NEWPORT COAST AND LAGUNA BEACH ASBS PROTECTION PROGRAM

CROSS CONTAMINATION STUDY

APPENDIX B

TECHNICAL REPORT

Submitted to:

City of Newport Beach
Public Works Department
3300 Newport Boulevard
Newport Beach, CA 92663

Contact: Robert Stein, Principal Civil Engineer

Submitted by:

Everest International Consultants, Inc.
444 West Ocean Boulevard, Suite 1104
Long Beach, California 90802

Contact: Ying-Keung Poon, Project Manager

August 2008

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

ASBS	Areas of Special Biological Significance
CCA	Critical Coastal Area
CDFG	California Department of Fish and Game
ICWMP	Integrated Coastal Watershed Management Plan
MMA	Marine Managed Area
MPA	Marine Protected Area
MUN	Municipal and Domestic Supply
NPDES	National Pollution Discharge Elimination System
NPS	Nonpoint Source
OWPP	Ocean Water Protection Program
REC1	Water Contact Recreation
REC2	Non-Contact Recreation
SARWQCB	Santa Ana Regional Water Quality Control Board
SDRWQCB	San Diego Regional Water Quality Control Board
SWQPA	State Water Quality Protection Area
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
RWQCB	Regional Water Quality Control Board
USACE	U.S. Army Corps of Engineers

1. INTRODUCTION

1.1 Background

Biological resources along the California shoreline are protected through water quality regulations that include the following:

- Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California (Temperature Plan)
- Water Quality Control Plan for Ocean Waters of California (Ocean Plan)
- Marine Life Protection Act
- California's Nonpoint Source Plan

These water quality regulations are implemented by various programs and agencies that include the "areas of special biological significance" (ASBS) designated by the State Water Resources Control Board (SWRCB), marine protected areas (MPAs), ecological reserves, and marine managed areas (MMAs) managed by the California Department of Fish and Game (CDFG), and the Critical Coastal Areas (CCAs) Program.

The Temperature and Ocean Plans established the concept of "areas of special biological significance" for the waters of California. These areas, as designated by the SWRCB along with the nine Regional Water Quality Control Boards (RWQCBs), provide *"protection of species or biological communities to the extent that alteration of natural water quality is undesirable."* The purpose of the ASBS is *"to afford special protection for marine life to the extent that waste discharges are prohibited within the areas."* Prohibited waste discharges include discharge of elevated temperature wastes, point source sewage or industrial process wastes, and nonpoint source discharges (e.g., storm water runoff, silt and urban runoff) to the extent practicable. There are currently 34 ASBS that were designated between 1974 and 1975 (SWRCB 1976). The official ASBS names are documented in Appendix V of the California Ocean Plan (SWRCB 2001). In January 2003, the term ASBS was changed to State Water Quality Protection Area (SWQPA) as required under the Public Resources Code Section 36750 with the most recent publication of the legal definitions (i.e., legal boundaries) of the SWQPAs in June 2003 (SWRCB 2003). However, for this document the term ASBS will be used.

The ASBS overlap ecological reserves, marine parks, marine reserves, marine life refuges, and MPAs, which are protected under the Marine Life Protection Act and managed by CDFG. The designations of the ASBS were primarily based on the MPAs.

In addition to the protection of the ASBS and MPAs, the Critical Coastal Areas (CCAs) Program was established as part of the California's Nonpoint Source Plan to coordinate efforts by local stakeholders and governmental agencies in protecting coastal watersheds from polluted runoff that threaten coastal resources. The CCA Program is a non-regulatory planning tool coordinated by the CCA Committee led by the California Coastal Commission with the goal to ensure that NPS management measures are effectively implemented to protect or restore coastal water quality in CCAs. Community-based action plans will be developed to integrate and build on existing local watershed protection and restoration efforts, identify needs and available resources, focus the attention of responsible agencies, and coordinate with other relevant water quality protection programs. Currently there are 101 CCAs (updated in 2002), which are coastal watershed areas that drain into 303(d) impaired coastal water bodies or where 303(d) impaired waters flow into MPAs or ASBS. Action plans are being developed for four Orange County CCAs: CCA #69 Upper Newport Bay, CCA #70 Newport Beach Marine Life Refuge, CCA #71 Irvine Coast Marine Life Refuge, and CCA #72 Heisler Park.

The City of Newport in cooperation with the City of Laguna Beach has obtained a SWRCB Proposition 50 grant for the Newport Coast and Laguna Beach ASBS Protection Program (Program) to address the three ASBS adjacent to the Cities' jurisdictions:

(1) ASBS 32 – Newport Beach Marine Life Refuge

(2) ASBS 33 - Irvine Coast Marine Life Refuge

(3) ASBS 30 – Heisler Park Ecological Reserve

The goal of the Program is to provide for water quality improvement and habitat restoration across the three ASBS regions and assist conformance with the protection of these ASBS under the Ocean Plan. The objectives of the Program are to identify and quantify the environmental impacts with the most detrimental effects on water quality and habitats in the ASBS and to prepare an Integrated Coastal Watershed Management Plan (ICWMP). The Program is composed of four components – Public Use Impact Study, Laguna Beach Flow and Water Quality Assessment, Pilot Restoration Experiment, and Cross-Contamination Study. This study pertains to the Cross-Contamination Study (Study).

1.2 Study Objectives

The objectives for this Study are: 1) to identify and quantify potential pollutant loadings from the coastal watersheds, 2) to determine potential impacts of these pollutants to the ASBSs, and 3) to support the development of an ICWMP. These objectives are being achieved by the following tasks:

(4) Collect and analyze available data to quantify potential pollutant and sediment loadings to the Study Area

(5) Conduct a sediment budget analyses for the Study Area and evaluate sediment erosion/deposition characteristics of the ASBSs

(6) Prepare a pollutant loading report

(7) Develop and use a hydrodynamic and water quality model to evaluate potential impacts to the three ASBSs from various pollutant and sediment sources

(8) Prepare a cross-contamination report

Tasks 1 through 3 pertaining to the pollutant loading and sediment budget analyses are summarized in Appendix A. Data from the pollutant loading analysis was used to determine pollutant loadings into the ASBS, which was used in conjunction with the numerical modeling to assess potential cross-contamination of the harbor and creek discharges to the ASBS. This Cross Contamination Study Technical Appendix provides details of the methodologies and results of the numerical modeling under Task 4 to support the evaluation of potential impacts presented in the Cross-Contamination Study main report.

The pollutant sources were evaluated for potential impacts to the ASBS by addressing three issues: 1) do constituents from the Harbor and coastal creeks have the potential to reach the ASBS, 2) what is the most probable direction of transport for constituent discharges, and 3) how are constituent concentrations mixing along the coastline. The potential impacts were determined using a numerical model developed for the Study Area.

