Total Maximum Daily Loads and Site-Specific Objectives for Selenium in the Newport Bay Watershed, Orange County, California

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Nitrogen and Selenium Management Program

CALIFORNIA
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DRAFT Technical Staff Report for Peer Review, October 2009

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LIST OF ACRONYMS

A	Area
ACWF18	Agua Chinon Channel
AE	Assimilation efficiency
AGR	Agricultural supply
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient water quality criteria
BAF	Bioaccumulation factor
Basin Plan	Water Quality Control Plan for the Santa Ana River Basin
BAT	Best available technology
Baxter	Baxter Healthcare Corporation
BCF	Bioconcentration factor
BCF04	Bonita Canyon Channel
BCW	Big Canyon Wash
BIOL	Preservation of biological habitats of special significance
BMP	Best management practice
BPAs	Basin plan amendments
BSAF	Biota-sediment accumulation factor
C	Concentration
CAAs	Compliance Assessment Areas
CalEPA	California Environmental Protection Agency
Caltrans	California Department of Transportation District 12
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations

cfs	cubic feet per second
CMCG02	Costa Mesa Channel
COLD	Cold freshwater habitat
COMM	Commercial and sportfishing
Cr	Chromium
CTR	California Toxics Rule
CVs	Curriculum vitae
CWA	Clean Water Act
CWC	California Water Code
CWP	Cooperative Watershed Program
DDT	dichlorodiphenyltrichloroethane
DOC	Dissolved organic carbon
dw	dry weight
DWR	Department of Water Resources
EC	Effects concentration
EF	Enrichment function
Eh	Oxidation/reduction potential
EO	Executive Officer
ESA	Endangered Species Act
EST	Estuarine habitat
ETC	Eastern Transportation Corridor
FCG	Fish contaminant goal
FED	Functional equivalent document
Fillets	Muscle tissues
GSL	Great Salt Lake
gw	groundwater
GWR	Groundwater recharge

GWRS	Ground Water Replenishment System
Hg	Mercury
IAP	Independent Advisory Panel (Individual Action Plan in Section 12.0, Implementation of the technical staff report)
ID	Integrated depth
IND	Industrial service supply
IR	Ingestion rate
IRWD	Irvine Ranch Water District
IRWD Wetlands	Irvine Ranch Water District treatment wetlands
K_d	Partitioning coefficient
Ke	Efflux rate
Kesterson NWR	Kesterson National Wildlife Refuge
LA	Load allocation
Lower SDC	San Diego Creek downstream of Jeffrey Road
LWRM	Limited warm freshwater habitat
MAR	Marine habitat
MBTA	Migratory Bird Treaty Act
MCAS	Marine corps air station
MCL	Maximum Contaminant Limit
mgd	million gallons per day
mg/kg	milligrams per kilogram
MOS	Margin of safety
MS4	Municipal Separate Storm Sewer System
MUN	Municipal and domestic supply
NAS	National Academy of Sciences
NAV	Navigation
NEC	No effect concentration

NIWQP	National Irrigation Water Quality Program
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPS	Non-point source
NSMP	Nitrogen and Selenium Management Program
NTIS	National Technical Information Service
NWRI	National Water Research Institute
OAL	State of California Office of Administrative Law
OC	Organochlorine compounds
OCEMA	Orange County Environmental Management Agency
OCRDMD	Orange County Resources and Development Management Department
OCPW	Orange County Department of Public Works
OCSD	Orange County Sanitation District
OEHHA	Office of Environmental Health Hazard Assessment
OFR	Open-file report
OP	Organophosphate
PBDEs	Polybrominated diphenyl ethers
PCBs	Polychlorinated biphenyls
PCW	Peters Canyon Wash
ppb	parts per billion
ppm	parts per million
POW	Hydropower generation
PRBs	Permeable Reactive Barriers
PROC	Industrial process supply
PS	Point source
Q	Flow rate
QA	Quality assurance

QAPP	Quality Assurance Project Plan
QC	Quality control
RARE	Rare, threatened, or endangered species
REC1	Water contact recreation
REC2	Non-contact water recreation
Regional Water Board	Santa Ana Regional Water Quality Control Board
RMP	Regional Monitoring Program
ROWD	Report of Waste Discharge
RWQCB9	Santa Ana Regional Water Quality Control Board
SADC	Santa Ana Delhi Channel
SAR	Santa Ana Regional Water Quality Control Board
SARWQCB	Santa Ana Regional Water Quality Control Board
SCCWRP	Southern California Coastal Water Research Project
SDC	San Diego Creek
SDC Reach 1	San Diego Creek downstream of Jeffrey Road (lower San Diego Creek
SDC Reach 2	San Diego Creek upstream of Jeffrey Road (upper San Diego Creek)
Se, Se^0	Elemental Selenium
Se^{2-}	Selenide
SeIV, Se^{4+}	Selenite
SeVI, Se^{6+}	Selenate
SED	Substitute environmental document
SF	Surface-flow
SHEL	Shellfish harvesting
SIP	State Implementation Policy; Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (2005)

SJFMR	San Joaquin Freshwater Marsh Reserve
SMWP	State Mussel Watch Program
SOF	Swamp of the Frogs
SPDP	Special Purpose Discharge Permit
SPWN	Spawning, reproduction, and development
SSF	Subsurface-flow
SSO	Site-specific objective
State Listing Policy	2004 Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List
State Water Board	State Water Resources Control Board
STRC	Selenium Technical Review Committee
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TDS	Total Dissolved Solids
Technical TMDL	TMDL does not include an implementation plan
TMDL	Total Maximum Daily Load
TOC	Total organic carbon
Toxics TMDL	USEPA 2002 technical TMDLs for toxic pollutants for San Diego Creek/Newport Bay
TRAP	Toxicity Relationship Analysis Program
TRIP	Toxics Reduction and Investigation Program
TSMP	Toxic Substances Monitoring Program
TTF	Trophic transfer factor
TSD	Transport, storage and disposal
TSS	Total Suspended Solids
Tustin MCAS	Marine corps air station at Tustin
UCI Wetlands	San Joaquin Freshwater Marsh Reserve at the University of California – Irvine

UCNRS	University of California Natural Reserve System
µg/g	micrograms per gram
µg Se/g	micrograms selenium per gram
µg/L	micrograms per liter
µg Se/L	micrograms selenium per liter
UNB	Upper Newport Bay
UNBER	Upper Newport Bay Ecological Reserve
Upper SDC	San Diego Creek upstream of Jeffrey Road (San Diego Creek Reach 2)
USBR	US Bureau of Reclamation
USDOI	US Department of the Interior
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
V	Volume
WARM	Warm freshwater habitat
WCGs	Water column guidelines
WDRs	Waste discharge requirements
WER	Water-effects ratio
WILD	Wildlife habitat
WLA	Waste load allocation
WMI	Watershed Management Initiative
ww	wet weight
Xo	Exposure value

1.0 INTRODUCTION

1.1 Purpose of Report

The purpose of this report[1] is to provide the scientific, technical and regulatory[2] basis for the development and adoption of Basin Plan amendments to incorporate total maximum daily loads (TMDLs) and site-specific objectives (SSOs) for selenium for the Newport Bay watershed[3]. This report, and the TMDLs and SSOs it describes and documents, was developed with significant assistance from the Nitrogen and Selenium Management Program (NSMP) Working Group and their consultant team (Section 1.4.2), with input and guidance from the Selenium Technical Review Committee (STRC) convened by Regional Water Board staff (Section 1.4.3).

These amendments will be considered through the Basin Planning process. As described in Appendix 1A, this process requires compliance with applicable requirements of the California Environmental Quality Act (CEQA). This technical report and the accompanying Environmental Checklist and analysis (Appendix x) form the basis of the Substitute Environmental Document (SED) developed to comply with CEQA. This SED also includes the Basin Plan amendments (Attachment x), public and agency comments, Regional Water Board staff's responses to those comments (comments and responses are provided in Appendix x), a Statement of Overriding Considerations, and the Regional Water Board resolution for consideration of adoption of the amendments (Attachment x). The SED provides the requisite CEQA analysis of the reasonably foreseeable methods of compliance with the TMDLs/SSOs, alternatives and mitigation measures. **[THIS PARAGRAPH SUBJECT TO REVISION ONCE BPA PROCESS IS NEAR COMPLETION]**

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[1] This is a draft report; it has not yet been subjected to external scientific peer review or public review as required by the Basin Planning amendment process. The final version of the report will reflect changes made in response to comments received during the review process.

[2] The regulatory framework for the consideration of Basin Plan amendments is described in Appendix 1A

[3] The Newport Bay watershed encompasses both upper and lower Newport Bay and its tributaries, San Diego Creek, Santa Ana Delhi, and Big Canyon subwatersheds, and the Costa Mesa and Santa Isabel channels. Previous TMDLs and amendments to the Basin Plan for the Santa Ana Region have referred to the watershed as the "San Diego Creek/Newport Bay" watershed. However, the County of Orange recently performed a comprehensive evaluation of all the watersheds located within their boundaries with the intent of verifying watershed divisions and nomenclature. The County decided that the San Diego Creek/Newport Bay watershed would simply be referred to as the Newport Bay watershed. All of the County programs, including the NPDES program, and all County documents now refer to the Newport Bay watershed. For consistency with the new nomenclature, these TMDLs/SSOs will also refer to the watershed as the Newport Bay watershed.

The Basin Planning process also requires conformance with requirements for independent peer review and public participation. Compliance with these requirements is described in Sections 1.3 and 1.4, respectively.

The adoption of site-specific objectives requires consideration of certain factors, including economics, identified in California Water Code Section 13241. Economics must also be considered pursuant to CEQA. This report provides the requisite analyses of these factors (Sections 13.0 and 15.0, respectively).

Upon approval of the amendments by the Regional Water Board, the amendments will be forwarded to the State Water Resources Control Board (SWRCB or State Water Board) and California Office of Administrative Law (OAL) for consideration of approval. Pursuant to the Administrative Procedures Act, OAL must review the regulatory provisions of the proposed amendments and make specific findings regarding authority, clarity, consistency, and other factors. This report provides an analysis of these factors to facilitate OAL review. The TMDLs and their components, including numeric targets and allocations based on the selenium SSOs, will become effective upon approval by OAL. Once OAL has completed its review, the amendments will be forwarded to the US Environmental Protection Agency (USEPA) for approval. The selenium SSOs will become effective upon approval by USEPA.

1. 2 Report Organization

(To be completed when report is final).

1.3 External Scientific Peer Review

Pursuant to Health & Safety Code Section 57004 all California Environmental Protection Agency (CalEPA) organizations are required to submit all proposed rules that have a scientific basis or components for external scientific peer review (Appendix 1A, Section 4.2). Basin Plan Amendments (BPAs), such as those to incorporate TMDLs or SSOs, are subject to this requirement.

This report and the recommended Basin Plan amendments were submitted for scientific peer review through the CalEPA peer review process. Peer review comments were received on ______(date). Regional Water Board staff responded to the peer reviewers' comments and revised the technical staff report and draft Basin Plan amendments as needed. The peer review request letters, peer reviewers' Curriculum Vitae (CVs), comments on the technical staff report/draft Basin Plan amendments, and Regional Water Board staffs' responses to their comments are in included in Appendix xx, Peer Review Process. These responses include specific descriptions of the changes made, if any, in response to each of the peer reviewer's comments, and the rationale for why changes were or were not made in response to the reviewers' comments.

1.4 Public Participation/Agency Consultation

Federal and state law and regulation require that the Regional Water Board provide public notice and opportunity for comment on basin plan amendments, including amendments to incorporate TMDLs and changes to water quality standards, such as site-specific objectives (Appendix 1A, Section 4.3). Pursuant to CEQA regulations, consultation is also required with agencies with expertise with regard to the potential environmental effects of the amendments (Appendix 1A, Section 4.3).

The selenium TMDLs and SSOs for the Newport Bay watershed were developed through a collaborative process that included Regional Water Board staff, State Water Board staff, Federal agencies and private consultants conversant in selenium, as well as the County of Orange, local agencies and municipalities, environmental group representatives and other stakeholders in the watershed. Advice, assistance, and review of these TMDLs/SSOs were provided through a technical review committee, a stakeholder working group, and through discussions with federal and state resource agencies. In addition, the technical and scientific portions of the TMDLs and the SSOs were submitted for independent peer review, as required by Health & Safety Code Section 57004 (Section 1.3). As described in the following paragraphs, public participation, agency consultation and review by scientific experts during the development of the selenium TMDLs and SSOs far exceeded applicable requirements.

1.4.1 Public Meetings and Notices

Regional Water Board staff initiated the development of selenium TMDLs for the Newport Bay watershed in 2000-2001. Relying in part on this work, in 2002, the USEPA developed and promulgated “technical” TMDLs for selenium and other toxic substances for Newport Bay and San Diego Creek (“Total Maximum Daily Loads for Toxic Pollutants, San Diego Creek and Newport Bay, California”). (Technical TMDLs include the elements required under federal law and regulation (Appendix 1A, Section 3.0) but do not include implementation plans, which are to be developed by the Regional Water Board). Specifically, USEPA established selenium TMDLs for San Diego Creek, Upper Newport Bay, Lower Newport Bay and the Rhine Channel (at the west end of Lower Newport Bay). The public review process for these TMDLs was initiated during the TMDL development process. Regional Water Board staff conducted several technical and public workshops to discuss staff TMDL proposals and USEPA staff provided updates on its TMDL development activities at several Regional Water Board meetings. A public comment period on the USEPA draft technical TMDLs, including the proposed selenium technical TMDLs, was held from April 12 through May 28, 2002. Two public meetings were also held during the public comment period to discuss technical issues. Comments were received and the technical TMDLs include a responsiveness summary.

Since USEPA's technical TMDLs for toxic pollutants did not include an implementation plan and since there remained significant uncertainty with regard to selenium sources and impacts in the Newport watershed, Regional Water Board staff continued to solicit public input through various stakeholder meetings, primarily through the Newport Bay Watershed Management Committee meetings, and staff updates at Regional Water Board meetings. As discussed in detail below in Section 1.4.3, in 2004, a stakeholder group was formed in response to the issuance by the Regional Water Board of permit requirements for discharges of selenium (and nitrogen) in short-term groundwater-related discharges in the Newport Bay watershed (Order No. R8-2004-0021, NPDES No. CAG998002). This working group of stakeholders formed the Nitrogen and Selenium Management Program (NSMP) Working Group, which has implemented a Regional Water Board-approved Work Plan to investigate selenium (and nitrogen) in the Newport watershed and to provide data, analyses and recommendations to support Basin Plan amendments to incorporate selenium TMDLs and SSOs, together with an implementation plan. Public participation is a key component of the NSMP effort.

TMDL-related documents and public notices are posted and periodically updated, as appropriate, on the Regional Water Board web site: http://www.waterboards.ca.gov/santaana/. Similarly, the County of Orange maintains a public NSMP website on behalf of the Working Group and posts relevant meeting notices, meeting handouts and work products: http://www.ocnsmp.com.

In addition to the NSMP and Regional Water Board meeting updates, Regional Water Board staff held a CEQA scoping meeting on November 20, 2008, to discuss and solicit comments from stakeholders on the proposed Selenium TMDLs and SSOs for the Newport Bay watershed. Notice of the CEQA scoping meeting was provided to all interested parties, posted on the Regional Water Board and NSMP websites, and published in the Orange County Register on October 20, 2008. Participants included both NSMP members and other interested stakeholders.

The proposed Basin Plan amendments, draft technical staff report and CEQA analysis for the Selenium TMDLs/SSOs were posted on the Regional Water Board/NSMP websites and distributed for peer review and public comment on [date]. The comment period for submittal of written comments was established (comments as soon as possible but no later than [date]. At the Regional Water Board meeting on August 28, 2009, an informational item concerning the status of development of the selenium TMDLs and SSOs was presented. Notice of the informational item was provided to all interested parties and posted on the Regional Water Board/NSMP websites. On [date], the Regional Water Board conducted a public hearing to consider approval of Resolution No. R8-20xx-xxxx, adopting (1) the Findings of Fact and Statement of Overriding Considerations shown in Attachment 1 to the Resolution; and, (2) the amendments to the Basin

Plan shown in Attachment 2 to the Resolution to incorporate Selenium TMDLs and SSOs, with an implementation plan, for the Newport Bay watershed into the Basin Plan. Notice of the public hearing was published on [date], posted on the Regional Water Board/NSMP websites and distributed to all interested parties. The proposed amendments, SED, resolutions and related attachments were made available at least 45 days prior to the hearing and posted on the Regional Water Board/NSMP websites. Regional Water Board staff prepared written responses to comments received from peer reviewers, members of the public, resource agencies, and others by the established comment deadline, which was **x** days prior to the hearing. The responsiveness summary is included in Appendix XX. The responsiveness summary was available at the hearing and distributed to those who had provided comments and to other interested parties in advance**. [THIS PARAGRAPH SUBJECT TO REVIEW/REVISION BASED ON ACTUAL EVENTS]**

Upon approval of the amendments by the State Water Board, Office of Administrative Law and the USEPA, the Regional Water Board will file a CEQA Notice of Decision with the Secretary for Resources. The notice will be posted for public inspection for a period of not less than 30 days.

1.4.2 Selenium Technical Review Committee

In 2002, Regional Water Board staff formed a Selenium Technical Review Committee (STRC) to provide input on the development of the selenium TMDLs and to provide review of pertinent studies and investigations into selenium sources and cycling in the Newport watershed. Participation in the STRC was strictly voluntary; members were not reimbursed for their time. The current members of the STRC are:

Dr. Eugenia McNaughton, US Environmental Protection Agency
Dr. Samuel Luoma, US Geological Survey
Dr. Harry Ohlendorf, CH2MHill
Dr. Theresa Presser, US Geological Survey
Mr. Gary Santolo, CH2MHill
Dr. Joseph Skorupa, US Fish and Wildlife Service
Dr. Martha Sutula, Southern California Coastal Water Research Project

The STRC members have provided Regional Water Board staff with expert advice, technical articles and resources, and timely reviews of data and reports. The STRC has also played an important role in educating both Regional Water Board staff and the watershed stakeholders about selenium and its potential impacts, especially with regards to the beneficial uses in the Newport Bay watershed. Drs. McNaughton, Presser, Luoma, and Skorupa are employed by federal resource agencies that actively participated in the development of the site-specific objectives for selenium for the Newport Bay watershed. Dr. Martha Sutula did not participate in the SSO process since SCCWRP is not a federal or state resource agency. Dr. Harry Ohlendorf and Gary Santolo of CH2MHill participated in the development of the selenium SSOs as members of the NSMP consultant team.

1.4.3 Stakeholder Collaborative Process: Nitrogen and Selenium Management Program

In December 2004, the Regional Board adopted Order No. R8-2004-0021, NPDES No. CAG998002[4] to prescribe general waste discharge requirements for groundwater-related discharges to the surface waters in the Newport Bay watershed. This regulatory approach was taken to address the concern that the groundwater-related discharges had the potential to adversely affect surface waters due to the elevated concentrations of selenium and nitrogen and may not comply with the established nutrient and selenium TMDLs[5]. The Order recognized that certain dischargers agreed to form a Working Group and develop and implement a Work Plan to address the management of nitrogen and selenium discharges and inflows to surface waters.

In response to Order No. R8-2004-0021, many of the watershed stakeholders/ dischargers established a Nitrogen and Selenium Management Program (NSMP) Working Group. The Working Group includes representatives from local governments, agencies, developers and other private entities, water districts, State agencies including the Regional Water Board, and environmental groups (see Table 1-1). Meetings of the Working Group are open to all interested parties, and an open public comment period is included on each meeting agenda.

The NSMP Work Plan and Compliance Strategy (Work Plan) was approved by the Executive Officer of the Regional Water Board in July 2005. The Working Group has been implementing the approved Work Plan from July 2005 through December 2009. The Work Plan was developed to assist in identifying a comprehensive management plan for selenium and nitrogen and, in particular, to identify an approach for addressing one of the largest sources of selenium in the watershed, rising groundwater[6].

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[4] General Waste Discharge Requirements for Short-Term Groundwater-Related Discharges and De Minimus Wastewater Discharges to Surface Waters within the Newport Bay Watershed. This Order was subsequently amended by Order No. R8-2006-0065.

[5] In April 1998, the Regional Board adopted Resolution No. 98-9, amending the Basin Plan to incorporate a Nutrient TMDL for the Newport Bay watershed. The TMDL was amended by Resolution No. 98-100 in October 1998 and approved by the SWRCB, OAL, and EPA. The Nutrient TMDL included an implementation plan. USEPA established technical TMDLs for selenium for Newport Bay watershed in 2002.

[6] Although rising groundwater is a non-point source, it is, collectively, the largest source of selenium within the watershed (See Section 7.0, Sources and Loads)

The Work Plan includes a number of selenium-related tasks, including the development of a conceptual model, an evaluation of the sources and loads, an assessment of the bioavailability and impacts of selenium, an evaluation of speciation methods, an evaluation and selection of viable BMPs and treatment technologies, the development of a simple treatment-related model, the development of a BMP strategic plan that would define a path to testing and implementing the most promising treatment technologies for selenium, and the development of site-specific objectives for selenium, if appropriate. Work products completed by the NSMP in accordance with the Work Plan can be found at http://www.ocnsmp.com under the library heading.

1.4.4. Development of Selenium Site-Specific Objectives: Coordination with USEPA and Resource Agencies

In March of 2000, the USFWS, under Endangered Species Act (ESA) Section 7 consultation with USEPA, suggested that the current selenium CTR criterion of 5 µg/L was not protective for some threatened and endangered species. In addition, extensive data from Newport Bay watershed have shown that CTR criteria for both freshwater and saltwater may be over- or under- protective in different parts of the watershed due to the bioaccumulative nature of selenium and the unique local hydrogeology and ecosystem. As part of the NSMP Work Plan, an independent advisory panel (IAP) of third-party experts was organized by the National Water Research Institute (NWRI) to determine whether establishing tissue-based SSOs was the most appropriate approach to protecting and restoring the beneficial uses of the waters in the Newport Bay watershed. The IAP supported the decision to develop tissue-based SSOs and recommended close coordination with regulatory agencies involved with setting selenium standards (NWRI, 2006).

To assure that the selenium SSOs were both scientifically defensible and fulfilled all regulatory requirements, the NSMP actively sought and received participation from state and federal resources agencies, including USEPA, US Fish and Wildlife Service and the US Geological Survey. As described in Section 1.4.2, representatives of these agencies also participated on the Selenium Technical Review Committee. These agencies are also part of a task force that is charged with developing a new selenium criterion for the State of California that better protects aquatic ecosystems and their components, including wildlife and threatened/endangered species.

