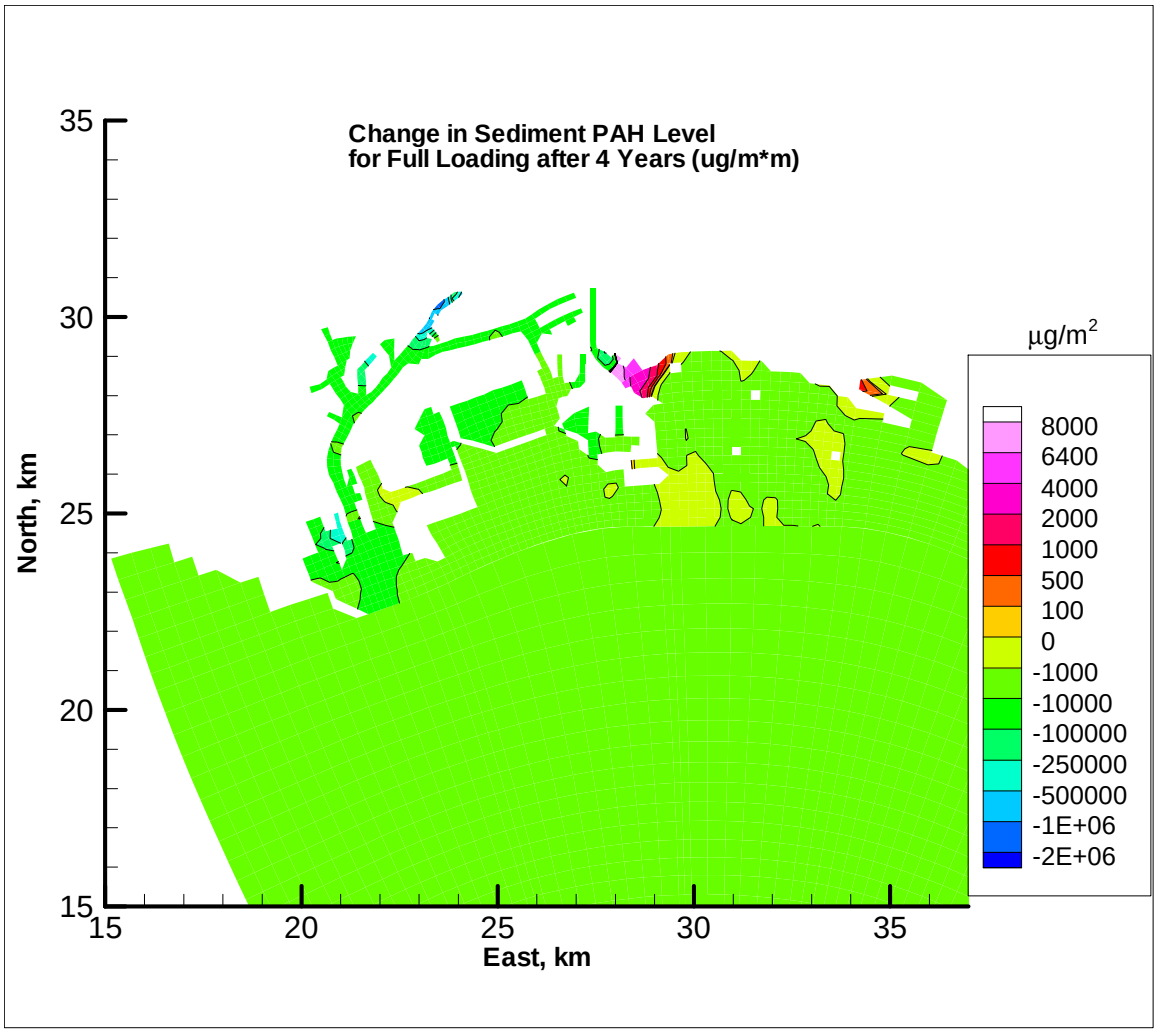
Note: Areal Concentration Change from Load Reduction Simulation = Final Areal Baseline Simulation Concentration in 2005 – Final Areal Load Reduction Concentration in 2005 (based on 50 percent load reduction from the rivers and near shore watersheds). Results are presented in $\mu g/m^2$.

Figure D-22. Areal concentration change from load reduction simulation – DDT



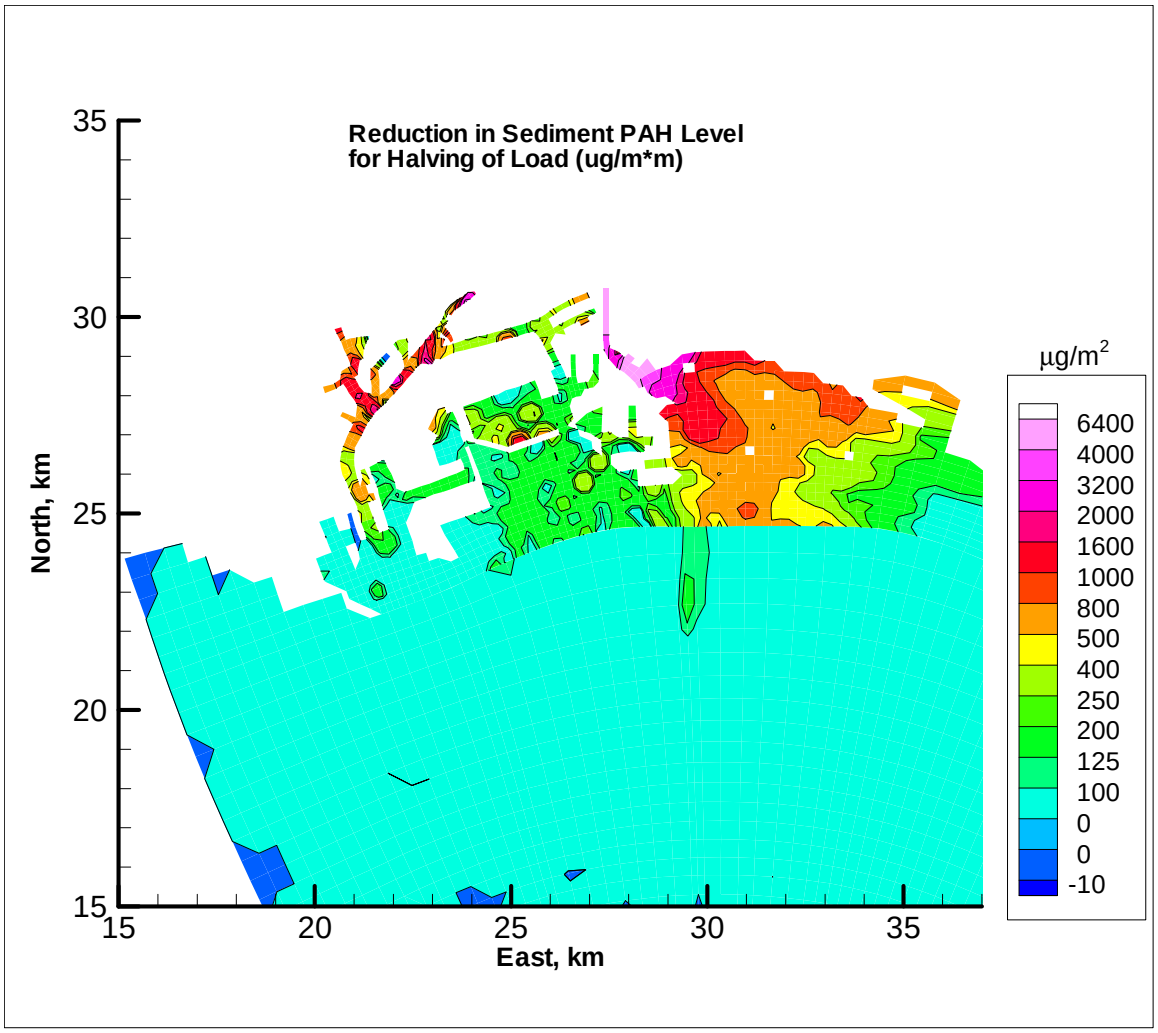
Note: Relative Change in Load Reduction Simulation = Relative Change in Load Reduction Change (normalized by initial top bed layer concentration). Results are proportions and can be multiplied by 100 to obtain percent.

Figure D-23. Relative change in load reduction simulation – DDT



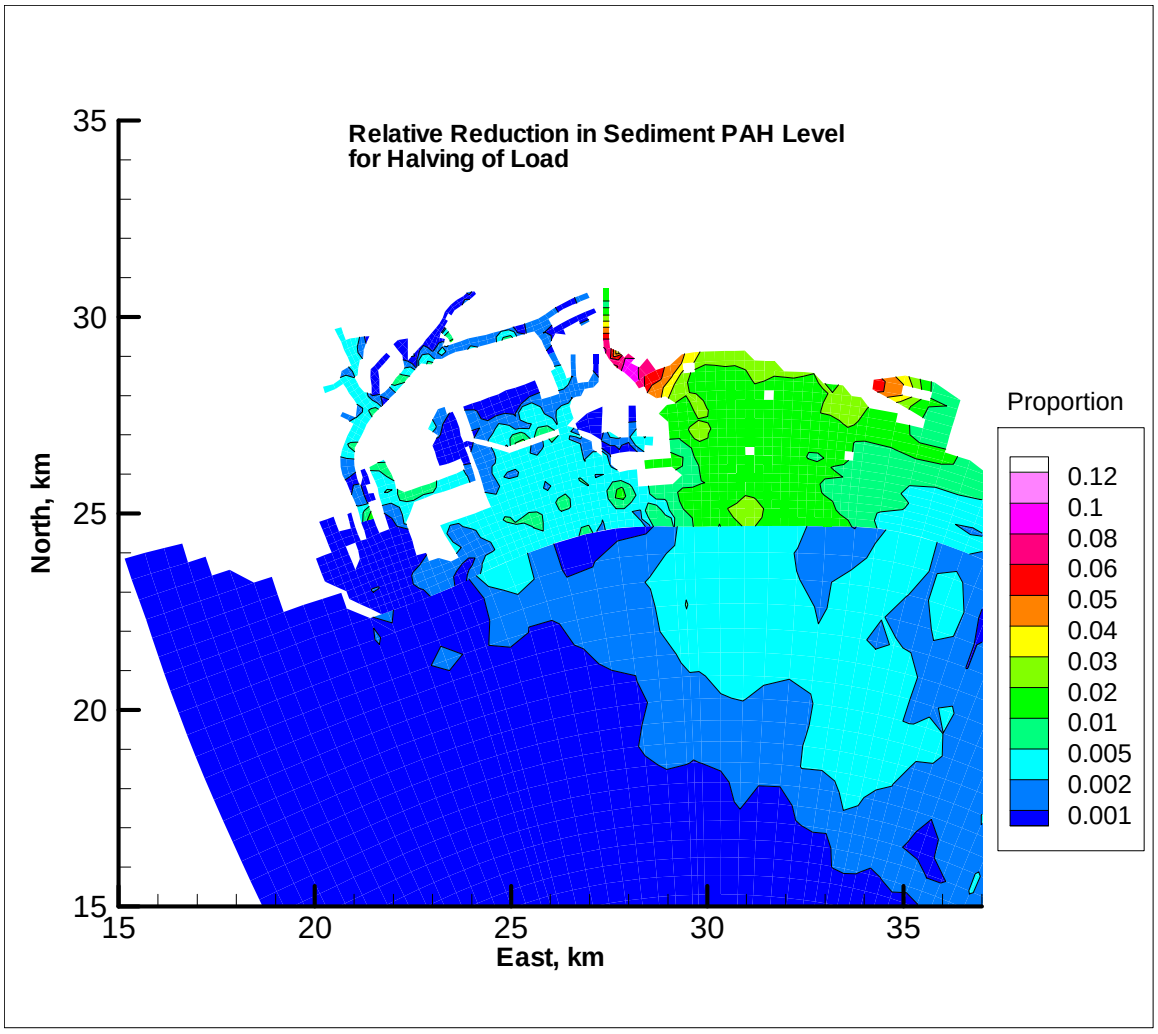
Note: Areal Concentration Change in Baseline Simulation Over Time = Final Areal Concentration using Baseline Conditions in 2005 (after 4 years) – Initial Areal Concentration using Baseline Conditions in 2002 (beginning of simulation period). Results are presented in $\mu g/m^2$.

Figure D-24. Areal concentration change in baseline simulation over time (after four years) – PAH



Note: Areal Concentration Change from Load Reduction Simulation = Final Areal Baseline Simulation Concentration in 2005 – Final Areal Load Reduction Concentration in 2005 (based on 50 percent load reduction from the rivers and near shore watersheds). Results are presented in $\mu g/m^2$.

Figure D-25. Areal concentration change from load reduction simulation – PAH



Note: Relative Change in Load Reduction Simulation = Relative Change in Load Reduction Change (normalized by initial top bed layer concentration). Results are proportions and can be multiplied by 100 to obtain percent.

Figure D-26. Relative change in load reduction simulation – PAH

Appendix E: Analysis of Additional Water Column Metals and Suspended Solids Data

FINAL

May 2011

Prepared for:
USEPA Region 9
Los Angeles Regional Water Quality Control Board

Prepared by:
Tetra Tech, Inc.

Introduction

Subsequent to conducting the calibration and sensitivity simulations for metals, described in Chapter 8 and Appendix C, using water column partition coefficients in column 5 of Table 21, additional water column metals and sediment concentration data sets became available. These data sets include dissolved and total metals data collected during January and March 2006 and dissolved and total metals and suspended solids data collected in January 2008. The locations of these data sets correspond to the 2005 locations shown in Figure 25. The following sections present, analyze, and discuss these data sets.

Water Column Metals Data: 2006

Dissolved and total metals concentrations were reported for 66 mid-water column sampling locations in January and March of 2006 in waters of the Port of Los Angeles. For comparison with the 2005 POLA and 2006 POLB data, these data were used to determine the ratio of the particulate to dissolved fraction, which also corresponds to the product of the equilibrium partition coefficient and suspended solids concentration according to

$$K_p \bullet P = \frac{C_p}{C_d} \qquad (6)$$

where P is the suspended sediment concentration. Figure E-1 shows scatter plots of the ratio for copper, lead, and zinc. Table E-1 summarizes the average values of the ratios and compares them with results for 2005 POLA and 2006 POLB stations (Figure 26 and Table 21, fourth column). The concentration ratios for the three metals, copper, lead, and zinc, are very consistent between the two data sets. The range of average partition coefficients corresponding to an assumed range of sediment concentrations is shown in the fourth column of Table E-1.

Water Column Metals and Suspended Solids Data: 2008

Dissolved and total metals concentrations and total suspended solids were reported for 43 mid-water column sampling locations in January 2008 in waters of the Port of Los Angeles. For comparison with the 2005 POLA and 2006 POLB data, these data were used to determine the partition coefficient with the following equation:

$$K_p = \frac{1}{P}\frac{C_p}{C_d} \qquad (5C)$$

where P is the suspended sediment concentration. Figure E-2 shows the partition coefficients for copper, lead, and zinc as function of the suspended sediment concentration. The fifth column of Table E-1 summarizes the average values of the partition coefficients. These can be compared to the range estimated using the POLA 2006 particulate to dissolved concentration ratio.

For comparison, the model calibration and sensitivity simulations (Chapter 8 and Appendix C) conducted before these data became available used partition coefficients of 0.25, 1.25, and 0.05 L/mg for copper, lead, and zinc, respectively. The model simulation values used for copper and lead, 0.25 and 1.25, are very consistent with the observation-based values of 0.17 and 1.5. The model simulation value for zinc (0.05 L/mg) is significantly less than the average observation-based value, but still within the range of shown for zinc in Figure E-1 and Table E-1.

Table E-1. Equilibrium Partition Coefficients and Particulate to Dissolved Concentration Ratios for Metals

Contaminant	**Water Column Particulate to Dissolved Concentration Ratio *POLA2005 POLB2006***	**Water Column Particulate to Dissolved Concentration Ratio *POLA2006***	**Range of Partition Coefficients, L/mg Corresponding to TSS range of 1 to 10 mg/L (based on *POLA2006*)**	**Average Partition Coefficients, L/mg for *POLA2008***
Copper	0.51	0.72	0.05 to 0.7	0.17
Lead	7.12	6.28	0.6 to 7	1.5
Zinc	0.20	0.19	0.02 to 0.2	0.20

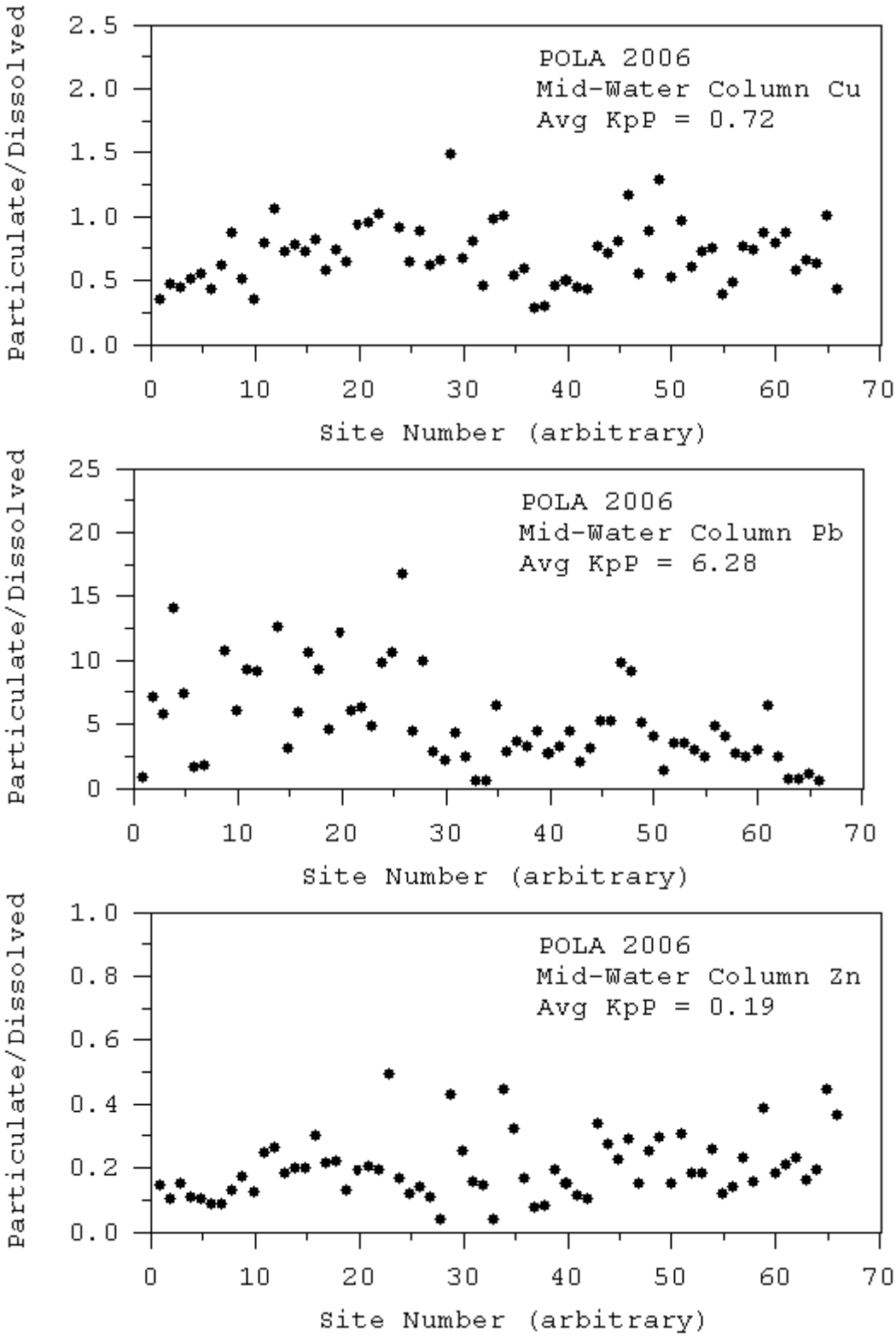


Figure E-1. Particulate to dissolved concentration ratio (equal to product of partition coefficient and adsorption site particle concentration) for 2006 POLA mid-water column metals samples

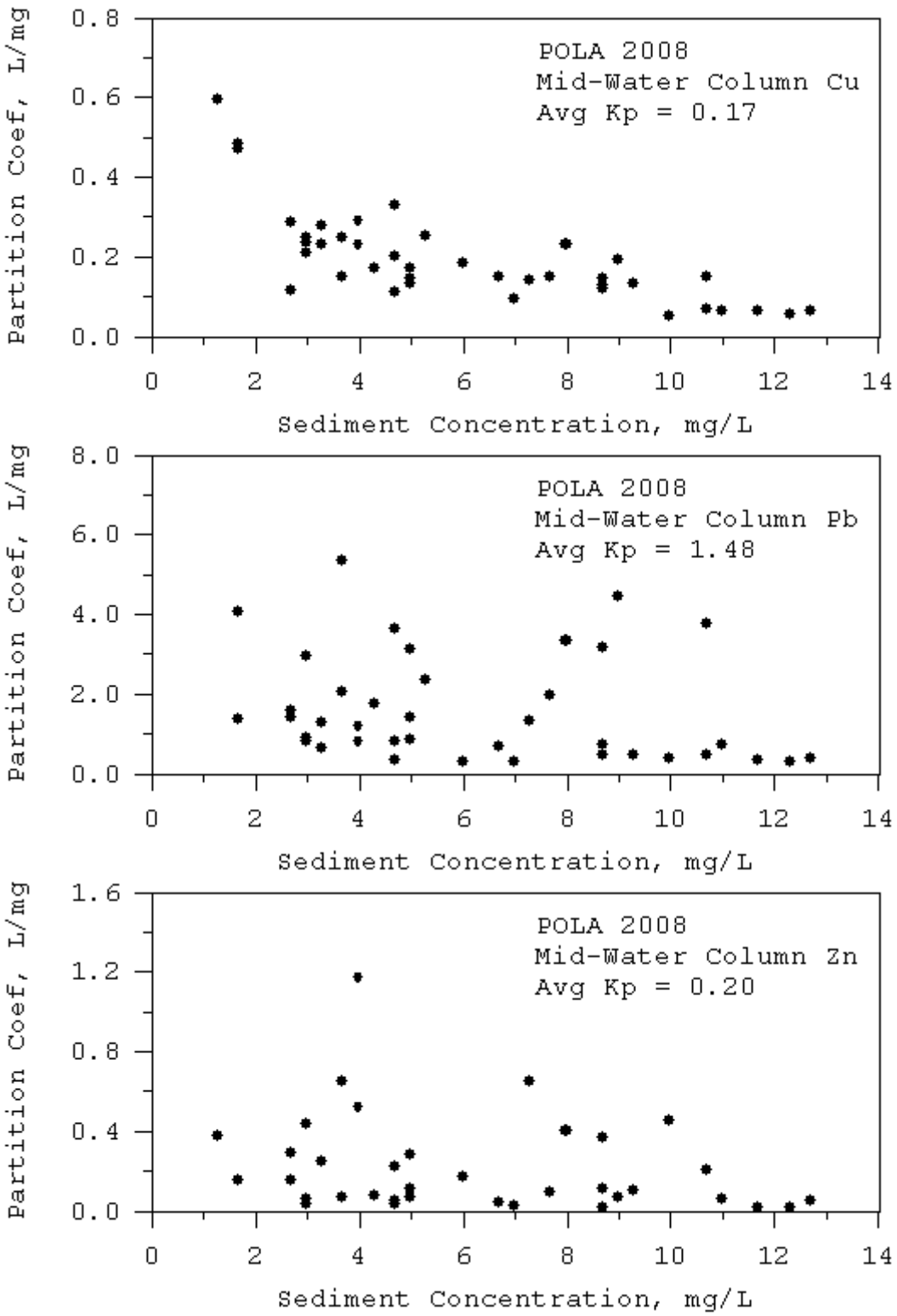


Figure E-2. Partition coefficients for copper, lead, and zinc as a function of suspended sediment concentration for 2008 POLA mid-water column samples

Appendix II:

LSPC Watershed Model Development for Simulation of Loadings to the Los Angeles/Long Beach Harbors

May 2011

Appendix II Sections

Modeling Report, *pages 1-70*

Appendix A: Water Quality Validation Time-series Plots for the Nearshore Watersheds, *pages A1-A20*

Appendix B: Annual Loads for Watersheds Draining to the Harbors & San Pedro Bay, *pages B1-B3*

Appendix II Summary

The *Watershed Model Development for Simulation of Loadings to the Los Angeles/Long Beach Harbors* Report describes the approach used to estimate metals and organic pollutant loads from the Los Angeles River, the San Gabriel River, and other nearshore watershed areas. These models, in addition to the Dominguez Channel model, were used to determine the pollutant loadings to Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters. Key findings of the report include:

- Pollutants of interest include metals such as copper, lead, and zinc, and several organic pollutants (PAHs, DDT, PCBs, and chlordane).
- Separate approaches were used to represent dry- and wet-weather conditions.
- The wet weather analyses are based on an eleven-year simulation using the LSPC watershed model (Section 3). A new model was developed to address nearshore areas, while previously developed models were used for the Los Angeles and San Gabriel River watersheds. Metals loadings were estimated based on direct LSPC simulations (using regionally calibrated modeling parameters). Watershed model parameters were not available to represent organics loadings. To determine PAHs loads, land use-specific EMCs from stormwater monitoring studies were applied to predicted flows. Specifically, stormwater total PAH concentrations for each model subwatershed were predicted using weighted averages of land use EMCs based on area and runoff potential of each land use in each subwatershed. For DDT, PCBs, and chlordane, a different approach was required because no detectable levels of these pollutants were found in the mass emissions monitoring stations (DDT was only detected in stations associated with agricultural runoff). Sediment concentrations from Bight 03 monitoring data were applied to predicted sediment loads to estimate loads of these pollutants.
- Dry-weather models used for TMDL calculations have been typically based on steady-state assumptions for flows and pollutant concentrations and heavily rely on robust monitoring efforts (Section 4). Assumptions for steady-state, dry-weather flows were based on a combination of monitoring data and simplified methods based on land use. Monitoring results from the Los Angeles River, San Gabriel River, and Ballona Creek were extrapolated for prediction of pollutant loads from the remaining watersheds.
- The average daily loadings of metals, PAHs, DDT and PCBs to each receiving waterbody are shown in Figures 30 through 35. These average daily loadings are based on eleven year loads and were ultimately used as inputs to the EFDC receiving water model (see Appendix I). Annual loads for an 11-year period to each receiving waterbody were calculated for each pollutant and are presented in Appendix B.

LSPC Watershed Model Development for Simulation of Loadings to the Los Angeles/Long Beach Harbors

FINAL

May 2011

Prepared for:
USEPA Region 9
Los Angeles Regional Water Quality Control Board

Prepared by:
Tetra Tech, Inc.

1. Introduction

Estimation of pollutant loadings to the Los Angeles and San Gabriel estuaries, Los Angeles and Long Beach Harbors (Harbors), and San Pedro Bay (SPB) requires development of approaches that address both wet and dry conditions. Previous modeling studies performed by Tetra Tech for Los Angeles River (LAR) and San Gabriel River (SGR) supported calculation of metals loadings to those waterbodies. Recent modeling of Dominguez Channel (DC) by the Southern California Coastal Water Research Project (SCCWRP) will be based on consistent modeling approaches for metals (SCCWRP, unpublished results). For the remaining watershed area not included in the LAR, SGR, and DC models (hereafter referred to as nearshore areas), including areas draining to estuaries of LAR and SGR, Tetra Tech worked with SCCWRP, Los Angles Regional Water Quality Control Board (Regional Board) staff, and EPA to develop and implement an approach to calculate pollutant loadings from the nearshore areas (see Figure 1).

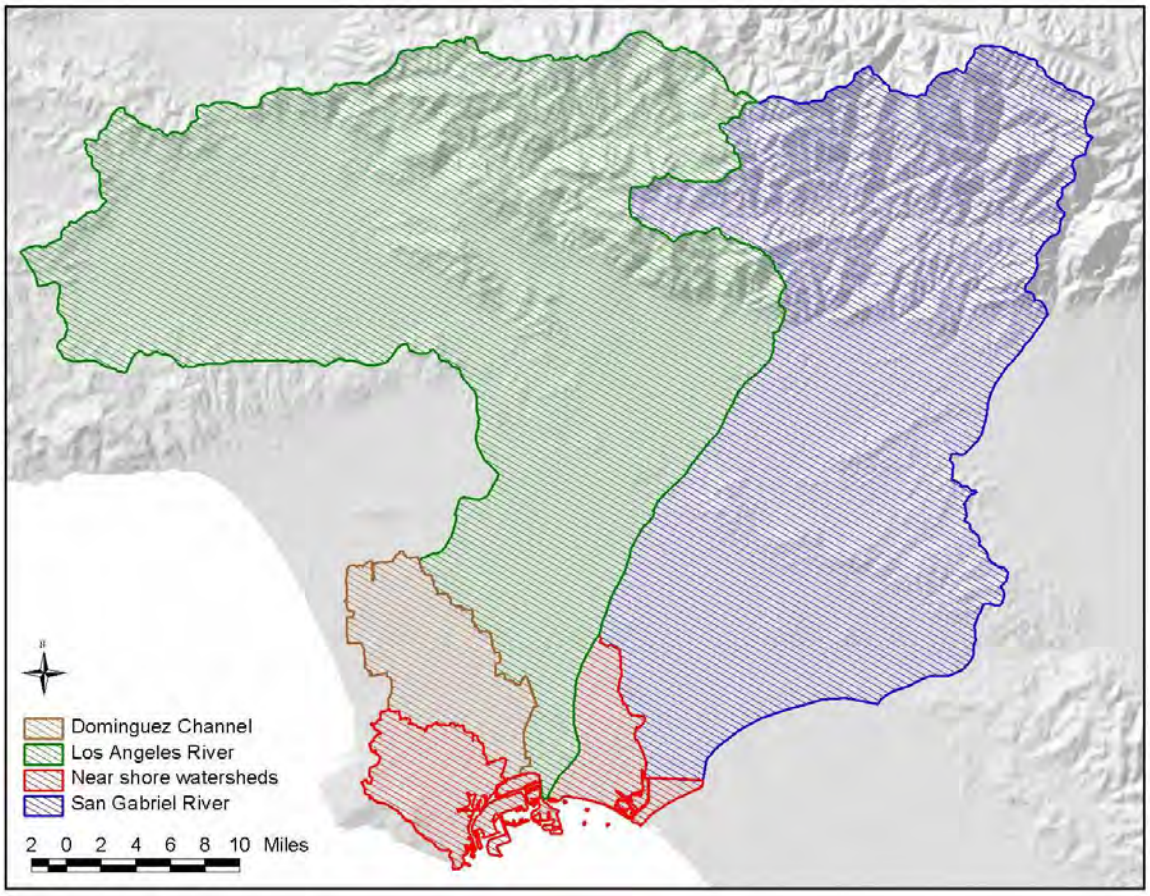


Figure 1. Watersheds of the Harbors and San Pedro Bay

This report provides a summary of the approach Tetra Tech used for estimation of metals and organic pollutant loads (polycyclic aromatic hydrocarbons [PAHs], dichlorodiphenyltrichloroethane [DDT], polychlorinated biphenyls [PCBs], and chlordane) from LAR, SGR, and nearshore areas. Pollutant loadings from the DC Los Angeles Harbor were estimated in a separate study performed by SCCWRP (SCCWRP, unpublished results).

2. Model Domain

The entire watershed modeling domain for the current study is depicted in Figure 1. As discussed, this study utilized previously developed models of LAR and SGR, as well as a model of DC developed through a separate study performed by SCCWRP. The remaining nearshore areas required development of new models for simulation of runoff pollutant loads to SGR and LAR estuaries, the Harbors, and SPB (depicted in red in Figure 1). As opposed to the LAR, SGR, and DC models of major watersheds and associated rivers/channels discharging to estuaries, the nearshore watersheds are representative of smaller tributaries and sewersheds discharging directly to receiving waters.

Tetra Tech delineated the nearshore subwatersheds based on a combination of sewersheds provided by the POLA and the Port of Long Beach (POLB); monitoring locations; model domains of LAR, SGR, and DC watersheds; receiving water model domain of the Harbors and SPB; and a USGS digital elevation model (Figure 2). These subwatershed boundaries were used in development of hydrologic and water quality models of these areas.

Because the pollutant sources and their means of transport to receiving waters vary between wet and dry conditions (McPherson et al., 2005a; LARWQCB, 2005a, 2005b, 2005c, Stein et al., 2003), Tetra Tech developed technical approaches that are consistent with our understanding of the processes for each weather condition—this assumption is consistent with most other TMDLs adopted in the Los Angeles Region (LARWQCB, 2005a, 2005b, 2005c, 2006). The following sections describe our technical approach and estimated pollutant loads for each condition.

3. Wet Weather

The transport of metals and organic pollutants during wet-weather events is generally believed to be associated with the detachment and transport of sediment (Buffleben et al., 2002; CALTRANS, 2003; Hoffman et al., 1982; Lau and Stenstrom, 2005; Logonathan et al., 1997; Stein et al., 2005; Yunker et al., 2002). Specifically, during rainy periods, these pollutant loads are delivered to the waterbody through creeks and stormwater collection systems.

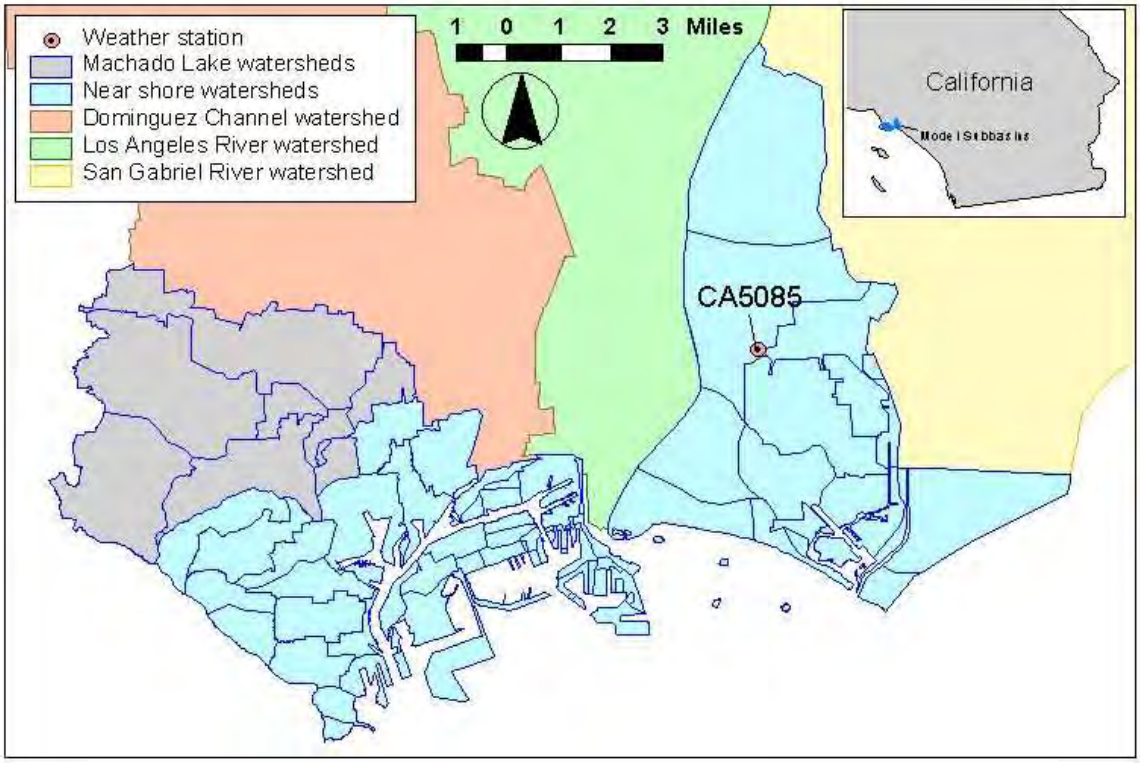


Figure 2. Subwatershed Delineation for the Nearshore Watersheds

Specific watershed sources of metals and organic pollutants vary based on location and pollutant and, for some pollutants, concentration “hot spots” are present. These “hot spots” are typically associated with spills or other events that lead to higher pollutant concentrations and their presence and impact to receiving waters are difficult to identify/characterize. Additionally, available data to characterize the pollutant sources are often limited. Metals and organic pollutants can also be linked to specific land use types that have higher relative accumulation rates of the pollutant(s), higher relative loads of sediment from the land surface, or are more likely to deliver sediment and associated pollutants to waterbodies due to delivery through stormwater collection systems.

To assess the link between sources of sediment, metals, and organic pollutants and the impaired waters, a modeling system was utilized that simulates land use-based sources of sediment and associated metals loads and the hydrologic and hydraulic processes that affect delivery. The hydrology and sediment model results along with monitoring data were utilized to determine organic pollutant loads to the Harbors.

The U.S. Environmental Protection Agency’s (USEPA) Loading Simulation Program C++ (LSPC) (Shen et al., 2004; USEPA, 2003a) was used to represent the hydrologic and water quality conditions in the Harbors’ watersheds. LSPC is a component of the USEPA’s TMDL Modeling Toolbox (USEPA, 2003b), which

has been developed through a joint effort between USEPA and Tetra Tech, Inc. It integrates a geographical information system (GIS), comprehensive data storage and management capabilities, a dynamic watershed model (a re-coded version of USEPA's Hydrological Simulation Program – FORTRAN [HSPF] [Bicknell et al., 2001]), and a data analysis/post-processing system into a convenient PC-based windows interface that dictates no software requirements.

LSPC is capable of representing loading and both flow and water quality from non-point and point sources as well as simulating in-stream processes. LSPC can simulate flow, sediment, metals, nutrients, pesticides, and other conventional pollutants for pervious and impervious lands and waterbodies. The model has been successfully applied and calibrated in Southern California for the Los Angeles River, the San Gabriel River, the San Jacinto River, and multiple watersheds draining to impaired beaches of the San Diego Region. For the nearshore watersheds, LSPC was used to simulate sediment and metals (copper, lead, and zinc) for determining loads to the Harbors.

Previous wet-weather watershed modeling and TMDL efforts by Tetra Tech and SCCWRP have led to the development of a regional watershed modeling approach to simulate hydrology, sediment, and metals transport in Los Angeles watersheds. The regional modeling approach assumes that metals loadings can be dynamically simulated based on hydrology and sediment transported from land uses in a watershed. Development of the approach resulted from application and testing of models for multiple small-scale land use sites and larger watersheds in the Los Angeles Region. SCCWRP developed watershed models, based on HSPF (Bicknell et al., 2001), of multiple homogeneous land use sites in the region. Sufficient stormflow and water quality data were available at these locations to facilitate calibration of land-use-specific HSPF modeling parameters. These parameters were validated in an additional HSPF model of Ballona Creek (Ackerman et al., 2005a; SCCWRP, 2004), and similar models of LAR (Tetra Tech, Inc., 2004) and SGR (Tetra Tech, Inc, 2005a) based on LSPC. These models were used to calculate TMDLs for each of these waterbodies (LARWQCB, 2005a, 2005c, and 2006; USEPA, 2007).

Wet-weather days were determined based on flow criteria for each subwatershed. Specifically, for the nearshore areas, all days with flow greater than the dry-weather flow calculated in Section 4 are designated as wet days. Similarly, for LAR and SGR, all days with flow greater than the 90th percentile observed flow in the watershed are designated as wet days (Section 4), which is consistent with the designation of wet days in the LAR Metals TMDL (LARWQCB, 2005c). All wet days in the model were assigned pollutant loads based on the approaches described in Section 3.3, while all dry days in the model were assigned loads based on the approaches described in Section 4.

Wet-weather events for the study areas were simulated using previously calibrated LSPC models of the LAR and SGR watersheds (illustrated in green

and blue in Figure 1, respectively) and newly developed LSPC models for the nearshore areas (Figure 2). The simulation time frames for the LAR and SGR watershed models were extended to overlap with the current study period. To perform this temporal extension, updated flow, copper, lead, and zinc point source data for the major dischargers in the watershed were required. With these data, simulations were performed to obtain flow, total suspended solid (TSS), and total metals model output for the LAR and SGR watersheds.

The following sections describe wet-weather model configuration, calibration, validation, and application. While they focus largely on the newly developed models of the nearshore areas, details associated with the extension of the LAR and SGR models and their application to determine loadings to their respective estuaries are also provided, where pertinent.

3.1. Model Configuration

The watershed model represented the variability of wet-weather runoff source contributions through dynamic representation of hydrology and land practices. It included all point and non-point source contributions. Key components of the watershed modeling that are discussed below are:

- Watershed segmentation
- Meteorological data
- Land use representation
- Soils
- Reach characteristics
- Point source discharges
- Hydrology representation
- Pollutant representation
- Flow data

3.1.1. Watershed Segmentation

To evaluate sources contributing to an impaired waterbody and to represent the spatial variability of these sources, the contributing drainage area was represented by a series of sub-watersheds. This subdivision was primarily based on the stream networks and topographic variability, and secondarily on the locations of flow and water quality monitoring stations, consistency of hydrologic factors, land use consistency, and existing watershed boundaries (e.g., California Interagency Watershed Map of 1999 [CalWater 2.2; CalWater, 1999] watershed boundaries and municipal storm sewersheds). The nearshore watersheds were divided into 76 sub-watersheds for appropriate hydrologic connectivity and representation (Figure 2). Nine additional watersheds that drain to Machado Lake were delineated, but are not assumed to be hydrologically connected to

areas draining to the Harbors except during extremely large and rare meteorological events.

Specifically, Machado Lake is assumed to be a sink in the nearshore watershed model, resulting in zero flow and pollutant loading reaching the Harbors from this drainage area. This assumption is supported by several technical considerations, many of which were dependent on the available data. In general, data and information to characterize the Machado Lake overflows and loading are sparse or non-existent. Summary data that are available include water quantity data downstream of Machado Lake that represent the volume of overflow for June 2008 to February 2010, which is a small fraction of the total volume to the Harbors. In addition, there is no monitoring data on water or sediment quality from the Machado Lake overflows; therefore, there is no means for estimating loads (or even just concentrations) to the Harbors. In lake processes may play an important role in downstream loading. That is, Machado Lake likely acts as a sink for contaminated sediments. While water may overflow, most of the sediment remains in Machado Lake, along with its associated contaminants. Sediment that does overflow the dam is likely deposited in the wetlands immediately downstream and prior to the storm outlet; so, the pollutants of concern are not consistently reaching the Harbors. Overall, the available data are too limited for adequate analysis to represent the system and estimate pollutant loading to the Harbors. In addition, Proposition O funds are currently dedicated to remediate existing sediments in Machado Lake, so this small source will become diminishing in the future.

3.1.2. Meteorological Data

Meteorological data are a critical component of the watershed model. LSPC requires appropriate representation of precipitation and potential evapotranspiration (ET). In general, hourly precipitation (or finer resolution) data are recommended for nonpoint source modeling. Therefore, only weather stations with hourly-recorded data were considered in the precipitation data selection process. Rainfall-runoff processes for each subwatershed were driven by precipitation data from the most representative station. These data provide necessary input to LSPC algorithms for hydrologic and water quality representation.

National Climatic Data Center (NCDC) precipitation data were reviewed based on geographic location, period of record, and missing data to determine the most appropriate meteorological stations to represent the nearshore areas. Hourly rainfall data were obtained from the Long Beach weather station (CA5085) located in the eastern portion of the nearshore watersheds (Figure 2). Precipitation data were obtained for January 1, 1990 through July 31, 2005.

Additional localized precipitation data were obtained from the Ports of Long Beach and Los Angeles. These data were specific to monitoring locations and storm events. (See Section 3.1.9 for more information on the monitoring locations.) Data from these local stations were used to replace the CA5085 precipitation data for the particular storm events to create separate weather files for each monitoring location and its surrounding subwatersheds.

Because rainfall gages are not always in operation and accurately recording data, the resulting dataset may contain various intervals of accumulated, missing, or deleted data. Missing or deleted intervals are periods over which either the rainfall gage malfunctioned or the data records were somehow lost. Accumulated intervals represent cumulative precipitation over several hours, but the exact hourly distribution of the data is unknown. To address the incomplete portions of CA5085, which accounted for less than 5 percent of the records during the model period (and generally occurred in the summer months when there is little rain in the area), it was necessary to patch (for missing or deleted data) or disaggregate (for accumulated intervals) the rainfall data with information from nearby gages.

Specifically, *missing or deleted intervals* were patched with data from nearby stations. This process identifies days with missing records and matches these days with nearby stations to see if they have data. If so, the normal-ratio method (Dunne & Leopold, 1978) was used to estimate the rainfall (factoring average rainfall amounts) from identified nearby stations. To address days that had *accumulated intervals* (which only occurred for a few intervals), the daily rainfall total was summed and treated as an accumulated interval for that entire 24-hour period. The normal-ratio method (Dunne & Leopold, 1978) was used to disaggregate these daily totals to hourly based on hourly rainfall distributions at nearby gages. To apply this normal-ratio method, a composite hourly distribution was first estimated for station *A* (where accumulated data exist). This distribution was determined by using a weighted average from surrounding *n* stations with similar rainfall patterns and where unimpaired data were measured for the same time period.

Subsequently, the observed daily values were distributed across the resulting hourly time series, keeping the original rainfall volume intact. Using this same methodology, missing or deleted intervals in the data were patched using the normal-weighted hourly distributions at nearby gages. Because the normal ratio considers the long-term average rainfall as the weighting factor, this method is adaptable to regions where there is large orographic precipitation variation since elevation differences will not bias the predictive capability of the method.

Potential evapotranspiration, which is also required by the LSPC model, was calculated from data obtained from NCDC. Specifically, long-term hourly wind speed, cloud cover, temperature, and dew point data available for the Los

Angeles International Airport (WBAN #23174) were used to calculate potential evapotranspiration for the weather station representing the nearshore areas.

In addition to developing the new weather file for the nearshore model, weather files for the LAR and SGR models were extended to cover the entire modeling period. The original weather files for LAR and SGR ended in 2001 and 2004, respectively. Data associated with each of the LAR and SGR stations were obtained and updated weather files were created consistent with methods used in development of the original models (Tetra Tech, Inc., 2004 and 2005a).

3.1.3. Land Use Representation

The watershed model requires a basis for distributing hydrologic and pollutant loading parameters. This is necessary to appropriately represent hydrologic variability throughout the basin, which is influenced by land surface and subsurface characteristics. It is also necessary to represent variability in pollutant loading, which is highly correlated with land practices. The basis for this distribution was provided by the land use coverage of the entire watershed. The land use data used to represent the nearshore areas was the Southern California Association of Governments (SCAG) 2000 land use dataset that covers Los Angeles and Orange Counties.

Although the multiple categories in the land use coverage provide much detail regarding spatial representation of land practices in the watershed, such resolution is unnecessary for watershed modeling if many of the categories share hydrologic or pollutant loading characteristics. Therefore, many land use categories were grouped into similar classifications, resulting in a subset of eight categories for modeling: agriculture, commercial, high-density residential, industrial, low-density residential, mixed urban, open, and port activities. Selection of these land use categories was based on the availability of monitoring data and literature values that could be used to characterize individual land use contributions and critical metal-contributing practices associated with different land uses. The distributions of the eight land uses in the 76 subwatersheds are presented in Table 1.

LSPC algorithms require that land use categories be divided into separate pervious and impervious land units for modeling. The division of the eight land use categories identified above to represent impervious and pervious areas in the model was based on typical impervious percentages associated with different land use types as defined in the TR-55 Manual (USDA, 1986). This division resulted in 14 unique pervious or impervious land uses in the nearshore watersheds.

Table 1. Land Use Areas (acres) of each Subwatershed

Sub-watershed number	Agri-culture	Com-mercial	High density residential	Industrial	Low density residential	Mixed urban	Open	Port activities
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254.2
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.1
3	0.0	0.0	0.0	8.6	0.0	5.7	0.0	128.5
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.9
5	0.0	22.9	0.0	0.0	0.0	0.0	0.0	25.7
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.0
7	0.0	0.0	0.0	2.9	0.0	0.0	0.0	54.3
8	0.0	2.9	0.0	0.0	11.4	0.0	0.0	74.3
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0
11	0.0	2.9	0.0	5.7	20.0	8.6	14.3	171.4
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3
15	0.0	0.0	0.0	5.7	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7
17	0.0	57.1	0.0	8.6	14.3	42.8	20.0	11.4
18	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0
19	0.0	1.0	0.0	86.0	0.0	5.7	10.7	300.9
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9
21	0.0	0.0	0.0	63.8	0.0	1.5	12.7	6.9
22	0.0	0.0	0.0	0.0	0.0	2.6	0.0	177.9
23	0.0	0.0	0.0	21.9	0.0	44.0	7.3	4.1
24	0.0	0.0	0.0	20.0	0.0	5.7	0.0	117.1
25	0.0	0.0	0.0	20.0	0.0	0.0	0.0	128.5
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.8
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.4
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.4
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	154.2
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	108.5
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	108.5
33	0.0	0.0	0.0	48.6	0.0	14.3	48.6	208.5
34	0.0	11.4	0.0	137.1	0.0	42.8	20.0	102.8
35	0.0	34.3	0.0	17.1	25.7	5.7	5.7	237.1
36	0.0	0.0	0.0	97.1	0.0	11.4	2.9	397.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	614.1
38	0.0	0.0	0.0	185.7	0.0	31.4	34.3	2.9
39	0.0	117.1	277.1	160.0	77.1	237.1	57.1	71.4
40	0.0	97.1	114.3	148.5	71.4	65.7	11.4	222.8
41	8.6	108.5	85.7	468.4	91.4	68.6	57.1	568.4
42	0.0	177.1	494.1	5.7	94.3	28.6	11.4	0.0
43	0.0	60.0	251.4	25.7	108.5	51.4	142.8	37.1
44	5.7	85.7	339.9	45.7	74.3	14.3	45.7	0.0
45	0.0	74.3	568.4	0.0	262.8	2.9	179.9	0.0
46	0.0	11.4	185.7	0.0	419.9	40.0	397.0	0.0
47	0.0	68.6	0.0	25.7	142.8	0.0	31.4	28.6

Sub-watershed number	Agri-culture	Com-mercial	High density residential	Industrial	Low density residential	Mixed urban	Open	Port activities
48	0.0	214.2	199.9	2.9	391.3	22.9	14.3	0.0
49	0.0	11.4	0.0	20.0	51.4	2.9	85.7	140.0
50	0.0	71.4	277.1	0.0	345.6	0.0	22.9	0.0
51	0.0	14.3	288.5	0.0	120.0	2.9	134.2	0.0
52	0.0	22.9	331.3	0.0	71.4	8.6	122.8	0.0
53	0.0	5.7	65.7	0.0	122.8	37.1	51.4	0.0
54	0.0	0.0	40.0	0.0	40.0	2.9	40.0	0.0
101	0.0	0.0	0.0	5.7	0.0	0.0	0.0	0.0
102	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0
103	0.0	0.0	0.0	11.4	0.0	0.0	0.0	0.0
104	0.0	0.0	0.0	8.6	0.0	0.0	0.0	0.0
105	0.0	291.3	285.6	0.0	448.4	131.4	154.2	5.7
106	0.0	288.5	674.1	165.7	585.5	54.3	42.8	0.0
107	0.0	8.6	125.7	0.0	179.9	8.6	85.7	0.0
108	0.0	0.0	0.0	0.0	71.4	0.0	0.0	0.0
109	0.0	40.0	68.6	0.0	85.7	2.9	2.9	0.0
110	0.0	157.1	585.5	11.4	239.9	2.9	302.8	0.0
111	8.6	77.1	297.1	2.9	151.4	2.9	74.3	0.0
112	0.0	34.3	137.1	0.0	11.4	5.7	20.0	0.0
113	0.0	80.0	17.1	262.8	14.3	14.3	62.8	0.0
114	0.0	40.0	11.4	102.8	0.0	0.0	40.0	0.0
115	0.0	45.7	142.8	0.0	82.8	2.9	62.8	0.0
116	0.0	140.0	188.5	194.2	734.1	225.6	971.1	0.0
117	0.0	828.3	1,105.4	22.9	145.7	188.5	74.3	0.0
118	0.0	48.6	211.4	0.0	17.1	22.9	0.0	0.0
119	0.0	239.9	551.3	0.0	0.0	34.3	0.0	0.0
120	0.0	219.9	1,062.5	0.0	0.0	14.3	102.8	0.0
121	0.0	1,322.5	1,216.8	782.6	77.1	105.7	534.1	0.0
122	80.0	976.9	2,433.6	371.3	748.4	122.8	97.1	0.0

3.1.4. Soils

Soil data for the watershed were obtained from the State Soil Geographic Data Base (STATSGO). There are four main Hydrologic Soil Groups (Groups A, B, C, and D). These groups, which are described below, range from soils with low runoff potential to soils with high runoff potential (USDA, 1986).

The total area associated with each specific soil type was determined for all 76 subwatersheds. The representative soil group for each model subwatershed was based on the dominant soil type found in that subwatershed.

<u>Group A Soils</u> have low runoff potential and high infiltration rates even when wet. They consist chiefly of sand and gravel and are well drained to excessively-drained.

Group B Soils have moderate infiltration rates when wet and consist chiefly of soils that are moderately-deep to deep, moderately- to well-drained, and moderately course.

Group C Soils have low infiltration rates when wet and consist chiefly of soils having a layer that impedes downward movement of water with moderately-fine to fine texture.

Group D Soils have high runoff potential, very low infiltration rates and consist chiefly of clay soils. These soils also include urban areas.

3.1.5. Reach Characteristics

Each delineated subwatershed was represented with a single stream assumed to be a completely mixed, one-dimensional segment with a trapezoidal cross-section. While some reach segments were based on EPA's Reach File, Version 3 (RF3), most of the reaches are based on storm sewer systems, since much of the flow in the nearshore watersheds drains through storm sewers. Once the representative reach was identified for each subwatershed, slopes were calculated based on Digital Elevation Model (DEM) data, and stream lengths measured from the reach coverage. Because much of the area surrounding POLA/POLB has no topographic variation, several subwatersheds had a slope of zero. To ensure that the model would predict flow through these areas, a slope of 0.001 was assigned.

In addition to stream slope and length, mean depths and channel widths are required to route flow and pollutants through the hydrologically connected subwatersheds. Mean stream depth and channel width were estimated using regression curves that relate upstream drainage area to stream/sewer dimensions. An estimated Manning's roughness coefficient of 0.02 was also applied to each representative stream reach.

3.1.6. Point Source Discharges

During watershed model configuration, National Pollutant Discharge Elimination System (NPDES) discharges can be incorporated into the model as point sources of flow and pollutants. There were no major point sources located in the nearshore watersheds, so this step was excluded during model development.

To extend the LAR and SGR models through the entire modeling period, the temporal ranges of NPDES discharge data for flow, copper, lead, and zinc were extended. The dischargers and time periods associated with these data are presented in Table 2. Many of the discharge datasets had missing months or

other missing flow and water quality data; however, representation of these point sources were made using the best available data and information. In the previously calibrated LAR and SGR models, water quality was incorporated as a constant value based on the discharge effluent concentrations. These constant concentrations were extended to cover the entire modeling period. For dischargers with variable flow that had missing or limited flow data for the more recent time periods, daily averages calculated from the existing data were used in the model and applied to that date for all years in the future (this was usually the case for the San Gabriel River dischargers and the WWRPs in the Los Angeles River watershed). For dischargers with nearly constant flows, longer averages (e.g., monthly) were included in the model. These averaged flows are identified in the modeling database and can be easily modified if more complete flow data become available.

Table 2. LAR and SGR Point Source Dischargers and Date Ranges

San Gabriel River			
NPDES #	**Facility**	**Pipe**	**Period**
CA0053619	Pomona WWRP	PO001	01/1986–01/2006
CA0053716	Whittier Narrows WWRP	WN001	01/1986–12/ 2005
CA0053911	San Jose Creek WWRP	SJC001e	01/1986–07/2005
		SJC001w	12/1992–09/2005
		SJC002	01/1986–12/ 2005
		SJC003	12/1992–12/ 2005
CA0054011	Los Coyotes WWRP	LC001	01/1986–12/ 2005
CA0054119	Long Beach WWRP	LB001	01/1986–12/ 2005
Los Angeles River			
NPDES #	**Discharger**	**Facility**	**Period**
CA0001309	The Boeing Company	Rocketdyne Div. - Santa Susana	01/1988–12/2005
CA0052949	Southern California Edison	Dominguez Hills Fuel Oil Facility	01/1988–12/2005
CA0053953	LA City Bureau of Sanitation	L.A.-Glendale WWRP, NPDES	01/1988–12/2005
CA0055531	Burbank, City Of Public Works	Burbank WWRP, NPDES	01/1988–12/2005
CA0056227	LA City Bureau of Sanitation	Tillman WWRP, NPDES	01/1988–12/2005
CA0064271	Las Virgenes MWD	Tapia Park WWRP, NPDES	01/1988–12/2005

3.1.7. Hydrology Representation

Watershed hydrology plays an important role in the determination of nonpoint source flow and ultimately nonpoint source loadings to a waterbody. The watershed model must appropriately represent the spatial and temporal variability of hydrologic characteristics within a watershed. Key hydrologic characteristics include interception storage capacities, infiltration properties, evaporation and transpiration rates, and watershed slope and roughness. LSPC's algorithms are identical to those in HSPF. The LSPC/HSPF modules

used to represent watershed hydrology for TMDL development included PWATER (water budget simulation for pervious land units) and IWATER (water budget simulation for impervious land units). A detailed description of relevant hydrological algorithms are presented in the HSPF User's Manual (Bicknell et al., 2001).

Key hydrologic parameters in the PWATER and IWATER modules are infiltration, groundwater flow, and overland flow. The nearshore models were initially populated using hydrologic parameters for the LAR watershed model (LARWQCB, 2005c; Tetra Tech, Inc., 2004). These parameters were refined as part of model calibration since there were some relevant hydrology data available in the nearshore watersheds.

3.1.8. Watershed Runoff Pollutant Representation

The various pollutants draining to the Harbors were represented through their association with sediment and/or flow. Therefore, to simulate sediment contributions to the nearshore watersheds, the SEDMNT, SOLIDS, and SEDTRN modules were implemented and are discussed below. The sediment model results were then incorporated into the loading estimates and sensitivity analyses for each pollutant. The pollutant-specific approaches and results are discussed in Section 3.3.

The SEDMNT module simulates the production and removal of sediment from all pervious land segments in the model. The removal of sediment by water is simulated as washoff of detached sediment and scour of the soil matrix. Both processes are highly dependent on land use. Washoff depends on both the amount of detached sediment available to be carried away by the overland flow and the transport capacity of the overland flow. The amount of detached sediment available to be transported depends primarily on the rainfall intensity. The transport capacity of the overland flow depends on surface water storage and surface water flow.

The SOLIDS module represents the accumulation and removal of sediment/solids from impervious lands. The removal of sediment/solids is simulated by washoff of available sediment. Sediment/solids accumulation represents atmospheric fallout and general land surface accumulation for urban areas.

Once the sediment is transported to the stream channel by overland flow, the SEDTRN module simulates the transport, deposition, and scour of sediment in the stream channels. These processes depend primarily on sediment characteristics, e.g. settling velocity, critical shear stress for deposition, critical shear stress for resuspension, and predicted bottom shear stresses.

3.1.9. Flow Data

Three storm events were monitored by POLB and POLA (note: the data used for calibration and validation were provided by the Ports, they were collected as part of a SCCWRP study to further characterize industrial sites; i.e., Port land use activities). Information about each flow station, including outflow subwatershed, the station identification number, and period used for model calibration, is presented in Table 3, and their locations are illustrated in Figure 3.

Table 3. Flow Data Used for LSPC Model Calibration and Validation

Station ID	Model subwatershed	Dates
Forest Industries	27	2/24/03–2/25/03
Maritime Museum (MM)	48	3/17/02
Pier A	22	2/24/03–2/25/03

3.2. Model Calibration and Validation

After the model was configured, model calibration and validation were performed. This is generally a two-phase process, with hydrology calibration and validation completed before repeating the process for water quality. Upon completion of the calibration and validation at selected locations, a calibrated dataset containing parameter values for each modeled land use and pollutant was developed.

Calibration refers to the adjustment or fine-tuning of modeling parameters to reproduce observations. Calibration was performed for different LSPC modules at the Forest subwatershed (Figure 3). Subsequently, model validation was performed to test the calibrated parameters at different locations (Pier A and Maritime Museum [Figure 3]), without further adjustment.

3.2.1. Hydrology Calibration and Validation

Hydrology is the first model component calibrated because estimation of sediment loading relies heavily on flow prediction. The hydrology calibration involves a comparison of model results to in-stream flow observations at selected locations. After comparing the results, key hydrologic parameters were adjusted and additional model simulations were performed. This iterative process was repeated until the simulated results closely represented the system and reproduced observed flow patterns and magnitudes.

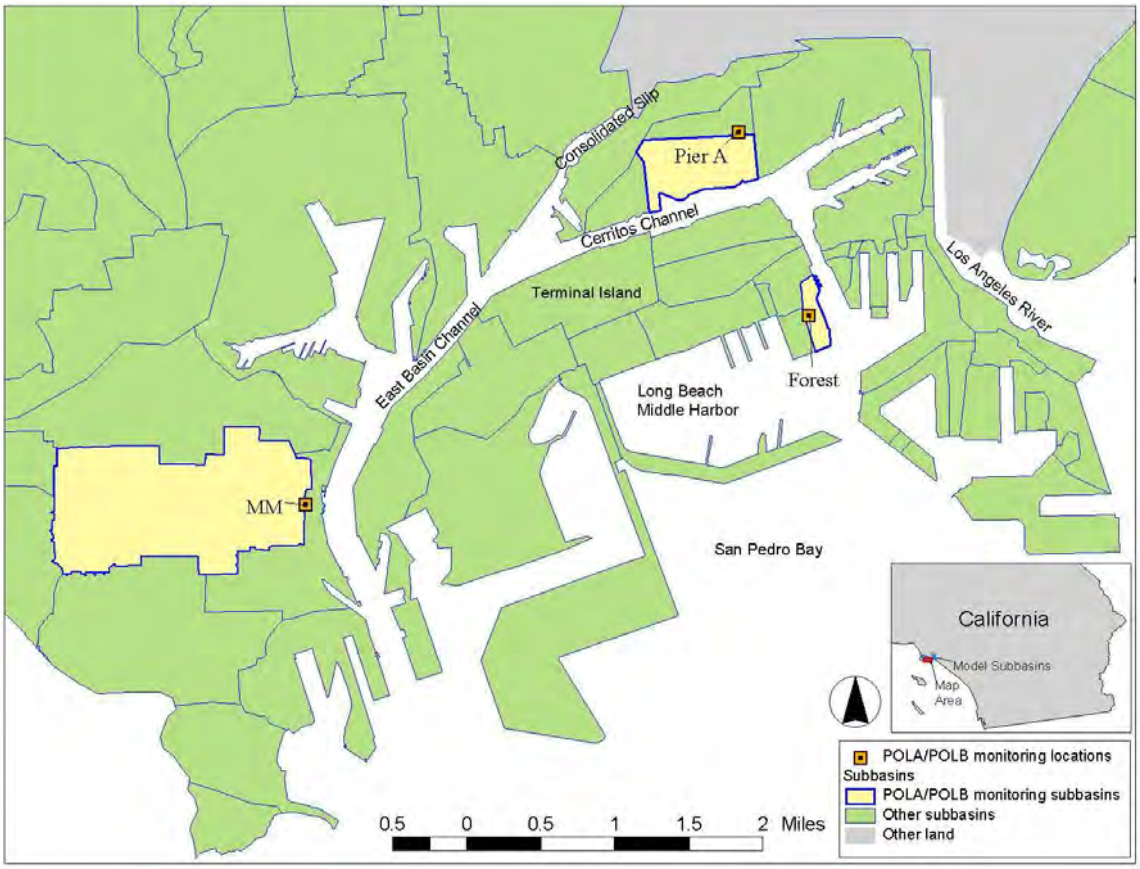


Figure 3. Locations of Monitoring Stations Used for Model Calibration

The nearshore models were initially populated using hydrologic parameters for the LAR watershed model (LARWQCB, 2005c; Tetra Tech, Inc., 2004). The LAR watershed had very similar land uses to the nearshore watersheds, so the parameters were easily transferred. However, the Port Activities land use was not present in the LAR watershed. Therefore, this land use was initially parameterized with the LAR watershed industrial land use parameters and subsequently adjusted during model calibration.

Limited storm data were available for calibration and validation of the nearshore areas, specifically to parameterize the Port Activities land use. For the nearshore watersheds, predicted hydrology was compared to observed flow from a single storm event at each of three monitoring stations (Forest, Pier A, and Maritime Museum), which are identified in Figure 3 (note: these data used for calibration and validation were provided by the Ports; however, they were part of a SCCWRP study). The Forest site was considered a calibration location because it consisted of solely the Port Activities land use, while Pier A and Maritime Museum were used as validation locations (Pier A contained some Port Activities areas along with other land uses, while Maritime Museum was made up of all non-Port Activities land). Final hydrology model parameter values are presented in Table 4, including newly calibrated parameters for the Port Activities land use.

Table 4. Hydrology Parameters in the Nearshore Watershed Model

Modeled land use	LZSN	INFILT	KVARY	AGWRC	PETMAX	PETMIN	INFEXP	INFILD	DEEPFR
Agriculture	11	0.17	3	0.97	35	30	2	2	0.43
Commercial	9	0.17	3	0.965	35	30	2	2	0.38
High density residential	9	0.17	3	0.965	35	30	2	2	0.38
Industrial	9	0.17	3	0.965	35	30	2	2	0.38
Low density residential	7	0.05	3	0.965	35	30	2	2	0.38
Mixed urban	9	0.17	3	0.965	35	30	2	2	0.38
Open	9	0.17	3	0.965	35	30	2	2	0.38
Port activities	11	0.17	3	0.965	35	30	2	2	0.38
Commercial (impervious)	7	0	3	0.965	35	30	2	2	0.15
High Density Residential (impervious)	7	0	3	0.965	35	30	2	2	0.15
Industrial (impervious)	7	0	3	0.965	35	30	2	2	0.15
Low Density Residential (impervious)	7	0	3	0.965	35	30	2	2	0.15
Mixed Urban (impervious)	7	0	3	0.965	35	30	2	2	0.15
Port Activities(impervious)	7	0	3	0.965	35	30	2	2	0.15

Modeled land use	BASETP	AGWETP	CEPSC	UZSN	NSUR	INTFW	IRC	LZETP
Agriculture	0.05	0.05	0.23	0.7	0.25	2	0.7	0.7
Commercial	0.05	0.04	0.17	0.6	0.2	2	0.6	0.5
High density residential	0.05	0.04	0.17	0.6	0.2	2	0.6	0.5
Industrial	0.05	0.04	0.17	0.6	0.2	2	0.6	0.5
Low density residential	0.05	0.04	0.17	0.6	0.2	2	0.6	0.5
Mixed urban	0.05	0.04	0.17	0.6	0.2	2	0.6	0.5
Open	0.05	0.04	0.17	0.6	0.2	2	0.6	0.5
Port activities	0.05	0.04	0.17	0.6	0.2	2	0.6	0.5
Commercial (impervious)	0.05	0	0.06	0.5	0.06	2	0.7	0.5
High Density Residential (impervious)	0.05	0	0.06	0.5	0.06	2	0.7	0.5
Industrial (impervious)	0.05	0	0.1	0.5	0.06	2	0.7	0.5
Low Density Residential (impervious)	0.05	0	0.06	0.5	0.06	2	0.7	0.5
Mixed Urban (impervious)	0.05	0	0.1	0.5	0.06	2	0.7	0.5
Port Activities(impervious)	0.05	0	0.17	0.5	0.06	2	0.7	0.5

Parameter Descriptions:

- LZSN is the lower zone nominal soil moisture storage (inches).
- INFILT is the index to the infiltration capacity of the soil (in/hr).
- KVARY is the variable groundwater recession (1/inches).
- AGWRC is the base groundwater recession.
- PETMAX is the air temperature below which evapotranspiration will is reduced (℉).
- PETMIN is the air temperature below which evapotranspiration is set to zero (℉).
- INFEXP is the exponent in the infiltration equation.
- INFILD is the ratio between the maximum and mean infiltration capacities over the PLS.
- DEEPFR is the fraction of groundwater inflow that will enter deep groundwater.
- BASETP is the fraction of remaining potential evapotranspiration that can be satisfied from baseflow.
- AGWETP is the fraction of remaining potential evapotranspiration that can be satisfied from active groundwater.
- CEPSC is the interception storage capacity (inches).
- UZSN is the upper zone nominal storage (inches).
- NSUR is the Manning's *n* for the assumed overland flow plane.
- INTFW is the interflow inflow parameter.
- IRC is the interflow recession parameter.
- LZETP is the lower zone evapotranspiration parameter.