In this Technical Appendix, a brief description of the study area including CCA #69, ASBS 32, ASBS 33, ASBS 30, and the adjacent watersheds is provided in Section 2. The development of a hydrodynamic and water quality model is provided in Section 3, while the application of the model for the cross contamination study is discussed in Section 4. The findings and conclusions of this report are summarized in Section 5 and references for the study are listed in Section 6.

2. STUDY AREA

The Study Area, shown in Figure 2.1, is comprised of CCA #69, ASBS 32, ASBS 33, ASBS 30, and the adjacent coastal watersheds. The coastal watersheds are Newport Bay, Newport Coast, and Laguna Canyon Watersheds. CCA #69 is located in Upper Newport Bay within the Newport Bay Watershed. Major discharges to CCA #69 are San Diego Creek, Santa Ana-Delhi Channel, Santa Isabella Channel, and Big Canyon. ASBS 32 and 33 are located along the Newport Coast Watershed. Buck Gully and Morning Canyon drain into ASBS 32. Pelican Point Creek, Pelican Point Middle Creek, Pelican Hill Waterfall Creek, Los Trancos Creek (Crystal Cove Creek), Muddy Creek, and El Moro Canyon discharge into ASBS 33. Laguna Canyon discharges just downcoast to ASBS 30. A summary of watersheds and creeks within the Study Area are shown in Table 2.1.

Table 2.1 Summary of Study Area

<table>
<tr><th>Watershed</th><th>ASBS</th><th>CCA</th><th>Creek / Beach</th><th>MMA</th></tr>
<tr><td rowspan="6">Newport Bay</td><td rowspan="6">--</td><td rowspan="4">69</td><td>San Diego Creek</td><td rowspan="4">Upper Newport Bay Ecological Reserve and State Marine Park</td></tr>
<tr><td>Santa Ana Delhi Channel</td></tr>
<tr><td>Santa Isabella Channel</td></tr>
<tr><td>Big Canyon</td></tr>
<tr><td></td><td>East Costa Mesa Channel</td><td></td></tr>
<tr><td></td><td>Big Corona Beach</td><td></td></tr>
<tr><td rowspan="11">Newport Coast</td><td rowspan="2">32</td><td rowspan="2">70</td><td>Buck Gully / Little Corona Beach</td><td rowspan="2">Robert E. Badham State Park</td></tr>
<tr><td>Morning Canyon</td></tr>
<tr><td rowspan="6">33</td><td rowspan="6">71</td><td>Pelican Point Creek</td><td rowspan="6">Irvine Coast State Marine Park and Crystal Cove State Marine Conservation Area</td></tr>
<tr><td>Pelican Point Middle Creek</td></tr>
<tr><td>Pelican Hill Waterfall Creek</td></tr>
<tr><td>Los Trancos Creek</td></tr>
<tr><td>Muddy Creek</td></tr>
<tr><td>El Moro Canyon</td></tr>
<tr><td></td><td></td><td>Irvine Cove</td><td></td></tr>
<tr><td></td><td></td><td>Cameo Cove</td><td></td></tr>
<tr><td></td><td></td><td>Emerald Canyon / Emerald Bay Beach</td><td></td></tr>
<tr><td rowspan="7">Laguna Canyon</td><td></td><td></td><td>Crescent Bay Point Beach</td><td rowspan="5">Laguna Beach State Marine Park</td></tr>
<tr><td></td><td></td><td>Crescent Bay Beach</td></tr>
<tr><td></td><td></td><td>Shaws Cove</td></tr>
<tr><td></td><td></td><td>Fisherman’s Cove</td></tr>
<tr><td rowspan="2">30</td><td rowspan="2">72</td><td>Diver’s Cove</td></tr>
<tr><td>Heisler Park / Rockpile Beach</td><td>Heisler Park State Marine Reserve</td></tr>
<tr><td></td><td></td><td>Laguna Canyon Channel / Main Beach</td><td>Laguna Beach State Marine Park</td></tr>
</table>

Figure 2.1 Study Area

2.1 Newport Bay Watershed

The Newport Bay Watershed, shown in Figure 2.2, consists of approximately 154-square miles in the cities of Newport Beach, Irvine, Costa Mesa, Santa Ana, Orange, Tustin, Lake Forest, and Laguna Hills that drain into Upper and Lower Newport Bay, which are divided by Pacific Coast Highway. The watershed is predominantly urbanized, with about 70% urban, 10% agricultural, and 20% vacant land uses (SARWQCB 2004).

Drainages for UNB include San Diego Creek, Santa Ana Delhi Channel, Santa Isabella Channel, and Big Canyon. The approximate drainages areas for each of these creeks are listed in Table 2.2. San Diego Creek is the largest of these creeks, draining 119-square miles that include Serrano Creek, Borrego Canyon Wash, Agua Chinon Wash, Bee Canyon, Marshburn Channel, Peters Canyon Channel, Barranca Channel, Round Canyon, Lane Channel, San Joaquin Channel, Sand Canyon, and Bonita Channel. San Diego Creek was channelized in the early 1960's by the Orange County Flood Control District.

Table 2.2 CCA #69 Drainage Areas

Watershed	Drainage Area (sq. miles)
San Diego Creek	119
Santa Ana Delhi Channel	17.3
Santa Isabella Channel	~3.1
Big Canyon Creek	2.0

Source: SARWQCB 2004

The Newport Bay Watershed coincides with the SARWQCB Newport Bay Management Area. Newport Bay is a 303(d) impaired water body with TMDLs for nutrients, sediment, toxic constituents, and fecal coliform. Toxic constituents include metals and pesticides for UNB and metals, pesticides, and priority organics for the lower portion of the bay. Sediment, nutrients, and toxics TMDLs have been developed jointly for both Newport Bay and San Diego Creek, while the fecal coliform TMDL has been developed for Newport Bay. CCA #69 is within the jurisdiction of the Santa Ana Regional Water Quality Control Board (SARWQCB).

Figure 2.2 Newport Bay Watershed

2.1.1 CCA #69 – Upper Newport Bay

CCA #69 consists of the Upper Newport Bay Ecological Reserve and Upper Newport Bay State Marine Park, both MPAs managed by CDFG, as well as the coastal watershed that drains into the reserve. Upper Newport Bay Ecological Reserve is located on 752-acres in the upper portion of Newport Bay, north of Shellmaker Island. The ecological reserve was originally established on 527 acres in 1975 with the expansion to 752 acres by 1982. Upper Newport Bay State Marine Park is located below mean high tide within the ecological reserve. Surrounding the ecological reserve along the north and northwest bluffs is the 140-acre Upper Newport Bay Nature Preserve, which is maintained by the County of Orange.

Upper Newport Bay Ecological Reserve serves as a nesting and feeding habitat for approximately 182 migratory species on the Pacific Flyway and 33 year-round species of birds. The bay is also home to six federal or state threatened and endangered species; five bird species (light-footed clapper rail, California least tern, Belding's Savannah sparrow, California brown pelican, American peregrine falcon, and California black rail) and one plant species (Saltmarsh bird's beak) (USACE 2000). The other sensitive bird species include the snowy plover, California coastal gnatcatcher, San Diego cactus wren, and burrowing owl.