The NSMP organized three regulatory and resource agency briefings on September 18, 2008, January 15, 2009 (via conference call), and May 14, 2009, to discuss the technical and regulatory issues in developing selenium SSOs for the Newport Bay watershed. Each meeting was attended by key representatives from USEPA, State Water Board, Regional Water Board, USGS, USFWS, and consultants who have been involved in the development of selenium SSOs for the Great Salt Lake (Utah) and Bay Delta (California).

In these regulatory and resource agency briefings, it was agreed that a biodynamic model developed by USGS staff (Presser and Luoma, 2009) based on the dataset from Newport Bay watershed should be the basis for of linking tissue concentrations and the protection of beneficial uses with water column selenium concentrations. USFWS staff endorsed in principle that a fish tissue criterion of 5 mircograms selenium per gram dry weight (µg Se/g dw) and bird egg tissue criterion of 8 µg Se/g dw are appropriate for the Newport Bay watershed ecosystem. Using the biodynamic model, the tissue-based SSOs are translated into water column guidelines (WCGs) for different portions of the watershed. Attainment of the water column guidelines is expected to ensure that the tissue-based objectives are achieved. Due to large uncertainties in the data used in the model, the model may need to be refined as more monitoring data become available. Thus, the water column guidelines, which are used as the basis for determination of loading capacities, TMDLs, and allocations and will be used for assessment and other regulatory purposes, may need to be revised over time.

Early involvement by key regulatory and resource agencies in the process has proven to be crucial to the timely development of scientifically defensible SSOs that fulfill all regulatory requirements, and to the development of TMDLs that will assure the attainment of water quality standards. The TMDLs incorporate the proposed SSOs as numeric targets that will supplant CTR-based targets if and when approved by USEPA. A discussion of the technical and scientific justification for the SSOs is included in this report in Section 6.0.

2.0 BACKGROUND AND REGULATORY HISTORY OF SELENIUM

Selenium (Se) is a naturally occurring element that persists in soils and aquatic sediments and readily bioaccumulates through the food chain at levels that can cause adverse effects on higher-level aquatic life and wildlife, including fish and birds that prey on fish and invertebrates. Though selenium is an essential nutrient for fish, birds, animals, and humans, there is a very narrow margin between nutritionally optimal and potentially toxic dietary exposures for vertebrate animals (Wilber 1980). Excessive amounts of selenium are found to cause toxicity in wildlife. Toxicological effects of selenium on wildlife include lowered reproduction rates (e.g., impaired hatching), shortened life spans, stunted growth, and impaired immune response. Many of these effects are not readily observable and detailed biological studies are required to determine whether or not selenium is negatively impacting biota in a watershed (USEPA, 2002).

2.1 Selenium Case Studies

The two most famous example of selenium poisoning occurred in North Carolina (Belews Lake) and California (Kesterson National Wildlife Refuge).

2.1.1 Kesterson National Wildlife Refuge, CA

Starting in 1969, a series of evaporation and seepage basins (Kesterson Reservoir) were used to dispose of excess irrigation water from the Central Valley (http://www.nunnglow.com/documents/Selenium%20Case%20Study.pdf). In 1970, the Kesterson Reservoir was combined with the surrounding 1872 hectares of grasslands to form the Kesterson National Wildlife Refuge (Kesterson NWR). The San Luis Drain carried agricultural drainage water that contained selenium to the Kesterson ponds, where evaporation concentrated selenium salts in the ponds, sediments and adjacent soils to very high concentrations. Selenium concentrations in the shallow ponds at Kesterson NWR averaged about 150 microgams selenium per liter (µg Se/L) (concentrations in the 12 ponds ranged from 15-350 µg Se/L) (USDOI, 1998). Starting in 1982, biological surveys found that selenium was bioaccumulating in the food chain at the refuge. The high levels of selenium were causing developmental deformities in both embryos and chicks of the majority of the birds nesting at Kesterson (Figure 1-1). Deformities were present in up to 65% of the birds. In 1983, there was a massive fish kill and a high percentage of stillbirths in the local mosquitofish population – mosquitofish were the only fish that appeared to tolerate the seleniferious conditions. In 1986, Kesterson was removed from the wildlife refuge list and the US Bureau of Reclamation (USBR) was tasked with cleaning up the site.

2.1.2 Belews Lake, NC

In 1974, and continuing until 1985, water from Belews Lake was pumped from the lake to a coal-fired electric generating facility to mix with its ash waste. The wastewater (ash slurry) was pumped into an ash basin located near the lake. Return flows high in selenium (150-200 ug/L) were discharged to the western side of Belews Lake via an ash sluice water canal (Lemly, 1985, 2002). The selenium poisoning of the fish in Belews Lake that followed is the most extensively documented case of selenium poisoning in freshwater fish (Lemly, 1999). Selenium bioaccumulation in the aquatic food chain in the lake resulted in severe reproductive failure and developmental (teratogenic) deformities (Figure 1-2) in fish (Cumbie and Van Horn, 1978; Lemly, 1985, 1999b, 2002). Eighteen (18) of the twenty (20) species of fish that originally inhabited the lake were eliminated due to reproductive failure even though the concentrations of selenium in the lake water were only 10-20 times those in nearby uncontaminated reservoirs (Lemly, 2002). Though the electric plant changed the way it handled its ash waste, and selenium concentrations in the lake water subsequently fell to less than 1 µg Se/L, developmental abnormalities in young fish persisted into 1996.

USEPA's decision to lower the national water quality freshwater criterion for selenium from 35 µg Se/L to 5 µg Se/L (the same freshwater criterion currently used in California) was based on the field studies on selenium toxicity conducted at Belews Lake (USEPA, 1987).

2.2 Selenium in the Newport Bay Watershed

While the selenium concentrations in the Newport Bay watershed are not nearly as high as those measured at the Kesterson NWR, dissolved selenium concentrations in San Diego Creek at Campus, and in tributaries to San Diego Creek, consistently exceed the chronic (4-day average) California Toxics Rule (CTR) criterion for freshwater (5 µg Se/L). This has been observed in numerous studies, which also cite occasional exceedances of the National Toxics Rule acute (1 hour maximum) criterion of 20 µg Se/L (Hibbs and Lee, 2000; IRWD, 1999; Lee and Taylor, 2001). There is no acute freshwater selenium criterion in the CTR.

Dissolved selenium concentrations in Newport Bay do not exceed the CTR saltwater chronic criterion of 71 µg Se/L. However, fish tissue (Allen et al. 2004, 2008) and bird egg tissue (CH2MHill, 2006) data indicate that selenium loadings that enter the Bay from the freshwater drainages may be causing toxicity, or contributing to conditions threatening wildlife, in Upper Newport Bay. As will be discussed in more detail (Section 5.0), some fish tissue and bird eggs collected from Upper Newport Bay exceeded the ecological risk guidelines established by the USDOI (1998) and Presser et al. (2004).

On June 14, 2002, the United States Environmental Protection Agency (USEPA) established Total Maximum Daily Loads (TMDLs) for 14 toxic pollutants, including selenium, for San Diego Creek, Upper and Lower Newport Bay, and the Rhine Channel (USEPA, 2002) (http://www.epa.gov/region09/water/tmdl/nbay/summary0602.pdf).

The USEPA TMDLs for selenium were supported by a report prepared by Regional Water Board staff (SARWQCB, 2000).

This report summarizes the information presented in the USEPA TMDL document (USEPA 2002) and presents additional information and modifications. In 2004, the State Water Board approved the new “Water Quality Control Policy for Developing California’s Clean Water Act Section 303(d) List” (State Listing Policy). For these TMDLs, the assessment of impairment was performed using the new State Listing Policy. The results of this impairment assessment differ from that previously performed by USEPA in that the water body-pollutant combinations requiring TMDLs have been revised, consistent with the new findings of impairment (Section 5.0, Problem Statement).

In addition, the completion of several studies on the sources and cycling of selenium have broadened our understanding of selenium fate and transport in the Newport Bay watershed and provided sufficient data to allow the development of site-specific objectives (SSOs) for selenium (Section 6.0). Since selenium is bioaccumulated primarily through diet, the adoption of fish tissue and bird egg tissue selenium objectives is recommended. Implementation and attainment of these fish and bird egg tissue SSOs is expected to result in the restoration of the beneficial uses in the watershed. The adoption of tissue objectives is consistent with USEPA, USGS, and USFWS efforts to revise the current CTR selenium criteria, which are water column-based. USEPA, USGS, and USFWS staff participated in the development of the selenium SSOs for the Newport Bay watershed (see Sections 1.4.4 and 6.0), and the process used to develop these SSOs is similar to that being used by USEPA to revise the CTR criteria.

3.0 WATERSHED CHARACTERISTICS

The Newport Bay watershed covers an area of 152 square miles (97,280 acres) in central Orange County, California. Cities located partly or fully within the watershed include Orange, Tustin, Santa Ana, Irvine, Lake Forest, Laguna Hills, Costa Mesa, and Newport Beach (Figure 3-1); some unincorporated lands within the county are located within the watershed boundaries. The San Diego Creek watershed is part of the larger Newport Bay watershed and occupies about 119 square miles. The Santa Ana Delhi Channel watershed, located just west of the San Diego Creek watershed occupies approximately 17 square miles. The remainder of the Newport Bay watershed (about 16 square miles) includes both Upper and Lower Newport Bay, and other small tributary drainages (e.g., Big Canyon Wash, Costa Mesa Channel, Santa Isabel channel).

The central portion of the watershed is largely occupied by the relatively flat Tustin Plain, bounded to the northeast by the Santiago Hills and by the San Joaquin Hills to the southwest (Figure 3-2). Runoff from the mountains drains across the Tustin Plain and enters Newport Bay primarily via Peters Canyon Wash and San Diego Creek.

Lower Newport Bay is considered to be that portion of the Bay south of the Pacific Coast Highway Bridge (Highway 1). The Lower Bay harbor is important for recreational use and supports nearly 10,000 pleasure boats, as well as many residential and commercial facilities. Upper Newport Bay (north of the Pacific Coast Highway Bridge) includes a 752-acre estuary and ecological reserve, where saltwater from the Pacific Ocean mixes with fresh water derived primarily from San Diego Creek (Figure 3-3). The Upper Bay supports six threatened or endangered bird species: California least tern, Belding's Savannah sparrow, brown pelican, coastal California gnatcatcher, peregrine falcon, and light-footed clapper rail. In 1992, more than 70 percent of the nation's remaining light-footed clapper rail population occurred here. The Bay is also a major stopping place for birds migrating along the Pacific Flyway, and up to 30,000 birds are present from August to April. At least 78 species of fish occur in the Bay, providing recreational opportunities for anglers (mostly in the Lower Bay) and a source of food for predatory birds. Figure 3-4a shows important habitat areas for federally listed species in proximity to Newport Bay, and Figure 3-4b shows habitat areas throughout the watershed.

3.1 Land Use

Land use has changed dramatically in the watershed over the last 150 years. In the late 19th and early 20th centuries, land use changed from ranching and grazing to farming. After World War II, agricultural land use gave way to urbanization. In 1983, agriculture accounted for 22% of the land use in the watershed, while urban land use comprised 48% of the watershed area. By 2002, agriculture accounted for only about 5% of the total land use, while about 75% of the area was urbanized (Figure 3-5). The watershed still contains large areas of open space, mainly in the foothills and headland areas of the watershed l

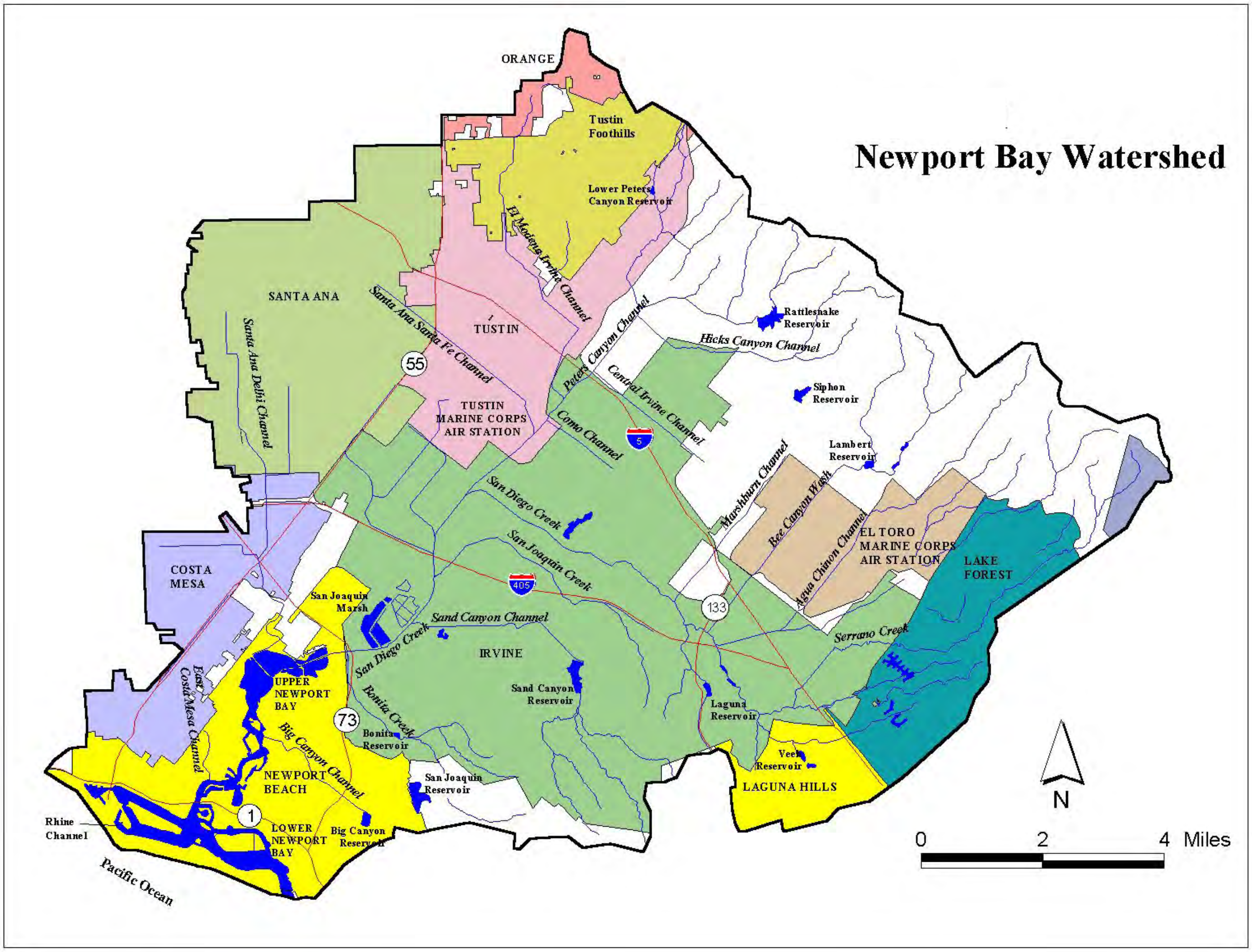

Figure 3-1. Newport Bay Watershed including cities, water bodies, and freeways.

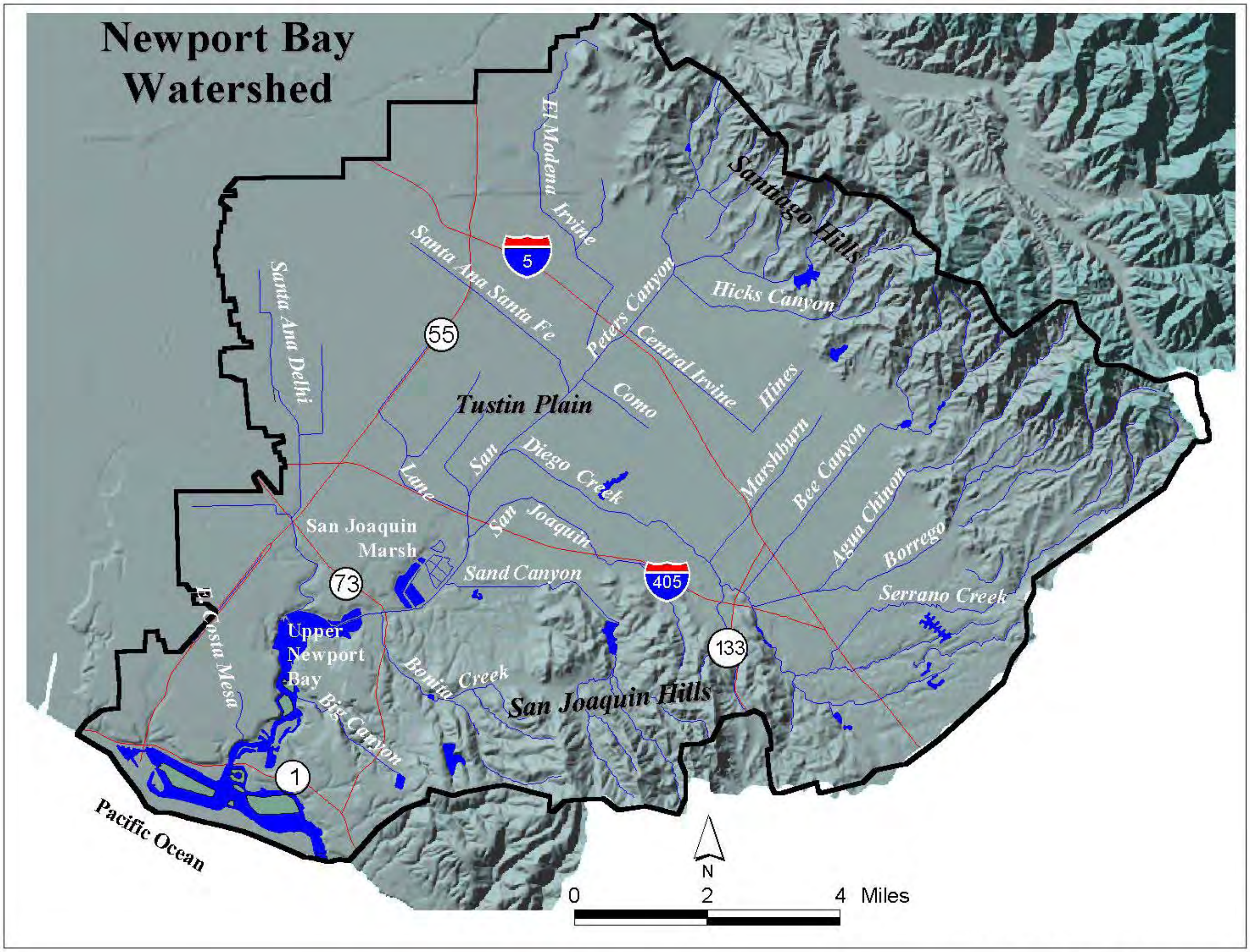

Figure 3-2. Topography and geomorphology of the Newport Bay watershed.

Figure 3-3. Upper and Lower Newport Bay.

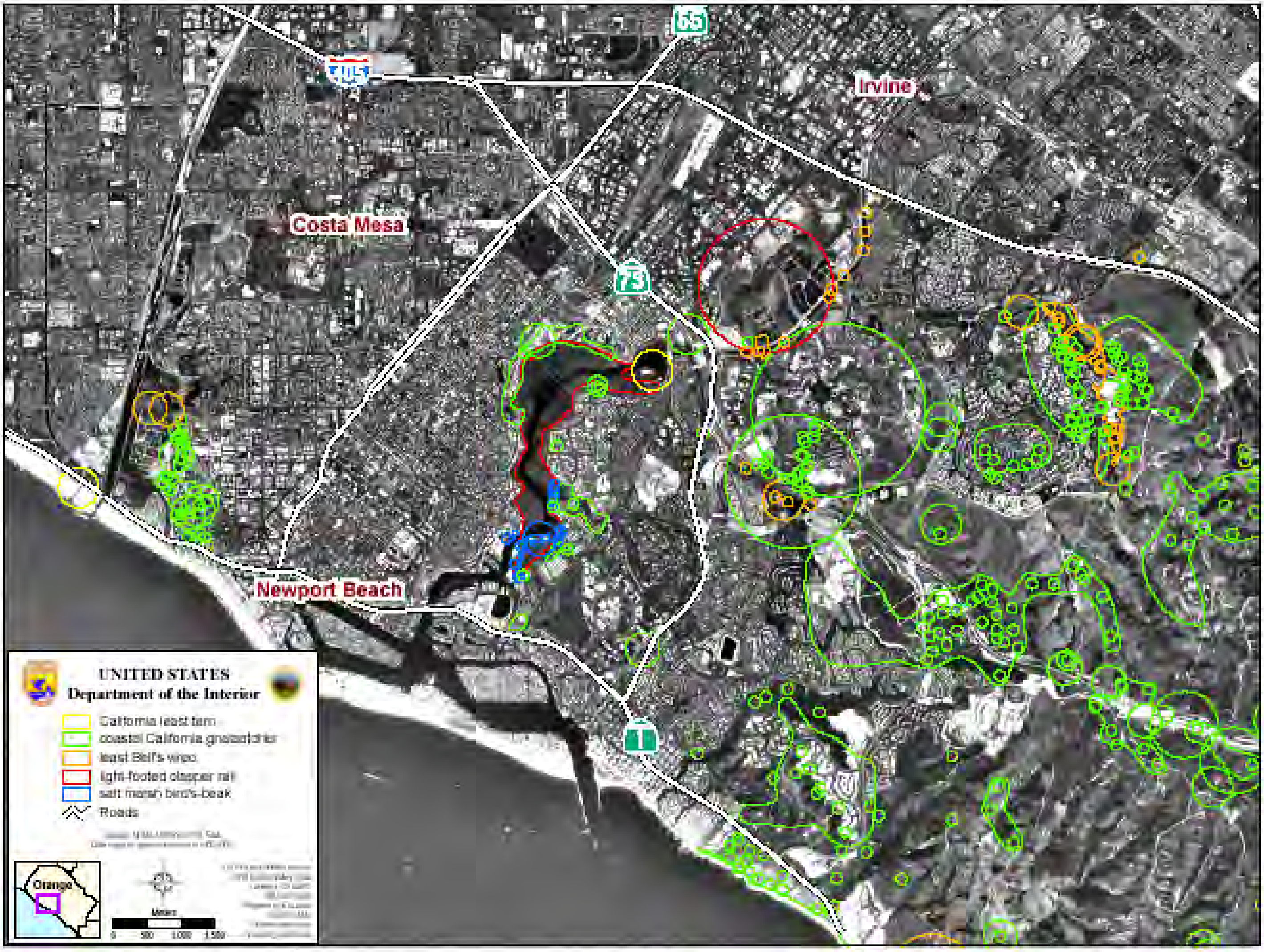

Figure 3-4a. Important habitat areas for federally-listed species in proximity to Newport Bay. (Figure provided by USFWS, Carlsbad, CA.)