The model's accuracy was primarily assessed through interpretation of the time-variable plots. Time-variable plots of observed versus modeled flow provided insight into the model's representation of storm hydrographs, baseflow recession, and time distribution. Time-variable plots for each station are shown in Figure 4 through Figure 6.

During low flow conditions, the model is unable to predict dry urban runoff associated with human activities (e.g., lawn irrigation, car washing) without data quantifying the spatial distribution, flow, and loadings associated with these sources. As a result, the LSPC watershed model is not used for dry-weather load estimates and a separate methodology was used to calculate dry weather loadings (see Section 4).

3.2.1.1. Hydrology Calibration

Figure 4 shows the calibration results for the Forest monitoring station, which is entirely represented by the Port Activities land use. The plot shows modeled and measured flow versus time. As this plot indicates, the predicted flow for the Forest subwatershed has a similar pattern, but slightly higher peaks than the observed flow at the POLA/POLB stormwater sampling station. This small discrepancy in flow is well within acceptable modeling ranges and the differences in volume are likely not too significant since the flows are so low.

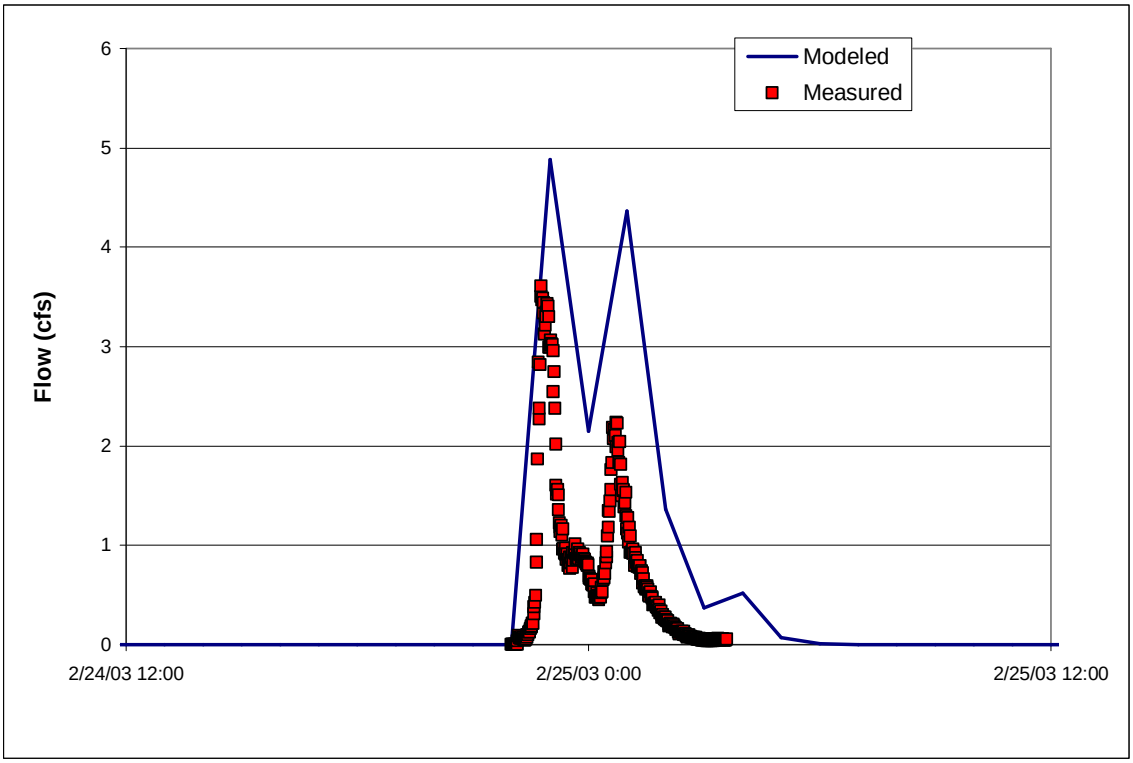


Figure 4. Modeled and Observed Flow for the Forest Subwatershed

3.2.1.2. Hydrology Validation

After calibrating hydrology for the Ports Activity land use using the single storm at the Forest subwatershed, a validation of the hydrologic parameters was made through a comparison of model output to different monitoring locations. Model validation essentially confirmed the applicability of the watershed-based hydrologic parameters derived during the calibration process (both the calibration process above to obtain parameter values for the Port Activities land use as well as the calibration for development of the regional modeling parameters [SCCWRP, 2004; Tetra Tech, 2004, 2005a]). Validation results were assessed in a similar manner to calibration. At the Pier A monitoring station, flow was simulated fairly well (Figure 5). The initial peak was low; however, the second peak was fairly close.

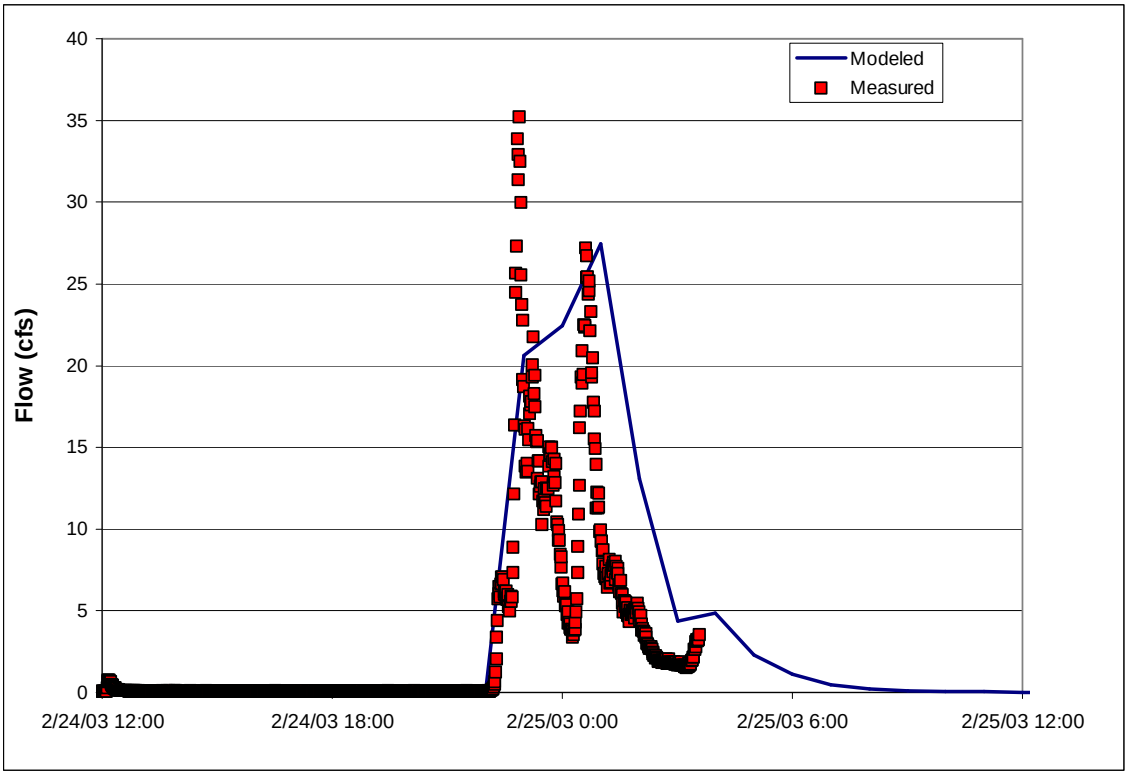


Figure 5. Modeled and Observed Flow for the Pier A Subwatershed

For the Maritime Museum station, the validation results did not match the measured flow (Figure 6). An effort was made to further calibrate the hydrology parameters to more closely match the measured data; however, such efforts would have caused some of the previously calibrated LAR watershed parameters to be adjusted outside of recommended ranges. Although the results at Maritime Museum were poor, given the limited storm data available for this study there were not enough data to justify re-calibration of the calibrated and validated

regional parameters for the LAR watershed model (Tetra Tech, Inc, 2004). During this validation, it was determined that the calibrated Port Activities parameter values achieved the best fit when balancing the results at both the calibration and validation subwatersheds. In addition, the results below compare an hourly modeling frequency (including hourly input rainfall data) with sub-hourly observed data, so exact matches between modeled and observed values are not possible. Therefore, the calibrated nearshore hydrology parameters remained unchanged.

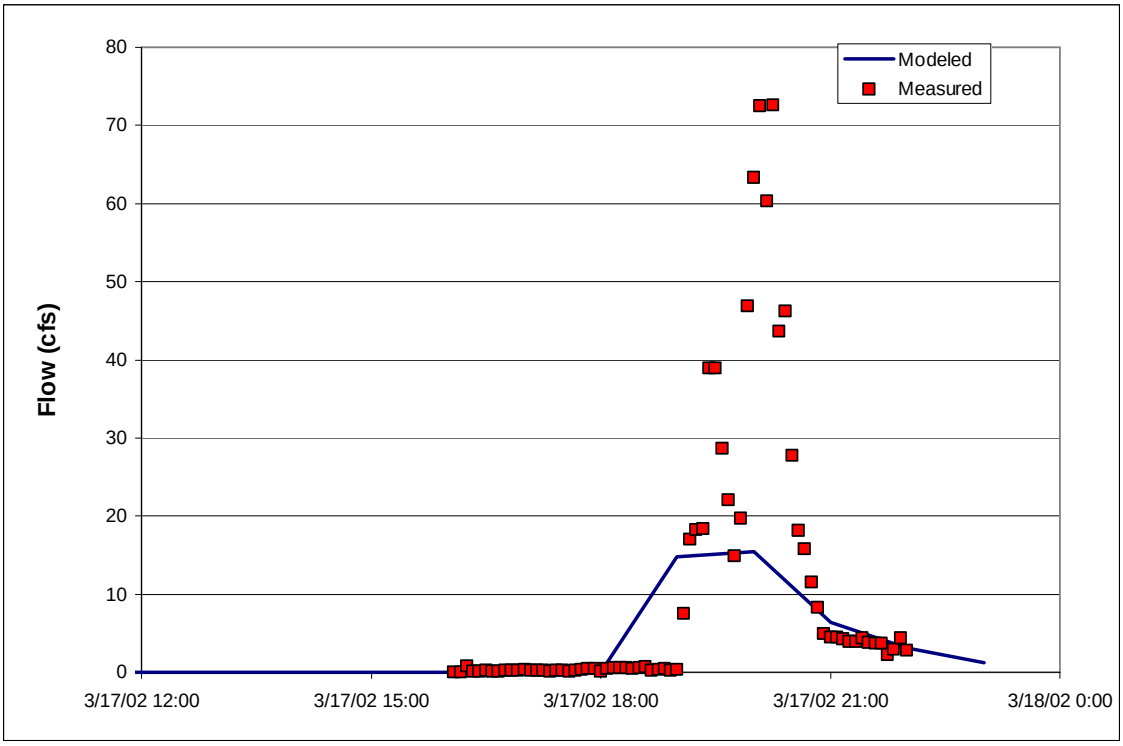


Figure 6. Modeled and Observed Flow for the Maritime Museum Subwatershed

3.2.2. Sediment Calibration and Validation

Once the model was calibrated and validated for hydrology, the regional modeling approach was applied to simulate sediment in the nearshore areas. The robust calibration and validation process previously performed for land use sites, Ballona Creek, LAR, and SGR are considered sufficient for documenting the performance of modeling parameters and verifying the transferability of the parameters among models of adjacent watersheds in the region (SCCWRP, 2004; Tetra Tech, 2004, 2005a). The application of the regional modeling approach provides increased opportunity for verification as additional datasets become available for comparison with model predictions.

3.2.2.1. Sediment Calibration

Similar to the hydrology simulations, for the nearshore watersheds, predicted TSS was compared to observed TSS from a single storm event at each of three monitoring stations (Forest, Pier A, and Maritime Museum), which are identified in Figure 3 (note: these data used for calibration and validation were provided by the Ports; however, they were part of a SCCWRP study). The Forest site was considered a calibration location, while Pier A and Maritime Museum were used as validation locations.

For this study, the sediment parameters from the regional modeling approach (SCCWRP, 2004; Tetra Tech, Inc, 2004 & 2005a) were applied to the appropriate land uses in the nearshore watersheds. The Port Activities land use was initially assigned the same sediment parameter values as the heavy industrial land use, and further adjusted through the model calibration process that included adjustment of the KEIM and JEIM parameter values, which are the coefficient and exponent in the solids washoff equation, respectively. Limited storm data were available for calibration and validation of the nearshore areas, specifically to parameterize the Port Activities land use. Final model parameter values, including newly calibrated parameters for the Port Activities land use, are presented in Table 5.

To assess the predictive capability of the model, the output was graphically compared to observed data. The sediment calibration results at Forest are presented in Figure 7 and Figure 8 for concentrations and loads, respectively. The modeled TSS concentrations in the Forest subwatershed has a higher peak and a more gradual decline than the observed data. Similar to the hydrology results, these discrepancies are well within acceptable modeling ranges, especially considering the limited data available for calibration.

Table 5. Sediment Parameters in the Nearshore Watershed Model

Parameter	Agri-culture	Commer-cial	High density residential	Industrial	Low density residential	Mixed urban	Open	Port activities
PERVIOUS LAND USE								
Splash detachment								
SMPF	1	1	1	1	1	1	1	1
KRER	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
JRER	2	2	2	2	2	2	2	2
AFFIX	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
COVER	0	0	0	0	0	0	0	0
NVSI	20	20	20	20	20	20	20	20
Soil matrix scouring								
KSER	8	8	8	8	8	8	8	8
JSER	2	2	2	2	2	2	2	2
KGER	0	0	0	0	0	0	0	0
JGER	2	2	2	2	2	2	2	2

IMPERVIOUS LAND USE						
Parameter	**Commercial**	**High density residential**	**Industrial**	**Low density residential**	**Mixed urban**	**Port activities**
KEIM	0.05	0.1	0.35	0.15	0.05	0.35
JEIM	2	2	2	2	2	1.75
ACCSDP	0.004	0.004	0.004	0.004	0.004	0.004
REMSDP	0.025	0.025	0.025	0.025	0.025	0.025

Parameter Descriptions:

- *SMPF* is the supporting management practice factor.
- *KRER* is the coefficient in the soil detachment equation.
- *JRER* is the exponent in the soil detachment equation.
- *AFFIX* is the fraction by which detached sediment storage decreases each day as a result of soil compaction.
- *COVER* is the fraction of land surface which is shielded from rainfall erosion.
- *NVSI* is the rate at which sediment enters detached storage from the atmosphere negative value may be used to simulate removal by human activity or wind.
- *KSER* is the coefficient in the detached sediment washoff equation.
- *JSER* is the exponent in the detached sediment washoff equation.
- *KGER* is the coefficient in the matrix soil scour equation, which simulates gully erosion.
- *JGER* is the exponent in the matrix soil scour equation, which simulates gully erosion.
- *KEIM* is the coefficient in the solids washoff equation.
- *JEIM* is the exponent in the solids washoff equation.
- *ACCSDP* is the rate at which solids accumulate on the land surface.
- *REMSDP* is the fraction of solids storage which is removed each day when there is no runoff.

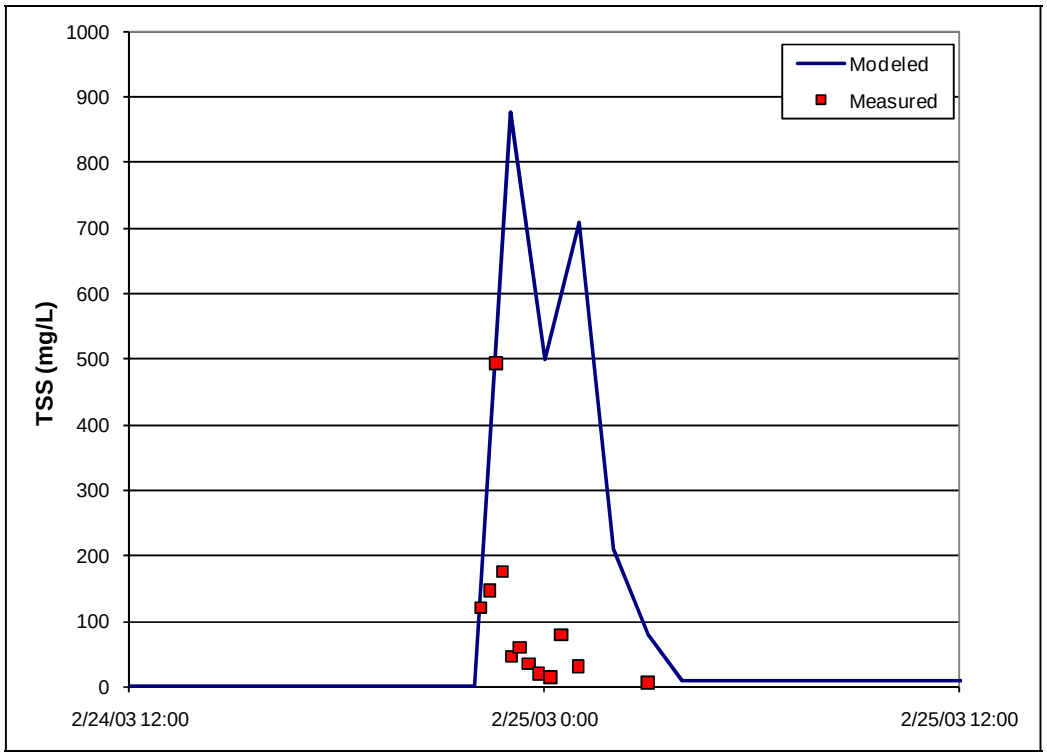


Figure 7. Modeled and Observed TSS Concentrations for the Forest Subwatershed

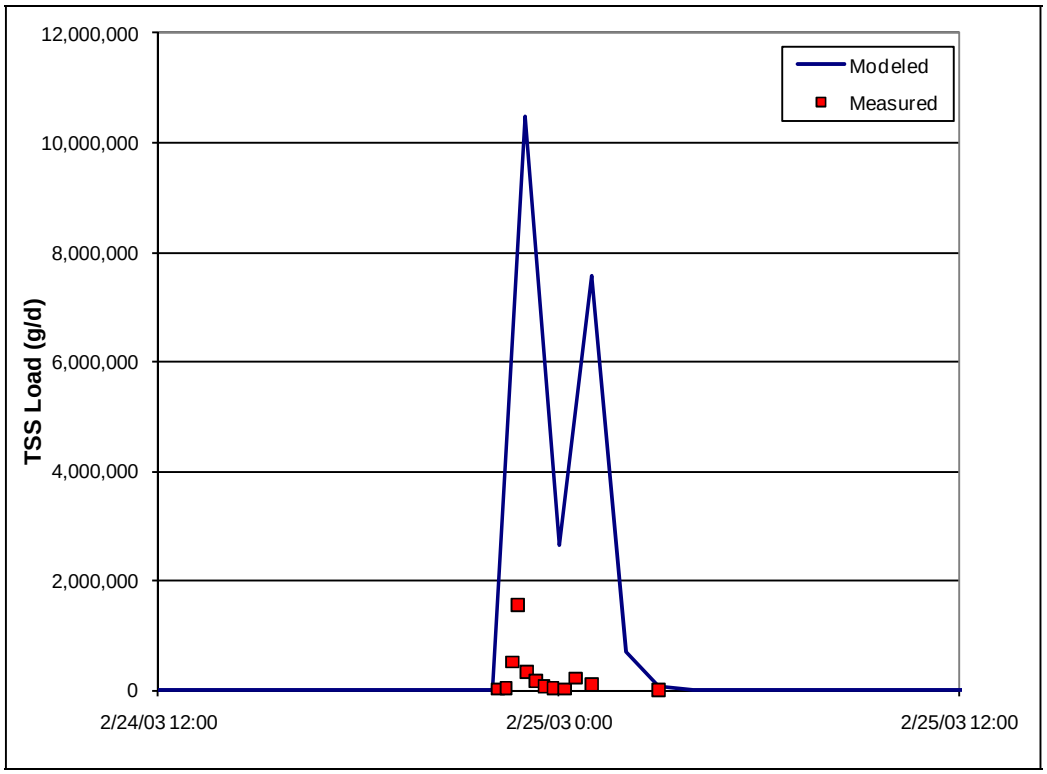


Figure 8. Modeled and Observed TSS Loads for the Forest Subwatershed

3.2.2.2. Sediment Validation

The sediment validation results at Pier A and Maritime Museum are presented in Figure 9 through Figure 12 for concentrations and loads. The modeled TSS concentrations in the Pier A subwatershed have a higher peak and a more gradual decline than the observed data. Overall, the validation at Pier A had similar results to the Forest calibration.

The Maritime Museum discrepancy between modeled and predicted results was expected because the model did not predict observed flow well (Figure 6) and would, therefore, not simulate TSS accurately. In addition, multiple land uses are represented in the Maritime Museum, including commercial (26%), high-density residential (24%), low-density residential (47%), and mixed urban (3%). These land uses were represented based on the regionally calibrated land-use-specific parameters listed in Table 5. Note that this site does not include the Port Activities land use, with associated parameters calibrated and validated for Forest and Pier A, respectively. Based on the land use distribution in the Maritime Museum watershed, it was impossible to isolate impacts from individual land use assumptions and therefore determine which regional parameters could have contributed to the error and subsequently required further calibration. If the regionally calibrated parameters are to be validated for all land uses surrounding the harbors, more monitoring is recommended at different sites that isolate land uses. Additional monitoring is also recommended at the Maritime Museum site to determine if the storm flows previously monitored during the single rain event are anomalous, or if the model consistently under-predicts flows for this location.

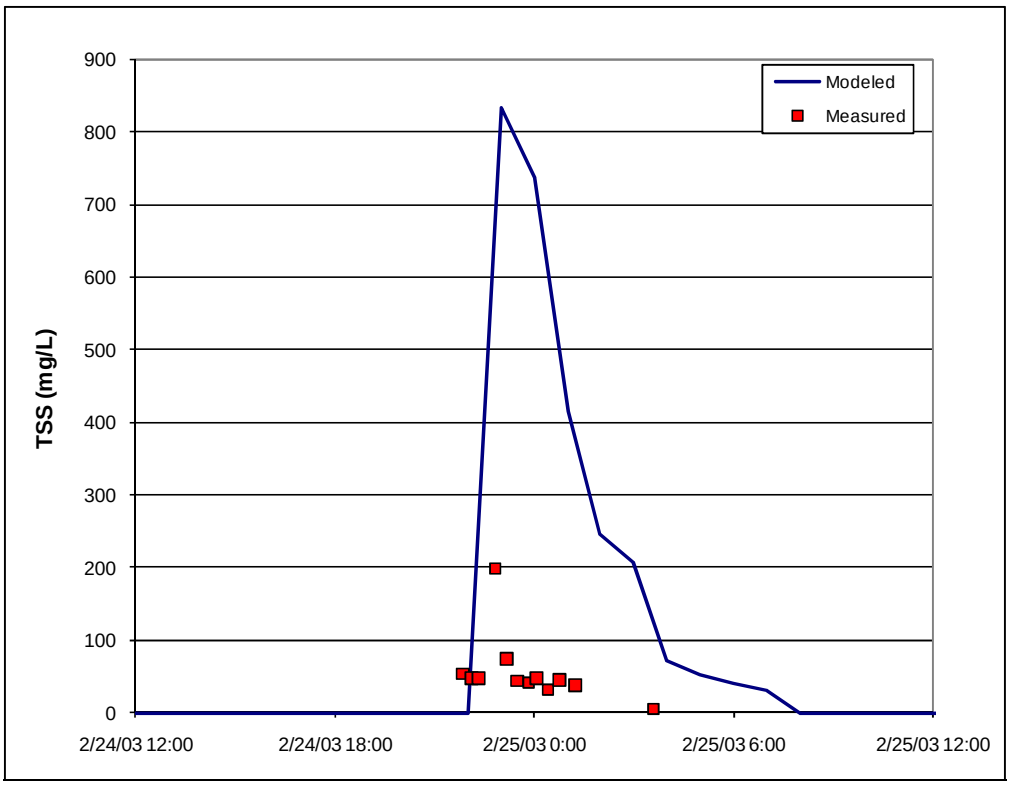


Figure 9. Modeled and Observed TSS Concentrations for the Pier A Subwatershed

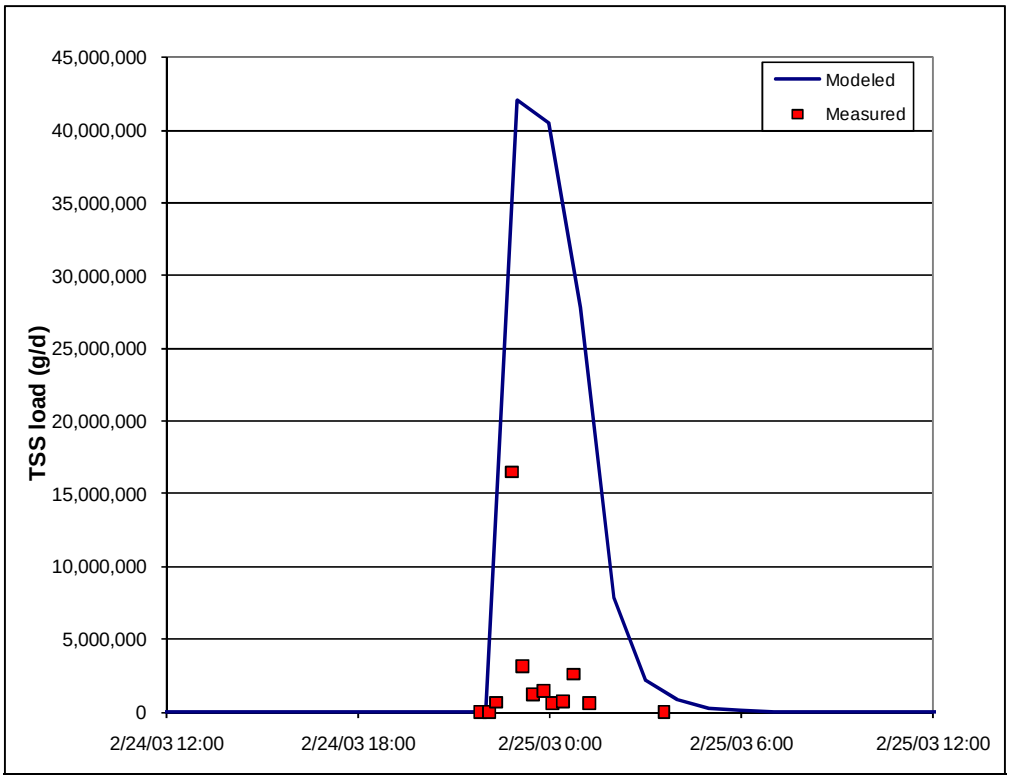


Figure 10. Modeled and Observed TSS Loads for the Pier A Subwatershed

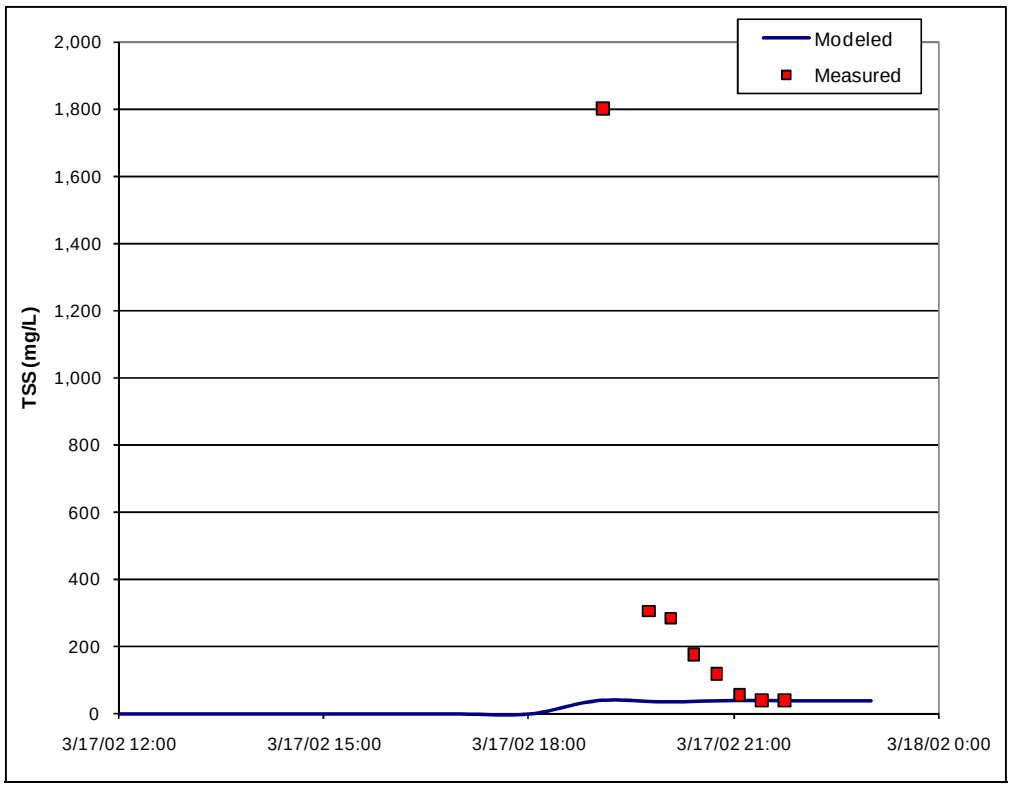


Figure 11. Modeled and Observed TSS Concentrations for the Maritime Museum Subwatershed

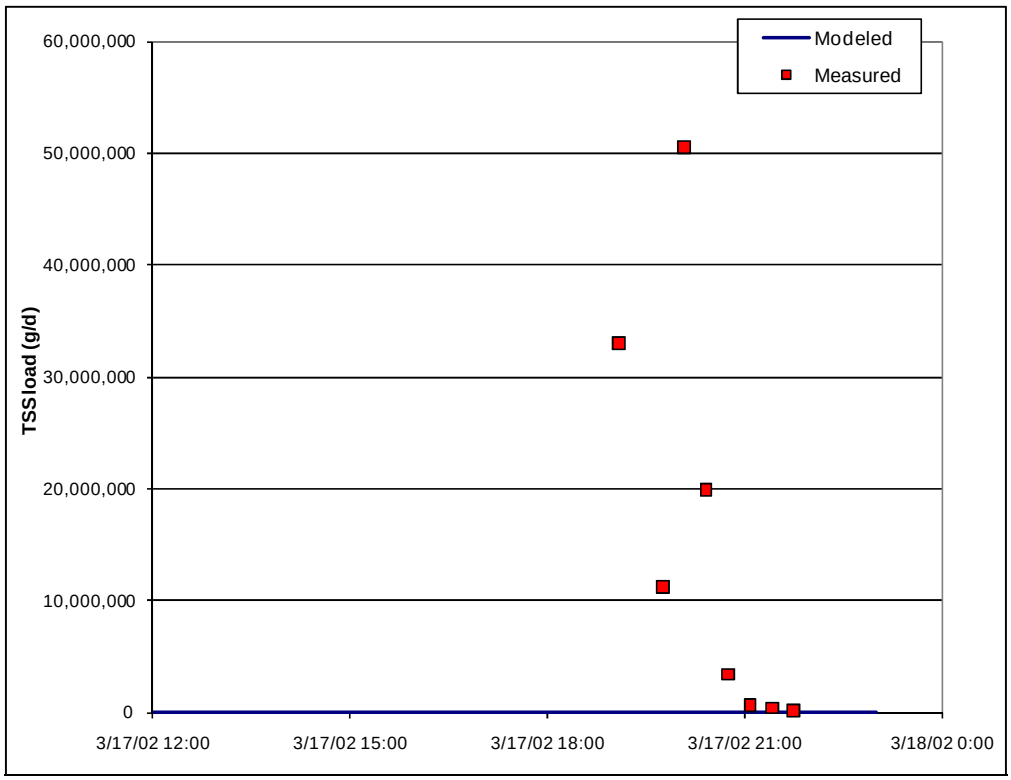


Figure 12. Modeled and Observed TSS Loads for the Maritime Museum Subwatershed

To further validate the nearshore model, model TSS results and observed data were compared using time-series plots at several POLB stormdrain monitoring stations in the nearshore watersheds, for a single storm event at each location. Figure A-1 of Appendix A illustrates the sampling stations in the nearshore areas, while Figures A-2 through A-15 of Appendix A present the time-series plots. These figures indicate that the model predicts TSS concentrations generally within the range of observed data.

Overall, the model appears to reproduce the magnitude of observed data reasonably well. Deviations from the observed data may be caused by localized conditions that are not captured as input to the model. Similar to the hydrology simulations, it was determined that the calibrated Port Activities parameter values achieved the best fit when balancing the results at both the calibration and validation subwatersheds. In addition, the results above compare an hourly modeling frequency (including hourly input rainfall data) with sub-hourly observed data, so exact matches between modeled and observed values are not possible. Therefore, the calibrated nearshore sediment parameters remained unchanged, including the regionally calibrated values.

3.3. Application of Wet-Weather Watershed Model

As described below, metals for both the LAR and SGR watersheds and nearshore areas were simulated directly using regionally-calibrated parameters in LSPC (see Section 3.3.1). To determine loadings for PAHs, DDT, PCBs, and chlordane, it was necessary to develop pollutant-specific approaches. These approaches, which are described in detail below, all use LSPC model output from January 1995 through July 2005 for the LAR and SGR watersheds and nearshore areas. Specifically, for PAHs, the simulated flow is combined with land-use specific event mean concentrations (EMCs) to calculate loadings in the nearshore areas, while watershed-specific observed concentrations were applied to the LAR and SGR watersheds (see Section 3.3.2). Simulated TSS results are combined with pollutant concentrations associated with sediment samples to determine DDT, PCBs, and chlordane loads (see Section 3.3.3). In addition, for the PAH, DDT, PCB, and chlordane analyses, the LSPC subwatersheds were further combined (i.e. all upstream subwatersheds were merged) so that each subwatershed represented a direct loading to the Harbors. The pollutant-specific wet-weather approaches and results for the Forest, Pier A, and Maritime Museum subwatersheds are presented in the following sections and annual loads to the receiving waterbodies for each pollutant are provided in Appendix B.

3.3.1. Metals

The time periods associated with the previously calibrated models of the LAR and SGR watersheds (LARWQCB, 2005c; Tetra Tech, Inc, 2004 & 2005a) were expanded using longer input weather data to determine total metal loads to their respective estuaries in the receiving water model for the entire Los Angeles Region modeling period. For modeling wet-weather metals loads from nearshore areas (Figure 2), Tetra Tech developed LSPC models based on the regionally calibrated land use modeling parameters described above. Metals loadings from the calibrated and validated nearshore model were determined for the entire modeling period and ultimately applied as direct loadings to the Harbors in the receiving water model.

The regional modeling approach described above for sediment was also applied to simulate metals in the nearshore watersheds. Copper, lead, and zinc were represented in the model through their association with sediment. In order to simulate sediment contributions to the nearshore watersheds, the SEDMNT, SOLIDS, and SEDTRN modules were implemented. After using the sediment module to simulate TSS, metals associated with sediment were simulated using the LSPC water quality module. The relationships between sediment and copper, lead, and zinc were simulated using the POTFW parameter, which does not take any reactions into consideration. POTFW is the washoff potency factor or the ratio of constituent yield to sediment outflow. A unique value for POTFW can be assigned for each constituent and these values can vary by land use.

After sediment was calibrated and validated (see Section 3.2.2), the metals parameters based on the regional modeling approach (SCCWRP, 2004; Tetra Tech, Inc, 2004 & 2005a) were applied to the nearshore areas. Similar to the previous simulations, predicted total copper, lead, and zinc were compared to observed total metals concentrations from a single storm event at each of three monitoring stations (Forest, Pier A, and Maritime Museum), which are identified in Figure 3. Similar to the previous results, the Forest site was considered a calibration location, while Pier A and Maritime Museum were used as validation locations.

3.3.1.1. <u>Metals Calibration</u>

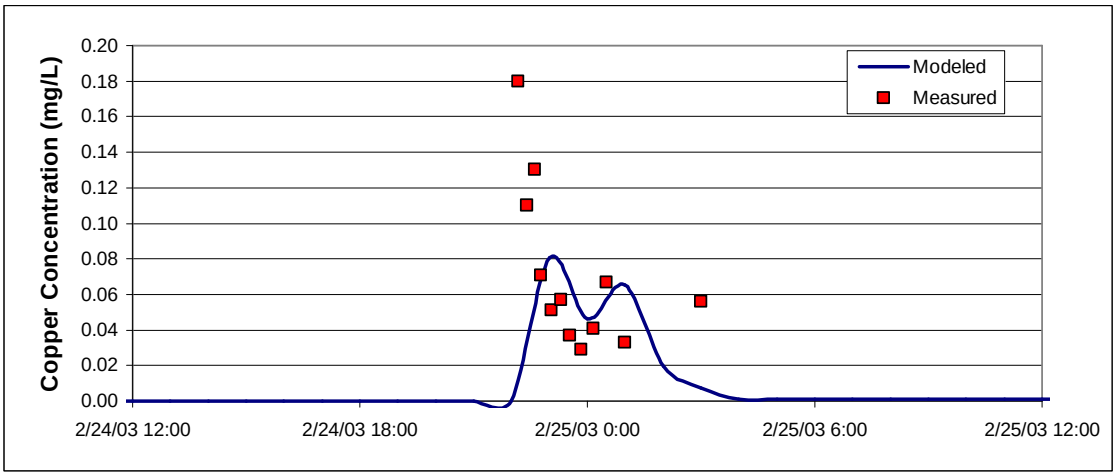
For this study, the regionally-calibrated metals parameters reported in SCCWRP (2004) and Tetra Tech, Inc. (2005a) were applied to the appropriate land uses in the nearshore watersheds. The Port Activities land use was initially assigned the same metals parameter values as the heavy industrial land use, and calibration was performed for the Forest subwatershed to develop specific parameters for Port Activities. Specifically, model results were compared to stormwater sampling data for a single storm event and slight adjustments were made to the metals parameters to more closely match the observed data at the Forest station

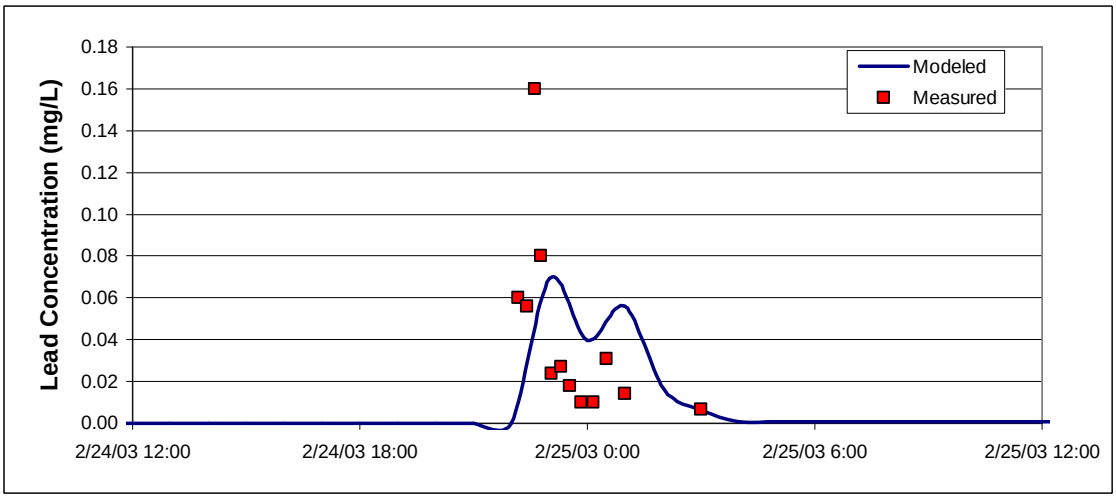
(note: these data used for calibration and validation were provided by the Ports; however, they were part of a SCCWRP study). This methodology is consistent with the minor calibrations performed in the SGR model (Tetra Tech, Inc, 2005a) to more closely match the local conditions in the watershed. Calibrated POTFW parameter values are presented in Table 6.

To assess the predictive capability of the model, the output was graphically compared to observed data. Model results for metals concentrations in the Forest subwatershed are presented in Figure 13 and their associated loads are presented in Figure 14. These graphs illustrate that, for total copper, lead, and zinc, the predicted concentrations are slightly lower than the observed concentrations. The predicted loads are fairly close to the observed POLA/POLB stormwater data for the single storm in 2003. These model results are within acceptable modeling ranges, especially given the limited data available for calibration.

Table 6. Total Metals Washoff Potency Factors in the Nearshore Wet-Weather Watershed Model

Land Use	Copper	Lead	Zinc
Agriculture	0.3	0.1	2.5
Commercial	1	1	10.2
Commercial (impervious)	1	1	10.2
High density residential	0.80	0.80	7.50
High density residential (impervious)	0.80	0.80	7.50
Industrial	0.3	0.18	4
Industrial (impervious)	0.3	0.18	4
Low density residential	0.62	0.27	1.93
Low density residential (impervious)	0.62	0.27	1.93
Mixed urban	0.8	0.25	5
Mixed urban (impervious)	0.8	0.25	5
Open	0.3	0.1	2.5
Port activities	0.175	0.15	1.5
Port activities (impervious)	0.175	0.15	1.5





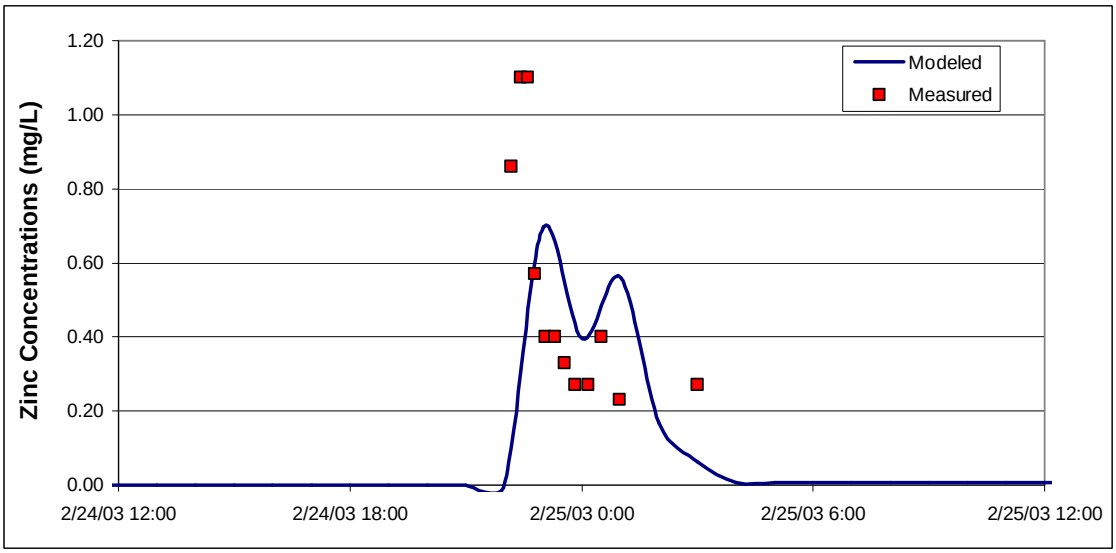


Figure 13. Modeled and Observed Total Copper, Lead, and Zinc Concentrations for the Forest Subwatershed

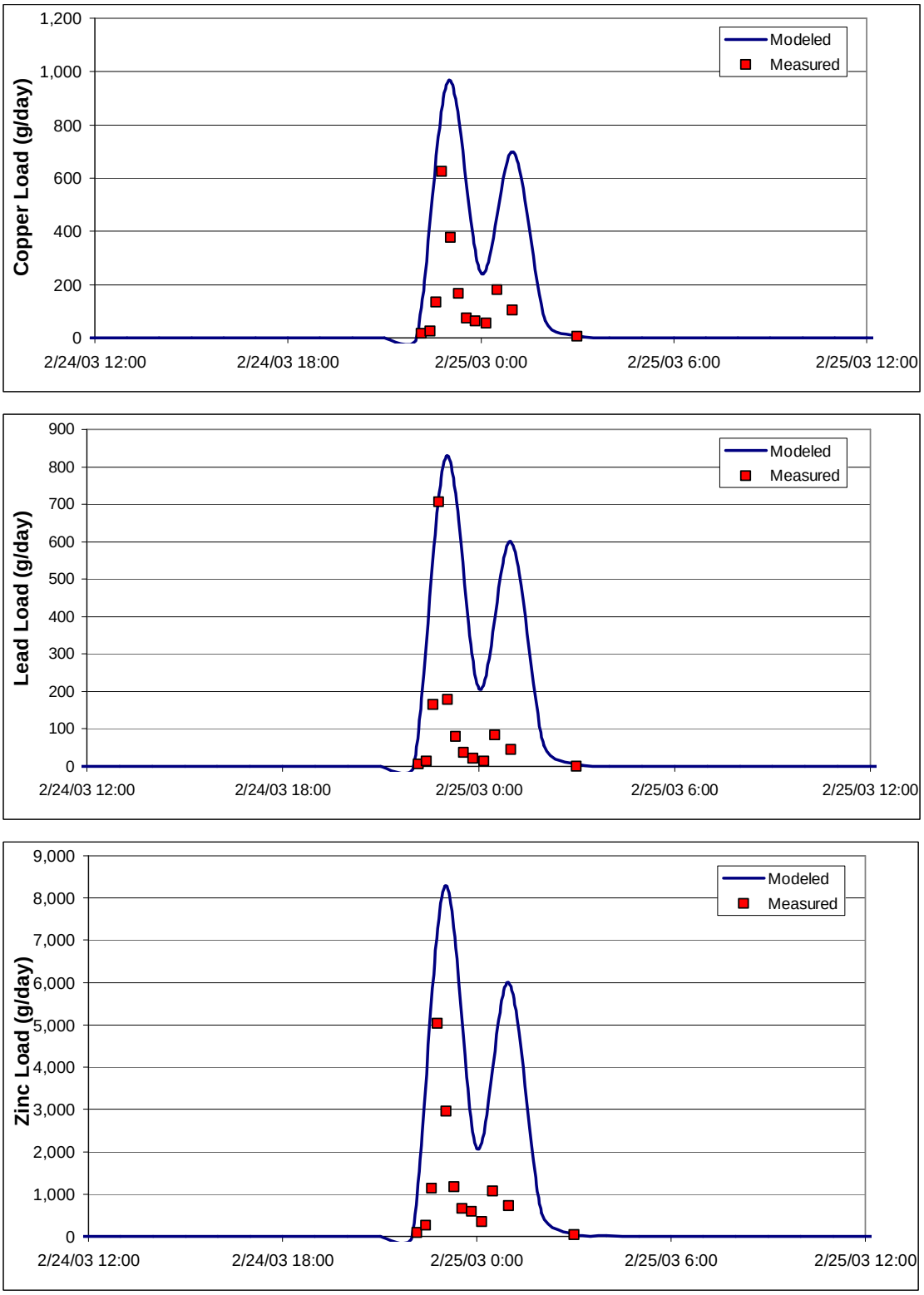


Figure 14. Modeled and Observed Total Copper, Lead, and Zinc Loads for the Forest Subwatershed

To further assess overall model performance in predicting pollutographs and associated metals loads, observed flow-weighted event mean concentrations (EMCs) were compared to flow-weighted EMCs calculated using hourly model output (Figure 15). EMC comparisons at Forest showed that the model EMCs were similar to observed EMCs (percent differences ranging from 3 to 20%) (Table 7).

Table 7. Modeled and Observed Total Copper, Lead, and Zinc Flow-Weighted Event Mean Concentrations at Forest, Pier A, and Maritime Museum

Date	Copper (mg/L)			Lead (mg/L)			Zinc (mg/L)		
	Measured	Modeled	Percent Difference	Measured	Modeled	Percent Difference	Measured	Modeled	Percent Difference
Forest Industries	0.057	0.059	3%	0.042	0.050	20%	0.440	0.505	15%
Pier A	0.059	0.047	-20%	0.040	0.040	1%	0.460	0.406	-12%
Maritime Museum	0.098	0.014	-86%	0.093	0.012	-87%	0.701	0.114	-84%

3.3.1.2. Metals Validation

The validation results for metals concentrations for the Pier A subwatershed are presented in Figure 16 and their associated loads are presented in Figure 17. Similarly, the concentration and load results for the Maritime Museum subwatershed are presented in Figure 18 and Figure 19, respectively. The modeled concentrations in the Pier A subwatershed have lower peaks than the observed data (Figure 16) and the peak for the copper and zinc predicted loads were very similar to those for the observed loads (Figure 17). The predicted concentrations and loads have a smooth curve over the course of the storm, but the observed data do not follow such a pattern, making it difficult to directly compare the modeled and observed results. Overall, the validation at Pier A show that the model results were well within the ranges of observed data during this single event.

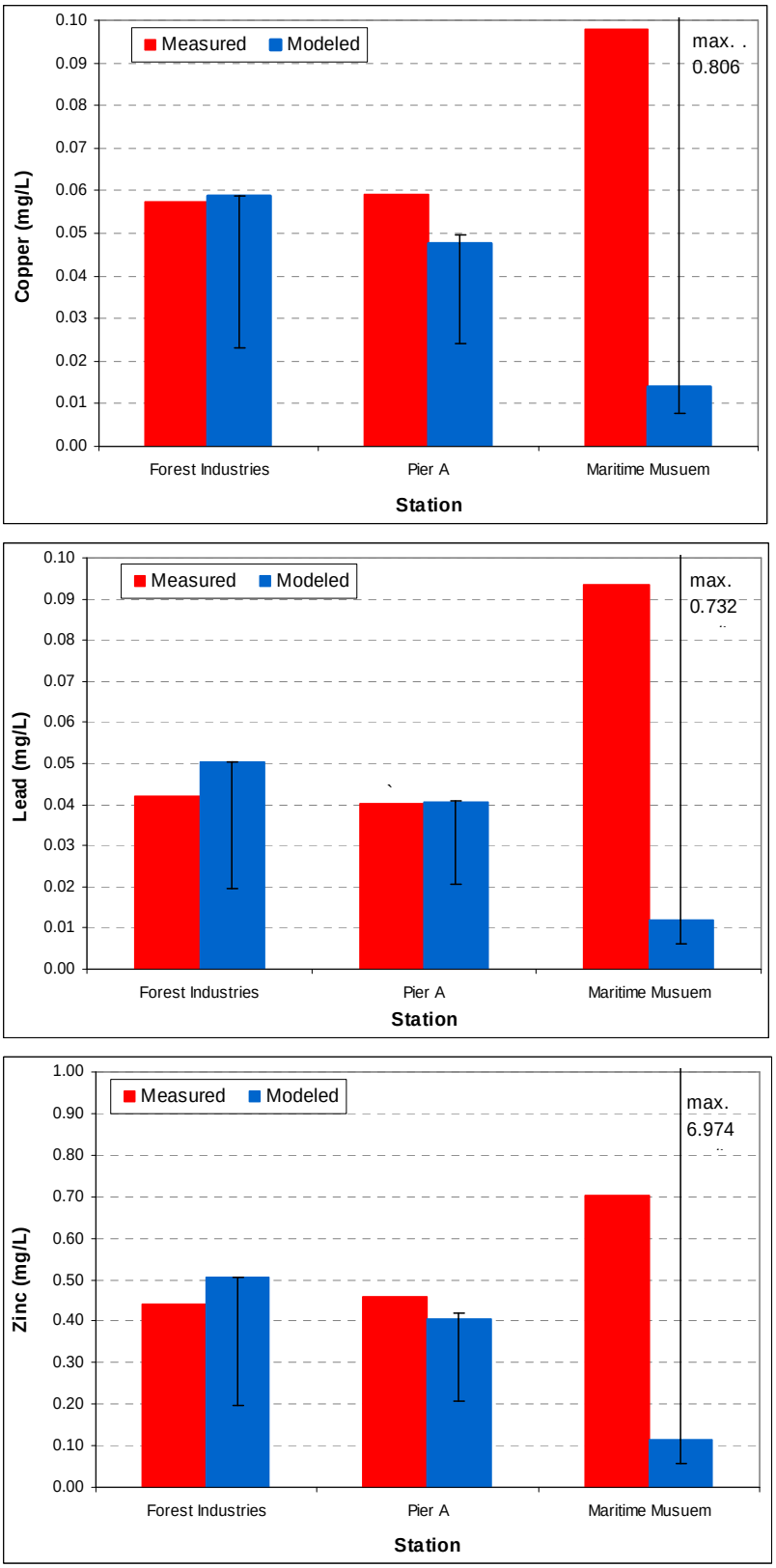


Figure 15. Modeled and Observed Total Copper, Lead, and Zinc Flow-Weighted Event Mean Concentrations for Forest, Pier A, and Maritime Museum

For the Maritime Museum validation, the model results did not capture the observed peak in either concentrations or loads (Figure 18 and Figure 19, respectively). The Maritime Museum discrepancy between modeled and predicted results was expected because the model did not predict observed flow and TSS well and would, therefore, not simulate metals accurately. However, there were not enough data to justify re-calibration of the well-validated regional parameter ranges (SCCWRP, 2004; Tetra Tech, 2005a).

Similar to the model calibration at the Forest subwatershed, observed storm EMCs were compared to EMCs calculated using hourly model output for Pier A and Maritime Museum (Figure 15). EMC comparisons at Pier A showed that the model EMCs were very similar to observed EMCs (percent differences range from -20 to 1%) (Figure 15 and Table 7). At Maritime Museum, the model consistently under-predicted metals EMCs (percent differences range from -87 to -84%) (Figure 15 and Table 7).

To further validate the nearshore model, modeled copper, lead, and zinc results and observed data were compared using time-series plots at several POLB stormdrain monitoring stations in the nearshore watersheds. Figure A-1 of Appendix A illustrates the sampling stations in the nearshore areas, while Figures A-16 through A-27 present the time-series plots. Figures A-16 through A-27 of Appendix A indicate that the model predicts copper, lead, and zinc concentrations generally similar to or below the observed range of data.

Overall, the model appears to reproduce the magnitude of observed data reasonably well. Deviations from the observed data may be caused by localized conditions that are not captured as inputs to the model. Similar to the hydrology and sediment simulations, it was determined that the calibrated Port Activities parameter values achieved the best fit when balancing the results at both the calibration and validation subwatersheds. In addition, the results compare an hourly modeling frequency (including hourly input rainfall data) with sub-hourly observed data, so exact matches between modeled and observed values are not possible. Therefore, the calibrated nearshore metals parameters remained unchanged, including the regionally calibrated values.

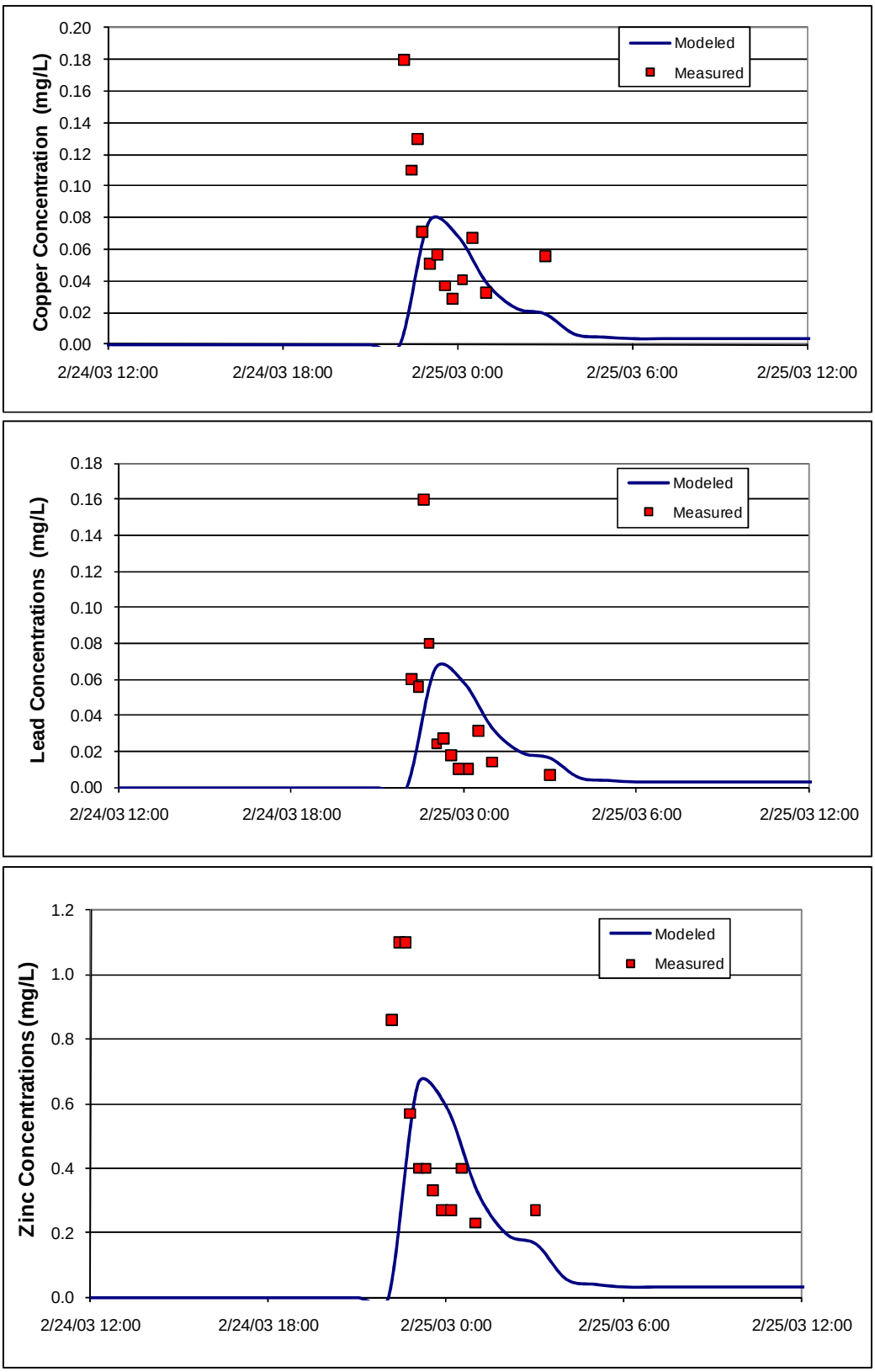


Figure 16. Modeled and Observed Total Copper, Lead, and Zinc Concentrations for the Pier A Subwatershed

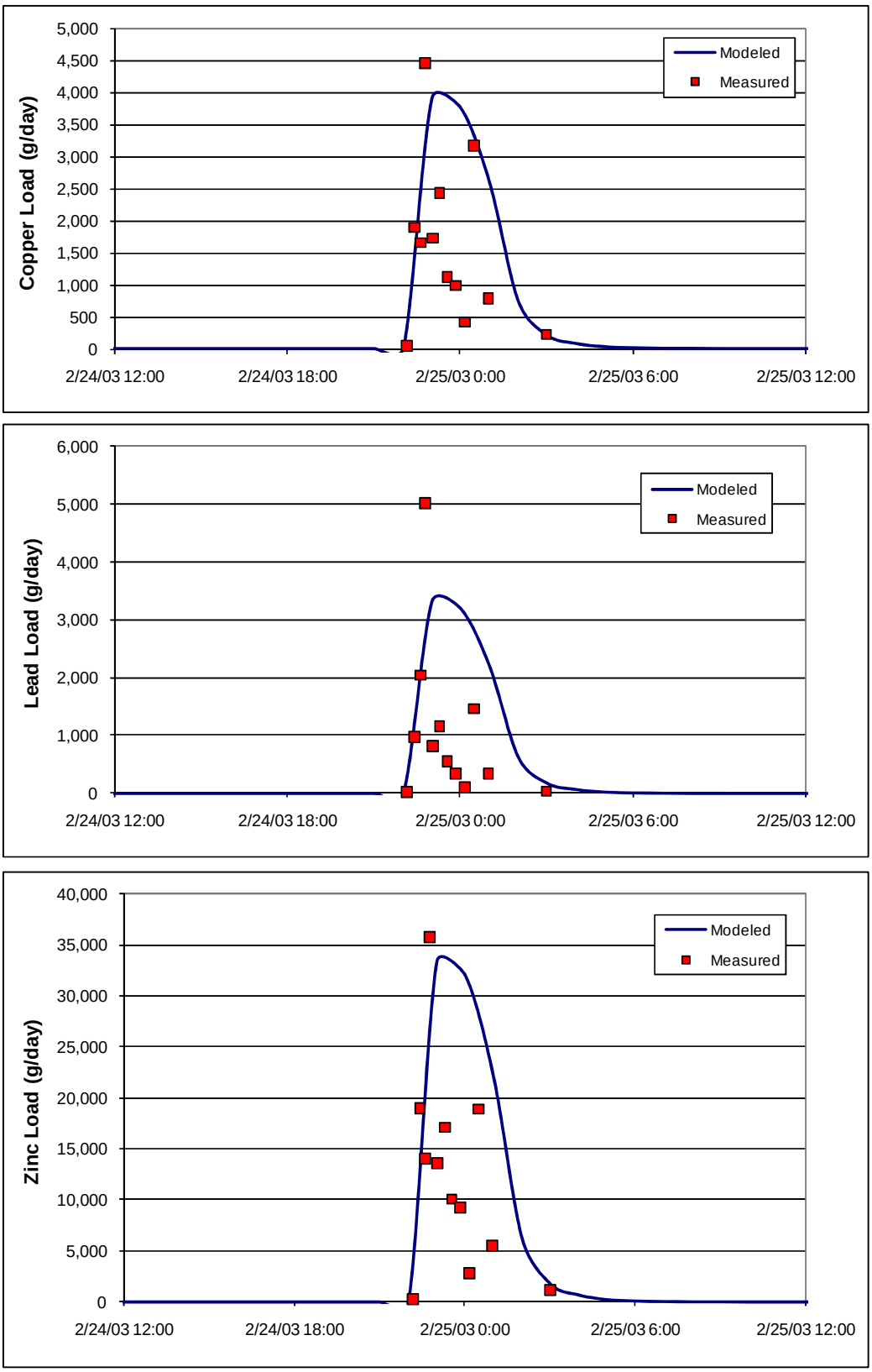


Figure 17. Modeled and Observed Total Copper, Lead, and Zinc Loads for the Pier A Subwatershed

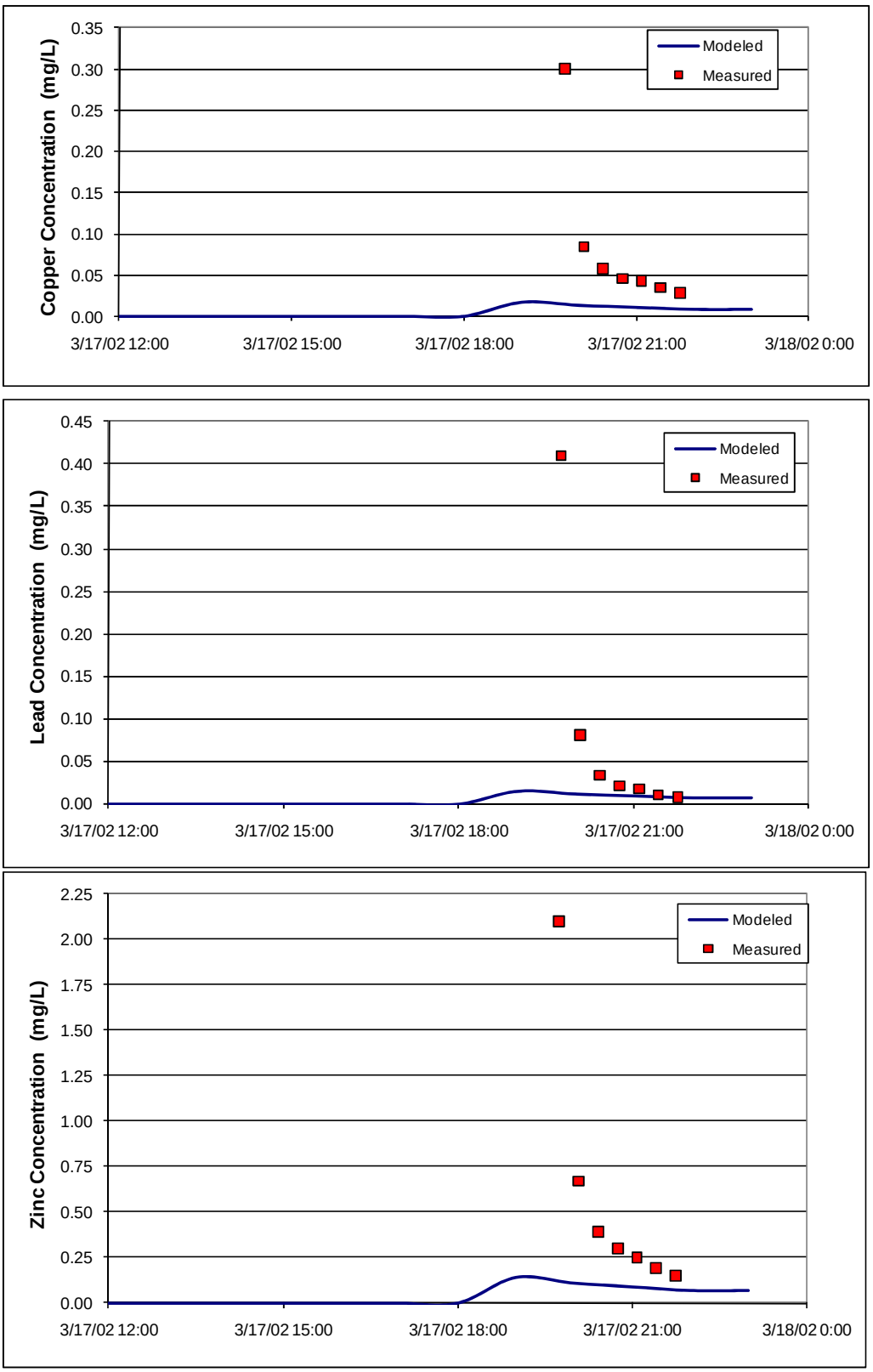


Figure 18. Modeled and Observed Total Copper, Lead, and Zinc Concentrations for the Maritime Museum Subwatershed

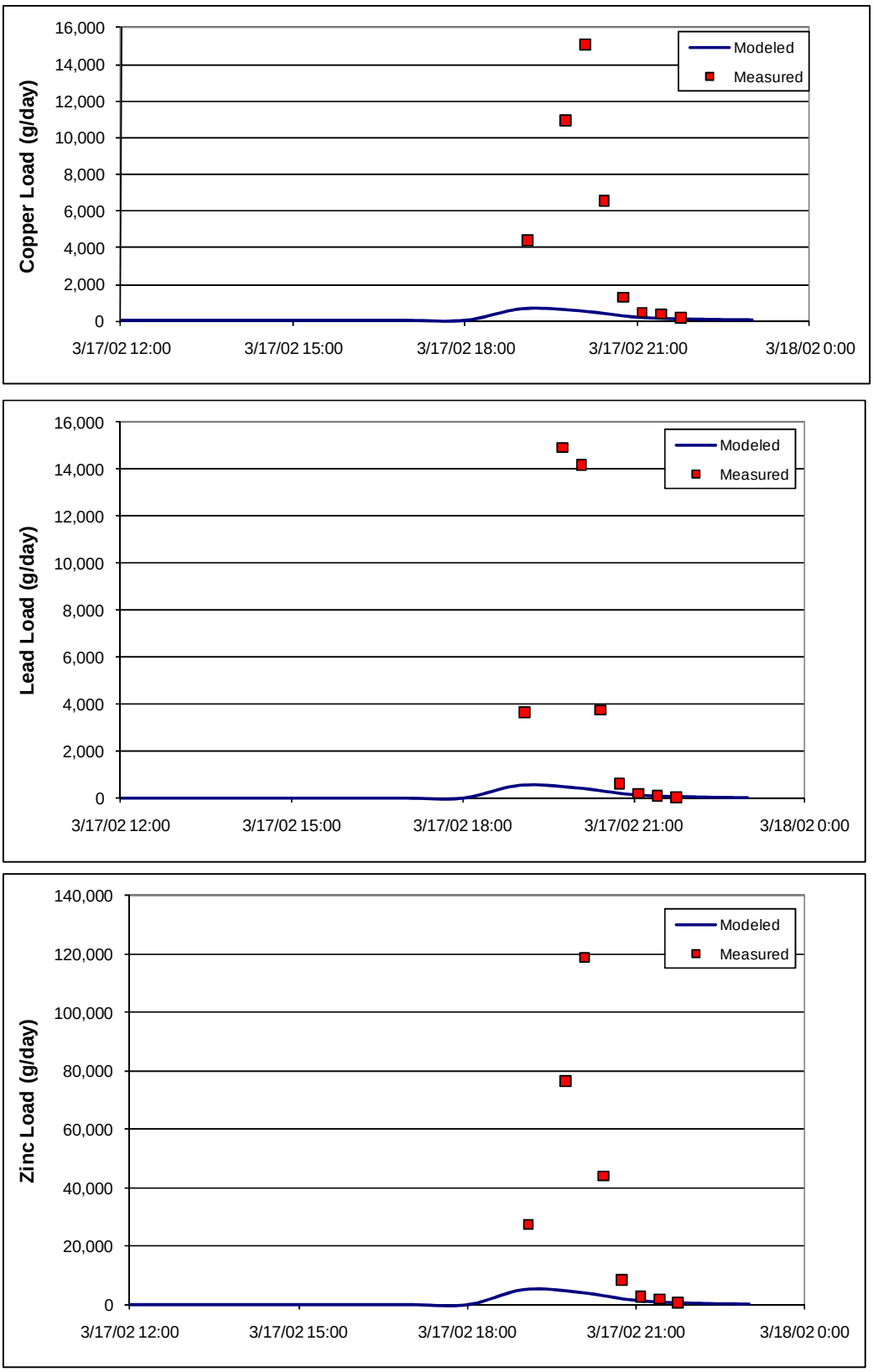


Figure 19. Modeled and Observed Total Copper, Lead, and Zinc Loads for the Maritime Museum Subwatershed

3.3.1.3. Metals Sensitivity Analysis

Sensitivity analyses were performed for comparison with model results. These analyses included modifying the KEIM and JEIM sediment parameters and re-running the model. KEIM is the coefficient in the solids washoff equation and JEIM is the exponent in the same equation. These parameters, which were part of the regionally calibrated parameters provided by SCCWRP (2004), vary by land use and help define the rate at which built-up solids wash off of the land surface. During the SGR modeling effort, analyses were performed to determine the acceptable ranges of these parameters for the SGR watershed (Tetra Tech, Inc, 2005a).