2.2 Newport Coast Watershed

The Newport Coast Watershed covers approximately 12 square miles between Corona Del Mar Beach to north of Laguna Beach within the cities of Newport Beach, Corona Del Mar, Irvine, and an unincorporated portion of Orange County that includes the Newport Coast Planned Community. Predominant land uses within the watershed include open space, agriculture, residential, and commercial uses.

The Newport Coast Watershed is comprised of the drainage areas (Table 2.3) for Buck Gully, Morning Canyon, Pelican Point Creek, Pelican Point Middle Creek, Pelican Hill Waterfall Creek, Los Trancos Creek, Muddy Creek, El Moro Canyon, and Emerald Canyon. Eight of the creeks discharge directly into ASBS 32 or 33 with the exception of Emerald Canyon.

The watershed area that discharges directly into ASBS 32 is the drainage areas for Buck Gully and Morning Canyon, which comprise CCA #70. Buck Gully discharges to Little Corona Beach. Morning Canyon discharges onto a beach. Pelican Point Creek, Pelican Point Middle Creek, Pelican Point Waterfall Creek, Los Trancos Creek (also called Crystal Cove Creek), Muddy Creek, and El Moro Canyon flow directly into ASBS 33 and correspond to CCA #71. These creeks discharge into the beach area of Crystal Cove State Park and waters of the Irvine Coast State Marine Park and Crystal Cove State Marine Conservation Area.

Table 2.3 Newport Coast Drainage Areas

Subwatershed	Drainage Area Square Miles (Acres)
Buck Gully	1.97 (1,261)
Morning Canyon	0.60 (387)
Pelican Point Community	0.04 (23)
Pelican Point Creek	No Data
Pelican Point Middle Creek	0.37 (235)
Pelican Point Waterfall Creek	0.22 (143)
Los Trancos Creek	1.85 (1,181)
Muddy Canyon	1.56 (996)
El Moro Canyon	3.35 (2,143)
Emerald Canyon*	2.27 (1,453)

Source: Weston 2007
*Source: City of Laguna Beach 1988

Emerald Canyon discharges into Emerald Bay Beach located between ASBS 33 and 30. The drainage area for Emerald Canyon includes Crystal Cove State Park, Laguna Coast Wilderness Park, and an unincorporated area.

The Newport Coast Watershed is within the Newport Coast Management Area, shown in Figure 2.3, under jurisdiction of the SARWQCB with the exception of El Moro Canyon and Emerald Canyon, which are in the San Juan Watershed Management Area under SDRWQCB jurisdiction. Buck Gully (below Pacific Coast Highway) and Los Trancos Creek (below Pacific Coast Highway) is 303(d)-listed for total and fecal coliform. In addition, Pelican Point Creek, Los Trancos Creek, and Muddy Creek are in violation of one or more designated beneficial uses (REC1, REC2, and MUN) (SARWQCB 2004). The Pacific Ocean Shoreline upcoast from Emerald Bay in Cameo Cove is 303(d) listed for bacteria indicators (SWRCB 2003).

Figure 2.3 Newport Coast Watershed

2.2.1 ASBS 32 – Newport Beach Marine Life Refuge

ASBS 32 Newport Beach Marine Life Refuge coincides with the Robert E. Badham State Marine Park (formerly called Newport Beach Marine Life Refuge), which was established in 1968 and is currently administered by CDFG. This ASBS is located along 0.7 miles of coastline (Little Corona Beach) between Poppy Avenue and the eastern boundary of the City of Newport Beach at Cameo Shores Road. ASBS 32 was designated by SWRCB Resolution No. 74-32. This area also corresponds to CCA #70, which was identified where the 303(d) impaired waters of Lower Newport Bay and Buck Gully Creek flows into MMAs or ASBS.

ASBS 32 is backed by sandstone bluffs that are covered with native coastal scrub including lemonadeberry bush, rhus integrifolia, bladderpod, and daises Encelia sp., as well as introduced vegetation. Intertidal habitat includes sandy beach and rocky outcrops. Intertidal biota is reduced in number and diversity, while the offshore reefs are healthy and diverse. Subtidal habitat consists of small patches of rocky reef with sandy bottom (SWRCB 1979a).

2.2.2 ASBS 33 – Irvine Coast Marine Life Refuge

ASBS 33 Irvine Coast Marine Life Refuge overlaps the CDFG MMA Irvine Coast State Marine Park (formerly called Irvine Coast Marine Life Refuge) located adjacent to ASBS 32 at Cameo Shores Road extending 3.4 miles to the northwestern boundary of the City of Laguna Beach near Abalone Point. ASBS 33 was designated by SWRCB Resolution No. 74-32. Crystal Cove State Marine Conservation Area also overlaps the Irvine Coast State Marine Park, but extends farther offshore and does not provide the same level of protection as the marine park. The watershed that drains into ASBS 33 has been identified as CCA #71, which includes the 303(d) impaired Los Trancos Creek. ASBS 33 falls within the jurisdiction of both the Santa Ana and San Diego RWQCBs.

This stretch of shoreline is comprised of coarse sand beaches with occasional rock outcroppings with rich and diverse plant and animal communities. The coastal bluffs backing ASBS 33 are covered with coastal sage scrub vegetation community. Most flora along the bluffs are native to the Southern California coastline, however there are some introduced species. The subtidal area is sandy with small rocky reefs scattered throughout the refuge. Beds of giant kelp are present, although not in large beds due to the small reefs (SWRCB 1979b).

2.3 Laguna Canyon Watershed

The Laguna Canyon Watershed, shown in Figure 2.4, drains an area of about 9.76 sq. miles (6,246 acres) into Main Beach (City of Laguna Beach 1988). The Laguna Canyon Channel, along with Niguel Creek and Laurel Canyon tributaries, flows through portions of the cities of Aliso Viejo, Laguna Beach, and Laguna Woods.

The Laguna Canyon Watershed is part of the Laguna Beach HSA, as part of the SDRWQCB San Juan Management Area. The Pacific Ocean shoreline at Heisler Park – North and along the Laguna Canyon Watershed (Main Laguna Beach, Laguna Beach at Ocean Avenue, and Laguna Beach at Laguna Avenue) are 303(d) listed for bacteria indicators.

2.3.1 ASBS 30 – Heisler Park Ecological Reserve

ASBS 30 Heisler Park Ecological Reserve, which was designated by SWRCB Resolution No. 74-28 (March 21, 1974), is located seaward of Heisler Park along approximately 0.5 miles of coastline between Hawthorne Road and Aster Street in the City of Laguna Beach. ASBS 30 coincides with Heisler Park State Marine Reserve (formerly called Heisler Park Ecological Reserve), which is located within the Laguna Beach State Marine Park (formerly Laguna Beach Marine Life Refuge) and both managed by CDFG. Heisler Park State Marine Reserve was established in 1973 and Laguna Beach State Marine Park established in 1968. CCA #72 is the watershed that drains into Heisler Park State Marine Reserve and Laguna Beach State Marine Park.