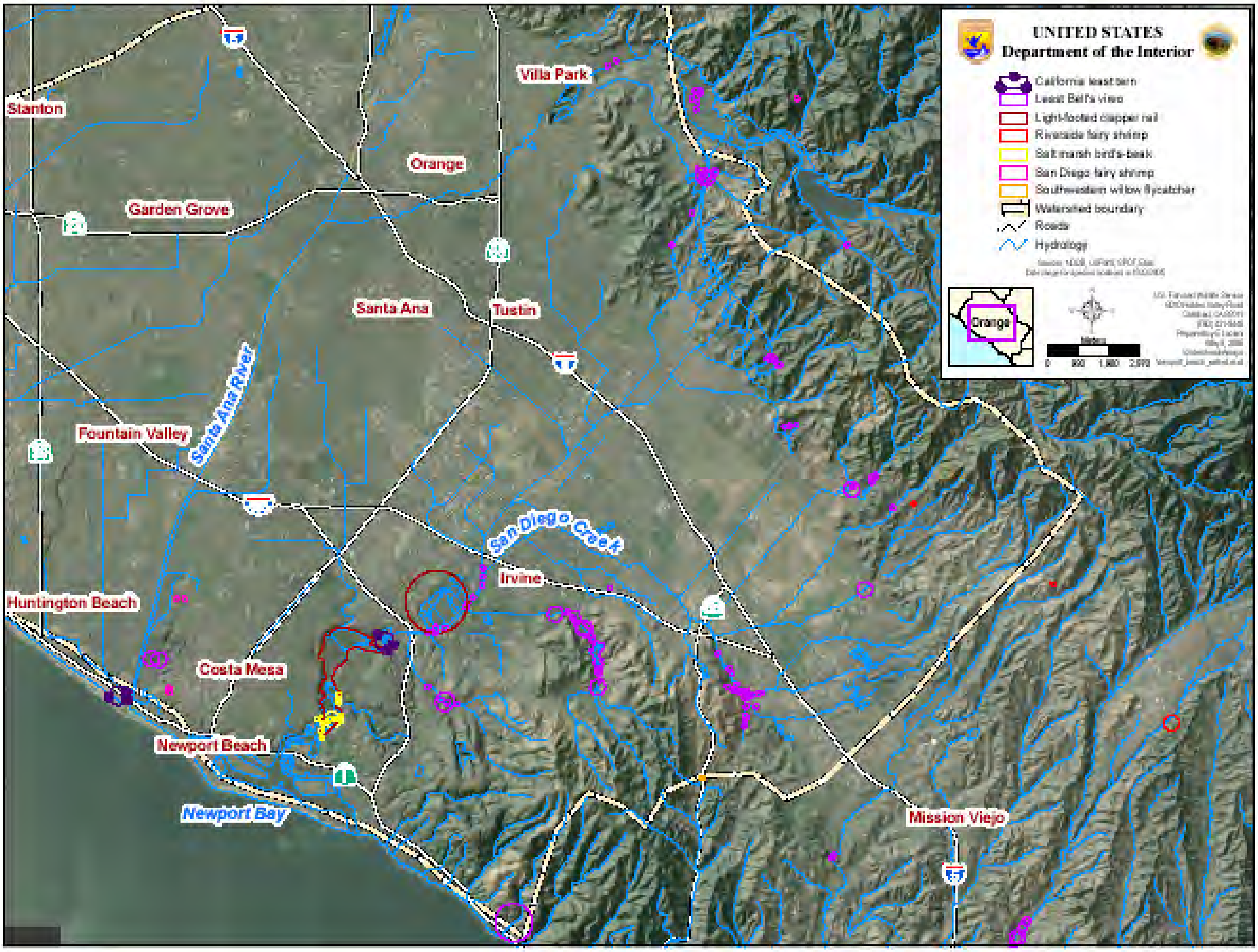

Figure 3-4b. Important habitat areas for federally-listed plants and wildlife in the Newport Bay watershed. (Figure provided by USFWS, Carlsbad, CA.)

where development has not yet occurred. Table 3-1 provides the latest available land use data for the San Diego Creek drainage and the Newport Bay watershed as a whole.
Table 3-1. Land Use in the Newport Bay Watershed.

Table 3-1. Land Use in the Newport Bay Watershed

Land Use	San Diego Creek		Newport Bay Watershed	
	Acres	Percent	Acres	Percent
Vacant	21,910	28.5	23,462	23.9
Residential	11,668	15.2	19,420	19.7
Education/Religion/Recreation	15,811	20.6	17,393	17.7
Roads	10,295	13.4	15,774	16.0
Commercial	6,381	8.3	9,641	9.8
Industrial	3,965	5.2	5,263	5.4
Agriculture	5,092	6.6	5,147	5.2
Transportation	1,177	1.5	1,326	1.3
No code	440	0.6	936	0.9
Total	76,739	100	98,362	99.9

Source: Orange County Public Facilities and Resources Department, provided March 2002

The area is heavily developed with industrial and residential land uses and has undergone extensive hydromodification (e.g., changes in hydrology resulting from the draining of wetlands, widespread channelization of streams, groundwater dewatering and remediation activities, and urban runoff and irrigation). Although the San Diego Creek and Newport Bay watersheds are highly urbanized, they contain undeveloped open space areas of major ecological significance. The Upper Newport Bay Nature Preserve and Ecological Reserve occupy about 1,000 acres of protected habitat in the watershed. The Nature Preserve's 140 acres include the bluffs surrounding Newport Bay, which provide habitat for three sensitive species: California Gnatcatcher, San Diego Cactus Wren, and Burrowing Owl. Two important plant communities are also found on the bluffs - grasslands and coastal sage scrub. The Upper Newport Bay Ecological Reserve includes 752 acres of coastal wetland. This area is one of the largest wetlands in southern California and is renowned as one of the finest bird watching sites in North America. Newport Bay's coastal wetland is home to six rare or endangered bird species (Light Footed Clapper Rail, Brown Pelican, Belding's Savannah Sparrow, Black Rail, Peregrine Falcon, Black Skimmer, and California Least Tern) and one endangered plant species (Saltmarsh Bird's Beak) (see Figures 3-4a and 3-4b).

3.2 Climate

The watershed experiences a Mediterranean climate, characterized by short, mild winters and dry summers. Average rainfall is about 13 inches per year, with 90 percent of the rainfall occurring between November and April.

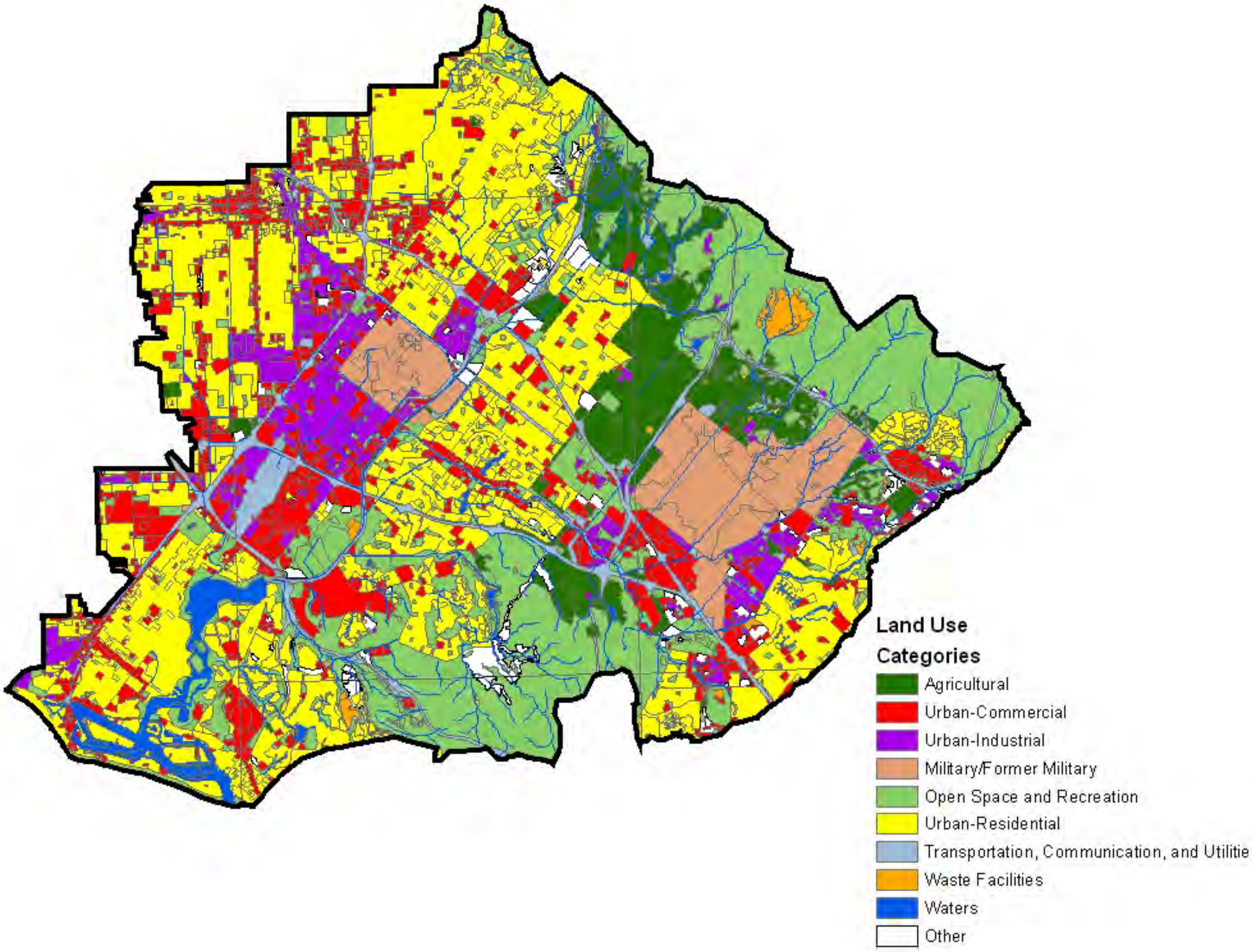

Figure 3-5 Land use categories in the Newport Bay watershed. (Source: Southern California Association of Governments 2001 land use data. Data aggregated into ten categories shown on the map above by Regional Water Board staff in 2006.)

3.3 Hydrology and Hydromodification

The hydrology of the watershed has been substantially altered compared to historic conditions. In the mid-1800s, the Santa Ana River flowed into Newport Bay, while San Diego Creek and the small tributaries that drained the foothills flowed into a large swamp, called "La Cienega de las Ranas", or Swamp of the Frogs (Trimble 1998). Overflow from the swamp discharged to the southwest into an ephemeral lake and alkali flat, and then ultimately to the Santa Ana River to the west. To enable row crop cultivation in the area, in the early 1900s, the wetlands were drained and vegetation was cleared and agricultural drainage channels were excavated to lower the water table and carry off the excess water (Trimble 1998). As the area shifted from agriculture to urban uses, agricultural channels became flood control channels, and many of the drainages that formerly flowed only intermittently became perennial over time as urban runoff, irrigation and rising groundwater provided a constant source of flow to surface waters in the area. (Figure 3-6).

In 1920, the Santa Ana River was diverted from Lower Newport Bay to the west and permanently channelized to its current configuration for discharge to the ocean. With increasing urbanization, hydraulic capacity was increased in many of the drainages to prevent flooding, and grade controls, channel improvements and other hydromodifications were put in place. In the early 1960s, San Diego Creek was channelized so that it discharged directly to Upper Newport Bay (Trimble 1998). The present estuarine conditions in the Bay developed as a result of the increased freshwater flows entering the Bay from San Diego Creek and its tributaries.

San Diego Creek is the major drainage channel in the Newport Bay watershed and contributes about 85% of the freshwater flow volume into Upper Newport Bay. San Diego Creek is divided into two reaches. Reach 1 is designated as the portion of the creek that extends from Upper Newport Bay northward to Jeffrey Road, while Reach 2 is the remaining section that extends northeastward from Jeffrey Road to the headwaters of the creek in the foothills of the Santa Ana Mountains (Figures 3-7, 3-8, and 3-9). The drainage area of San Diego Creek (including its largest tributary, Peters Canyon Channel) accounts for about 77% of the watershed.

Daily flow records for San Diego Creek at the Campus Drive monitoring station reveal a wide range of flow rates. In dry weather, base flow typically ranges from 8 to 23 cubic feet per second (cfs). During wet weather, average daily storm flows in San Diego Creek can range up to about 9,200 cfs, although most storm flows (90th percentile) fluctuate between 23 and 850 cfs (Orange County, flow data, 1997-2008; see Appendix 3A) (see Figures 3-9a and 3-9b).

The second largest drainage in the watershed is that of the Santa Ana Delhi Channel, which accounts for about 11% of the Newport Bay watershed area (approximately 11,000 acres) and provides about 10% of the freshwater flow to Upper Newport Bay (Figure 3-10). Average dry weather flows in the Santa Ana Delhi channel are typically between 1 and 2 cfs, with storm flows ranging up to 1,370 cfs.

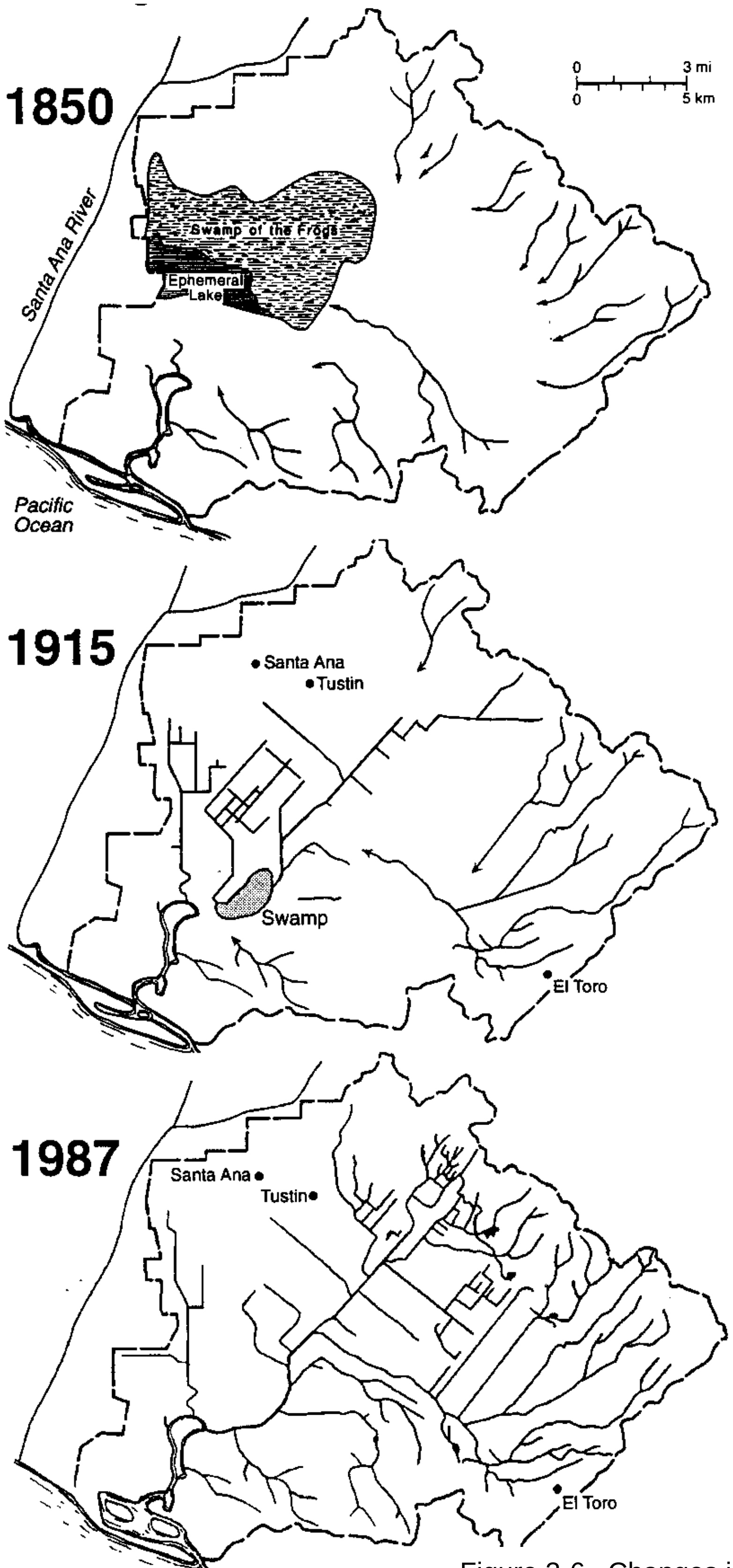

Figure 3-6. Changes in hydrography in the Newport Bay watershed, circa 1850, 1915, and 1987. (From Trimble, 1998).

Figure 3-7. Google Earth™ image showing a portion of the San Diego Creek subwatershed including Reach 1 or Lower San Diego Creek, Reach 2, and Peters Canyon Wash, the largest tributary to San Diego Creek.

Figure 3-8a. Peters Canyon Wash

Figure 3-8b. San Diego Creek Reach 2 (upper SDC).

Figure 3-9a. San Diego Creek Reach 1 (Lower San Diego Creek)

Figure 3-9b. High flow conditions in San Diego Creek Reach 1.

Big Canyon Wash drains an area of approximately 2 square miles and is also an important freshwater tributary to Upper Newport Bay (Figure 3-11). In 2007, baseflows (dry season flows) at the lower end of Big Canyon Creek upstream of where it enters Upper Newport Bay were measured at 0.67 cfs by Weston Solutions, Inc. (2007, 2008). There are currently only very limited storm flow measurements for this small watershed, but flows are expected to be less than those measured in the Santa Ana Delhi Channel.

Freshwater wetlands in the San Diego Creek Watershed (including the San Joaquin Wildlife Refuge and San Joaquin Freshwater Marsh Reserve) and Big Canyon Wash are no longer groundwater-supported wetlands but are dependent on storm water runoff and the perennial surface flows in the creeks. Surface water in San Diego Creek is diverted and transported through the Irvine Ranch Water District (IRWD) treatment wetlands in the San Joaquin Wildlife Refuge; excess flows can be diverted through the Carlson Marsh to the San Joaquin Freshwater Reserve (Figure 3-12). Surface flows in Big Canyon support the freshwater marsh ponds located near the mouth of the creek where it flows into Upper Newport Bay. These wetlands could not be supported without the presence of perennial freshwater flows in the creeks. The anthropogenic activities that have taken place primarily over the last 100 years in the Newport Bay watershed have significantly altered the quality and hydrology of the shallow groundwater and the surface flows and aquatic habitats in the watershed.

Newport Bay is divided into Upper Newport Bay and Lower Newport Bay; the division between the two areas is the Pacific Coast Highway crossing (Figure 3-13). Upper Newport Bay contains the 752 acre Upper Newport Bay Ecological Reserve. Lower Newport Bay is the largest small pleasure craft harbor in the continental US. A photographic tour of the Newport Bay watershed is available in Appendix 3B.

3.4 Water Quality

San Diego Creek and Newport Bay are identified on the State's Clean Water Act 2006 §303(d) list of impaired waters. Impairment in San Diego Creek Reach 1 has been attributed to fecal coliform, selenium and toxaphene; impairment in San Diego Creek Reach 2 has been attributed to metals. Impairment in Peters Canyon Channel, the primary tributary to San Diego Creek Reach 1, is attributed to DDT and toxaphene. Both Upper and Lower Newport Bay are listed as impaired due to chlordane, DDT, PCBs, copper, and sediment toxicity. The Rhine Channel, which is listed as a high priority toxic hot spot (SWRCB 1999) and is located in the west half of Lower Newport Bay (west of Lido Peninsula), is impaired due to copper, lead, mercury, zinc, sediment toxicity, and polychlorinated biphenyls (PCBs). Potential sources of these pollutants include urban runoff, rising groundwater, groundwater dewatering/remediation, contaminated sediments, boatyards, agriculture, nurseries, atmospheric deposition and unknown non-point sources.

TMDLs for the San Diego Creek-Newport Bay watershed (http://www.waterboards.ca.gov/santaana/water_issues/programs/tmdl/index.shtml#projects) have been adopted and are currently being implemented for fecal coliform (Newport Bay), sediments and nutrients (San Diego Creek and Newport Bay), diazinon (San Diego Creek) and chlorpyrifos (San Diego Creek and Newport Bay). TMDLs for the organochlorine pollutants (DDT, PCBs, chlordane and toxaphene) were approved by the Regional Board on September 7, 2007, but are

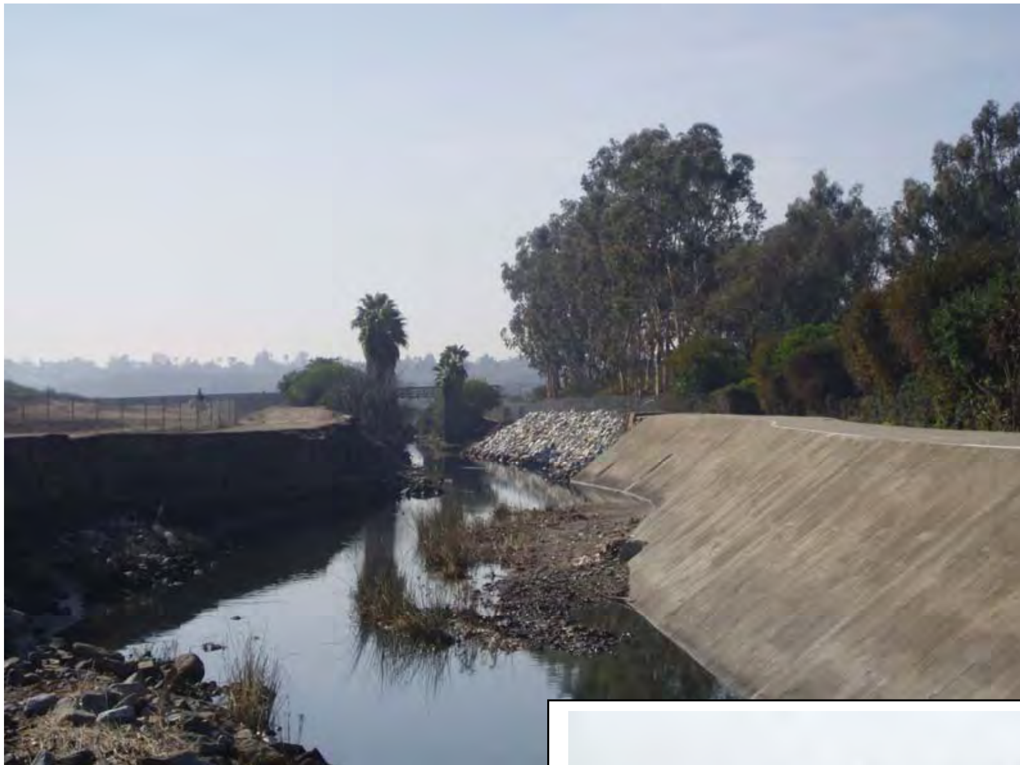

Figure 3-10. Santa Ana Delhi Channel

Figure 3-11. Big Canyon Wash

Figure 3-12. Oblique aerial photograph showing the hydrologic connections between San Diego Creek, the IRWD treatment wetlands, Carlson Marsh, the UCI wetlands (San Joaquin Freshwater Marsh Preserve), and Upper Newport Bay.