To assess their sensitivity on model output for the nearshore areas, model runs were performed using the minimum and maximum KEIM and JEIM values from the SGR model (Tetra Tech, Inc, 2005a). These analyses should only be used as a relative comparison of parameter sensitivity on TSS, and ultimately, metals, concentrations. The results of these analyses are represented by the error bars on the metals EMCs in Figure 15. While the KEIM and JEIM parameters are important factors associated with the TSS levels output by the model, the error bars indicate that the minimum and maximum values have more of an impact on metals when the TSS concentrations are higher.

3.3.2. PAHs

Presently, no land-use-based watershed models have been developed for simulation of wet-weather sources of PAHs in the Los Angeles Region. However, monitoring at land use sites throughout the Los Angeles Region has yielded information that can be used for the present study. Stein et al. (2005) report EMCs of total PAHs for various land uses based on land use sites monitored in the Los Angeles Region. At each location, 10 to 15 grab samples were collected at a frequency of 30 to 60 minutes during storm events (see Stein et al., 2005 for additional information about the data, including the period of record, detection limits, etc.). The Port Activities land use was not included in the land use monitoring performed by Stein et al. (2005); therefore, storm monitoring data provided by POLA/POLB for the Forest and Pier A monitoring stations, which are surrounded by the Port Activities land use, were analyzed to determine a land use-specific PAH EMC.

The land use categories associated with the EMCs described by Stein et al. (2005) and calculated from the POLA/POLB data are slightly different than those from the regional modeling approach for metals (Table 8). Therefore, the SCAG 2000 land use data were used to represent the study area and were reclassified to maintain consistency with the EMC land use categories (Table 8).

The average EMCs and respective standard deviations reported by Stein et al. (2005) and calculated from the POLA/POLB data for each land use are listed in Table 9. As shown in this table, PAH concentrations are commonly observed in stormflows from each land use. Stein et al. (2005) indicated that some apparent differences in PAH EMCs and fluxes were observed between land uses, with no significant differences in EMCs and fluxes among land use categories.

Table 8. Land Use Categories

LSPC watershed model land use categories	**PAH wet weather assumptions land use categories**
Mixed urban	Transportation
Industrial	Industrial
Commercial	Commercial
Low-density residential	Low-density residential
High-density residential	High-density residential
Agriculture	Agriculture
Open	Open
	Recreational
Port activities	Port activities

Table 9. Average EMCs for PAHs at Land Use Sites (Stein et al., 2005)

Land use	**EMC (ng/L)**	**Standard deviation**
Industrial	1.50E+03	8.60E+02
Commercial	1.20E+03	5.80E+02
Low-density residential	1.40E+03	6.00E+02
High-density residential	4.40E+03	2.60E+03
Agricultural	8.60E+02	1.00E+03
Open	1.38E+02	0.00E+00
Recreational	4.60E+02	3.00E+02
Transportation	4.80E+02	2.80E+02
Port Activities*	1.70E+03	7.40E+02

* Based on analysis of POLA/POLB storm monitoring data

To estimate loading of PAHs from subwatersheds, LSPC flow predictions were combined with EMCs listed in Table 9. Specifically, stormwater total PAH concentrations for each model subwatershed were predicted using weighted averages of land use EMCs based on area and runoff potential of each land use in each subwatershed. The following equation (1) was used to determine representative EMCs for each subwatershed:

$$EMC_{avg}. = \frac{\sum_{i=LU} A_i C_i (EMC_i)}{\sum_{i=LU} A_i C_i} \qquad (1)$$

where, EMC_{avg} = average subwatershed EMC
LU = land use category
A = land use area
C = runoff coefficient

Runoff coefficients for each land use are based on values reported by Ackerman and Schiff (2003) for modeling stormwater mass emissions in Southern California and are presented in Table 10. These land uses do not correlate exactly to the EMC land use categories. To overcome this limitation, the residential runoff coefficient was assigned to both the high density and low density residential land uses, the open runoff coefficient was assigned to the open and recreation land uses, and the other urban runoff coefficient was assigned to the transportation and the port activity land use.

Table 10. Runoff Coefficients by Land Use (Ackerman and Schiff, 2003)

Land use	Runoff coefficient
Industrial	0.64
Commercial	0.61
Residential	0.39
Agriculture	0.10
Open	0.06
Other urban	0.41

EMCs determined for each subwatershed are assumed to be constant for all stormflows. These EMCs were multiplied by hourly flows predicted by LSPC models for estimation of dynamic loads of total PAHs from the watersheds. Although the total PAH concentrations are assumed to be constant, variability of model-predicted stormflows resulted in likewise variable loadings to the Harbors and SPB. Table 11 presents the average PAH EMC calculated for the Forest, Pier A, and Maritime Museum subwatersheds. These concentrations were used to predict loads for their respective subwatersheds. Figure 20 through Figure 22 show the time-variable flows, constant EMC, and resulting time-variable loads for Forest, Pier A, and Maritime Museum, respectively. These figures illustrate that the predicted PAH concentrations are generally within the range of observed data. This methodology was applied to the model output from all other model nearshore subwatersheds and the resulting loads were included as input to the receiving water model.

Table 11. Wet-Weather PAH Concentrations

Watershed	Concentration
Forest	1.68 ± 0.74 (range 0.94-2.42) (µg/L)
Pier A	1.59 ± 0.76 (range 0.82-2.35) (µg/L)
Maritime Museum	1.84 ± 0.94 (range 0.90-2.77) (µg/L)

For the LAR watershed, an EMC value from the LAR at Wardlow monitoring station was obtained from Stein et al. (2005). The values included in the LAR PAH analysis were obtained by averaging the two EMCs and standard deviations presented for the station. The PAH EMC was then multiplied by the modeled flows to calculate LAR loadings.

To obtain EMCs for the SGR watershed, PAH monitoring data for three storms each on the SGR and Coyote Creek were utilized (Stein, 2006). The observed concentrations for each storm were multiplied by their respective flows, summed, and then divided by the total storm flow to determine the EMC for each storm at each stream reach. SGR and Coyote Creek representative EMCs were determined by averaging their three storm EMCs and respective standard deviations associated with each reach (SGR and Coyote Creek) . The SGR and Coyote Creek EMCs were multiplied by their LSPC modeled flow and then summed to obtain watershed-wide SGR wet-weather PAH loads.

Although in reality total PAH concentrations are typically higher during the rising limb of the storm hydrograph due to first flush, mass loading exhibits only a moderate first flush for storms monitored in Los Angeles (Stein et al., 2005). Therefore, assuming constant total PAH concentrations for stormflows is reasonable. Based on a similar method of using EMCs assigned to dynamic flows predicted for Ballona Creek using EPA's Storm Water Management Model (SWMM) to predict wet-weather nutrient loads, McPherson et al. (2005b) state that in most cases, the total load estimated using EMCs for long-term simulation can have similar accuracy as more complex models (e.g., HSPF/LSPC).

To assess the uncertainty of model predictions based on EMCs, sensitivity analyses of assumed values were performed. For each subwatershed, upper and lower ranges of average EMCs (based on equation (1)) were determined using land-use-specific EMCs plus/minus one standard deviation, as listed in Table 9. Resulting ranges of wet-weather loadings to the Harbors and SPB were quantified to provide understanding of the sensitivity of loads potentially due to uncertainty of modeling assumptions. For the Forest, Pier A, and Maritime Museum subwatersheds, the PAH EMC and upper and lower ranges are provided in Table 11 and presented graphically in Figure 20 though Figure 22, respectively. While the observed concentrations are generally higher than the EMC-based predictions at the Forest subwatershed, they are generally lower at the Pier A subwatershed. The average of all observed EMCs for these two subwatersheds is 1,757 ng/L. The average of the predicted Forest and Pier EMCs is 1,633 ng/L. These averages are within 10%, indicating that the use of EMCs to determine PAH loading is representative of the overall nearshore watershed existing conditions. Sensitivity analyses for LAR and SGR were performed by determining the loads associated with EMCs plus/minus one standard deviation.

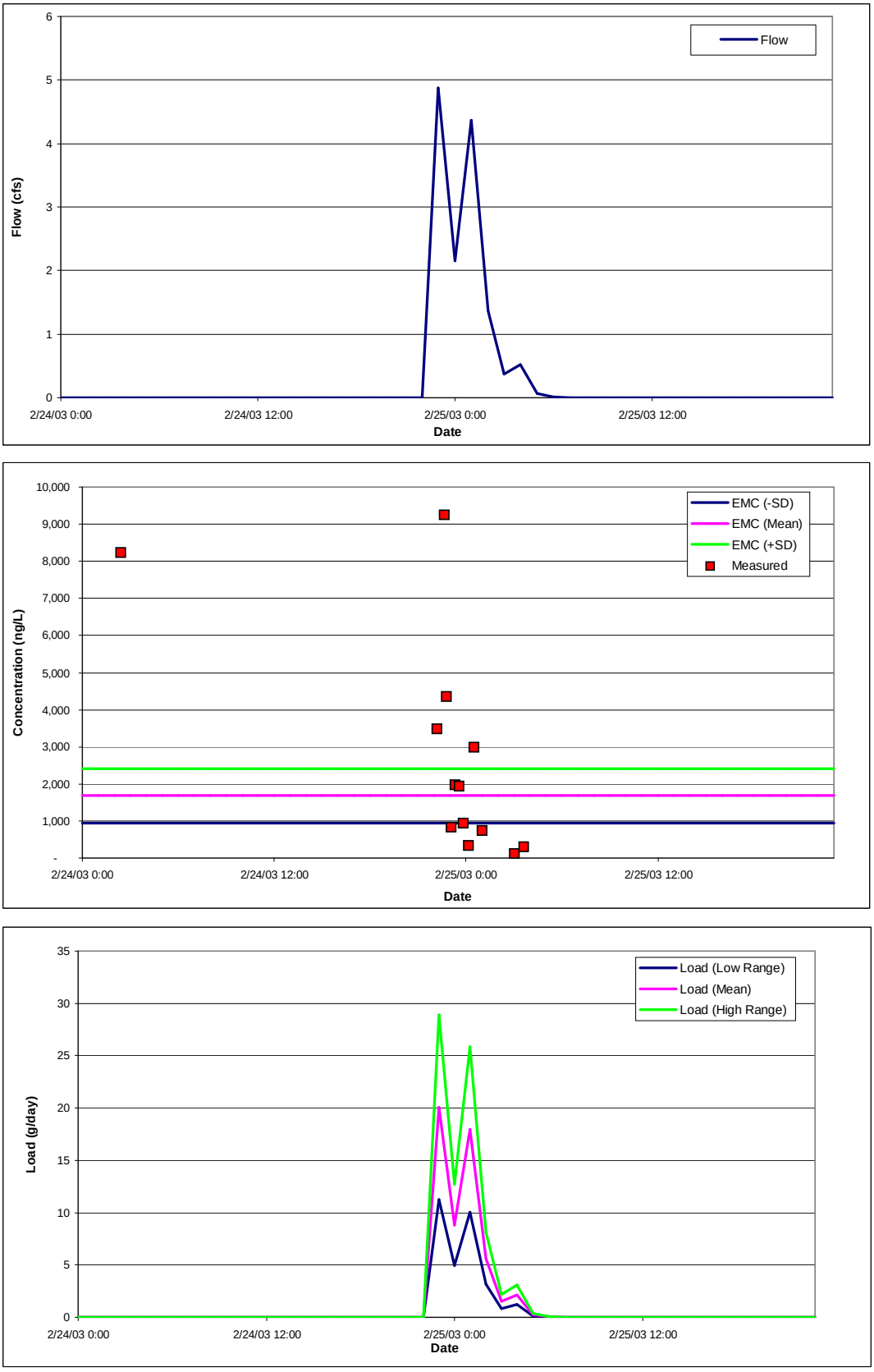


Figure 20. Modeled and Observed PAH Concentrations and Loads for the Forest Subwatershed

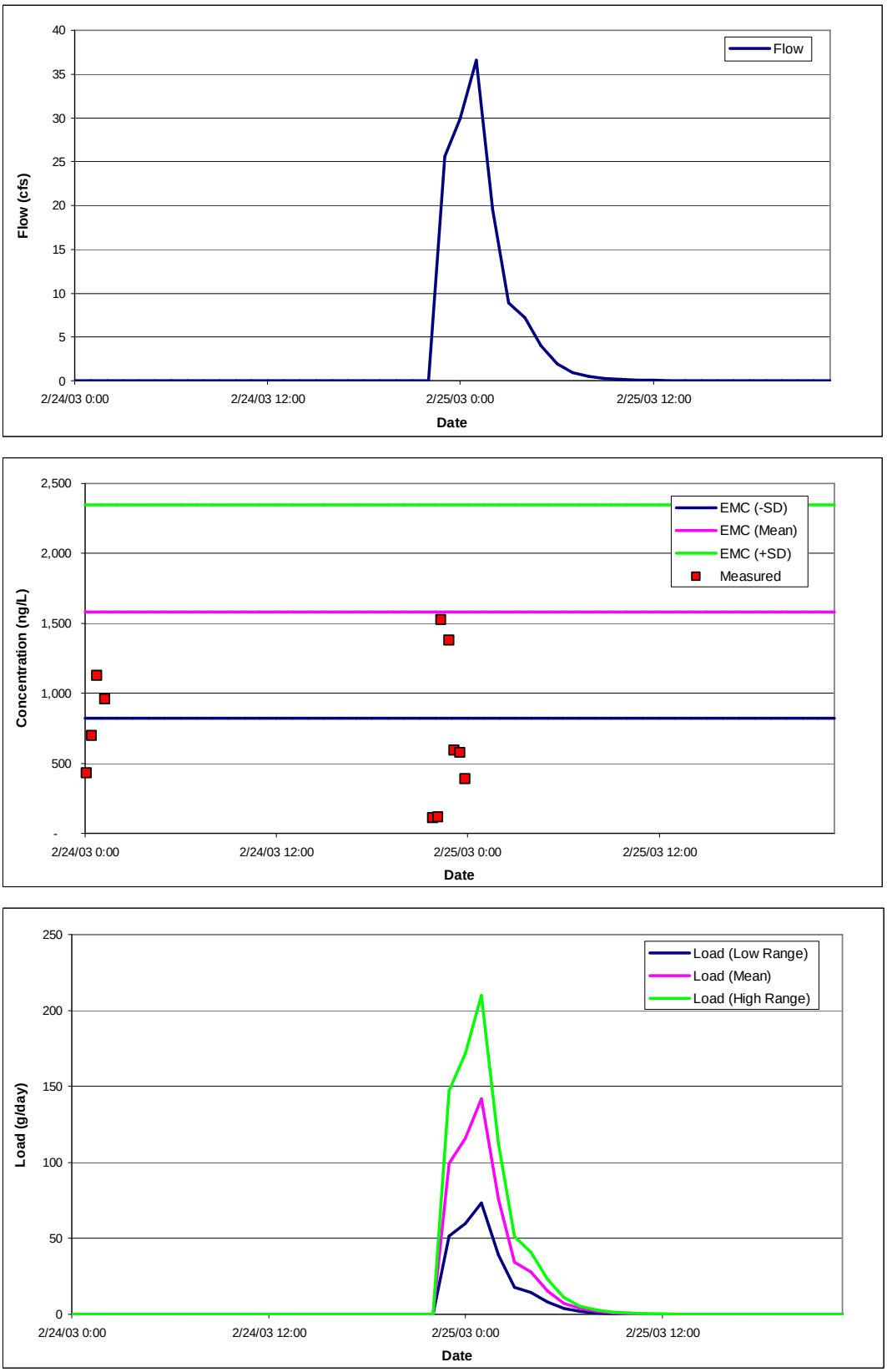


Figure 21. Modeled and Observed PAH Concentrations and Loads for the Pier A Subwatershed

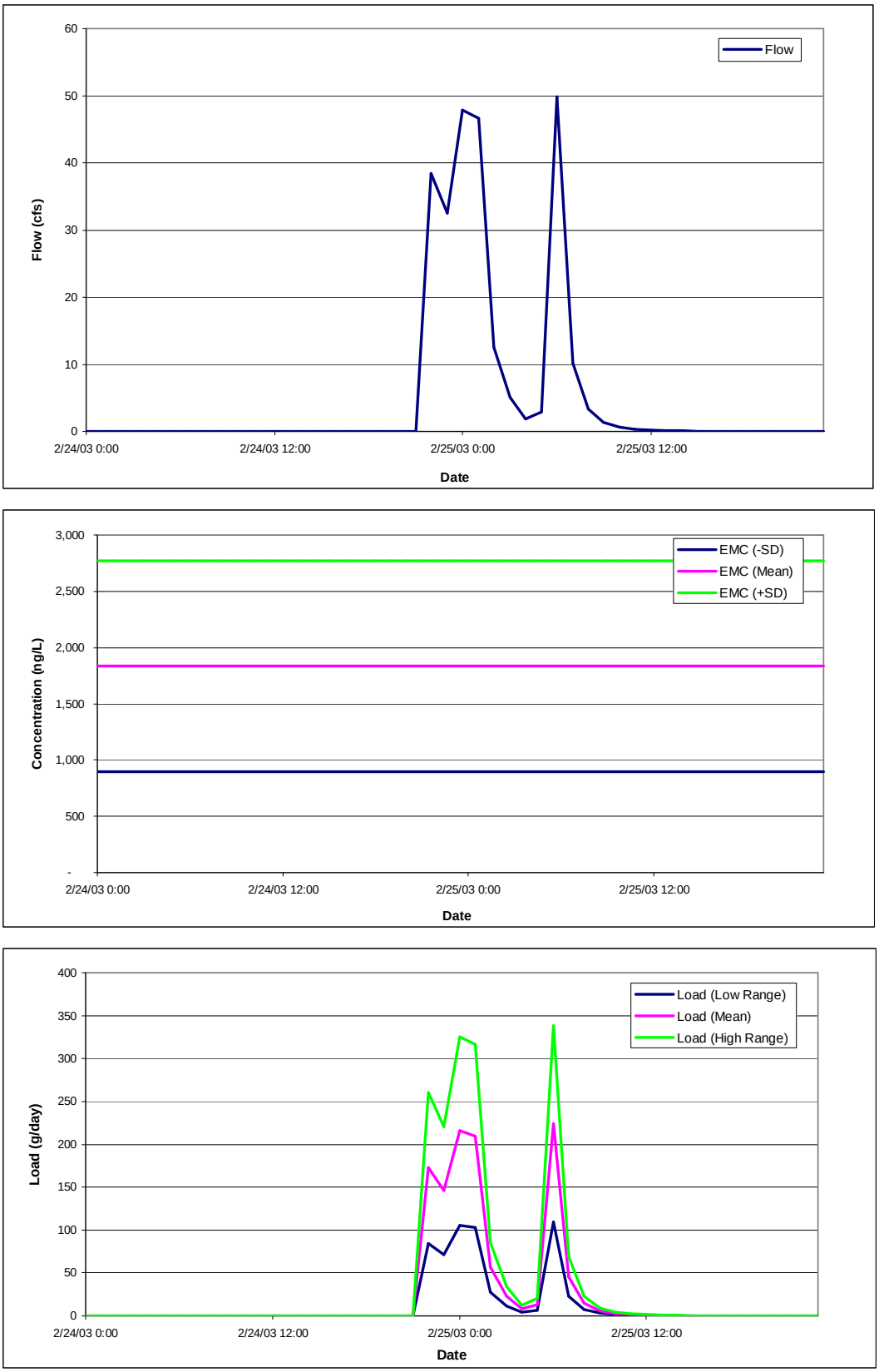


Figure 22. Modeled PAH Concentrations and Loads for the Maritime Museum Subwatershed

PAHs were modeled as total PAHs, and not separately based on molecular weight. The benefit of this approach is the simplicity of assumptions, and the resulting ease at which these assumptions can be understood and utilized in following efforts for modeling to support TMDL implementation and BMP planning. Assumptions will be made for the region during the source identification process, based on whether the pollutant is a high molecular weight PAH or a low molecular weight PAH. Since each specific PAH has its own toxicity and fate and transport, the results above for total PAHs cannot be used to predict the actual toxicity of the discharges. Although the use of EMCs assumes no variability in storm concentrations, first flush, and indication of sediment association that are important considerations for planning and assessment of BMP effectiveness, they are regularly used by municipalities for assessment and planning activities, and reduce the need for using more-complex watershed models for load estimation.

3.3.3. DDT, Chlordane, and PCBs

While the sources and land uses associated with DDT, chlordane, and PCBs differ, their transport mechanisms are generally similar. Therefore, these pollutants were modeled using a similar approach and with similar data. DDT is considered a legacy pollutant because it is believed that active uses/sources of the pollutant do not exist. However, because of the persistence of DDT in the environment, reservoirs of the pollutant are often present in the watershed and in the receiving waters. Few detectable levels of DDT have been observed at mass emissions stations in the Los Angeles Region (4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were measured, each with a detection limit of 0.1 μg/L) (LADPW, 2006). Ackerman and Schiff (2003) report EMCs for DDT for land use monitoring performed by San Diego, Ventura, and Los Angeles municipalities as part of their NPDES permit programs. These EMCs resulted from flow-weighted composite samples collected throughout the duration of storm events. Of the five land uses analyzed (agriculture, commercial, industrial, open, and residential), only agricultural land use was shown to have detectable levels of DDT in runoff. PCBs and chlordane are also referred to as legacy pollutants, and similar to DDT, watershed sources of these pollutants may exist. However, no detectable levels of PCBs and chlordane have been observed at County mass emissions stations (LADPW, 2006) (detection limits for PCBs and chlordane are 0.05 and 0.5 μg/L, respectively).

More-detailed study and collection of stormwater concentrations of DDT, PCBs, and chlordane (at lower detection limits) may provide necessary information for development of a detailed regional modeling approach similar to the metals or land use specific EMCs similar to the PAHs. In the absence of such datasets to characterize wet-weather loads from the watersheds, sediment concentrations were used to model these pollutants in the Harbor watersheds. Similar to methods used in prediction of existing DDT, PCBs, and chlordane loads to

support development of the Newport Bay Toxics TMDL (SARWQCB, 2000), loads can be predicted as a sediment concentration assigned to all sediment loads transported from watersheds to the receiving waters. For the current study, sediment loads to the Harbors and SPB are predicted based on LSPC models of SGR, LAR, and nearshore areas.

Additional assumptions for sediment concentrations of DDT, PCBs, and chlordane, expressed as constant values for all sediment transported from each watershed, are required. Sediment concentrations for the Harbor region have been calculated for the Bight 03 sediment stations. Bight 03 data were collected during summer 2003 at various stations throughout the southern California Bight, including the harbor region. In general, a single sample was collected at each location (see Bight 03 documentation available from SCCWRP regarding the detection limits and other details on the data). Figure 23 through Figure 25 illustrate the range of sediment concentrations found at these stations for DDT, PCBs, and chlordane. These figures show that, for the LAR estuary, DDT, PCBs, and chlordane concentrations are all higher near the mouth of the river than throughout the rest of the estuary. This trend does not persist in the SGR estuary, which tends to have lower concentrations of all three organics compared to the rest of the Harbor and SPB, where, as expected, higher concentrations are generally seen in areas with reduced circulation and flushing.

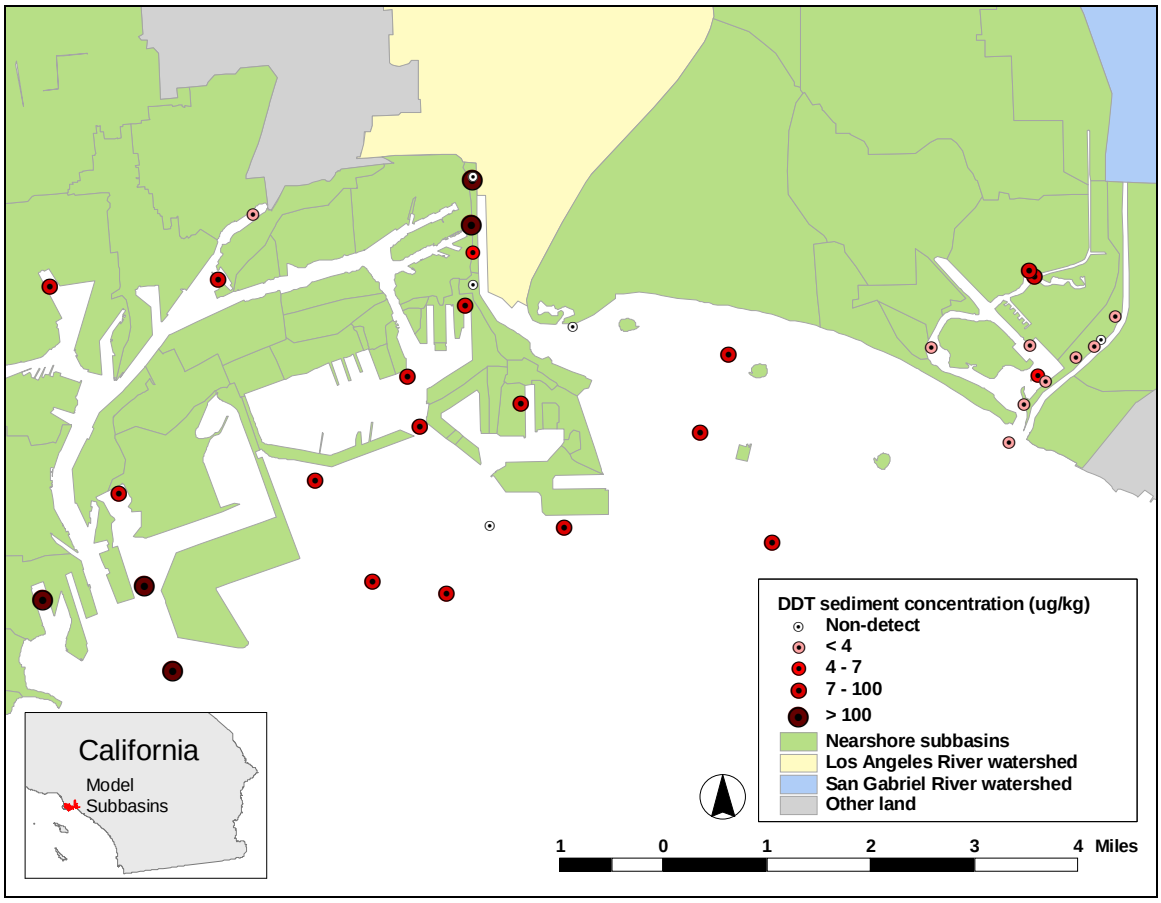


Figure 23. DDT Gradients at the Harbor Bight 03 Sampling Stations

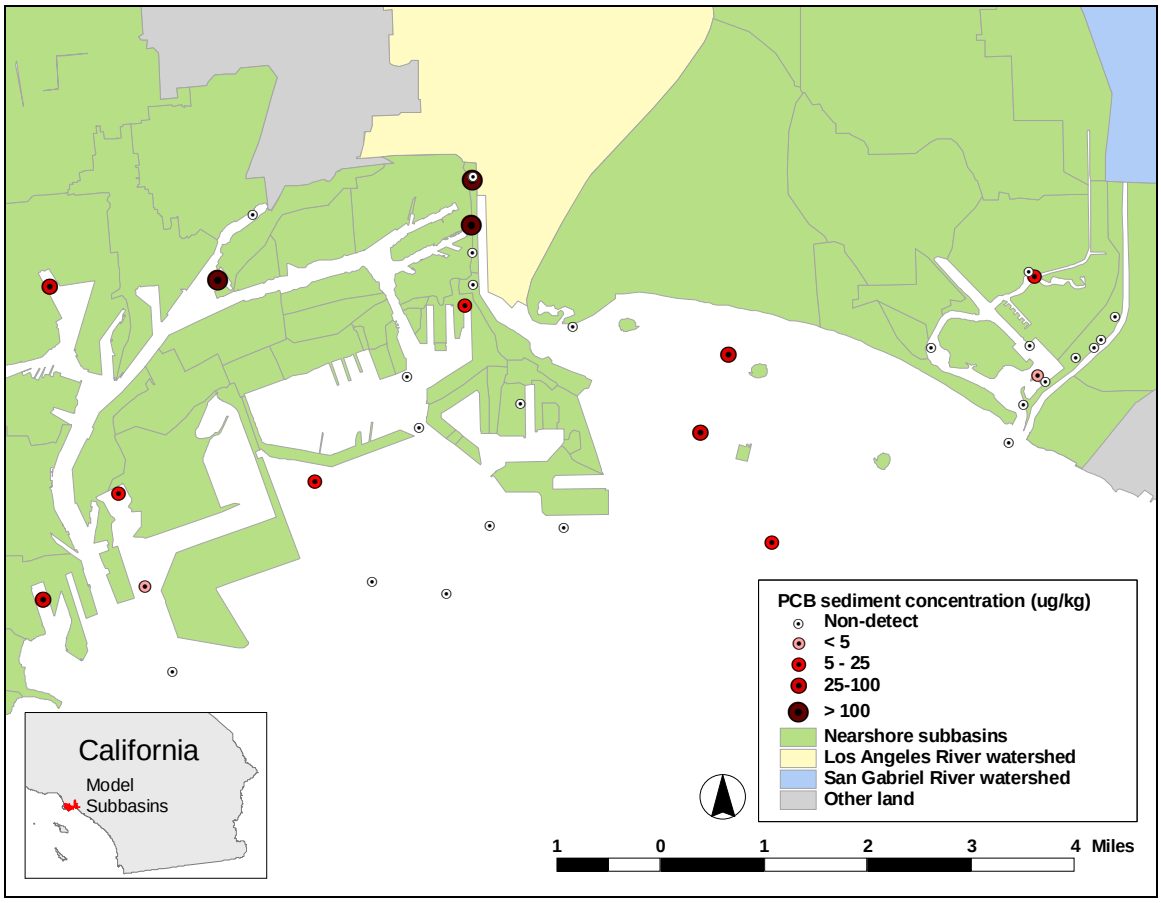


Figure 24. PCBs Gradients at the Harbor Bight 03 Sampling Stations

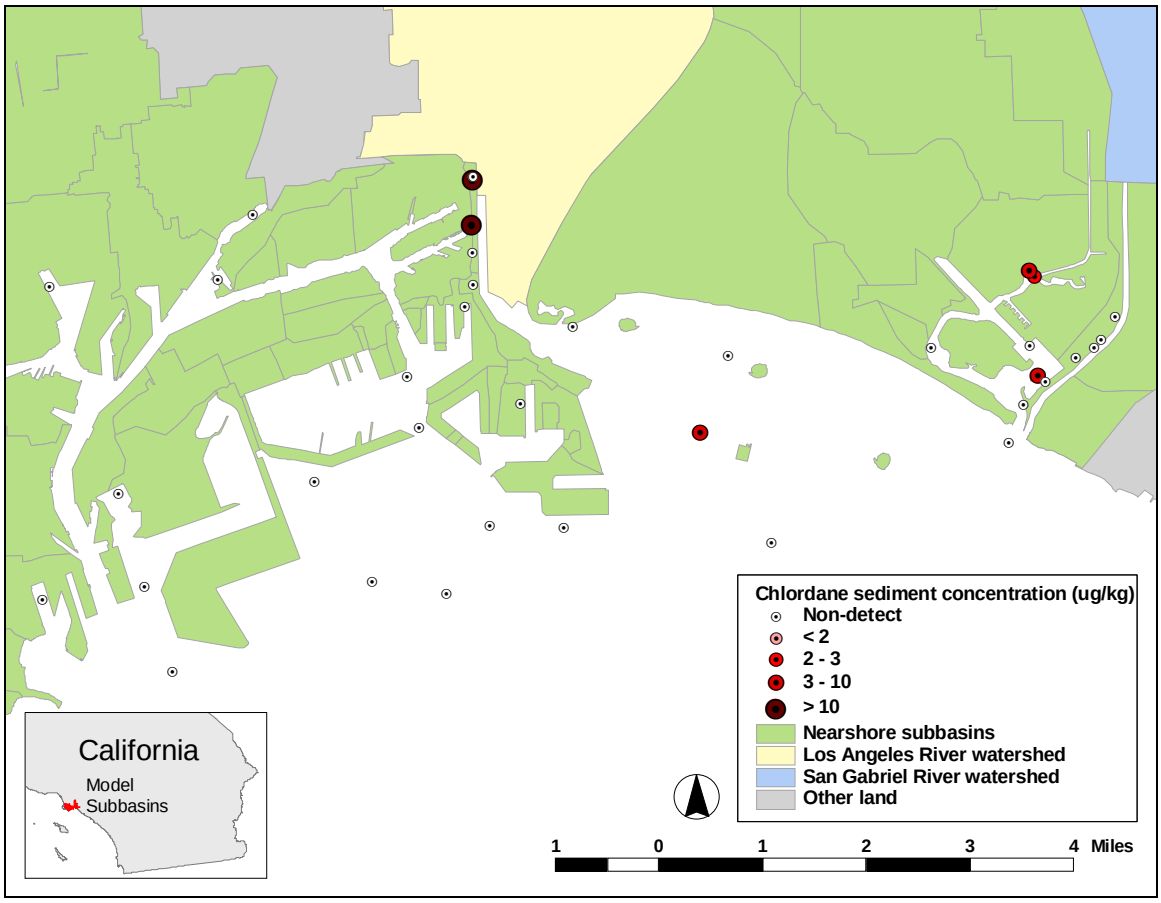


Figure 25. Chlordane Gradients at the Harbor Bight 03 Sampling Stations

The nearshore, LAR, and SGR subwatersheds were all assigned a representative waterbody. These assignments were primarily based on which waterbody was the receiving water of the representative reach. If there were no Bight 03 stations within the representative waterbody, the closest waterbody that contained Bight 03 stations was selected. Figure 26 illustrates the waterbody assignments for all subwatersheds and the Bight 03 stations used to represent these waterbodies (also identified in Table 12). Although Fish Harbor contains a Bight 03 station, the representative reaches for the model subwatersheds surrounding this waterbody drained directly to the Inner Harbor. Therefore, none of the model subwatersheds were assigned to Fish Harbor and its Bight 03 station (station BRI-03) was excluded from the analyses. Similarly, Cabrillo Marina contains a Bight 03 station (station 4138) that was not used in the analyses. There was just a single sample representing this waterbody, while all other waterbodies had multiple stations that could be combined for a more robust analysis, including ranges based on standard deviations. Therefore, the Inner Harbor stations were assigned to the watersheds draining to Cabrillo Marina (note: the results for the single sample in Cabrillo Marina were higher than the average from the Inner Harbor stations, but within the same order of magnitude and generally in the same range).

The Bight 03 DDT, PCB, and chlordane samples within each waterbody were averaged to determine their representative concentrations (for non-detected results, one-half of the Bight 03 detection limit was assigned as the representative concentration). Standard deviations were also calculated for each pollutant-waterbody combination, where enough data were available. Table 13 presents the representative concentrations, which were subsequently applied to each subwatershed assigned to a particular waterbody. The sediment concentration value from the Bight 03 data was then multiplied by the subwatershed's in-stream sediment concentrations (predicted based on LSPC models), resulting in an estimated in-stream concentration of DDT, PCB, and chlordane.

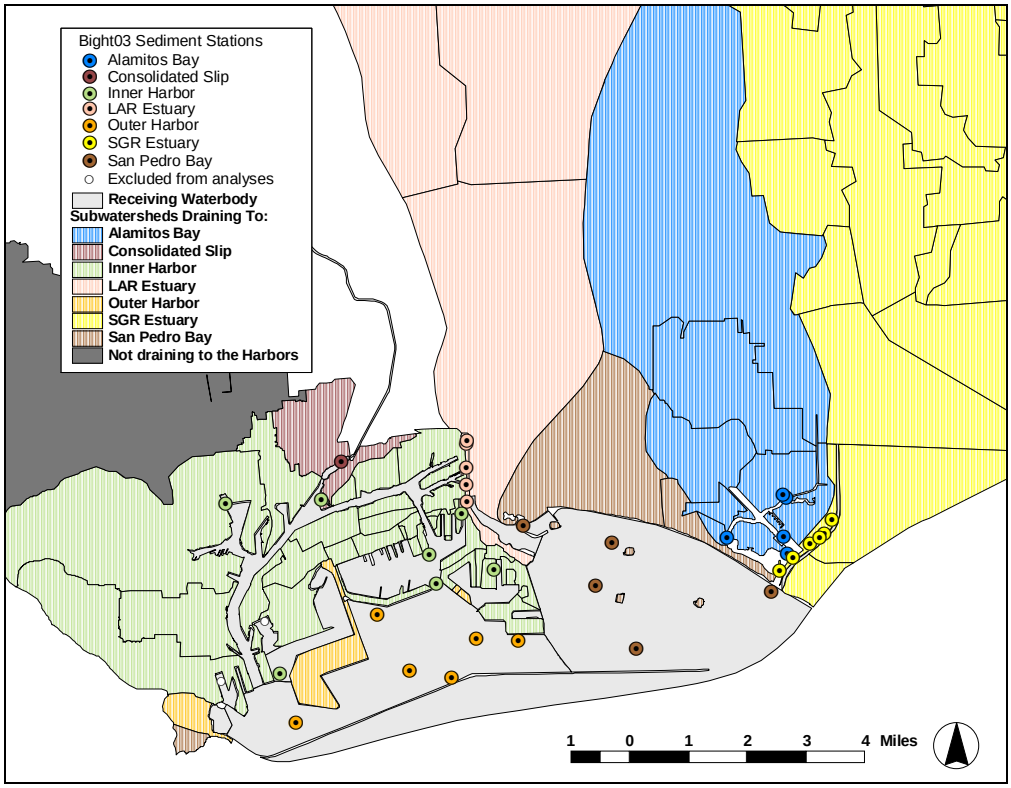


Figure 26. Waterbodies and Bight 03 Stations Assigned to Model Subwatersheds

Table 12. Bight 03 Stations by Waterbody

Waterbody	Bight 03 Station Identification Number
Alamitos Bay	4018
	4130
	4386
	4424
	4456
Los Angeles Harbor - Consolidated Slip	BRI-05
Los Angeles/Long Beach Inner Harbor	4010
	4050
	4146
	4210
	4266
	4338
	4354
Los Angeles River Estuary	4142
	4440
	4600
	4788
	4856
Los Angeles/Long Beach Outer Harbor (inside breakwater)	4178
	4242
	4306
	4400
	4162
	4370
San Gabriel River Estuary	4002
	4258
	4520
	4194
	4322
	4034
San Pedro Bay Near/Off Shore Zones	BRI-06
	4066
	4098
	4274
	4408

The Forest, Pier A, and Maritime Museum subwatersheds were all assigned to the Inner Harbor and Table 13 presents the average DDT, PCBs, and chlordane sediment concentrations for the Inner Harbor. These concentrations were multiplied by the variable subwatershed-specific TSS values from the LSPC model to obtain a water column concentration for Forest, Pier A, and Maritime Museum, which are presented in Figure 27 through Figure 29, respectively. The graphs showing concentrations for each pollutant are on the left side of the figures. These graphs illustrate the predicted concentrations based on the

modeled TSS and the Bight 03 sediment concentrations. The POLA/POLB detection limits are included in the graphs for reference (they were excluded from the Maritime Museum graphs [Figure 29] because no organics data were available for this station). The predicted chlordane values are below the POLA/POLB detection limits because these samples were all non-detects for the Inner Harbor. For PCBs and DDT, the predicted concentrations were initially below the observed detection limit, but increased as the TSS peaked during the storm. The resulting loads are also presented for each pollutant on the right side of Figure 27 through Figure 29. The loads for the entire modeling period will be applied to the receiving water model. This methodology was applied to the model output from all other model subwatersheds (LAR, SGR, and other nearshore subwatersheds).

Table 13. Bight 03 DDT, PCB, and Chlordane Sediment Concentrations by Waterbody

Waterbody	Lower range	Mean	Upper range	Notes
DDT (µg/kg)				
Alamitos Bay	1.92	7.71	13.51	a
Los Angeles Harbor - Consolidated Slip	1.30	1.30	1.30	b
Los Angeles/Long Beach Inner Harbor	9.58	45.14	80.69	a
Los Angeles River Estuary	0.00	88.48	200.19	a
Los Angeles/Long Beach Outer Harbor (inside breakwater)	13.64	56.41	99.19	a
San Gabriel River Estuary	1.56	2.35	3.14	a
San Pedro Bay Near/Off Shore Zones	2.65	26.83	51.02	a
Chlordane (µg/kg)				
Alamitos Bay	0.58	2.26	3.93	a
Los Angeles Harbor - Consolidated Slip	0.00	0.50	1.00	c
Los Angeles/Long Beach Inner Harbor	0.00	0.29	0.58	c
Los Angeles River Estuary	16.46	16.60	16.74	d
Los Angeles/Long Beach Outer Harbor (inside breakwater)	0.00	0.29	0.58	c
San Gabriel River Estuary	0.00	0.43	0.86	c
San Pedro Bay Near/Off Shore Zones	0.78	1.09	1.41	d
PCBs (µg/kg)				
Alamitos Bay	3.48	3.78	4.08	d
Los Angeles Harbor - Consolidated Slip	0.00	0.50	1.00	c
Los Angeles/Long Beach Inner Harbor	0.00	31.63	78.17	a
Los Angeles River Estuary	245.66	246.34	247.02	d
Los Angeles/Long Beach Outer Harbor (inside breakwater)	1.10	1.88	2.66	d
San Gabriel River Estuary	0.00	0.63	1.26	c
San Pedro Bay Near/Off Shore Zones	0.00	13.31	29.12	a

[a] Upper and lower ranges based on calculated standard deviations

[b] Only one sample was available; therefore upper and lower ranges were not calculated.

[c] Results were all non-detects. Lower ranges are set equal to zero and upper ranges are set equal to the average detection limit.

[d] Limited detected samples were available to calculate standard deviations; therefore, the average lower ranges were calculated using zero for the non-detected samples and average upper ranges were calculated using the detection limit for the non-detected samples.

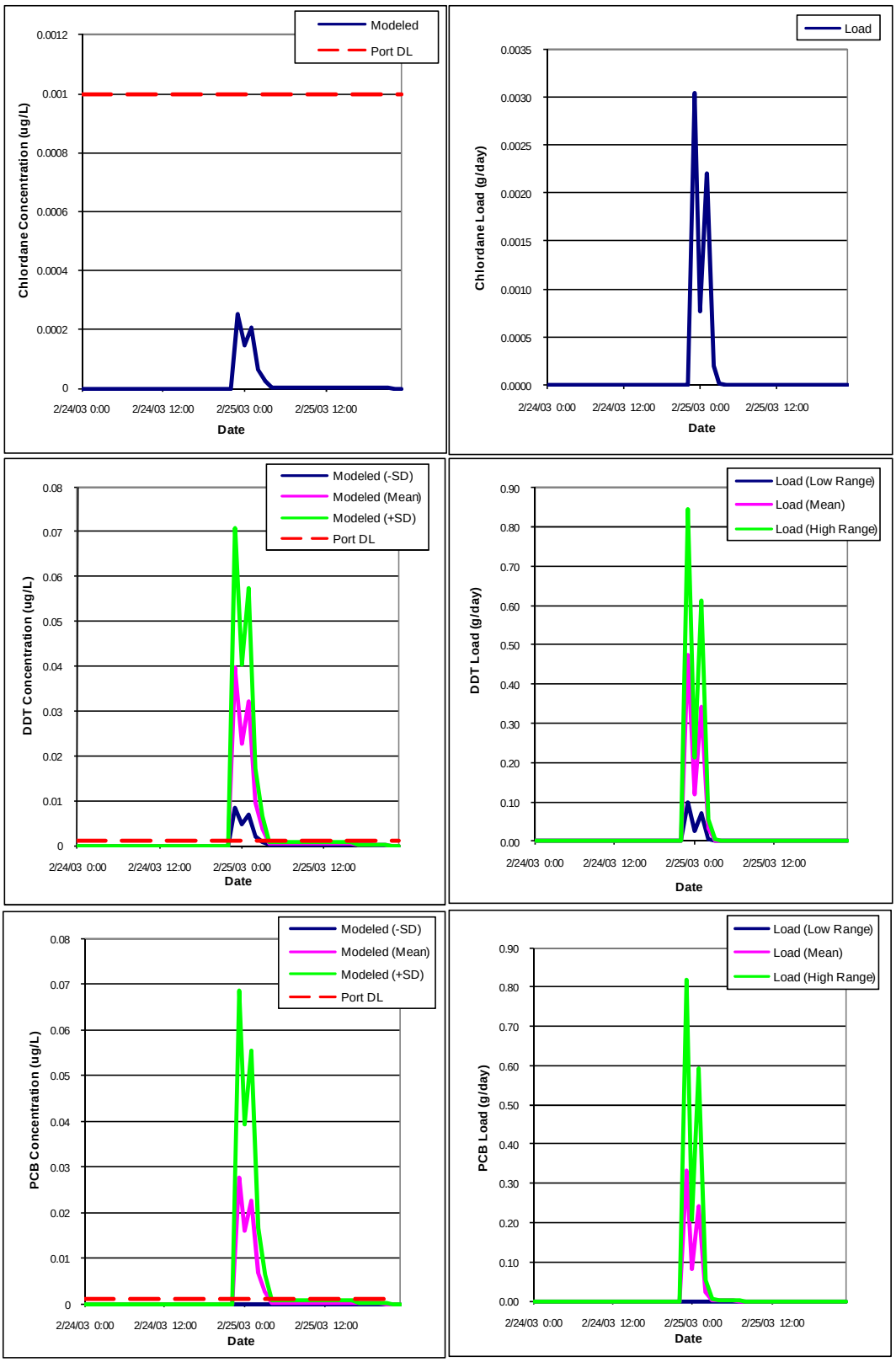


Figure 27. Modeled and Observed Chlordane, DDT, and PCBs Concentrations and Loads for the Forest Subwatershed (note: Port DL = Detection limit from the Ports data)

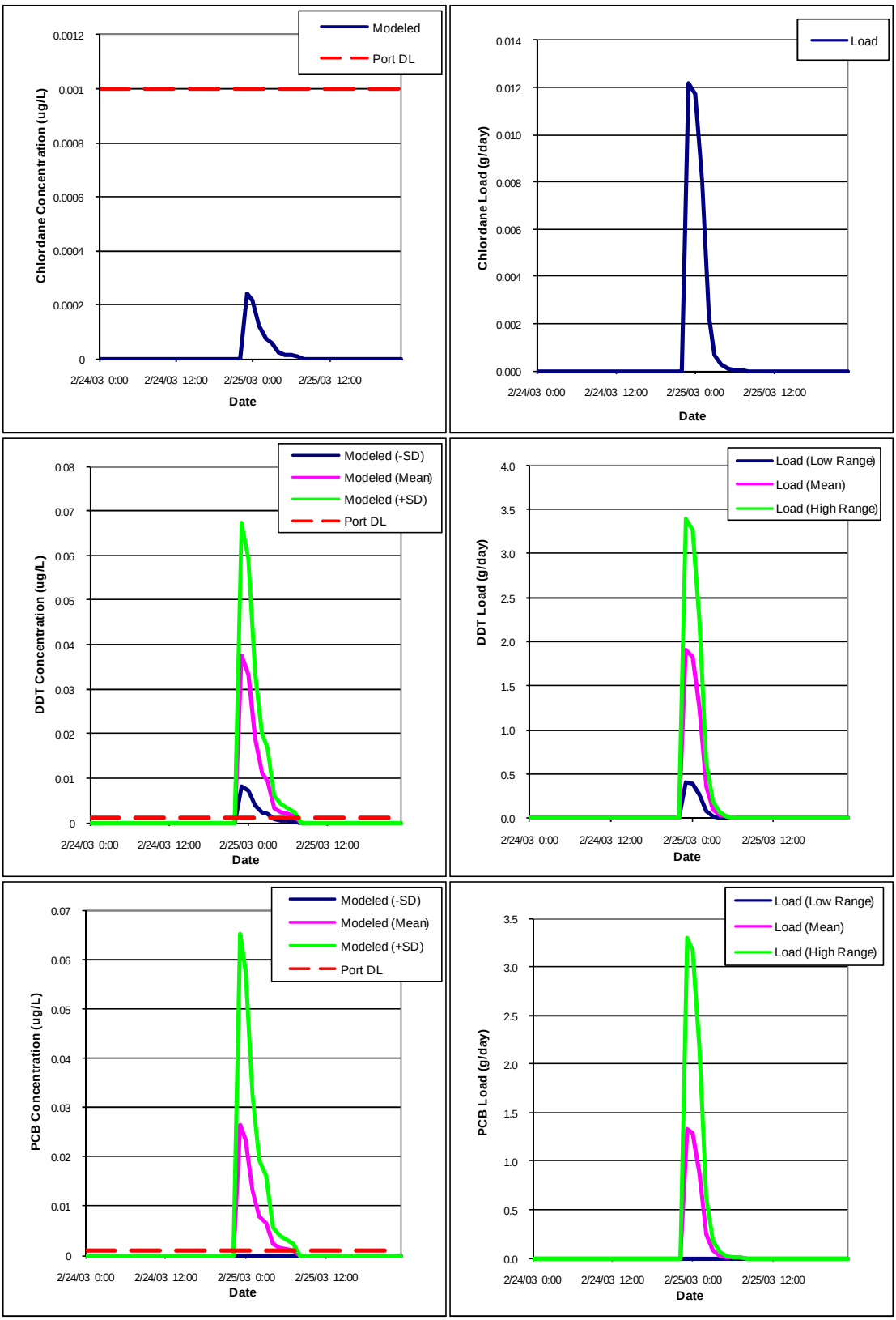


Figure 28. Modeled and Observed Chlordane, DDT, and PCBs Concentrations and Loads for the Pier A Subwatershed (note: Port DL = Detection limit from the Ports data)

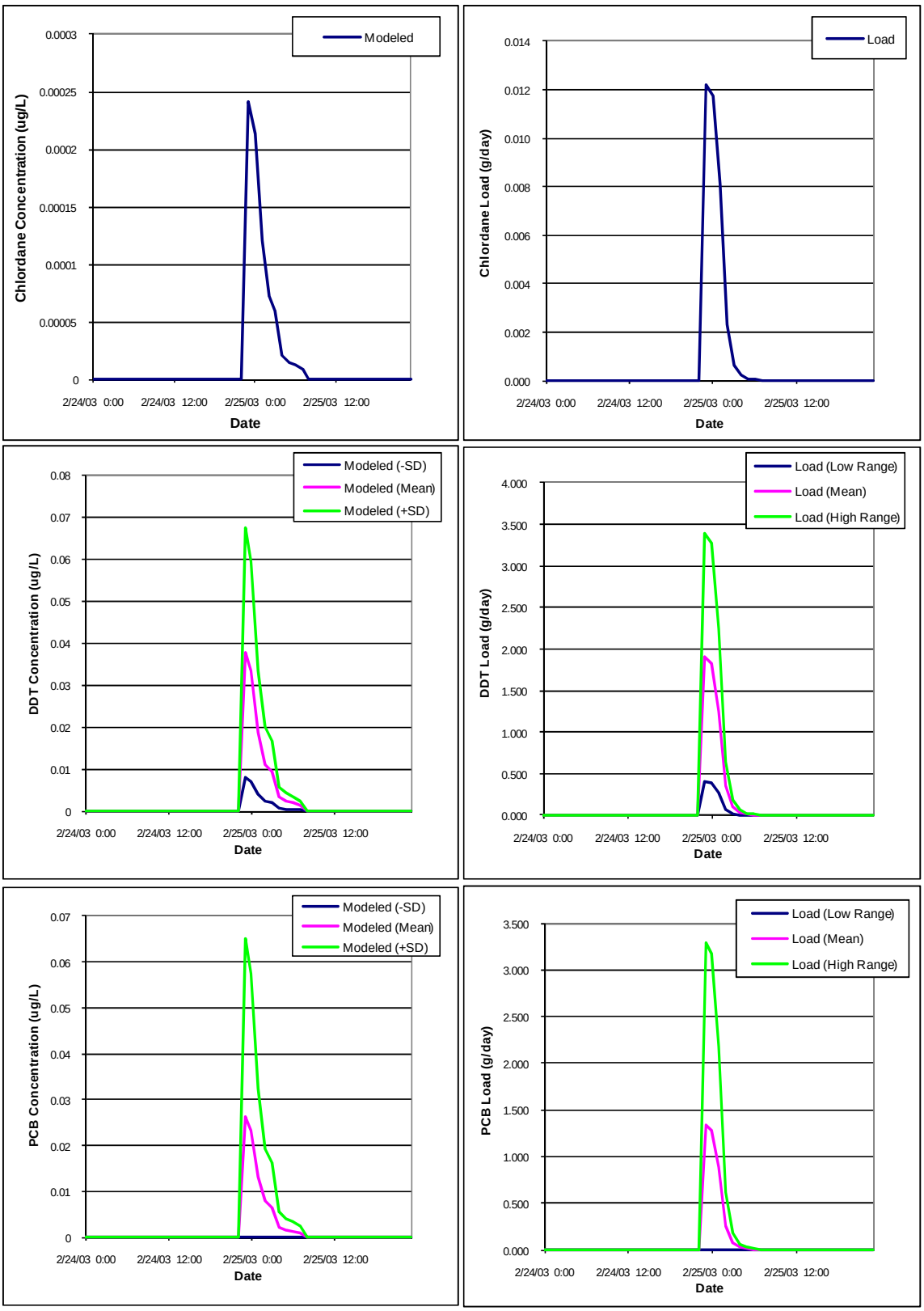


Figure 29. Modeled Chlordane, DDT, and PCBs Concentrations and Loads for the Maritime Museum Subwatershed (note: Port DL = Detection limit from the Ports data)

To assess the uncertainty of model predictions based on average sediment concentrations, sensitivity analyses of assumed values were performed. For each subwatershed, upper and lower ranges of average concentrations were determined using the average Bight 03 concentration plus/minus one standard deviation or using assumptions to represent non-detected samples, as listed in Table 13. Specifically, if three or more samples were detected, standard deviations were calculated and used to determine upper and lower ranges in the sensitivity analyses. However, if all of the samples were non-detects, the lower range was set equal to zero and the upper range was equal to the detection limit. Similarly, if less than three samples were detects, the non-detected samples were set equal to zero for the lower range and equal to the detection limit for the upper range. The average concentrations were then calculated to represent the upper and lower ranges.

Resulting ranges of wet-weather loadings to the Harbors and SPB were quantified to provide understanding of the sensitivity of loads potentially due to uncertainty of modeling assumptions. For the Forest, Pier A, and Maritime Museum subwatersheds, the DDT, PCB, and chlordane upper and lower ranges for concentrations and loads are presented graphically in Figure 27 though Figure 29, respectively. Sensitivity analyses for LAR, SGR, and the other nearshore areas were similarly performed.

4. Dry Weather

During dry weather, watershed flows are dominated by wastewater reclamation plants (WWRP) effluent, groundwater inflow, and discharges to the stormwater conveyance system from illicit connections, excess irrigation, and other residential and commercial practices (McPherson et al., 2005a; Stein and Ackerman, 2007). Although dry-weather flows are substantially less than stormflows in the region, their long-term contribution of pollutants can be substantial (McPherson et al., 2005a; Stein et al., 2003). Model representation of dry-weather pollutant loads in the region for calculation of TMDLs has been typically based on steady-state assumptions for flows and pollutant concentrations (LARWQCB, 2005a and 2005c; Tetra Tech, Inc, 2005b). Thus far, these approaches have relied heavily on robust monitoring efforts in LAR (Ackerman et al., 2003), SGR (Ackerman et al., 2005b), and Ballona Creek (Stein and Tiefenthaler, 2005). Results of these studies can be extrapolated for prediction of pollutant loads from the remaining watersheds of the Harbors and SPB.

Assumptions for steady-state, dry-weather flows are based on a combination of monitoring data and simplified methods based on land use. Observed flow data were ultimately used to represent the LAR (rather than modeled inflows); therefore, these measured dry flows were considered appropriate for use in the

dry weather loading estimates. For estimation of dry-weather river flows into the SGR estuary, the LSPC modeled flows were used since these are dominated by the continuous point sources (the best available DMR data were used to represent these point sources).

Additional assumptions are required for prediction of dry-weather loads from the nearshore areas, which have much smaller subwatersheds and are largely impervious urban areas. A regional comparison of dry-weather flows performed by Stein and Ackerman (2007) provides insight into patterns for dry urban runoff in the region. For six watersheds in the Los Angeles Region, measured flows were reported for multiple sampling events. These watersheds include the LAR, SGR, Coyote Creek, San Jose Creek, Walnut Creek, and Ballona Creek. Ballona Creek was monitored during a single day during the dry season, whereas the remaining watersheds were monitored twice during consecutive dry seasons. Dry flows in LAR, SGR, Coyote Creek, and San Jose Creek were influenced by WWRP effluent flows. For each watershed, Stein and Ackerman summarized the relative contribution of flows from WWRPs, stormdrains, and upstream boundaries of the study domain. Adding the measured boundary and stormdrain flows, and averaging the combined flows for those watersheds with two sampling events, we determined a single representative flow for each watershed. These flows represent a combination of all runoff, baseflow, etc. that does not include WWRP contributions. A regression analysis of these flows verses urban area (summation of commercial, high-density residential, low-density residential, industrial, and mixed urban land uses) in each watershed revealed a noticeable relationship ($R^2 = 0.96$) between dry-weather flows and urban land use (Figure 30). Dry-weather flows for all nearshore areas were estimated based on the following equation (2) determined through the regression analysis.

$$Flow = 0.0024 \times (UrbanArea) \qquad (2)$$

where, *Flow* is in cubic meters per second (m^3/s) and *UrbanArea* is in square kilometers (km^2).

The Forest subwatershed has an urban area of 0.16 km^2. Using this equation, the estimated dry-weather flow is 0.0004 m^3/s or 0.014 cfs for the Forest subwatershed. Similar calculations were performed for the Pier A and Maritime Museum subwatersheds. When the applicable urban areas were assigned, the estimated dry weather flow for the Pier A subwatershed is 0.0025 m^3/s or 0.088 cfs, while the Maritime Museum subwatershed had an estimated flow of 0.0380 m^3/s or 1.343 cfs.

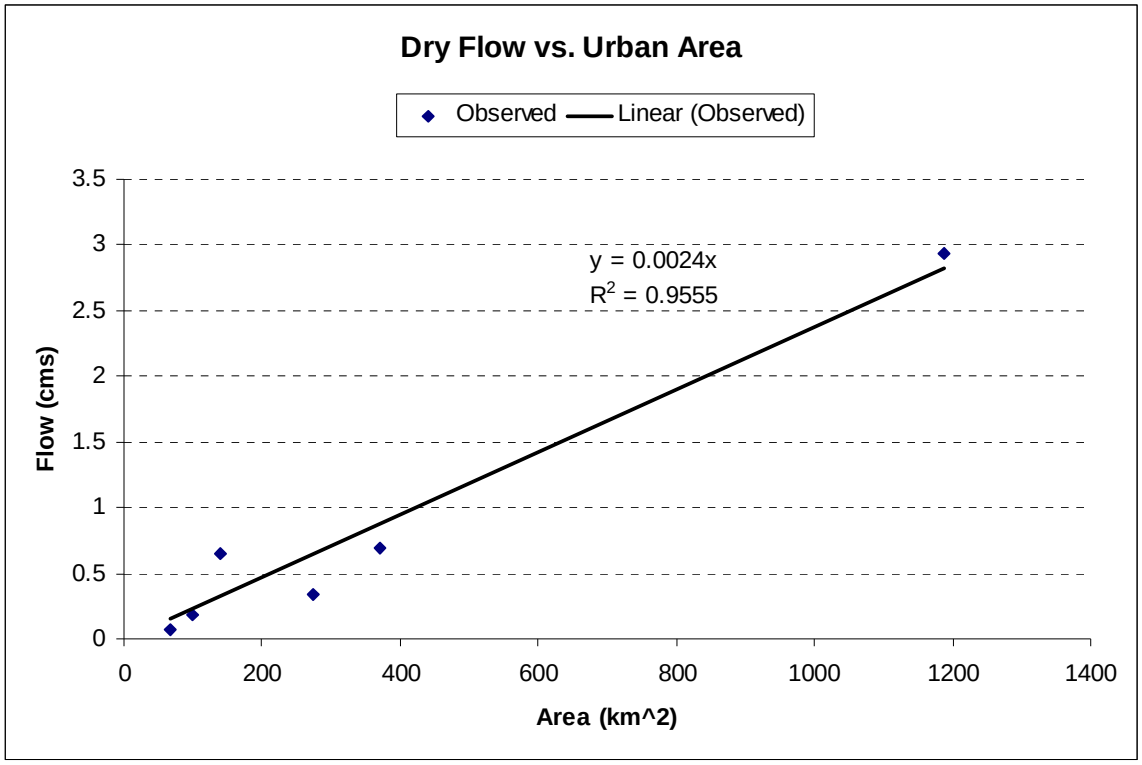


Figure 30. Regression Analysis of Dry-Weather Flows Versus Urban Area

To calculate pollutant loads based on the above flow predictions, additional assumptions for water quality concentrations were required. The availability of water quality data varies by pollutant; therefore, resulting assumptions for water quality predictions are discussed separately in the following sections.

4.1. Metals

Average dry-weather in-stream and stormdrain concentrations of metals in LAR and SGR, based on dry-weather monitoring organized by SCCWRP, are reported by Ackerman et al. (2003), Ackerman et al. (2005b), and Stein and Ackerman (2007). These results were used to estimate existing conditions for dry-weather loadings in LAR and SGR to support development of total metals TMDLs for the rivers (LARWQCB, 2005c, 2006; USEPA, 2007). For the current study, metals concentrations for flows to estuaries from LAR and SGR were based on the LSPC metals simulations. These concentrations were multiplied by their respective dry-weather flows to determine loadings to the receiving water model.

To address dry-weather metals loadings in the nearshore areas, average concentrations and standard deviations were calculated using available

stormdrain data. These data consisted of 255 stormdrain samples collected between 2000 and 2003 in the LAR and SGR watersheds (Ackerman et al., 2003; Ackerman et al., 2005b). Because these data represented runoff from various land uses, they were used to estimate average representative metals concentrations for all of the nearshore subwatersheds. The average dry-weather metals concentrations along with ranges based on the mean plus/minus the standard deviation are presented in Table 14. These values were heavily influenced by several high concentrations, resulting in high standard deviation values. Analyses were performed to evaluate the elimination of these outliers; however, all data were ultimately included because the conditions at the time of sampling were unknown so it was difficult to form a basis for exclusion of specific samples.

Table 14. Dry-Weather Total Metals Concentrations Included in Loading Analyses (Ackerman et al., 2003; Ackerman et al., 2005b)

Region-Wide Concentrations			
	Mean minus the standard deviation*	**Mean**	**Mean plus the standard deviation**
Copper concentration (mg/L)	0	0.037	0.159
Lead concentration (mg/L)	0	0.011	0.067
Zinc concentration (mg/L)	0	0.152	0.877

* The means minus their standard deviations result in negative values, but are presented as zero.

Table 15 presents the associated loads for the Forest, Pier A, and Maritime Museum subwatersheds. These were obtained by multiplying the average metals concentrations presented in Table 14 by the subwatershed-specific constant dry-weather flows. This methodology was repeated for all other nearshore model subwatersheds to determine metals loads to the Harbors, which will be input to the receiving water model.

Table 15. Dry-Weather Total Metals Loads for the Forest, Pier A, and Maritime Museum Subwatersheds

Subwatershed	Pollutant (grams/day)	Low Range	Mean	High Range
Forest Subwatershed	Copper Load	0	1.22	5.23
	Lead Load	0	0.36	2.20
	Zinc Load	0	5.02	28.90
Pier A Subwatershed	Copper Load	0	7.97	34.23
	Lead Load	0	2.43	14.43
	Zinc Load	0	32.86	189.11
Maritime Museum Subwatershed	Copper Load	0	34.00	145.96
	Lead Load	0	9.98	61.52
	Zinc Load	0	140.10	806.36

Sensitivity analyses were performed for the dry-weather loadings to assess the uncertainty of predictions based on average metals concentrations. For each subwatershed, the upper and lower concentrations (Table 14) based on the mean metals concentration plus/minus one standard deviation were multiplied by the subwatershed-specific flow to determine the associated loads. Resulting ranges of dry-weather loadings to the Harbors and SPB were quantified to provide understanding of the sensitivity of loads potentially due to uncertainty of analysis assumptions (note: the analyses were based on limited data; therefore, there is considerable uncertainty in the load estimates). For the Forest, Pier A, and Maritime Museum subwatersheds, the metals loading ranges are presented in Table 15.

4.2. PAHs, DDT, Chlordane, and PCBs

No detectable levels of organic pollutants are typically observed during dry weather based on LADPW mass emissions stations in the region (LADPW, 2006). In the absence of local detectable levels, assumptions may be based on values from studies performed outside of the Los Angeles Region. However, organic pollutant concentrations are assumed to be zero for dry-weather runoff since evidence suggests that sources are not prevalent during these conditions.

5. Model Assumptions

Assumptions are inherent to the modeling process as the model user attempts to represent the actual system as accurately as possible. The assumptions associated with the LSPC model and its algorithms are described in the HSPF User's Manual (Bicknell et al., 2001). There were several additional modeling assumptions used in the model of the watersheds draining to the Harbor, which are described below.