Figure 2.4 Laguna Canyon Watershed

3. MODEL DEVELOPMENT

A hydrodynamic and water quality model of Newport Bay and the ASBS was developed to evaluate potential impacts to the three ASBS from various pollutant and sediment sources. The model was developed using the RMA2 and RMA4 models developed by the U.S. Army Corps of Engineers (USACE). RMA2 is a depth-averaged two-dimensional hydrodynamic model, which can be used to simulate changes in water elevations and depth-averaged velocities of a water body due to tidal forcing or other inflows. The RMA2 model results can then be used to drive the water quality model RMA4 to simulate water quality conditions of the water body including mixing and dispersion characteristics.

This section documents the data used to develop the numerical model of Newport Bay and ASBS. Data summarized includes data used for the model grid setup, comparison of the hydrodynamic model to field data, and inputs for model simulations.

3.1 Grid Setup

The numerical model grid used for this Study was a composite of two model grids previously developed for the City by Everest (2004 and 2005). For Upper Newport Bay, only the subtidal channel was included. The coastal shoreline was expanded upcoast near Newport Pier and downcoast to Laguna Beach. In order to improve the model efficiency, two grids, which are shown in Figure 3.1, were developed with different resolutions. The first grid has very fine grid resolutions between the bay entrance and ASBS 32 and near Buck Gully, while the second grid uses very fine grid sizes for the areas near the mouths of the other coastal creeks.

The bathymetry used in preparing the model grid is based on several different sources. Majority of the Lower Newport Bay bathymetry is based on a survey conducted by USACE in April 2002. Bathymetry of Upper Newport Bay is based on survey conducted by USACE in 2003. Bathymetry for the Newport Island Channels at the west end of Newport Harbor is based on the City of Newport Beach 1976 dredged plan. For the rest of the Newport Harbor where bathymetric data are not available and the coastal region, the bathymetry is based on the 1999 NOAA Chart (No. 18754).

Figure 3.1 Numerical Model Grids

3.2 Model Inputs

3.2.1 Tide

Tidal forcings in the model simulations were based on tide elevations at the NOAA tide station at the Newport Bay Entrance (Station 9410580). Tidal datums from the NOAA 1983 – 2001 Tidal Epoch bench marks for the Newport Bay Entrance are summarized in Table 3.1.

Model simulations used a tidal forcing of either a mean tide representing typical tidal conditions or real tide elevations from the NOAA tide station. A mean tide representing daily tidal conditions is a period of 24 hours consisting of two high tides (MHHW and MHW) and two low tides (MLW and MLLW).

Table 3.1 Newport Bay Tide Elevations

Tide	Elevation (ft, MLLW)
Mean Higher High Water (MHHW)	5.410
Mean High Water (MHW)	4.672
Mean Low Water (MLW)	0.915
Mean Lower Low Water (MLLW)	0.000

Source: NOAA 2003

3.2.2 Inflows

Dry weather flows from coastal creeks, which are summarized in Table 3.2, were estimated using a relationship based on the drainage area of each creek. The relationship for dry weather flow was determined from monitoring data of storm drains discharging into Newport Bay (Everest 2004).

Table 3.2 Dry Weather Flows

Creek	Drainage Area (acres)	Flow (cfs)
San Diego Creek	87,438	13.15
Santa Ana-Delhi Channel		
Santa Isabella Channel		
Big Canyon Wash	~1,280	0.19
Costa Mesa Channel	~640	0.10
Remaining Newport Bay	8,335.386	1.25
Buck Gully	1,261.32	0.19
Morning Canyon	387	0.058
Pelican Point Creek	Unknown	--
Pelican Point Middle Creek	235	0.035
Pelican Point Waterfall Creek	143	0.022*
Los Trancos Creek	1,181	0.18**
Muddy Creek	996	0.15**
El Moro Creek	2,143	0.32
Emerald Canyon	1,453	0.22
Laguna Canyon Channel	6,246	0.94

*Flows only observed during wet weather
**Not simulated due to dry weather diversion

Wet weather data for San Diego Creek were available for the December 6, 1997 storm event with a peak flow rate of 43,400 cfs measured at Campus Drive (USACE 2000). This hydrograph was then scaled to match the FEMA 100-year peak flow. To account for wet weather flows from the remaining drainage area into Newport Bay, the San Diego Creek hydrograph 100-year hydrograph was scaled to the remaining drainage area representing wet weather flows to LNB.

For the coastal creeks, continuous flow measurements for Buck Gully were available between January 2005 and March 2006 (WESTON 2007). Wet weather model simulations used flow data from the February 28, 2006 rain event with a peak flow rate of 2.45 cfs.

3.2.3 Water Quality

Water quality data are required to determine the amount of pollutants being discharged from the Harbor and coastal creeks. Ideally, simultaneously measured flow data and pollutant concentrations are needed to calculate the pollutant loading discharging from the Harbor or the coastal creeks. As part of the pollutant loading analysis, available water quality and pollutant loading data for the coastal creeks were reviewed and summarized from continuous monitoring programs and field data collection programs. Data for a wide range of pollutants and sampling locations were analyzed. Details of the water quality and pollutant loading analysis are provided in Appendix A. The pollutant loading analysis provided sufficient data to estimate pollutant loadings for Buck Gully. Dissolved metal concentrations collected for Buck Gully are summarized in Table 3.3. These data were based on the sampling conducted for the Newport Coast water quality assessment by the City of Newport Beach (WESTON 2007). There were simultaneously collected flow data that can be used in conjunction with the concentrations shown in Table 3.3 to calculate the corresponding metal loadings discharging from Buck Gully into the coastal areas. However, there is insufficient data to estimate pollutant loadings for other coastal creeks.

Table 3.3 Water Quality Data for Buck Gully

Dissolved Metal (IN PPM)	Dry Weather		Wet Weather	
	Average	Maximum	Average	Maximum
Ag – Silver	0.000123	0.00017	ND	ND
As – Arsenic	0.000723	0.00176	0.002713	0.00373
Cd – Cadmium	0.025830	0.00639	0.003400	0.00366
Cr – Chromium	0.001330	0.00219	0.001893	0.00307
Cu – Copper	0.006823	0.00906	0.014463*	0.02540*
Ni – Nickel	0.012133	0.02230	0.012323	0.01720
Pb – Lead	ND	ND	0.000060	0.00008
Zn – Zinc	0.014283	0.02190	0.016540	0.02760

ND – Non detect
*Exceeds minimum toxicity value (see Table 4.1)

Based on the pollutant loading analysis, no data were available to calculate pollutant loadings exiting the Harbor entrance into the coastline. As such, a conservative assumption was used to estimate the pollutant loadings. It was assumed that dissolved metal concentrations exiting the Harbor (i.e., simulated as a point source similar to a creek discharge at the Harbor exit) are the same as the dissolved metal concentrations within the Newport Bay which are summarized in Table 3.4. The data shown in the table are based on data collected for the eight NPDES estuary/wetland monitoring stations in Newport Bay. The metal concentrations shown in the table are multiplied with typical dry and wet weather flow rates exiting the Harbor entrance to come up with the corresponding estimated pollutant loadings.