Figure 3-13a. Upper Newport Bay Ecological Reserve. (Source: Regional Water Board staff photograph)

Figure 3-13b. Lower Newport Bay, Rhine Channel area. (Source: Regional Water Board staff photograph).

still awaiting approval by the State Water Board and USEPA (see Table 3-1). However, implementation of these TMDLs is already underway through the Toxics Reduction and Investigation Program (TRIP) stakeholder working group.

Dissolved selenium concentrations in San Diego Creek at Campus, and in tributaries to San Diego Creek, consistently exceed the chronic (4-day average) California Toxics Rule criterion for selenium in freshwater (5 µg/L). Selenium concentrations often exceed background in sediment, some plants and algae, invertebrates, fish tissue, and bird egg tissue in many areas within the Newport Bay watershed. The exceedances of water column criteria (CTR criteria) and ecological risk guidelines for selenium (Presser et al. 2004) warrant the development of TMDLs for this constituent (see Section 5.0, Problem Statement).

3.5 Geology and Hydrogeology

The San Diego Creek and Newport Bay watersheds sit at the eastern margin of the Los Angeles physiographic and structural basin. The local geology consists of a Cretaceous crystalline basement overlain by Tertiary and Quaternary sequences of alluvial, fluvial and marine sediments and has had a dynamic depositional history (Meixner et al., 2004; Hibbs, 2008) (Figure 3-14). In the San Diego Creek watershed, the subsurface hydrogeology of the watershed consists of two principle aquifers: a shallow, perched aquifer and a deeper, regional aquifer. The shallow aquifer is located within the upper 150 feet of the subsurface strata and can be divided into three water-bearing zones in the vicinity of the former Tustin MCAS (Bechtel, 1998). The aquifer consists primarily of inter-bedded silty sands, silts and clays and is primarily recharged by local precipitation. The regional aquifer lies below, and is hydraulically separated from the upper, perched aquifer by a thick sequence of confining clays. The regional aquifer provides water for municipal and agricultural purposes and is recharged by precipitation falling in the foothills and alluvial fans of the Santa Ana Mountains (Camp Dresser & McKee, Inc., 1985). Both aquifers contain selenium; however, the shallow, perched aquifer generally contains much higher concentrations of selenium than the deeper regional aquifer, and only the shallow aquifer discharges to surface waters in the watershed (Meixner et al., 2004).

The geology and hydrogeology of the watershed play an important role in the presence of selenium in surface waters. While the geologic formations in the foothills and basins contain selenium-bearing minerals, the concentration of these minerals by both natural and anthropogenic processes has resulted in the accumulation of selenium in surface waters, sediment, and biota in the watershed. The sources and mechanisms for mobilization of selenium in the San Diego Creek Watershed differ from those in the Big Canyon Watershed. A brief discussion of the geologic sources and geochemistry of selenium in these sub-watersheds follows.

3.5.1 San Diego Creek Subwatershed

A century of urbanization in the San Diego Creek watershed has had dramatic impacts on surface geomorphology (Trimble 1998). Draining of historic wetlands and subsequent channel incision has caused oxidation and mobilization of toxic trace elements accumulated in the former wetlands (Hibbs and Lee 2000). Elevated concentrations of selenium enter the watershed's drainage network through a complex chemical mechanism directly influenced by local land use changes and development. The anthropogenic changes in the watershed are the primary reason for the current selenium concentrations in surface waters in this watershed.

In the late 1800s and early 1900s, sheep and cattle grazing dominated the watershed. The central portion of the watershed (Tustin plain) was covered in marshlands (Camp Dresser & McKee, Inc., 1985) supported by springs and groundwater seeps (Trimble, 1998). This large marshland, locally known as the Swamp of the Frogs, was drained in the early 1900s to make way for row crop cultivation. A network of agricultural channels was formed to transport the swamp waters and agricultural waste water (irrigation return flows) away from the cultivated areas. The network of channels was expanded as the area developed and by the early 1960s this network of channels was extended to conduct flood waters directly to Upper Newport Bay (Figure 3-6).

Selenium and other trace metals accumulated in the marsh soils, likely from runoff from source rocks in the local foothills, and possibly from springs and groundwater seeps. Selenium concentrations as high as 200 µg/L have been measured in Tomato Springs, a group of small springs located in the foothill area between Bee and Round Canyons. Selenium in storm water runoff has been measured in Hicks Canyon and Round Canyon Washes during a single storm event (January 6-7, 2008). Selenium concentrations in storm flows from Hicks Canyon were measured at 8-13 µg Se/L, while those at Round Canyon were measured at <1 to 1.2 µg Se/L (Hibbs et al., 2008); the difference in selenium concentrations in these drainages are likely indicative of the natural variability in selenium concentrations in the source rocks. Runoff from both these drainages as well as other drainages in the foothills ultimately collected in the Swamp of the Frogs. Selenium likely accumulated in the swamp soils over a period of several hundreds to thousands of years until the swamp was drained in the early 1900s.

The result of the hydromodification of the surface water drainages in this area of the San Diego Creek subwatershed has been to lower the groundwater table, forever altering the hydrologic regime of the watershed. Lowering the water table introduced oxygen into previously hydric soils, resulting in the mobilization of some redox-sensitive elements, such as selenium. The presence of nitrates in the shallow groundwater from the watershed's agricultural past appear also to be helping to mobilize selenium and other trace metals from the old swamp deposits (Meixner et al., 2004). Local precipitation appears to be flushing selenium and nitrate out of the vadose zone soils into shallow groundwater, which then enters surface waters. Approximately 76% of the nitrate and 96% of the selenium in San Diego Creek and its tributaries is believed to be from groundwater (Meixner et al. 2004).

3.5.2 Big Canyon Wash Subwatershed

Big Canyon Wash is a small tributary drainage to Upper Newport Bay that drains a watershed of approximately 2 square miles (Figure 3-14). The majority of the watershed (approximately 96%) is highly developed with homes, commercial areas, a golf course, cemetery, and other urban features. The downstream, undeveloped portion of the canyon flows into the Upper Newport Bay Ecological Reserve. The 60-acre Big Canyon Creek Nature Park is located in this part of the watershed.

High selenium concentrations in surface waters in the Big Canyon Nature Park were measured during water quality monitoring that was conducted as part of the restoration efforts for the nature park. Water column concentrations throughout the nature park exceeded the CTR freshwater chronic criterion for selenium of 5 µg/L (Weston Solutions, Inc. 2007). Soil samples collected at the mouth of Big Canyon as part of a study of urban wetlands by the Southern California Coastal Water Research Project (SCCWRP), exceeded the selenium screening value for substantial ecological risk of 4 milligrams per kilogram (mg/kg) dry weight (Presser et al. 2004).

In June 2008, a baseline monitoring study was completed by CH2MHill for the City of Newport Beach in the Big Canyon Creek Nature Park. Samples of water, sediment and biota from different areas within the nature park were collected to evaluate selenium concentrations and potential impacts in the food webs in the area. The analytical data indicated that selenium concentrations in water, sediment, and biota were elevated throughout the park, even in the middle and upper sections of the canyon (CH2MHill, 2008).

The sources of selenium in the watershed have not been identified. The steep cliffs that rim Big Canyon Wash are formed primarily of the Miocene Monterey Formation (Figure 3-15). This formation is a known source of selenium in California and is a likely source of selenium in Big Canyon. Selenium may have also accumulated in the canyon bottom soils, especially in the freshwater marsh areas.

The changes in canyon hydrology and the areas tributary to Big Canyon Wash as the watershed has developed have likely contributed to the mobilization of selenium. Shallow groundwater is found throughout much of the upper portion of the watershed. Urban landscape irrigation, the construction of an 18-hole golf course in the up-gradient part of the canyon east of Jamboree Road (Figure 3-14), Big Canyon Reservoir, and storm drain systems that discharge to the canyon, have changed the canyon's flow regime from ephemeral to perennial. This has resulted in significant changes in habitat and has likely contributed to the high selenium concentrations that have been found in the soils and water in the canyon. The City of Newport Beach and Regional Water Board staff are working together to determine the sources of selenium and possible remediation options for the selenium issues in Big Canyon (see Section 12.0, Task 11 Special Studies).

3.5.3 Newport Coast and Aliso Creek Watersheds

High selenium concentrations in surface waters have also been measured in baseflows in Buck Gully (OCRDMD, Annual Storm Water Reports, SAR Bioassessment Site Data, 2005-2008) and Aliso Creek (Brown and Bay, 2005) (see Table 3-2), two coastal drainages, and in two small drainages in the Laguna Hills/Laguna Woods area that are tributary to San Diego Creek Reach 2 (Orange County NPDES Dry Weather Reconnaissance Monitoring Program, 2008) (see Table 3-3 and Figure 3-16). The Monterey Formation outcrops along the eastern edge of Newport Bay and extends southwestward along the Newport Coast to Moro Canyon (Figure 3-17), which is located in the San Diego Region, and it also outcrops in the middle portion of the Aliso Creek watershed in the Laguna Hills/Laguna Woods area (Figure 3-18). This formation underlies much of coastal and inland Orange County and is a likely source of selenium in runoff and springs in the foothills (e.g Hicks Canyon, Tomato Springs; see Section 5.0 of this report).

Many of the drainages that intersect the Monterey Formation contain perennial flows as a result of urbanization and increased irrigation. The presence of seleniferous rocks and soils coupled with shallow groundwater may present conditions where selenium is actively bioaccumulating, similar to what has been found in Big Canyon Wash.

Figure 3-14. Big Canyon Wash Watershed and Vicinity.

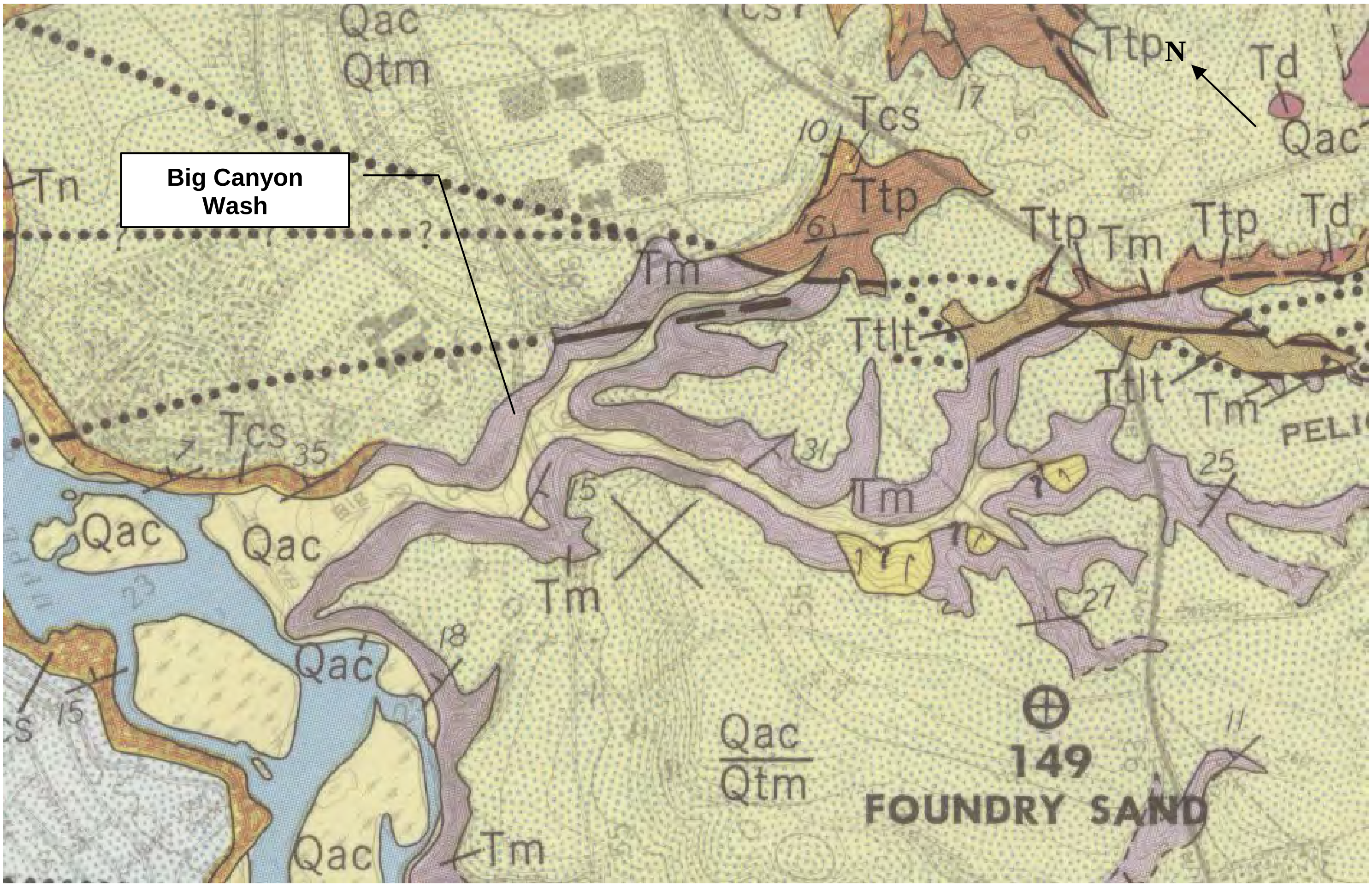

Figure 3-15. Geologic map showing Monterery Formation (light purple unit labeled Tm), a known source of selenium, outcropping along the edges of Big Canyon Wash. (Source: Morton and Miller, 1981.)

Table 3-2 Selenium Concentrations in Measured in Dry Weather Flows in Buck Gully and Aliso Creek

BUCK GULLY			**ALISO CREEK WET CAT INSTREAM WETLAND†**			
Station*	Date	Se (ug/L)	Station	Date	Se (ug/L)	
BGH01	10/27/05	73			Inflow	Outflow
BGH01	10/4/06	61	Wet CAT[1]	11/18/04	36.6	29.9
BGH01	6/7/07	26	Wet CAT	12/16/04	43.9	39.4
BGH01	11/6/07	24	Wet CAT[2]	1/20/05	52	44.6
BGH01	5/13/08	18	Wet CAT	3/09/05	52.4	42.7

* Buck Gully Wash at Little Corona Beach (Source: OCRDMD 2008 Annual Storm Water Report)
† Aliso Creek Wetland Capture and Treatment (Wet CAT) network BMP (Source: SCCWRP 2005, Technical Report 461): [1]pre-BMP samples [2] post-BMP samples

Table 3-3 Selenium Concentrations in Measured in Dry Weather Flows in the Laguna Woods/Laguna Hills Area

LGHF23@SV		**LGHF23S02**	
Date	Se (ug/L)	Date	Se (ug/L)
5/24/07	26	5/17/06	27
6/28/07	26	7/13/06	26
7/25/07	29	9/6/06	16
8/30/07	23	5/10/07	22
9/18/07	26	6/26/07	19
5/22/08	25	8/29/07	16
6/24/08	22	5/28/08	7.6
7/22/08	10	7/29/08	15
8/14/08	21	8/14/08	16
9/11/08	21		

Figure 3-16. Photograph of station LCHF23S02.

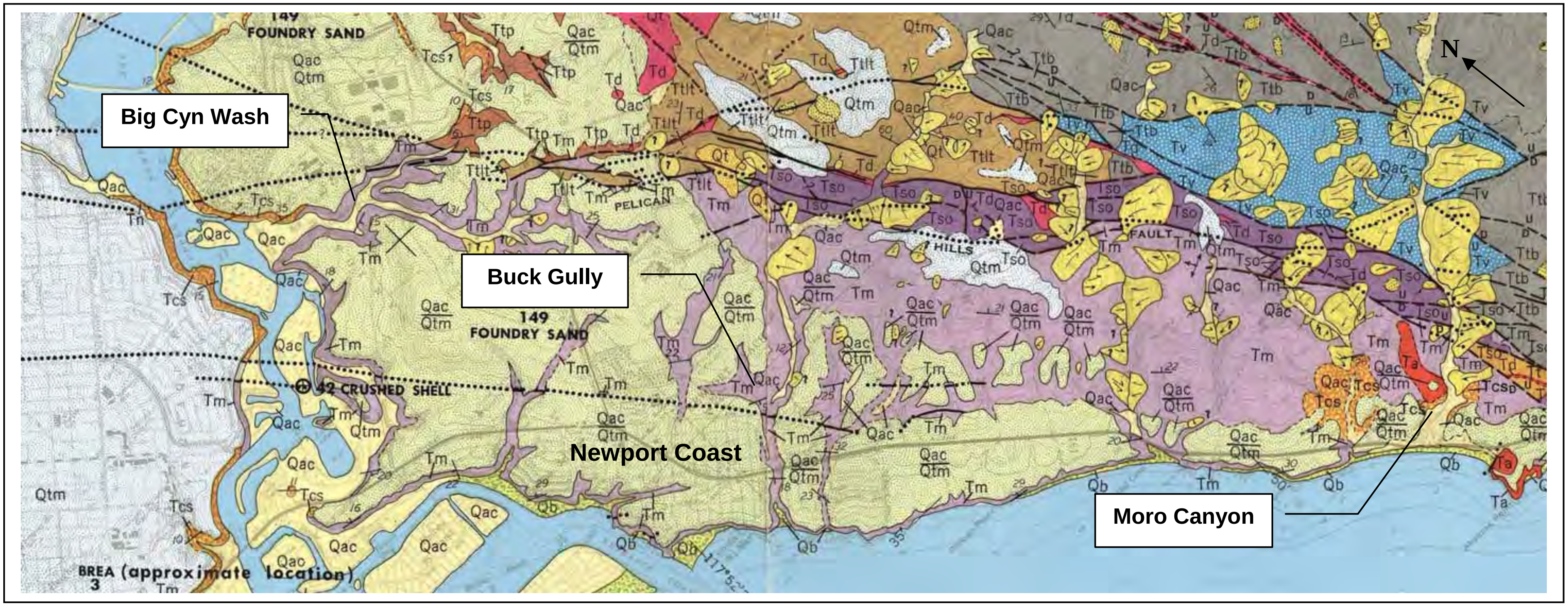

Figure 3-17. Geologic map showing the extent of the Monterey Formation (light purple unit labeled Tm) along the Newport Coast. (Source: Morton and Miller, 1981.)

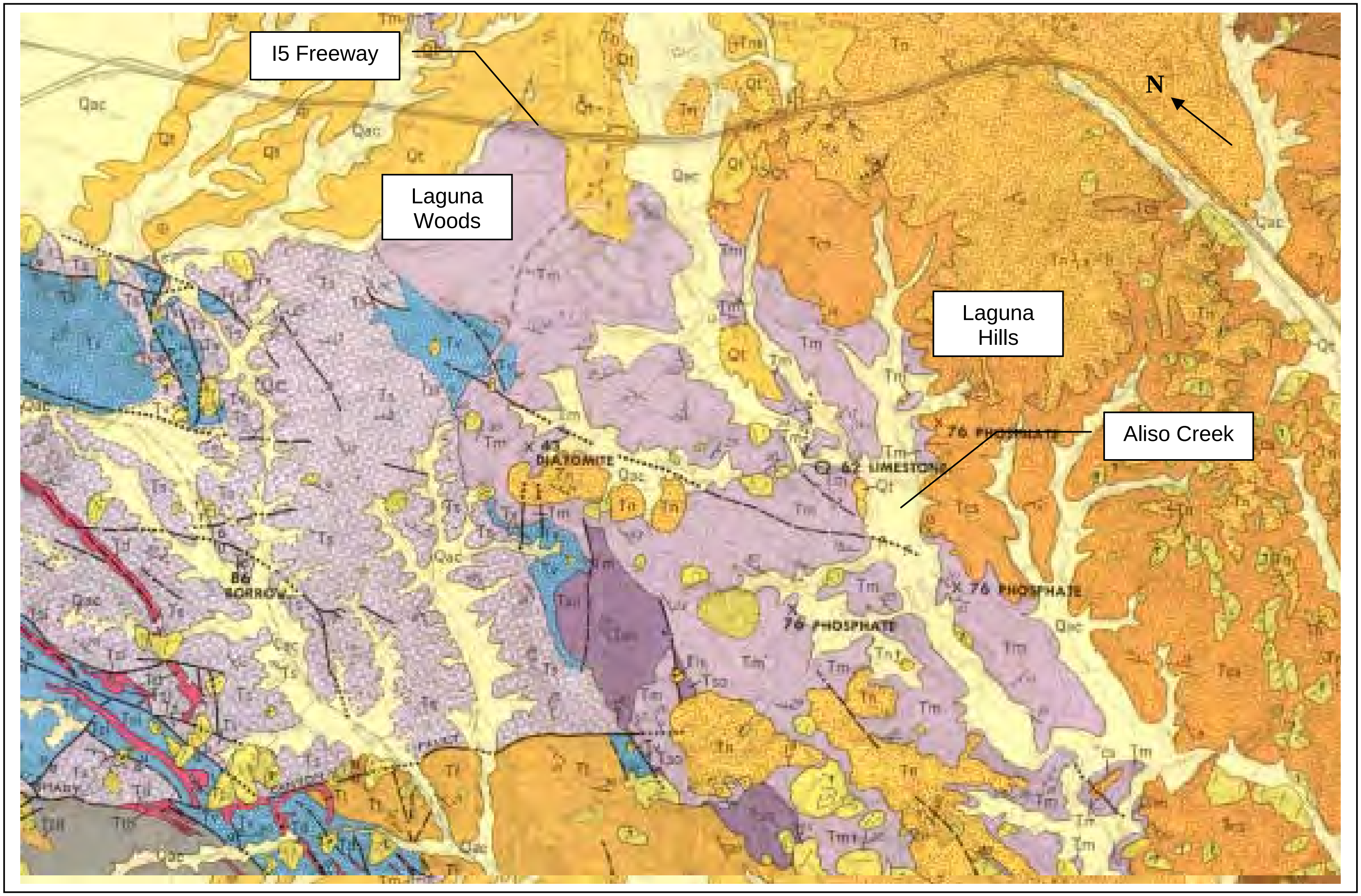

Figure 3-18. Geologic map showing the middle portion of the Aliso Creek watershed and the cities of Laguna Woods and Laguna Hills. The Monterey Formation underlies much of this area (light purple unit labeled Tm). (Source: Morton and Miller, 1981).