- Land use practices are consistent for all that fall within a given category and associated modeling parameters are transferable between subwatersheds.
- The average flows (daily or monthly) assigned from the point source data used to extend the LAR and SGR models were similar to actual discharger flows.
- The previously developed models of LAR and SGR were representative of the loadings from their respective watersheds without further validation.
- Sediment wash off from pervious areas occurred via detachment of the soil matrix for the wet-weather model. This process was considered uniform regardless of the land use type or season.
- Sediment in the watershed consisted of 5% sand, 40% clay, and 55% silt.

- For the wet-weather model, trace metals were linearly related to total suspended solids. As described in SCCWRP (2004), analysis of stormwater data supports this assumption.
- Consistent with the regional modeling approach, trace metals were bound to a particle during wet-weather wash off until they dissociated upon reaching the receiving waterbody (note: this assumption may not entirely reflect conditions in the receiving waters, which are dependent on the dissolved metals concentrations, the kinetics of desorption, and the mode by which the metals are bound to particles).
- The wet-weather PAH EMCs were representative of the watershed PAH loadings. Use of EMCs assumes no variability in storm concentrations, first flush, and indication of sediment association.
- PAHs were modeled as total PAHs, and not separately based on molecular weight.
- Non-detected values of DDT, PCBs, and chlordane were assigned a value of one-half of the detection limit while calculating wet-weather sediment concentrations.
- DDT, PCB, and chlordane sediment concentrations were assumed to be representative of DDT, PCB, and chlordane in-stream concentrations.
- Sensitivity analyses were performed for DDT, PCB, and chlordane using standard deviations, where possible, and variations on the detection limits when data were limited or results were non-detects.
- Dry-weather flows were predicted based on a relationship between flow and urban land use area for all nearshore areas. The data used for this relationship are based on 1-2 samples collected during dry weather at multiple drains located in six watersheds.
- Dry-weather metals data collected from storm drains in the LAR and SGR watersheds were considered representative of the concentrations in the nearshore areas.
- Dry-weather metals concentrations measured at the bottom of the LAR and SGR watersheds in monitoring surveys provided by SCCWRP (Ackerman et al. 2003; Ackerman et al., 2005b) are sufficient for characterizing typical concentrations for all dry periods.

6. Conclusions

Loads from the wet- and dry-weather metals, PAHs, DDT, PCB, and chlordane analyses described above were summed to determine annual loads for each subwatershed draining to the Harbors and SPB. To assess the uncertainty of model predicted loadings to each receiving waterbody, sensitivity analyses of the assumed values were performed. Upper and lower concentrations based on the pollutant-specific approaches described above were combined with LSPC model output for wet-weather and estimated flows for dry-weather to determine the loading ranges associated with the varying concentrations.

Figure 31 and Figure 32 identify the model subwatersheds and their associated receiving waterbody for the major drainage areas and the nearshore areas, respectively (specifics on the distribution methodology are described in the receiving water modeling report). It should be noted that Dominguez Channel was not included in this study, and therefore their calibration and validation results are not presented above (SCCWRP, unpublished results). However, to quantify comprehensive loads to Consolidated Slip, loads from Dominguez Channel are presented in the figures below. Ultimately, hourly loadings for LAR, SGR, and DC and daily loadings for the nearshore areas were incorporated into the receiving water model of the Harbors. The calibration and validation of the hydrodynamic and sediment-contaminant portions of the receiving water model is discussed in a separate report (Appendix I).

Figure 33 through Figure 38 present the average daily loadings to each receiving waterbody (based on eleven year loads) for metals, PAHs, DDT, and PCBs. These loads incorporate point and nonpoint sources to the TMDL receiving waterbodies (see Appendix I for discussion on how these loads were used in the receiving water model and Appendix III and the TMDL Staff Report for presentation on the TMDLs and associated wasteload and load allocations). The average daily loads below present the average of wet and dry conditions. Separate wet and dry average daily loads based on these results are presented in Appendix I, Tables 23 and 24. The loadings for the Consolidated Slip, San Gabriel River Estuary, and Los Angeles River Estuary include loadings from the near shore watersheds as well as their larger drainage areas (Dominguez Channel, San Gabriel River, and Los Angeles River watersheds, respectively). Annual loads for an 11-year period to each receiving waterbody were calculated for each pollutant and are presented in Appendix B.

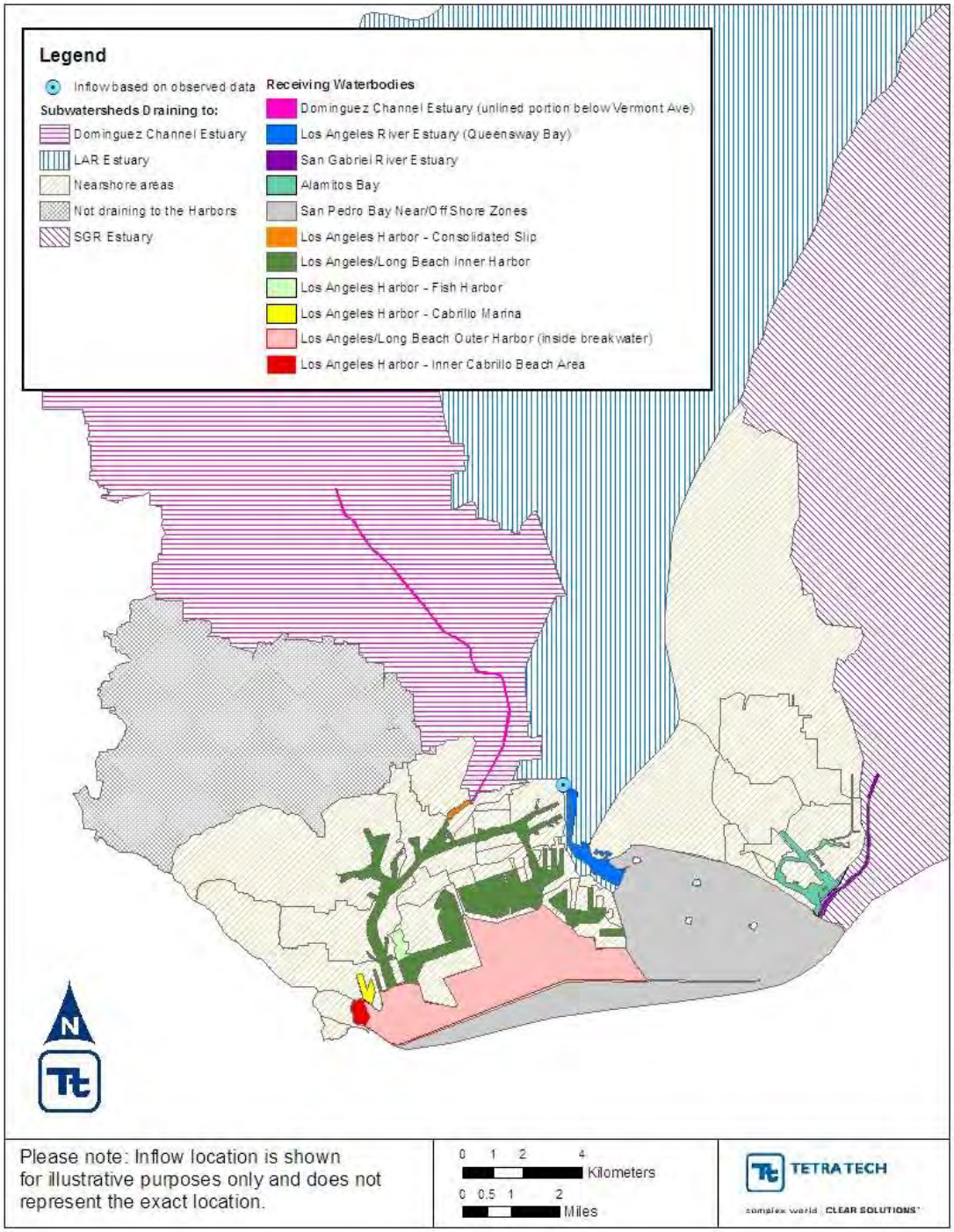


Figure 31. Major Drainage Areas and Waterbody Designations

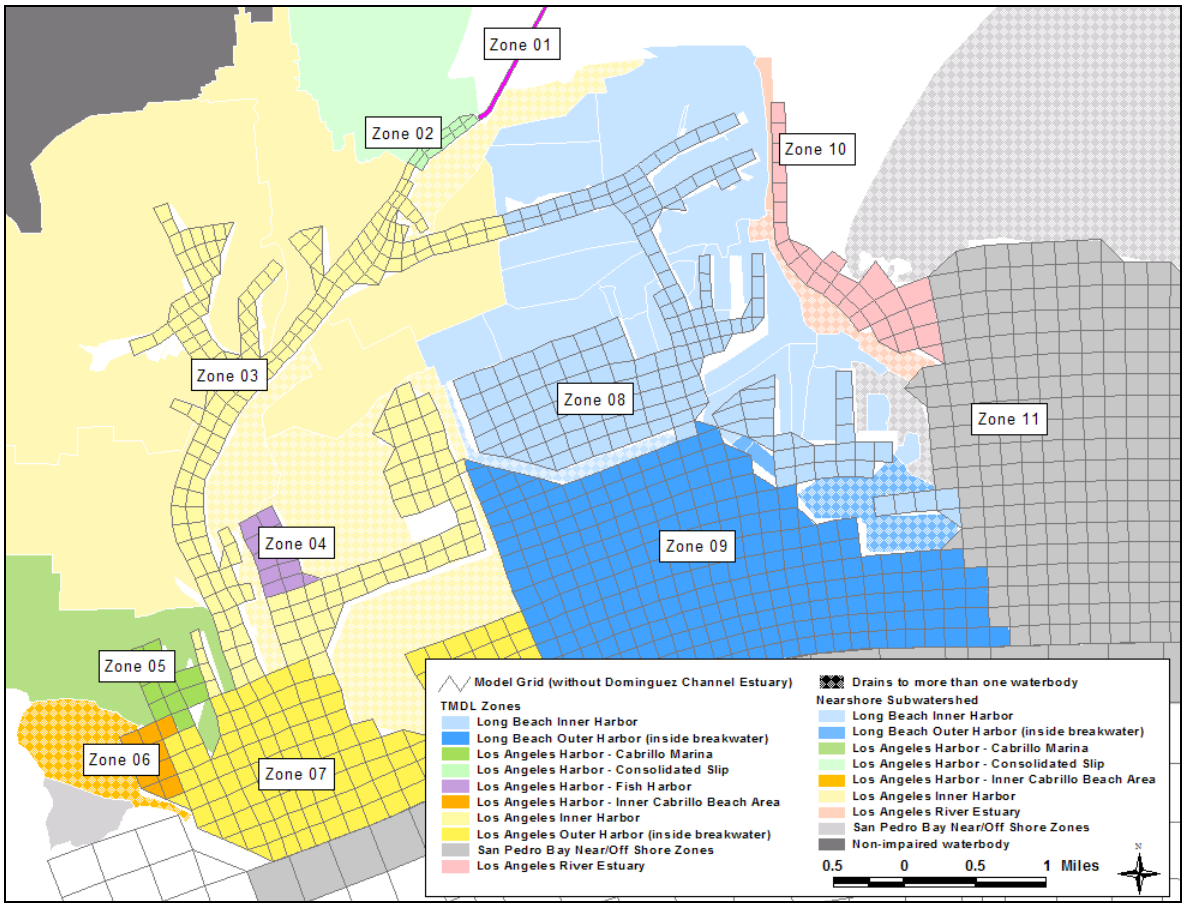


Figure 32. Nearshore Subwatersheds and Waterbody Designations

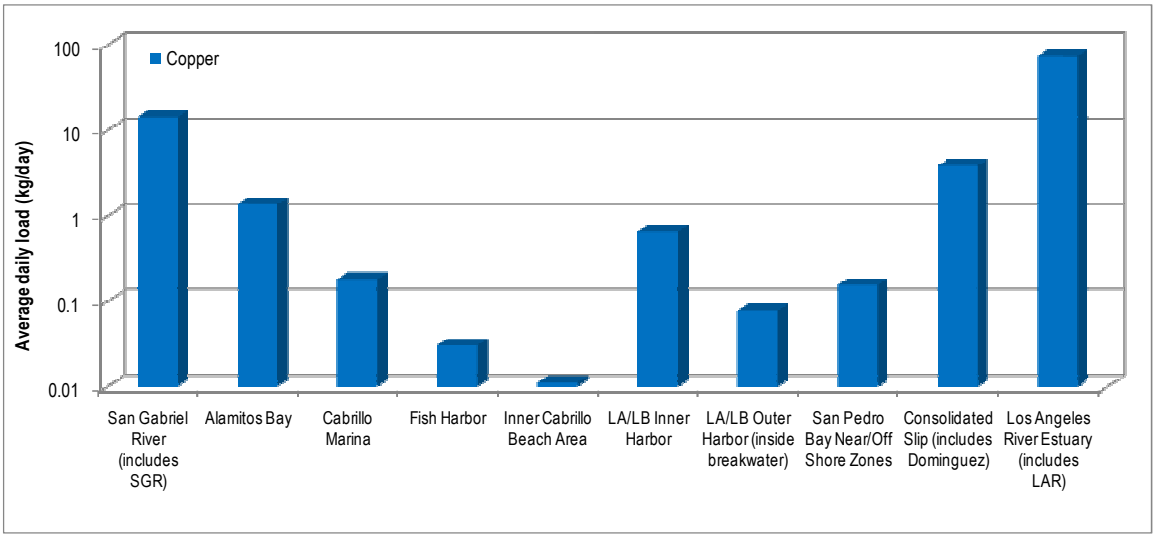


Figure 33. Average Daily Copper Loads

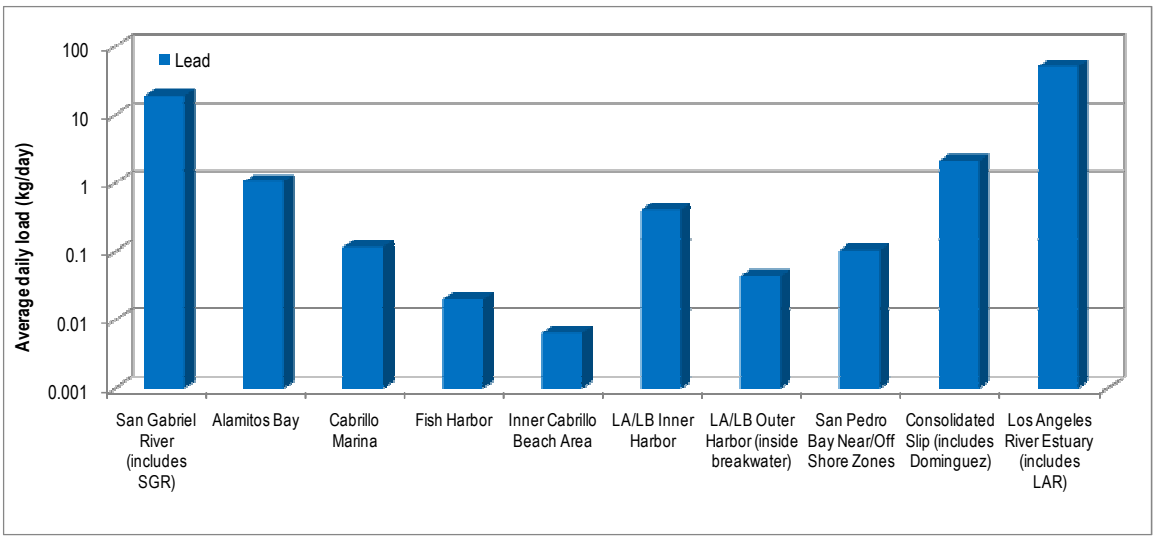


Figure 34. Average Daily Lead Loads

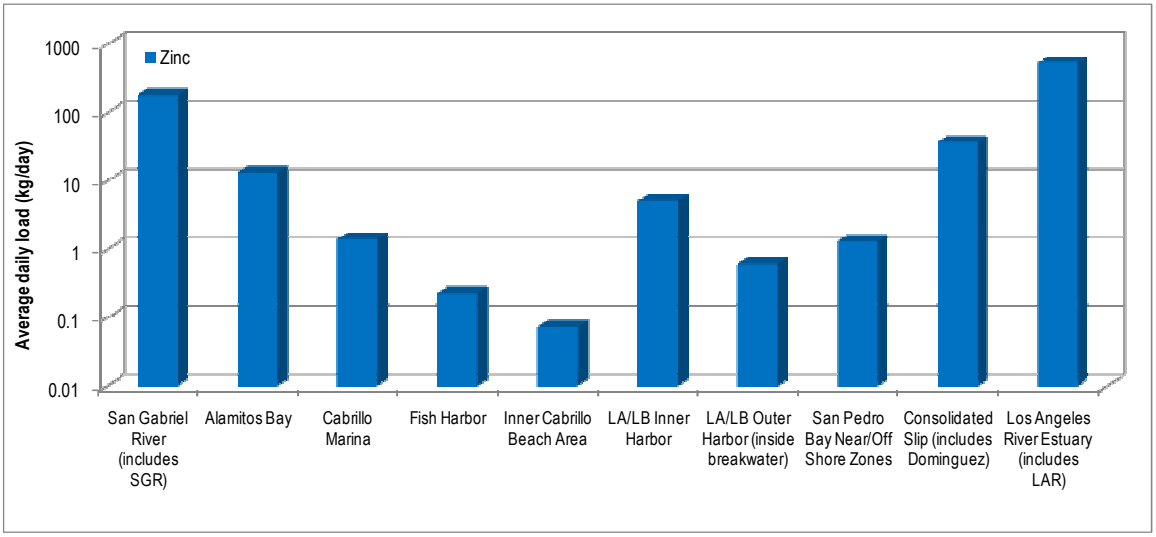


Figure 35. Average Daily Zinc Loads

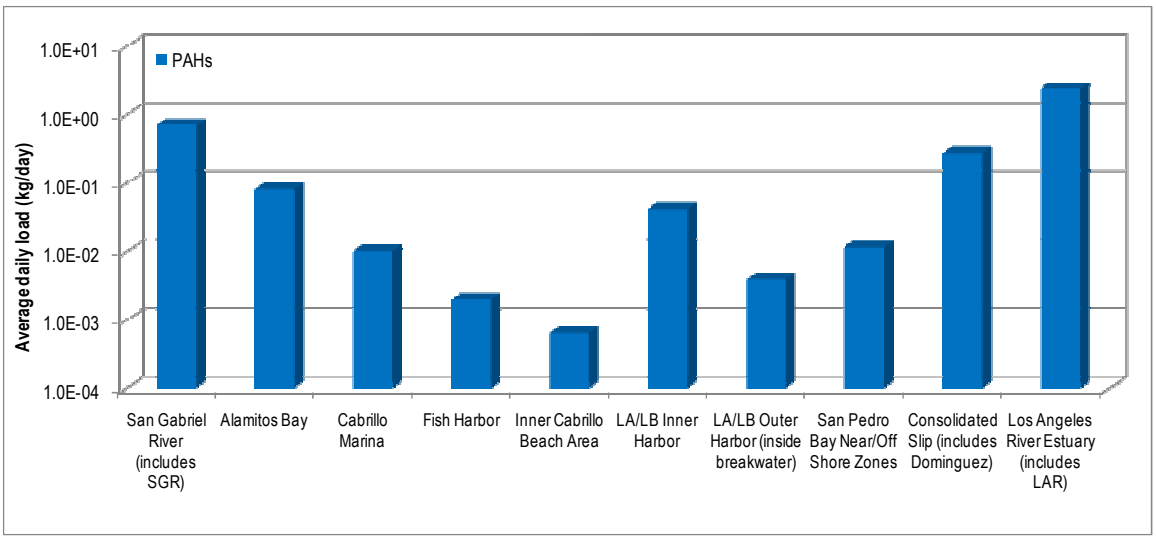


Figure 36. Average Daily PAH Loads

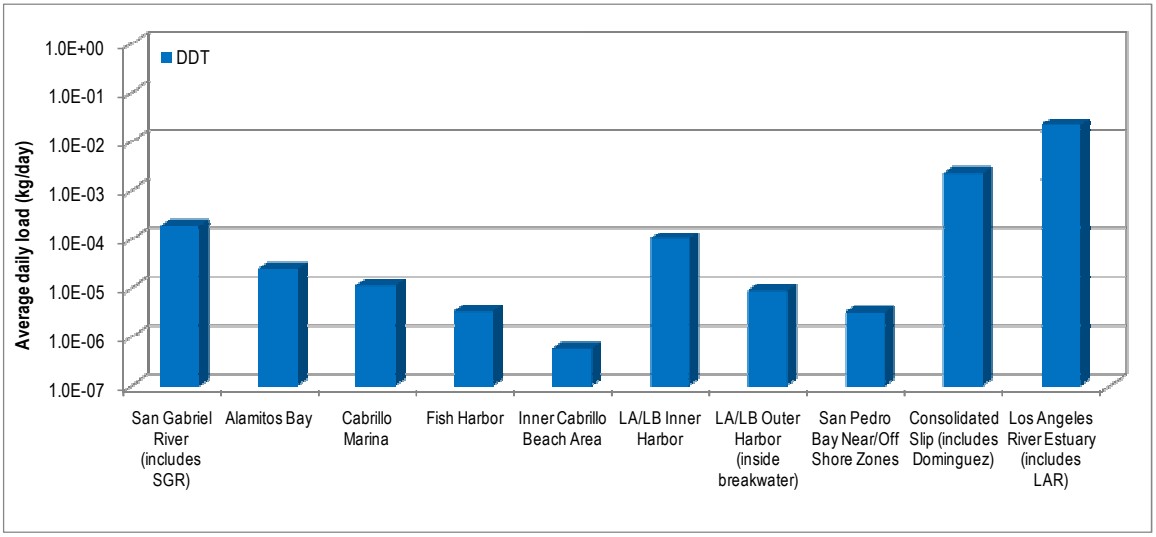


Figure 37. Average Daily DDT Loads

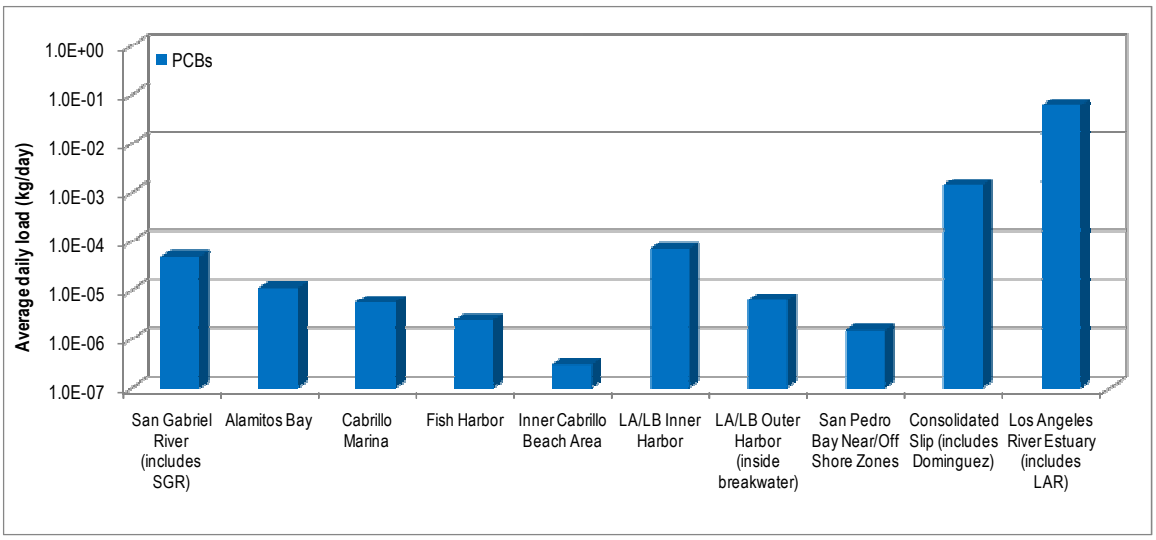


Figure 38. Average Daily PCB Loads

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Appendix A: Water Quality Validation Time-series Plots for the Nearshore Watersheds

FINAL

May 2011

Prepared for:
USEPA Region 9
Los Angeles Regional Water Quality Control Board

Prepared by:
Tetra Tech, Inc.

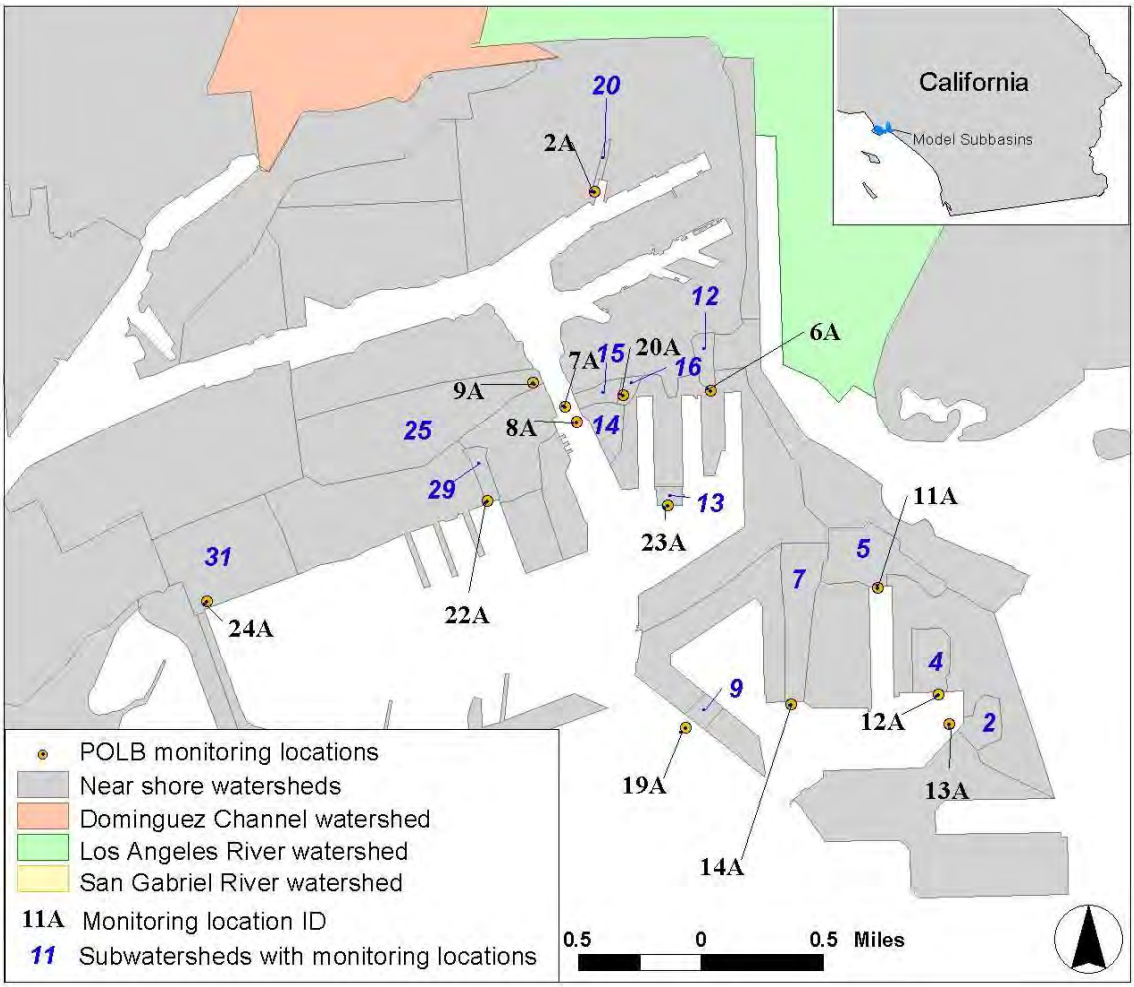


Figure A-1. Sampling Locations Used for Water Quality Validation

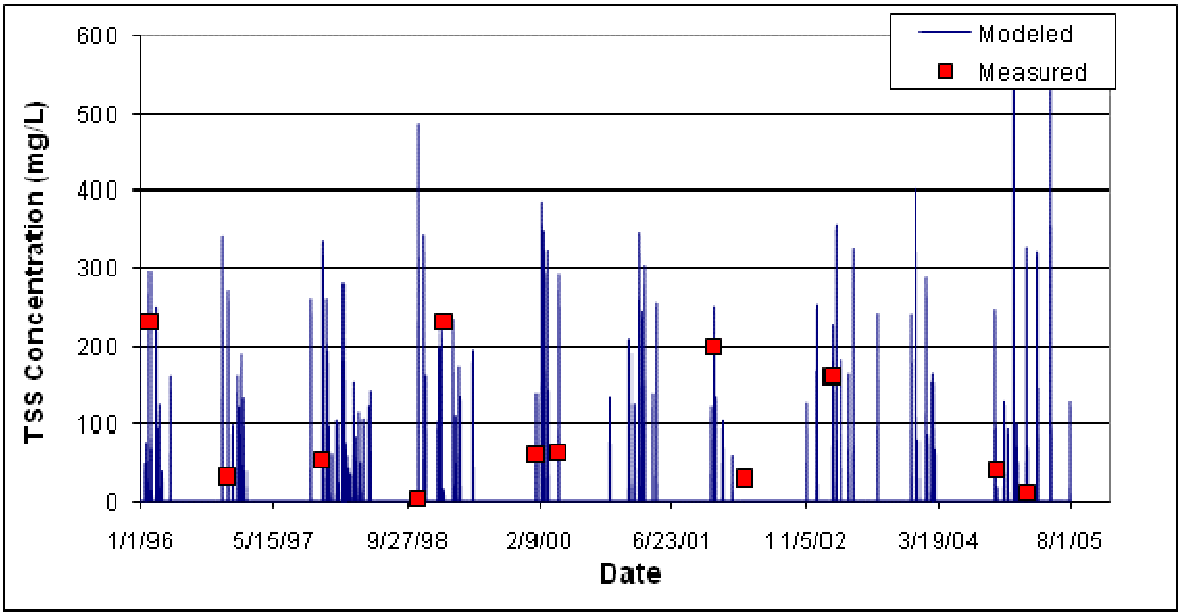


Figure A-2. Modeled and Observed TSS Concentrations for Subwatershed 2 (POLB Station 13A)

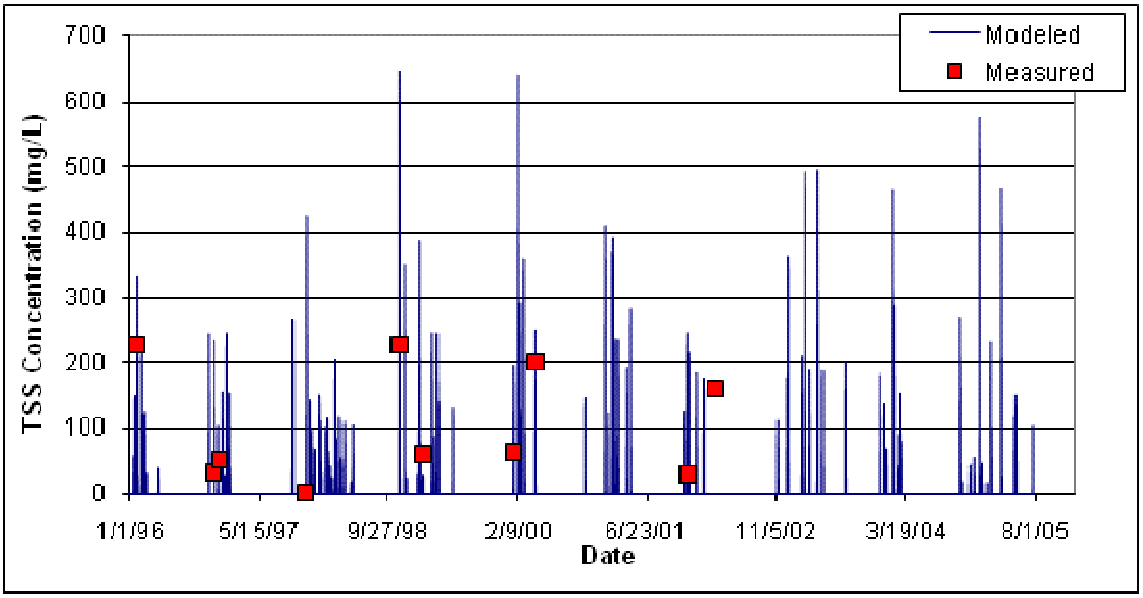


Figure A-3. Modeled and Observed TSS Concentrations for Subwatershed 4 (POLB Station 12A)

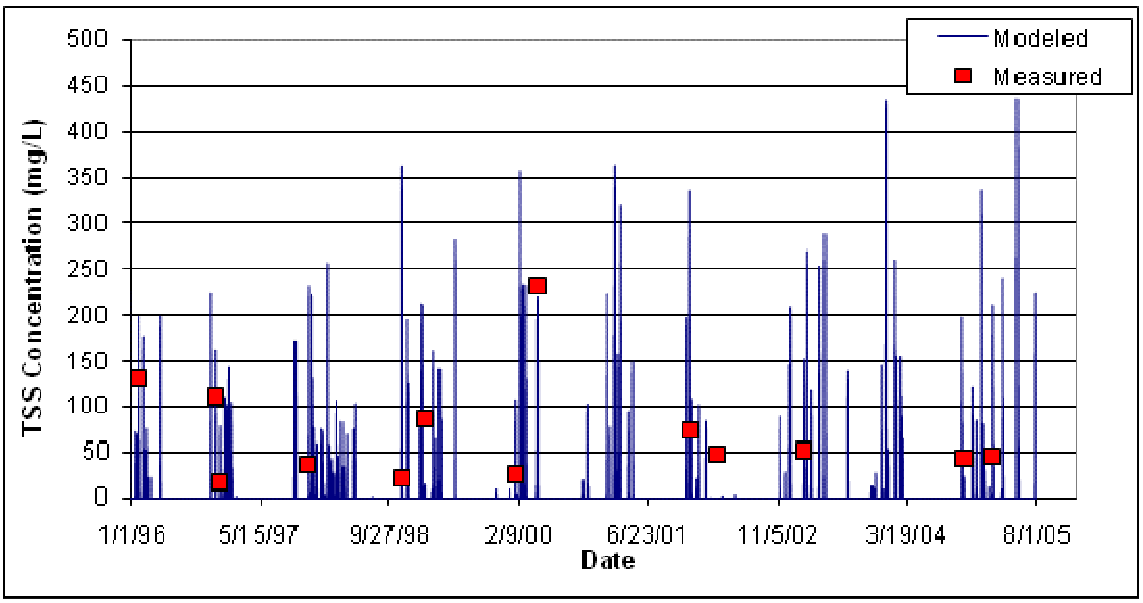


Figure A-4. Modeled and Observed TSS Concentrations for Subwatershed 5 (POLB Station 11A)

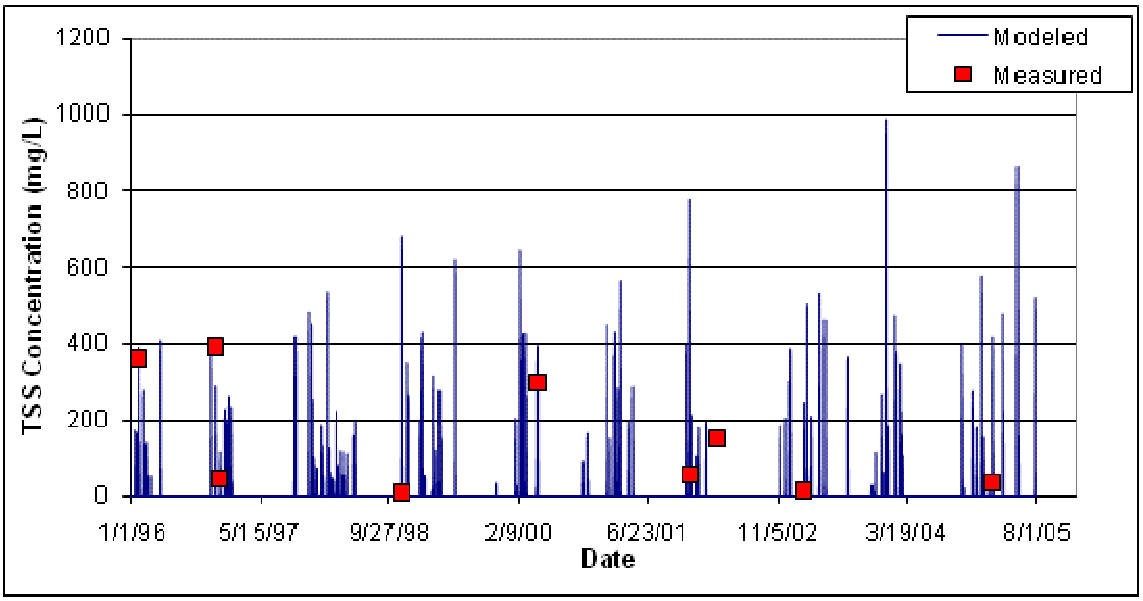


Figure A-5. Modeled and Observed TSS Concentrations for Subwatershed 7 (POLB Station 14A)

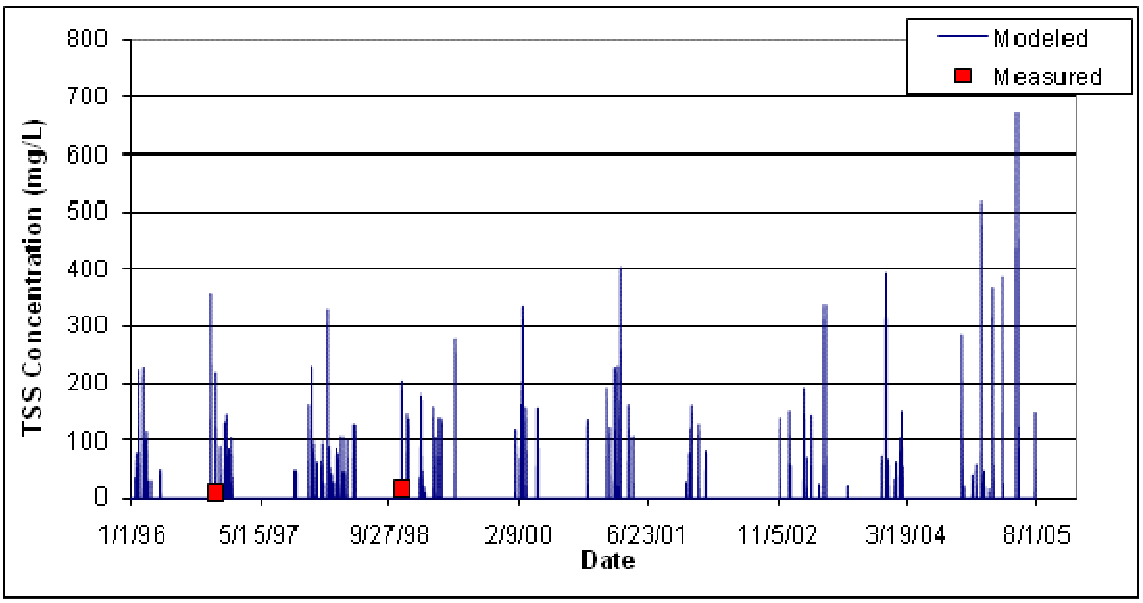


Figure A-6. Modeled and Observed TSS Concentrations for Subwatershed 9 (POLB Station 19A)

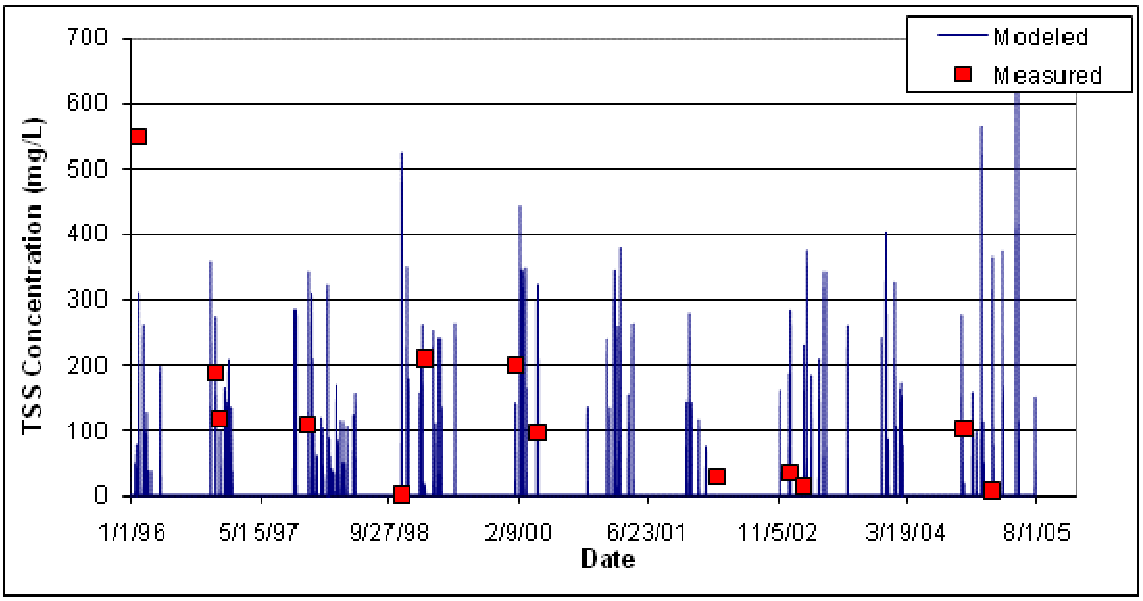


Figure A-7. Modeled and Observed TSS Concentrations for Subwatershed 12 (POLB Station 6A)

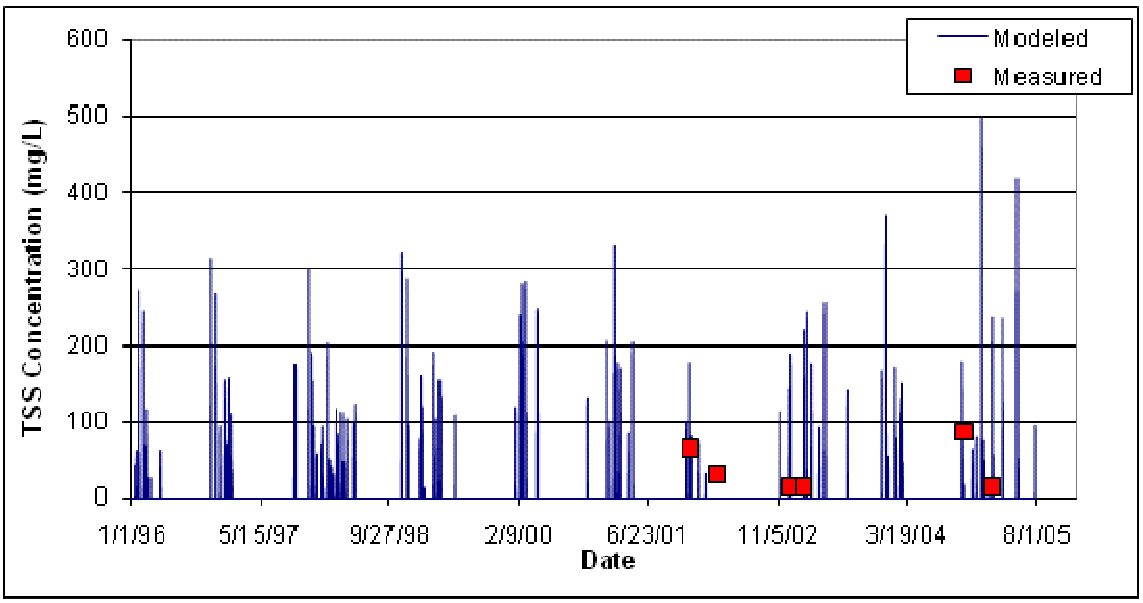


Figure A-8. Modeled and Observed TSS Concentrations for Subwatershed 13 (POLB Station 23A)

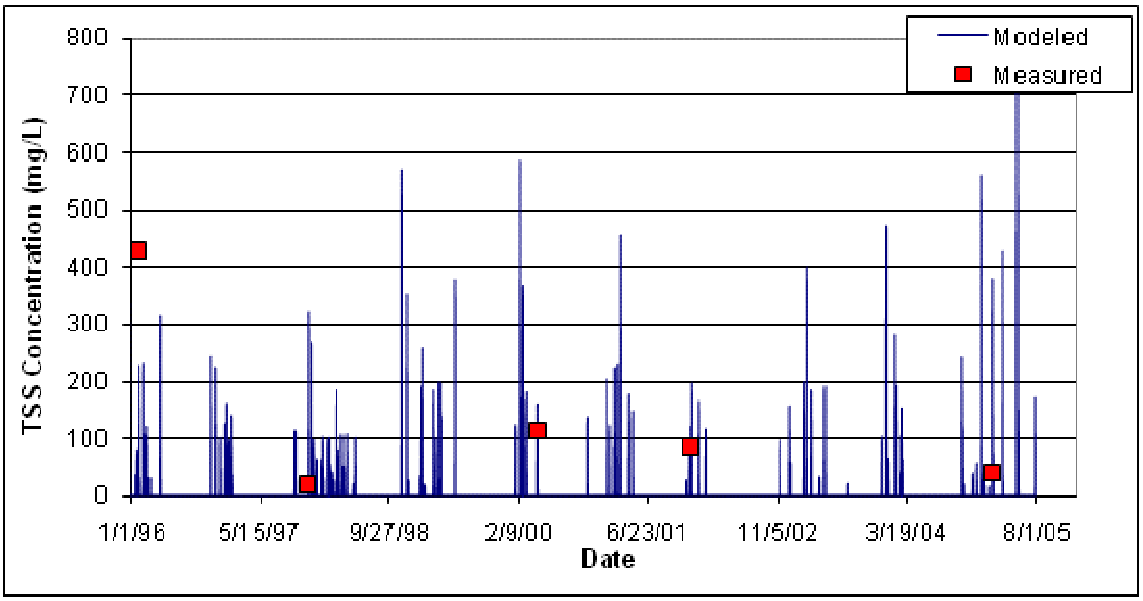


Figure A-9. Modeled and Observed TSS Concentrations for Subwatershed 14 (POLB Station 8A)

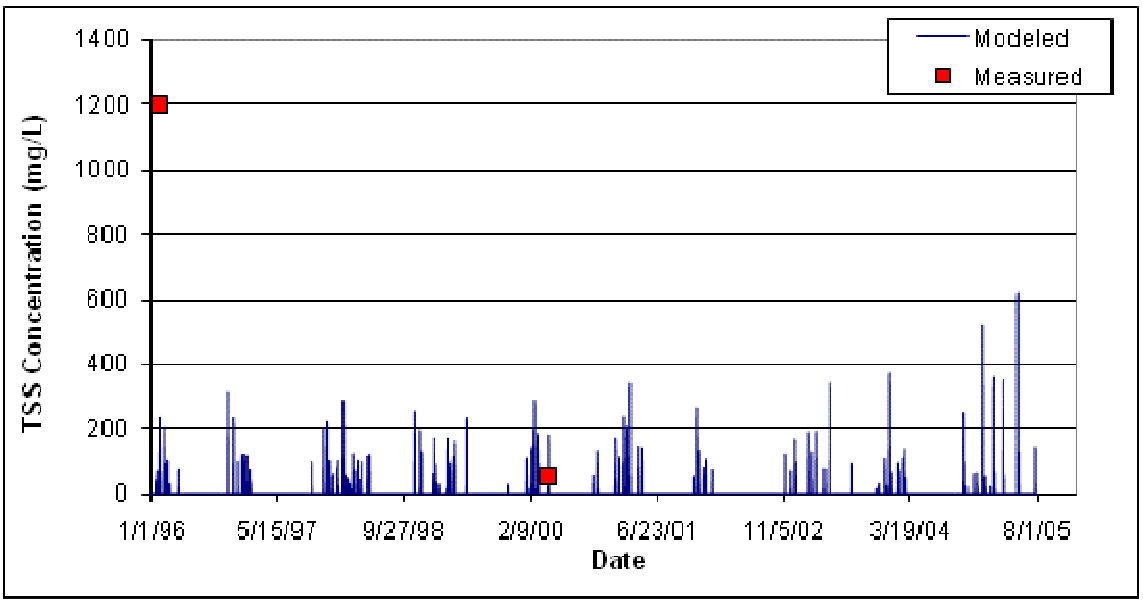


Figure A-10. Modeled and Observed TSS Concentrations for Subwatershed 15 (POLB Station 7A)

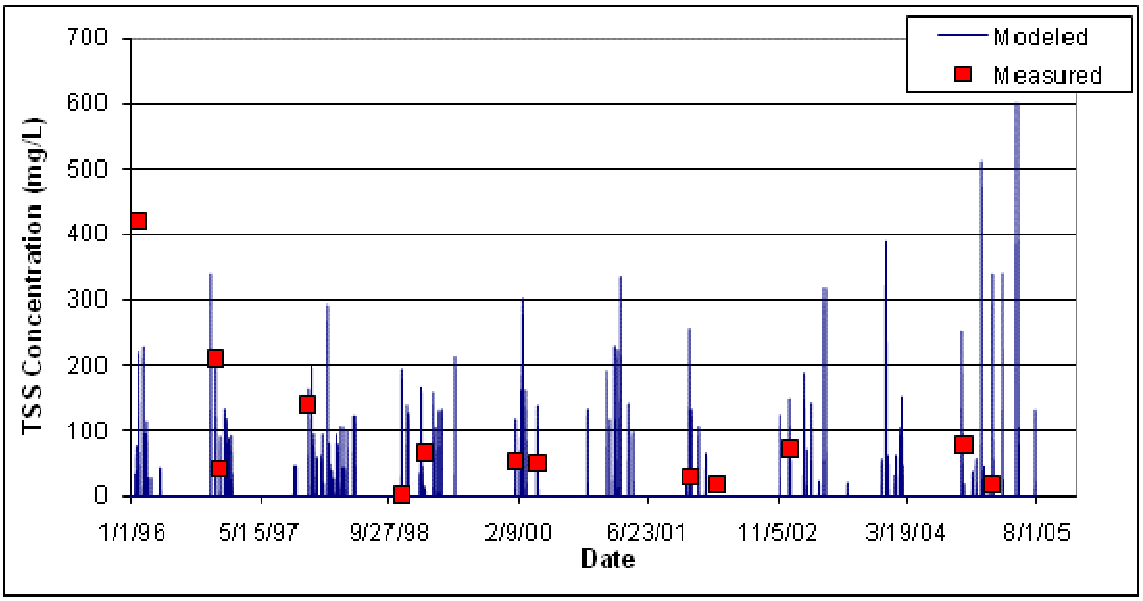


Figure A-11. Modeled and Observed TSS Concentrations for Subwatershed 16 (POLB Station 20A)

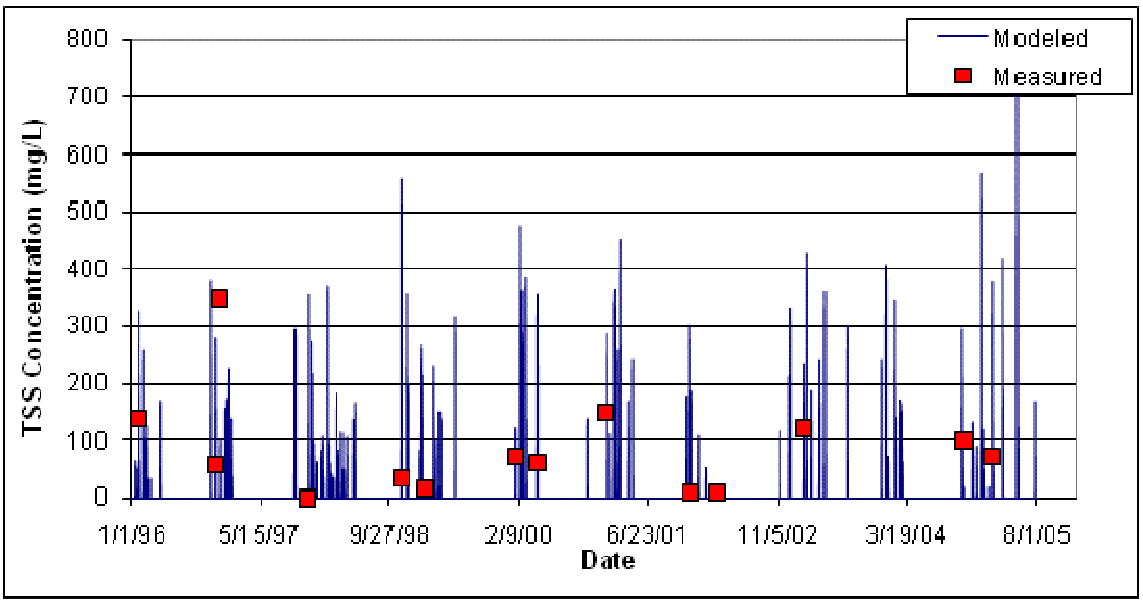


Figure A-12. Modeled and Observed TSS Concentrations for Subwatershed 20 (POLB Station 2A)

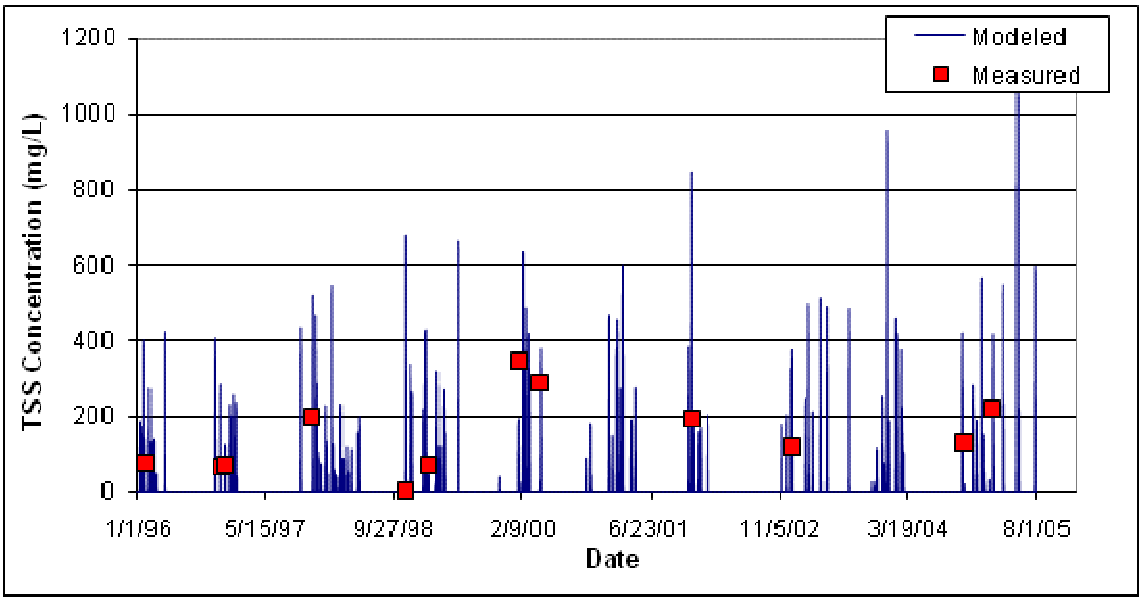


Figure A-13. Modeled and Observed TSS Concentrations for Subwatershed 25 (POLB Station 9A)

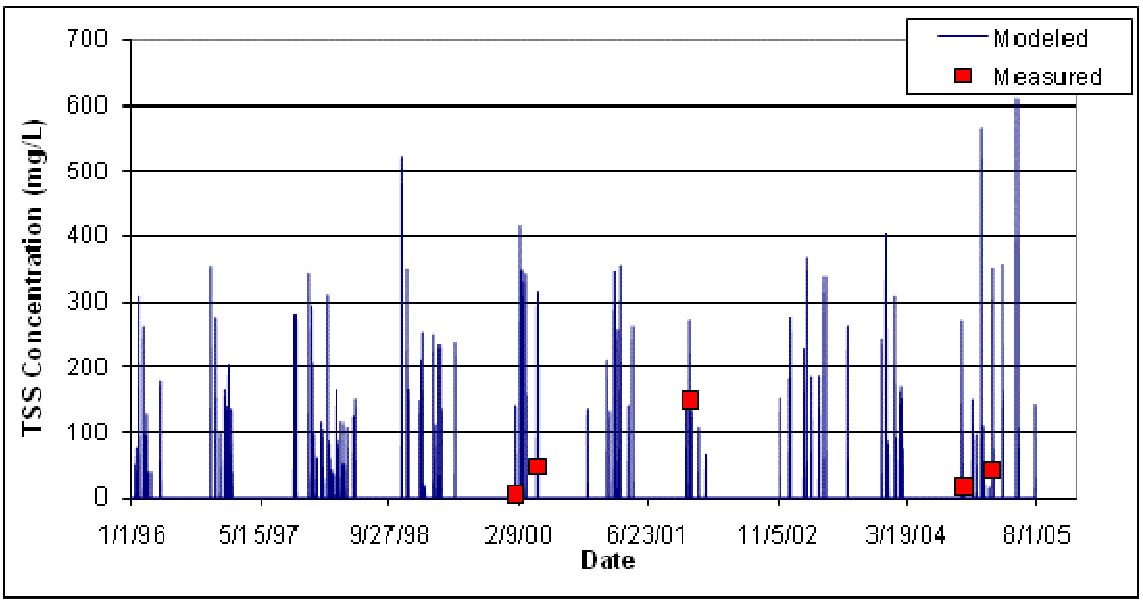


Figure A-14. Modeled and Observed TSS Concentrations for Subwatershed 29 (POLB Station 22A)

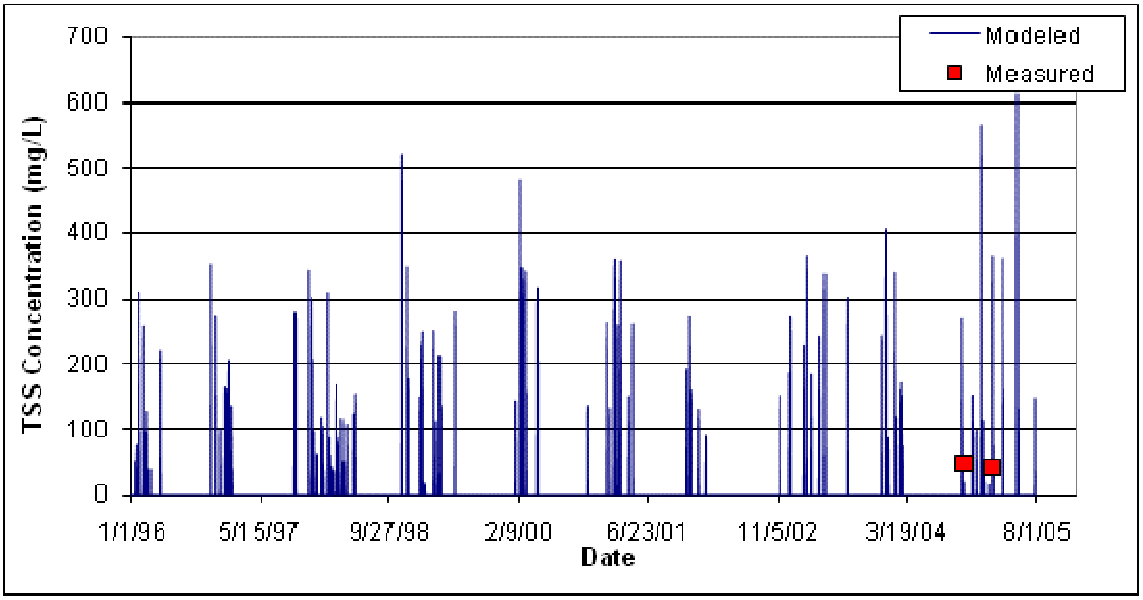


Figure A-15. Modeled and Observed TSS Concentrations for Subwatershed 31 (POLB Station 24A)

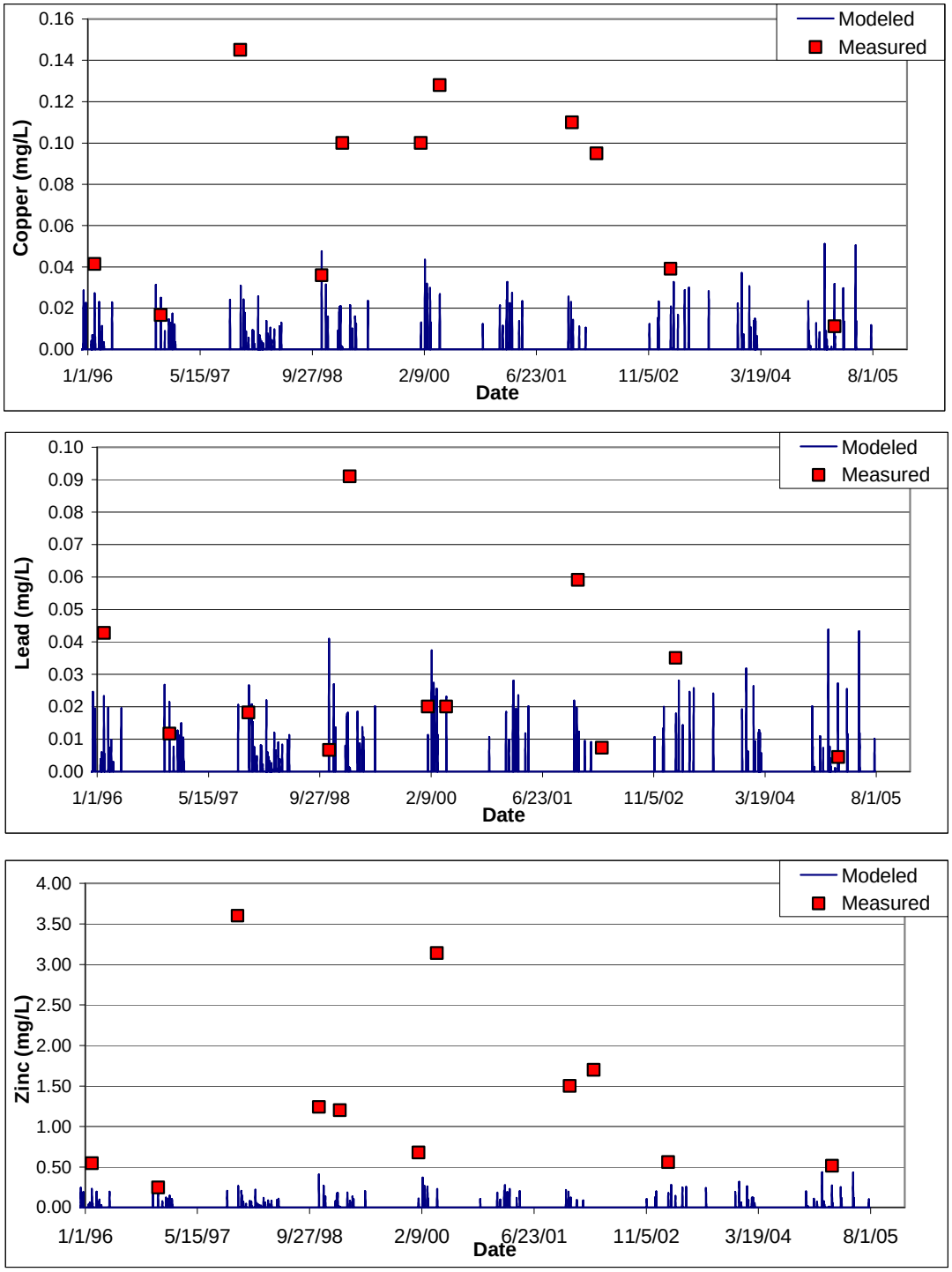
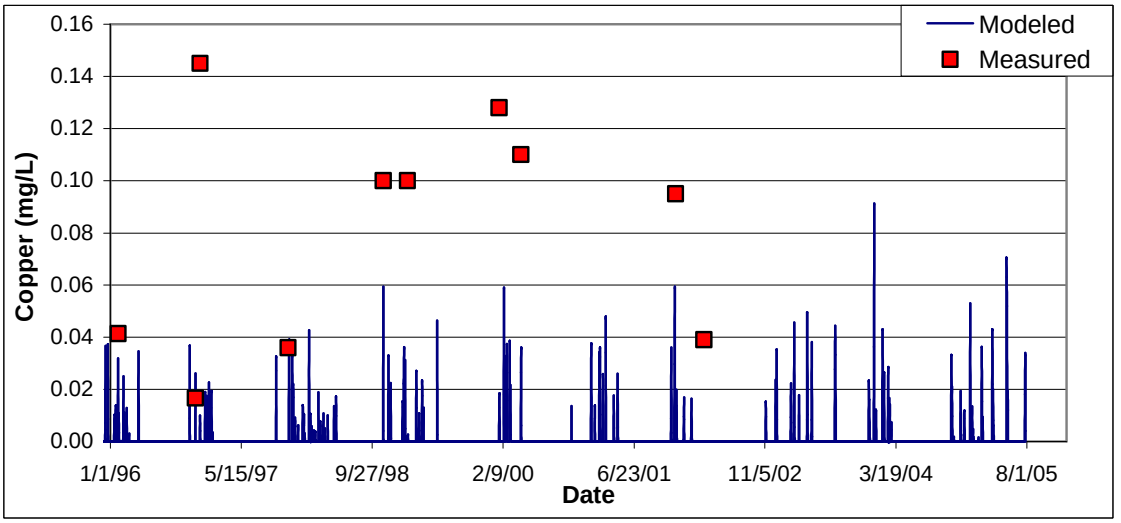
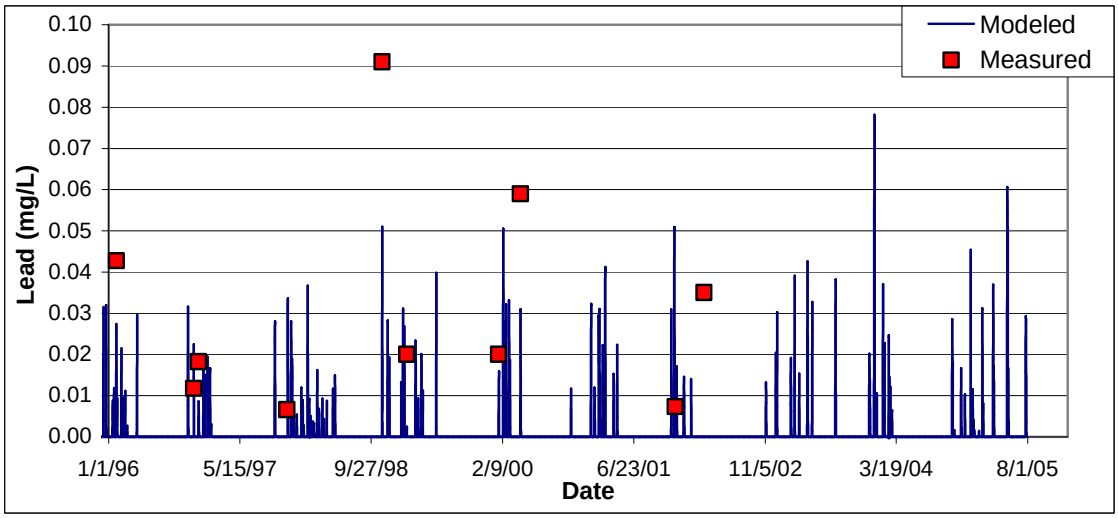


Figure A-16. Modeled and Observed Metal Concentrations for Subwatershed 2 (POLB Station 13A)