Table 3.4 Dissolved Metal Concentrations for Newport Bay

Dissolved Metal (in ppm)	Dry Weather		Wet Weather	
	Average	Maximum	Average	Maximum
Ag – Silver	0.001236	0.0040	0.00154	0.0022
As – Arsenic	0.001397	0.00244	0.001804	0.0049
Cd – Cadmium	0.000663	0.0020	0.00793	0.0033
Cr – Chromium	0.004450	0.0160	0.005612	0.0086
Cu – Copper	0.005793	0.0180*	0.006936	0.0450*
Ni – Nickel	0.007286	0.0240	0.008087	0.0210
Pb – Lead	0.001272	0.0040	0.001616	0.0046
Zn – Zinc	0.017769	0.0770	0.018861	0.0850

*Exceeds minimum toxicity value (see Table 4.1)

4. HYDRODYNAMIC AND WATER QUALITY MODELING

The pollutant sources were evaluated for potential impacts to the ASBS by addressing three issues: 1) do constituents from the Harbor and coastal creeks have the potential to reach the ASBS, 2) what is the most probable direction of transport for constituent discharges, and 3) how are constituent concentrations mixing along the coastline.

The potential impacts were determined using the numerical model developed for the Study Area discussed in Section 3. The hydrodynamic model has previously been verified with available field data that the model provides accurate predictions for tidal elevations and currents within Newport Bay (Everest 2005). The model was used to evaluate the potential impacts to the ASBS from various discharges in two ways. The first was to use the model to track the movement of "numerical tracers" representing pollutants discharging from the Harbor and coastal creeks. This method called "particle tracking" allows the efficient assessment of transport conditions by releasing numerical tracers from the discharge locations for different tide and flow conditions. The particle tracking was used to determine if pollutants from the Harbor and other coastal creeks have the potential to reach the ASBS and the most probable direction of transport. Secondly, the water quality model was used to simulate the mixing and dispersion of pollutants being discharged along the coastline. By releasing pollutants from different discharge locations, the relative impacts of pollutants from different sources on the ASBS can be evaluated.

4.1 Particle Tracking

The transport conditions or movement of pollutants entering the ocean are predominantly dependent on the tide and flow conditions that occur at the time when the pollutant is discharged into the ocean, as well as where the pollutant is discharged. For example, pollutants discharged at the Harbor entrance while high flows are exiting the Harbor (e.g., peak ebb tide) would be transported further out of the Harbor as compared to pollutants discharged during high flows entering the Harbor (e.g., peak flood tide). Thus, the particle tracking analysis was conducted for a wide range of tide, flow, release times, and release location combinations selected to capture the most probable transport conditions.

The combination of tide, flows, and release times are shown in Figure 4.1 while the release locations are shown in Figure 4.2. For dry weather or tide dominant conditions, a mean tide representing an average tidal condition and dry weather flows based on drainage area of each creek discussed previously were used in combination with five release times (marked by the red dots on the top panel of Figure 4.1). Dry weather conditions were also simulated for the Harbor and coastal creek release locations. Wet weather conditions from the Harbor

Figure 4.1 Particle Tracking Release Times

Figure 4.2 Particle Tracking Release Locations

were simulated using a mean tide and 100-year flood flow entering Newport Bay with the peak flow occurring at the same time as the peak ebb tide. This extreme wet weather condition for the Harbor was evaluated with five release times. Harbor release locations divided into four groups along the Harbor entrance. Due to limited flow data for the coastal creeks, wet weather conditions were only evaluated for Buck Gully. Wet weather conditions for the Buck Gully particle tracking analysis utilized prior flow data measurements (WESTON 2007) with corresponding tide conditions during one rain event along with four release times covering the duration of wet weather flow.

The particle tracking results from the Harbor are shown in Figures 4.3 and 4.4 for dry and wet weather conditions, respectively. Each figure shows the particle tracks indicated by colored lines for each particle release location from Group 1. Each panel corresponds to a different tide condition. The gray-shaded area indicates ASBS 32 and 33. Under dry weather conditions, pollutants exiting the Harbor are transported downcoast along the coastline to ASBS 32 and 33. Movement of the particle into or out of the Harbor show the oscillation attributed to the tidal fluctuations. Transport into the Harbor occurs under flood tide conditions, while transport out of the Harbor occurs during ebb tide. As expected, under wet weather conditions, the particle tracks show more prominent offshore transports due to the higher flows exiting the Harbor. For both dry and wet weather conditions, the transport pattern can vary depending on the release location. For example, in the dry weather particle tracks released at MHHW, the blue release location shows movement into and out of the Harbor entrance before moving downcoast, whereas the other particle tracks show transport directly out of the Harbor and moving downcoast.

To account for the spatial variability, additional release locations and release times were also simulated under dry and wet weather conditions. The complete set of Harbor particle release locations and times under dry and wet weather conditions are shown in Figures 4.5 and 4.6, respectively. In the figures, the particles tracks are shown in the same color with the exception of the center release location shown in red. The particle tracks together illustrate the most probable extents of the transporting pollutants. Overall, results for particles released just prior to or during ebb tides move downcoast through ASBS 32 and 33, particularly particles from the east side of the Harbor exit. Flood tide conditions draw particles into the Harbor which later exit the Harbor and move downcoast during the ebb tide. Particle release locations further inside of the Harbor inlet also shows the same transport patterns. Under extreme wet weather conditions particles also show similar transport patterns, but with a tendency to move offshore rather than downcoast.

The dry weather particle tracking results for the coastal creeks release locations are shown in Figure 4.7. The results show a dominant transport in the downcoast direction with the greatest transport from the creeks closer to the Harbor entrance. In particular, transport from Buck Gully and Morning Canyon initially move in the upcoast direction, but reverse to the downcoast directions into ASBS 32 and 33 upon entrainment in the flows from the Harbor.

Figure 4.3 Dry Weather Particle Tracking Results for Harbor

Figure 4.4 Wet Weather Particle Tracking Results for Harbor

Figure 4.5 Dry Weather Particle Tracking Results for Additional Harbor Releases

Figure 4.6 Wet Weather Particle Tracking Results for Additional Harbor Releases

Figure 4.7 Dry Weather Particle Tracking Results for Coastal Creeks

Additional release locations from the coastal creeks were also evaluated under dry weather conditions. An additional seven locations were evaluated for Buck Gully for five release times as shown in Figure 4.8. For the other coastal creeks with the exception of Pelican Point Creek, 12 additional release locations were evaluated for release time at MHHW and MLLW, which based on the previous results in the greatest transport distances. Additional release locations were not simulated for Pelican Point Creek because of the lack of flow data for this creek. The additional results for Morning Canyon, Pelican Point Middle Creek, Pelican Point Waterfall Creek, and Los Trancos Creek are shown in Figure 4.9, while the additional results for Muddy Creek, El Moro Canyon, Emerald Canyon, and Laguna Canyon Channel are shown in Figure 4.10.