4.0 PHYSIOCOCHEMICAL AND BIOGEOCHEMICAL PROPERTIES OF SELENIUM

Selenium (Se) is a semi-metallic trace element which has biochemical properties similar to those of sulfur and is widely distributed in rocks, soils, and living organisms (USDOI 1998). Selenium-bearing minerals are often found in Upper Cretaceous and Tertiary marine sedimentary rocks (Seiler, 1995; Presser et al. 2004). Selenium can become mobilized and concentrated by weathering and evaporation in the process of soil formation and alluvial fan deposition in arid and semiarid climates (Presser et al., 1994). Selenium can also be leached from sediments as a result of irrigation practices, elevation of the groundwater table, or other modifications in the natural hydrologic regime (USEPA 2002).

Selenium exists in different environmental compartments that are atmospheric, marine, and terrestrial in nature. Heterogeneity in its distribution results in movement of selenium among those compartments (Nriagu, 1989). Selenium contamination of aquatic ecosystems is of special concern in large parts of California, and other semi-arid regions of western North America (Seiler *et al.,* 1999).

Selenium is the most dose-sensitive of all nutrients (Presser and Skorupa, 2009: http://wwwrcamnl.wr.usgs.gov/Selenium/intro.htm). Biochemical pathways in organisms are often unable to distinguish Se from sulfur, thus substituting excess Se into proteins and altering their structure and function, resulting in toxicity. Developmental abnormalities (teratogenesis) in fish and aquatic birds are overt expressions of such toxicity (Presser and Skorupa, 2009).

The chemical speciation of selenium is a critical consideration in assessing selenium contamination as the bioavailability and toxicity of selenium are greatly affected by its chemical forms. Selenium species bioaccumulate at different rates, so it is important to know which forms of selenium are present. The type of aquatic environment (e.g., lotic/lentic, marsh/riparian, etc.) and food webs present in a waterbody also effect selenium bioavailability and toxicity (Lemly 1998; Luoma and Presser, 2000; Presser and Luoma, 2006; Skorupa, 1998).

4.1 Selenium Speciation and Cycling

Selenium can occur in four different oxidation states: selenide (–2), elemental selenium (0), selenite (+4), and selenate (+6). In general, selenate (Se^{6+}) has a high solubility and is the most mobile in water. Selenite (Se^{4+}) is soluble in water but its strong affinity to be adsorbed to soil particles greatly reduces its mobility. Elemental selenium (Se^{0}) exists in a crystalline form and is usually incorporated in soil particles. Selenide can occur as metal selenides (similar to metal sulfides), which tend to be deposited in bottom sediments, or as organic selenides (primarily as dimethylselenide) through methylation and volatilization. Selenium is often an analog to sulfur in many biochemical reactions and can cause problems in animals if it replaces sulfur in some metabolic pathways.

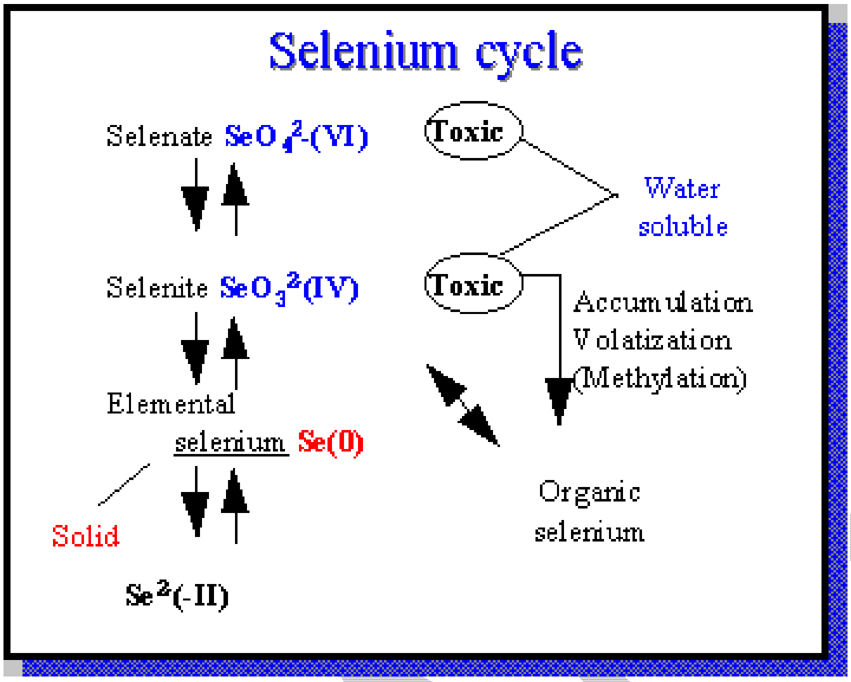

Figure 4-1. Selenium speciation and cycling. While conversions from selenate to selenite and then to organic forms of selenium (via reduction or biological uptake) can occur fairly rapidly, conversion of organic selenium or selenite back to selenate may take thousands of years.

Selenium commonly occurs as a mixture of several different chemical forms in surface waters (Salton Sea Authority, undated document at http://www.saltonsea.ca.gov/media/archives/selenium.pdf). Soluble selenates are the predominant form under oxidizing conditions in alkaline soils commonly found in arid areas such as the Newport Bay watershed. Selenium in oxygenated water entering a wetland is usually in the form of selenate but is converted slowly to selenite or elemental selenium as reducing conditions form. Selenite is the more common soluble form of selenium under reducing conditions and in acidic soils, which occur more typically in higher-rainfall areas. Metal and organic selenides formed from selenite reduction are common in bottom sediments, but generally are insoluble and not readily bioavailable, though they can be oxidized to more bioavailable forms under aerobic conditions (http://www.saltonsea.ca.gov/media/archives/selenium.pdf).

Low selenium concentrations in water may reflect low mass loading of selenium, but low concentrations may also reflect high biotic uptake of selenium. Several different biogeochemical processes may influence the cycling of selenium through different environmental compartments (http://www.saltonsea.ca.gov/media/archives/selenium.pdf). Bacterially mediated oxidation-reduction reactions are the most important processes controlling selenium speciation, precipitation/dissolution, sorption/desorption, methylation, and volatilization in wetlands. Rates for these processes vary widely and are dependent on temperature, moisture, organic carbon content of soil/sediment, selenium concentration and chemical form, and microbiological activity (http://www.saltonsea.ca.gov/media/archives/selenium.pdf).

Mobilization of selenium, either from geologic formations or selenium-enriched soils, is primarily a result of anthropogenic activities (Presser et al., 2004). Activities such as mining, oil production, agriculture, and hydromodification can all result in the oxidation and mobilization of selenium from natural deposits. The mass of selenium mobilized by such activities is larger than the total flux of natural terrestrial, marine and atmospheric sources on an annual basis (Haygarth, 1994).

Selenite is the most bioavailable of the dissolved phase inorganic species (Maier *et al.,* 1993; Skorupa, 1998). The difference in the bioavailability of the different species of selenium can be illustrated by comparing the selenium concentrations and species in water, and the selenium concentrations in tissue, between San Diego Creek Reach 1 and Big Canyon Creek.

The data collected from the Big Canyon Creek Nature Park indicate that selenium concentrations in sediment and the biota in the park are extremely high – an order of magnitude higher than the concentrations measured in biota in the lower part of San Diego Creek – despite the fact that the total selenium concentrations in the surface waters in Big Canyon Creek are similar to those measured in San Diego Creek (Table 4-1).

Table 4-1. Comparison of Median Selenium Concentrations in Surface Waters and Biota in San Diego Creek Basin No. 2 and the Big Canyon Creek Nature Park

MEDIA	SAN DIEGO CREEK BASIN 2	BIG CANYON CREEK
Water	15 µg/L	19 µg/L
Sediment	0.5 mg/kg dry weight	54 mg/kg dry weight
Macroinvertebrates	7 mg/kg dry weight	32 mg/kg dry weight
Fish	7 mg/kg dry weight	57 mg/kg dry weight

Selenium speciation analysis was performed on water column samples collected from several areas in the Big Canyon Creek Nature Park (CH2MHill, 2008). The selenium speciation data indicate that the selenium in the surface flows in the nature park is composed of a significant amount of selenite (Se^{+4}) compared to the flows in the lower part of San Diego Creek. Approximately 21 percent (%) to 40% of the selenium in the baseflow in the canyon was composed of selenite. By comparison, generally less than 5% of the selenium in San Diego Creek is selenite. The presence of the relatively high proportions of selenite in the surface waters in the park is the most likely reason for the extremely high concentrations of selenium in sediment, algae, invertebrates, frogs and fish. Selenite was also the primary form of selenium found in Belews Lake, North Carolina (see Section 2.1.2).

Several things can happen to selenium when it enters an aquatic system: it can bind or complex with particulate matter or surficial sediments (usually through the deposition of particulate and detrital materials); it can be absorbed or ingested by organisms; or it can remain free in solution in the system (Lemly, 1998). Therefore, the biological productivity of a system plays an important role in selenium transformations and accumulation in most aquatic systems.

Selenium is often found with particulate matter, which may include primary producers (*e.g.*, phytoplankton), bacteria, detritus, suspended inorganic material, and sediments. Interactions and transformation of selenium between dissolved and particulate phases can be biological, chemical, and/or physical in nature. These reactions play an important role in selenium toxicity (Luoma and Presser, 2000). Bioaccumulation of selenium in lower trophic level invertebrates (*e.g.*, zooplankton and bivalves) is a critical step in determining the effects of selenium since higher trophic level predators such as fish and birds feed on invertebrates. Luoma and Presser (2000) postulated that direct uptake of particulate selenium by invertebrates via filter-feeding or deposit feeding is the primary route for selenium to enter the food web (Figure 4-2).

Selenium concentrations can be magnified at each step in the foodweb transfer. It is usually the upper trophic level species (predators) that are most vulnerable to adverse effects from selenium contamination (Presser et al., 2004). However, selenium toxicity is dependent on the species (chemical form) of selenium, the sensitivity of the organism, and the dose, duration, and, frequently, the timing of the exposure (in relation to reproductive state). The most sensitive toxic endpoints are immune system suppression, reduced juvenile growth, and reduced hatching success (Skorupa, 1998).

Hydraulic linkages also play an important role in selenium cycling. Connections between riverine systems and wetlands, lakes, impoundments, and estuaries can result in accelerated selenium accumulation in these hydrologically connected waterbodies even though the riverine system itself may not appear to be effected (Luoma et al., 1992; Skorupa, 1998; Lemly, 1998). The aquatic systems that are most efficient at accumulating selenium are shallow, slow-moving waters with low flushing rates, such as most lentic systems (Lemly, 1998). Lotic systems, such as fast-moving streams and rivers, do not tend to accumulate particulate matter, and plants and animals that accumulate selenium may be scarce. However, even lotic systems may have lentic areas, such as pools or standing backwaters. Therefore, it is important to look at, and accurately classify, all aspects of an aquatic system, especially downstream of a site, to determine how selenium may be cycling through these different, but connected, hydrologic areas.

5.0 PROBLEM STATEMENT

Selenium is a non-metallic element that can bioaccumulate at concentrations that may cause toxicity in humans, fish, and wildlife. Selenium concentrations in many of the surface water drainages in the Newport Bay watershed exceed the CTR selenium freshwater chronic criterion of 5 µg/L. Selenium concentrations in invertebrates, fish, and bird eggs collected from the watershed have been found to exceed the published ecological risk guidelines of the US Department of the Interior (USDOI, 1998) and Presser et al. (2004).

Section 303(d)(1)(A) of the CWA requires that "(E)ach State shall identify those waters within its boundaries for which the effluent limitations are not stringent enough to implement any water quality standard applicable to such waters". Water bodies that have been identified in accordance with that requirement are placed on the CWA 303(d) list; these waters are not expected to meet water quality standards even after implementation of technology-based control practices. The CWA requires states to establish a priority ranking of waters on the 303(d) list and establish Total Maximum Daily Loads (TMDLs) for such waters. San Diego Creek Reach 1 is listed as impaired for selenium on the 2006 303(d) list (Appendix 5A).
(http://www.swrcb.ca.gov/water_issues/programs/tmdl/docs/303dlists2006/epa/r8_06_303d_reqtmdls.pdf).

5.1 Regulatory Background

In the early 1990s, the Regional Board placed Newport Bay and San Diego Creek on the CWA §303(d) list due to violations, or threatened violations, of the Basin Plan narrative objectives for toxic substances. The listings were based primarily on data obtained from the State Mussel Watch Program (SMWP) and Toxic Substances Monitoring Program (TSMP), which showed evidence of declining, but continuing, bioaccumulation of some toxic substances in mussel and fish tissue at levels that could potentially threaten the biota (SARWQCB Final Problem Statement, 2000). Those listings, and subsequent monitoring data supporting those listings, prompted SARWQCB staff to begin development of TMDLs for toxic pollutants.

On October 31, 1997, USEPA entered into a consent decree, Defend the Bay, Inc. v. Marcus, (N.D. Cal. No. C97-3997 MMC), which established a schedule for development of TMDLs in San Diego Creek and Newport Bay. The decree required development of TMDLs for a variety of pollutants by January 15, 2002; this date was subsequently extended to June 15, 2002. Because the SARWQCB was unable to complete development of TMDLs for toxic pollutants by the date specified in the consent decree, USEPA was required to do so. USEPA, therefore, promulgated TMDLs for 14 toxic pollutants on June 14, 2002. These technical TMDLs for toxics can be found at http://www.epa.gov/region09/water/tmdl/final.html (scroll down to "San Diego Creek, Newport Bay Toxics TMDLs").

The consent decree included a list of chemicals for which TMDLs would be prepared; however it specifically provided that USEPA was under no obligation to establish TMDLs for any pollutants that USEPA determined were not necessary, consistent with Section 303(d) of the Clean Water Act. USEPA Region 9 evaluated all readily available data for San Diego Creek and Newport Bay, and used a weight of evidence approach to independently determine which chemicals warranted TMDLs. Their determination as to which chemicals warranted TMDLs is discussed in the Decision Document, Part H of the Technical TMDL (USEPA 2002).

Subsequent to USEPA's promulgation of technical TMDLs, the State Water Resources Control Board (SWRCB) adopted the State Listing Policy in September 2004. This policy specifies methodology for placing a water body on the CWA §303(d) list. The State's methodology differs somewhat from the methodology used by USEPA for developing the toxics TMDLs. In 2006, as part of the biennial 303(d) listing process, SWRCB staff listed San Diego Creek Reach 1 as impaired for selenium. However, both USEPA staff's and SWRCB staff's assessments of impairment due to selenium for the San Diego Creek/Newport Bay watershed only considered water column data. Selenium is bioaccumulated primarily through diet. Therefore, SARWQCB staff assessed impairment using water column, fish tissue, and egg tissue data as allowed by the State Listing Policy. That assessment is discussed in Section 5.3.

5.2 Water Quality Standards

Water quality standards include beneficial uses, water quality objectives (numeric and narrative) and an antidegradation policy.

5.2.1 Beneficial Uses

Beneficial uses of San Diego Creek and Newport Bay are designated in the region's Water Quality Control Plan (Basin Plan; SARWQCB, 1995, as amended: http://www.waterboards.ca.gov/santaana/water_issues/programs/basin_plan/index.shtml), and are listed below in Tables 5.2-1 and 5.2-2. Adverse impacts to these beneficial uses that result from discharges of toxic pollutants are violations of the second narrative objective for toxic substances specified in the Basin Plan (see Section 4.2.3). The beneficial uses potentially most at risk from selenium bioaccumulation are WARM, EST, MAR, BIOL, WILD, RARE, and SPAWN.

5.2.2 Numeric Water Quality Objectives

In 2000, USEPA established numeric criteria for priority toxic pollutants for the State of California (40 CFR 131; California Toxics Rule [CTR]). The CTR includes numeric water aquatic life criteria for 23 priority toxic pollutants and numeric human health criteria for 57 priority toxic pollutants. The 2000 CTR established numeric water quality criteria for selenium for freshwater and enclosed bays. The USFWS however, issued a biological opinion on the CTR selenium criteria that judged that the proposed criteria were “not sufficiently protective” of certain endangered or sensitive species (Spear and McInnis, 2000). The reasoning behind this opinion is that selenium bioaccumulates primarily through diet, not water, and that water column-based criteria were under-protective of certain species of fish and birds. USEPA and the USFWS agreed to revise the selenium criteria to protect both aquatic life and aquatic-dependent wildlife (as well as to review and revise the criteria for several other pollutants). That process is still underway (see Section 6.0).

5.2.3 Narrative Water Quality Objectives

The Basin Plan specifies two narrative water quality objectives for toxic substances. These are:

(1) Toxic substance shall not be discharged at levels that will bioaccumulate in aquatic resources to levels which are harmful to human health, and
(2) The concentration of toxic substances in the water column, sediment or biota shall not adversely affect beneficial uses.

Evidence that toxic substance concentrations in the water column, sediment or biota exceed applicable numeric or narrative objectives indicates that beneficial uses are being impaired or threatened.

Table 5-1 Designated Beneficial Uses for San Diego Creek and Newport Bay

	Beneficial Use																			
	MUN	**AGR**	**IND**	**PROC**	**GWR**	**NAV**	**POW**	**REC1**	**REC2**	**COMM**	**WARM**	**LWRM**	**COLD**	**BIOL**	**WILD**	**RARE**	**SPWN**	**MAR**	**SHEL**	**EST**
Lower Newport Bay	+					X		X	X	X					X	X	X	X	X	
Upper Newport Bay	+							X	X	X				X	X	X	X	X	X	X
San Diego Creek Reach 1 – Below Jeffrey Road	+							X[1]	X		X				X					
San Diego Creek Reach 2 – above Jeffrey Road to headwaters	+				I			I	I		I				I					
Other tributaries – Bonita Creek, Serrano Creek, Peters Canyon Wash, Hicks Canyon Wash, Bee Canyon Wash, Borrego Canyon Wash, Agua Chinon Wash, Laguna Canyon Wash, Rattlesnake Canyon Wash, Sand Canyon Wash[2], and other tributaries to these creeks	+				I			I	I		I				I					

[1] Access prohibited in all or part by Orange County Environmental Management Agency (OCEMA)
[2] Sand Canyon Wash also has RARE Beneficial Use
X= present or potential
I= intermittent

Table 5-2 Beneficial Use Definitions.

MUN – Municipal and domestic supply
AGR – Agricultural supply
IND – Industrial service supply
PROC – Industrial process supply
GWR – Groundwater recharge
NAV - Navigation
POW – Hydropower generation
REC1 – Water contact recreation
REC2 – Non-contact water recreation
COMM – Commercial and sportfishing
WARM – Warm freshwater habitat
LWRM – Limited warm freshwater habitat
COLD – Cold freshwater habitat
BIOL – Preservation of biological habitats of special significance
WILD – Wildlife habitat
RARE – Rare, threatened, or endangered species
SPWN – Spawning, reproduction, and development
MAR – Marine habitat
SHEL – Shellfish harvesting
EST – Estuarine habitat

5.3 Impairment Assessment for Selenium in the Newport Bay Watershed

Section 303(d)(1) of the Clean Water Act (CWA) requires states to identify waters that do not meet applicable water quality standards following implementation of technology-based controls, and to prioritize such waters for development of Total Maximum Daily Loads (TMDLs) (40 CFR 130.7(b)). Water quality limited segments are defined as "any segment [of a water body] where it is known that water quality does not meet applicable water quality standards, and/or is not expected to meet applicable water quality standards, even after application of technology-based effluent limitations required by CWA sections 301(b) or 306…" (40 CFR 130.2(j)). States are required to assemble and evaluate all existing and readily available water quality-related data and information (40 CFR 130.7(b)(5)) to determine which waters should be included on their Section 303(d)(1) lists of water quality limited segments. The State's 2004 Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List (the Listing Policy) requires a weight-of-evidence approach in evaluating these data to assess impairment.
(http://www.swrcb.ca.gov/tmdl/docs/ffed_303d_listingpolicy093004.pdf)

5.3.1 Data Evaluated in Impairment Assessment

The impairment assessment for selenium performed by USEPA as part of their technical TMDLs for toxic pollutants in the San Diego Creek/ Newport Bay watershed (2002) evaluated data obtained between 1997 and 1998. The State

Water Resources Control Board (State Water Board) also conducted an impairment assessment in support of its recommendations for the 2006 303(d) listings, using data from 2002 (Appendix 3A). However, both USEPA's and State Water Board staff's impairment assessments relied only on comparison of water column data to the current CTR chronic selenium criteria. In contrast, data evaluated in this impairment assessment include selenium concentrations in water (both fresh and salt water), fish tissue, and bird eggs (Appendix 3B). Relevant sources of data (monitoring programs, special studies, etc.) are listed in Appendix 3C. Water column selenium concentrations are compared to the current CTR criteria (as required by the State Listing Policy), but in addition, fish tissue and bird egg tissue selenium concentrations are compared to ecological risk guidelines established for reproductive effects in fish and birds (USDOI 1998; Presser et al., 2004; Luoma and Presser, 2006). Because selenium bioaccumulates primarily through diet, not water, measurement of selenium concentrations in fish and bird egg tissue provides a direct link to assessment of impairment effects due to selenium. Tissue-based assessments thus provide an appropriate means of assessing compliance with the narrative objectives for toxic substances. Section 6.1.3 of the 2004 State Listing Policy allows for the selection of alternative guidelines to interpret narrative water quality objectives and protect beneficial uses.