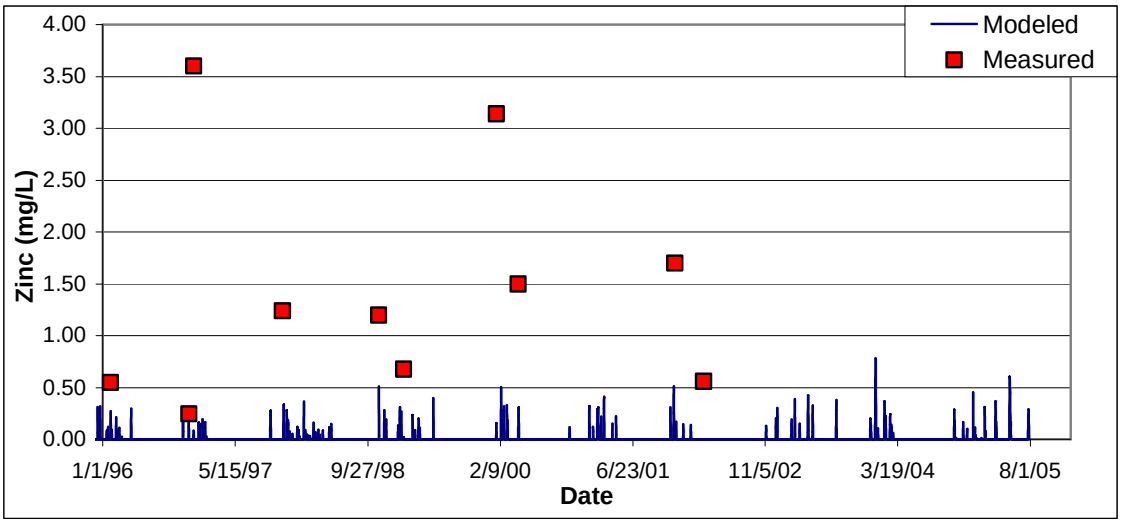
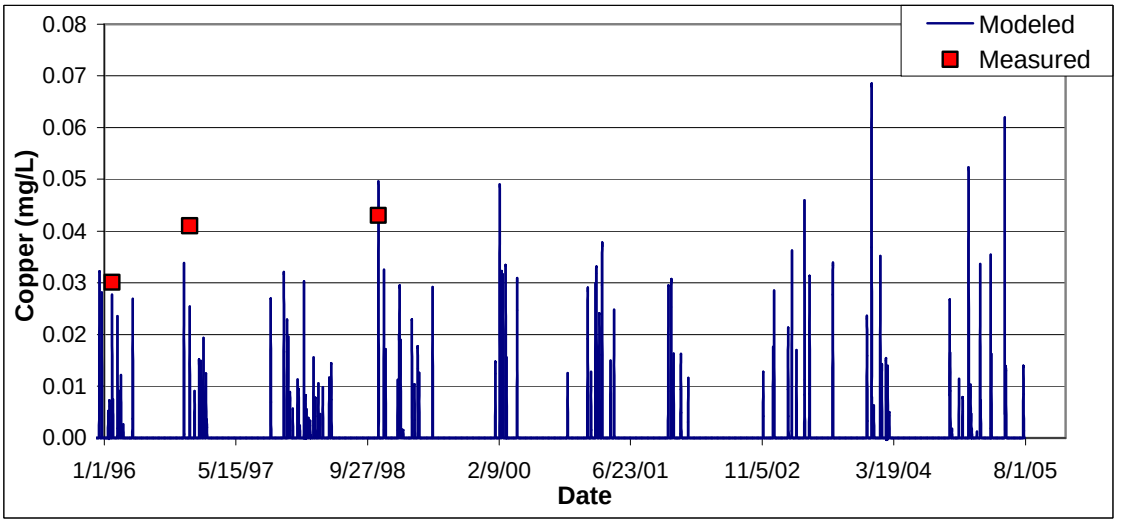
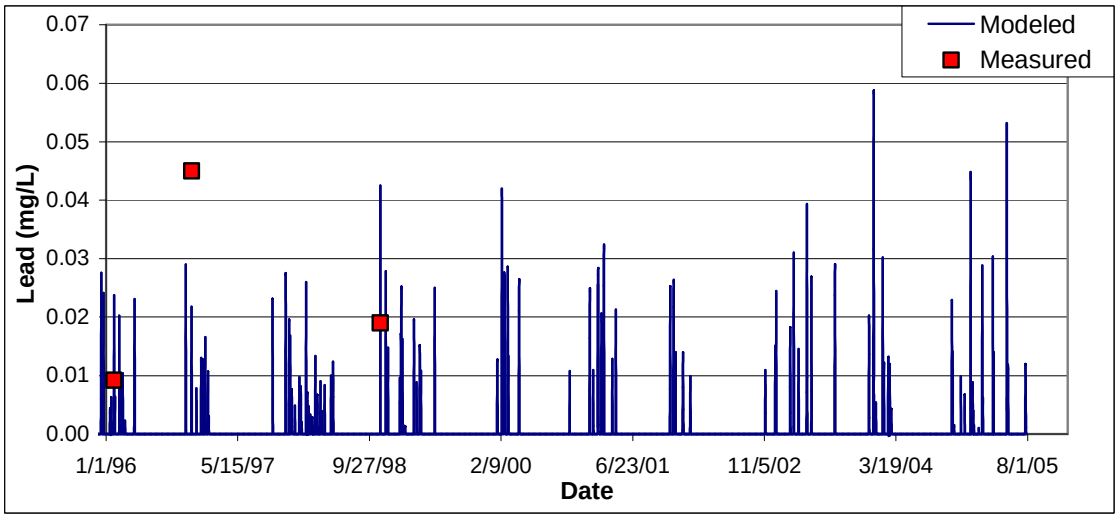


Figure A-17. Modeled and Observed Metal Concentrations for Subwatershed 4 (POLB Station 12A)





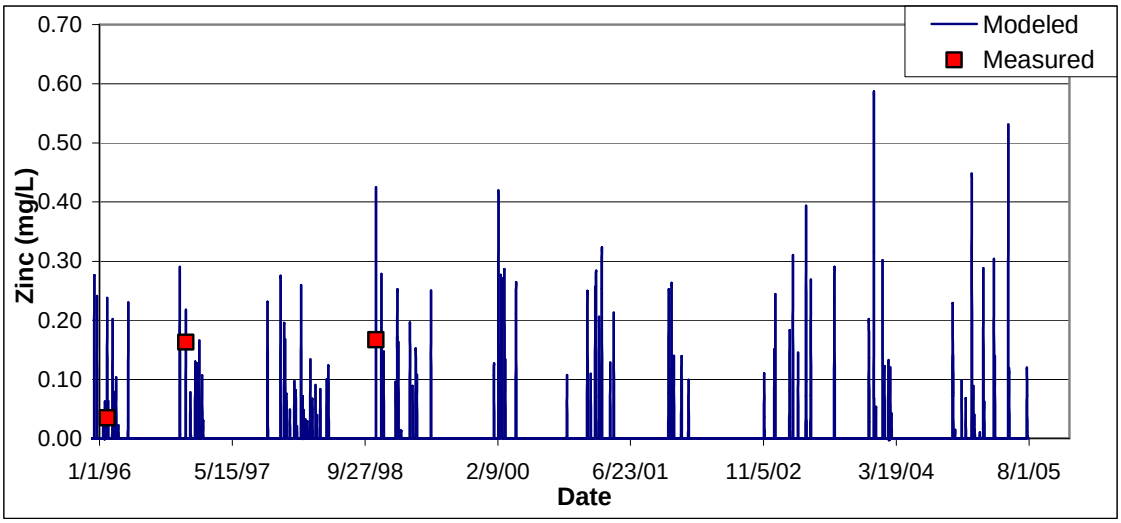


Figure A-18. Modeled and Observed Metal Concentrations for Subwatershed 9 (POLB Station 19A)

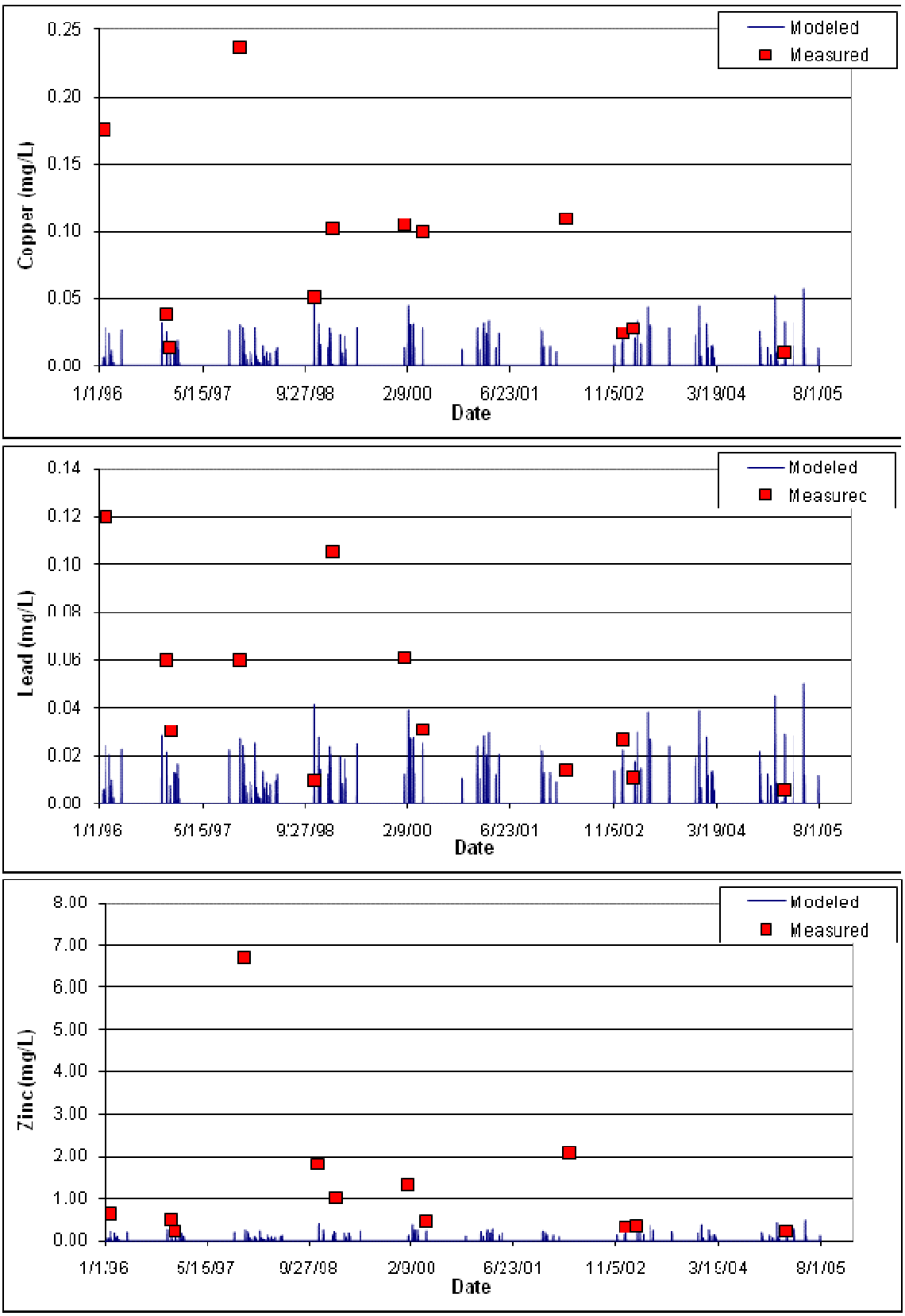
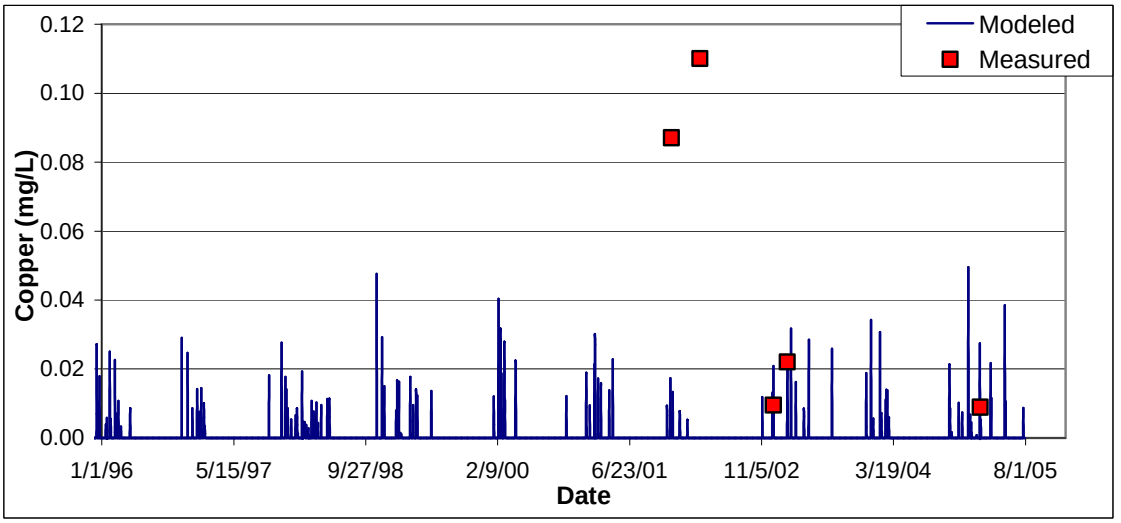
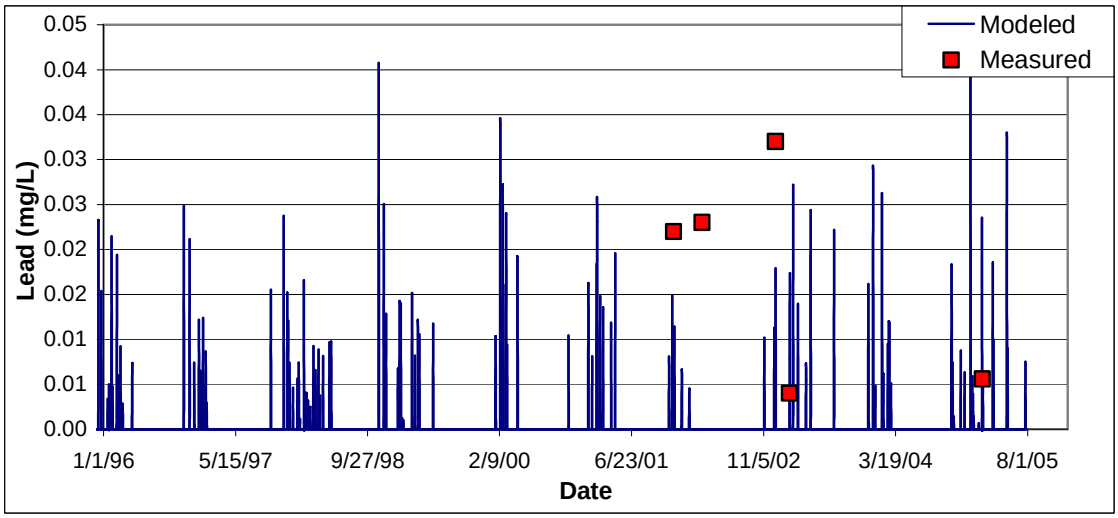


Figure A-19. Modeled and Observed Metal Concentrations for Subwatershed 12 (POLB Station 6A)





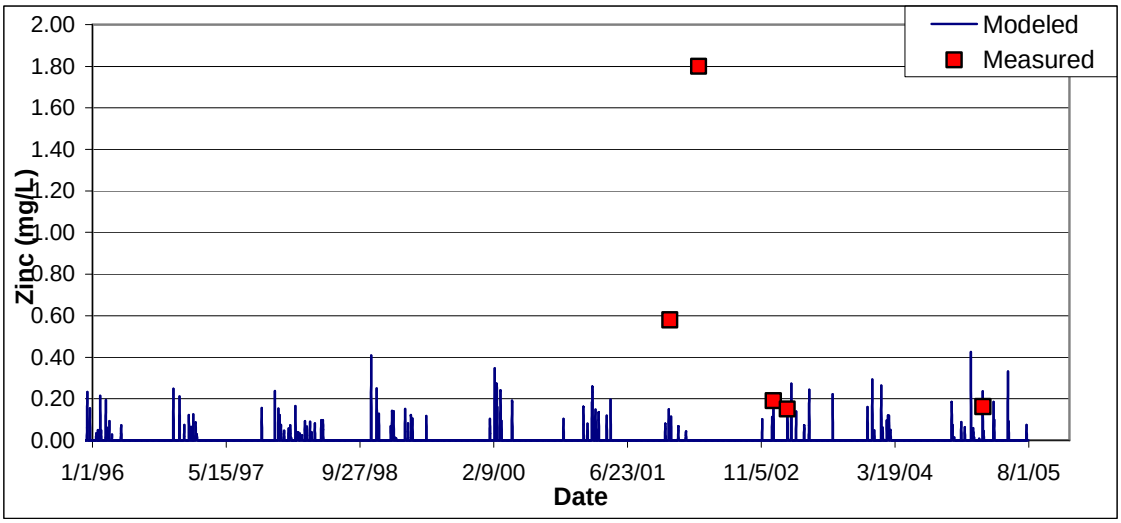


Figure A-20. Modeled and Observed Metal Concentrations for Subwatershed 13 (POLB Station 23A)

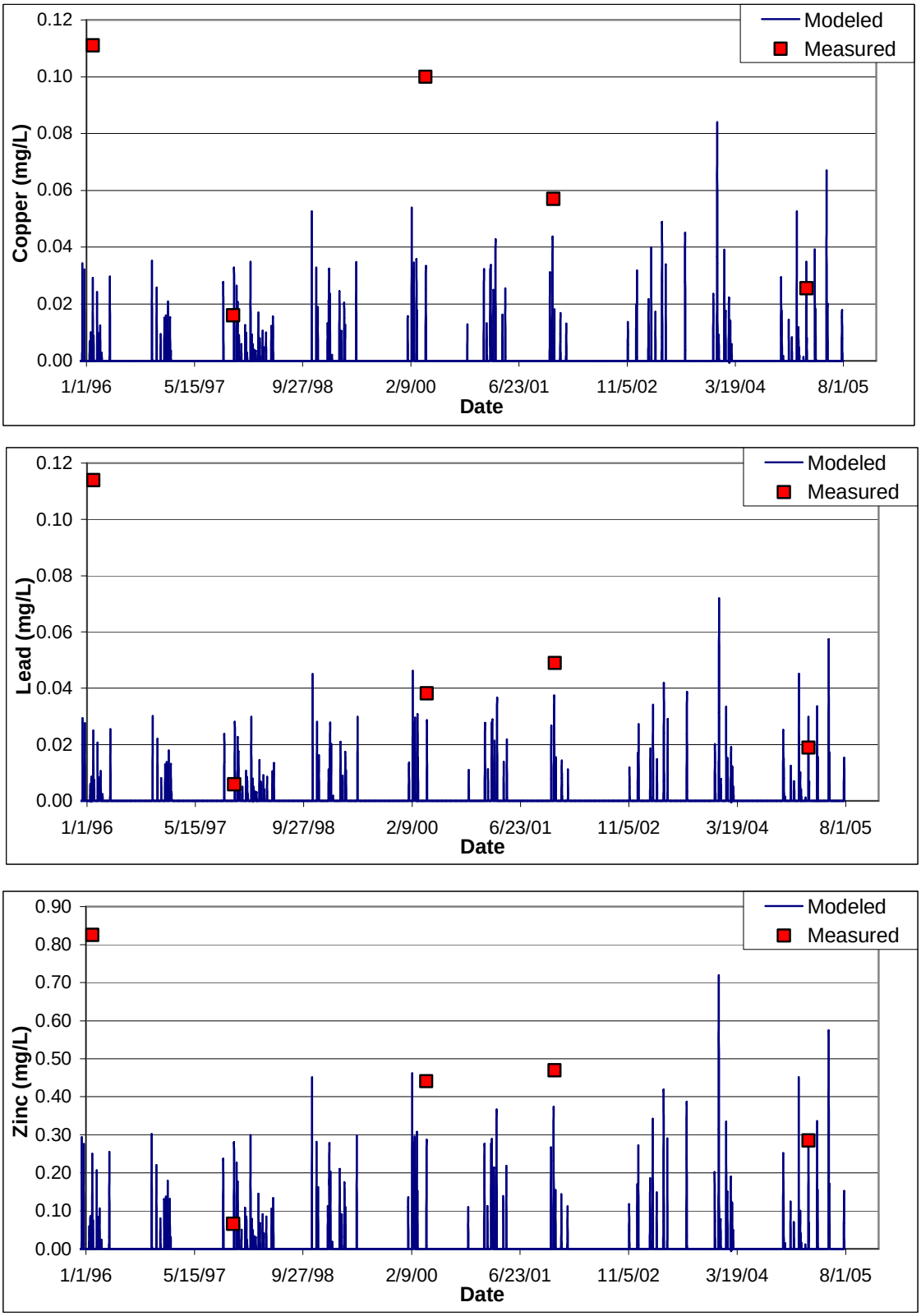


Figure A-21. Modeled and Observed Metal Concentrations for Subwatershed 14 (POLB Station 8A)

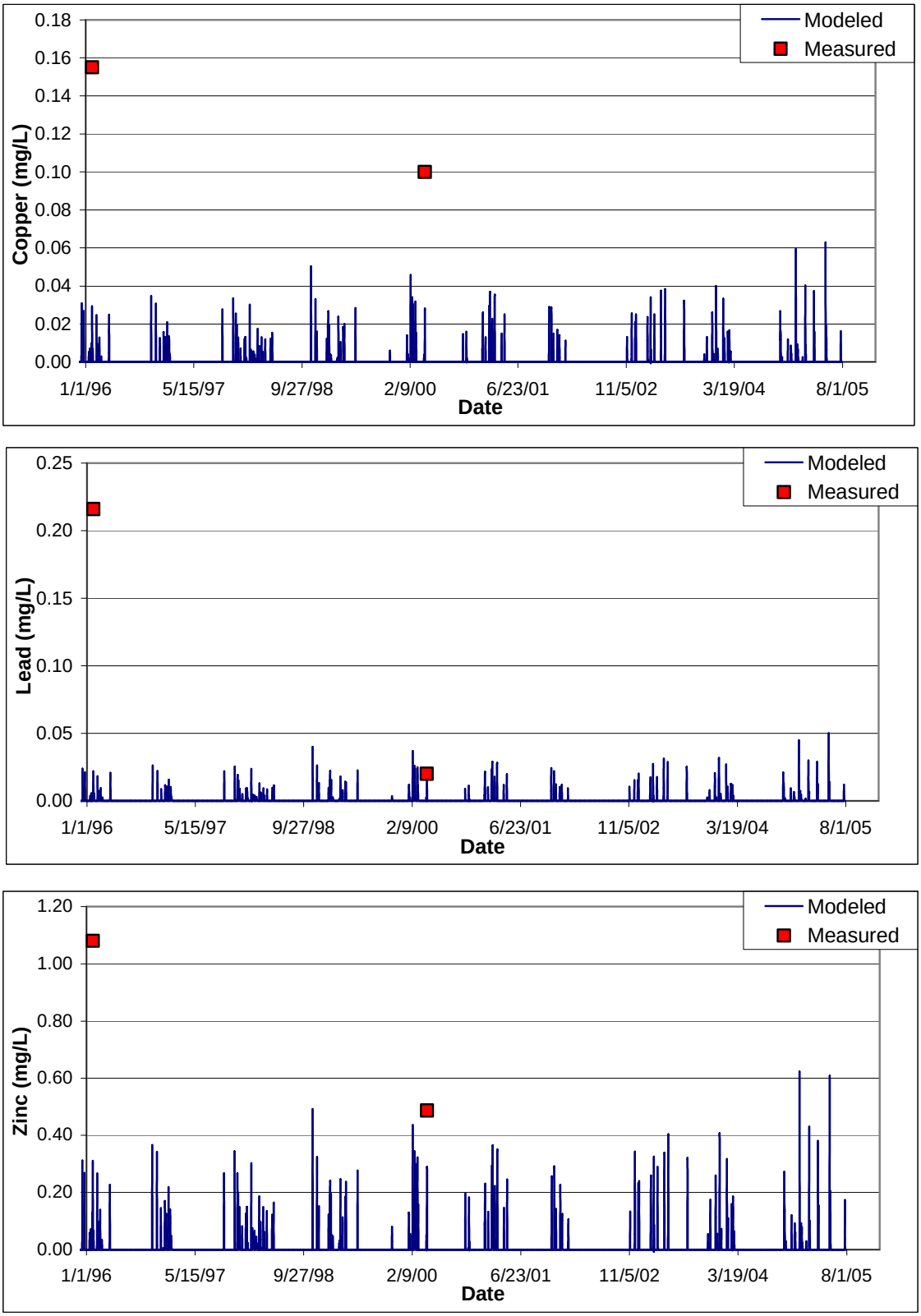
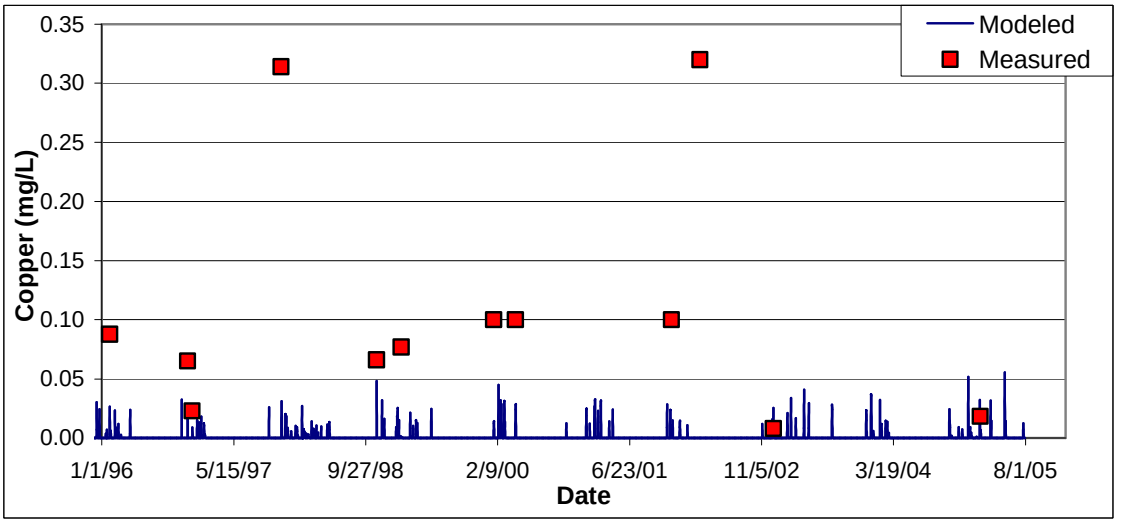
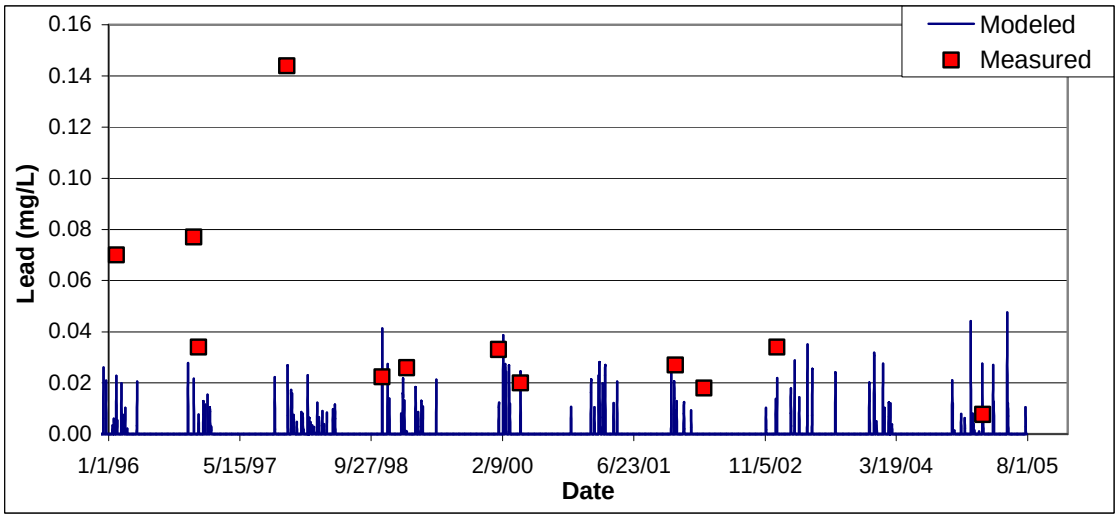


Figure A-22. Modeled and Observed Metal Concentrations for Subwatershed 15 (POLB Station 7A)





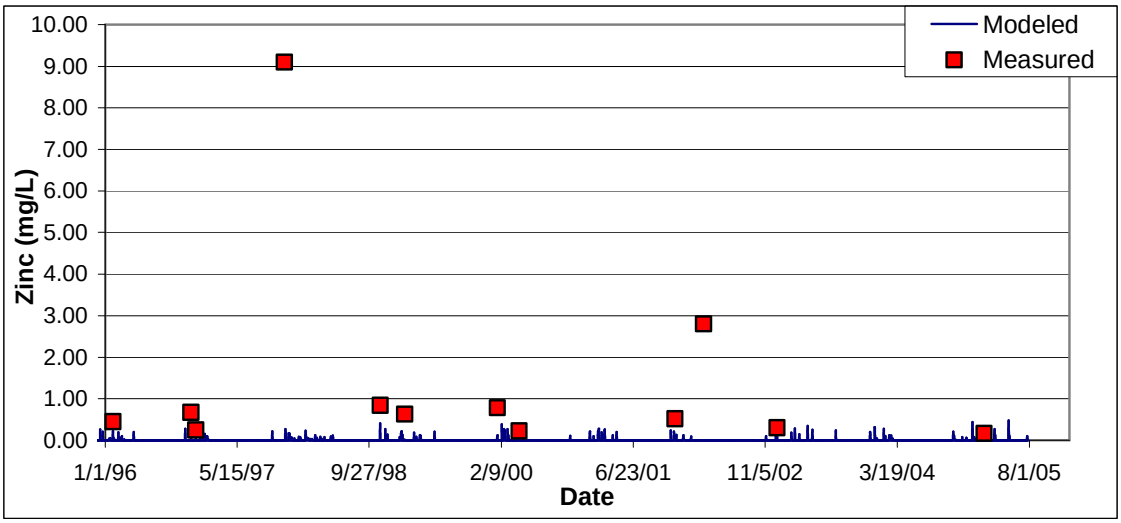


Figure A-23. Modeled and Observed Metal Concentrations for Subwatershed 16 (POLB Station 20A)

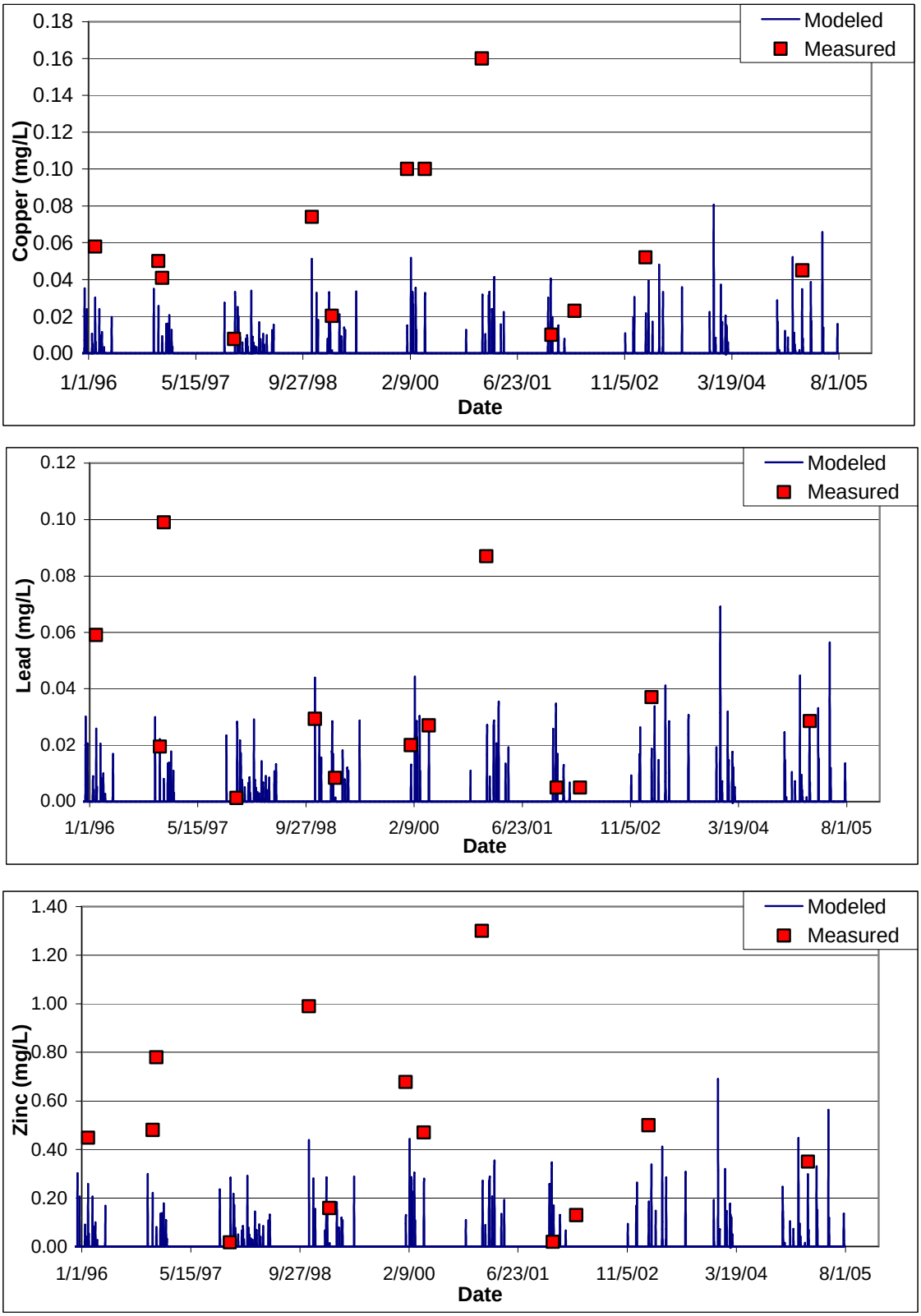


Figure A-24. Modeled and Observed Metal Concentrations for Subwatershed 20 (POLB Station 2A)

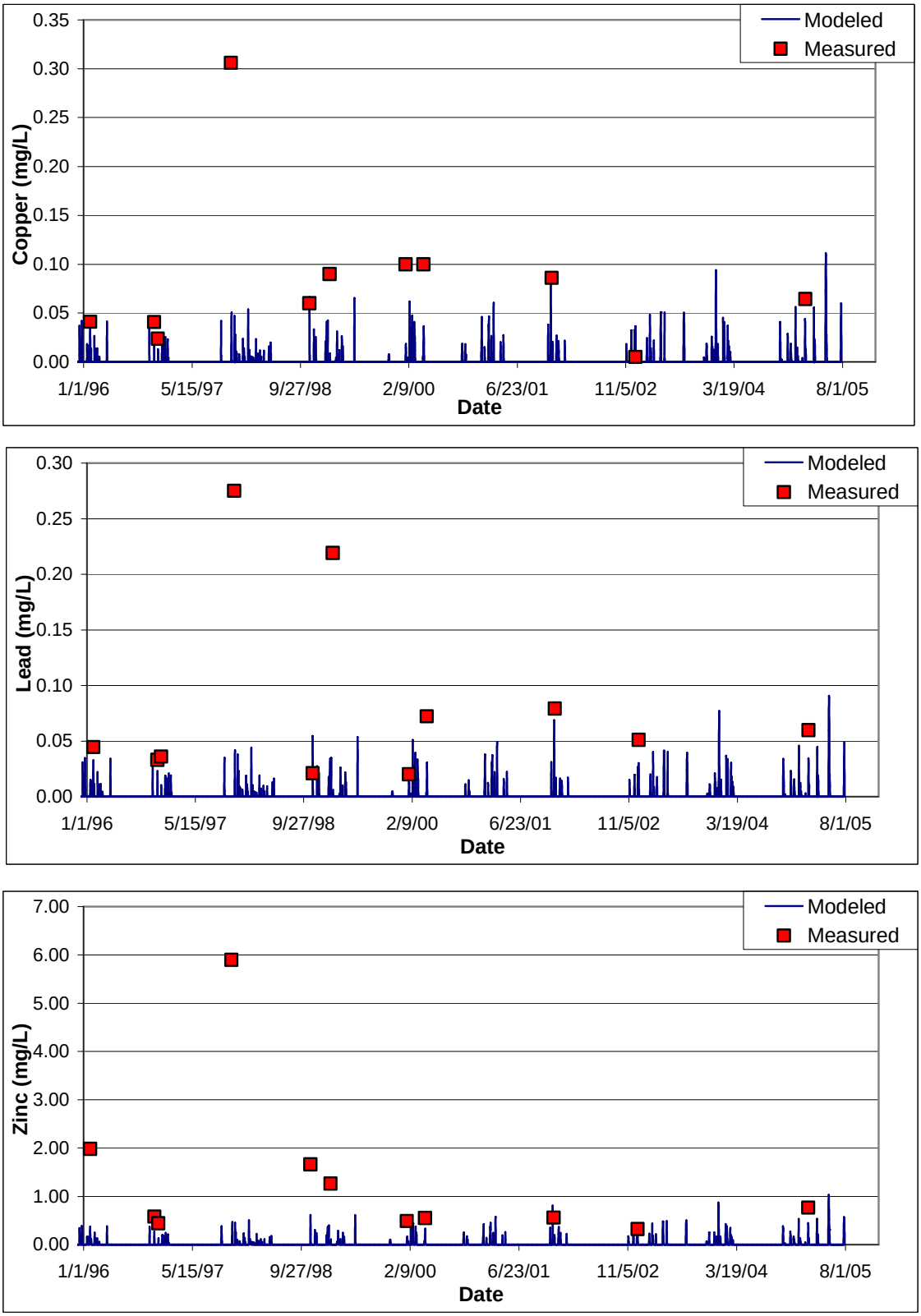


Figure A-25. Modeled and Observed Metal Concentrations for Subwatershed 25 (POLB Station 9A)

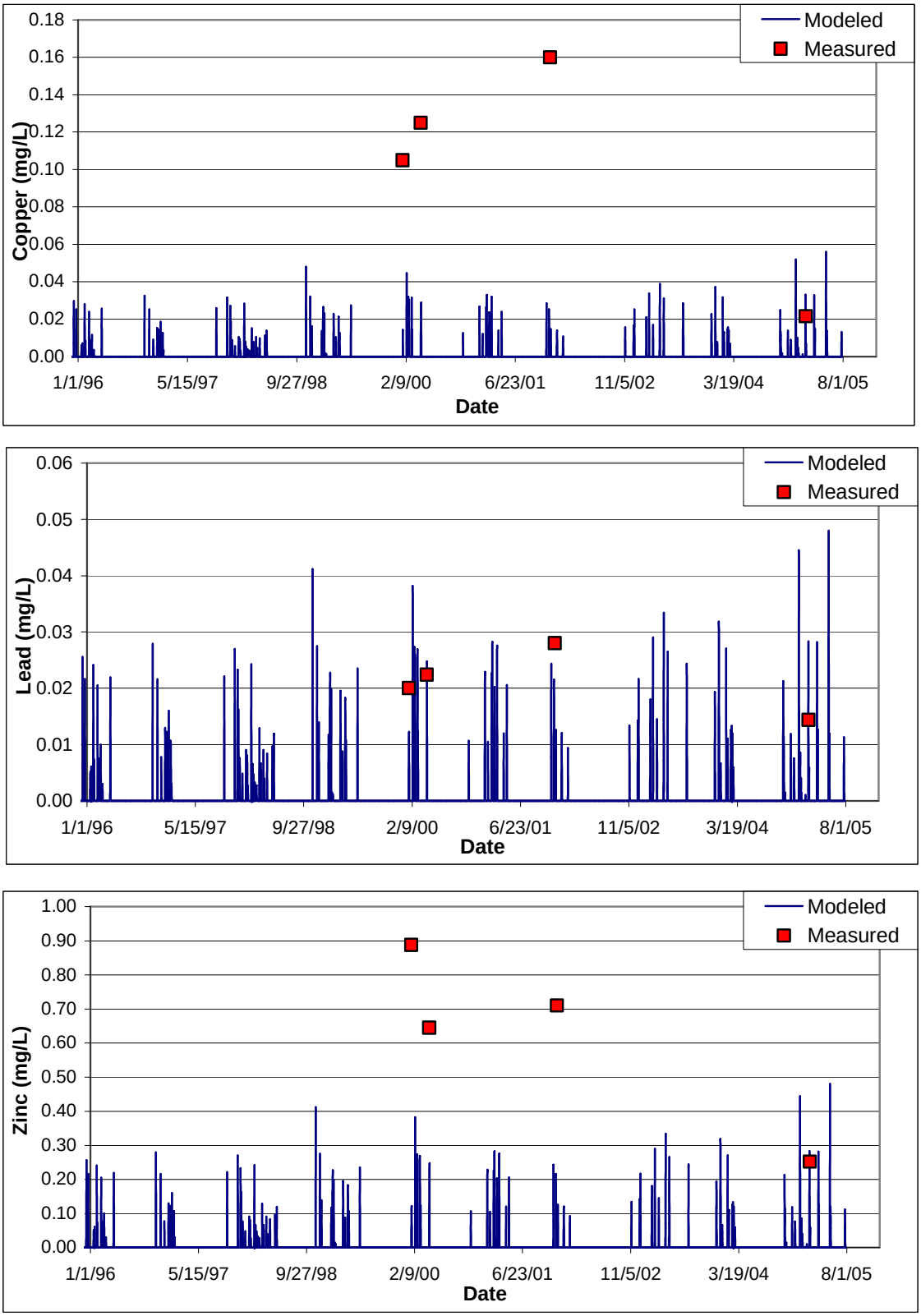


Figure A-26. Modeled and Observed Metal Concentrations for Subwatershed 29 (POLB Station 22A)

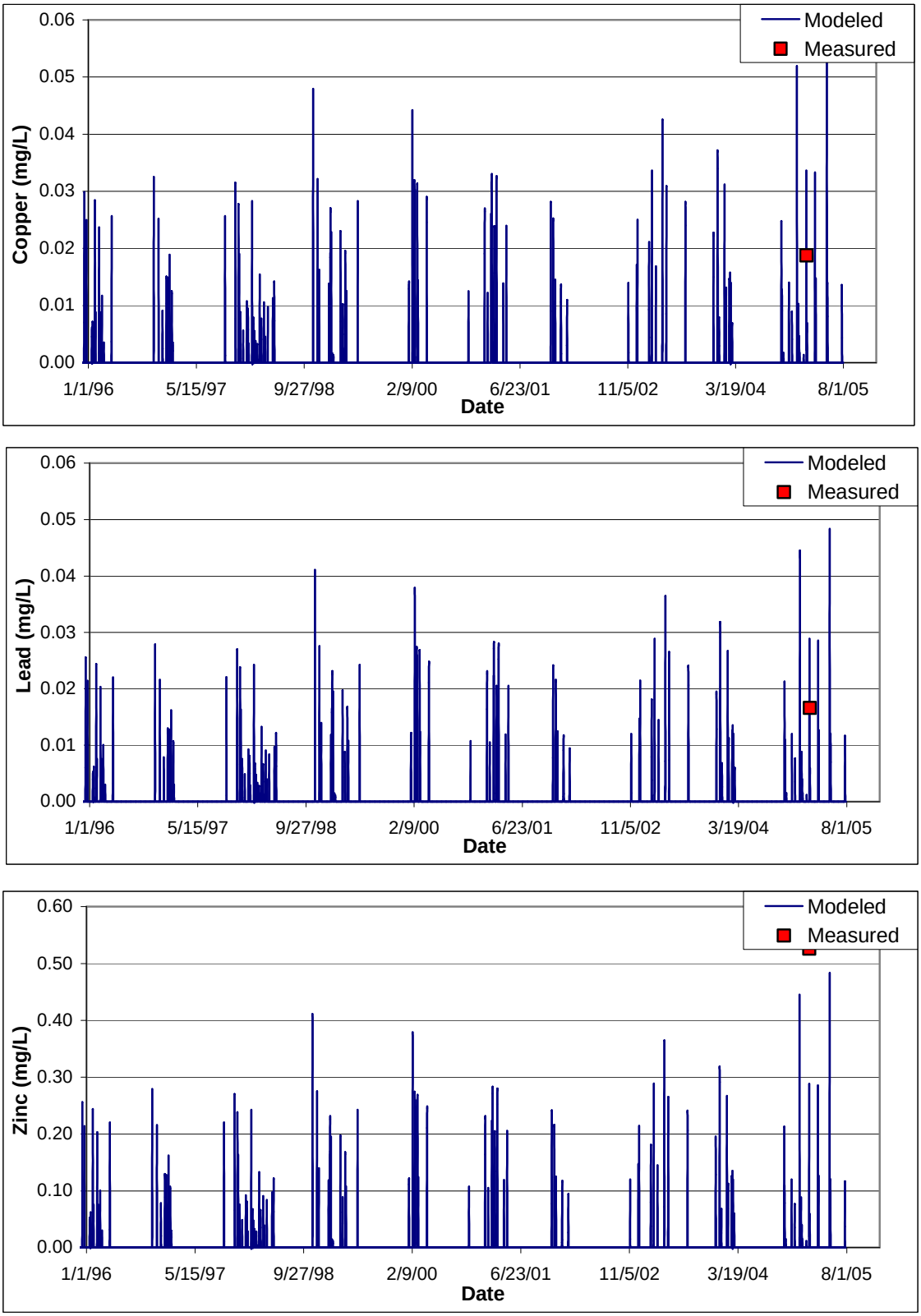


Figure A-27. Modeled and Observed Metal Concentrations for Subwatershed 31 (POLB Station 24A).

Appendix B: Annual Loads for Watersheds Draining to the Harbors & San Pedro Bay

FINAL

May 2011

Prepared for:
USEPA Region 9
Los Angeles Regional Water Quality Control Board

Prepared by:
Tetra Tech, Inc.

Table B-1. Annual Loads (kg/yr) for Subwatersheds Draining to Alamitos Bay

Year	Copper	Lead	Zinc	DDT	PAHs	PCBs
1995	699	560	6,937	0.015	55.56	0.007
1996	579	471	5,766	0.013	34.59	0.006
1997	503	399	4,818	0.008	29.47	0.004
1998	647	536	6,678	0.013	65.92	0.006
1999	258	157	2,169	0.004	13.18	0.002
2000	423	316	3,970	0.008	18.20	0.004
2001	650	544	6,184	0.009	17.47	0.004
2002	211	111	1,511	0.002	4.74	0.001
2003	472	363	4,485	0.009	19.56	0.004
2004	542	417	5,295	0.010	34.19	0.005
2005	482	366	4,536	0.008	30.03	0.004

Table B-2. Annual Loads (kg/yr) for Subwatersheds Draining to Los Angeles/Long Beach Inner Harbor

Year	Copper	Lead	Zinc	DDT	PAHs	PCBs
1995	332	216	2,719	0.061	28.24	0.041
1996	275	181	2,260	0.054	17.58	0.036
1997	239	154	1,888	0.035	14.98	0.024
1998	307	206	2,617	0.054	33.51	0.037
1999	122	60	850	0.017	6.70	0.011
2000	201	122	1,556	0.033	9.25	0.022
2001	309	210	2,424	0.036	8.88	0.025
2002	100	43	592	0.008	2.41	0.005
2003	224	140	1,758	0.039	9.94	0.026
2004	257	161	2,075	0.042	17.38	0.029
2005	229	141	1,778	0.034	15.26	0.023

Table B-3. Annual Loads (kg/yr) for Subwatersheds Draining to Los Angeles/Long Beach Outer Harbor (inside the breakwater)

Year	Copper	Lead	Zinc	DDT	PAHs	PCBs
1995	40	23	324	0.005	2.67	0.004
1996	33	19	269	0.005	1.67	0.003
1997	29	17	225	0.003	1.42	0.002
1998	37	22	311	0.005	3.17	0.003
1999	15	6	101	0.001	0.63	0.001
2000	24	13	185	0.003	0.88	0.002
2001	37	23	288	0.003	0.84	0.002
2002	12	5	70	0.001	0.23	0.000
2003	27	15	209	0.003	0.94	0.002
2004	31	17	247	0.004	1.65	0.003
2005	27	15	212	0.003	1.45	0.002

Table B-4. Annual Loads (kg/yr) for Subwatersheds Draining to Los Angeles Harbor—Consolidated Slip (including Dominguez Channel)

Year	Copper	Lead	Zinc	DDT	PAHs	PCBs
1995	2,078	1,217	19,565	1.086	171.71	0.720
1996	1,553	864	15,801	1.080	109.44	0.684
1997	1,306	694	11,853	0.763	84.68	0.477
1998	2,352	1,463	23,417	1.380	171.22	0.897
1999	699	370	6,825	0.472	53.38	0.296
2000	1,220	650	11,721	0.805	76.78	0.494
2001	1,293	671	11,510	0.581	90.34	0.338
2002	569	280	5,344	0.373	42.08	0.230
2003	1,034	521	9,909	0.681	72.45	0.428
2004	1,736	912	15,540	0.863	93.63	0.516
2005	1,664	963	15,354	0.919	119.80	0.586

Table B-5. Annual Loads (kg/yr) for Subwatersheds Draining to Los Angeles Harbor—Inner Cabrillo Beach Area

Year	Copper	Lead	Zinc	DDT	PAHs	PCBs
1995	5.72	3.44	38.98	0.0003	0.45	0.0002
1996	4.74	2.90	32.39	0.0003	0.28	0.0002
1997	4.12	2.46	27.07	0.0002	0.24	0.0001
1998	5.30	3.30	37.52	0.0003	0.53	0.0002
1999	2.11	0.96	12.19	0.0001	0.11	0.0000
2000	3.47	1.94	22.31	0.0002	0.15	0.0001
2001	5.32	3.35	34.74	0.0002	0.14	0.0001
2002	1.73	0.68	8.49	0.0000	0.04	0.0000
2003	3.87	2.23	25.20	0.0002	0.16	0.0001
2004	4.44	2.57	29.75	0.0002	0.27	0.0001
2005	3.95	2.25	25.48	0.0002	0.24	0.0001

Table B-6. Annual Loads (kg/yr) for Subwatersheds Draining to Los Angeles River Estuary (including Los Angeles River)

Year	Copper	Lead	Zinc	DDT	PAHs	PCBs
1995	71,111	50,199	497,457	21.29	1,336	59.28
1996	18,286	12,172	139,851	5.45	850	15.16
1997	13,098	8,293	96,314	3.72	644	10.34
1998	64,902	45,751	458,350	19.45	1,515	54.16
1999	5,948	3,281	43,544	1.70	380	4.73
2000	13,437	8,654	100,428	3.90	647	10.85
2001	21,404	14,905	165,034	6.37	917	17.74
2002	10,178	6,590	77,724	2.96	433	8.25
2003	16,149	11,111	126,157	4.78	673	13.30
2004	23,131	16,365	179,538	6.80	884	18.94
2005	36,597	25,632	265,994	11.31	1,379	31.48

Table B-7. Annual Loads (kg/yr) for Subwatersheds Draining to San Pedro Bay Nearshore/ Offshore Zones

Year	Copper	Lead	Zinc	DDT	PAHs	PCBs
1995	78.97	54.95	691.80	0.0019	7.90	0.0009
1996	65.42	46.20	575.00	0.0017	4.92	0.0008
1997	56.83	39.20	480.46	0.0011	4.19	0.0005
1998	73.20	52.57	665.95	0.0017	9.38	0.0008
1999	29.14	15.37	216.29	0.0005	1.87	0.0003
2000	47.87	30.97	395.91	0.0010	2.59	0.0005
2001	73.49	53.42	616.71	0.0011	2.49	0.0005
2002	23.84	10.85	150.66	0.0002	0.67	0.0001
2003	53.38	35.65	447.23	0.0012	2.78	0.0006
2004	61.27	40.95	528.03	0.0013	4.86	0.0006
2005	54.53	35.89	452.34	0.0011	4.27	0.0005

Table B-8. Annual Loads (kg/yr) for Subwatersheds Draining to San Gabriel River Estuary (includes San Gabriel River)

Year	Copper	Lead	Zinc	DDT	PAHs	PCBs
1995	5,801	7,997	78,117	0.09	444.19	0.025
1996	6,558	8,977	84,054	0.08	291.41	0.023
1997	3,867	4,533	46,291	0.04	203.14	0.010
1998	8,813	13,265	126,696	0.16	446.80	0.043
1999	2,418	2,739	26,793	0.02	153.65	0.006
2000	3,871	4,981	47,002	0.04	192.84	0.012
2001	5,119	6,515	61,860	0.06	239.91	0.015
2002	2,380	2,608	25,803	0.02	103.95	0.006
2003	4,909	6,375	59,336	0.05	186.94	0.014
2004	7,179	9,758	91,344	0.09	237.97	0.024
2005	6,136	8,121	77,256	0.08	309.26	0.021

Appendix III:

Supplemental Technical Information for TMDLs for Toxic Pollutants in Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters

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Appendix III.1 – TMDL Loading Calculations for Saltwater Waterbodies

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Appendix III.1 Summary

The information below was used for TMDL calculations, existing load calculations, and to support distribution of allocations.

EFDC model simulations to support TMDL development were based on a four-year simulation period (2002 through 2005). This period was selected because it contained the vast majority of the calibration data as well as it overlapped with the LSPC simulation period (1995-2005). More information on EFDC model calibration is documented in Appendix I.

Data and information below were used to support TMDL calculations and allocations. The direct air deposition rates (see Section III.6) and percent of nearshore contributions (see Table 2 through Table 7 in Section III.8) were also used to support allocations. Additional details on the TMDL and existing load calculations as well as allocations are described below.

Section III.1-1. TMDL and Existing Load Calculations

Information Used:

- Sediment Deposition Rates (Table III.1-1)
- Numeric Targets for TMDL Calculations (TMDL Staff Report, Section 3)
- Existing Sediment Concentrations (Table III.1-2)

Methodology:

Sediment deposition rates were used in the calculation of both TMDLs and existing loads (Table III.1-1). Sediment deposition rates were calculated by approximating the average mass of total sediment (fine and coarse particles) deposited in each waterbody annually based on average annual 2002-2005 EFDC model output. Sediment flux for each grid cell, which is dependent on watershed inputs as well as tidal movements between waterbodies, was obtained from the EFDC model output. These values were summarized across each TMDL zone, resulting in the average deposition of both sediment fines and sand by waterbody. Total deposition rate is simply the sum of the rates for fines and sand and this value is the waterbody-specific average annual (clean) sediment deposition rate. The total deposition rate was ultimately used for TMDL calculations and existing load calculations.

To determine the loading capacities for each pollutant, the total deposition rate (Table III.1-1) was multiplied by the applicable sediment target (TMDL Staff Report, Section 3) and a conversion factor (to yield TMDLs in kilograms or grams per year, depending on the pollutant) (see equation and sample calculation below). TMDLs for other pollutants (cadmium, chromium, mercury, chlordane, dieldrin, and toxaphene) are concentration-based loading capacities in sediment (see TMDL Staff Report, Section 3).

TMDL = Sediment Deposition Rate *x* Numeric Target *x* Conversion Factor

<u>Example</u>: Copper in Dominguez Channel Estuary

Cu TMDL = 84 kg/yr =	2,470,201 kg/yr	*x*	34 mg/kg	*x*	1×10^{-6}
	(sed. dep. rate) Table III.1-1		*(Cu target) Table III.1-2*		*(conv. factor)*

Similarly, to calculate existing loads, the total deposition rate (Table III.1-1) was multiplied by the applicable existing sediment concentration (Table III.1-2), and a conversion factor (to yield current loads in kilograms or grams per year, depending on the pollutant) (see equation and sample calculation below). The existing sediment concentrations for copper,

lead, zinc, DDT, PAHs and PCBs were based on the average simulated sediment concentration in the top 5 cm of sediment during the 2002-2005 EFDC simulation period (Table III.1-2), while the existing concentration for mercury (Table III.1-3) was based on the average sediment concentration associated with AMEC and Bight 03 data in the Consolidated Slip.

Existing Load = Sediment Deposition Rate *x* Existing Concentration *x* Conversion Factor

Example: Copper in Dominguez Channel Estuary

Cu Existing = 327.6 kg/yr = 2,470,201 kg/yr *x* 133 mg/kg *x* $1x10^{-6}$

(sed. dep. rate) Table III.1-1 *(Cu Avg. [Existing]) Table III.1-2* *(conv. factor)*

Table III.1-1. Waterbody Information

Waterbody Name	TMDL Zone	Area (acres)[1]	Area (m^2)[1]	Avg Fines Deposition (kg/yr)[2]	Avg Sand Deposition (kg/yr)[2]	Total Deposition (kg/yr)[2]
Dominguez Channel Estuary	01	140	567,900	465,680	2,004,522	2,470,201
Consolidated Slip	02	36	147,103	282,935	72,625	355,560
Inner Harbor - POLA	03	1,539	6,228,431	1,564,089	16,720	1,580,809
Inner Harbor - POLB	08	1,464	5,926,130	666,968	7,636	674,604
Fish Harbor	04	91	368,524	29,994	599	30,593
Cabrillo Marina	05	77	310,259	35,575	3,284	38,859
Cabrillo Beach	06	82	331,799	26,904	186	27,089
Outer Harbor - POLA	07	1,454	5,885,626	570,489	1,860	572,349
Outer Harbor - POLB	09	2,588	10,472,741	1,827,320	1,088	1,828,407
Los Angeles River Estuary	10	207	837,873	(2,152,248)	23,762,530	21,610,283
San Pedro Bay	11	8,173	33,073,517	9,055,624	10,000,647	19,056,271

[1] Area obtained from GIS layer of the 2006 303(d) list. Available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/303d_lists2006_gis.shtml

[2] Sediment deposition rates were calculated by approximating the average mass of total sediment (fine and coarse particles) deposited in each waterbody annually based on 2002-2005EFDC output. Sediment flux for each grid cell, which is dependent on watershed inputs as well as tidal movements between waterbodies, was obtained from the EFDC model output. These values were summarized across each TMDL zone, resulting in the average deposition of both sediment fines and sand by waterbody. The total deposition rate is simply the sum of the rates for fines and sand and this value is the waterbody-specific average annual (clean) sediment deposition rate.

Table III.1-2. Sediment Concentration Information per model zone (top 5 cm)

Waterbody Name	TMDL Zone	Total Cu (mg/kg)	Total Pb (mg/kg)	Total Zn (mg/kg)	Total DDT (total) (ug/kg)	Total PAH (total) (ug/kg)	Total PCB (total) (ug/kg)
Target		34	46.7	150	1.58	4022	3.2
Average Existing Concentration[1]							
Dominguez Channel Estuary	01	133	185	728	22	11,368	23
Consolidated Slip	02	259	358	1,122	138	32,373	236
Inner Harbor - POLA	03	85	51	261	11	1,940	15
Inner Harbor - POLB	08	66	37	192	7	679	8
Fish Harbor	04	47	20	138	5	113	2
Cabrillo Marina	05	236	59	235	43	6,083	27
Cabrillo Beach	06	110	24	167	36	889	11
Outer Harbor - POLA	07	62	21	147	19	586	27
Outer Harbor - POLB	09	46	30	174	11	159	11
Los Angeles River Estuary	10	75	122	930	11	404	19
San Pedro Bay	11	66	91	429	11	191	6

[1] Average existing sediment concentrations for total copper, total lead, total zinc, total DDT, total PAHs and total PCBs were based on the average simulated concentration in the top 5 cm of sediment. These average concentrations were determined for each TMDL zone by summarizing EFDC model output of contaminant flux by grid cell. The EFDC model was run for 2002-2005 and initial sediment bed concentrations (which were inputs to the model) were based on observed data from 2000-2006 (see Appendix I for additional details).

Table III.1-3. Sediment Concentration Information for Other Pollutants

Waterbody Name	Parameter	Units	Target Conc.	Existing Conc.	Notes
Dominguez Channel Estuary	Total Cadmium	ug/kg	1.2	3.2	WEMAP 99 & Bight 03 data
Dominguez Channel Estuary	Total Copper	ug/kg	34	191	WEMAP 99 & Bight 03 data
Dominguez Channel Estuary	Total Chlordane	ug/kg	0.5	43.6	WEMAP 99 & Bight 03 data
Dominguez Channel Estuary	Dieldrin	ug/kg	0.02	ND	WEMAP 99 data
Consolidated Slip	Total Cadmium	mg/kg	1.2	5.5	AMEC & Bight 03 data
Consolidated Slip	Total Chromium	mg/kg	81	167	AMEC & Bight 03 data
Consolidated Slip	Total Mercury	mg/kg	0.15	1.11	AMEC & Bight 03 data
Consolidated Slip	Total Chlordane	ug/kg	0.5	25.6	AMEC & Bight 03 data
Consolidated Slip	Dieldrin	ug/kg	0.02	7.2	AMEC & Bight 03 data
Consolidated Slip	Toxaphene	ug/kg	0.10	n/a	No sediment data available
Fish Harbor	Total Mercury	mg/kg	0.15	1.15	Bight 98 & Bight 03 data

Section III.1-2. Allocations

Information Used:

- Relative load contribution from watersheds (Appendix III.8, Tables 2 through 7)
- Contribution to each waterbody by jurisdictional area (Table III.1-4 and III.1-5)

Methodology:

As described in Appendix III.8, the EFDC model was used to generate a baseline as well as several other management scenarios and to evaluate relative contributions from various inputs. The baseline scenario started with the initial conditions and then simulated four years ahead to determine average water and sediment conditions if no implementation occurs) to characterize existing contaminant loads. Pollutant load reduction scenarios were performed to support allocation analyses and implementation alternatives. The "no upland sources" scenario, which simulates conditions assuming no upland (watershed) contaminant loads, was used to support allocation of the TMDL loads. Generally speaking, the baseline scenario is "let it run for four years under normal conditions"; whereas no upland scenario is "assume no contaminants come from watershed sources and let it run for four years."

Results of the "no upland sources" scenario were compared with results from the baseline scenario to quantify the relative contributions from the watersheds (see Tables 2 through 7 in Appendix III.8). Specifically, the model was run for 2002-2005 for these two scenarios and the resulting average sediment bed concentrations in the top 5 cm of sediment in each waterbody were quantified. The waterbody-specific values from each scenario were compared and the difference between them was represented as a percentage. This percentage was interpreted as the waterbody-specific percent contribution of the contaminant to the bed sediments from the upstream watersheds; i.e., the freshwater contributions. These percentages were ultimately applied to both the TMDLs and the existing conditions to determine the wasteload allocation and existing load, respectively, associated with watershed inputs.

The resulting WLAs were further distributed among MS4 permits based on the area draining to each waterbody. Specifically, the areas and percent area draining to each waterbody for MS4 permittees were calculated from GIS analyses of the nearshore areas (Table III.1-4 and III.1-5, respectively). Assumptions were made regarding the width of state and US highways under Caltrans jurisdiction (see footnote to Table III.1-4). The percent area for each MS4 permittee (Table III.1-5) was applied to the previously calculated WLA to determine the WLA for each responsible MS4 permittee(s) based on land area. See equation and sample calculation below.

Watershed WLA = TMDL *x* Relative Watershed Contribution (%)

Individual WLAs = Watershed WLA *x* Relative Drainage Area (%) by Permittee

<u>Example</u>: Copper in Dominguez Channel Estuary

Watershed (WS) WLA = 23 kg/yr =	84 kg/yr *(Cu TMDL)* *Staff Report* *Table 6-3*	*x*	28% *(WS%)* *Table 2,* *App. III.8*

County LA WLA = 22.4 kg/yr = 23 kg/yr *(WS WLA) Staff Report Table 6-3* *x* 95.7% *(Juris. %) Table III.1-5*

City LB WLA = 0.6 kg/yr = 23 kg/yr *(WS WLA) Staff Report Table 6-3* *x* 2.7% *(Juris. %) Table III.1-5*

Caltrans WLA = 0.384 kg/yr = 23 kg/yr *(WS WLA) Staff Report Table 6-3* *x* 1.6% *(Juris. %) Table III.1-5*

Table III.1-4. Jurisdictional Area by TMDL Waterbody

	Area (m^2)[1]				
Waterbody	**Caltrans**	**Long Beach**	**Seal Beach**	**Los Angeles County**	**Total Draining to Waterbody**
Alamitos Bay	1,532,228	47,845,709	9,755,623	19,470,250	78,603,810
Cabrillo Marina	83,979	0	0	8,565,770	8,649,748
Consolidated Slip	68,532	0	0	4,316,131	4,384,663
Fish Harbor	1,868	0	0	577,108	578,976
Inner Cabrillo Beach Area	0	0	0	754,681	754,681
Los Angeles River Estuary	34,870	2,574,272	0	242,130	2,851,272
Inner Harbor	639,325	9,281,439	0	33,932,244	43,853,008
Outer Harbor (inside breakwater)	4,002	1,392,732	0	2,010,330	3,407,063
San Pedro Bay Near/Off Shore Zones	69,278	10,808,304	767,157	1,588,764	13,233,503
Dominguez Channel Estuary	1,357,065	2,225,713	0	79,292,407	82,875,185

[1] Area calculations using the following data sources:
Watershed boundaries: Calwater GIS layer (http://www.atlas.ca.gov/) delineated using stream reach and storm drain layers (see Appendix II for more information)
City boundaries: County of Los Angeles, DPW GIS data (http://gis.dpw.lacounty.gov/oia/site_options.cfm)
Caltrans areas calculated based on US Highway and State Highway lengths (GIS layers from http://www.atlas.ca.gov/) multiplied by assumed average widths. Average widths determined from average lane and shoulder widths and average number of lanes (US highway width = 172 feet; State highway width = 101 feet)

Table III.1-5. Contribution of freshwater inputs (relative to each other)

Waterbody	Percent of Total Area by Waterbody				
	Caltrans	Long Beach	Seal Beach	Los Angeles County	Total Draining to Waterbody
Alamitos Bay	1.9%	60.9%	12.4%	24.8%	100.0%
Cabrillo Marina	1.0%	0.0%	0.0%	99.0%	100.0%
Consolidated Slip	1.6%	0.0%	0.0%	98.4%	100.0%
Fish Harbor	0.3%	0.0%	0.0%	99.7%	100.0%
Inner Cabrillo Beach Area	0.0%	0.0%	0.0%	100.0%	100.0%
Los Angeles River Estuary	1.2%	90.3%	0.0%	8.5%	100.0%
Inner Harbor	1.5%	21.2%	0.0%	77.4%	100.0%
Outer Harbor (inside breakwater)	0.1%	40.9%	0.0%	59.0%	100.0%
San Pedro Bay Near/Off Shore Zones	0.5%	81.7%	5.8%	12.0%	100.0%
Dominguez Channel Estuary	1.6%	2.7%	0.0%	95.7%	100.0%

Appendix III.2 – Dominguez Channel Freshwater Metals Loading Calculations

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Appendix III.2 Summary

The following sections present the wet weather LSPC modeling results for the freshwater sections of Dominguez Channel and the wet weather TMDLs calculated for total copper, total lead, and total zinc. In addition, input information used to calculate the TMDLs and allocations are defined.