The additional coastal creek release locations still show the same transport patterns as that shown previously in Figure 4.7. The greatest transport is observed for particles released from Buck Gully that travels into the Harbor and downcoast through ASBS 32 and 33. The various combination of release times and locations generally show that transport from Buck Gully initially moves upcoast and eventually into the Harbor. Once in the Harbor, transport conditions are similar to the particle tracking results for the Harbor release locations resulting in transport downcoast.

The release locations of the remaining coastal creeks show progressively less transport the further the creek from the Harbor. Results for the Morning Canyon release locations show similar transport patterns to a lesser degree. The transport patterns for Pelican Point Middle Creek, Pelican Point Waterfall Creek, and Los Trancos Creek show transport in the downcoast direction. It is likely that transport from Pelican Point Creek, which was not simulated with additional release locations, would be similar. Transport patterns for Muddy Creek and El Moro Canyon also show transport in the downcoast direction, but to a lesser extent compared to the other creeks. Transport patterns for Emerald Canyon show transport in the upcoast direction most likely attributed to the coastline feature of Emerald Bay. Transport patterns for Laguna Canyon Channel also move in the upcoast direction into ASBS 30.

Particle tracking results for Buck Gully under wet weather conditions are shown in Figures 4.11. The lower right panel of the figure shows the particle release locations. Under simulated wet weather conditions, the transport pattern from Buck Gully does not vary from dry weather conditions. The results also show that pollutants from Buck Gully can be transported into the Harbor. Although a larger rain event was not simulated, it could be expected that particles would initially be transported in the offshore direction rather than upcoast and then move downcoast due to the influence of the Harbor, resulting in transport in the downcoast direction along ASBS 32 and 33.

The particle tracking model results are consistent with the sediment budget analyses (Appendix A) which show that there is a small but net downcoast longshore sediment transport along the Newport Beach coastline.

Figure 4.8 Dry Weather Particle Tracking Results for Additional Buck Gully Releases

Figure 4.9 Dry Weather Particle Tracking Results for Additional Releases – Morning Canyon, Pelican Point Middle Creek, Pelican Point Waterfall Creek, and Los Trancos Creek

Figure 4.10 Dry Weather Particle Tracking Results for Additional Releases – Muddy Creek, El Moro Canyon, Emerald Canyon, and Laguna Canyon

Figure 4.11 Wet Weather Particle Tracking Results for Buck Gully

4.2 Water Quality

The results for the particle tracking simulations show that pollutants discharging from the Harbor and coastal creeks have the potential to impact the ASBS. To further evaluate the potential impacts to the ASBS, the water quality model RMA4 was used to evaluate the mixing and dispersion characteristics of pollutants being discharged. The water quality model simulated a pollutant loading being discharged into the coastal waters. The predicted pollutant concentrations at the ASBS were then compared to toxicity values for marine species to assess the cross contamination impact of the pollutant discharge to the ASBS.

The location, amount, and type of pollutants being discharged were estimated based on the pollutant loading analysis described in Appendix A as well as data summarized previously in Section 3. Only pollutant loadings from the Harbor and Buck Gully were modeled because of the lack of data to estimate pollutant loadings for the other coastal creeks. As mentioned previously, pollutant loading data were not available for the Harbor and a conservative assumption was used in estimating pollutant loadings exiting the Harbor entrance. Pollutant loadings from Buck Gully were calculated based on data collected for both dry and wet weather conditions. The water quality analysis focused on dissolved metals. The estimated dissolved metal concentrations from the Harbor and Buck Gully under dry and wet weather conditions were presented previously in Section 3. The pollutant was simulated as a conservative tracer and the resulting concentrations in the ASBS were compared to toxicity values for marine species. Acute toxicity values of dissolved metals for marine species found in the ASBS are shown in Table 4.1. The discharge of pollutants into coastal waters inherently results in lower concentrations from dilution; hence the type of pollutants simulated was limited to loadings that exceeded the acute toxicity level for any of the marine species.

For dissolved copper from the Harbor, the maximum dry and wet weather concentrations exceeded the minimum toxicity value for sea urchin. The dissolved copper data from Buck Gully indicated that the average and maximum wet weather dissolved copper concentration exceeds the minimum toxicity value. Thus, these four conditions – two from the Harbor and two from Buck Gully, were simulated. All the other metals were not simulated because their discharge concentrations are lower than the acute toxicity level.

The same dry and wet weather hydrodynamic conditions used for the particle tracking simulations were used to simulate pollutant discharges from the Harbor and Buck Gully. Results for the maximum dry and wet weather loadings from the Harbor are shown in Figures 4.12 and 4.13. Figure 4.12 shows the change in copper concentrations discharging from the Harbor over 72 hours. The color scale was selected such that the “red” indicates a copper concentration that exceeds the lowest acute toxicity for copper, which is 0.011 ppm for sea urchins. The maximum dry weather copper loading from the Harbor resulted in toxic copper concentrations within ASBS 32. The results also show the reduction in copper

Table 4.1 Acute Toxicity Values for Dissolved Metals

Common Name	Habitat	Acute Toxicity Values (ppm)							
		Ag	As	Cd	Cr	Cu	Ni	Pb	Zn
Giant Kelp	Nearshore reef					0.03 – 0.02	2		0.6 – 5.5
Red Abalone	Intertidal/subtidal reef					0.09 – 0.13			0.32
Pelecypod	Intertidal/subtidal reef			0.96		0.035 – 0.4		8.8	1.55 – 20.8
Annelid Worm	Harbors/bays soft benthos		7.4	14.1	3.9	0.13		>10	1.5
Barnacle	High rocky intertidal					0.48			
Shrimp	Nearshore sand and mud bottom		5.6	0.5	20	0.5		>5	0.9
Hermit Crab	East coast rocky intertidal			0.7 – 15.0	5.0 – 20.0		30 – 130		0.2 – 12.0
Sea Urchin	Intertidal/subtidal reef	0.013 – 0.115		0.067 – 18.4		0.011 – 0.08	0.4 – 16.0		0.095 – 0.14
Tide Pool Sculpin	Tide pools						30 -130		

Source: Coastal Resources Management, Inc.

Figure 4.12 Maximum Dry Weather Loading from Harbor

Figure 4.13 Maximum Wet Weather Loading from Harbor

concentration when flows are not exiting the Harbor, as such toxic levels can be achieved in ASBS 32 depending on the tidal conditions. Copper concentrations resulting from the maximum wet weather loading from the Harbor is shown in Figure 4.13. Toxic copper concentrations were observed throughout ASBS 32 and part of ASBS 33 from the maximum wet weather copper loading from the Harbor.