This impairment assessment covers data collected from 2000-2008 since most of the biological data were collected within this time frame. Because selenium is bioaccumulated by organisms primarily through diet, it is best to collect, where possible, a comprehensive suite of water column, sediment, and biological samples (including plants and/or algae, invertebrates, fish, and bird eggs) from different areas in the watershed to determine how selenium is cycling and what food webs are most at risk from bioaccumulation of selenium in that particular hydrologic compartment. While a complete suite of biological species data and multi-year data are not yet available from each hydrologic unit in the watershed, data for two or more of these media are now available for portions of Peters Canyon Wash, Santa Ana – Santa Fe Channel, San Diego Creek (both Reach 1 and Reach 2), the San Joaquin Freshwater Marsh Reserve at the University of California – Irvine (UCI wetlands), the Irvine Ranch Water District (IRWD) treatment wetlands (IRWD wetlands), the Santa Ana Delhi Channel, Big Canyon Wash, and Upper and Lower Newport Bay (Appendix 3B). Water column data but not biological data are available for several tributary channels to Peters Canyon Wash, San Diego Creek, and Upper Newport Bay. For these channels, impairment was determined based only on exceedances of the CTR chronic criterion of 5 µg Se/L.

The dataset used in this impairment assessment includes water column samples collected from 2000-2008, freshwater fish tissue samples collected from 2002-2008, salt water fish tissue samples collected from 2000-2007, and bird egg tissue samples collected from 2003-2006.

Sediment, plant, and invertebrate tissue samples were also considered in this assessment but were not used to determine impairment because they do not provide a direct link to selenium effects in birds and fish. Additionally, the dietary items that were collected may not adequately represent the types or proportions of organisms consumed by the species of concern. However, since dietary items are important in determining how exposed a sensitive species may be to selenium, an assessment of the potential risk to birds and fish from different food webs was also made by grouping the organisms into representative feeding guilds (herbivores, invertivores, omnivores, and piscivores). The selenium concentrations in these groups of organisms were then compared to the middle of the range of the Presser et al. 2004 marginal ecological risk dietary guidelines (see Section 5.3.8).

While some of the water column data (2002) that were used in this assessment can be compared to the data used by State Water Board staff in their impairment assessment for the 2006 303(d) list, this assessment includes a much larger and more comprehensive set of combined water column and biological data that provide a more thorough evaluation of the extent of selenium bioaccumulation and its potential impacts to beneficial uses in the watershed. The data also include the second wettest year on record (2005) and the driest year on record (2006) for the watershed.

5.3.2 Methodology

The Listing Policy (SWRCB, 2004) was followed in conducting this impairment assessment. A weight of evidence approach to evaluating impairment is required under the Policy. According to the Final Functional Equivalent Document (FED) for the Listing Policy (http://www.swrcb.ca.gov/water_issues/programs/tmdl/docs/ffed_093004.pdf):

> The expression "weight of evidence" describes whether the evidence in favor or against some hypothesis is more or less strong (Good, 1985). In general, components of the weight-of-evidence consist of the strength or persuasiveness of each measurement endpoint and concurrence among various endpoints. Confidence in the measurement endpoints can vary depending on the type or quality of the data and information available or the manner in which the data and information is used to determine impairment.
>
> Scientists have used a variety of definitions for "weight of evidence." A scientific conclusion based on the weight of evidence is often assembled from multiple sets of data and information or lines of evidence. Lines of evidence can be chemical measurements, biological measurements (bioassessment), and concentrations of chemicals in aquatic life tissue.

In describing how the State Water Board and Regional Water Boards are to implement a weight-of-evidence approach, the FED states:

> The weight of evidence approach would be a narrative process where individual lines of evidence are evaluated separately and combined using the professional judgment of the RWQCBs and SWRCB. The lines of evidence would be combined to make a stronger inference about water quality standards attainment….Using this approach the SWRCB and RWQCBs would use their judgment to weigh the lines of evidence to determine the attainment of standards based on the available data…Using this approach, a single line of evidence, under certain circumstances, could be *sufficient by itself* to demonstrate water quality standards attainment. (Emphasis added.)

According to the Listing Policy, water segments will be deemed impaired if any of the conditions specified in Sections 3.1-3.11 of the Policy are met. Conditions include *Numeric Water Quality Objectives and Criteria for Toxicants in Water; Health Advisories; Bioaccumulation of Pollutants in Aquatic Life Tissue; Water/Sediment Toxicity; Adverse Biological Response; Degradation of Biological Populations and Communities; Trends In Water Quality; Situation-Specific Weight of Evidence Listing Factors*; and others. Each of these factors requires a minimum number of measured exceedances in order to justify a finding of impairment. The minimum number is based on a binomial test, as presented below in Table 5.3-1. A finding of impairment was made if the number of exceedances was equal or greater than the minimum number required by the Listing Policy for any one of the above-listed factors. Data quality requirements of the Listing Policy were followed with respect to spatial representation, quality assurance (QA) and quality control (QC).

Table 5-3

MINIMUM NUMBER OF MEASURED EXCEEDANCES NEEDED TO PLACE A WATER SEGMENT ON THE SECTION 303(d) LIST FOR TOXICANTS.[1]

Null Hypothesis: Actual exceedance proportion ≤ 3 percent.
Alternate Hypothesis: Actual exceedance proportion > 18 percent.
The minimum effect size is 15 percent.

Sample Size	List if the number of exceedances equal or is greater than
2 – 24	2*
25 – 36	3
37 – 47	4
48 – 59	5
60 – 71	6
72 – 82	7
83 – 94	8
95 – 106	9
107 – 117	10
118 – 129	11

* Application of the binomial test requires a minimum sample size of 16. The number of exceedances required using the binomial test at a sample size of 16 is extended to smaller sample sizes.

For sample sizes greater than 129, the minimum number of measured exceedances is established where α and $\beta \leq 0.2$ and where $|\alpha - \beta|$ is minimized.

α = Excel® Function BINOMDIST(n-k, n, 1 – 0.03, TRUE)
β = Excel® Function BINOMDIST(k-1, n, 0.18, TRUE)
where n = the number of samples,
k = minimum number of measured exceedances to place a water on the section 303(d) list,
0.03 = acceptable exceedance proportion
0.18 = unacceptable exceedance proportion

[1] SWRCB 2004

Since the primary route for selenium bioaccumulation is diet, not water, and as allowed by Section 6.1.3 of the Policy, Board staff has elected to assess impairment of beneficial uses from selenium in the Newport Bay watershed using published ecological risk guidelines collated by USGS and USFWS staff (Presser et al., 2004[1]). However, this impairment assessment also relies on the comparison of water column data for the freshwater and saltwater bodies in the

[1] The Presser et al. 2004 guidelines were compiled by both USGS and USFWS and updated the USDOI 1998 guidelines for selenium. The Presser et al. 2004 guidelines were used for comparison to the tissue data in the impairment assessment.

watershed to the appropriate CTR criteria, since the CTR criteria are the legally applicable numeric objectives.

Section 6.1.3 of the Policy allows the use of alternative evaluation guidelines (to those recommended by the Policy) if the selected guidelines meet the following criteria:

- Applicable to the beneficial use
- Protective of the beneficial use
- Linked to the pollutant under consideration
- Scientifically-based and peer reviewed
- Well described
- Identifies a range above which impacts occur and below which no or few impacted are predicted. For non-threshold chemicals, risk levels shall be consistent with comparable water quality objective or water quality criteria.

The 2004 ecological risk guidelines (Presser et al.) selected by Board staff fulfill all 6 of the requirements in Section 6.1.3 of the Policy. These guidelines are an updated version of the selenium ecological risk guidelines originally published by the National Irrigation Water Quality Program (NIWQP) in 1998 (USDOI, NIWQP Information Report No. 3; http://www.usbr.gov/niwqp/guidelines/). The updated 2004 guidelines were published in Volume 8 of the Handbook of Exploration and Environmental Geochemistry, published by Elsevier. Both the NIWQP guidelines and the 2004 guidelines are scientifically-based and have been extensively peer reviewed. The 2004 guidelines have also been through the USGS' extensive peer review process (Appendix 5D). These ecological risk guidelines are directly applicable to the beneficial uses in the watershed (WARM, EST, MAR, BIOL, WILD, RARE, SPAWN) because they include values that are directly linked to the primary mechanisms of selenium uptake by organisms (diet) and the effects of selenium in higher trophic level predators (fish and birds).

Ecological risk threshold ranges are indicative of the endpoints used to measure adverse biological effects (USDOI, 1998). The 2004 guidelines include a range of values that define three (3) levels of ecological risk from selenium: no risk (none), marginal risk, and ecological risk (Table 5-4). Guidelines for five (5) different media are recommended: selenium in water, sediment, diet (fish or bird diet), fish tissue, and bird egg tissue (Presser et al. 2004). This impairment assessment compares selenium concentrations measured in whole body fish tissue and bird egg tissue samples collected from the watershed with the middle of the range of the 2004 marginal ecological risk guidelines for fish and birds. Marginal risk levels lie between no effect concentrations and toxicity thresholds and thus provide reasonable protection of beneficial uses (Presser et al. 2004). The middle of the range of marginal ecological risk concentrations for fish (5 µg Se/g dw) and for bird eggs (8 µg Se/g dw) were selected to assess potential impairment due to selenium bioaccumulation to ensure that both the most sensitive and potentially most exposed species, especially threatened and endangered species, would be considered. In addition, these guidelines have been determined to be appropriate site-specific objectives for selenium for the San Diego Creek and Newport Bay watersheds by USEPA and USFWS staff (see full discussion of the selenium SSO process in Section 6.0).

Selenium water column concentrations were compared to the current (2000) CTR chronic criteria of 5 µg/L total selenium for freshwater and 71 µg/L for saltwater, since these are the existing legally applicable objectives.

Table 5-4

2004 GUIDELINES FOR ASSESSING RISK TO AQUATIC LIFE AND AQUATIC-DEPENDENT WILDLIFE
ECOLOGICAL RISK THRESHOLDS FOR SELENIUM[1]

	None	Marginal	Substantive
Freshwater (µg/L)	<2	2–5	>5
Sediment (mg/kg	<2	2–4	>4
Diet (mg/kg)	<3	3–7	>7
Fish (mg/kg diet) (whole body)	<4	4–6	>6
Avian eggs (mg/kg)	<6	6–10	>10

Note: sediment and tissue guidelines are dry weight values
[1] Presser et al., 2004

Selenium concentrations in fish fillets are compared to the Office of Environmental Health Hazard Assessment's (OEHHA) 2008 Fish Contaminant Goals (FCGs) for selenium for the protection of human health (Klasing and Brodberg, 2008;
http://www.oehha.ca.gov/fish/gtlsv/pdf/FCGsATLs27June2008.pdf).

While there is a substantial body of data on both fish and bird food dietary items collected from the watershed, the linkages between these items and the species that consume them are very complex and can vary significantly between species, locations, seasons, and reproductive life cycle. Analysis of tissue concentrations in species of concern that are linked to specific effects (e.g., reproductive impairment) offers a more direct assessment of potential or threatened impairment. However, selenium concentrations in dietary items have been used to identify those foodwebs most at risk from selenium (see Section 5.4).

Selenium concentrations in sediment were also not used in the impairment assessment because there is a lack of consistency in sample collection methods, depths and, in some cases, locations. There also appear to be large disparities in selenium concentrations in samples that were taken at the same locations but at different times. It is not clear if these apparent fluctuations in selenium concentrations are a result of slight changes in sample locations, sample depths, sampling methods, or whether they actually represent seasonal or annual fluctuations in selenium sediment concentrations.

Selenium concentrations in water, fish tissue or bird egg tissue were compared to the selected guidelines; if sufficient numbers of samples exceeded the selenium guideline in accordance with the requirements in Section 3 of the Listing Policy (Table 3.3-1), a determination of impairment was made.

5.3.2.1 Pollutant Concentrations in Water (Section 3.1 of the Policy).
According to the Listing Policy, a finding of impairment is made for any pollutant-water body combination for which there is a sufficient number of samples showing exceedances of pollutant concentrations in the water column, compared to the California Toxics Rule (CTR) criteria. Since the CTR criteria are, at present, the legally-applicable water quality objectives, water column concentrations in the San Diego Creek and Newport Bay watersheds are compared to the CTR selenium criteria in Table 3.3-3 for the purpose of assessing impairment.

There is no CTR freshwater acute criterion for selenium. Additionally, questions have been raised about how USEPA derives their acute criteria for bioaccumulative pollutants (Wilson, 2005). The standard guidelines USEPA uses to develop acute criteria (Stephan et al., 1985) do not consider bioaccumulation of pollutants in the acute criterion flow paths (Reiley et al., 2003). Therefore, only the CTR chronic criteria were used in this impairment assessment.

The CTR freshwater chronic criterion of 5 µg/L is for total recoverable selenium, while the saltwater chronic criterion of 71 µg/L is for total dissolved selenium. Monitoring results from the watershed indicate that there is little difference between the concentrations of total recoverable and total dissolved selenium in most areas. For this reason, if total recoverable selenium data were not available for a monitoring location or event, but total dissolved selenium had been measured, then the total dissolved selenium data were compared to the CTR freshwater chronic criterion to determine impairment. Similarly, total recoverable selenium data were used to compare to the CTR saltwater chronic criterion where total dissolved selenium data were not available. It is interesting to note that in some instances, total dissolved selenium concentrations (filtered samples) were higher than total recoverable selenium concentrations (unfiltered samples) measured from the same location (Larry Walker and Associates, 2006). The reason for this is not known and the problem is not limited to a particular analytical method. This problem has been noted in other monitoring programs. . For example, approximately 30% of the more than 800 selenium measurements made by the San Francisco Bay Regional Monitoring Program show total dissolved selenium concentrations that are more than the matching total recoverable selenium concentrations (Larry Walker and Associates, 2006).

Table 5-5. CTR Criteria for Selenium

Freshwater		Saltwater	
Criterion Maximum Concentration (CMC) *[Acute Criterion]*	Criterion Continuous Concentration (CCC) *[Chronic Criterion]*	Criterion Maximum Concentration (CMC) *[Acute Criterion]*	Criterion Continuous Concentration (CCC) *[Chronic Criterion]*
µg/L			
Reserved[3]	5.0[1]	290	71[2]

[1] Expressed as total recoverable selenium
[2] Expressed as total dissolved selenium
[3] Per USFWS recommendation, USEPA agreed to reserve the acute freshwater aquatic life criterion in the final CTR for determination at a later date.

5.3.2.2 Pollutant Concentrations in Fish Tissue (Section 3.5 of the Policy).
A finding of impairment is made for any pollutant-water body combination in which tissue pollutant concentrations exceed an appropriate evaluation guideline and where the minimum number of exceedances is met using a binomial distribution. In this assessment, pollutant concentrations in fish fillet samples were compared to the 2008 OEHHA fish contaminant goal (FCG) for selenium (Klasing and Brodberg, 2008) for protection of human health, and whole fish tissue concentrations were compared to the middle range of the marginal ecological risk guidelines (Presser et al., 2004) for protection of aquatic life and aquatic-dependent wildlife (Table 5-4). The OEHHA selenium FCG was not used for evaluation of shellfish tissue data because the FCG was developed using sport fish muscle tissue concentrations (fillets). There are no National Academy of Sciences (NAS, 1972) guidelines for selenium in fish tissue or shellfish for the protection of aquatic life.

Table 5-6

Fish Tissue Concentrations Used to Assess Impairment Due to Selenium		
Human Health[1]		Ecological Risk[2]
(8 ounce fillet per week/32 grams per day)		(whole body)
7.4 µg/g wet wt.	30 µg/g dry wt.[3]	5 µg/g dry wt.

[1] Klasing and Brodberg, 2008
[2] Presser et al., 2004
[3] Dry weight conversion made by assuming an average moisture content of 75%.

5.3.2.3 Pollutant Concentrations in Bird Egg Tissue (Section 3.5 of the Policy).
A finding of impairment is made for any pollutant-water body combination in which tissue pollutant concentrations exceed an appropriate evaluation guideline and where the minimum number of exceedances is met using a binomial test. In

this assessment, pollutant concentrations in bird egg tissue samples and turtle eggs (one location only – opportunistic samples from the San Joaquin Marsh Freshwater Reserve Phase I pond area) were compared to the marginal ecological risk guidelines (Presser et al., 2004) for protection of aquatic life and aquatic-dependent life (Table 5-4). While the egg tissue concentrations in Presser et al. 2004 are for comparison to birds, since there are little data for selenium effects in reptiles, it was determined that comparison of the turtle egg tissue data to the bird egg guidelines was appropriate (J. Skorupa, USFWS, electronic mail communication, March 6, 2008). However, while the middle of the marginal ecological risk range (8 µg/g dw) was selected for comparison to bird egg tissue selenium concentrations, the lower end of the range (6 µg/g dw) was selected for comparison to the turtle eggs due to the lack of data on selenium effects in reptiles. The decision to include these turtle eggs in the impairment assessment was due to concerns about selenium effects on the State-listed Western pond turtle, which is present within the San Joaquin Freshwater Marsh Reserve. The Western pond turtle is a Federal and State Species of Concern. The eggs are from the invasive Red-eared slider turtle (*Trachemys scripta elegans*), which has a dietary requirements similar to the Western pond turtle.

Table 5.-7 summarizes the guidelines used in this impairment assessment. Note however, that sediment and dietary guidelines are not included for the reasons explained previously (Section 5.3.2).

Table 5-7

GUIDELINES USED TO ASSESS IMPAIRMENT DUE TO SELENIUM IN THE NEWPORT BAY WATERSHED

Media	CTR Ambient Water Quality Chronic Criteria		Human Health[1]	Ecological Risk [2]
	Freshwater	Saltwater		
Water (µg/L)	5	71		
Fish tissue (µg/g dry weight)			30[a]	5
Egg tissue (µg/g dry weight)				8

Note: tissue guidelines are dry weight values

[1] Klasing and Brodberg, 2008

[2] Presser et al., 2004

[a] OEHHA Fish Contaminant Goal (FCG) of 7400 µg/kg (ppb) Se wet weight at a consumption rate of 32 g/day converted to a dry weight basis by using an average fish tissue moisture content of 75%.

5.3.3 Limitations of Impairment Assessment

The Listing Policy outlines methodology to evaluate impairment through direct effects of a given pollutant in a particular water body. These effects can be related to human health risk from consumption of contaminated fish, or to aquatic life or aquatic-dependent wildlife risk resulting in direct effects on aquatic organisms and/or the wildlife that feed on those organisms. Selenium is generally not considered to cause acute toxicity to aquatic organisms at the concentrations currently found in the Newport Bay watershed. Instead, chronic adverse effects to biota may be caused through bioaccumulation in the food web of sensitive species (e.g., bioaccumulations of selenium in bird eggs can result in reduced hatching success or deformities). The guidelines used in this impairment assessment take into account these potential adverse effects by linking these effects to selenium tissue concentrations in fish tissue and bird eggs.

5.3.4 Results

The following pages summarize data collected from 2000 to 2008 for selenium in water, fish tissue, and bird eggs collected from San Diego Creek, Peters Canyon Wash, Santa Ana Delhi Channel, Big Canyon Wash, Upper Newport Bay, and Lower Newport Bay (and channels tributary to these waterbodies) and quantify exceedances of applicable guidelines. Bird eggs were not found in the Santa Ana Delhi Channel, Peters Canyon Wash, Big Canyon Wash, or channels tributary to San Diego Creek or Peters Canyon Wash (e.g. Lane Channel). Suitable habitat for nesting is not available in the Delhi Channel or the tributary channels; limited potential nesting habitat is available in Peters Canyon Wash but no nests were found during monitoring. Suitable habitat for nesting is available in Big Canyon Wash but no nesting birds were observed during the baseline monitoring conducted in June 2008. This may have been a result of the lateness of the monitoring in the nesting season (which usually starts in March/April) or due to disturbance from the mosquito abatement procedures being used by the Orange County Vector Control District in the freshwater marsh ponds. Fish tissue fillet composites are composed of a minimum of 2 fillets, while whole body fish tissue composites are composed of a minimum of 3 fish. The smallest fish in any composite is 75% of the size of the largest fish. The results of these analyses are summarized in Table 5-8.

I. UPPER PETERS CANYON WASH (Upstream of Bryan Avenue)

1. Water Column Concentrations

(a) Thirty-seven samples (n=37) with collection dates ranging from 2002-2006 from various locations in Upper Peters Canyon Wash. Samples collected by County of Orange (2006-2008); Meixner et al., 2004 (2002-2003); CH2MHill (one sample in 2006). 2/37 exceedances compared to the CTR freshwater chronic criterion for selenium (5 µg/L).

2. Fish Tissue Concentrations – No data available.

3. Egg Tissue Concentrations – No data available.

Sample Type	**Upper Peters Canyon Wash - Number of Exceedances/Total Samples**			
	CTR Freshwater Chronic Criterion (>5 µg/L)	**Human Health FCG (>30 µg/g dw)**	**Ecological Risk – Fish Tissue (>5 µg/g dw)**	**Ecological Risk – Bird Egg Tissue (>8 µg/g dw)**
Water column	2/37	--	--	--
Fish fillets	--	No Data	--	--
Whole body fish tissue	--	--	No Data	--
Bird egg tissue	--	--	--	No Data

II. LOWER PETERS CANYON WASH (Downstream of Bryan Avenue)

1. Water Column Concentrations

(a) One hundred ninety-one samples (n=191) were collected from 2002-2008 from various locations in Lower Peters Canyon Wash by County of Orange (2002-2008); Meixner et al., 2004 (2002-2004); Hibbs et al. 2008 (2005); CH2MHill (one sample in 2006 and one in 2007). There were155/191 exceedances compared to the CTR freshwater chronic criterion for selenium (5 µg/L).

2. Fish Tissue Concentrations

(a) Human Health – No data available.

(b) Ecological Risk – Six samples (n=6) with collection dates ranging from 2002-2006, at several sampling locations Lower Peters Canyon Wash Tissue were collected by Horne et al. 2006 (2002-2004); CDFG (2006). They include tissue composites of fathead minnow, mosquitofish, red shiner; number of fish per composite is more than 3 individuals. There were 6/6 exceedances compared to the middle range of the 2004 marginal ecological risk guidelines for selenium (5 µg/g dry weight).

3. Egg Tissue Concentrations – No data available.

Sample Type	**Lower Peters Canyon Wash - Number of Exceedances/Total Samples**			
	CTR Freshwater Chronic Criterion (>5 µg/L)	**Human Health FCG (>30 µg/g dw)**	**Ecological Risk – Fish Tissue (>5 µg/g dw)**	**Ecological Risk – Bird Egg Tissue (>8 µg/g dw)**
Water column	155/191	--	--	--
Fish fillets	--	No Data	--	--
Whole body fish tissue	--	--	6/6	--
Bird egg tissue	--	--	--	No Data

III. SAN DIEGO CREEK REACH 2

1. Water Column Concentrations

(a) Forty-nine samples (n= 49) with collection dates ranging from 2002-2006 from various locations in San Diego Creek Reach 2 were collected by County of Orange (2006); Meixner et al., 2004 (2002-2004); Hibbs et al. 2008 (2004-2005); CH2MHill (one sample in 2006). There were 3/49 exceedances compared to the CTR freshwater chronic criterion for selenium (5 µg/L).