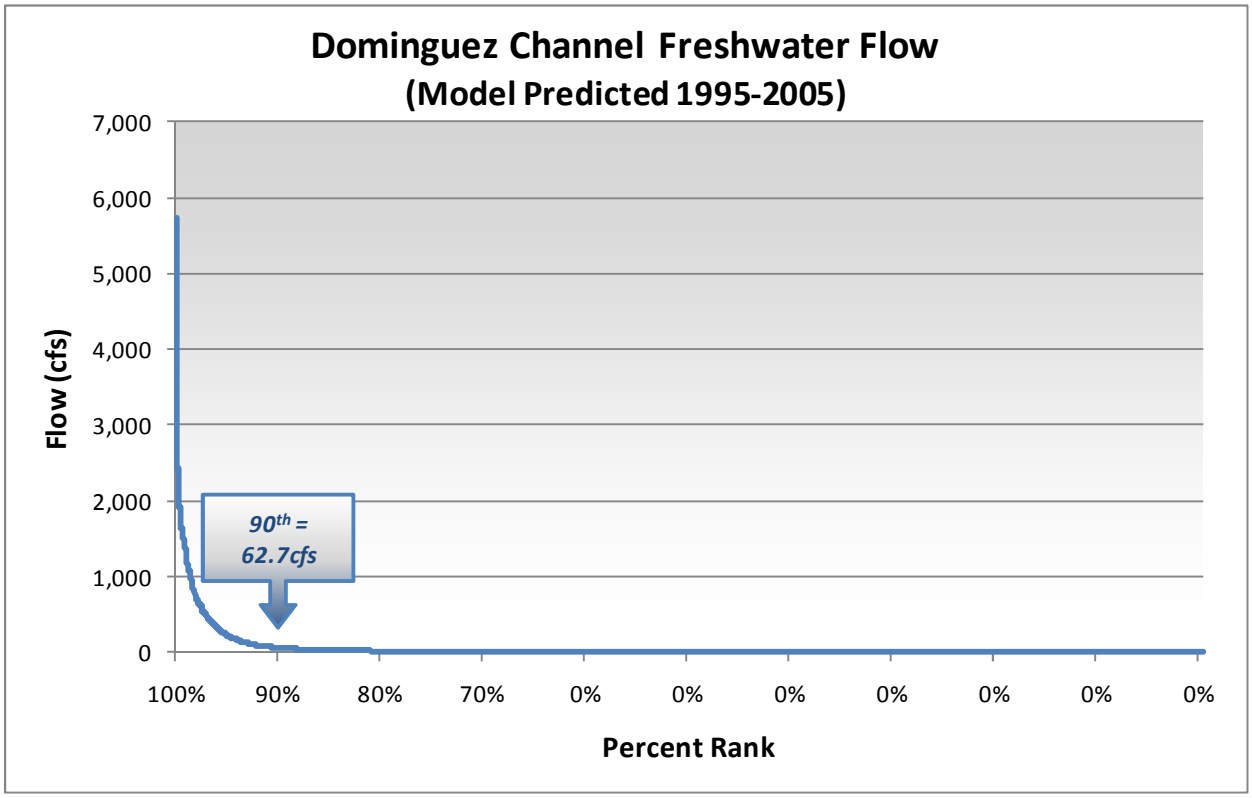
The LSPC model was run for an 11-year period (1995-2005) and output included daily average model results for flow and metals concentrations. Wet weather days were identified as greater than 62.7 cfs (90th percentile modeled flow; Figure III.2-1). Output associated with these wet days over the 11-year period were used to develop load duration curves. The loading capacity (blue lines in the figures below) was determined by multiplying the simulated water volume and the applicable numeric target (allowable load), while existing loads were calculated from the volume and associated simulated metals concentrations (modeled load). Copper and zinc existing loads were consistently above the allowable load, requiring 72 percent and 76 percent reductions, respectively. The overall average annual existing lead load is below the average annual allowable lead load (based on wet days in the 11-year modeling period); however, in certain instances, lead exceeds the allowable daily load, as indicated by the red bars in the lead load duration curve figure below (Figure III.2-3) (requiring a 3.1 percent reduction).

Section III.2-1. Wet Weather Modeling Results

Wet weather was defined as the 90th percentile flow (or greater). Using the 1995-2005 LSPC watershed model results, the 90th percentile flow is 62.7 cfs. The 90th percentile observed flow for 2001-2006 was 61.5 cfs, which is nearly identical to the modeled flow (less than a 2% difference). The LSPC modeled flows are presented by percent rank in Figure III.2-1.

Figure III.2-1. Model-Predicted Freshwater Flows in Dominguez Channel

Note: 90th percentile predicted flow is 62.7 cfs. 90th percentile observed flow is 61.5 cfs.



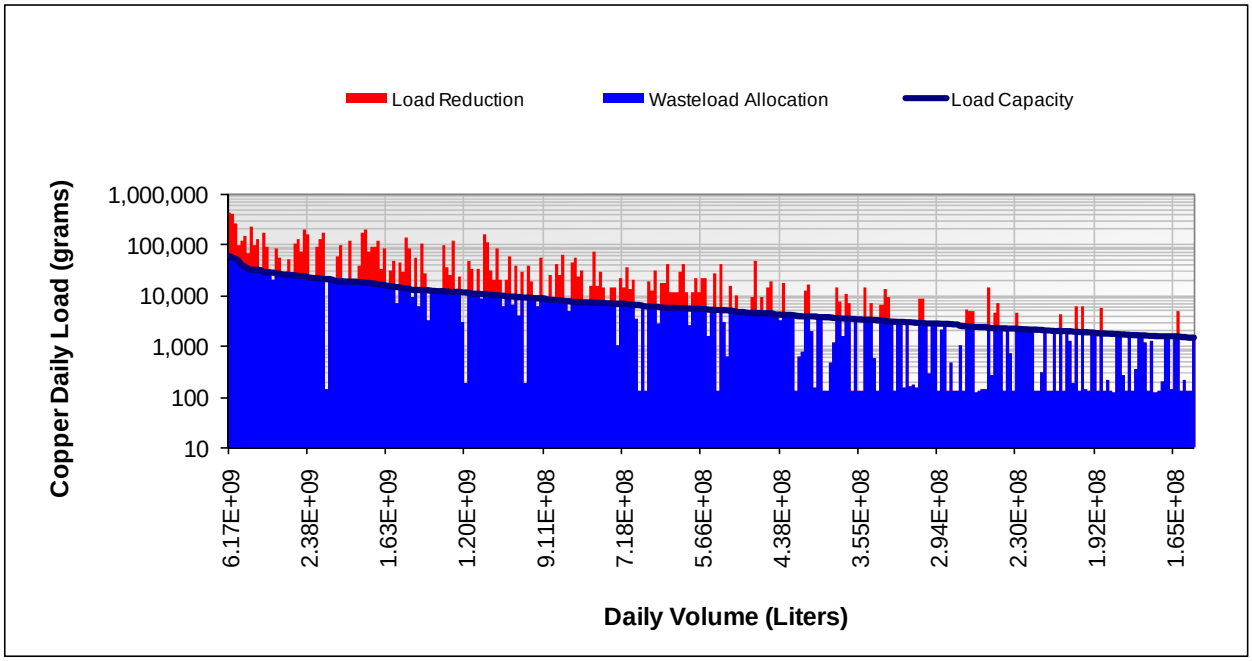
The loads presented in Table III.2-1 below are based the load duration curves; therefore, the numbers used in these calculations are from the bars in the load duration curves presented for each metal or the total loads under the loading capacity curves (Figures III.2-2 to III.2-4). Specifically, for the existing loads, the loads associated with all bars in the load duration curves are summed, but for the average annual allowable loads, the total possible loads below the loading capacity curve are summed. These total existing loads or total allowable loads (which are based solely on wet days over the eleven-year modeling period) were divided by eleven to yield average annual wet weather loads. It is important to note that these “annual” loads are only based on the wet days. If they are converted to average daily loads for comparison with the TMDL loads in Table III.2-2, they should be divided by an average of 28 wet days per year (in the eleven-year simulation period, there were a total of 307 wet days). The percent reductions

for all three metals in Table III.2-1 are estimates to provide readers with an approximate level of pollutant reductions required based on daily loads.

Table III.2-1. Dominguez Channel Freshwater – Modeled Annual Loading Summary

Dominguez Channel (freshwater), 1995-2005 Model Simulation (kg/year)			
	Total Copper	**Total Lead**	**Total Zinc**
Average Annual Allowable Load	245	1,080	1,763
Average Annual Modeled Load	776	440	6,747
Percent Reduction	**72.0%**	**3.1%**	**76.4%**

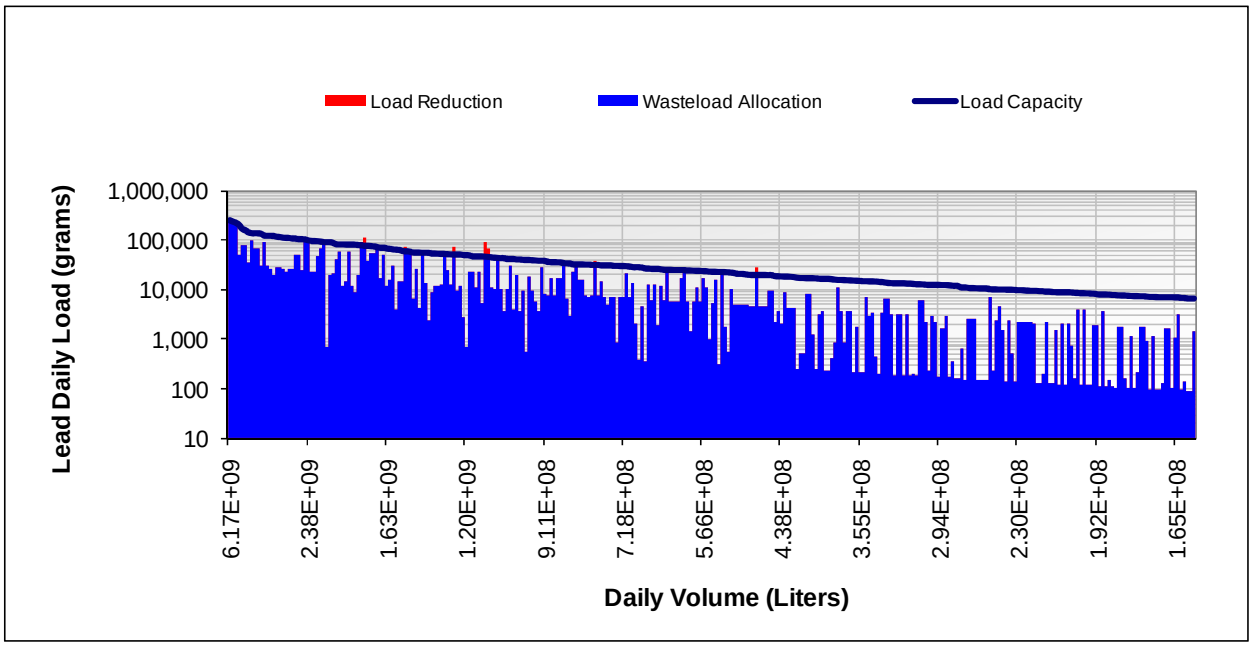
Figure III.2-2. Copper Load Duration Curve (by volume) for Wet Days



Computed Load Indicators:	Value	Units
Total Storms Over 11-Year Period	307	none
Total Below Load Capacity Curve:	2,695	kg
Existing Condition (Red and Blue)	8,538	kg
Existing Load Below Load Capacity Curve (Blue):	2,392	kg
Existing Load Above Load Capacity Curve (Red):	6,146	kg
TMDL Wasteload Reduction:	72.0%	none

Summary of Annual Average Loads	Value	Units
Average Annual Volume	24,305	million liters
Average Annual Existing Load	776	kg
Average Annual Exceedance Load	559	kg
Average Annual Load Capacity	245	kg
% Reduction	72.0%	none

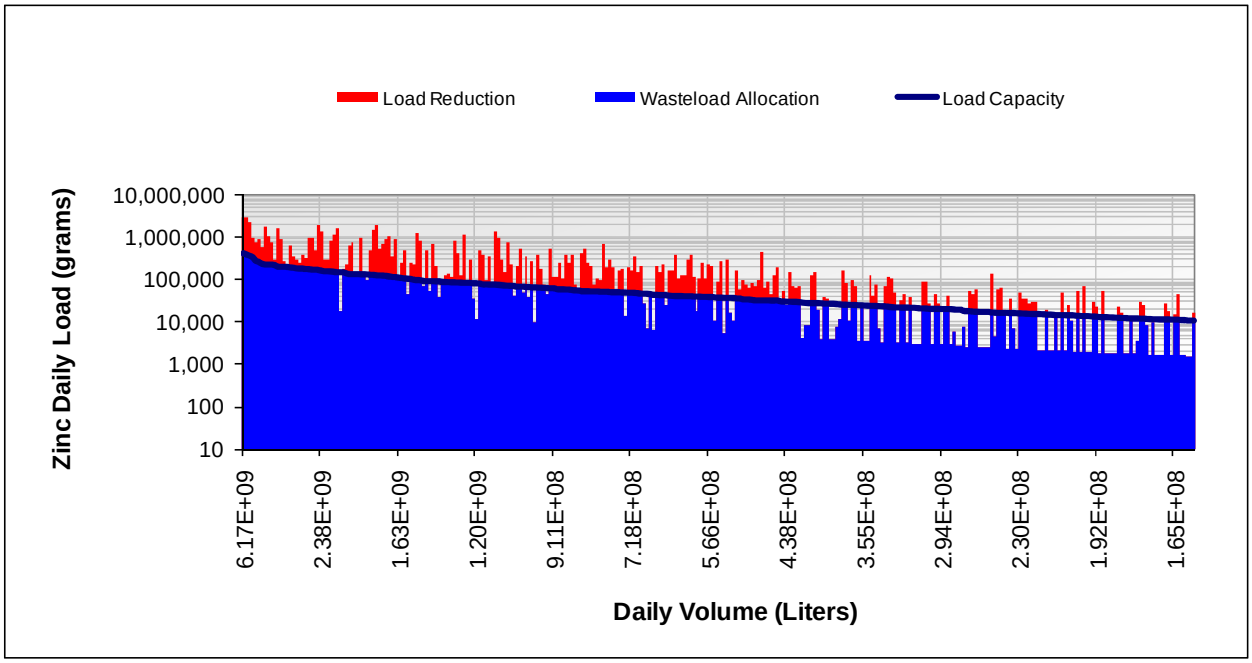
Figure III.2-3. Lead Load Duration Curve (by volume) for Wet Days



Computed Load Indicators:	Value	Units
Total Storms Over 11-Year Period	307	none
Total Below Load Capacity Curve:	11,885	kg
Existing Condition (Red and Blue)	4,837	kg
Existing Load Below Load Capacity Curve (Blue):	4,685	kg
Existing Load Above Load Capacity Curve (Red):	152	kg
TMDL Wasteload Reduction:	3.1%	none

Summary of Annual Average Loads	Value	Units
Average Annual Volume	24,305	million liters
Average Annual Existing Load	440	kg
Average Annual Exceedance Load	14	kg
Average Annual Load Capacity	1,080	kg
% Reduction	3.1%	none

Figure III.2-4. Zinc Load Duration Curve (by volume) for Wet Days



Computed Load Indicators:	Value	Units
Total Storms Over 11-Year Period	307	none
Total Below Load Capacity Curve:	19,393	kg
Existing Condition (Red and Blue)	74,220	kg
Existing Load Below Load Capacity Curve (Blue):	17,486	kg
Existing Load Above Load Capacity Curve (Red):	56,735	kg
TMDL Wasteload Reduction:	76.4%	none

Summary of Annual Average Loads	Value	Units
Average Annual Volume	24,305	million liters
Average Annual Existing Load	6,747	kg
Average Annual Exceedance Load	5,158	kg
Average Annual Load Capacity	1,763	kg
% Reduction	76.4%	none

Section III.2-2. Dominguez Channel Freshwater Wet Weather TMDL Calculations and Allocations

The TMDLs, or allowable loads, presented in Table III.2-2 below are based the numeric targets (values on the left side) (see Table III.2-3 for calculation of the total recoverable numeric targets using conversion factors). Allowable daily loads and allocations (values on the right side) are presented based on an example daily storm volume of 62.7 cfs (90th percentile observed flow; Figure III.2-1). Allocations for Los Angeles County Department of Public Works MS4 Permit and Caltrans Stormwater Permit are based on the percentages presented in Table III.2-4. Additional information is provided in Section 6.1 of the Staff Report.

Table III.2-2. TMDL Calculations and Allocations

	CONCENTRATIONS (µg/L) (x 10^{-6} x storm volume)			**LOADS based on 62.7 cfs (gram/day)**		
Calculation	**Total Copper**	**Total Lead**	**Total Zinc**	**Total Copper**	**Total Lead**	**Total Zinc**
TMDL	**9.7**	**42.7**	**69.7**	**1,485.1**	**6,548.8**	**10,685.5**
10% Explicit MOS	0.968	4.269	6.966	148.5	654.9	1,068.6
TMDL minus MOS (available for allocations)	8.713	38.422	62.692	1,336.6	5,894.0	9,617.0
	Allocations: µg/L (x 10^{-6} x storm volume)			**Allocations based on 62.7 cfs (gram/day)**		
Direct Deposition (0.3%)	0.0261	0.1153	0.1881	4.0	17.7	28.9
TMDL minus Direct Dep	8.687	38.307	62.504	1,332.6	5,876.3	9,588.1
Los Angeles County Dept. of Public Works MS4 Permit	8.476	37.378	60.988	1,300.3	5,733.7	9,355.5
Caltrans Stormwater Permit	0.211	0.929	1.516	32.3	142.6	232.6

Note: Allocations in the bottom half of the table for Los Angeles County Department of Public Works MS4 Permit and Caltrans Stormwater Permit are based on the percentages presented in Table III.2-4 below. Both the concentrations (left-hand set of allocations) and the loads (right-hand set of allocations) are distributed from the associated TMDL values above using these percentages.

Table III.2-3. Wet-weather numeric targets expressed as dissolved and total recoverable values

Metal	Target* (µg/L)	Dissolved to Total Conversion Factor	Target (µg/L)
	Dissolved		Total Recoverable
Copper	6.99	0.722	9.7
Lead	30.14	0.706	42.7
Zinc	65.13	0.935	69.7

** Targets are based on a median hardness of 50 mg/L (sample size = 35).*

Table III.2-4. Watershed Area by Permittee

Category	Area in Acres[1]	Percent of Watershed Area
Los Angeles County Dept. of Public Works MS4 Permit[2]	24,846	97.3%
Caltrans Stormwater Permit	618	2.4%
Water	76	0.3%
Total	**25,540**	**100%**

[1] Area calculations using the following data sources:
Watershed boundaries: County of Los Angeles, DPW GIS data (http://gis.dpw.lacounty.gov/oia/site_options.cfm)
City boundaries: County of Los Angeles, DPW GIS data (http://gis.dpw.lacounty.gov/oia/site_options.cfm)
Caltrans areas calculated based on US Highway and State Highway lengths (GIS layers from http://www.atlas.ca.gov/) multiplied by assumed average widths. Average widths determined from average lane and shoulder widths and average number of lanes (US highway width = 172 feet; State highway width = 101 feet)

[2] LACDPW MS4 Permit area used for the TMDL allocations was 97.6% since the total area used was 25,464 (land area only; i.e., water area was subtracted from the total area above).

Appendix III.3 – Initial Conditions for EFDC Model

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Appendix III.3 Summary

The following three tables include the initial chemical (organics and metals concentrations) and physical conditions used to populate the EFDC model. The distribution of initial concentrations were based on the observed data presented below. Specifically, observed concentrations were used to represent the grid cell at their specific location and the concentrations between the individual data points were estimated by interpolating between the known concentrations. See Appendix I, Section 7.1 for additional information.

Table III.3-1. Sediment Bed Initial Conditions – Organics Concentrations

Longitude	Latitude	Total DDT (mg/kg)	Total PAHs (mg/kg)	Total PCBs (mg/kg)	Year	TMDL Zone
-118.266129	33.761856	0.0324	21.566999	0.013700	2006	Los Angeles Inner Harbor
-118.276443	33.757252	0.03099	0.957900	0.025840	2006	Los Angeles Inner Harbor
-118.276642	33.757084	0.0316	4.114500	0.018200	2006	Los Angeles Inner Harbor
-118.250229	33.763939	0.03478	1.181600	0.036320	2006	Los Angeles Inner Harbor
-118.275215	33.765251	0.02057	0.842900	0.030000	2006	Los Angeles Inner Harbor
-118.270973	33.74873	0.003	0.265200		2006	Los Angeles Inner Harbor
-118.254234	33.761452	0.04197	1.090200	0.030190	2006	Los Angeles Inner Harbor
-118.260147	33.758026	0.04065	1.301400	0.025990	2006	Los Angeles Inner Harbor
-118.261147	33.756371	0.03684	1.526600	0.016910	2006	Los Angeles Inner Harbor
-118.27507	33.748257	0.0487	2.446400	0.043400	2006	Los Angeles Inner Harbor
-118.258835	33.727703	0.0153	0.123300		2006	Los Angeles Inner Harbor
-118.273338	33.728874	0.0244	0.747650	0.019150	2006	Los Angeles Inner Harbor
-118.262131	33.729378	0.0125	0.079700		2006	Los Angeles Inner Harbor
-118.275398	33.740715	0.007	0.221500	0.003600	2006	Los Angeles Inner Harbor
-118.251671	33.748417	0.0129	1.782500	0.060700	2006	Los Angeles Inner Harbor
-118.268829	33.730362	0.0486	10.178000	0.035500	2006	Los Angeles Inner Harbor
-118.270348	33.7257	0.0032	0.114500		2006	Los Angeles Inner Harbor
-118.276863	33.720718	0.1876	37.855999	0.207200	2006	Los Angeles Harbor - Cabrillo Marina
-118.264336	33.726715	0.02985	0.720500		2006	Los Angeles Inner Harbor
-118.247612	33.734066	0.0136	0.231400	0.001100	2006	Los Angeles Inner Harbor
-118.28009	33.712036	0.1515	1.113300	0.032700	2006	Los Angeles Harbor - Inner Cabrillo Beach
-118.281494	33.710442	0.0229	0.300400		2006	Los Angeles Harbor - Inner Cabrillo Beach
-118.276978	33.715755	0.1107	0.294900	0.006400	2006	Los Angeles Outer Harbor
-118.235764	33.714821	0.0586	0.220700	0.001500	2006	Los Angeles Outer Harbor
-118.274979	33.714191	0.0946	1.987300	0.023900	2006	Los Angeles Outer Harbor
-118.271591	33.711048	0.0279	0.611900	0.008000	2006	Los Angeles Outer Harbor
-118.271805	33.707703	0.0105	0.291300		2006	Los Angeles Outer Harbor
-118.251648	33.715622	0.0884	0.231000	0.009400	2006	Los Angeles Outer Harbor
-118.249382	33.711052	0.067	0.115700	0.006200	2006	Los Angeles Outer Harbor
-118.27108	33.713184	0.0394	0.911300	0.010200	2006	Los Angeles Outer Harbor
-118.217407	33.774048	0.075	5.394900	0.055600	2006	Long Beach Inner Harbor
-118.23262	33.766983	0.0241	0.815500	0.021500	2006	Long Beach Inner Harbor
-118.20472	33.771378	0.0025	0.740200		2006	Los Angeles River Estuary
-118.219826	33.768177	0.0696	2.940100	0.068600	2006	Long Beach Inner Harbor
-118.221428	33.765331	0.057	1.783900	0.023000	2006	Long Beach Inner Harbor
-118.21241	33.774307	0.0182	3.088300	0.014200	2006	Long Beach Inner Harbor
-118.223022	33.768414	0.0703	1.100500	0.047300	2006	Long Beach Inner Harbor
-118.211823	33.771019	0.0233	4.626000	0.036500	2006	Long Beach Inner Harbor

Longitude	Latitude	Total DDT (mg/kg)	Total PAHs (mg/kg)	Total PCBs (mg/kg)	Year	TMDL Zone
-118.217552	33.757893	0.01213	0.456800	0.006170	2006	Long Beach Inner Harbor
-118.220612	33.772102	0.02679	1.130800	0.009200	2006	Long Beach Inner Harbor
-118.19619	33.743042	0.0178	0.417900		2006	Long Beach Inner Harbor
-118.21376	33.755638	0.0169	0.746400	0.013700	2006	Long Beach Inner Harbor
-118.206978	33.746826	0.0292	3.657900	0.053100	2006	Long Beach Inner Harbor
-118.201187	33.742382	0.0039	0.120100		2006	Long Beach Inner Harbor
-118.232559	33.754124	0.0179	2.361300	0.037100	2006	Long Beach Inner Harbor
-118.227867	33.75016	0.0157	0.504800	0.024500	2006	Long Beach Inner Harbor
-118.187904	33.737217	0.01022	0.126550		2006	Long Beach Inner Harbor
-118.204094	33.740528	0.00496	0.950300		2006	Long Beach Inner Harbor
-118.225174	33.748158	0.0078	0.225800	0.001300	2006	Long Beach Inner Harbor
-118.203789	33.743156	0.0086	0.393700		2006	Long Beach Inner Harbor
-118.229446	33.721703	0.0518	0.312500		2006	Los Angeles Outer Harbor
-118.184067	33.753365	0.0332	0.651800	0.008500	2006	San Pedro Bay Near/Off Shore Zones
-118.221809	33.734745	0.0127	0.389300		2006	Los Angeles Outer Harbor
-118.222313	33.732468	0.00977	0.233200	0.001070	2006	Los Angeles Outer Harbor
-118.215019	33.731087	0.01536	0.201300	0.002130	2006	Los Angeles Outer Harbor
-118.232841	33.724655	0.01075	0.200150		2006	Los Angeles Outer Harbor
-118.19281	33.732067	0.0414	0.319400		2006	Los Angeles Outer Harbor
-118.213501	33.737457	0.01651	0.240700	0.001650	2006	Los Angeles Outer Harbor
-118.23111	33.735413	0.0405	0.403800	0.016600	2006	Los Angeles Outer Harbor
-118.212311	33.73381	0.0249	0.360900	0.001360	2006	Los Angeles Outer Harbor
-118.227898	33.807991	0.9132	5.226200	0.314800	2003	Dominguez Channel Estuary
-118.227898	33.807991	0.6092	3.567400	0.177000	2003	Dominguez Channel Estuary
-118.240547	33.820023	0.4073	4.529200	0.322500	2003	Dominguez Channel Estuary
-118.228149	33.809132	1.1469	4.109900	0.378300	2003	Dominguez Channel Estuary
-118.227058	33.803066	0.022	1.861800	0.012320	2003	Dominguez Channel Estuary
-118.235512	33.815979	0.057	3.868800	0.062300	2003	Dominguez Channel Estuary
-118.227112	33.802235	0.0093	9.086000	0.013230	2003	Dominguez Channel Estuary
-118.265999	33.844379	0.445	6.100000	1.500000	2002	Dominguez Channel Estuary
-118.265999	33.844379	0.9866	14.000000	0.840000	2002	Dominguez Channel Estuary
-118.269821	33.848305	0.219	2.700000	0.130000	2002	Dominguez Channel Estuary
-118.269821	33.848305	1.89	32.000000	2.000000	2002	Dominguez Channel Estuary
-118.287285	33.866657	1.17	24.000000	1.200000	2002	Dominguez Channel Estuary
-118.287285	33.866657	0.515	3.700000	0.150000	2002	Dominguez Channel Estuary
-118.287277	33.868874	0.0791	0.630000	0.068000	2002	Dominguez Channel Estuary
-118.287277	33.868874	0.0748	0.850000	0.056000	2002	Dominguez Channel Estuary
-118.287277	33.868874	0.506	2.500000	1.100000	2002	Dominguez Channel Estuary
-118.288803	33.870327	0.0349	59.000000	0.059000	2002	Dominguez Channel Estuary
-118.288803	33.870327	0.0643	1.000000	0.086000	2002	Dominguez Channel Estuary

Longitude	Latitude	Total DDT (mg/kg)	Total PAHs (mg/kg)	Total PCBs (mg/kg)	Year	TMDL Zone
-118.247208	33.826752	0.694	4.900000	0.500000	2002	Dominguez Channel Estuary
-118.249153	33.826534	0.1834	10.000000	0.170000	2002	Dominguez Channel Estuary
-118.258202	33.836483	0.831	2.800000	0.130000	2002	Dominguez Channel Estuary
-118.259247	33.837593	0.898	6.200000	0.260000	2002	Dominguez Channel Estuary
-118.26033	33.838703	0.2083	1.700000	0.170000	2002	Dominguez Channel Estuary
-118.228409	33.810669	0.55	3.300000	0.200000	2002	Dominguez Channel Estuary
-118.236168	33.81588	0.7	4.600000	1.200000	2002	Dominguez Channel Estuary
-118.238693	33.816574	1.736	1.700000	0.170000	2002	Dominguez Channel Estuary
-118.240646	33.821323	0.337	64.000000	0.780000	2002	Dominguez Channel Estuary
-118.240837	33.822742	0.8929	1.300000	0.180000	2002	Dominguez Channel Estuary
-118.235443	33.784019	0.1932	4.100000	2.300000	2002	Dominguez Channel Estuary
-118.228981	33.793499	0.015	0.440000	0.028000	2002	Dominguez Channel Estuary
-118.227829	33.798519	0.37	4.000000	0.470000	2002	Dominguez Channel Estuary
-118.226898	33.803123	0.1089	8.300000	0.099900	2002	Dominguez Channel Estuary
-118.26268	33.839687	0.144	20.000000	0.074000	2002	Dominguez Channel Estuary
-118.26268	33.839687	0.2097	4.400000	0.400000	2002	Dominguez Channel Estuary
-118.26265	33.841099	0.172	2.700000	0.120000	2002	Dominguez Channel Estuary
-118.26265	33.841099	0.1823	4.600000	0.140000	2002	Dominguez Channel Estuary
-118.263229	33.841599	0.1363	0.960000	0.075000	2002	Dominguez Channel Estuary
-118.263229	33.841599	1.563	18.000000	1.300000	2002	Dominguez Channel Estuary
-118.26326	33.841709	0.436	3.800000	0.220000	2002	Dominguez Channel Estuary
-118.26326	33.841709	0.864	9.000000	0.730000	2002	Dominguez Channel Estuary
-118.263672	33.842049	2.539	6.500000	0.260000	2002	Dominguez Channel Estuary
-118.263672	33.842049	0.392	14.000000	0.980000	2002	Dominguez Channel Estuary
-118.129417	33.755322	0.0029	0.084100		2003	Alamitos Bay
-118.111816	33.764885	0.0099	0.662000	0.015700	2003	Alamitos Bay
-118.112839	33.755314	0.0038	0.160900		2003	Alamitos Bay
-118.111633	33.75106	0.0051	0.409500	0.004200	2003	Alamitos Bay
-118.112694	33.765686	0.0169	0.431700		2003	Alamitos Bay
-118.279144	33.722775	0.16069	3.193100	0.051930	2003	Los Angeles Harbor - Cabrillo Marina
-118.241241	33.776897	0.0403	1.300000	0.027200	2002	Los Angeles Harbor - Consolidated Slip
-118.241241	33.776897	0.033	0.140250	0.023400	2002	Los Angeles Harbor - Consolidated Slip
-118.241241	33.776897	0.033	8.900000	0.020700	2002	Los Angeles Harbor - Consolidated Slip
-118.241241	33.776897	0.009	5.600000	0.022400	2002	Los Angeles Harbor - Consolidated Slip
-118.241241	33.776897	0.009	490.000000	0.023000	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	1.209	53.000000	0.910000	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	0.463	77.000000	0.177000	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	0.422	8.900000	0.119000	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	0.0102	14.000000	0.025300	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	0.0102	66.000000	0.024100	2002	Los Angeles Harbor - Consolidated Slip

Longitude	Latitude	Total DDT (mg/kg)	Total PAHs (mg/kg)	Total PCBs (mg/kg)	Year	TMDL Zone
-118.247131	33.77655	0.0084	8.100000	0.020300	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	0.0078	5.500000	0.160700	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	0.0078	130.000000	0.019000	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	1.922	50.000000	0.905000	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	0.579	5.700000	1.645000	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	0.1683	11.000000	0.265000	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	0.0126	110.000000	0.152000	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	0.0096	8.500000	0.021700	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	0.0096	7.000000	0.022400	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	0.0078	490.000000	0.018800	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	0.0084	0.429560	0.019600	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	1.911	0.430000	0.949000	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	0.892	11.000000	1.530000	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	0.0336	11.000000	0.020300	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	0.0078	63.000000	0.018200	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	0.0078	0.142420	0.018900	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	0.0078	7.100000	0.018200	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	0.0072	11.000000	0.016100	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	0.009	3.000000	0.020300	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	0.474	0.014000	0.302500	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	0.326	0.590000	0.230000	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	1.189	130.000000	0.739000	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	1.373	86.000000	1.850000	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	1.7038	25.000000	1.858500	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	0.3438	9.000000	1.140000	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	0.4974	10.000000	1.755000	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	0.5582	30.000000	3.785000	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	0.2028	0.280000	1.444000	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	0.4222	6.751800	0.671000	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	1.1928	19.000000	0.688500	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	1.7636	73.000000	1.908000	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	0.637	200.000000	3.575000	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	0.2558	0.530000	0.765000	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	0.009	0.390000	0.021000	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	0.0072	196.899994	0.016800	2002	Los Angeles Harbor - Consolidated Slip
-118.244186	33.774967	0.3906	8.370400	0.572500	2002	Los Angeles Harbor - Consolidated Slip
-118.244186	33.774967	0.508	12.590000	0.540000	2002	Los Angeles Harbor - Consolidated Slip
-118.244186	33.774967	0.975	30.669001	0.710500	2002	Los Angeles Harbor - Consolidated Slip
-118.244186	33.774967	1.6288	59.346001	1.298500	2002	Los Angeles Harbor - Consolidated Slip
-118.244186	33.774967	1.6158	0.016000	1.129000	2002	Los Angeles Harbor - Consolidated Slip

Longitude	Latitude	Total DDT (mg/kg)	Total PAHs (mg/kg)	Total PCBs (mg/kg)	Year	TMDL Zone
-118.244186	33.774967	1.3832	6.000000	1.745500	2002	Los Angeles Harbor - Consolidated Slip
-118.244186	33.774967	0.3128	8.600000	1.395000	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	0.1956	0.066000	0.428000	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	0.2566	0.023000	0.403500	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	0.3848	1.725800	1.456000	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	1.8486	9.100000	1.088000	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	0.5532	0.400000	0.562500	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	0.0133	0.055000	0.023600	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	0.0084	17.285000	0.019600	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	0.0078	130.000000	0.018200	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	0.2602	0.380000	0.491500	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	0.4336	4.347800	0.542500	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	0.5552	0.390000	0.801500	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	1.3258	7.800000	0.909000	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	0.3536	0.119760	0.483000	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	0.0072	220.000000	0.017500	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	0.0081	0.066000	0.018900	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	0.0072	7.000000	0.017500	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	0.4254	330.000000	0.458000	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	0.2645	5.800000	0.305500	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	0.4947	9.200000	0.799500	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	1.2354	31.000000	1.028500	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	0.4115	85.000000	1.238500	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	0.2334	680.000000	2.068000	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	0.0694	180.000000	0.163800	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	0.0225	11.000000	0.235400	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	0.2346	12.000000	0.462000	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	0.4169	0.061000	0.623000	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	0.2828	0.380000	0.441000	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	0.9141	0.400000	0.800500	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	1.7619	0.140000	1.599000	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	0.8366	140.000000	1.386500	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	0.0353	0.350000	0.123000	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	0.3573	0.063000	0.733000	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	0.3909	1800.000000	0.388500	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	0.6159	750.000000	0.869000	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	1.6908	0.100000	0.958000	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	1.2369	0.710000	1.299000	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	0.3465	0.390000	1.065000	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	0.0078	190.000000	0.019400	2002	Los Angeles Harbor - Consolidated Slip

Longitude	Latitude	Total DDT (mg/kg)	Total PAHs (mg/kg)	Total PCBs (mg/kg)	Year	TMDL Zone
-118.247139	33.773693	0.0078	140.000000	0.019000	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	0.7172	0.018890	16.822001	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	0.9409	18.000000	15.319000	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	1.7906	69.000000	0.657500	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	0.2552	0.127080	0.454000	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	0.1261	0.384820	0.203000	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	0.009	0.022000	0.021800	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	0.0078	21.000000	0.019000	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	0.0078	0.230000	0.018500	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	0.4308	5.837400	0.569000	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	0.3928	10.000000	0.749500	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	1.2598	6.000000	1.009000	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	0.6822	190.000000	1.366500	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	1.3644	640.000000	1.942000	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	0.0447	330.000000	0.110500	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	0.0084	12.000000	0.019700	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	0.0078	21.000000	0.021000	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	0.009	22.000000	0.026500	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	0.009	7.000000	0.022500	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	0.0096	9.200000	0.025800	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	0.0096	290.000000	0.026000	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	0.0078	0.230000	0.020300	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	0.0078	0.156880	0.020600	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	0.0078	14.000000	0.020300	2002	Los Angeles Harbor - Consolidated Slip
-118.249397	33.770981	0.2672	24.000000	2.392000	2002	Los Angeles Inner Harbor
-118.249397	33.770981	0.4011	530.000000	3.331500	2002	Los Angeles Inner Harbor
-118.249397	33.770981	0.4977	12.000000	0.967000	2002	Los Angeles Inner Harbor
-118.249397	33.770981	0.009	18.000000	0.023100	2002	Los Angeles Inner Harbor
-118.249397	33.770981	0.0084	54.000000	0.021100	2002	Los Angeles Inner Harbor
-118.249397	33.770981	0.0078	120.000000	0.023200	2002	Los Angeles Inner Harbor
-118.249397	33.770981	0.0072	13.000000	0.020400	2002	Los Angeles Inner Harbor
-118.249397	33.770981	0.0078	15.000000	0.019200	2002	Los Angeles Inner Harbor
-118.2481	33.766891	0.08285	0.807320	0.117210	2003	Los Angeles Inner Harbor
-118.261627	33.724464	0.1068	0.186050	0.002130	2003	Los Angeles Inner Harbor
-118.215065	33.745552	0.0099	0.113380		2003	Los Angeles Outer Harbor
-118.217766	33.752518	0.02441	0.334970		2003	Long Beach Inner Harbor
-118.277214	33.766346	0.0251	2.496200	0.075370	2003	Los Angeles Inner Harbor
-118.207733	33.762493	0.03621	2.580700	0.023910	2003	Long Beach Inner Harbor
-118.198273	33.748741	0.0307	3.184500		2003	Long Beach Inner Harbor
-118.205421	33.765663	0.0033	0.320100	0.000380	2003	Los Angeles River Estuary

Longitude	Latitude	Total DDT (mg/kg)	Total PAHs (mg/kg)	Total PCBs (mg/kg)	Year	TMDL Zone
-118.205421	33.773895	0.278	4.807200	0.712600	2003	Los Angeles River Estuary
-118.204819	33.779449	0.1556	3.035600	0.515700	2003	Los Angeles River Estuary
-118.205536	33.770031	0.0064	0.380800	0.002330	2003	Los Angeles River Estuary
-118.168518	33.74403	0.04039	0.355240	0.034190	2003	San Pedro Bay Near/Off Shore Zones
-118.156792	33.728451	0.05114	0.205590	0.005090	2003	San Pedro Bay Near/Off Shore Zones
-118.163353	33.754883	0.04113	0.287590	0.026270	2003	San Pedro Bay Near/Off Shore Zones
-118.234344	33.710922	0.0605		0.090000	2001	San Pedro Bay Near/Off Shore Zones
-118.234344	33.710922	0.02666		0.248100	2002	San Pedro Bay Near/Off Shore Zones
-118.234344	33.710922	0.0368		0.035900	2003	San Pedro Bay Near/Off Shore Zones
-118.234344	33.710922	0.0506		0.035900	2004	San Pedro Bay Near/Off Shore Zones
-118.10218	33.754917	0.0015	0.037800		2003	San Gabriel River Estuary
-118.113335	33.746525	0.0028	0.176960	0.000800	2003	San Gabriel River Estuary
-118.104942	33.752922	0.0022	0.157000		2003	San Gabriel River Estuary
-118.098228	33.758781	0.0037	1.876800		2003	San Gabriel River Estuary
-118.110046	33.749508	0.002	0.054100		2003	San Gabriel River Estuary
-118.1008	33.755856	0.00227	0.357500	0.000960	2003	San Gabriel River Estuary
-118.257408	33.712337	0.11952	0.181990		2003	Los Angeles Outer Harbor
-118.223854	33.724758	0.02767	0.157020		2003	Los Angeles Outer Harbor
-118.233002	33.73838	0.07416	0.268910		2003	Los Angeles Outer Harbor
-118.211411	33.722389	0.07928	0.242530		2003	Los Angeles Outer Harbor
-118.240974	33.724262	0.04558		0.090000	2001	Los Angeles Outer Harbor
-118.240974	33.724262	0.03196		0.248100	2002	Los Angeles Outer Harbor
-118.244949	33.713669	0.05758		0.090000	2001	Los Angeles Outer Harbor
-118.244949	33.713669	0.0264		0.310000	2002	Los Angeles Outer Harbor
-118.244949	33.713669	0.0345		0.036900	2004	Los Angeles Outer Harbor
-118.258713	33.712418	0.0529		0.090000	2001	Los Angeles Outer Harbor
-118.258713	33.712418	0.0676		0.310000	2002	Los Angeles Outer Harbor
-118.258713	33.712418	0.059		0.036900	2004	Los Angeles Outer Harbor
-118.270607	33.712944	0.0909		0.090000	2001	Los Angeles Outer Harbor
-118.270607	33.712944	0.04122		0.310000	2002	Los Angeles Outer Harbor
-118.270607	33.712944	0.054		0.036900	2004	Los Angeles Outer Harbor
-118.244507	33.72316	0.04051		0.090000	2001	Los Angeles Outer Harbor
-118.244507	33.72316	0.04706		0.310000	2002	Los Angeles Outer Harbor
-118.244507	33.72316	0.045		0.036900	2004	Los Angeles Outer Harbor
-118.242256	33.722816	0.04533		0.090000	2001	Los Angeles Outer Harbor
-118.242256	33.722816	0.03266		0.248100	2002	Los Angeles Outer Harbor
-118.242256	33.722816	0.0483		0.036900	2003	Los Angeles Outer Harbor
-118.242256	33.722816	0.0287		0.036900	2004	Los Angeles Outer Harbor
-118.231773	33.72599	0.0512		0.090000	2001	Los Angeles Outer Harbor
-118.231773	33.72599	0.02676		0.248100	2002	Los Angeles Outer Harbor

Longitude	Latitude	Total DDT (mg/kg)	Total PAHs (mg/kg)	Total PCBs (mg/kg)	Year	TMDL Zone
-118.231773	33.72599	0.0181		0.036900	2004	Los Angeles Outer Harbor
-118.239975	33.722561	0.0851		0.090000	2001	Los Angeles Outer Harbor
-118.239975	33.722561	0.04489		0.248100	2002	Los Angeles Outer Harbor
-118.243538	33.721428	0.03362		0.090000	2001	Los Angeles Outer Harbor
-118.243538	33.721428	0.05182		0.310000	2002	Los Angeles Outer Harbor
-118.243538	33.721428	0.039		0.036900	2004	Los Angeles Outer Harbor
-118.228813	33.722149	0.03973		0.090000	2001	Los Angeles Outer Harbor
-118.228813	33.722149	0.02896		0.248100	2002	Los Angeles Outer Harbor
-118.228813	33.722149	0.0393		0.036900	2004	Los Angeles Outer Harbor
-118.239738	33.718784	0.07452		0.090000	2001	Los Angeles Outer Harbor
-118.239738	33.718784	0.04313		0.310000	2002	Los Angeles Outer Harbor
-118.239738	33.718784	0.0173		0.036900	2004	Los Angeles Outer Harbor
-118.237854	33.716152	0.05626		0.090000	2001	Los Angeles Outer Harbor
-118.237854	33.716152	0.03318		0.248100	2002	Los Angeles Outer Harbor
-118.237854	33.716152	0.0481		0.036900	2004	Los Angeles Outer Harbor
-118.211411	33.722389		0.242530		2003	Los Angeles Outer Harbor
-118.200935	33.731632		0.059750		2003	Los Angeles Outer Harbor
-118.205360	33.780640		0.032900		2003	Los Angeles River Estuary
-118.116272	33.741222		0.027700		2003	San Pedro Bay Near/Off Shore Zones
-118.191193	33.730927		0.109760		2003	Los Angeles Outer Harbor

Table III.3-2. Sediment Bed Initial Conditions – Metals Concentrations

Longitude	Latitude	Total Copper (mg/kg)	Total Lead (mg/kg)	Total Zinc (mg/kg)	Year	TMDL Zone
-118.266129	33.761856	133.100006	42.509998	165.75	2006	Los Angeles Inner Harbor
-118.276443	33.757252	101.360001	27.684000	154.190002	2006	Los Angeles Inner Harbor
-118.276642	33.757084	104.300003	32.125000	153.399994	2006	Los Angeles Inner Harbor
-118.250229	33.763939	133.960007	52.504002	229.190002	2006	Los Angeles Inner Harbor
-118.275215	33.765251	48.683998	16.554001	93.677002	2006	Los Angeles Inner Harbor
-118.270973	33.74873	35.650002	9.371000	65.831001	2006	Los Angeles Inner Harbor
-118.254234	33.761452	97.984001	45.264000	207.589996	2006	Los Angeles Inner Harbor
-118.260147	33.758026	79.194000	38.383999	153.889999	2006	Los Angeles Inner Harbor
-118.261147	33.756371	99.524002	39.034000	191.389999	2006	Los Angeles Inner Harbor
-118.27507	33.748257	75.430000	35.680000	117.639999	2006	Los Angeles Inner Harbor
-118.258835	33.727703	51.916000	19.377001	91.051003	2006	Los Angeles Inner Harbor
-118.273338	33.728874	40.320000	17.170000	72.640999	2006	Los Angeles Inner Harbor
-118.262131	33.729378	45.136002	11.437000	86.960999	2006	Los Angeles Inner Harbor
-118.275398	33.740715	61.610001	8.859000	57.140999	2006	Los Angeles Inner Harbor
-118.251671	33.748417	72.825996	34.657001	123.449997	2006	Los Angeles Inner Harbor
-118.268829	33.730362	220.199997	50.119999	226.550003	2006	Los Angeles Inner Harbor
-118.270348	33.7257	70.599998	20.059999	116.139999	2006	Los Angeles Inner Harbor
-118.276863	33.720718	376.320007	74.077003	287.149994	2006	Los Angeles Harbor - Cabrillo Marina
-118.264336	33.726715	53.849998	13.800000	98.960999	2006	Los Angeles Inner Harbor
-118.247612	33.734066	58.529999	14.760000	106.550003	2006	Los Angeles Inner Harbor
-118.28009	33.712036	134.020004	21.806999	166.550003	2006	Los Angeles Harbor - Inner Cabrillo Beach
-118.281494	33.710442	48.226002	9.010000	96.901001	2006	Los Angeles Harbor - Inner Cabrillo Beach
-118.276978	33.715755	54.796001	16.747000	101.349998	2006	Los Angeles Outer Harbor
-118.235764	33.714821	51.390999	20.922001	101.300003	2006	Los Angeles Outer Harbor
-118.274979	33.714191	209.520004	28.226999	162.550003	2006	Los Angeles Outer Harbor
-118.271591	33.711048	75.475998	16.787001	121.849998	2006	Los Angeles Outer Harbor
-118.271805	33.707703	43.546001	7.230000	82.801003	2006	Los Angeles Outer Harbor
-118.251648	33.715622	51.355999	18.847000	100.25	2006	Los Angeles Outer Harbor
-118.249382	33.711052	50.175999	17.487000	94.280998	2006	Los Angeles Outer Harbor
-118.27108	33.713184	103.720001	19.927000	136.350006	2006	Los Angeles Outer Harbor
-118.217407	33.774048	94.671997	50.376999	363.880005	2006	Long Beach Inner Harbor
-118.23262	33.766983	77.476997	29.892000	152.830002	2006	Long Beach Inner Harbor
-118.20472	33.771378	8.863000	5.332000	44.296001	2006	Los Angeles River Estuary
-118.219826	33.768177	126.970001	50.257000	227.279999	2006	Long Beach Inner Harbor
-118.221428	33.765331	87.552002	36.067001	176.080002	2006	Long Beach Inner Harbor
-118.21241	33.774307	81.889999	41.060001	152.050003	2006	Long Beach Inner Harbor
-118.223022	33.768414	103.269997	44.777000	233.380005	2006	Long Beach Inner Harbor
-118.211823	33.771019	142.300003	46.380001	203.350006	2006	Long Beach Inner Harbor

Longitude	Latitude	Total Copper (mg/kg)	Total Lead (mg/kg)	Total Zinc (mg/kg)	Year	TMDL Zone
-118.217552	33.757893	70.374001	26.264000	144.339996	2006	Long Beach Inner Harbor
-118.220612	33.772102	116.059998	40.344002	226.990005	2006	Long Beach Inner Harbor
-118.19619	33.743042	76.781998	17.877001	99.876999	2006	Long Beach Inner Harbor
-118.21376	33.755638	64.489998	23.480000	119.75	2006	Long Beach Inner Harbor
-118.206978	33.746826	159.399994	30.150000	147.449997	2006	Long Beach Inner Harbor
-118.201187	33.742382	20.261999	5.521000	47.327	2006	Long Beach Inner Harbor
-118.232559	33.754124	56.251999	17.707001	95.357002	2006	Long Beach Inner Harbor
-118.227867	33.75016	49.962002	19.316999	97.647003	2006	Long Beach Inner Harbor
-118.187904	33.737217	47.923000	15.790000	102.589996	2006	Long Beach Inner Harbor
-118.204094	33.740528	15.653000	6.088000	41.176998	2006	Long Beach Inner Harbor
-118.225174	33.748158	29.172001	10.337000	67.647003	2006	Long Beach Inner Harbor
-118.203789	33.743156	94.142998	36.139999	193.089996	2006	Long Beach Inner Harbor
-118.229446	33.721703	38.952000	14.217000	90.167	2006	Los Angeles Outer Harbor
-118.184067	33.753365	80.309998	62.490002	278.549988	2006	San Pedro Bay Near/Off Shore Zones
-118.221809	33.734745	31.202000	19.327000	92.806999	2006	Los Angeles Outer Harbor
-118.222313	33.732468	27.413000	10.890000	75.046997	2006	Los Angeles Outer Harbor
-118.215019	33.731087	44.403000	20.610001	107.089996	2006	Los Angeles Outer Harbor
-118.232841	33.724655	67.321999	11.587000	136.679993	2006	Los Angeles Outer Harbor
-118.19281	33.732067	29.152000	14.337000	80.806999	2006	Los Angeles Outer Harbor
-118.213501	33.737457	45.333000	21.980000	111.690002	2006	Los Angeles Outer Harbor
-118.23111	33.735413	62.882000	30.337000	135.179993	2006	Los Angeles Outer Harbor
-118.212311	33.73381	47.912998	22.990000	119.690002	2006	Los Angeles Outer Harbor
-118.227898	33.807991	175	493	789	2003	Dominguez Channel Estuary
-118.240547	33.820023	248	288	666	2003	Dominguez Channel Estuary
-118.228149	33.809132	171	720	822	2003	Dominguez Channel Estuary
-118.227058	33.803066	26.400000	37.900002	86.900002	2003	Dominguez Channel Estuary
-118.235512	33.815979	117	139	461	2003	Dominguez Channel Estuary
-118.227112	33.802235	205	94.300003	254	2003	Dominguez Channel Estuary
-118.265999	33.844379	9.200000	29	57	2002	Dominguez Channel Estuary
-118.265999	33.844379	15	81	81	2002	Dominguez Channel Estuary
-118.269821	33.848305	73	270	290	2002	Dominguez Channel Estuary
-118.269821	33.848305	190	630	710	2002	Dominguez Channel Estuary
-118.287285	33.866657	51	300	460	2002	Dominguez Channel Estuary
-118.287285	33.866657	28	200	1600	2002	Dominguez Channel Estuary
-118.287277	33.868874	17	160	180	2002	Dominguez Channel Estuary
-118.287277	33.868874	13	370	140	2002	Dominguez Channel Estuary
-118.287277	33.868874	46	510	410	2002	Dominguez Channel Estuary
-118.288803	33.870327	38	43	190	2002	Dominguez Channel Estuary
-118.288803	33.870327	49	230	210	2002	Dominguez Channel Estuary
-118.247208	33.826752	91	490	590	2002	Dominguez Channel Estuary

Longitude	Latitude	Total Copper (mg/kg)	Total Lead (mg/kg)	Total Zinc (mg/kg)	Year	TMDL Zone
-118.249153	33.826534	400	170	490	2002	Dominguez Channel Estuary
-118.258202	33.836483	58	120	200	2002	Dominguez Channel Estuary
-118.259247	33.837593	100	190	450	2002	Dominguez Channel Estuary
-118.26033	33.838703	71	170	360	2002	Dominguez Channel Estuary
-118.228409	33.810669	79	310	430	2002	Dominguez Channel Estuary
-118.236168	33.81588	100	380	590	2002	Dominguez Channel Estuary
-118.238693	33.816574	84	160	370	2002	Dominguez Channel Estuary
-118.240646	33.821323	82	110	390	2002	Dominguez Channel Estuary
-118.240837	33.822742	110	160	320	2002	Dominguez Channel Estuary
-118.235443	33.784019	63	90	130	2002	Dominguez Channel Estuary
-118.228981	33.793499	40	30	87	2002	Dominguez Channel Estuary
-118.227829	33.798519	220	220	500	2002	Dominguez Channel Estuary
-118.226898	33.803123	140	55	150	2002	Dominguez Channel Estuary
-118.26268	33.839687	16	13	76	2002	Dominguez Channel Estuary
-118.26268	33.839687	8.700000	22	48	2002	Dominguez Channel Estuary
-118.26265	33.841099	11	31	61	2002	Dominguez Channel Estuary
-118.26265	33.841099	13	24	68	2002	Dominguez Channel Estuary
-118.263229	33.841599	6.700000	16	35	2002	Dominguez Channel Estuary
-118.263229	33.841599	30	160	190	2002	Dominguez Channel Estuary
-118.26326	33.841709	11	22	63	2002	Dominguez Channel Estuary
-118.26326	33.841709	30	110	170	2002	Dominguez Channel Estuary
-118.263672	33.842049	12	38	61	2002	Dominguez Channel Estuary
-118.263672	33.842049	41	160	150	2002	Dominguez Channel Estuary
-118.129417	33.755322	92.099998	67	190	2003	Alamitos Bay
-118.111816	33.764885	87.300003	61.549999	248	2003	Alamitos Bay
-118.112839	33.755314	85	44.400002	175	2003	Alamitos Bay
-118.111633	33.75106	60.799999	43.599998	175	2003	Alamitos Bay
-118.112694	33.765686	121	66.400002	260	2003	Alamitos Bay
-118.279144	33.722775	202	44.700001	180	2003	Los Angeles Harbor - Cabrillo Marina
-118.241241	33.776897	49	21	100	2002	Los Angeles Harbor - Consolidated Slip
-118.241241	33.776897	27	8.300000	70	2002	Los Angeles Harbor - Consolidated Slip
-118.241241	33.776897	25	7.400000	65	2002	Los Angeles Harbor - Consolidated Slip
-118.241241	33.776897	25	6.800000	57	2002	Los Angeles Harbor - Consolidated Slip
-118.241241	33.776897	43	14	84	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	3600	1100	1600	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	520	720	590	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	170	2700	5400	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	40	56	98	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	38	22	98	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	35	19	74	2002	Los Angeles Harbor - Consolidated Slip

Longitude	Latitude	Total Copper (mg/kg)	Total Lead (mg/kg)	Total Zinc (mg/kg)	Year	TMDL Zone
-118.247131	33.77655	12	4.100000	42	2002	Los Angeles Harbor - Consolidated Slip
-118.247131	33.77655	18	7.900000	51	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	1800	1100	1500	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	1800	660	1600	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	1400	660	1000	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	230	2900	4000	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	35	24	90	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	40	22	96	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	35	16	80	2002	Los Angeles Harbor - Consolidated Slip
-118.241966	33.776291	19	7.100000	64	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	170	1100	1000	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	730	820	930	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	31	43	84	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	14	7	45	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	18	7.400000	66	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	20	7.500000	59	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	24	8.100000	61	2002	Los Angeles Harbor - Consolidated Slip
-118.242188	33.775982	41	15	78	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	140	240	790	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	110	190	560	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	200	500	1200	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	220	950	1100	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	190	1000	1200	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	120	180	600	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	1000	730	1200	2002	Los Angeles Harbor - Consolidated Slip
-118.242554	33.775982	2500	770	2200	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	150	200	650	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	120	220	630	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	170	480	1000	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	170	690	950	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	740	680	1400	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	1100	590	890	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	33	26	81	2002	Los Angeles Harbor - Consolidated Slip
-118.244102	33.775574	13	6.100000	44	2002	Los Angeles Harbor - Consolidated Slip
-118.244186	33.774967	130	200	640	2002	Los Angeles Harbor - Consolidated Slip
-118.244186	33.774967	110	190	560	2002	Los Angeles Harbor - Consolidated Slip
-118.244186	33.774967	190	370	870	2002	Los Angeles Harbor - Consolidated Slip
-118.244186	33.774967	170	880	1100	2002	Los Angeles Harbor - Consolidated Slip
-118.244186	33.774967	170	1100	1100	2002	Los Angeles Harbor - Consolidated Slip
-118.244186	33.774967	160	710	840	2002	Los Angeles Harbor - Consolidated Slip

Longitude	Latitude	Total Copper (mg/kg)	Total Lead (mg/kg)	Total Zinc (mg/kg)	Year	TMDL Zone
-118.244186	33.774967	1900	680	1200	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	85	130	380	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	150	170	660	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	99	180	510	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	170	940	1100	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	830	560	1100	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	180	540	1000	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	8.200000	5.400000	39	2002	Los Angeles Harbor - Consolidated Slip
-118.244881	33.777294	6.700000	3.300000	47	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	130	170	570	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	170	180	570	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	150	230	600	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	170	660	830	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	85	190	310	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	5.500000	3.100000	31	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	7.500000	3.700000	47	2002	Los Angeles Harbor - Consolidated Slip
-118.245354	33.775436	5.400000	3	32	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	98	190	620	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	75	170	470	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	160	320	860	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	210	490	890	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	160	670	1100	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	920	660	1300	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	480	640	1000	2002	Los Angeles Harbor - Consolidated Slip
-118.245857	33.774441	440	200	180	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	120	150	590	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	160	200	780	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	220	170	610	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	170	360	610	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	220	690	1100	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	980	600	1200	2002	Los Angeles Harbor - Consolidated Slip
-118.246857	33.774662	120	1600	2300	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	170	200	850	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	110	150	590	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	170	480	3000	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	160	780	990	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	230	510	870	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	1600	950	1500	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	41	75	93	2002	Los Angeles Harbor - Consolidated Slip
-118.247139	33.773693	12	4.700000	38	2002	Los Angeles Harbor - Consolidated Slip

Longitude	Latitude	Total Copper (mg/kg)	Total Lead (mg/kg)	Total Zinc (mg/kg)	Year	TMDL Zone
-118.248001	33.773724	140	190	490	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	140	280	720	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	150	680	810	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	280	450	580	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	250	470	660	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	52	190	290	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	6.500000	2.200000	24	2002	Los Angeles Harbor - Consolidated Slip
-118.248001	33.773724	27	7	56	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	120	200	450	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	150	290	670	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	180	600	800	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	190	560	880	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	290	560	1000	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	670	950	1900	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	35	35	90	2002	Los Angeles Harbor - Consolidated Slip
-118.248032	33.772915	20	6.800000	58	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	47	21	120	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	44	16	96	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	32	13	100	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	14	4.600000	49	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	19	5.800000	56	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	22	6.700000	71	2002	Los Angeles Harbor - Consolidated Slip
-118.247948	33.772247	22	6.700000	72	2002	Los Angeles Harbor - Consolidated Slip
-118.249397	33.770981	140	140	340	2002	Los Angeles Inner Harbor
-118.249397	33.770981	140	150	560	2002	Los Angeles Inner Harbor
-118.249397	33.770981	150	260	580	2002	Los Angeles Inner Harbor
-118.249397	33.770981	27	13	63	2002	Los Angeles Inner Harbor
-118.249397	33.770981	43	15	73	2002	Los Angeles Inner Harbor
-118.249397	33.770981	34	12	84	2002	Los Angeles Inner Harbor
-118.249397	33.770981	26	7.700000	68	2002	Los Angeles Inner Harbor
-118.249397	33.770981	23	5.900000	66	2002	Los Angeles Inner Harbor
-118.2481	33.766891	191	90.599998	240	2003	Los Angeles Inner Harbor
-118.261627	33.724464	51.400002	8.030000	80.699997	2003	Los Angeles Inner Harbor
-118.215065	33.745552	20.600000	5.110000	46.200001	2003	Los Angeles Outer Harbor
-118.217766	33.752518	45.700001	10.600000	84.699997	2003	Long Beach Inner Harbor
-118.277214	33.766346	87.099998	28.600000	126	2003	Los Angeles Inner Harbor
-118.207733	33.762493		23.900000	139	2003	Long Beach Inner Harbor
-118.198273	33.748741	71.300003	70	241	2003	Long Beach Inner Harbor
-118.27504	33.77705	71		130	2001	Los Angeles Inner Harbor
-118.27504	33.77705	56		110	2002	Los Angeles Inner Harbor

Longitude	Latitude	Total Copper (mg/kg)	Total Lead (mg/kg)	Total Zinc (mg/kg)	Year	TMDL Zone
-118.27504	33.77705	26		56	2003	Los Angeles Inner Harbor
-118.278671	33.771515	78		140	2001	Los Angeles Inner Harbor
-118.278671	33.771515	63		120	2002	Los Angeles Inner Harbor
-118.278671	33.771515	25		52	2003	Los Angeles Inner Harbor
-118.281456	33.764576	38		75	2001	Los Angeles Inner Harbor
-118.281456	33.764576	31		26	2002	Los Angeles Inner Harbor
-118.281456	33.764576	36		68	2003	Los Angeles Inner Harbor
-118.20536	33.78064	5.740000	4.320000	49.049999	2003	Los Angeles River Estuary
-118.205421	33.765663	28.200001	33	98.800003	2003	Los Angeles River Estuary
-118.205421	33.773895	61.299999	37.200001	211	2003	Los Angeles River Estuary
-118.204819	33.779449	12.700000	7.610000	55.700001	2003	Los Angeles River Estuary
-118.205536	33.770031	24.600000	19.400000	101	2003	Los Angeles River Estuary
-118.116272	33.741222	7.460000	4.730000	22	2003	San Pedro Bay Near/Off Shore Zones
-118.168518	33.74403	51.500000	59.900002	180	2003	San Pedro Bay Near/Off Shore Zones
-118.156792	33.728451	51.700001	46.700001	168	2003	San Pedro Bay Near/Off Shore Zones
-118.163353	33.754883	71.800003	69.300003	240	2003	San Pedro Bay Near/Off Shore Zones
-118.234344	33.710922	10	6.500000	33	2001	San Pedro Bay Near/Off Shore Zones
-118.234344	33.710922	10.100000	8.090000	42.900002	2002	San Pedro Bay Near/Off Shore Zones
-118.234344	33.710922	9.440000	5.050000	47.099998	2003	San Pedro Bay Near/Off Shore Zones
-118.234344	33.710922	10.900000	3.290000	44.299999	2004	San Pedro Bay Near/Off Shore Zones
-118.10218	33.754917	9.120000	11.500000	37.200001	2003	San Gabriel River Estuary
-118.113335	33.746525	17	18.299999	47	2003	San Gabriel River Estuary
-118.104942	33.752922	13.500000	15.800000	43.5	2003	San Gabriel River Estuary
-118.098228	33.758781	14.500000	10.800000	39.599998	2003	San Gabriel River Estuary
-118.110046	33.749508	11.300000	21.400000	36.099998	2003	San Gabriel River Estuary
-118.110046	33.749508	11.600000	11.300000	37.299999	2003	San Gabriel River Estuary
-118.1008	33.755856	8	9.770000	48.299999	2003	San Gabriel River Estuary
-118.191193	33.730927	24.799999	10.400000	87.5	2003	Los Angeles Outer Harbor
-118.257408	33.712337	54.900002	7.950000	84.699997	2003	Los Angeles Outer Harbor
-118.223854	33.724758	48.700001	8.610000	76.199997	2003	Los Angeles Outer Harbor
-118.233002	33.73838	87	20.700001	122	2003	Los Angeles Outer Harbor
-118.200935	33.731632	43.599998	14.700000	118	2003	Los Angeles Outer Harbor
-118.211411	33.722389	43	12.800000	85.400002	2003	Los Angeles Outer Harbor
-118.244949	33.713669	20	7	41	2001	Los Angeles Outer Harbor
-118.244949	33.713669	38.900002	12.900000	85.699997	2002	Los Angeles Outer Harbor
-118.244949	33.713669	27.600000	0.610000	70.199997	2004	Los Angeles Outer Harbor
-118.258713	33.712418	28	8	55	2001	Los Angeles Outer Harbor
-118.258713	33.712418	54.700001	16.200001	109	2002	Los Angeles Outer Harbor
-118.258713	33.712418	61.099998	6.610000	116	2004	Los Angeles Outer Harbor
-118.270607	33.712944	57	13	63	2001	Los Angeles Outer Harbor

Longitude	Latitude	Total Copper (mg/kg)	Total Lead (mg/kg)	Total Zinc (mg/kg)	Year	TMDL Zone
-118.270607	33.712944	106	25.799999	132	2002	Los Angeles Outer Harbor
-118.270607	33.712944	76.400002	0.810000	134	2004	Los Angeles Outer Harbor
-118.240974	33.724262	19	8.100000	48	2001	Los Angeles Outer Harbor
-118.240974	33.724262	35.700001	15.200000	84.199997	2002	Los Angeles Outer Harbor
-118.244507	33.72316	21	7.100000	50	2001	Los Angeles Outer Harbor
-118.244507	33.72316	28.200001	10.600000	73	2002	Los Angeles Outer Harbor
-118.244507	33.72316	31.100000	2.900000	78.199997	2004	Los Angeles Outer Harbor
-118.242256	33.722816	21	8	50	2001	Los Angeles Outer Harbor
-118.242256	33.722816	43.400002	17	96.300003	2002	Los Angeles Outer Harbor
-118.242256	33.722816	32.299999	2.790000	90.099998	2003	Los Angeles Outer Harbor
-118.242256	33.722816	57	4.150000	117	2004	Los Angeles Outer Harbor
-118.231773	33.72599	22	12	52	2001	Los Angeles Outer Harbor
-118.231773	33.72599	38.299999	17.799999	89.5	2002	Los Angeles Outer Harbor
-118.231773	33.72599	61.400002	8.440000	123	2004	Los Angeles Outer Harbor
-118.239975	33.722561	29	14	58	2001	Los Angeles Outer Harbor
-118.239975	33.722561	40.099998	18.500000	90.099998	2002	Los Angeles Outer Harbor
-118.243538	33.721428	14	5	38	2001	Los Angeles Outer Harbor
-118.243538	33.721428	44.900002	14.800000	93.800003	2002	Los Angeles Outer Harbor
-118.243538	33.721428	55.599998	2.990000	109	2004	Los Angeles Outer Harbor
-118.228813	33.722149	20	10	48	2001	Los Angeles Outer Harbor
-118.228813	33.722149	27	30.299999	67.199997	2002	Los Angeles Outer Harbor
-118.228813	33.722149	46.299999	6.460000	100	2004	Los Angeles Outer Harbor
-118.239738	33.718784	17	14	43	2001	Los Angeles Outer Harbor
-118.239738	33.718784	24.100000	10.500000	60.799999	2002	Los Angeles Outer Harbor
-118.239738	33.718784	59.799999	2.240000	111	2004	Los Angeles Outer Harbor
-118.237854	33.716152	16	6.300000	41	2001	Los Angeles Outer Harbor
-118.237854	33.716152	34.400002	17.400000	82.400002	2002	Los Angeles Outer Harbor
-118.237854	33.716152	59.299999	1.680000	114	2004	Los Angeles Outer Harbor

Table III.3-3. Initial Physical Conditions

(Note: BDEN = density; PORO = porosity, –99 = not measured)