The model-predicted dispersion pattern of the maximum wet weather loading from the Harbor was consistent with visual observations. Figure 4.14 shows a comparison of the model-predicted pollutant plume with an aerial photograph taken after a rain event. It can be seen that the model-predicted dispersion pattern matches the general shape and size of the plume shown in the photograph.

For pollutants from Buck Gully, the mixing and dispersion was simulated based on the average and maximum wet weather loadings for dissolved copper. The average copper loading did not result in a toxic concentration within ASBS 32. Hence, the results are shown to illustrate the dispersion patterns in Figures 4.15 and 4.16, for the average and maximum copper loadings, respectively. In these figures, the copper concentration is exaggerated in that “red” indicates a concentration of 0.001 ppm, which is lower than the toxic concentration to illustrate the mixing and dispersion pattern. The dispersion pattern shows the dilution of the copper concentration as well as the transport in the upcoast direction. The maximum copper loading showed a similar dispersion pattern and did result in a toxic concentration within ASBS 32. The maximum copper loading from Buck Gully based on toxic levels is shown Figure 4.17.

Figure 4.14 Dispersion Pattern Comparison to Visual Observation

Figure 4.15 Dispersion Pattern of Average Wet Weather Loading from Buck Gully

Figure 4.16 Dispersion Pattern of Maximum Wet Weather Loading from Buck Gully

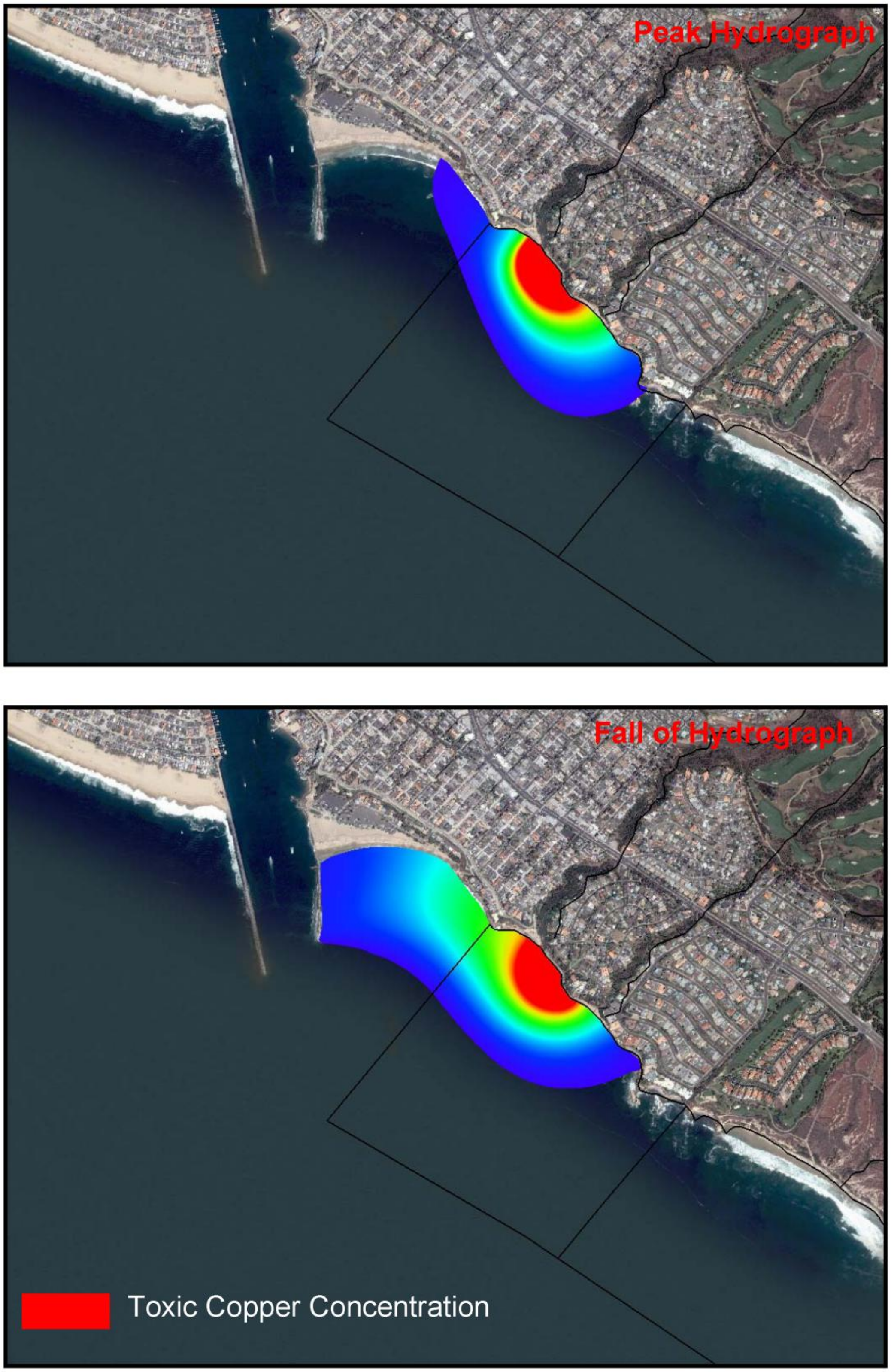

Figure 4.17 Maximum Wet Weather Loading from Buck Gully

5. SUMMARY

The City of Newport in cooperation with the City of Laguna Beach has obtained a SWRCB Proposition 50 grant for the Newport Coast and Laguna Beach ASBS Protection Program (Program) to provide for water quality improvement and habitat restoration across the three ASBS regions adjacent to the Cities' jurisdictions: ASBS 32 – Newport Beach Marine Life Refuge, ASBS 33 - Irvine Coast Marine Life Refuge, and ASBS 30 – Heisler Park Ecological Reserve. The objectives of the Program are to identify and quantify the environmental impacts with the most detrimental effects on water quality and habitats in the ASBS and to prepare an Integrated Coastal Watershed Management Plan (ICWMP). As a component of the Program, the Cross-Contamination Study is being conducted to identify and quantify potential pollutant loadings from the coastal watersheds, to determine potential impacts of these pollutants to the ASBSs, and to support the development of an ICWMP.

The study area includes three coastal watersheds – Newport Bay, Newport Coast, and Laguna Canyon Watersheds. Major discharges to CCA #69, which is located in Upper Newport Bay, are San Diego Creek, Santa Ana-Delhi Channel, Santa Isabella Channel, and Big Canyon. ASBS 32 and 33 are located along the Newport Coast Watershed with Buck Gully and Morning Canyon draining into ASBS 32 and Pelican Point Creek, Pelican Point Middle Creek, Pelican Hill Waterfall Creek, Los Trancos Creek, Muddy Creek, and El Moro Canyon discharging into ASBS 33. Emerald Canyon flows to the coastline between ASBS 33 and 30, while Laguna Canyon Channel empties into the ocean just downcoast of ASBS 30.