2. Fish Tissue Concentrations – No data available.

3. Egg Tissue Concentrations – No data available.

Sample Type	**San Diego Creek Reach 2 - Number of Exceedances/Total Samples**			
	CTR Freshwater Chronic Criterion (>5 µg/L)	**Human Health FCG (>30 µg/g dw)**	**Ecological Risk – Fish Tissue (>5 µg/g dw)**	**Ecological Risk – Bird Egg Tissue (>8 µg/g dw)**
Water column	3/49	--	--	--
Fish fillets	--	No Data	--	--
Whole body fish tissue	--	--	No Data	--
Bird egg tissue	--	--	--	No Data

IV. SAN DIEGO CREEK REACH 1

1. Water Column Concentrations

(a) Four hundred eighty-five samples (n= 485) with collection dates ranging from 2001-2008 from various locations in San Diego Creek Reach 1 were collected by County of Orange (2001-2008); Meixner et al., 2004 (2002-2004); Hibbs 2008 (2006); CH2MHill (2006-2007). There were 347/485 exceedances compared to the CTR freshwater chronic criterion for selenium (5 µg/L).

2. Fish Tissue Concentrations

(b) Human Health – Thirteen samples (n=13) were collected, including one white catfish fillet collected by Regional Board staff in 2003 and 12 carp fillets collected by CH2MHill in 2007 from San Diego Creek Basin No. 2. There were no (0/13) exceedances compared to OEHHA Fish Contaminant Goal (FCG) for selenium of 30 µg/g dry weight (7.4 µg/g wet weight).

(c) Ecological Risk – Eighteen samples (n=18) with collection dates ranging from 2003-2006, at various locations in San Diego Creek Reach 1 were collected by Regional Board staff (2003), IRWD (2004), CDFG (2006-2007), and CH2MHill (2004-2006). The samples included tissue composites (each species was composited separately) of bluegill, black crappie, catfish, common carp, fathead minnow, largemouth bass, red shiners; number of fish per composite ranges from 3 to 160 individuals. There were16/18 exceedances compared to the middle range of the 2004 marginal ecological risk guidelines for selenium (5 µg/g dry weight).

3. Egg Tissue Concentrations

(a) Ecological Risk – Eighteen samples (n=18) were collected from 2004-2006 by CH2MHill at two sampling locations in San Diego Creek. They include individual bird eggs of American avocet, black-necked stilt, killdeer, and pied-billed grebe. There were 4/18 exceedances compared to the middle range of the 2004 marginal ecological risk guidelines for selenium (8 µg/g dry weight).

Sample Type	**San Diego Creek Reach 1 - Number of Exceedances/Total Samples**			
	CTR Freshwater Chronic Criterion (>5 µg/L)	**Human Health FCG (>30 µg/g dw)**	**Ecological Risk – Fish Tissue (>5 µg/g dw)**	**Ecological Risk – Bird Egg Tissue (>8 µg/g dw)**
Water column	347/485	--	--	--
Fish fillets	--	0/13	--	--
Whole body fish tissue	--	--	16/18	--
Bird egg tissue	--	--	--	4/18

V. IRVINE RANCH WATER DISTRICT TREATMENT WETLANDS

1. Water Column Concentrations

(a) One hundred and six samples (n=106) were collected from 2003-2007 from various locations in the IRWD wetlands by Horne et al. 2006 (data from 2003-2005); Hibbs et al. 2008 (data from 2004-2007). There were 92/106 exceedances compared to the CTR freshwater chronic criterion for selenium (5 µg/L).

2. Fish Tissue Concentrations

(a) Human Health – No data available.

(b) Ecological Risk – Eleven samples (n=11) were collected in 2003-2005 from the ponds and riparian areas within the IRWD wetlands by Horne et al. 2006 (2003) and CH2MHill (2004 -2005). They were tissue composites of mosquitofish; number of fish per composite ranges is 3 or more individuals. There were 7/11 exceedances compared to the middle range of the 2004 marginal ecological risk guidelines for selenium (5 µg/g dry weight).

3. Egg Tissue Concentrations

(a) Ecological Risk – Fifteen samples (n=15) were collected in 2003 from various locations in the IRWD wetlands by Byard (2003) and CH2MHill (2005-2006). Samples included individual bird eggs of American avocet, black-necked stilt, killdeer, and mallard. There were 3/15 exceedances compared to the middle range of the 2004 marginal ecological risk guidelines for selenium (8 µg/g dry weight).

Sample Type	**IRWD Treatment Wetlands - Number of Exceedances/Total Samples**			
	CTR Freshwater Chronic Criterion (>5 µg/L)	**Human Health FCG (>30 µg/g dw)**	**Ecological Risk – Fish Tissue (>5 µg/g dw)**	**Ecological Risk – Egg Tissue (>8 µg/g dw)**
Water column	92/106	--	--	--
Fish fillets	--	No data	--	--
Whole body fish tissue	--	--	7/11	--
Bird egg tissue				3/15

VI. SAN JOAQUIN FRESHWATER MARSH RESERVE

1. Water Column Concentrations

(a) Seven samples (n=7) with collection dates ranging from 2003-2007 from various locations in the San Joaquin marsh. Samples collected by Meixner et al., 2004 (2003); CH2MHill (2006-2007). 1/7 exceedances compared to the CTR freshwater chronic criterion for selenium (5 µg/L).

2. Fish Tissue Concentrations

(a) Human Health – No data available.

(b) Ecological Risk – Two samples (n=2) with collection dates in 2005 and 2006, in the Phase I ponds in the San Joaquin marsh. Tissue samples collected by CH2MHill (2005 and

2006). Tissue composites of mosquitofish; minimum of 3 individual fish per composite. 2/2 exceedances compared to the middle range of the 2004 marginal ecological risk guidelines for selenium (5 µg/g dry weight).

3. Egg Tissue Concentrations

(a) Ecological Risk to Birds – Nineteen samples (n=19) with collection dates ranging from 2005-2006 sampled from areas adjacent to the Phase I ponds. Individual bird eggs of American avocet, black-necked stilt, pied-billed grebe. Samples collected by CH2MHill (2005-2006). 2/19 exceedances compared to the middle range of the 2004 marginal ecological risk guidelines for selenium (8 µg/g dry weight).

(b) Ecological Risk to Turtles – Six samples (n=6) collected by CH2MHill in 2005 from areas adjacent to the Phase I ponds. Individual eggs of red-eared slider turtles. 0/6 exceedances compared to the 2004 lower end of the marginal ecological risk guidelines for selenium (6 µg/g dry weight).

Sample Type	**San Joaquin Marsh Reserve - Number of Exceedances/Total Samples**				
	CTR Freshwater Chronic Criterion (>5 µg/L)	**Human Health FCG (>30 µg/g dw)**	**Ecological Risk Fish Tissue (>5 µg/g dw)**	**Ecological Risk Egg Tissue (>6 µg/g dw)**	**Ecological Risk Egg Tissue (>8 µg/g dw)**
Water column	1/7	--	--		--
Fish fillets	--	No data	--		--
Whole body fish tissue	--	--	2/2		--
Bird egg tissue					2/19
Turtle egg tissue	--	--	--	0/6	--

VII. SANTA ANA DELHI CHANNEL

1. Water Column Concentrations

(a) One hundred nineteen samples (n=119) collected from 2002-2008 from several locations in the Santa Ana Delhi Channel. Orange County NPDES monitoring results from 2002-2008; Meixner et al. 2004 (data from 2002-2004); Hibbs et al. 2008 (data from 2004-2005); CH2MHill (two sampling events, one in 2006 and one in 2007). 99/119 exceedances of the CTR chronic criterion for selenium (5 µg/L).

2. Fish Tissue Concentrations – No data available.

3. Egg Tissue Concentrations – No data available.

Sample Type	**Santa Ana Delhi Channel - Number of Exceedances/Total Samples**			
	CTR Freshwater Chronic Criterion (>5 µg/L)	**Human Health FCG (>30 µg/g dw)**	**Ecological Risk – Fish Tissue (>5 µg/g dw)**	**Ecological Risk – Bird Egg Tissue (>8 µg/g dw)**
Water column	99/119	--	--	--
Fish fillets	--	No Data	--	--
Whole body fish tissue	--	--	No Data	--
Bird egg tissue	--	--	--	No Data

VIII. BIG CANYON WASH

1. Water Column Concentrations

(a) Twenty-five samples (n=25) collected from 2005-2008 from several locations in the Big Canyon Nature Park, downstream of Jamboree Road, and one location at in Big Canyon Creek at MacArthur Boulevard. Orange County NPDES monitoring results from 2005-2008; Weston Solutions monitoring data from 2007-2008; CH2MHill baseline monitoring data results from 2008. 24/25 exceedances of the CTR chronic criterion for selenium (5 µg/L).

2. Fish Tissue Concentrations

(a) Human Health – No data available

(b) Ecological Risk – Four (n=4) whole body fish tissue composites from two locations within the nature park. Two mosquitofish composites composed of 3 or more individual whole fish collected from the freshwater marsh pond near the mouth of the canyon; one mosquitofish composite and one fathead minnow composite collected from the riparian creek area located in the upper part of the nature park, downstream from Jamboree Road. Samples collected by CH2MHill (2008). 4/4 exceedances compared to the middle range of the 2004 marginal ecological risk guidelines for selenium (5 µg/g dry weight).

3. Egg Tissue Concentrations – No data available.

Sample Type	Big Canyon Wash - Number of Exceedances/Total Samples			
	CTR Freshwater Chronic Criterion (>5 µg/L)	Human Health FCG (>30 µg/g dw)	Ecological Risk – Fish Tissue (>5 µg/g dw)	Ecological Risk – Bird Egg Tissue (>8 µg/g dw)
Water column	24/25	--	--	--
Fish fillets	--	No Data	--	--
Whole body fish tissue	--	--	4/4	--
Bird egg tissue	--	--	--	No Data

IX. UPPER NEWPORT BAY

1. Water Column Concentrations

(a) Forty-two samples (n= 42) with collection dates ranging from 2004-2007 from various locations in Upper Newport Bay. Samples collected by Horne et al. 2006 (one sample in 2004); City of Newport Beach (2006); Hibbs et al. 2008 (2006); CH2MHill (2007). 0/42 exceedances compared to the CTR saltwater chronic criterion for selenium (71 µg/L).

2. Fish Tissue Concentrations

(a) Human Health – Fifteen samples (n=15) available. Fish muscle tissue (fillets) of black perch, California halibut, diamond turbot, jacksmelt, shiner perch, spotted sandbass, spotted turbot collected by Allen et al. (2004) in winter 2000-2001 and summer 2001. 0/15 exceedances compared to OEHHA Fish Contaminant Goal (FCG) for selenium of 30 µg/g dry weight (7.4 µg/g wet weight).

(b) Ecological Risk – Sixty-two samples (n=62) with collection dates ranging from 2002-2006, at various locations in Upper Newport Bay. Whole body tissue samples collected by Allen et al. 2004 (2002); CH2MHill (2004-2005); SCCWRP (2005-2006); CDFG (2006). Tissue composites of arrow goby, black perch, California killifish, California halibut, cheekspot goby, deepbody anchovy, diamond turbot, Pacific staghorn sculpin, pile surfperch, shiner perch, striped mullet, topsmelt; number of fish per composite ranges from 4 to 620 individuals. 11/62 exceedances compared to the middle range of the 2004 marginal ecological risk guidelines for selenium (5 µg/g dry weight).

3. Egg Tissue Concentrations

(a) Ecological Risk – Sixty-two samples (n=62) with collection dates ranging from 2003-2006, at several locations in Upper Newport Bay. Individual bird eggs of American avocet, black-necked stilt, black skimmer, California light-footed clapper rail (fail-to-hatch eggs only), killdeer, Forster's tern. Clapper rail samples from Sutula et al. 2005 (2003-2004); all other bird eggs collected by CH2MHill (2004-2006). 4/62 exceedances compared to the middle range of the 2004 marginal ecological risk guidelines for selenium (8 µg/g dry weight).

Sample Type	Upper Newport Bay - Number of Exceedances/Total Samples			
	CTR Saltwater Chronic Criterion (>71 µg/L)	**Human Health FCG (>30 µg/g dw)**	**Ecological Risk – Fish Tissue (>5 µg/g dw)**	**Ecological Risk – Bird Egg Tissue (>8 µg/g dw)**
Water column	0/42	--	--	--
Fish fillets	--	0/15	--	--
Whole body fish tissue	--	--	11/62	--
Bird egg tissue	--	--	--	4/62

X. LOWER NEWPORT BAY

1. Water Column Concentrations

(a) Ninety-six samples (n= 96) with collection dates ranging from 2004-2007 from various locations in Lower Newport Bay. Samples collected by City of Newport Beach (2006); CH2MHill (2007). 0/96 exceedances compared to the CTR saltwater chronic criterion for selenium (71 µg/L).

2. Fish Tissue Concentrations

(a) Human Health – Thirty-five samples (n=35) available. Fish muscle tissue (fillets) of barred sand bass, black perch, California corbina, California halibut, C-O sole, diamond turbot, fantail sole, kelp bass, spotfin croaker, spotted sandbass, spotted turbot, yellowfin croaker, collected by Allen et al. (2004) in winter 2000-2001 and summer 2001. 0/35 exceedances compared to OEHHA Fish Contaminant Goal (FCG) for selenium of 30 µg/g dry weight (7.4 µg/g wet weight).

(b) Ecological Risk – Fifty-three samples (n=53) with collection dates ranging from 2002-2006, at various locations in Lower Newport Bay. Whole body tissue samples collected by Allen et al. 2004 (2002); CH2MHill (2004-2005); SCCWRP (2005-2006); CDFG (2006). Tissue composites of arrow goby, black perch, barred sandbass, California killifish, California halibut, cheekspot goby, diamond turbot, Pacific staghorn sculpin, shiner perch, topsmelt; number of fish per composite ranges from 4 to 500 individuals. 0/53 exceedances compared to the middle range of the 2004 marginal ecological risk guidelines for selenium (5 µg/g dry weight).

3. Egg Tissue Concentrations – No data available.

Sample Type	Lower Newport Bay - Number of Exceedances/Total Samples			
	CTR Saltwater Chronic Criterion (>71 µg/L)	**Human Health FCG (>30 µg/g dw)**	**Ecological Risk – Fish Tissue (>5 µg/g dw)**	**Ecological Risk – Bird Egg Tissue (>8 µg/g dw)**
Water column	0/96	--	--	--
Fish fillets	--	0/35	--	--
Whole body fish tissue	--	--	0/53	--
Bird egg tissue	--	--	--	No data

XI. Drainages Tributary to Peters Canyon Wash

1. Central Irvine Channel
   One line of evidence: Meixner et al. 2004 water column data. Fifteen samples (n=15) collected from 2002-2004. 10/15 exceedances of the CTR freshwater chronic criterion for selenium (5 µg/L).

2. El Modena – Irvine Channel
   One line of evidence: Meixner et al. 2004 water column data. Thirty-one samples (n=31) collected from 2002-2004. 6/31 exceedances of the CTR freshwater chronic criterion for selenium (5 µg/L).

3. Como Storm Channel
   One line of evidence: Meixner et al. 2004 water column data. Twenty-one samples (n=21) collected from 2002-2004. 19/21 exceedances of the CTR freshwater chronic criterion for selenium (5 µg/L).

4. Santa Ana – Santa Fe Channel
   Two lines of evidence: (1) Meixner et al. 2004 water column data. Nineteen samples (n=19) collected from 2002-2004. 18/19 exceedances of the CTR freshwater chronic criterion for selenium (5µg/L). (2) Horne et al. 2006 fish tissue data. One composite whole body fish tissue sample (3 or more fish per composite) of mosquitofish collected in 2002. 1/1 exceedance compared to 2004 marginal ecological risk guideline for selenium in fish tissue (5 µg/g dry weight).

5. Warner Channel
   One line of evidence: County of Orange NPDES monitoring results (2005). Thirty-six samples (n=36) collected in 2004. 36/36 exceedances of the CTR freshwater chronic criterion for selenium (5 µg/L).

6. Barranca Channel
   One line of evidence: Meixner et al. 2004 water column data from 2002-2003; CH2MHill water column data – one sample collected in 2007. Twenty-three samples (n=23) collected from 2002-2004. 2/23

exceedances of the CTR freshwater chronic criterion for selenium (5 µg/L).

XII. Drainages Tributary to San Diego Creek Reach 2

1. Agua Chinon
One line of evidence: County of Orange NPDES monitoring results (2007). Fourteen samples (n=14) collected in 2005-2006. 0/14 exceedances of the CTR freshwater chronic criterion for selenium (5 µg/L).

2. Hicks Canyon Wash
One line of evidence: Meixner et al. 2004 data (samples collected in 2002-2003) and County of Orange NPDES monitoring results (samples collected in 2004-2005). Forty-eight samples (n=48) collected in 2002-2005. 2/48 exceedances of the CTR freshwater chronic criterion for selenium (5 µg/L).

XIII. Drainages Tributary to San Diego Creek Reach 1

1. Lane Channel
One line of evidence: Meixner et al. 2004 water column data (2002-2003); County of Orange NPDES monitoring results (2002-2007); CH2MHill water column data (one sample collected in 2007). Fifty-nine samples (n=59) collected from 2002-2007. 46/59 exceedances of the CTR freshwater chronic criterion for selenium (5 µg/L).

2. San Joaquin Channel
One line of evidence: Water column data from Meixner et al. 2004 collected in 2002-2003 and County of Orange NPDES monitoring results collected in 2005 and 2006. Fifty-three samples (n=52) collected from 2002-2006. 2/53 exceedances of the CTR freshwater chronic criterion for selenium (5 µg/L).

3. Sand Canyon Channel
One line of evidence: Water column data from Meixner et al. 2004 collected in 2002-2003 and County of Orange NPDES monitoring results collected in 2008. Eight samples (n=8) collected from 2002-2008. 0/8 exceedances of the CTR freshwater chronic criterion for selenium (5 µg/L).

4. Bonita Channel
One line of evidence: Meixner et al. (2004) water column data collected in 2002 and 2003 and County of Orange NPDES monitoring results collected in 2004-2008. Forty-seven samples

(n=47) collected from 2002-2003. 2/47 exceedances of the CTR freshwater chronic criterion for selenium (5 µg/L).

XIV. Drainages Tributary to Upper Newport Bay

1. San Diego Creek (see sections III and IV)

2. Santa Ana Delhi Channel (see section VII)

3. Big Canyon Wash (see section VIII)

4. Santa Isabel Channel
One line of evidence: County of Orange NPDES monitoring results. Twenty-four samples (n=24) collected from 2002-2003. 2/24 exceedances of the CTR freshwater chronic criterion for selenium (5 µg/L).

5. Costa Mesa Channel
One line of evidence: County of Orange NPDES monitoring results. Three hundred fifty-three samples (n=353) collected from 2001-2008. 2/353 exceedances of the CTR freshwater chronic criterion for selenium (5 µg/L).

Table 5-8 Summary of Impairment Assessment

Watershed Subarea	Summary of Exceedance Frequencies Used to Determine Impairment				Impaired?[4]
	# of exceedances (total samples)				**Yes**/No
	Water	Fish Fillets[1]	Whole Body Fish Tissue[2]	Bird Egg Tissue[3]	
Freshwater Channels & Tributary Drainages					
Upper Peters Cyn Wash	2(37)	NA	NA	NA	No
Agua Chinon	0(14)	NA	NA	NA	No
Hicks Canyon Wash	2(48)	NA	NA	NA	No
Lower Peters Cyn Wash	155(191)	NA	6(6)	NA	**Yes**
Central Irvine Channel	10(15)	NA	NA	NA	**Yes**
El Modena-Irvine Channel	6(31)	NA	NA	NA	**Yes**
Como Storm Channel	19(21)	NA	NA	NA	**Yes**
Santa Ana-Santa Fe Ch.	18(19)	NA	1(1)	NA	**Yes**
Warner Channel	36(36)	NA	NA	NA	**Yes**
Barranca Channel	2(23)	NA	NA	NA	**Yes**
San Diego Creek Reach 2	3(49)	NA	NA	NA	No
San Diego Creek Reach 1	347(483)	0(13)	16(18)	4(18)	**Yes**
Lane Channel	46(59)	NA	NA	NA	**Yes**
San Joaquin Channel	2(53)	NA	NA	NA	No
Sand Canyon Channel	0(8)	NA	NA	NA	No
Bonita Channel	2(47)	NA	NA	NA	No
Santa Ana Delhi Channel	122(148)	NA	NA	NA	**Yes**
Big Canyon Wash	24(25)	NA	4(4)	NA	**Yes**
Santa Isabel Channel	2(24)	NA	NA	NA	**Yes**
Costa Mesa Channel	2(353)	NA	NA	NA	No
Freshwater Wetlands					
IRWD Treatment Wetlands	92(106)	NA	7(11)	3(15)	**Yes**
San Joaquin Freshwater Marsh	1(7)	NA	2(2)	2(19)	**Yes**
Saltwater Estuarine					
Upper Newport Bay	0(42)	0(15)	11(62)	4(62)	**Yes**
Lower Newport Bay	0(96)	0(35)	0(53)	NA	No

[1] Fish fillet samples are composites of 2 or more fillets

[2] Whole body fish tissue samples are composite samples of at least 3 or more fish

[3] Bird egg tissue samples are individual eggs, no shells

[4] A finding of impairment indicates that a TMDL will be necessary for that waterbody.