Longitude	Latitude	SAND	FINE	BDEN	PORO	YEAR	Study Name	Waterbody Name
-118.23000	33.79333	0.3984	0.6016	-99	-99	1999	Western EMAP 1999	Dominguez Channel Estuary
-118.22768	33.80225	0.32315	0.67685	1.53388	0.67644	2003	Bight 2003	Dominguez Channel Estuary
-118.22763	33.80308	0.82112	0.17888	1.81054	0.50876	2003	Bight 2003	Dominguez Channel Estuary
-118.22848	33.80801	0.16335	0.83665	1.4653	0.718	2003	Bight 2003	Dominguez Channel Estuary
-118.22874	33.80915	0.2929	0.7071	1.51079	0.69043	2003	Bight 2003	Dominguez Channel Estuary
-118.23612	33.81599	0.414	0.586	1.45205	0.72603	2003	Bight 2003	Dominguez Channel Estuary
-118.24117	33.82003	0.15396	0.84604	1.45997	0.72123	2003	Bight 2003	Dominguez Channel Estuary
-118.27700	33.71800	0.46486	0.53515	1.51793	0.6861	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles Harbor - Cabrillo Marina
-118.27720	33.72055	0.05265	0.94735	1.293	0.82242	2006	POLA/POLB 2006	Los Angeles Harbor - Cabrillo Marina
-118.27924	33.72082	0.00747	0.99252	-99	-99	2000	Biological Baseline Study 2000	Los Angeles Harbor - Cabrillo Marina
-118.27700	33.72100	0.33869	0.66131	1.48977	0.70317	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles Harbor - Cabrillo Marina
-118.27949	33.72260	0.1118	0.8882	1.2756	0.83297	2003	Bight 2003	Los Angeles Harbor - Cabrillo Marina
-118.24535	33.77488	0.08534	0.91466	-99	-99	2000	Biological Baseline Study 2000	Los Angeles Harbor - Consolidated Slip
-118.26592	33.72913	0.5675	0.4325	-99	-99	1997	BPTCP 1997	Los Angeles Harbor - Fish Harbor
-118.26128	33.73110	0.06	0.94	1.38446	0.76699	1998	Bight 1998	Los Angeles Harbor - Fish Harbor
-118.26760	33.73610	0.30063	0.69937	-99	-99	2000	Biological Baseline Study 2000	Los Angeles Harbor - Fish Harbor
-118.26673	33.73818	0.4542	0.5458	1.43904	0.73391	1999	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles Harbor - Fish Harbor
-118.28180	33.71025	0.39936	0.60064	1.477	0.71091	2006	POLA/POLB 2006	Los Angeles Harbor - Inner Cabrillo Beach Area
-118.28040	33.71185	0.05847	0.94153	1.506	0.69333	2006	POLA/POLB 2006	Los Angeles Harbor - Inner Cabrillo Beach Area
-118.28220	33.71538	0.1844	0.8156	-99	-99	1997	BPTCP 1997	Los Angeles Harbor - Inner Cabrillo Beach Area
-118.18450	33.75340	0.125	0.875	1.572	0.65333	2006	POLA/POLB 2006	Los Angeles River Estuary
-118.18510	33.75560	0.35	0.65	1.4653	0.718	1998	Bight 1998	Los Angeles River Estuary
-118.20589	33.76568	0.62363	0.37637	1.45469	0.72443	2003	Bight 2003	Los Angeles River Estuary
-118.20601	33.77005	0.27087	0.72913	1.90504	0.45149	2003	Bight 2003	Los Angeles River Estuary
-118.20520	33.77140	0.95646	0.04353	2.096	0.33576	2006	POLA/POLB 2006	Los Angeles River Estuary
-118.20591	33.77392	0.17139	0.82861	1.39772	0.75896	2003	Bight 2003	Los Angeles River Estuary
-118.20532	33.77948	0.54152	0.45848	1.8291	0.49752	2003	Bight 2003	Los Angeles River Estuary
-118.26198	33.72433	0.258	0.742	1.38805	0.76482	2003	Bight 2003	Los Angeles/Long Beach Inner Harbor
-118.27070	33.72555	0.10943	0.89057	1.44	0.73333	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor

Longitude	Latitude	SAND	FINE	BDEN	PORO	YEAR	Study Name	Waterbody Name
-118.25528	33.72611	0.1077	0.8923	-99	-99	1999	Western EMAP 1999	Los Angeles/Long Beach Inner Harbor
-118.26470	33.72658	0.29935	0.70065	1.583	0.64667	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.25920	33.72758	0.14194	0.85805	1.465	0.71818	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.27064	33.72796	0.18	0.82	1.40875	0.75227	1998	Bight 1998	Los Angeles/Long Beach Inner Harbor
-118.27370	33.72872	0.48595	0.51404	1.776	0.5297	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.26250	33.72925	0.27107	0.72894	1.682	0.58667	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.26920	33.73022	0.26103	0.73897	1.391	0.76303	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.25312	33.73160	0.15958	0.84042	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.27128	33.73322	0.6121	0.3879	1.79036	0.52099	2002	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.24800	33.73397	0.22501	0.775	1.529	0.67939	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.24238	33.73459	0.2	0.8	1.48426	0.70651	1998	Bight 1998	Los Angeles/Long Beach Inner Harbor
-118.18928	33.73671	0.598	0.402	1.89828	0.45559	2001	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.18830	33.73723	0.07722	0.92278	1.594	0.64	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.18843	33.73727	0.06258	0.93742	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.27648	33.73842	0.75336	0.24664	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.24558	33.73985	0.78882	0.21118	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.20450	33.74052	0.83493	0.16507	2.039	0.3703	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.27580	33.74057	0.82526	0.17474	1.854	0.48242	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.20160	33.74238	0.55903	0.44096	2.073	0.3497	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.25361	33.74278	0.5614	0.4386	-99	-99	1999	Western EMAP 1999	Los Angeles/Long Beach Inner Harbor
-118.19660	33.74305	0.17516	0.82484	1.681	0.58727	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.20420	33.74315	0.19112	0.80888	1.668	0.59515	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.19620	33.74370	0.24377	0.75622	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.23175	33.74400	0.25432	0.74568	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.20915	33.74433	0.59823	0.40173	1.74687	0.54735	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.21548	33.74553	0.78473	0.21527	1.72313	0.56174	2003	Bight 2003	Los Angeles/Long Beach Inner Harbor

Longitude	Latitude	SAND	FINE	BDEN	PORO	YEAR	Study Name	Waterbody Name
-118.22293	33.74600	0.23036	0.76965	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.21973	33.74630	0.2474	0.7526	-99	-99	1997	BPTCP 1997	Los Angeles/Long Beach Inner Harbor
-118.20740	33.74682	0.16889	0.83111	1.544	0.6703	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.21060	33.74707	0.16672	0.83328	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.25053	33.74782	0.05083	0.94917	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.27550	33.74812	0.44573	0.55427	1.577	0.6503	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.22560	33.74812	0.67036	0.32964	1.948	0.42545	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.25210	33.74833	0.01886	0.98114	1.655	0.60303	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.27140	33.74860	0.24092	0.75909	1.826	0.49939	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.19870	33.74875	0.1904	0.8096	1.37734	0.77131	2003	Bight 2003	Los Angeles/Long Beach Inner Harbor
-118.22000	33.74900	0.90934	0.09066	2.01751	0.38333	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.21703	33.74910	0.10651	0.89349	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.22830	33.75012	0.38429	0.61572	1.816	0.50545	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.22010	33.75100	0.73986	0.26015	1.96325	0.41621	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.22580	33.75140	0.39381	0.60618	1.72869	0.55837	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.22170	33.75180	0.36259	0.6374	1.71393	0.56731	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.21820	33.75250	0.3964	0.6036	1.49811	0.69812	2003	Bight 2003	Los Angeles/Long Beach Inner Harbor
-118.27473	33.75273	0.4477	0.5524	1.77258	0.53177	2001	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.21890	33.75290	0.44747	0.55253	1.70484	0.57283	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.22750	33.75330	0.61655	0.38345	1.72683	0.55949	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.23280	33.75350	0.50853	0.49148	1.78837	0.5222	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.26805	33.75357	0.2802	0.718	1.63374	0.61592	1999	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.27525	33.75373	0.4784	0.5215	1.81259	0.50752	2001	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor

Longitude	Latitude	SAND	FINE	BDEN	PORO	YEAR	Study Name	Waterbody Name
-118.27037	33.75382	0.6923	0.3077	-99	-99	1997	BPTCP 1997	Los Angeles/Long Beach Inner Harbor
-118.23300	33.75408	0.52004	0.47996	1.818	0.50424	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.23050	33.75410	0.50832	0.49168	1.70484	0.57283	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.27238	33.75463	0.3492	0.6507	1.67287	0.5922	1999	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.28328	33.75488	0.06491	0.93509	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.21420	33.75563	0.18464	0.81536	1.505	0.69394	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.26160	33.75627	0.25064	0.74935	1.648	0.60727	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.27710	33.75695	0.1552	0.84479	1.56	0.66061	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.27690	33.75712	0.12867	0.87134	1.547	0.66848	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.21800	33.75788	0.20383	0.79618	1.101	0.93879	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.27780	33.75788	0.7493	0.2507	1.90957	0.44875	2000	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.26060	33.75793	0.27559	0.72441	1.634	0.61576	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.21508	33.75860	0.2578	0.7422	1.40875	0.75227	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.20830	33.75948	0.00553	0.99446	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.25780	33.75960	0.3877	0.6136	1.66421	0.59745	1999	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.27598	33.76010	0.4695	0.5305	1.73993	0.55156	2000	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.25470	33.76137	0.19939	0.80061	1.59	0.64242	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.26660	33.76175	0.36801	0.632	1.687	0.58364	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.18375	33.76203	0.0658	0.9342	-99	-99	1997	BPTCP 1997	Los Angeles/Long Beach Inner Harbor
-118.25972	33.76218	0.58795	0.41206	1.78638	0.52341	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.20819	33.76250	0.0816	0.9184	1.3564	0.784	2003	Bight 2003	Los Angeles/Long Beach Inner Harbor
-118.25485	33.76265	0.28322	0.71678	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.25070	33.76387	0.25627	0.74373	1.521	0.68424	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.27460	33.76452	0.63146	0.36854	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor

Longitude	Latitude	SAND	FINE	BDEN	PORO	YEAR	Study Name	Waterbody Name
-118.27570	33.76513	0.61961	0.3804	1.669	0.59455	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.22190	33.76532	0.2365	0.7635	1.617	0.62606	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.23643	33.76597	0.5612	0.4387	1.73056	0.55724	1999	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.27770	33.76622	0.2405	0.7595	1.34279	0.79225	2003	Bight 2003	Los Angeles/Long Beach Inner Harbor
-118.24132	33.76646	0.26	0.74	1.40137	0.75674	1998	Bight 1998	Los Angeles/Long Beach Inner Harbor
-118.24858	33.76683	0.2613	0.7387	1.41247	0.75002	2003	Bight 2003	Los Angeles/Long Beach Inner Harbor
-118.23310	33.76695	0.18673	0.81327	1.66	0.6	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.23192	33.76718	0.5477	0.4523	1.76478	0.53649	1999	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.23255	33.76737	0.1988	0.80121	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.22030	33.76817	0.10928	0.89071	1.432	0.73818	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.22350	33.76840	0.11249	0.8875	1.592	0.64121	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.22453	33.76916	0.3	0.7	1.50091	0.69642	1998	Bight 1998	Los Angeles/Long Beach Inner Harbor
-118.22313	33.76928	0.0611	0.9389	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.21230	33.77103	0.23987	0.76012	1.52	0.68485	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.21028	33.77133	0.5462	0.4538	1.36718	0.77747	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.22270	33.77167	0.26013	0.73987	1.46664	0.71719	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.22110	33.77210	0.12003	0.87997	1.648	0.60727	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.21790	33.77405	0.37455	0.62546	1.591	0.64182	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.21290	33.77432	0.39507	0.60493	1.644	0.6097	2006	POLA/POLB 2006	Los Angeles/Long Beach Inner Harbor
-118.21467	33.77508	0.27817	0.7218	1.64827	0.60711	1998	POLA/POLB Special Studies (CSTF 1998-2002)	Los Angeles/Long Beach Inner Harbor
-118.21371	33.77515	0.30909	0.69092	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Inner Harbor
-118.26752	33.70712	0.72508	0.27493	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Outer Harbor
-118.27210	33.70753	0.155	0.845	1.463	0.71939	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.27390	33.70782	0.12165	0.87835	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Outer Harbor
-118.27517	33.70897	0.07865	0.92135	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Outer Harbor

Longitude	Latitude	SAND	FINE	BDEN	PORO	YEAR	Study Name	Waterbody Name
-118.27517	33.70903	0	1	-99	-99	1997	BPTCP 1997	Los Angeles/Long Beach Outer Harbor
-118.26325	33.70905	0.52801	0.47199	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Outer Harbor
-118.27018	33.71000	0	1	-99	-99	1997	BPTCP 1997	Los Angeles/Long Beach Outer Harbor
-118.24497	33.71053	0.9586	0.0414	-99	-99	1994	Bight 1994	Los Angeles/Long Beach Outer Harbor
-118.27190	33.71088	0.00786	0.99213	1.414	0.74909	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.24970	33.71093	0.07314	0.92686	1.582	0.64727	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.25773	33.71220	0.2346	0.7654	1.38685	0.76554	2003	Bight 2003	Los Angeles/Long Beach Outer Harbor
-118.27140	33.71302	0.00975	0.99026	1.361	0.78121	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.27530	33.71402	0.01487	0.98513	1.304	0.81576	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.27115	33.71440	0.036	0.964	-99	-99	1997	BPTCP 1997	Los Angeles/Long Beach Outer Harbor
-118.23610	33.71473	0.14348	0.85652	1.426	0.74182	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.25198	33.71550	0.04235	0.95765	1.472	0.71394	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.27730	33.71558	0.04602	0.95397	1.463	0.71939	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.27258	33.71598	0.5912	0.4088	-99	-99	1997	BPTCP 1997	Los Angeles/Long Beach Outer Harbor
-118.26894	33.71787	0.07298	0.92702	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Outer Harbor
-118.24025	33.71917	0.29412	0.70589	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Outer Harbor
-118.23250	33.71944	0.2448	0.7552	-99	-99	1999	Western EMAP 1999	Los Angeles/Long Beach Outer Harbor
-118.22980	33.72163	0.3613	0.63869	1.62	0.62424	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.21177	33.72235	0.3393	0.6607	1.45997	0.72123	2003	Bight 2003	Los Angeles/Long Beach Outer Harbor
-118.23530	33.72300	0.26	0.74	1.49532	0.69981	1998	Bight 1998	Los Angeles/Long Beach Outer Harbor
-118.21389	33.72389	0.7696	0.2304	-99	-99	1999	Western EMAP 1999	Los Angeles/Long Beach Outer Harbor
-118.21389	33.72389	0.7588	0.2412	-99	-99	1999	Western EMAP 1999	Los Angeles/Long Beach Outer Harbor
-118.23320	33.72458	0.04472	0.95528	1.318	0.80727	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.22422	33.72470	0.3473	0.6527	1.45205	0.72603	2003	Bight 2003	Los Angeles/Long Beach Outer Harbor
-118.19209	33.72833	0.35773	0.64227	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Outer Harbor
-118.23380	33.72910	0.37	0.63	1.4653	0.718	1998	Bight 1998	Los Angeles/Long Beach Outer Harbor
-118.19158	33.73093	0.5415	0.4585	1.59639	0.63855	2003	Bight 2003	Los Angeles/Long Beach Outer Harbor
-118.21540	33.73105	0.15377	0.84623	1.48	0.70909	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor

Longitude	Latitude	SAND	FINE	BDEN	PORO	YEAR	Study Name	Waterbody Name
-118.23526	33.73108	0.27	0.73	1.44163	0.73235	1998	Bight 1998	Los Angeles/Long Beach Outer Harbor
-118.20132	33.73162	0.2859	0.7141	1.45469	0.72443	2003	Bight 2003	Los Angeles/Long Beach Outer Harbor
-118.19320	33.73207	0.24808	0.75192	1.829	0.49758	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.22270	33.73242	0.43151	0.5685	1.791	0.52061	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.23817	33.73273	0.49727	0.50272	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Outer Harbor
-118.23817	33.73273	0.80179	0.19821	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Outer Harbor
-118.23685	33.73313	0.36956	0.63043	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Outer Harbor
-118.22334	33.73333	0.24121	0.75879	-99	-99	2000	Biological Baseline Study 2000	Los Angeles/Long Beach Outer Harbor
-118.21270	33.73378	0.1318	0.8682	1.871	0.47212	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.23149	33.73426	0.74	0.26	1.72498	0.56062	1998	Bight 1998	Los Angeles/Long Beach Outer Harbor
-118.22220	33.73470	0.20092	0.79907	1.84	0.49091	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.22098	33.73490	0.241	0.759	-99	-99	1997	BPTCP 1997	Los Angeles/Long Beach Outer Harbor
-118.23150	33.73535	0.08421	0.91579	1.51	0.69091	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.21390	33.73743	0.10932	0.89067	1.539	0.67333	2006	POLA/POLB 2006	Los Angeles/Long Beach Outer Harbor
-118.23340	33.73832	0.1462	0.8538	1.30674	0.8141	2003	Bight 2003	Los Angeles/Long Beach Outer Harbor
-118.11375	33.74664	0.83373	0.16627	1.81196	0.5079	2003	Bight 2003	San Gabriel River Estuary/Alamitos Bay
-118.11047	33.74963	0.8207	0.1793	1.80123	0.5144	2003	Bight 2003	San Gabriel River Estuary/Alamitos Bay
-118.11206	33.75118	0.51556	0.48444	1.58194	0.64731	2003	Bight 2003	San Gabriel River Estuary/Alamitos Bay
-118.11273	33.75187	0.2175	0.7825	-99	-99	1997	BPTCP 1997	San Gabriel River Estuary/Alamitos Bay
-118.10537	33.75305	0.94561	0.05439	1.90959	0.44873	2003	Bight 2003	San Gabriel River Estuary/Alamitos Bay
-118.10261	33.75505	0.89197	0.10803	1.8615	0.47788	2003	Bight 2003	San Gabriel River Estuary/Alamitos Bay
-118.12985	33.75543	0.08047	0.91953	1.34795	0.78912	2003	Bight 2003	San Gabriel River Estuary/Alamitos Bay
-118.11327	33.75544	0.39829	0.60171	1.51123	0.69016	2003	Bight 2003	San Gabriel River Estuary/Alamitos Bay
-118.10123	33.75599	0.9169	0.0831	1.88355	0.46452	2003	Bight 2003	San Gabriel River Estuary/Alamitos Bay
-118.09866	33.75892	0.68269	0.31731	1.69496	0.57881	2003	Bight 2003	San Gabriel River Estuary/Alamitos Bay
-118.11226	33.76502	0.46831	0.53169	1.55267	0.66505	2003	Bight 2003	San Gabriel River Estuary/Alamitos Bay
-118.11314	33.76582	0.3233	0.6767	1.46924	0.71561	2003	Bight 2003	San Gabriel River Estuary/Alamitos Bay
-118.16028	33.71783	0.7081	0.2919	-99	-99	1994	Bight 1994	San Pedro Bay Near/Off Shore Zones

Longitude	Latitude	SAND	FINE	BDEN	PORO	YEAR	Study Name	Waterbody Name
-118.13125	33.72158	0.954	0.046	-99	-99	1994	Bight 1994	San Pedro Bay Near/Off Shore Zones
-118.20733	33.72203	0.9	0.1	-99	-99	1994	Bight 1994	San Pedro Bay Near/Off Shore Zones
-118.15718	33.72850	0.1575	0.8425	1.34956	0.78814	2003	Bight 2003	San Pedro Bay Near/Off Shore Zones
-118.16562	33.73125	0.2008	0.7992	-99	-99	1997	BPTCP 1997	San Pedro Bay Near/Off Shore Zones
-118.14163	33.73240	0.1879	0.8121	-99	-99	1997	BPTCP 1997	San Pedro Bay Near/Off Shore Zones
-118.14513	33.73405	0.237	0.763	-99	-99	1994	Bight 1994	San Pedro Bay Near/Off Shore Zones
-118.18411	33.73478	0.178	0.822	1.66248	0.59849	2001	POLA/POLB Special Studies (CSTF 1998-2002)	San Pedro Bay Near/Off Shore Zones
-118.18292	33.73871	0.245	0.755	1.67987	0.58796	2001	POLA/POLB Special Studies (CSTF 1998-2002)	San Pedro Bay Near/Off Shore Zones
-118.18310	33.73923	0.87221	0.12779	-99	-99	2000	Biological Baseline Study 2000	San Pedro Bay Near/Off Shore Zones
-118.11668	33.74133	1	0	1.97533	0.40889	2003	Bight 2003	San Pedro Bay Near/Off Shore Zones
-118.17722	33.74139	0.194	0.806	-99	-99	1999	Western EMAP 1999	San Pedro Bay Near/Off Shore Zones
-118.14000	33.74333	0.2859	0.7141	-99	-99	1999	Western EMAP 1999	San Pedro Bay Near/Off Shore Zones
-118.16893	33.74408	0.2182	0.7818	1.47608	0.71147	2003	Bight 2003	San Pedro Bay Near/Off Shore Zones
-118.15472	33.75444	0.5192	0.4808	-99	-99	1999	Western EMAP 1999	San Pedro Bay Near/Off Shore Zones
-118.16379	33.75495	0.0832	0.9168	1.26157	0.84147	2003	Bight 2003	San Pedro Bay Near/Off Shore Zones
-118.18723	33.75892	0	1	-99	-99	1997	BPTCP 1997	San Pedro Bay Near/Off Shore Zones
-118.18983	33.75925	0	1	-99	-99	1997	BPTCP 1997	San Pedro Bay Near/Off Shore Zones

Appendix III.4 – Applicable Maps

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Figure III.4-1. Jurisdictions Draining to Freshwater and Estuarine Segments of the Dominguez Channel.....43

Figure III.4-2. Jurisdictions Draining to the Nearshore Subwatersheds 44

Figure III.4-3. SQO Monitoring Stations by Study.....45

GIS Data Sources:

Watershed boundaries: Calwater GIS layer (http://www.atlas.ca.gov/) delineated using stream reach and storm drain layers (see Appendix II for more information) or County of Los Angeles, DPW GIS data (http://gis.dpw.lacounty.gov/oia/site_options.cfm)

City boundaries: County of Los Angeles, DPW GIS data (http://gis.dpw.lacounty.gov/oia/site_options.cfm)

GIS layer of the 2006 303(d) list (http://www.waterboards.ca.gov/water_issues/programs/tmdl/303d_lists2006_gis.shtml)

Monitoring data: location information from Statewide Sediment Database or study-specific information

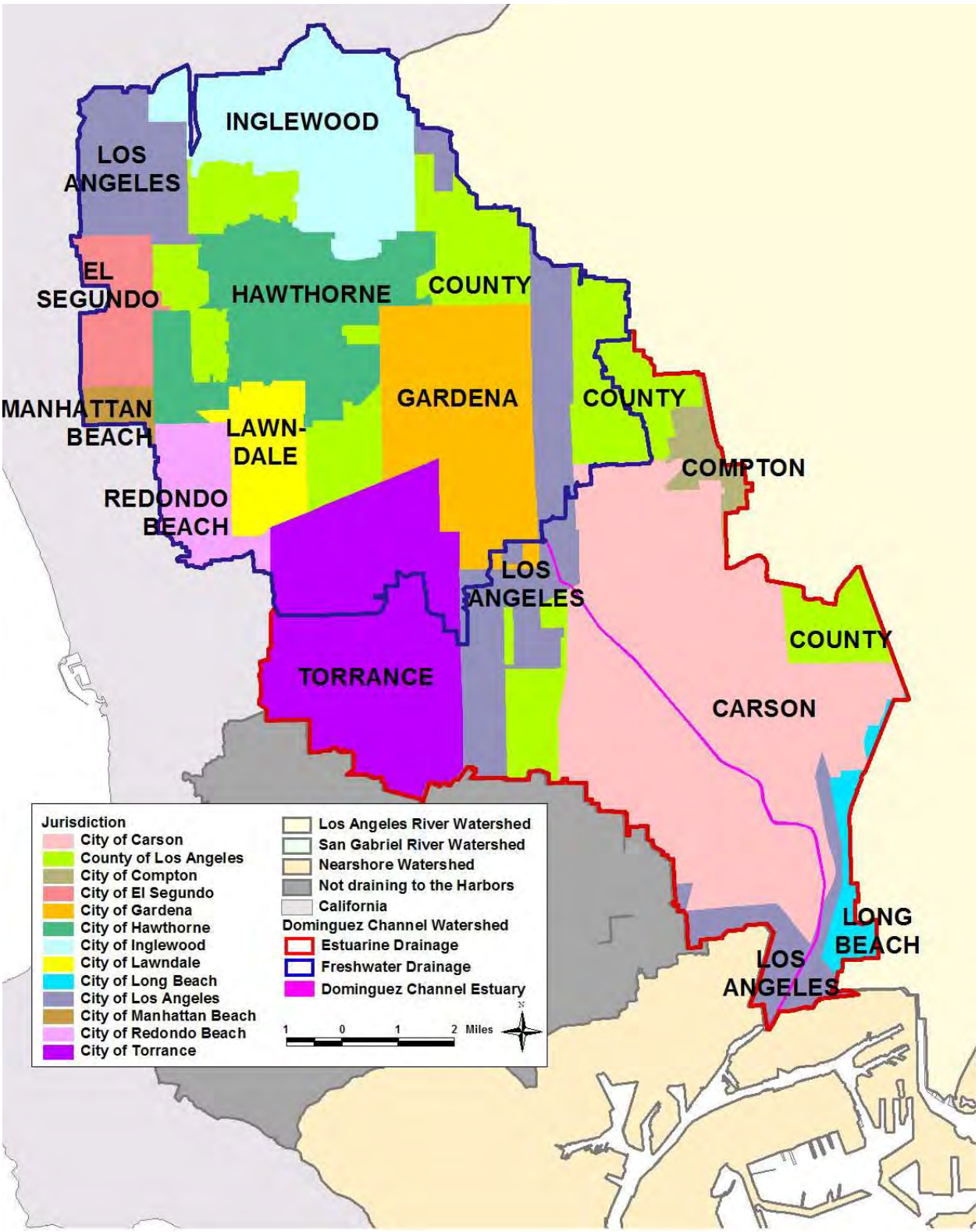

Figure III.4-1. Jurisdictions Draining to Freshwater and Estuarine Segments of the Dominguez Channel

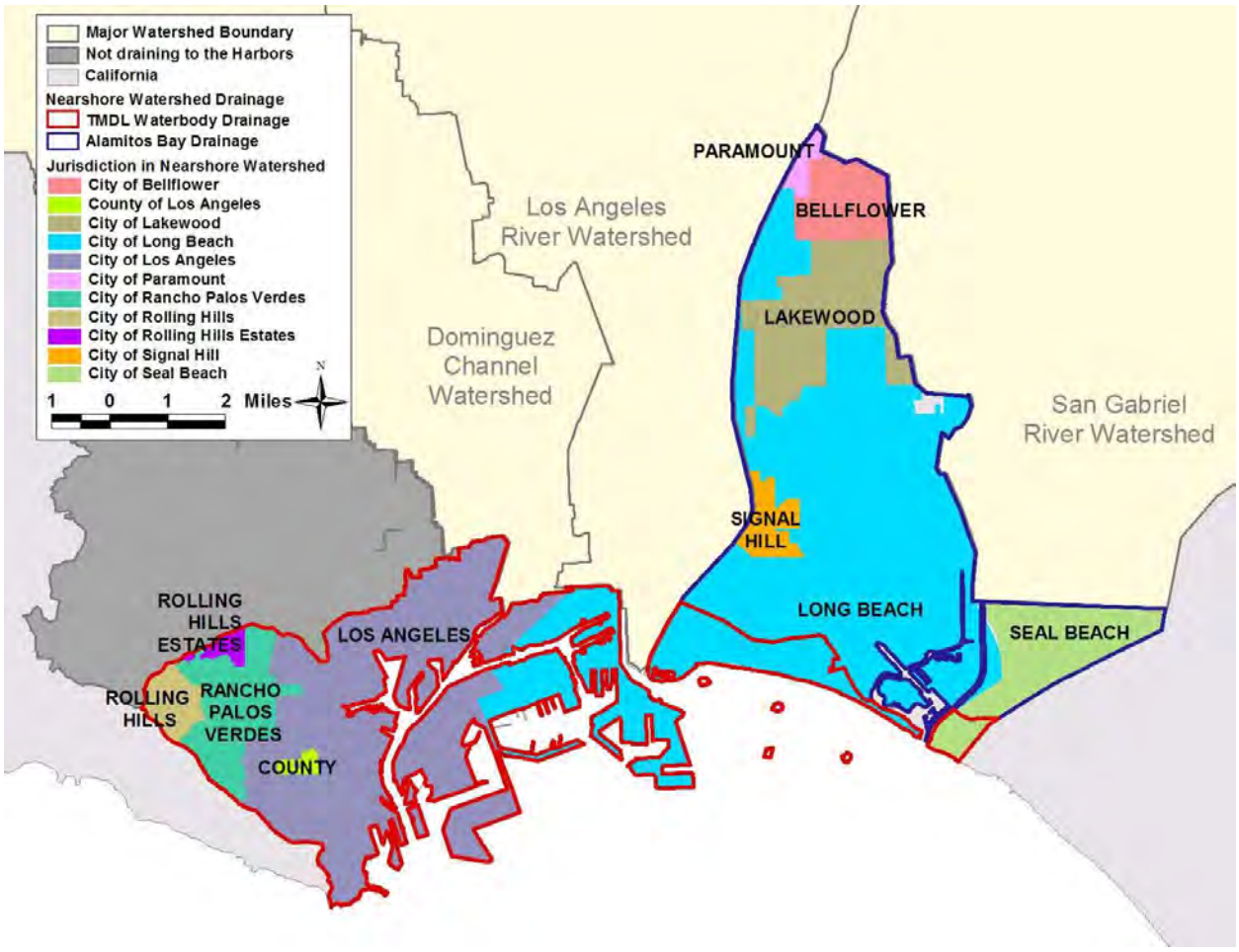

Figure III.4-2. Jurisdictions Draining to the Nearshore Subwatersheds

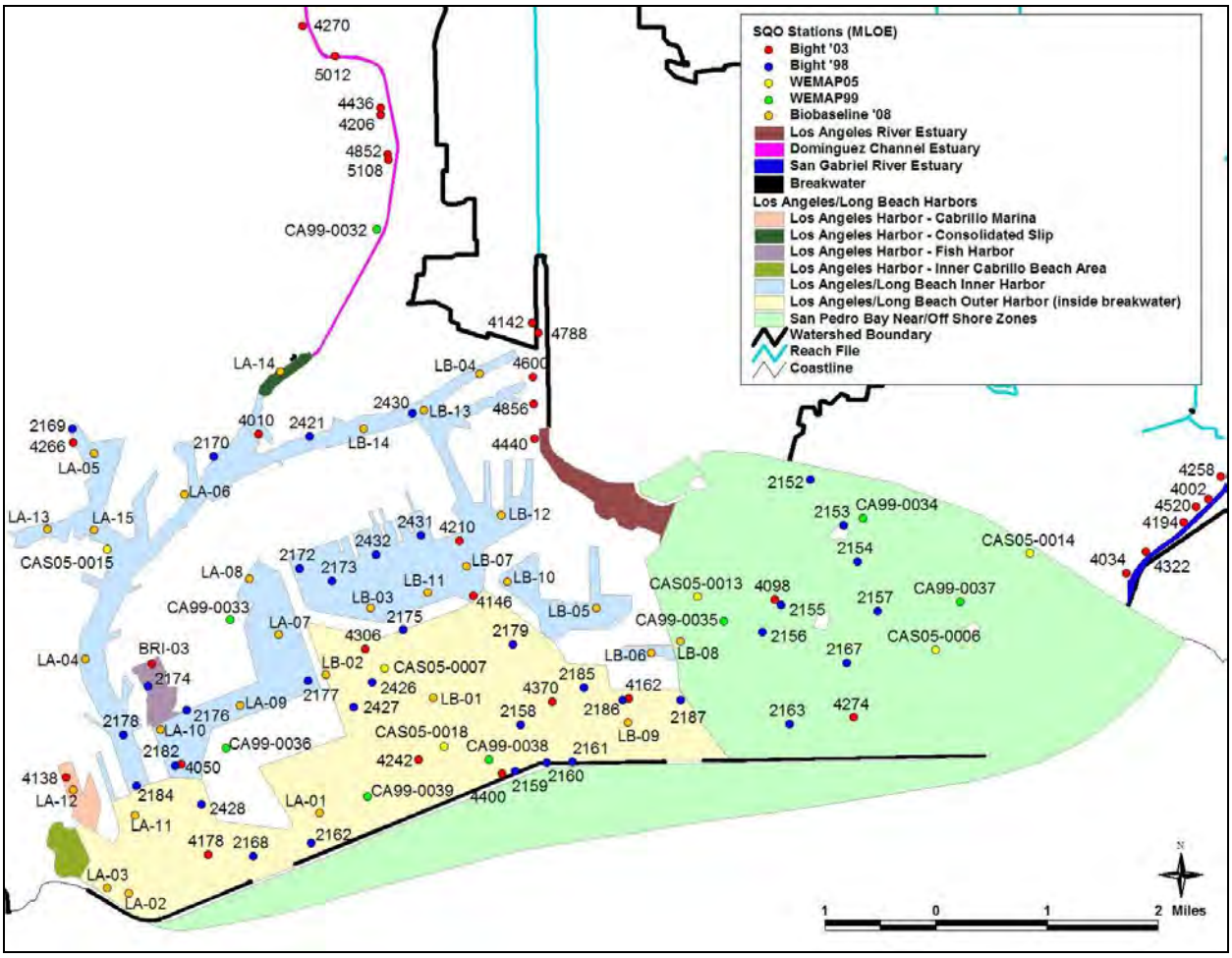

Figure III.4-3. SQO Monitoring Stations by Study

Note: the SQO Monitoring Station map illustrates stations that have sediment triad results by study (for data collected from 1998 to 2008; Bight 2008 data are not included in this map).

Appendix III.5 – SCCWRP Flux Monitoring Study

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Presentation on Flux of Trace Metals and Organics 47

Appendix III.5 Summary

The following section includes a presentation (by K. Schiff, SCCWRP) describing results of air-water and sediment-water flux for trace metals and organics, to Harbor Toxics TMDLs Technical Advisory Group on Sept. 17, 2009.

Atmospheric Deposition is a Potentially Large Contributor

- Atmospheric deposition of trace metals a significant source to Santa Monica Bay
  - Indirect deposition could be a large fraction of stormwater runoff
- Large scale distribution of trace metal deposition is unknown
  - Last large scale study was in 1975
- Deposition of organics previously unstudied

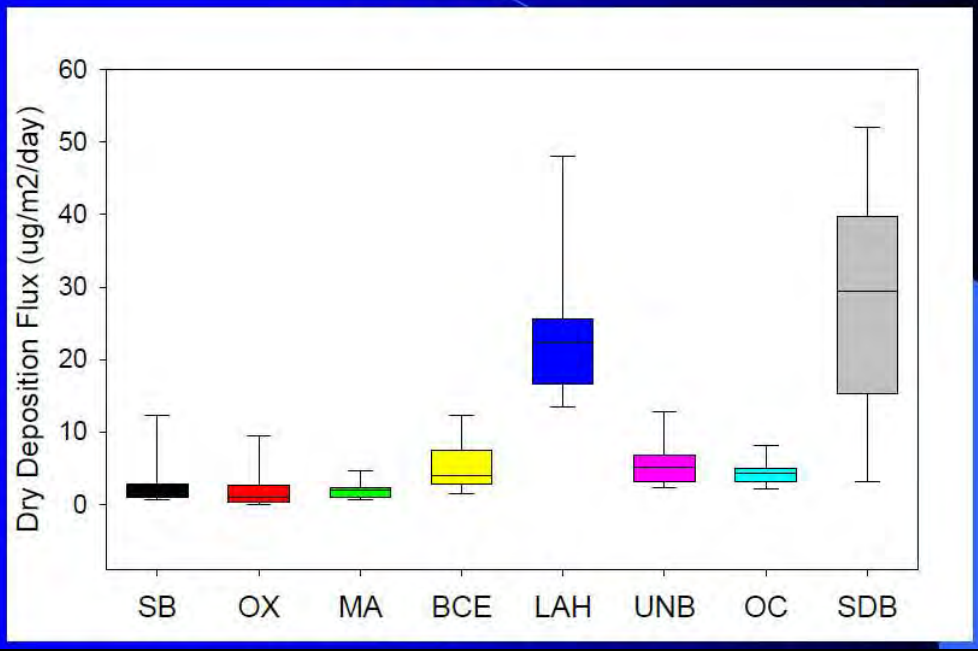
Atmospheric Deposition Questions

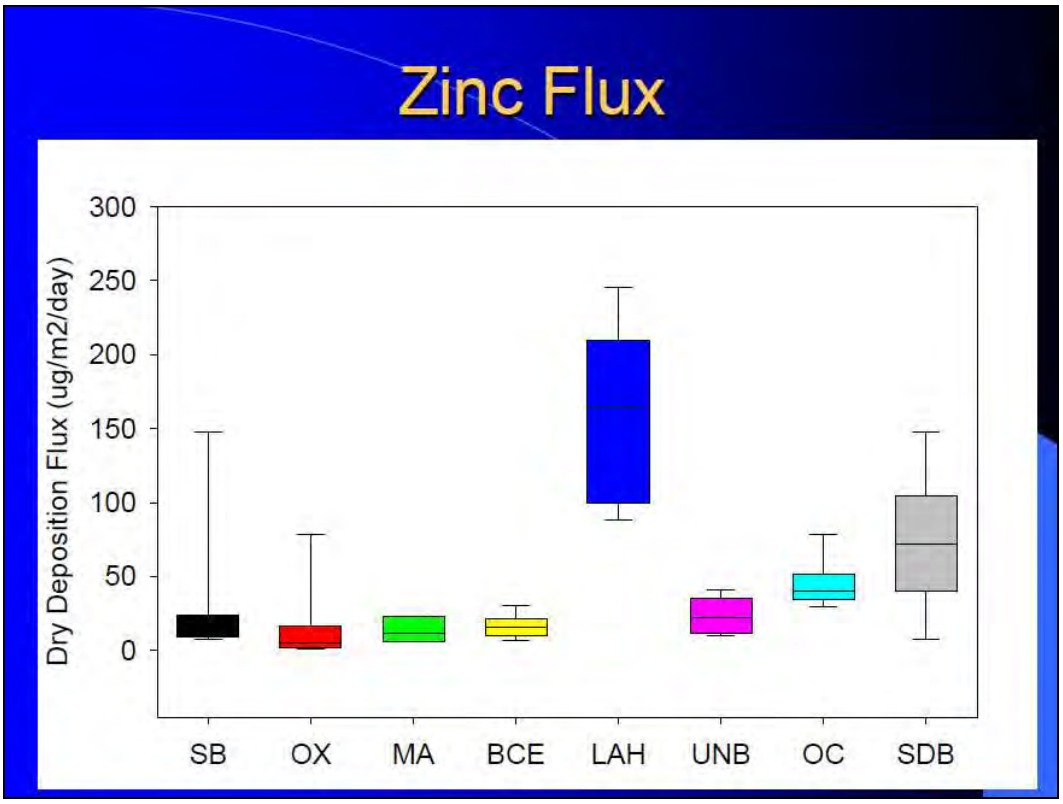
1. What is the air-water flux of trace metals along the So Cal coast?
   - Influence of urban air mass
2. What is the exchange of organic contaminants between environmental compartments?
   - air, water, sediment

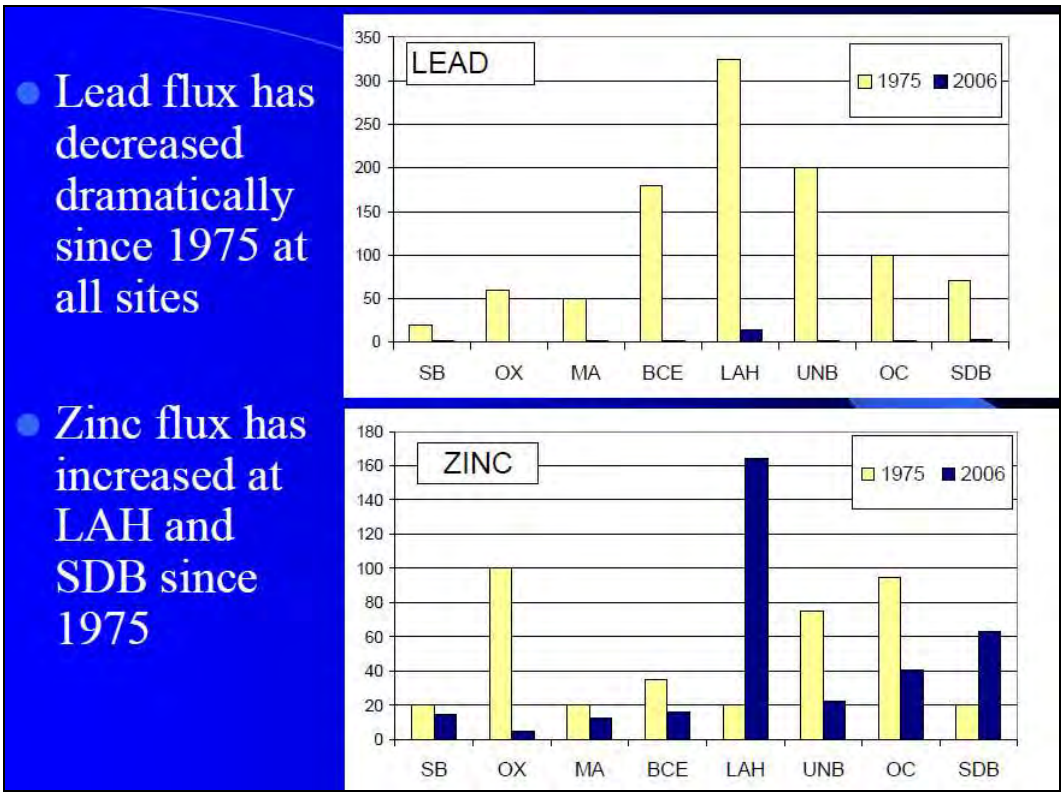
Methods

- Trace metals – coastal transect study
  - Dry particle deposition
  - 8 sites between Santa Barbara and San Diego
  - Comparison with data from 1970's
- Organics – multimedia study at 4 sites
  - Concentrations in air/water/sediment
    - DDT, PCB, PAH, Chlordane, other pesticides
  - Air-water Flux = gas exchange; dry particle deposition
  - Water-Sediment Flux = diffusive flux; sedimentation

Copper Flux

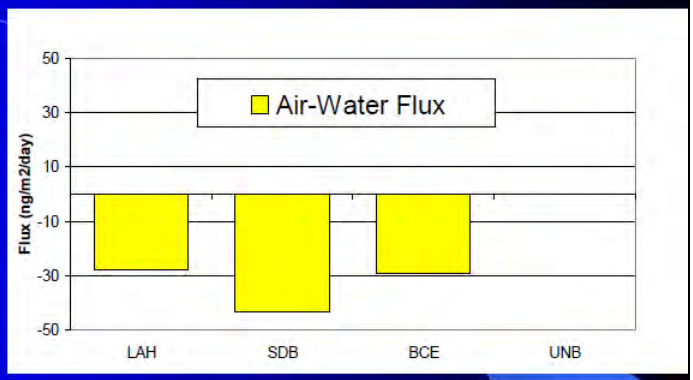


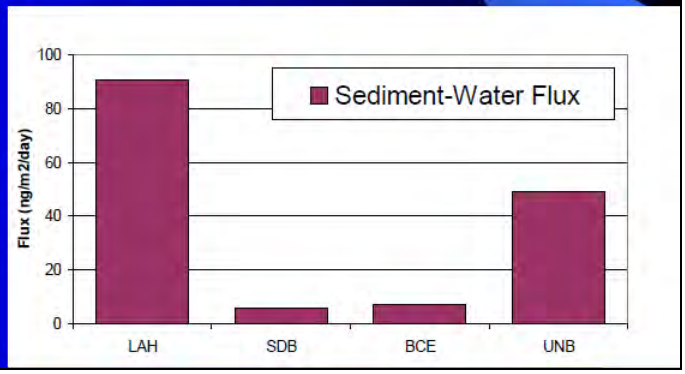

Zinc Flux
Dry Deposition Flux (ug/m2/day)
300
250
200
150
100
50
0
SB
OX
MA
BCE
LAH
UNB
OC
SDB


Lead flux has decreased dramatically since 1975 at all sites
Zinc flux has increased at LAH and SDB since 1975
LEAD
1975
2006
350
300
250
200
150
100
50
0
SB
OX
MA
BCE
LAH
UNB
OC
SDB
ZINC
1975
2006
180
160
140
120
100
80
60
40
20
0
SB
OX
MA
BCE
LAH
UNB
OC
SDB

DDT

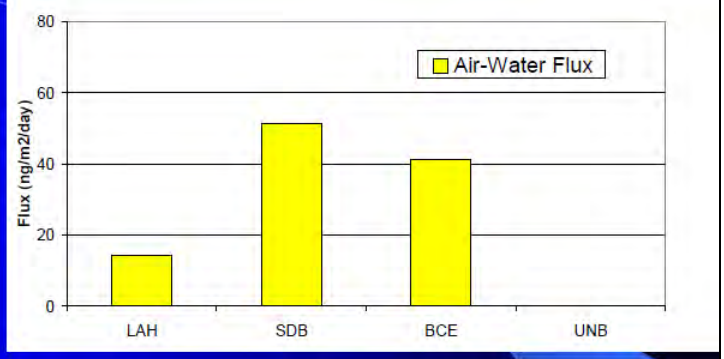
- Atmosphere is a source of DDT to the water column through gas exchange and dry deposition
- Sediment is a source of DDT to the water column
- LAH-sediment is larger source to water than air (~3x)
- SDB-air is larger source to water than sediment

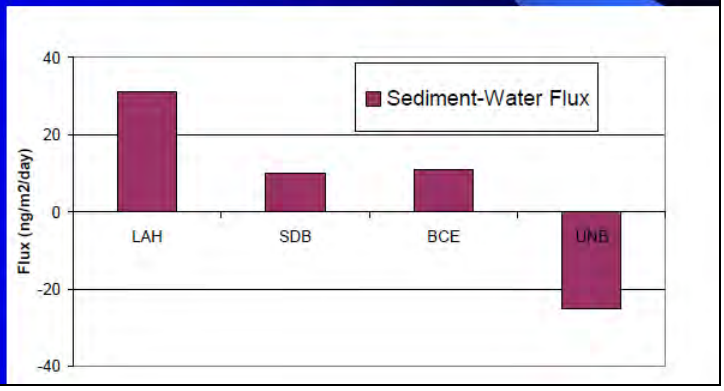




PCB

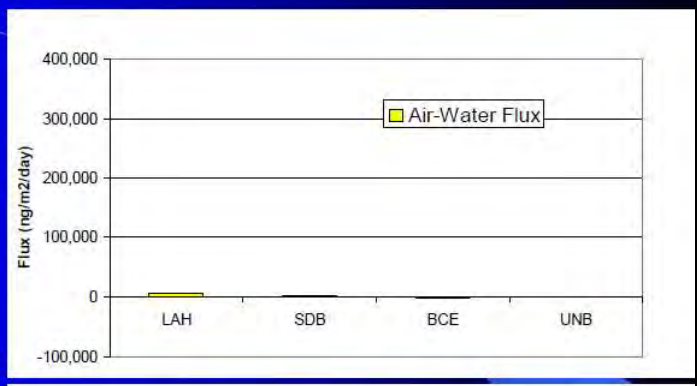
- Water column is a source of PCB to the atmosphere through gas exchange
- Sediment is a source of PCB to the water column through diffusive flux (except at UNB, due to high sedimentation flux)

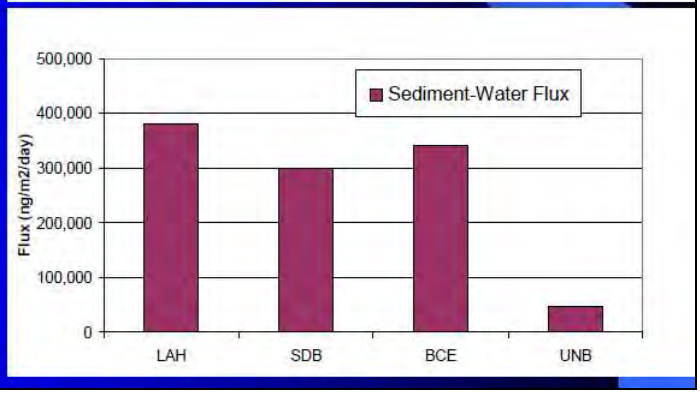




PAH

- Water is a source to the atmosphere through gas exchange
- Sediment is a source to water column through diffusive flux
- Sediment source to water is >> larger than loss to air





Current Status

- Trace metals
  - SCCWRP Technical Report
  - In press at ET&C
- Organics
  - Drafting SCCWRP Technical Report

Appendix III.6 – Metals Aerial Deposition Rates

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Table III.6-2. Comparison of metal dry deposition flux rates (µg/m2-day). 54

Table III.6-3. Estimates of current direct air deposition loading for metals and PAHs based on monitoring results from Sabin & Schiff (2007) and Sabin et al. (2010). 55

Appendix III.6 Summary

The section below provides a summary on the source of data used to estimate direct aerial deposition rates. It also presents the calculated loads for each waterbody using this information.

Note: Tables III.6-1 and III.6-1 2 were extracted from: Sabin, L.D. and K.C. Schiff. 2007. Metal Dry Deposition Rates Along a Coastal Transect in Southern California. SCCWRP Technical Report #509. March 2007.

Available at:
ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/509_metal_deposition_SoCaltransect_1975to2006.pdf

Calculation of Direct Air Deposition Rates

Direct air deposition estimates are included for Cu, Pb, Zn and PAHs based on atmospheric monitoring results cited by Sabin & Schiff (2007) or Sabin et al., (2010). Load estimates for certain waterbodies – Dominguez Channel Estuary, Consolidated Slip, Inner Harbor and LAR Estuary – were calculated using air monitoring results collected at the Wilmington sampling site (~3 km inland) close to Los Angeles/Long Beach Harbor.

For waterbodies with more coastal geographical position, we first determined the average deposition for each metal measured at six coastal sites; this was then applied to the following waterbodies: Fish Harbor, Cabrillo Marina, Inner Cabrillo Beach Area, Outer Harbor and San Pedro Bay.

See Table III.6-1 for information on dry deposition site measurements. See Table III.6-2 for monitoring results from various monitoring sites per Sabin & Schiff (2007). Table III.6-3 below provides dry deposition rates, waterbody surface areas, and estimates of current annual loading amounts for metals and PAHs.

Table III.6-1. Inventory of samples collected at each site by sampling week.

	Site							
Sampling Week	Santa Barbara	Oxnard	Malibu	Santa Monica Bay	Los Angeles Harbor	Upper Newport Bay	Oceanside	San Diego Bay
27-Jun-06								2
05-Jul-06	1	1	1	2				
11-Jul-06						1	1	2
18-Jul-06	1	1	1	1		1	1	1
26-Jul-06	1	1	1	1				
02-Aug-06						1	1	
08-Aug-06	1	1	1	1		1	1	1
16-Aug-06					1	1	1	1
22-Aug-06	1	1	1	1	1	1	1	1
30-Aug-06	1	1	1	1				
06-Sep-06					1	2	1	1
12-Sep-06	1	1	1	1				
19-Sep-06	1	1	1	1	1	1	1	1
26-Sep-06	1	1	1	1	1	1	1	1
03-Oct-06		1	1	1	1	1	1	1
17-Oct-06	1				2			
23-Oct-06					3			
01-Nov-06					1			
Number of Samples Collected at Each Site	10	10	10	11	12	11	10	12

Source: Sabin & Schiff, 2007

Table III.6-2. Comparison of metal dry deposition flux rates (µg/m^2-day).

	Chromium	Copper	Lead	Zinc
Lim et al., 2006				
Urban Sites in Los Angeles and Orange County, CA USA				
Los Angeles River -1	6	21	15	130
Los Angeles River -2	2.3	30	31	160
Los Angeles River -3	9	16	32	110
Ballona Creek	2.7	18	20	77
Dominguez Channel	3.3	12	11	74
Santa Ana River	4.3	30	10	180
Yi et al., 2001				
Chicago, IL USA	5.7	63	38	120
South Haven, MI USA	0.7	31	23	51
Sleeping Bear Dunes, MI USA	1.6	79	35	68
This Study				
Santa Barbara	0.34	2.0	1.3	14
Oxnard	0.23	0.89	0.52	4.8
Malibu	0.29	1.9	1.0	12
Hyperion	0.39	3.9	1.0	16
Los Angeles Harbor	3.6	22	14	160
Newport	0.64	5.1	1.8	22
Oceanside	0.48	4.2	1.4	40
San Diego Bay	0.99	29	3.3	63

Source: Sabin & Schiff, 2007

Table III.6-3. Estimates of current direct air deposition loading for metals and PAHs based on monitoring results from Sabin & Schiff (2007) and Sabin et al. (2010).

Waterbody	Area (m^2)	Wilmington site* (ug/m^2-day)			Coastal sites (n= 6) * (ug/m^2-day)			(ng/m^2-d)	NAAQS (ug/m^3)
		Cu 22	Pb 14	Zn 160	Cu 3	Pb 1.17	Zn 18.1	PAHs** 244	Pb 0.15
Annual Load (kg/year)									
Dominguez Channel Estuary	567,900	4.56	2.90	33.2				0.051	0.03
Consolidated Slip	147,103	1.18	0.75	8.59				0.013	0.01
Inner Harbor	12,154,560	97.6	62.1	709.8				1.08	0.67
LAR Estuary	837,873	6.73	4.28	48.93				0.075	0.05
Fish Harbor	368,524				0.40	0.16	2.43	0.033	0.02
Cabrillo Marina	310,259				0.34	0.13	2.05	0.028	0.02
Inner Cabrillo Beach Area	331,799				0.36	0.14	2.19	0.03	0.02
Outer Harbor	16,358,366				17.9	6.99	108.1	1.46	0.90
San Pedro Bay	33,073,517				36.2	14.1	218.5	2.95	1.81

*Metal deposition rates replicated (Wilmington site) or averaged (coastal sites) from Sabin & Schiff (2007)

**PAHs deposition rates from Sabin et al. (2010)

Appendix III.7 – Justification for Addition of Waterbody-Pollutant Combinations (in addition to 2006 303(d) list)

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Figure III.7-1. Dominguez Channel Watershed – Tributary Monitoring Station (TS19).....59

Appendix III.7 Summary

The following data and maps present data and information assessed to identify additional waterbody-pollutant combinations that are impaired (but are not currently on the 2010 303(d) list). These are associated with the TS19 Tributary Monitoring Station in the Dominguez Channel Watershed.

Note: The following data were obtained from 2008-2009 and 2009-2010 Annual Reports, Appendix B Wet Weather Mass Emission and Tributary Station Concentrations (County of Los Angeles, Department of Public Works)

TS19 Wet Weather Monitoring Data 2008-2009

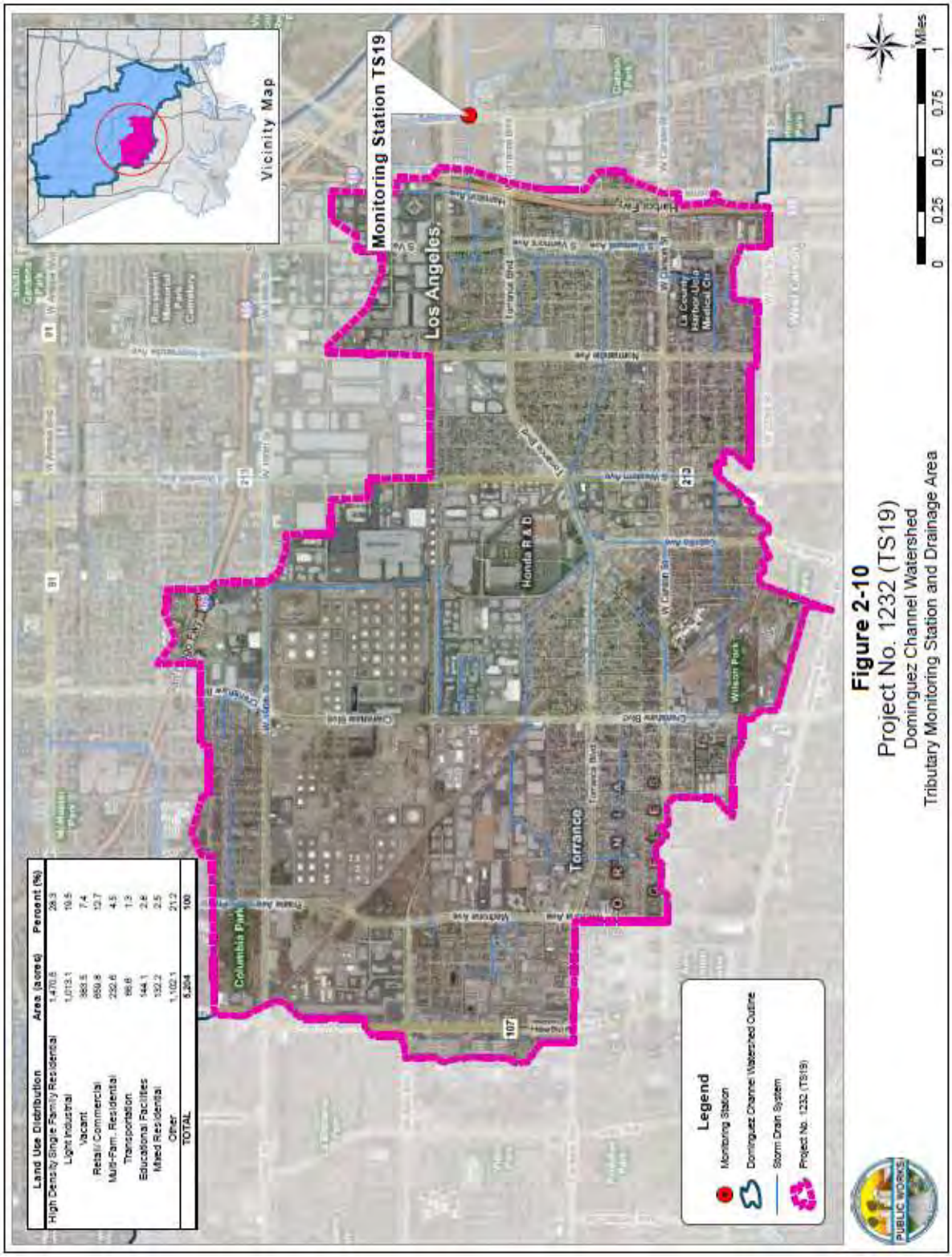
WEATHER CONDITION					Wet				
EVENT CODE					2008-09 Event03	2008-09 Event06	2008-09 Event09	2008-09 Event21	2008-09 Event23
DATE	Sample Type	EPA Method	PQL[3]	Units	11/4/2008	11/25/2008	12/15/2008	2/5/2009	2/13/2009
General									
Hardness	Comp	SM2340C	2.00	mg/L	90	55	60	55	30
Metals									
Dissolved Aluminum	Comp	EPA200.8	100.00	ug/L	64	-99	-99	-99	241
Total Aluminum	Comp	EPA200.8	100.00	ug/L	1150	255	243	580	1990
Dissolved Antimony	Comp	EPA200.8	0.50	ug/L	3.25	1.72	1.83	2.24	1.78
Total Antimony	Comp	EPA200.8	0.50	ug/L	6.8	3.98	2.81	4.29	3.57
Dissolved Arsenic	Comp	EPA200.8	1.00	ug/L	2.12	1.21	1.77	1.53	1.15
Total Arsenic	Comp	EPA200.8	1.00	ug/L	6.2	2.14	2.32	2.73	2.11
Dissolved Barium	Comp	EPA200.8	10.00	ug/L	38.1	22.7	22.2	23.4	21.8
Total Barium	Comp	EPA200.8	10.00	ug/L	319	96.3	55.2	102	105
Dissolved Beryllium	Comp	EPA200.8	0.50	ug/L	-99	-99	-99	-99	-99
Total Beryllium	Comp	EPA200.8	0.50	ug/L	0.29	-99	-99	0.13	0.13
Dissolved Cadmium	Comp	EPA200.8	0.25	ug/L	0.38	-99	0.2	0.11	0.16
Total Cadmium	Comp	EPA200.8	0.25	ug/L	2.81	0.81	0.47	1.49	0.73
Dissolved Chromium	Comp	EPA200.8	0.50	ug/L	3.56	1.75	2.88	2.08	2.46
Total Chromium	Comp	EPA200.8	0.50	ug/L	32.3	8.71	8.02	14.2	12.6
Dissolved Chromium +6	Comp	EPA218.6	0.25	ug/L	-99	-99	0.67	0.36	0.62
Total Chromium +6	Comp	EPA218.6	0.25	ug/L	-99	-99	0.67	0.36	0.62
Dissolved Copper	Comp	EPA200.8	0.50	ug/L	28.7	13.6	15	10	11.9
Total Copper	Comp	EPA200.8	0.50	ug/L	235	59.4	36.5	60.9	45.2
Dissolved Iron	Comp	EPA200.8	100.00	ug/L	786	124	85.7	88.5	210
Total Iron	Comp	EPA200.8	100.00	ug/L	12300	2420	2110	4310	4060
Dissolved Lead	Comp	EPA200.8	0.50	ug/L	6.95	1.47	2.31	1.36	3.04
Total Lead	Comp	EPA200.8	0.50	ug/L	97.6	31.2	16.3	33.1	31.2
Dissolved Mercury	Comp	EPA245.1	0.10	ug/L	-99	-99	-99	-99	-99
Total Mercury	Comp	EPA245.1	0.10	ug/L	-99	-99	-99	-99	0.18
Dissolved Nickel	Comp	EPA200.8	1.00	ug/L	10.2	5.97	5.04	3.75	2.9
Total Nickel	Comp	EPA200.8	1.00	ug/L	30.4	13.3	8.03	11.1	9.12
Dissolved Selenium	Comp	EPA200.8	1.00	ug/L	0.61	-99	-99	-99	-99
Total Selenium	Comp	EPA200.8	1.00	ug/L	0.91	1.28	0.67	-99	-99
Dissolved Silver	Comp	EPA200.8	0.25	ug/L	-99	-99	-99	-99	-99
Total Silver	Comp	EPA200.8	0.25	ug/L	0.65	-99	0.4	0.21	0.19
Dissolved Thallium	Comp	EPA200.8	0.50	ug/L	-99	-99	-99	-99	-99
Total Thallium	Comp	EPA200.8	0.50	ug/L	-99	-99	-99	-99	-99
Dissolved Zinc	Comp	EPA200.8	10.00	ug/L	141	130	158	129	112
Total Zinc	Comp	EPA200.8	10.00	ug/L	1540	414	282	416	306

Note:
1) blank cell indicates sample was not analyzed
2) -99 indicates concentration below minimum detection level
3) PQL = minimum level

TS19 Wet Weather Monitoring Data 2009-2010

WEATHER CONDITION			Wet				
EVENT CODE			2009-10 Event13	2009-10 Event15	2009-10 Event16	2009-10 Event19	2009-10 Event21
DATE	Analysis Method	Units	10/13/2009	12/7/2009	12/11/2009	1/17/2010	2/5/2010
General							
Hardness as CaCO3	SM2340C	mg/L	210	90	70	50	90
Metals							
Dissolved Aluminum	EPA200.8	ug/L	109	<50	<50	<50	<50
Dissolved Antimony	EPA200.8	ug/L	4.02	1.63	1.76	1.25	2.04
Dissolved Arsenic	EPA200.8	ug/L	2.84	1.73	1.82	1.7	2.42
Dissolved Barium	EPA200.8	ug/L	48.9	26.9	16.6	18.2	25.4
Dissolved Beryllium	EPA200.8	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Cadmium	EPA200.8	ug/L	0.294	<0.1	<0.1	<0.1	0.639
Dissolved Chromium	EPA200.8	ug/L	2.3	2.14	1.52	1.22	1.91
Dissolved Chromium +6	EPA218.6	ug/L	<0.25	<0.25	<0.25	<0.25	<0.25
Dissolved Copper	EPA200.8	ug/L	17.2	14.3	9.73	7.78	9.74
Dissolved Iron	EPA200.8	ug/L	297	115	<50	<50	<50
Dissolved Lead	EPA200.8	ug/L	2.99	1.15	0.647	1.16	0.769
Dissolved Mercury	EPA245.1	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Nickel	EPA200.8	ug/L	15.4	4.26	3.28	2.24	3.26
Dissolved Selenium	EPA200.8	ug/L	1.93	<0.5	<0.5	1.45	<0.5
Dissolved Silver	EPA200.8	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Thallium	EPA200.8	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Zinc	EPA200.8	ug/L	175	126	124	81.1	112
Aluminum	EPA200.8	ug/L	146	1020	348	3230	2830
Antimony	EPA200.8	ug/L	4.04	2.99	2.46	3.09	4.06
Arsenic	EPA200.8	ug/L	2.93	2.53	2.19	2.99	3.8
Barium	EPA200.8	ug/L	52.1	71.5	32.2	89.3	108
Beryllium	EPA200.8	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	EPA200.8	ug/L	0.345	0.486	<0.1	0.665	0.818
Chromium	EPA200.8	ug/L	2.62	6.2	3.32	10.1	12.5
Chromium +6	EPA218.6	ug/L	<0.25	<0.25	<0.25	<0.25	<0.25
Copper	EPA200.8	ug/L	23.2	44.8	24.2	39	46.2
Iron	EPA200.8	ug/L	366	1440	725	4830	5000
Lead	EPA200.8	ug/L	3.66	15.4	6.72	31.7	33
Mercury	EPA245.1	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	EPA200.8	ug/L	16.2	8.97	5.14	9.21	9.79
Selenium	EPA200.8	ug/L	2.07	<0.5	<0.5	1.72	<0.5
Silver	EPA200.8	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1
Thallium	EPA200.8	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	EPA200.8	ug/L	186	255	137	312	314

Note:
Values reported with a "< "are not detected (ND) at the method detection level, and reported as <MDL



Land Use Distribution	Area (acres)	Percent (%)
High Density Single Family Residential	1,470.8	28.3
Light Industrial	1,013.1	19.5
Vacant	383.5	7.4
Retail/Commercial	659.8	12.7
Multi-Fam. Residential	232.6	4.5
Transportation	66.6	1.3
Educational Facilities	144.1	2.8
Mixed Residential	132.2	2.5
Other	1,102.1	21.2
TOTAL	5,204	100

Figure III.7-1. Dominguez Channel Watershed – Tributary Monitoring Station (TS19)
Map source: County of Los Angeles, Department of Public Works

Appendix III.8 – Tetra Tech Memo on TMDL Scenarios

Contents

Technical Memorandum (dated April 14, 2011), *pages 1-15*

Appendix III.8 Summary

The technical memorandum included in this section summarizes the scenarios simulated to support TMDL development. This includes a discussion of the role of upland sources to the receiving waterbody sediment for metals and organic contaminants. These results were ultimately used to support TMDL allocations and calculate existing loads in each TMDL zone.

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MEMORANDUM

DATE: April 14, 2011

TO: Peter Kozelka, USEPA Region 9

FROM: Stephen Carter, Amy King, Andrew Parker, John Hamrick, and John Craig

SUBJECT: Los Angeles-Long Beach Harbors TMDL Scenario Development

Model Simulation Process

Results from LSPC (freshwater) model output for Dominguez Channel, Los Angeles River, San Gabriel River and nearshore areas were used as input to the EFDC model of receiving (saline) waters in greater LA/LB Harbor area. To determine the waterbodies in greater Los Angeles/Long Beach Harbor area not meeting applicable sediment quality criteria and to develop load reductions to attain the TMDL condition, EFDC model output for sediment pollutant concentrations in 11 TMDL zones (Table 1 and Figure 1) were examined.