Available water quality and loading data were analyzed to identify and quantify pollutants loadings into CCA #69, ASBS 32, ASBS 33, and ASBS 30. Water quality and loading data were reviewed and summarized from continuous monitoring programs for compliance with TMDL, NPDES permits, and OWPP, as well as field data collection programs. No loading data from the Harbor were available; however data were available for some of the creeks that discharge into the bay.

The data collected were used in conjunction with numerical modeling to assess potential cross-contamination (i.e., impacts) of the harbor and creek discharges to the ASBS. A hydrodynamic and water quality model for Newport Bay and coastline within the Study area was developed based on previous hydrodynamic models that were developed for the Newport Harbor and Bay. A two part methodology to apply the loading data and assess the impacts was developed based on the available data. The first was to use the model to track the movement of "numerical tracers" representing pollutants discharging from the Harbor and coastal creeks. This method called "particle tracking" allows efficient assessment of transport conditions to determine if hydrodynamic conditions were capable of transporting pollutants to the ASBS. The transport conditions were evaluated for a range of tide, flow, release times, and release locations.

For the second part, the water quality model was used to simulate the mixing and dispersion of pollutants being discharged from the Harbor and Buck Gully to determine if toxic concentrations within the ASBS could be expected. Due to limitations of pollutant loading data, a simplified conservative tracer analysis was conducted by simulating a loading from the Harbor using a fixed concentration from data taken throughout Newport Bay associated with flows out of the Harbor. The loading from Buck Gully was based on water quality data taken during wet weather conditions. The resulting concentrations in the ASBS were then compared to toxicity values for marine species found in the ASBS and used to assess the cross-contamination of the Harbor and creek discharge.

Based the analyses, the following conclusions about the cross-contamination of the ASBS were made:

- The general direction of transport for pollutants from the Harbor is in the downcoast direction and the hydrodynamic conditions of the study area are suitable to transport pollutants from the harbor to ASBS 32 and 33 under both dry and wet weather conditions. The magnitude of the impact of the pollutants from the Harbor to ASBS 32 and 33 would dependent on the pollutant loadings from the Harbor. Based on the limited data, it is possible that some of the pollutants reaching ASBS 32 could be higher than the toxicity values for some marine species.

- Hydrodynamic conditions are suitable to transport potential pollutants from Buck Gully to the Harbor, ASBS 32, and ASBS 33. In general, transport from Buck Gully is affected by tidal flow of the Harbor and is in the upcoast direction until being entrained into the Harbor flows. Potential pollutants from Buck Gully may impact ASBS 32 and 33; the magnitude of the impact is dependent on the pollutant loading. Transport and mixing conditions for potential pollutants from Morning Canyon is similar to Buck Gully

- Further down the coast, transport of pollutants from Pelican Point Creek, Pelican Point Middle Creek, Pelican Point Waterfall Creek, Los Trancos Creek, Muddy Creek, and El Moro Creek are likely to be confined within ASBS 33. Transport within ASBS 33 is generally in the downcoast direction. Potential pollutants from these creeks may impact ASBS 33, but is dependent on the pollutant loading.

- Hydrodynamic conditions are suitable to transport potential pollutants from Laguna Canyon Channel to ASBS 30. The general direction of transport is in the upcoast direction. Potential pollutants from Laguna Canyon Channel may impact ASBS 30; the magnitude of the impact is dependent on the pollutant loading.

- Tidal flow dominants transport conditions along the coastline. Transport patterns and direction are dependent on the coastline features and orientation. Discharges into bays generally move in the upcoast direction, while discharges along relatively straight coastline generally move in the downcoast direction.

The major finding for the study is that the hydrodynamic conditions at the study area are suitable to transport potential pollutants from the Harbor and the coastal creeks to the ASBS; however, the magnitude of the impact cannot be determined because of the lack of pollutant loadings data. Hence, it is recommended to continue the baseline monitoring of water quality of the coastal creeks, particularly the downstream end, and the coastline areas within the ASBS.

For coastal watershed management strategies to address pollutant sources impacting ASBS 32 and 33, it is recommended that pollutant sources into Newport Bay also be addressed, in addition to the coastal creeks discharging directly into ASBS 32 and 33.

For coastal watershed management strategies to address pollutant sources impacting ASBS 30, it is recommended that pollutant sources focus on Laguna Canyon Channel and the local storm drains discharging directly into ASBS 30.

To quantify the impacts of potential pollutants from the Harbor to ASBS 32 and 33, it is recommended that the water quality (e.g., pollutant loading) exiting the Harbor be determined. Determination of pollutant loadings from the Harbor can be achieved either by a field data collection program or by expanding the numerical modeling effort to include the mixing characteristics within the entire Harbor based on loadings from creeks and storm drains.

6. REFERENCES

City of Laguna Beach. 1988. Guidelines for Shoreline Protection. City of Laguna Beach. April 1, 1988.

Everest. 2004. City of Newport Beach Storm Drain Diversion Study. Prepared for City of Newport Beach. Prepared by Everest International Consultants, Inc. November 2004.

Everest. 2005. City of Newport Beach Newport Bay Model. Prepared for City of Newport Beach. Prepared by Everest International Consultants, Inc. April 2005.

NOAA. 2003. Published Bench Mark Sheet for 9410580 Newport Beach, Newport Bay Entrance. National Oceanic and Atmospheric Administration.

SARWQCB. 2004. *Watershed Management Initiative Chapter*. Santa Ana Regional Water Quality Control Board. http://www.waterboards.ca.gov/santaana/html/wmi.html

SWRCB. 1976. *Areas of Special Biological Significance.* California State Water Resources Control Board. July 1976.

SWRCB. 1979a. California Marine Waters Areas of Special Biological Significance reconnaissance Survey Report: Newport Beach Marine Life Refuge, Orange County. California State Water Resources Control Board. Water Quality Monitoring Report 79-4. March 1979.

SWRCB. 1979b. California Marine Waters Areas of Special Biological Significance reconnaissance Survey Report: Irvine Coast Marine Life Refuge, Orange County. California State Water Resources Control Board. Water Quality Monitoring Report 79-3. March 1979.

SWRCB. 2001. *California Ocean Plan*. California State Water Resources Control Board.

SWRCB. 2003. *California's Marine State Water Quality Protection Areas*. California State Water Resources Control Board.

USACE. 2000. Upper Newport Bay Ecosystem Restoration Feasibility Study Final Report Environmental Impact Report/Statement. U.S. Army Corps of Engineers Los Angeles District, County of Orange, State of California, and City of Newport Beach. September 2000. http://www.ocwatersheds.com/watersheds/pdfs/Ecosystem_Restoration_Feasibility_Study.pdf

Weston. 2007. Newport Coast Flow and Water Quality Assessment Final Report. Prepared for City of Newport Beach. Prepared by WESTON Solutions, Inc. January 2007.