Table 1. Waterbody Name and TMDL Zone

Waterbody Name	TMDL Zone
Dominguez Channel Estuary	01
Consolidated Slip	02
Inner Harbor – Port of Los Angeles	03
Fish Harbor	04
Cabrillo Marina	05
Inner Cabrillo Beach Area	06
Outer Harbor – Port of Los Angeles	07
Inner Harbor – Port of Long Beach	08
Outer Harbor – Port of Long Beach	09
Los Angeles River Estuary	10
San Pedro Bay	11

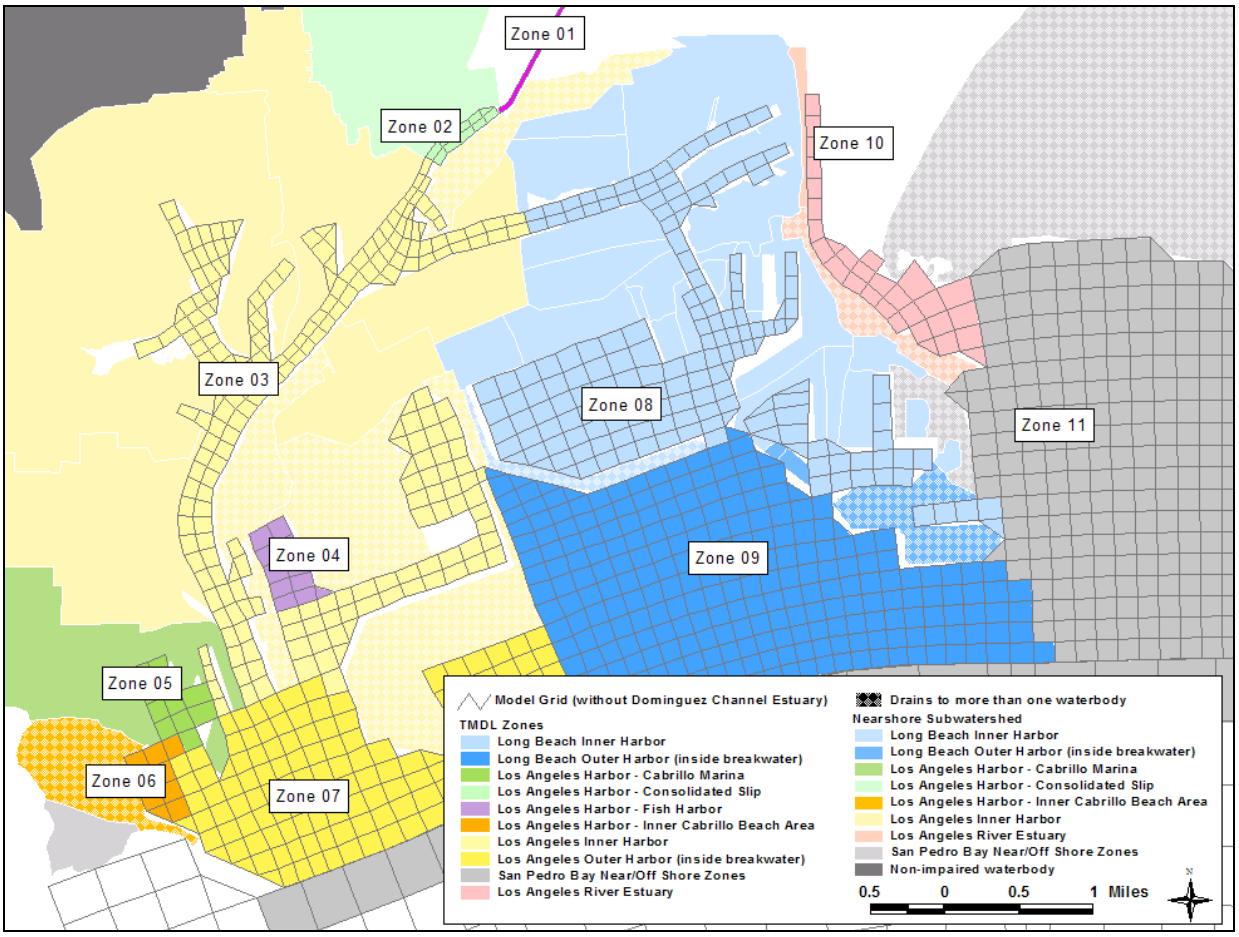

Figure 1. TMDL Zones

Model simulation runs were performed as described in the modeling report, Appendix I: Los Angeles-Long Beach Harbors and San Pedro Bay Hydrodynamic and Sediment-Contaminant Transport Model Calibration (Tetra Tech, Inc. 2011). Simulation time period consisted of four years, 2002-2005; the 2005 water year ranks in 97th percentile of annual rainfall levels dating back to 1944. Four day average water column and bed concentrations, external loads and advective fluxes in the water column and fluxes between the sediment bed and water column were accumulated as the model executed for each water column and bed cell. A post processor was used to aggregate the grid cell output into four-day average concentrations and mass of sediments and contaminants in 11 TMDL zones, as well as fluxes between the zones, fluxes between the bed and water column in each zone, and external loads to the zones.

For the purposes of TMDL development, model runs focused on sediment quality impairments. Analysis of model scenario outputs considered pollutant concentrations in the upper 5 centimeters (cm) of the sediment bed corresponding to approximately the top bed layer of the model. Additional model runs yielding information for the top 20 cm, corresponding to the top two bed layers of the model (top 5 cm plus the subsequent 15 cm), are available but not presented here. In general, results for the top 20 cm of the bed show similar trends to the top 5 cm, but slower responses since a larger mass of material is considered with the underlying 15 cm not changing significantly over the course of the model simulation.

Model Scenarios

Various scenarios were performed to evaluate implementation alternatives associated with the TMDL and/or to support allocation of the TMDL. These included the following scenarios:

1. Base scenario—simulation of existing contaminant loads

2. No upland sources scenario—simulation without upland contaminant loads
3. No Dominguez Channel scenario— simulation of existing contaminant loads excluding the Dominguez Channel
4. No LA River scenario— simulation of existing contaminant loads excluding the LA River
5. No Nearshore scenario— simulation of existing contaminant loads excluding the Nearshore areas
6. Hot spot cleanup scenario— simulation of setting contaminant loads in hot spots to levels at or below the applicable criteria

Analysis of the "no upland sources" scenario focused on determining sources of sediment quality violations, data trends, and required load reductions. Dominguez Channel Estuary, Consolidated Slip, and Inner Harbor-POLA (zones 01-03) are most impacted by the Dominguez Channel watershed. Nearshore watershed areas impacted Fish Harbor, Cabrillo Marina, Inner Cabrillo Beach Area, Inner Harbor-POLB and Outer Harbor-POLA (zones 04–08). Outer Harbor- POLB, LA River Estuary, and San Pedro Bay (zones 09–11) are dominated by loads from the LA River. These results are useful to support TMDL allocations and the average base scenario results were used to calculate existing loads in each zone for comparison with the TMDL results. Results are discussed and presented graphically below.

The "no upland sources" scenario was ultimately inclusive of scenarios #3 through #5; therefore, only results for the "no upland sources" scenario (scenario #2) are presented below and were used to support assignment of WLAs in the TMDL (see Appendix III.1 for more information on the process used to assign allocations). This scenario determined the extent of watershed sources of pollutants causing sediment quality violations. Overall, upland sources were contributing to the sediment bed impairments for metals in some zones, but model results suggest that upland sources are not contributing significantly to the sediment organics impairments.

The hot spot scenario (scenario #6) was performed to consider implementation alternatives. Specifically, copper hot spots within all zones were reduced so the average copper sediment concentration throughout each zone met the sediment quality target. Metal hotspots were in similar locations (depositional areas) for all metals, thus the copper reductions also resulted in sediment criteria being met for lead and zinc because copper contamination represents the worst-case scenario for metals. The copper based approach also results in reducing PAH concentrations in Cabrillo Marina (zone 05) below the PAH bed sediment criteria. Meeting copper criteria did not reduce PAH levels in Dominguez Channel Estuary and Consolidated Slip (zones 01 and 02) to criteria levels. DDT proved to be the most sensitive pollutant. Ultimately, reducing DDT to criteria in each zone resulted in all other pollutants achieving their respective targets. However, it should be noted that DDT remediation is required in all zones as the bed sediment concentrations were well above targets throughout the study area.

The remainder of this memo describes modeling results associated with the TMDL allocation scenarios, which are represented by the difference between the base scenario and the no upland sources scenario (scenarios #1 and #2, respectively). The model simulations incorporate the interactions between waterbodies, so sediment and pollutant movement between TMDL zones is accounted for in the loading estimates.

Allocation Scenario: Sediment Metals Contamination

Metals contamination modeled included copper (Cu), lead (Pb), and zinc (Zn). Tables 2 through 4 present the average and maximum Cu, Pb, and Zn sediment concentrations by zone for the base and no upland sources scenario, as well as the percent difference between the two scenarios. Concentrations that exceed the applicable criteria are highlighted in orange. An analysis of both initial conditions and current ambient bed conditions for the three metals indicates that copper is the critical metal. Reduction of bed copper concentrations (i.e., average zone concentration equal to the criteria) will also result in corresponding zone average lead and zinc concentrations meeting the criteria. A reduction of either lead or zinc will not result in the copper criteria being met in any of the zones.

Copper

The maximum and four day average copper sediment concentrations exceeded criteria in all zones for both scenarios with a single exception. The four day average concentration in LA River Estuary (zone 10) did meet criteria for the no upland sources scenario. In addition, after eliminating the upland sources, most zones appear to be in a trend of decreasing concentrations, suggesting that over time, the concentrations may ultimately achieve criteria. In many zones, achievement of criteria would take considerable time; thus additional remediation actions will likely be required. The percent difference in concentrations between the two scenarios shows that loading from upland sources is contributing to sediment copper concentrations for Dominguez Channel Estuary, Consolidated Slip, and Inner Harbor-POLA (zones 01–03) and Outer Harbor-POLB, LA River Estuary, and San Pedro Bay (zones 09–11). These reductions are likely due to both the reduction in watershed loads as well as the dilution in the bed due to the deposition of clean sediment. Concentrations in Fish Harbor, Cabrillo Marina, Inner Cabrillo Beach Area, and Outer Harbor-POLA (zones 04–07) are relatively stable and do not respond significantly to upland load reduction. These behaviors are illustrated in the time series plots of copper concentrations in Figures 2–7 in addition to being summarized in Table 2.

The model results show that the accumulation of contaminated sediments in Dominguez Channel Estuary, Consolidated Slip, and Inner Harbor-POLA (zones 01–03) are due to the Dominguez Channel and the elimination of the Dominguez Channel loading results in substantially decreasing levels in Dominguez Channel Estuary and Consolidated Slip as show in Figures 2 and 3. The increasing levels of copper in Outer Harbor-POLB, Los Angeles River Estuary, and San Pedro Bay (zones 09–11) are due to the LA River and elimination of the LA River copper load results in decreasing concentrations over time as shown in Figures 3 through 7. Near shore areas do not appear to be causing significant loading of copper contaminated sediments to Fish Harbor, Cabrillo Marina, Inner Cabrillo Beach Area, Outer Harbor-POLA, and Inner Harbor-POLB (zones 04-08).

Table 2. Sediment copper concentrations for the base and no upland sources scenarios

Zone	Waterbody Name	Cu in top 5 cm of sediment (mg/kg)					
		Criteria: 34.0 mg/kg					
		Base Scenario Avg	Base Scenario Max	No Upland Sources Scenario Avg	No Upland Sources Scenario Max	% Diff Avg	% Diff Max
01	Dominguez Channel Estuary	132.62	146.70	95.63	121.72	27.89	20.52
02	Consolidated Slip	259.15	269.62	199.62	262.76	22.97	2.61
03	Inner Harbor – POLA	84.79	90.65	80.43	81.33	5.14	11.47
04	Fish Harbor	46.87	47.75	46.87	46.90	-0.02	1.82
05	Cabrillo Marina	235.82	239.66	239.34	239.68	-1.49	-0.01
06	Inner Cabrillo Beach Area	110.00	110.92	110.87	110.91	-0.79	0.01
07	Outer Harbor – POLA	62.04	63.60	62.10	62.15	-0.09	2.34
08	Inner Harbor – POLB	65.83	68.20	65.46	65.53	0.57	4.07
09	Outer Harbor – POLB	45.66	51.88	43.98	44.15	3.67	17.51
10	Los Angeles River Estuary	74.59	112.29	32.33	51.24	56.65	119.16
11	San Pedro Bay	65.64	89.73	48.54	51.83	26.05	73.13

Base Avg = model run 2002-2005, average existing condition; Base Max = existing conditions with maximum values output
No Upland Avg = model run 2002-2005, no upstream inputs; No Upland Max = no upstream input with maximum
% Difference Avg = between Base Avg and No Upland Avg scenarios;
% Difference Max = between Base Max and No Upland Max scenarios
Orange color indicates average zone concentration exceeds contaminant sediment criteria

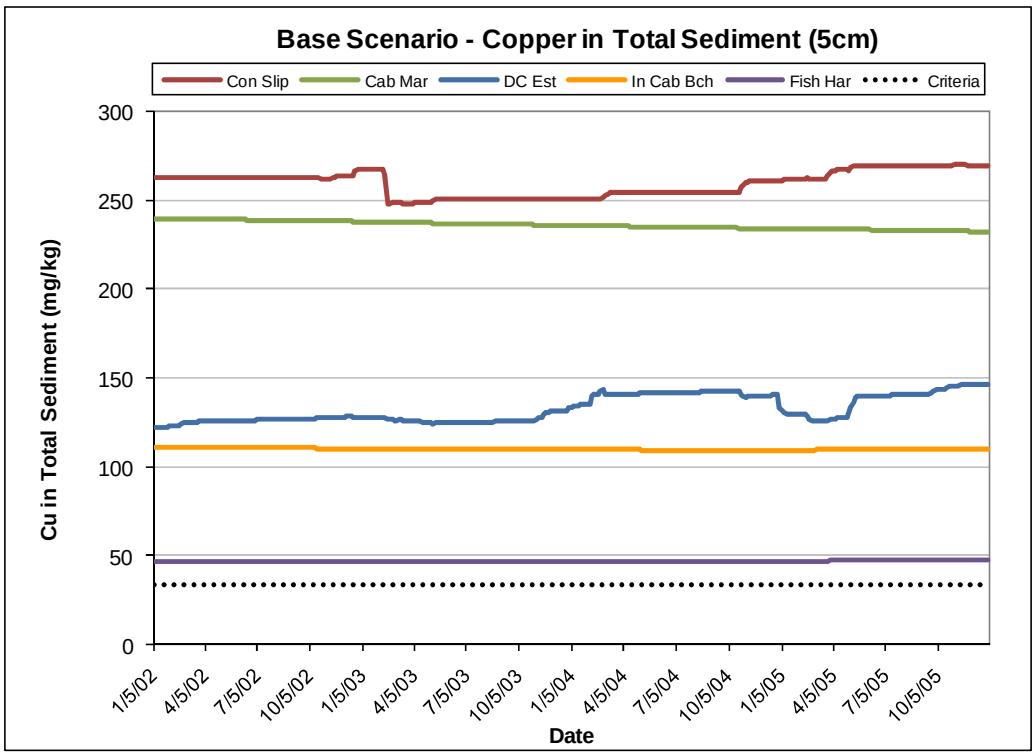

Figure 2. Sediment copper concentrations for the base scenario (Consolidated Slip, Dominguez Channel Estuary, Inner Cabrillo Beach Area, Cabrillo Marina, and Fish Harbor)

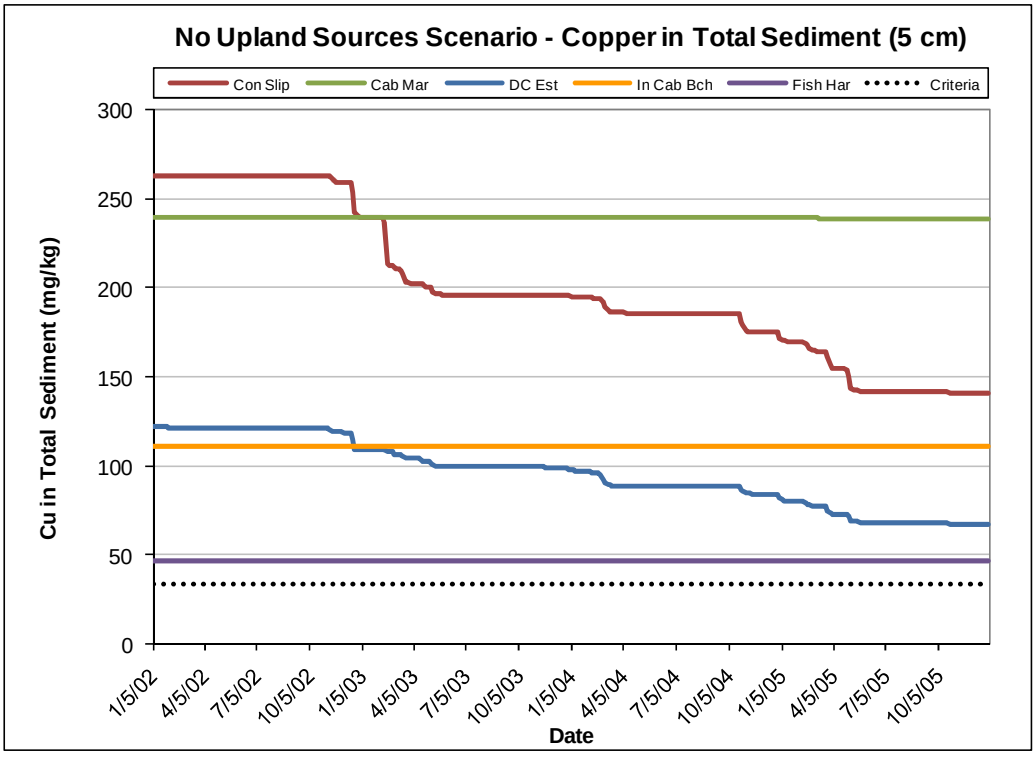

Figure 3. Sediment copper concentrations for the no upland sources scenario (Consolidated Slip, Dominguez Channel Estuary, Inner Cabrillo Beach Area, Cabrillo Marina, and Fish Harbor)

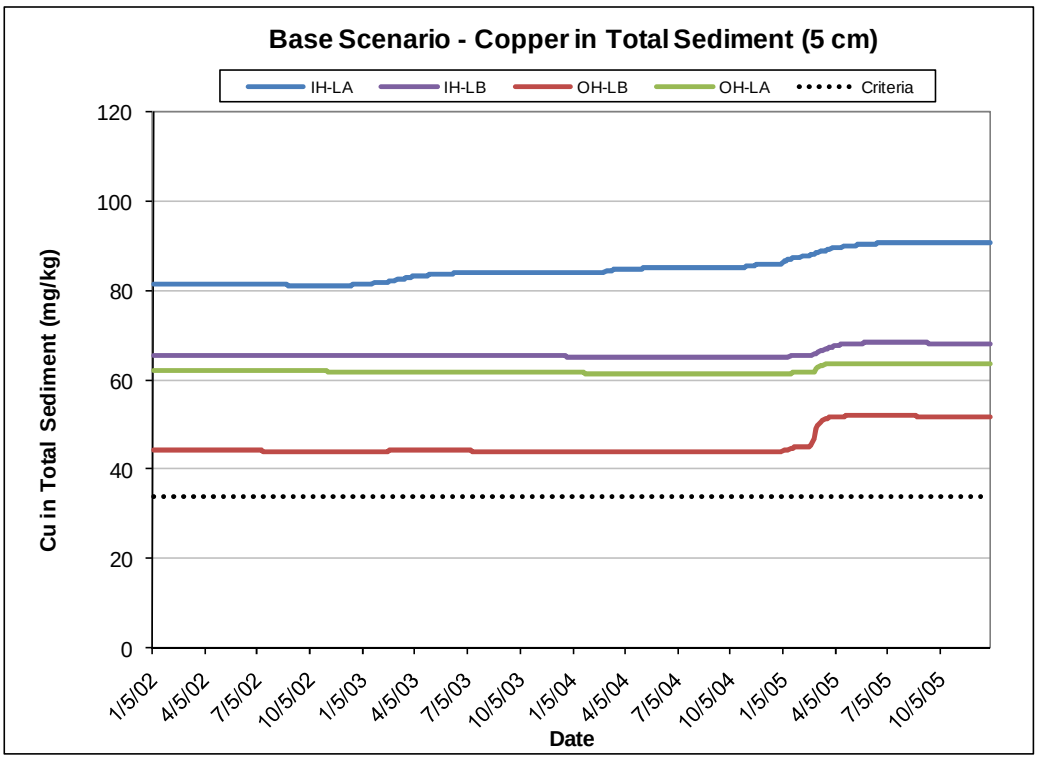

Figure 4. Sediment copper concentrations for the base scenario (Inner and Outer Harbors)

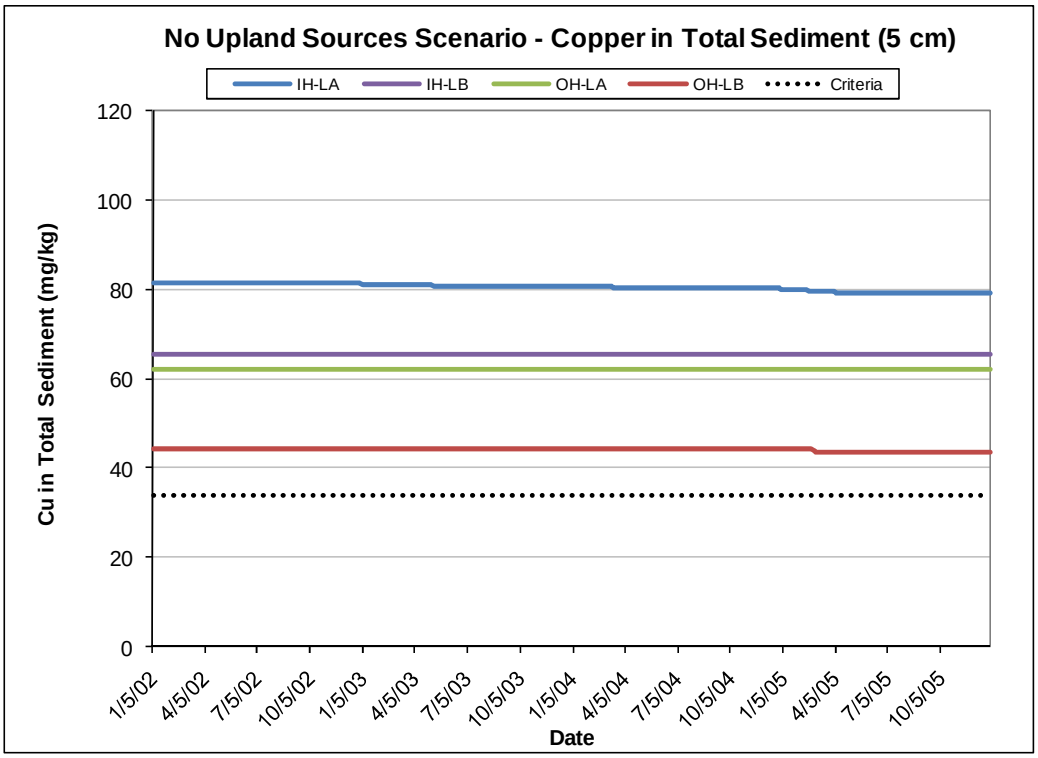

Figure 5. Sediment copper concentrations for the no upland source scenario (Inner and Outer Harbors)

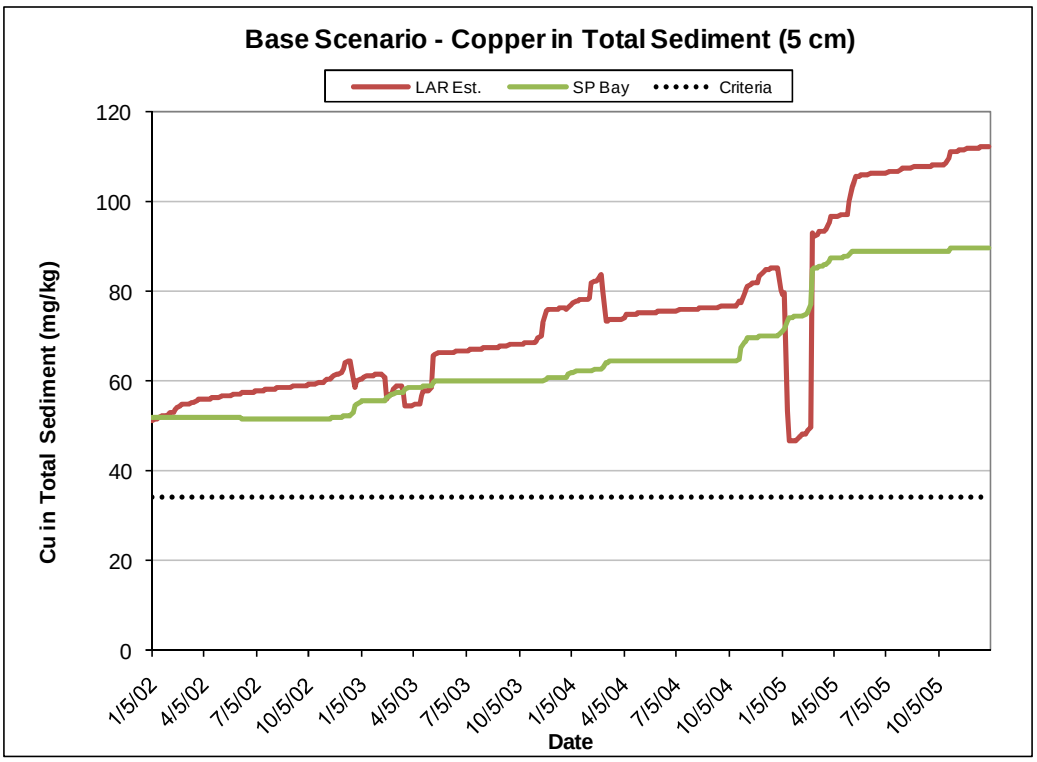

Figure 6. Sediment copper concentrations for the base scenario (San Pedro Bay and LA River Estuary)

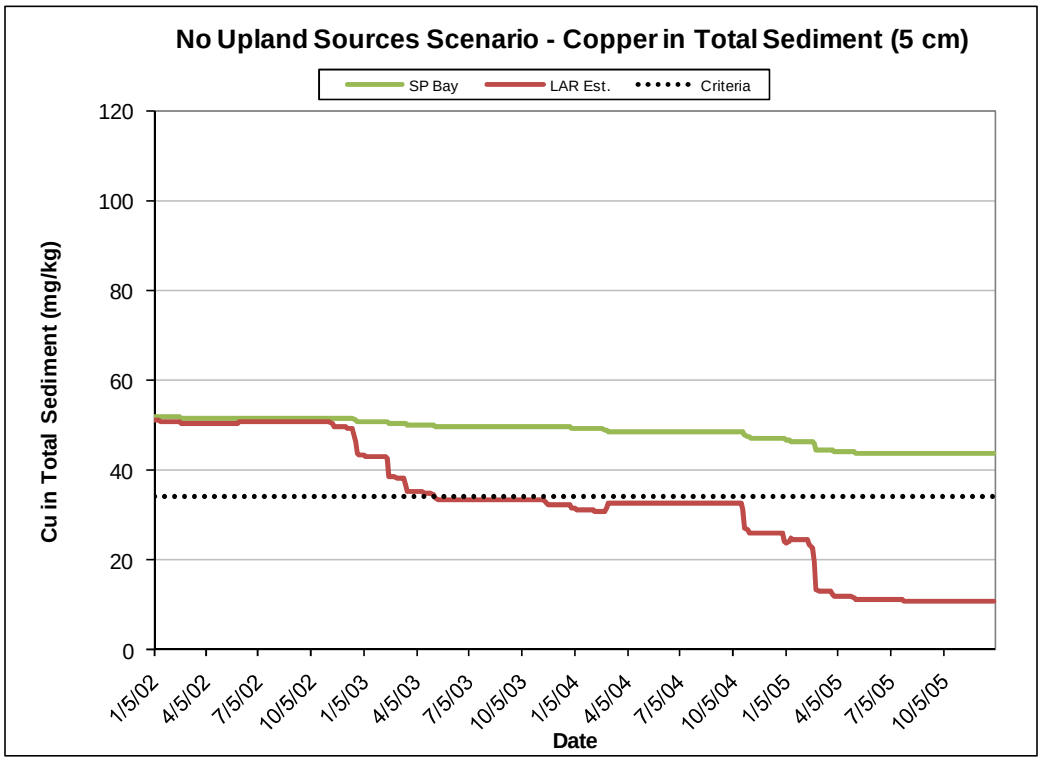

Figure 7. Sediment copper concentrations for the no upland sources scenario (San Pedro Bay and LA River Estuary)

Lead

The maximum lead sediment concentrations exceeded criteria in six zones for the base scenario and in four zones for the no upland sources scenario (Table 3). The six zones where maximum lead sediment concentrations exceeded criteria include Dominguez Channel Estuary, Consolidated Slip, Inner Harbor-POLA, Cabrillo Marina, LA River Estuary, and San Pedro Bay (zones 01-03, 05, 10, and 11). For the no upland sources scenario, maximum lead sediment concentrations exceeded criteria in Dominguez Channel Estuary, Consolidated Slip, Cabrillo Marina, and San Pedro Bay (zones 01, 02, 05, and 11). The average concentration exceeded criteria in the same zones as the maximum concentrations in the base scenario, but in only three of the four for the no upland sources scenario. The LA River Estuary (zone 10) did not violate the criteria. The percent difference in concentrations between the two scenarios shows that lead loading from upland scenarios is impacting bed sediment concentrations in all zones, but most noticeably in Dominguez Channel Estuary, Consolidated Slip, Inner Harbor-POLA, LA River Estuary, and San Pedro Bay (zones 01, 03, 10, and 11), which all showed increases in the average sediment concentration of over 45 percent. Similar to copper, these reductions are likely due to both the reduction in watershed loads as well as dilution in the bed due to the deposition of clean sediment. Temporal changes in lead concentrations for both scenarios follow similar trends as those shown for copper (Figures 2-7).

Table 3. Sediment lead concentrations for the base and no upland sources scenarios

Zone	Waterbody Name	Pb in top 5 cm of sediment (mg/kg)					
		Criteria: 46.7 mg/kg					
		Base Scenario Avg	Base Scenario Max	No Upland Sources Scenario Avg	No Upland Sources Scenario Max	% Diff Avg	% Diff Max
01	Dominguez Channel Estuary	185.37	192.66	94.35	120.05	49.10	60.48
02	Consolidated Slip	357.91	402.48	278.39	360.66	22.22	11.59
03	Inner Harbor – POLA	51.38	58.28	27.93	28.35	45.64	105.57
04	Fish Harbor	19.60	21.37	12.14	12.15	38.03	75.92
05	Cabrillo Marina	59.37	60.94	49.81	49.93	16.09	22.05
06	Inner Cabrillo Beach Area	24.18	25.68	19.89	19.90	17.73	29.03
07	Outer Harbor – POLA	21.42	23.95	13.85	13.86	35.37	72.87
08	Inner Harbor – POLB	36.60	40.50	22.72	22.75	37.91	78.04
09	Outer Harbor – POLB	29.79	38.15	16.78	16.84	43.66	126.50
10	Los Angeles River Estuary	122.22	204.49	28.47	44.66	76.71	357.86
11	San Pedro Bay	91.15	119.59	44.47	47.42	51.21	152.20

Orange color indicates average zone concentration exceeds contaminant sediment criteria

Zinc

The maximum zinc sediment concentration exceeded criteria in all zones but Fish Harbor (zone 04) for the base scenario, and exceeded criteria in Dominguez Channel Estuary, Consolidated Slip, Cabrillo Marina, Los Angeles River Estuary, and San Pedro Bay (zones 01, 02, 05, 10, and 11) for the no upland sources scenario (Table 4). The average concentration for the base scenario exceeded criteria in the same zones as the maximum concentrations, except Outer Harbor-POLA (zone 07). Four of the five zones that had maximum zinc concentrations violate criteria for the no upland sources scenario also had an average sediment concentration that violated criteria. Los Angeles River Estuary (zone 10) was the exception that did not violate criteria. The percent difference in concentrations between the two scenarios shows that zinc loadings from upland sources are impacting bed sediment concentrations in all zones, but most noticeably in Dominguez Channel Estuary, Consolidated Slip, Inner Harbor-POLA, Los Angeles River Estuary, and San Pedro Bay (zones 01, 02, 03, 10, and 11). These all showed that upland sources were contributing at least 50 percent of the average sediment concentration. Temporal changes in zinc concentrations for both scenarios follow similar trends as those shown for copper (Figures 2-7).

Table 4. Sediment zinc concentrations for the base and no upland sources scenarios

Zone	Waterbody Name	Zn in top 5 cm of sediment (mg/kg)					
		Criteria: 150.0 mg/kg					
		Base Scenario Avg	Base Scenario Max	No Upland Sources Scenario Avg	No Upland Sources Scenario Max	% Diff Avg	% Diff Max
01	Dominguez Channel Estuary	728.30	1,250.64	169.92	218.84	76.67	471.48
02	Consolidated Slip	1,122.01	1,585.41	508.32	653.84	54.70	142.48
03	Inner Harbor – POLA	261.04	327.61	128.36	130.13	50.83	151.75
04	Fish Harbor	137.57	144.02	88.76	88.81	35.48	62.17
05	Cabrillo Marina	235.32	243.14	205.12	205.43	12.83	18.36
06	Inner Cabrillo Beach Area	166.78	172.16	141.64	141.67	15.07	21.53
07	Outer Harbor – POLA	147.49	159.57	98.38	98.45	33.30	62.07
08	Inner Harbor – POLB	191.87	213.77	119.44	119.78	37.75	78.48
09	Outer Harbor – POLB	174.48	233.97	98.80	99.18	43.37	135.91
10	Los Angeles River Estuary	929.93	1,869.70	112.45	178.78	87.91	945.79
11	San Pedro Bay	428.55	686.35	162.43	173.61	62.10	295.34

Orange color indicates average zone concentration exceeds contaminant sediment criteria

Allocation Scenario: Sediment Organics Contamination

Organics contamination modeled in the harbor included total dichlorodiphenyltrichloroethane (DDT), total polycyclic aromatic hydrocarbons (PAH), and total polychlorinated biphenyls (PCB). Tables 5–7 present the average and maximum PAHs, DDT, and PCBs sediment concentrations by zone for the base and no upland sources scenarios, as well as the percent difference between the two scenarios. Similar to Tables 2–4, concentrations that exceed the applicable criteria are highlighted in orange. Temporal behavior of sediment PAH concentrations are shown in Figures 8 through 13. Behavior of DDT and PCBs follow similar trends in all of the zones; however, ambient sediment concentrations of DDT and PCBs are farther above their respective targets than PAHs. The temporal behavior for both scenarios and all zones is described by an exponential decay like reduction of bed concentration in the top 5 cm of the bed towards a diffusive equilibrium level. The high initial pollutant concentrations in the sediment bed pore water compared to the water column drive a significant diffusion flux from the top of the bed, which approaches equilibrium as the curve flattens out. This is due to the fact that the model sediment bed was

initialized to a uniform concentration over the thickness of the bed. The behavior of PAH concentration over a thicker bed region does not show such a rapid decrease in concentration.

PAHs

The maximum and average PAHs bed sediment concentration exceeded criteria for both the base and no upland sources scenarios in Dominguez Channel Estuary, Consolidated Slip and Cabrillo Marina (zones 01, 02, and 05) (Table 5). The percent difference in concentrations between the two scenarios shows that there appears to be no or minimal loadings from upland sources. This is shown in the time series plots of PAHs concentrations in Figures 8–13. In addition, most zones appear to be in a trend of decreasing concentrations, suggesting that over time, the concentrations may ultimately achieve criteria. In many zones, achievement of criteria would take considerable time; thus additional remediation actions will likely be required.

The concentrations of PAHs were approximately the same in all waterbodies for the base and no upland sources scenarios. Slight exceptions can be found in LA River Estuary and San Pedro Bay (zones 10 and 11), which show approximately 31 and 19 percent greater average concentrations, respectively, for the base scenario. This suggests that the LA River Estuary is contributing small loads of PAHs to bed sediments in these waterbodies, but less than what is required to maintain current concentrations and significantly less than what is necessary to cause violations of the applicable criteria (Figure 12). This generally indicates that PAHs contamination is a legacy issue and the combination of clean sediment deposition and the diffusion of legacy PAHs contamination are causing bed sediment concentrations to gradually decrease over time. In fact, by the end of the simulation period sediment quality standards are met in Cabrillo Marina (zone 05), which had exceeded criteria initially. It is noteworthy that reducing copper to criteria also results in meeting PAHs sediment target in Cabrillo Marina.

Table 5. Sediment PAHs concentrations for the base and no upland sources scenarios

Zone	Waterbody Name	PAHs (total) in top 5 cm of sediment (ug/kg)					
		Criteria: 4,022 ug/kg					
		Base Scenario Avg	Base Scenario Max	No Upland Sources Scenario Avg	No Upland Sources Scenario Max	% Diff Avg	% Diff Max
01	Dominguez Channel Estuary	11,368.33	24,688.59	11,208.22	24,688.43	1.41	0.00
02	Consolidated Slip	32,372.88	73,510.71	32,240.56	73,510.71	0.41	0.00
03	Inner Harbor – POLA	1,939.55	3,869.77	1,915.24	3,869.77	1.25	0.00
04	Fish Harbor	113.09	168.61	107.05	168.61	5.35	0.00
05	Cabrillo Marina	6,083.00	14,345.76	6,089.34	14,345.76	-0.10	0.00
06	Inner Cabrillo Beach Area	889.18	1,771.06	891.98	1,771.06	-0.32	0.00
07	Outer Harbor – POLA	586.29	1,180.22	583.60	1,180.22	0.46	0.00
08	Inner Harbor – POLB	678.75	1,246.81	670.25	1,246.81	1.25	0.00
09	Outer Harbor – POLB	159.08	265.25	153.93	265.25	3.24	0.00
10	Los Angeles River Estuary	403.60	682.03	277.28	681.38	31.30	0.10
11	San Pedro Bay	190.72	294.32	154.20	294.32	19.15	0.00

Orange color indicates average zone concentration exceeds contaminant sediment criteria

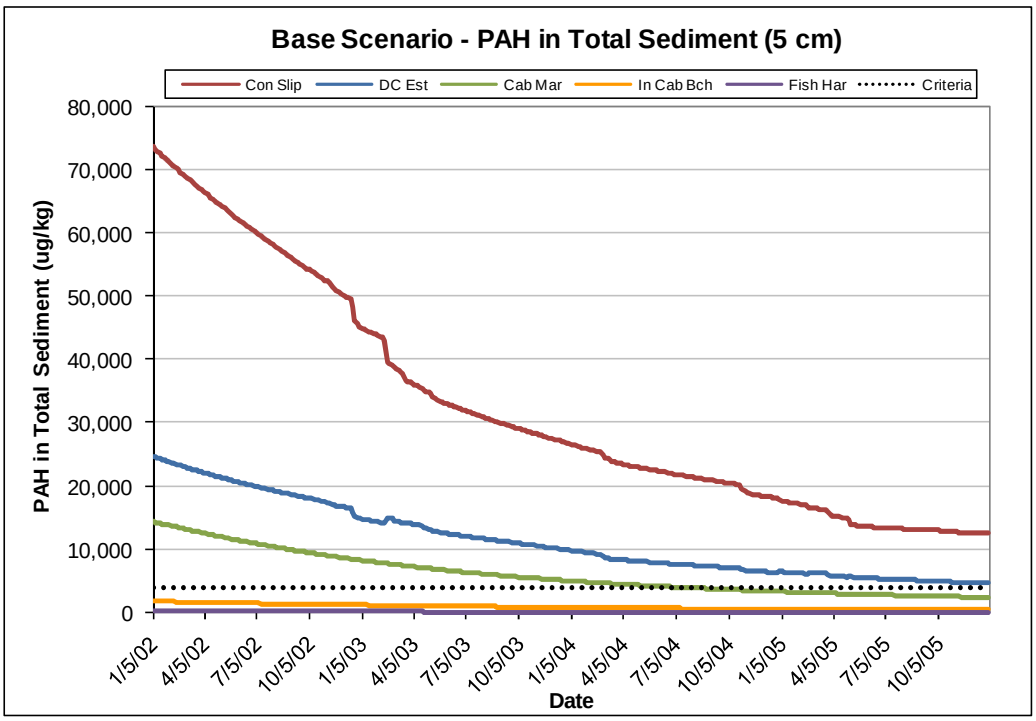

Figure 8. Sediment PAH concentrations for the base scenario (Consolidated Slip, Dominguez Channel Estuary, Inner Cabrillo Beach Area, Cabrillo Marina, and Fish Harbor)

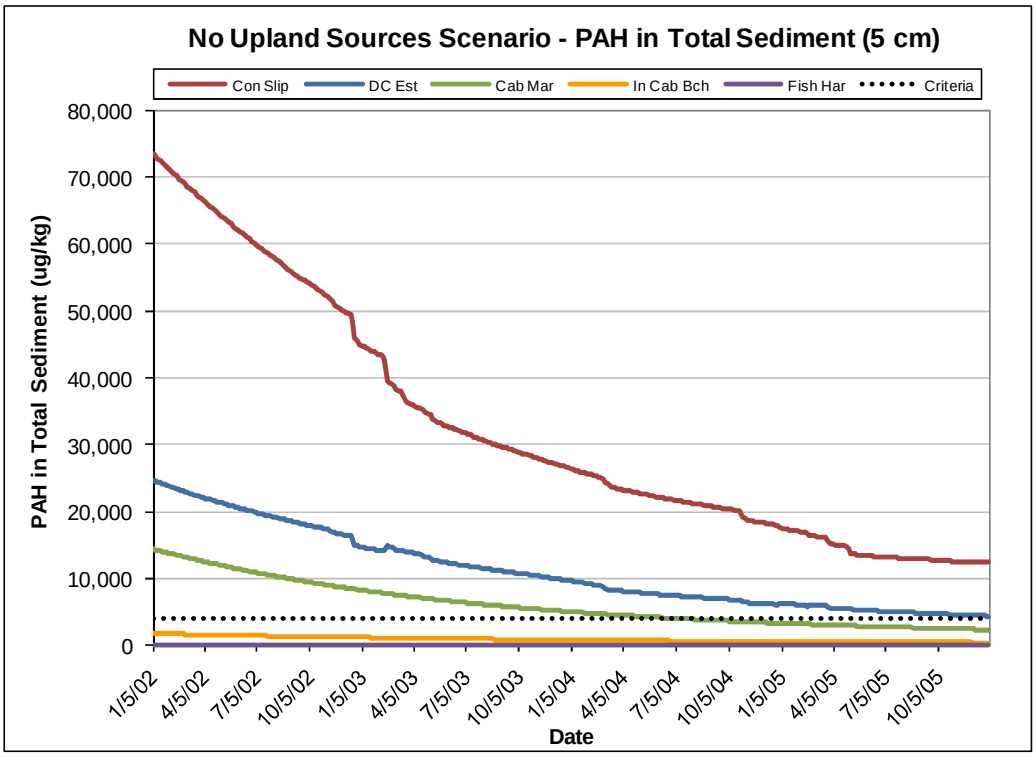

Figure 9. Sediment PAH concentrations for the no upland sources scenario (Consolidated Slip, Dominguez Channel Estuary, Inner Cabrillo Beach Area, Cabrillo Marina, and Fish Harbor)

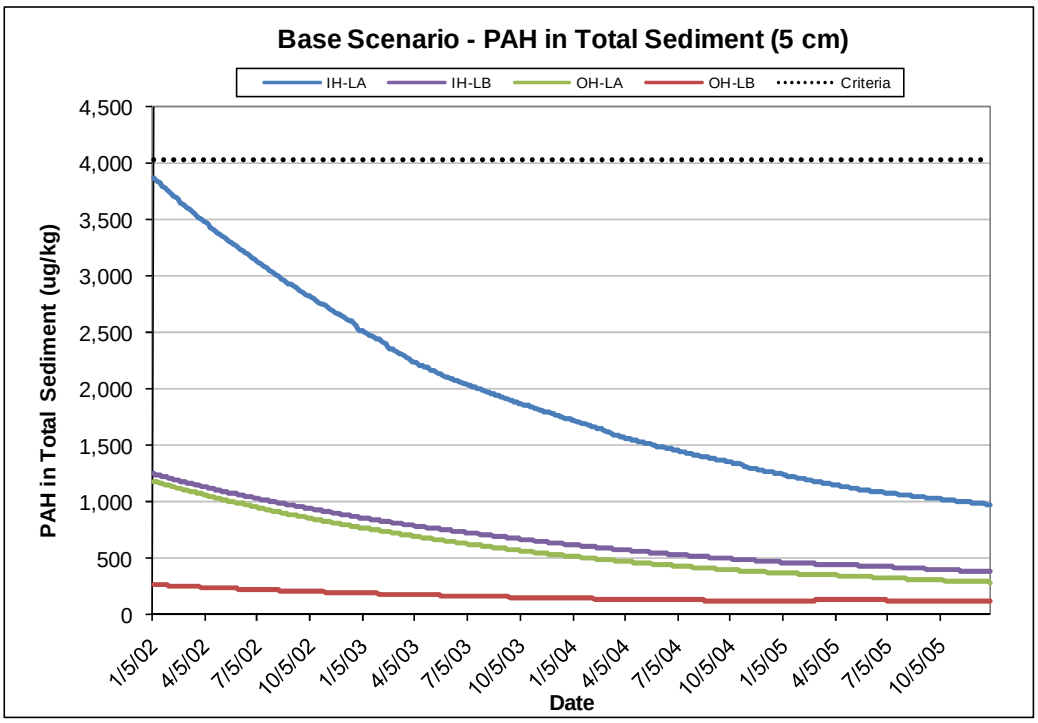

Figure 10. Sediment PAH concentrations for the base scenario (Inner and Outer Harbors)

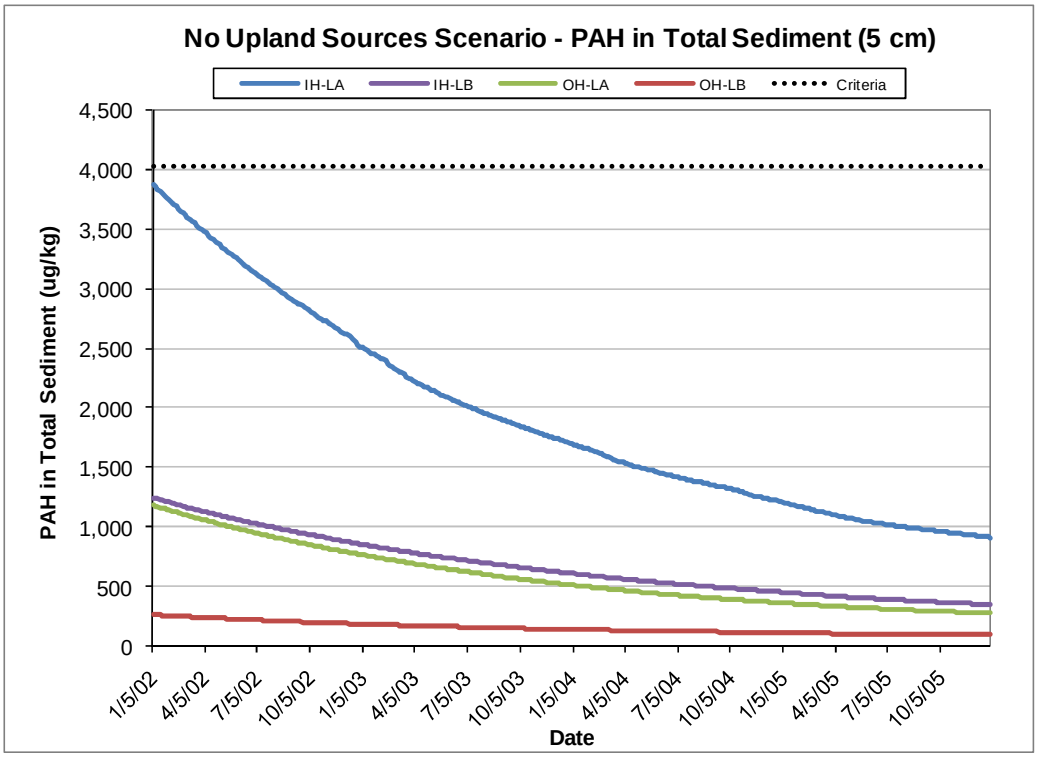

Figure 11. Sediment PAH concentrations for the no upland sources scenario (Inner and Outer Harbors)

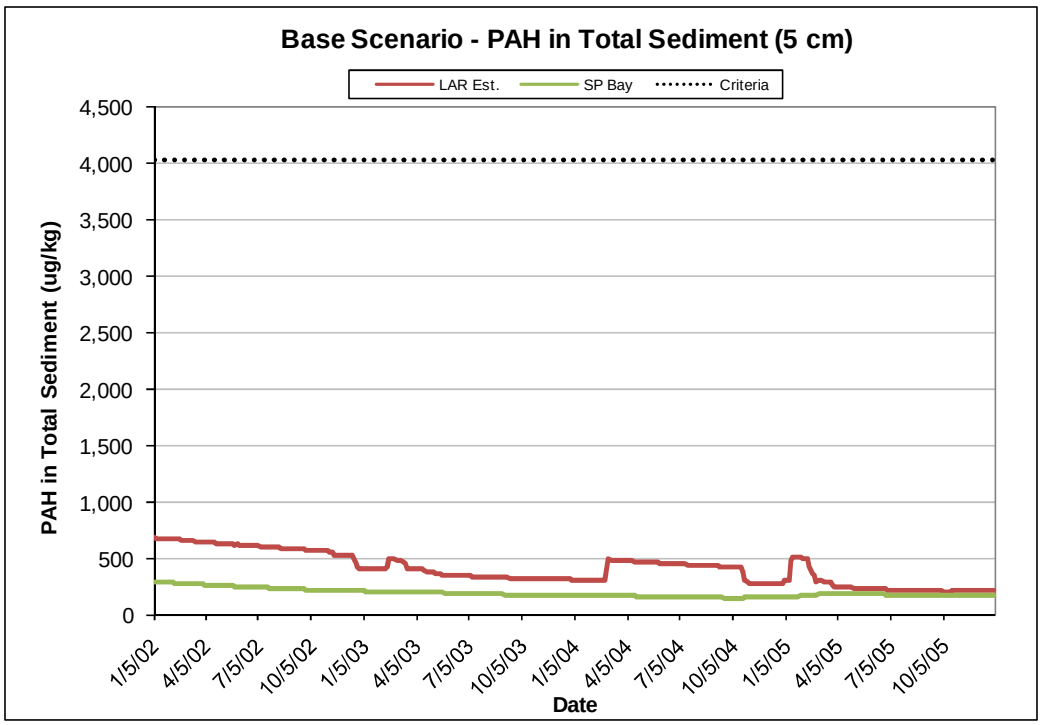

Figure 12. Sediment PAH concentrations for the base scenario (San Pedro Bay and LA River Estuary)

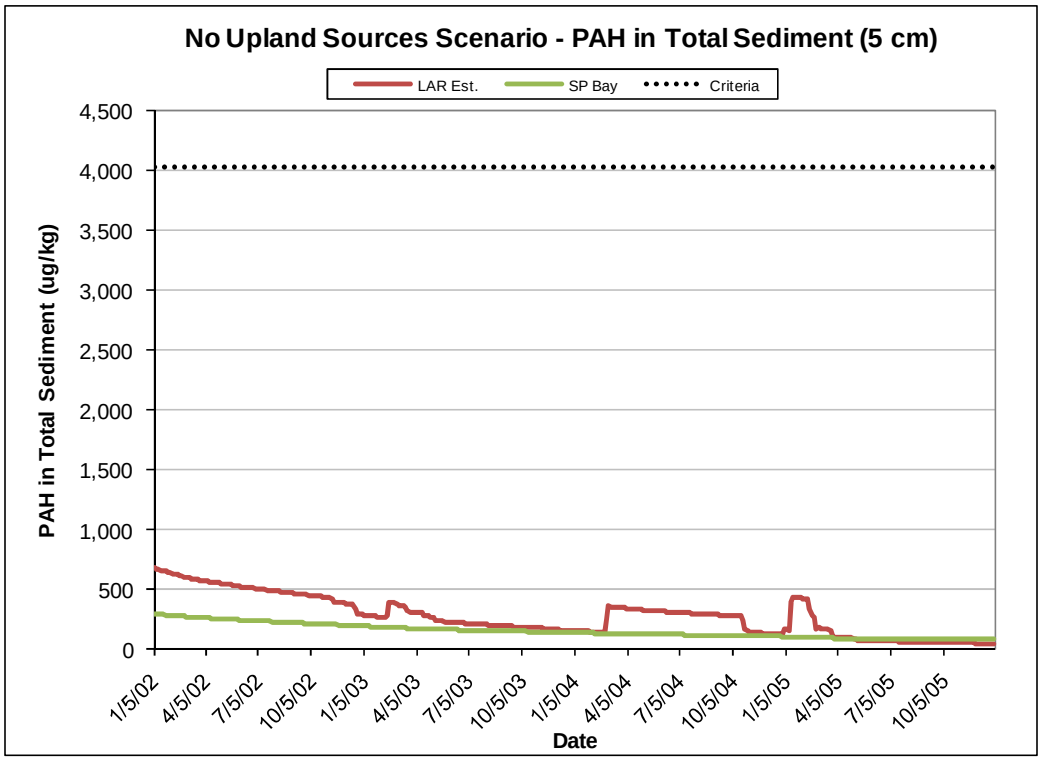

Figure 13. Sediment PAH concentrations for the no upland sources scenario (San Pedro Bay and LA River Estuary)

DDT

The maximum and average DDT sediment concentration exceeded criteria in all zones for both the base and no upland sources scenarios (Table 6). The percent difference in concentrations between the two scenarios shows that there appears to be minimal influence of loadings from upland sources. All waterbodies show approximately the same concentrations for the base and no upland sources scenarios. This indicates that DDT bed sediment contamination is predominantly a legacy issue and upland sources appear to be contributing loads of sediment that are cleaner than what is currently in bed sediments. Essentially, bed concentrations are well above the standards in each zone (for both scenarios), suggesting that sediment remediation is required in each zone to achieve sediment targets. The model shows that the combination of clean sediment deposition and the diffusion of legacy DDT contamination are causing bed sediment concentrations to gradually decrease over time. DDT is the most sensitive pollutant evaluated – ultimately, achieving sediment targets for DDT results in all other pollutants meeting their respective targets.

Table 6. Sediment DDT concentrations for the base and no upland sources scenarios

Zone	Waterbody Name	DDT (total) in top 5 cm of sediment (ug/kg)					
		Criteria: 1.58 ug/kg					
		Base Scenario Avg	Base Scenario Max	No Upland Sources Scenario Avg	No Upland Sources Scenario Max	% Diff Avg	% Diff Max
01	Dominguez Channel Estuary	21.85	66.16	20.38	66.16	6.70	0.00
02	Consolidated Slip	137.74	472.59	135.59	472.59	1.56	0.00
03	Inner Harbor – POLA	10.62	31.27	10.32	31.27	2.84	0.00
04	Fish Harbor	5.49	16.87	5.45	16.87	0.63	0.00
05	Cabrillo Marina	42.70	160.14	42.72	160.14	-0.05	0.00
06	Inner Cabrillo Beach Area	36.19	107.98	36.13	107.98	0.17	0.00
07	Outer Harbor – POLA	18.66	59.93	18.64	59.93	0.11	0.00
08	Inner Harbor – POLB	7.23	20.98	7.17	20.98	0.86	0.00
09	Outer Harbor – POLB	11.02	33.82	10.98	33.82	0.34	0.00
10	Los Angeles River Estuary	10.72	35.41	10.34	35.41	3.46	0.00
11	San Pedro Bay	10.77	34.30	10.62	34.30	1.36	0.00

Orange color indicates average zone concentration exceeds contaminant sediment criteria

PCBs

The maximum and average PCBs bed sediment concentrations exceeded criteria in all zones for both the base and no upland sources scenarios, except in Fish Harbor (zone 04) for which the average PCBs concentration met criteria (Table 7). The percent difference in concentrations between the two scenarios shows that there appears to be no or minimal loadings from upland sources. Similar to the DDT and PAHs results, PCBs concentrations were generally the same in both scenarios. This indicates that PCBs contamination is a legacy issue and upland sources appear to be contributing loads of sediment that are cleaner than what is currently in bed sediments. Similar to DDT, bed concentrations for both scenarios are well above the standards in each zone except for Fish Harbor (zone 04), suggesting that sediment remediation is required in most waterbodies to achieve sediment targets. The model shows that the combination of clean sediment deposition and the diffusion of legacy PCBs contamination are causing bed sediment concentrations to gradually decrease over time.

Table 7. Sediment PCBs concentrations for the base and no upland sources scenarios

Zone	Waterbody Name	PCBs (total) in top 5 cm of sediment (ug/kg)					
		Criteria: 3.20 ug/kg					
		Base Scenario Avg	Base Scenario Max	No Upland Sources Scenario Avg	No Upland Sources Scenario Max	% Diff Avg	% Diff Max
01	Dominguez Channel Estuary	23.26	72.89	22.62	72.89	2.74	0.00
02	Consolidated Slip	236.06	811.83	235.20	811.83	0.36	0.00
03	Inner Harbor – POLA	15.07	45.92	14.88	45.92	1.20	0.00
04	Fish Harbor	2.46	7.26	2.41	7.26	1.92	0.00
05	Cabrillo Marina	27.18	99.47	27.19	99.47	-0.02	0.00
06	Inner Cabrillo Beach Area	11.41	34.49	11.37	34.49	0.34	0.00
07	Outer Harbor – POLA	26.92	85.98	26.90	85.98	0.09	0.00
08	Inner Harbor – POLB	8.45	23.76	8.37	23.76	0.90	0.00
09	Outer Harbor – POLB	10.57	33.71	10.49	33.71	0.78	0.00
10	Los Angeles River Estuary	18.61	55.06	17.58	55.06	5.51	0.00
11	San Pedro Bay	5.81	17.62	5.46	17.62	6.04	0.00

Orange color indicates average zone concentration exceeds contaminant sediment criteria

References

Tetra Tech, Inc. 2011. Los Angeles-Long Beach Harbors and San Pedro Bay Hydrodynamic and Sediment-Contaminant Transport Model Calibration. Prepared for US EPA Region 9 and Los Angeles Regional Water Quality Control Board. May 2011. Fairfax, VA., 73 pp. (note: included as Appendix I to TMDL report)

Appendix III.9 – SQO Sediment Triad Results

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Table III.9-1. Sediment Triad Results Using Multiple Lines of Evidence 77

Appendix III.9 Summary

Using available sediment triad results (Bight 98, 03; WEMAP 99,05; BioBaseline 2008; see map in Figure III.4-3), staff performed an assessment for each waterbody using the SQO Part I-Direct Effects methodology. An exceedance of SQO Part I was considered for Possibly Impacted, Likely Impacted or Clearly Impacted at each station. Following the CA Listing Policy procedures outlined in Table 3-2 of that document, two or more exceedances per waterbody was interpreted as impaired. These assessment results confirmed impairment within two estuaries and marine waters identified in Table 2-18.

Table III.9-1. Sediment Triad Results Using Multiple Lines of Evidence

Study ID	Station ID	Waterbody Name	TOX LOE5	Chem LOE5	Benthic LOE5	MLOE Final5	MultiCondition5
Bight '03	4852	Dominguez Channel	1	2	3	2	Likely unimpacted
Bight '03	5108	Dominguez Channel	1	3	3	3	Possibly impacted
Bight '03	4206	Dominguez Channel	4	4	3	5	Clearly impacted
Bight '03	4270	Dominguez Channel	4	4	4	5	Clearly impacted
Bight '03	4436	Dominguez Channel	4	4	4	5	Clearly impacted
Bight '03	5012	Dominguez Channel	1	4	3	4	Likely impacted
WEMAP99	CA99-0032	Dominguez Channel	4	4	4	5	Clearly impacted
							Impaired (6 of 7 exceed SQO)
Biobaseline 2008	LA-14	Consolidated Slip	3	4	4	5	Clearly impacted
Bight '03	BRI-05	Consolidated Slip	4	3	2	3	Possibly impacted
							Impaired (2 of 2 exceed SQO)
Bight '03	BRI-03	Fish Harbor	3	4	2	4	Likely impacted
Bight '98	2174	Fish Harbor	1	3	2	1	Unimpacted
							(1 of 2 exceed SQO)
Bight '03	4138	Cabrillo Marina	4	4	2	4	Likely impacted
Biobaseline 2008	LA-12	Cabrillo Marina	2	3	2	3	Possibly impacted
							Impaired (2 of 2 exceed SQO)
Biobaseline 2008	LA-12	Inner Harbor	2	3	2	3	Possibly impacted
Biobaseline 2008	LA-14	Inner Harbor	3	4	4	5	Clearly impacted
Biobaseline 2008	LA-04	Inner Harbor	2	2	2	2	Likely unimpacted
Biobaseline 2008	LA-05	Inner Harbor	2	2	2	2	Likely unimpacted
Biobaseline 2008	LA-06	Inner Harbor	1	2	2	1	Unimpacted
Biobaseline 2008	LA-07	Inner Harbor	2	2	2	2	Likely unimpacted
Biobaseline 2008	LA-08	Inner Harbor	2	3	3	4	Likely impacted
Biobaseline 2008	LA-09	Inner Harbor	1	2	2	1	Unimpacted
Biobaseline 2008	LA-10	Inner Harbor	1	2	2	1	Unimpacted
Biobaseline 2008	LA-13	Inner Harbor	2	3	2	3	Possibly impacted
Biobaseline 2008	LA-15	Inner Harbor	2	2	2	2	Likely unimpacted
Biobaseline 2008	LB-03	Inner Harbor	2	3	2	3	Possibly impacted
Biobaseline 2008	LB-04	Inner Harbor	1	3	2	1	Unimpacted
Biobaseline 2008	LB-05	Inner Harbor	1	2	2	1	Unimpacted
Biobaseline 2008	LB-06	Inner Harbor	2	3	2	3	Possibly impacted
Biobaseline 2008	LB-07	Inner Harbor	1	3	2	1	Unimpacted
Biobaseline 2008	LB-10	Inner Harbor	1	3	2	1	Unimpacted
Biobaseline 2008	LB-11	Inner Harbor	1	3	2	1	Unimpacted
Biobaseline 2008	LB-12	Inner Harbor	1	3	2	1	Unimpacted
Biobaseline 2008	LB-13	Inner Harbor	1	3	2	1	Unimpacted

Study ID	Station ID	Waterbody Name	TOX LOE5	Chem LOE5	Benthic LOE5	MLOE Final5	MultiCondition5
Biobaseline 2008	LB-14	Inner Harbor	2	3	2	3	Possibly impacted
WEMAP05	CAS05-0015	Inner Harbor	2	2	2	2	Likely unimpacted
Bight '03	4146	Inner Harbor	1	1	1	1	Unimpacted
Bight '03	4050	Inner Harbor	1	2	2	1	Unimpacted
Bight '03	4210	Inner Harbor	1	2	2	1	Unimpacted
Bight '03	4266	Inner Harbor	1	3	2	1	Unimpacted
Bight '03	4010	Inner Harbor	3	4	3	5	Clearly impacted
WEMAP99	CA99-0033	Inner Harbor	1	2	1	1	Unimpacted
WEMAP99	CA99-0036	Inner Harbor	3	2	2	3	Possibly impacted
Bight '98	2176	Inner Harbor	3	2	3	4	Likely impacted
Bight '98	2177	Inner Harbor	3	2	4	4	Likely impacted
Bight '98	2182	Inner Harbor	2	2	4	3	Possibly impacted
Bight '98	2172	Inner Harbor	2	3	2	3	Possibly impacted
Bight '98	2173	Inner Harbor	2	3	2	3	Possibly impacted
Bight '98	2178	Inner Harbor	2	3	2	3	Possibly impacted
Bight '98	2421	Inner Harbor	2	3	2	3	Possibly impacted
Bight '98	2431	Inner Harbor	1	3	2	1	Unimpacted
Bight '98	2432	Inner Harbor	1	3	3	3	Possibly impacted
Bight '98	2169	Inner Harbor	3	4	3	5	Clearly impacted
Bight '98	2170	Inner Harbor	4	4	2	4	Likely impacted
Bight '98	2184	Inner Harbor	1	4	2	2	Likely unimpacted
Bight '98	2430	Inner Harbor	3	4	2	4	Likely impacted
							Impaired (20 of 40 exceed SQO)
Biobaseline 2008	LA-01	Outer Harbor	2	3	2	3	Possibly impacted
Biobaseline 2008	LA-02	Outer Harbor	2	3	2	3	Possibly impacted
Biobaseline 2008	LA-03	Outer Harbor	2	2	2	2	Likely unimpacted
Biobaseline 2008	LA-11	Outer Harbor	2	3	2	3	Possibly impacted
Biobaseline 2008	LB-01	Outer Harbor	1	2	2	1	Unimpacted
Biobaseline 2008	LB-02	Outer Harbor	1	2	1	1	Unimpacted
Biobaseline 2008	LB-09	Outer Harbor	1	2	2	1	Unimpacted
WEMAP05	CAS05-0007	Outer Harbor	1	2	2	1	Unimpacted
Bight '03	4162	Outer Harbor	1	2	1	1	Unimpacted
Bight '03	4242	Outer Harbor	1	2	1	1	Unimpacted
Bight '03	4400	Outer Harbor	3	2	2	3	Possibly impacted
Bight '03	4178	Outer Harbor	3	3	1	2	Likely unimpacted
Bight '03	4306	Outer Harbor	4	3	2	3	Possibly impacted
Bight '03	4370	Outer Harbor	3	3	2	3	Possibly impacted
WEMAP99	CA99-0038	Outer Harbor	1	1	1	1	Unimpacted
WEMAP99	CA99-0039	Outer Harbor	2	2	2	2	Likely unimpacted
Bight '98	2426	Outer Harbor	1	1	2	1	Unimpacted
Bight '98	2158	Outer Harbor	1	2	1	1	Unimpacted
Bight '98	2159	Outer Harbor	3	2	1	2	Likely unimpacted
Bight '98	2185	Outer Harbor	2	2	2	2	Likely unimpacted
Bight '98	2186	Outer Harbor	1	2	1	1	Unimpacted
Bight '98	2187	Outer Harbor	1	2	1	1	Unimpacted
Bight '98	2428	Outer Harbor	3	2	3	4	Likely impacted
Bight '98	2160	Outer Harbor	2	3	2	3	Possibly impacted

Study ID	Station ID	Waterbody Name	TOX LOE5	Chem LOE5	Benthic LOE5	MLOE Final5	MultiCondition5
Bight '98	2161	Outer Harbor	2	3	1	2	Likely unimpacted
Bight '98	2162	Outer Harbor	1	3	4	3	Possibly impacted
Bight '98	2168	Outer Harbor	3	3	2	3	Possibly impacted
Bight '98	2175	Outer Harbor	1	3	1	1	Unimpacted
Bight '98	2179	Outer Harbor	3	3	2	3	Possibly impacted
Bight '98	2427	Outer Harbor	4	3	2	3	Possibly impacted
							Impaired (12 of 30 exceed SQO)
Biobaseline 2008	LB-08	San Pedro Bay	1	2	2	1	Unimpacted
WEMAP05	CAS05-0014	San Pedro Bay	1	1	3	2	Likely unimpacted
WEMAP05	CAS05-0006	San Pedro Bay	1	2	1	1	Unimpacted
WEMAP05	CAS05-0013	San Pedro Bay	2	3	3	4	Likely impacted
Bight '03	4098	San Pedro Bay	3	3	1	2	Likely unimpacted
Bight '03	4274	San Pedro Bay	1	3	1	1	Unimpacted
WEMAP99	CA99-0034	San Pedro Bay	2	2	2	2	Likely unimpacted
WEMAP99	CA99-0037	San Pedro Bay	1	2	1	1	Unimpacted
WEMAP99	CA99-0035	San Pedro Bay	3	3	2	3	Possibly impacted
Bight '98	2153	San Pedro Bay	1	1	1	1	Unimpacted
Bight '98	2152	San Pedro Bay	1	2	1	1	Unimpacted
Bight '98	2154	San Pedro Bay	1	2	2	1	Unimpacted
Bight '98	2157	San Pedro Bay	3	2	2	3	Possibly impacted
Bight '98	2155	San Pedro Bay	2	3	2	3	Possibly impacted
Bight '98	2163	San Pedro Bay	2	3	1	2	Likely unimpacted
Bight '98	2167	San Pedro Bay	2	3	2	3	Possibly impacted
Bight '98	2156	San Pedro Bay	2	4	2	3	Possibly impacted
							Impaired (6 of 17 exceed SQO)
Bight '03	4142	LAR Estuary	1	2	4	2	Likely unimpacted
Bight '03	4440	LAR Estuary	3	2	2	3	Possibly impacted
Bight '03	4856	LAR Estuary	1	2	3	2	Likely unimpacted
Bight '03	4788	LAR Estuary	1	3	4	3	Possibly impacted
Bight '03	4600	LAR Estuary	3	4	3	5	Clearly impacted
							Impaired (3 of 5 exceed SQO)
Bight '03	4002	SGR Estuary	1	1	3	2	Likely unimpacted
Bight '03	4034	SGR Estuary	1	1	2	1	Unimpacted
Bight '03	4194	SGR Estuary	1	1	3	2	Likely unimpacted
Bight '03	4258	SGR Estuary	1	1	3	2	Likely unimpacted
Bight '03	4322	SGR Estuary	1	1	3	2	Likely unimpacted
Bight '03	4520	SGR Estuary	1	1	3	2	Likely unimpacted
							Likely unimpacted