NA No Samples Available

Screening values:

freshwater[a]	5 µg Se/L
saltwater[a]	71 µg Se/L
fish fillets[b]	30 µg Se/g dry weight fillet for human health risk
fish tissue[c]	5 µg Se/g dry weight whole body fish for aquatic life risk
bird egg tissue[c]	8 µg Se/g dry weight egg contents for risk to birds

[a] CTR chronic criteria [c] Presser et al., 2004

[b] OEHHA Fish Contaminant Goal (FCG) of 7400 µg/kg (ppb) Se wet weight at a consumption rate of 32 g/day converted to a dry weight basis by using an average fish tissue moisture content of 75%

5.3.5 Discussion

In all, twelve (12) freshwater drainages, three (3) freshwater wetlands, and Upper Newport Bay were found to be impaired due to selenium, thereby requiring the development of TMDLs. (Table 5.3-7). For fish, impairment due to ecological risk only was found for selenium; none of the fish fillets collected in San Diego Creek or Newport Bay were found to exceed the human health screening value (OEHHA's FCG for selenium). All of the freshwater drainages and the IRWD wetlands were found to be impaired due to selenium concentrations exceeding the CTR freshwater chronic criterion of 5 µg Se/L. Selenium concentrations in Upper and Lower Newport Bay did not exceed the CTR saltwater chronic criterion of 71 µg Se/L. Lower Peters Canyon Wash, Big Canyon Wash and the Santa Ana – Santa Fe Channel were also found to be impaired due to selenium accumulation in fish tissue (exceeding the middle of the range of marginal ecological risk guidelines from Presser et al. 2004 of 5 µg Se/g dw); San Diego Creek Reach 1 and the IRWD wetlands were found to be impaired due to selenium in water, fish and bird egg tissue (exceeding the middle of the range of the marginal ecological risk guidelines of 8 µg Se/g dry weight for egg tissue); the San Joaquin Freshwater Marsh Reserve (UCI wetlands) was found to be impaired due to selenium accumulations in fish and bird egg tissue; Upper Newport Bay was found to be impaired due to selenium accumulations in fish only.

Table 5-9 Summary of Waterbodies Impaired Due to Selenium Requiring TMDLs

Freshwater Drainages	Freshwater Wetlands	Saltwater-Estuarine
Lower Peters Canyon Wash	IRWD Treatment Wetlands	Upper Newport Bay
Central Irvine Channel	San Joaquin Freshwater Marsh Reserve	
El Modena-Irvine Channel	Big Canyon Nature Park Freshwater Wetlands	
Como Storm Channel		
Santa Ana-Santa Fe Channel		
Warner Channel		
Barranca Channel		
San Diego Creek Reach 1		
Lane Channel		
Santa Isabel Channel		
Santa Ana Delhi Channel		
Big Canyon Wash		

The San Joaquin Freshwater Marsh Reserve was not found to be impaired due to selenium concentrations in turtle eggs. The turtle eggs sampled were from red-eared slider turtles (*Trachemys scripta elegans*), an invasive species in California, not Western pond turtles (*Clemmys marmorata*), a California native species of concern. However, both species of turtles have similar diets and the red-eared slider eggs are considered to be an adequate surrogate for the Western pond turtle. Therefore, it does not appear, based on the information currently available, that the Western pond turtle is at risk from selenium in the San Joaquin Freshwater Marsh Reserve. The Western pond turtle may also be present in Big Canyon Wash. However, no pond turtles have been found in this drainage to date. While turtle eggs or bird eggs have not yet been collected from Big Canyon Wash, the high concentrations of selenium in sediment, algae, invertebrates, and fish in this watershed warrant additional investigations to determine if birds and/or turtles living and feeding in the creek and ponds in the canyon are at risk from selenium.

The majority of the freshwater bodies that were found to be impaired by selenium fall within the boundaries of the Swamp of the Frogs, whose soils are suspected of being the primary source of selenium in the San Diego Creek watershed (see discussion under Section 3.5.1). There are two exceptions to this: Santa Isabel Channel and Big Canyon Wash.

The Santa Isabel channel drains a very small area (less than 2 square miles) and is tributary to the western side of Upper Newport Bay. The Santa Isabel Channel lies outside of the influence of the Swamp of the Frogs and is not part of the San Diego Creek subwatershed. The median ambient water column selenium concentration is 2 µg Se/L, below the CTR freshwater criterion of 5 µg Se//L. A finding of impairment for this channel was made based on the minimum dataset required to determine impairment (2 of 24 samples equaled or exceeded the CTR freshwater chronic criterion). Given the small drainage area of this channel, its generally low selenium concentrations, and lack of suitable habitat for birds, it likely poses little ecological risk to fish or birds and it is not a significant source of selenium to Upper Newport Bay.

Big Canyon Wash is tributary to Upper Newport Bay. The Big Canyon Nature Park, located in the lower part of the canyon, contains a freshwater marsh and ponds and a flowing creek and riparian area. High selenium concentrations have been measured in water, sediment, algae, invertebrates, and fish throughout the nature park. Bird eggs have not yet been sampled. The high selenium concentrations in Big Canyon Wash are suspected to be the result of selenium-containing minerals in the Monterey Formation which underlies much of the canyon and adjacent areas, and hydromodification in the watershed that has resulted in a shallow perched groundwater aquifer in the upper part of the canyon and perennial flows in the creek (see Section 3.5.2 of this report). The sources of selenium in Big Canyon Wash are still being investigated.

5.3.6 Alternative Methodologies to Impairment Assessment
Several other methods to determine impairment due to selenium in the Newport Bay watershed were considered. Regional Water Board staff could have elected to use State Water Board staff's assessment for the 2006 303(d) list of impaired waterbodies. However, State Water Board staff's impairment assessment was based on very limited data (7 data points), compared water column selenium concentrations to the CTR freshwater chronic criterion only, and did not include any biological information. Regional Water Board staff's impairment assessment considered a very large amount of water column data, including data for the main freshwater drainages as well as their smaller, tributary drainages, and included biological selenium data for several areas in the watershed, including freshwater marshes, a type of hydrologic unit considered most

at risk for selenium accumulation (Lemly, 1998). Since selenium accumulates primarily through the food web, inclusion of biological data in the impairment assessment is considered essential.

Regional Water Board staff could also have elected to consider only fish tissue selenium concentrations, not bird egg tissue. This process would be similar to that followed by USEPA in their development of their revised CWA Section 304(a) aquatic life criteria for selenium. However, this methodology does not consider selenium effects in aquatic-dependent wildlife, such as birds. USEPA Region 9's agreement with the USFWS to revise the CTR selenium criteria requires that both effects to aquatic life and aquatic-dependent wildlife be considered (Spear and McInnis, 2000).

Regional Water Board staff could have used different guidelines for the assessment of selenium effects in fish and wildlife. For example, Regional Water Board staff could have compared fish tissue selenium concentrations to USEPA's 2004 draft 304(a) aquatic criterion of 7.91 µg Se/g dry weight in whole body fish tissue (http://www.epa.gov/seleniumcriteria/pdf/complete.pdf) or used the upper range of the marginal ecological risk guidelines of Presser et al. 2004 for both fish and bird egg tissue. Both approaches have their flaws, however. USEPA's 2004 draft fish tissue criterion does not address potential selenium effects in wildlife. The upper ranges of the marginal ecological risk guidelines for selenium in fish and bird egg tissue (Presser et al., 2004) are also the boundaries between marginal and substantive ecological effects (6 µg Se/g dw for fish tissue and 10 µg/g dw for bird egg tissue). Use of these upper range values for assessment purposes might not reflect potential impacts to sensitive species and/or Threatened and Endangered Species (e.g., California Light-footed clapper rail, California Least Tern) present in the watersheds. Dr. Joseph Skorupa, USFWS, is of the opinion that a No Effect Level (NEC) for bird eggs lies within the range of 3-8 µg Se/g dw (Skorupa, electronic communication, October 20, 2008). Selenium concentrations that lie within this range should be protective of sensitive bird species as well as the most sensitive endpoint for selenium effects in birds: impaired hatching success. USEPA and USFWS recently agreed to evaluate recommendations to adopt site-specific objectives for selenium for the San Diego Creek and Newport Bay watershed of 5 µg Se/g dry weight for fish tissue (including fish as a dietary item for birds) and of 8 µg Se/g dry weight for bird egg tissue. These objectives fall within the middle of the marginal ecological risk range; therefore, these recommended site-specific objectives for selenium were also used to assess impairment in the watershed (see full discussion of the selenium SSO process in Section 6.0 of this report).

A fourth option would have been to include dietary items in the impairment assessment. However, for the reasons given previously (Section 5.3.2), the decision was made to assess water quality standards impairment in the watershed based on water column, fish tissue, and egg tissue selenium concentrations.

5.4 Preliminary Assessment of Ecological Risk to Birds and Fish Due to Selenium Concentrations in Diet

Data on selenium concentrations in a variety of potential food items for birds and fish that may be at risk from selenium have been collected from several areas (hydrologic units) in the watershed including, Lower Peters Canyon Wash, San Diego Creek Reach 1, Santa Ana Delhi Channel, Big Canyon Wash, San Joaquin Freshwater Marsh Reserve (UCI wetlands), IRWD's treatment wetlands, and Upper and Lower Newport Bay. Data were collected by Horne et al. 2006 (2005), Allen et al. 2008 (2005-2006), and CH2MHill (2006-2008). Dietary components for four (4) feeding guilds (plant eaters [herbivores]; consumers primarily of invertebrates [invertivores]; consumers primarily of fish [piscivores]; and consumers of a diet composed of more than two of the previous food items: plants, invertebrates or fish [omnivores]) in each of these hydrologic units were compared to the Presser et al. 2004 guideline for the lower end of marginal ecological risk due to selenium bioaccumulation in diet of 3 µg Se/g dry weight. The more conservative lower end of the marginal ecological range was selected instead of the middle of the range (which was used to assess impairment in fish and bird egg tissue) due to the variability in diet among different species of fish and birds, and because not all potential dietary items are represented by the available data. Based on the percent of the total samples in each of these four feeding guilds that exceeded the dietary guideline, a determination was made as to whether or not each feeding guild appeared to be either at a low risk (<20% of the samples exceeded the dietary guideline), moderate risk (20-40% of samples exceeded the dietary guideline), moderate-high risk (40-60% of the samples exceeded the dietary guideline), high risk (60-80% of the samples exceeded the dietary guideline), or very high risk (>80% of the samples exceeded the dietary guideline) due to selenium bioaccumulation.

Table 5-10 summarizes the level of risk due to selenium accumulation in the different feeding guilds for birds and fish. Table 5-11 summarizes the overall risk to birds and fish that feed in one of the hydrologic units (watershed area) where biological data are available for dietary items. Insufficient data are available to determine potential risk from diet for birds and fish feeding in the Santa Ana Delhi Channel. Only two biological samples for this hydrologic unit are available: one composite sample of freshwater clams (which does exceed the dietary guideline) and one of algae (which does not exceed the dietary guideline). While the sample sizes for the San Joaquin Freshwater Marsh Reserve and Big Canyon Wash are generally small, in both cases the majority of potential food items exceeds the dietary guideline for selenium of 3 µg/g dry weight. A potentially very high risk level due to consumption of dietary items was indicated by the samples collected from San Diego Creek Reach 1, San Joaquin Freshwater Marsh Reserve, and Big Canyon Wash. Lower Peters Canyon Wash, the IRWD treatment wetlands, and Upper Newport Bay present a potentially high risk due to selenium in dietary items that may be consumed by fish and birds. Dietary items from Lower Newport Bay are expected to be of moderate risk to bird and fish predators (Table 5-10).

Table 5-10 Summary of Food Webs at Risk Due to Selenium Accumulation

Watershed Subarea	Risk to Birds or Fish from Dietary Items			
(Hydrologic Unit)	% of total samples exceeding dietary guideline of 3 µg Se/g dw[1] compared to the total number of samples			
Feeding Guild	*herbivores*	*omnivores*	*invertivores*	*piscivores*
Lower Peters Cyn Wash	47(32)	65(54)	88(16)	100(6)
San Diego Creek Reach 1	INS	82(39)	94(16)	89(18)
IRWD Treatment Wetlands	25(89)	41(129)	81(26)	73(15)
San Joaquin Marsh Reserve	NA	82(11)	100(3)	100(2)
Santa Ana Delhi Channel	INS	50(2)	INS	NA
Big Canyon Wash	100(4)	100(15)	100(6)	100(4)
Upper Newport Bay	8(13)	68(117)	82(45)	65(62)
Lower Newport Bay	50(4)	40(67)	60(10)	9(53)
Overall Risk to Food Web	*Mod-High*	*High*	*Very High*	*Very High*

[1] Presser et al. 2004

Risk Level	
Low	<20% of samples exceeded the dietary guideline
Moderate	20-40% of samples exceeded the dietary guideline
Moderately High	40-60% of samples exceeded the dietary guideline
High	60-80% of samples exceeded the dietary guideline
Very High	>80% of samples exceeded the dietary guideline

NA No Samples Available

INS Insufficient Samples Available for Assessment

Table 5-11 Summary of Hydrologic Units at Risk Due to Selenium Accumulation in Food Webs

Watershed Subarea	Risk to Birds or Fish from Dietary Items[1]				Risk Level to Hydrologic Unit
	Risk Level Based on Percent of Samples Exceeding Dietary Guideline				
Feeding Guild	*herbivores*	*omnivores*	*invertivores*	*piscivores*	
Lower Peters Cyn Wash	mod-high	high	very high	very high	High
San Diego Creek Reach 1	INS	very high	very high	very high	Very High
IRWD Treatment Wetlands	mod	mod-high	very high	high	High
San Joaquin Marsh Reserve	NA	very high	very high	very high	Very High
Santa Ana Delhi Channel	INS	mod-high	INS	NA	INS
Big Canyon Wash	very high	very high	very high	very high	Very High
Upper Newport Bay	low	high	very high	high	High
Lower Newport Bay	mod-high	mod	mod-high	low	Mod

[1] Risk level based on percent of samples exceeding dietary guideline of 3 µg Se/g dw (Presser et al. 2004) (See Table 3.2-8).

NA No Samples Available

INS Insufficient Samples Available for Assessment

6.0 TECHNICAL AND SCIENTIFIC JUSTIFICATION FOR DEVELOPMENT OF SITE-SPECIFIC OBJECTIVES (SSOS) FOR SELENIUM FOR THE NEWPORT BAY WATERSHED

As a part of the process of considering adoption of selenium site-specific objectives (SSOs), the Regional Water Board must present technical and administrative documentation to support the proposed SSOs in order to meet the requirements in the *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (State Implementation Policy or SIP), amended February 2005. The detailed documentation is presented in Appendix 1A. A summary of the technical and scientific information that was considered in development of the selenium SSOs for the Newport Bay watershed[1] follows.

6.1 Background

Water quality criteria for selenium in California have been established by USEPA in the California Toxics Rule (USEPA, 2000)[2]. These criteria are based on USEPA's *Ambient Water Quality Criteria for Selenium* (USEPA, 1987), which were derived by USEPA using national procedures described in *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (Stephan et al., 1985). The California Toxics Rule (CTR) establishes criteria for the protection of aquatic life from the potentially harmful effects of selenium, as well as for the protection of human consumers of water and organisms.

The 1987 ambient water quality criteria (AWQC) for selenium were developed based on: 1) laboratory-based acute and chronic toxicity tests that examined toxicological responses for a number of species; and, 2) field studies that evaluated the effects of selenium upon aquatic life.

The CTR saltwater chronic and acute selenium criteria were developed solely using laboratory-based methods, similar to the way most other AWQC have been developed. However, the CTR 5 µg/L freshwater chronic criterion for total recoverable selenium was based on field studies conducted at Belews Lake in North Carolina and other locations (see Section 2.1.2). In March of 2000, the USFWS, under consultation with USEPA, completed a biological opinion on the effects of the final promulgation of the CTR upon listed species and critical habitats in California (Spear and McInnis, 2000). The biological

[1] The Newport Bay watershed includes Newport Bay itself (saltwater) and the freshwater creeks and channels tributary to the Bay (San Diego Creek, Santa Ana Delhi Channel, Santa Isabel Channel, Costa Mesa Channel, and Big Canyon Wash.

[2] USEPA promulgated the CTR to fill a gap in California water quality standards that was created in 1994 when a state court overturned the state's water quality control plans, which contained criteria for priority toxic pollutants.

opinion suggested that the CTR criterion of 5 µg/L for selenium for freshwater was not protective of some threatened and endangered species, especially aquatic-dependent wildlife. Since selenium is primarily bioaccumulated through diet, recent efforts at revising the CTR criteria have recognized that a tissue standard may be a more appropriate way to regulate selenium (Hamilton, 2004).

In 2006, an independent advisory panel (IAP) convened by the Nitrogen and Selenium Management Program (NSMP) working group reviewed several documents and data regarding selenium concentrations in water, sediment and biota in the Newport Bay watershed. After discussions with Regional Water Board staff, stakeholders, and USFWS staff, the IAP found that site-specific objectives for the Newport Bay watershed were warranted and recommended that they be pursued (NWRI, 2006).

In 2008, after several meetings with staff from USEPA, USGS, USFWS, State Water Board, Regional Water Board, stakeholders and their consultants (primarily LWA and CH2MHill) and review of relevant information and documentation concerning the selenium characteristics of the Newport Bay watershed and the biota inhabiting the watershed, USFWS and USEPA jointly recommended a fish tissue SSO of 5 µg Se/g dry weight (dw) and a bird egg tissue SSO of 8 µg Se/g dw as appropriate for the protection of the beneficial uses in the watershed.

6.2 Development of Tissue SSOs

Many different values for the effects of selenium on reproduction, growth, or survival in fish and birds have been published during the last 20 years, as summarized by USDOI (1998), Eisler (2000), Hamilton (2003), Ohlendorf (2003), Luoma and Presser (2000), Presser and Luoma (2006), and other general references (CH2MHill, 2009a). Representative threshold values for selenium effects in fish (based on selenium concentrations in fish tissue) are presented in Table 6-2. Similarly, threshold values for effects in birds (based on selenium concentrations in bird eggs) are presented in Table 6-3. As shown in the tables, different concentrations have been identified for effects in different species of fish and birds; sometimes the values are different in the same species, depending on how the study results were analyzed or interpreted.

6.2.1 Fish Tissue SSO

For fish, a whole-body selenium concentration of 5 µg Se/g dw is being proposed as a site-specific objective for the Newport Bay watershed. Nationwide, background selenium concentrations (no effects level concentrations) in whole-body fish are <1-4 µg/g dw (typically <2 µg/g dw), and the lower ranges of whole-body selenium concentrations that are associated with minimal effects are slightly higher (4-6 µg/g dw) (Table 6-2). As early as 1998 the USDOI’s selenium guidelines identified a toxicity threshold range of 4-6 µg/g Se (dry weight basis, whole body) for fish (USDOI 1998); a value of 5 µg/g lies in the middle of that range (J. Skorupa, electronic communication dated October 20, 2008). In 2005, USFWS staff reviewed the available data and literature on selenium effects in fish and concluded that an appropriate toxicity threshold range for freshwater fish was 4-5 µg/g (USFWS 2005).

Estimating no effect concentrations (NECs) for fish is less precise and has a greater degree of uncertainty than those developed for birds since there are very few statistical analyses relating selenium effects and concentrations in fish (J. Skorupa, electronic communication dated June 29, 2009). Muscatello et al. (2006) calculated two statistically rigorous estimates of a 1% effects concentration (EC_{01})[1] (which is as close as you can get to estimating a NEC using logistic regression analysis) for selenium in northern pike (*Esox lucius*): 3.96 µg Se/g dw and 4.98 µg Se/g dw (essentially, 4-5 µg Se/g dw). The upper end of this range (5 µg Se/g dw) has been judged by USFWS staff to represent sufficient conservatism based on the specific fish resources requiring protection in the Newport Bay watershed (J. Skorupa, electronic communications dated October 20, 2008 and June 29, 2009). While data on selenium effects in saltwater fish species are limited, the 5 µg Se/g dw SSO value is also expected to be protective of the fish species that reside in both upper and lower Newport Bay. Some data suggest that marine fish are generally more tolerant of selenium than freshwater fish (Skorupa, electronic communication dated June 29, 2009).

The fish tissue SSO of 5 µg Se/g dw is also expected to be a fully protective dietary concentration for piscivorous birds in the Newport Bay watershed, including federally listed species such as the California least tern (*Sterna antillarum brownii*). As a dietary concentration for piscivorous birds, 5 µg Se/g dw would range from a 10% effects concentration (EC_{10}) (Ohlendorf 2003; logistic model) to an EC_{25} (Beckon et al., 2008; biphasic model) for mallard exposure to selenomethionine with an endpoint of egg hatchability (J. Skorupa, electronic communication, October 20, 2008). However, “fish selenium” [as coined by Goede (1993)] is chemically different than selenomethionine (Goede 1993), which is most commonly used in laboratory dietary experiments (selenomethionine and selenocystine are the major forms of selenium present in animal feeds [Ihnat, 1989]).

Selenomethionine is reported to be the primary form of selenium in plants (Olson et al., 1970; Allaway et al., 1967) and is the most harmful chemical form of selenium when mallard reproduction is measured (Heinz et al., 1989). Selenocystine has not been associated with adverse effects in birds and is considered to be harmless (Goede, 1993; Heinz et al., 1989). Fish selenium is an as yet unidentified selenium compound of marine animal origin (Goede, 1993). It has been experimentally demonstrated however, that “fish selenium” does not consist of selenomethionine, selenocystine, selenite, or selenate (Goede and Wolterbeek, 1993). Girling’s (1984) study found that selenium in most plant foods is 85-100% bioavailable compared to only 20-50%

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[1] An EC_{01} is as close as you can get to estimating a NEC using logistic regression as did Muscatello et al. (2006).

bioavailability of the selenium in tuna, meat, and fishmeal (“fish selenium”). Goede and Wolterbeek (1993) also found that fish selenium appeared to be less toxic to birds than selenomethionine. Therefore, there appears to be enough suggestive evidence for a working hypothesis that “fish selenium” is less toxicologically potent than selenomethionine (e.g., Goede 1993; Barceloux, 1999) and that the 5 ug/g dw fish tissue SSO will be sufficiently protective of fish-eating birds. In addition, studies of piscivorous species of birds (black-crowned night herons and oystercatchers) indicate that piscivorous birds may be less sensitive to the toxic effects of selenium than mallards (Smith et al., 1988 versus Heinz et al., 1987 and 1989; Goede 1993; Goede and Wolterbeek, 1993) and this may be a result of the selenium in fish being protein-bound and therefore, less bioavailable (Smith et al., 1988).

Table 6-2
Threshold Values for Selenium Effects in Fish Based on Selenium Concentrations in Fish Tissue

Tissue Concentration (µg/g, dw)	Location	Effect/Threshold	Reference(s)
<1-4 (whole-body) (typically <2)	Synthesis[1]	Background	USDOI, 1998
4–12 (whole-body)	Synthesis	Range of concern; toxicological and reproductive effects a certainty if upper limit exceeded/whole-body	Engberg et al., 1998
4 (whole-body) 8 (muscle) 12 (liver) 10 (egg)	Synthesis	Maximum allowable concentration (protective of reproduction)	Lemly, 2002
5–7 (whole body) 6–8 (muscle) 15–20 (liver) 5–10 (egg) 8–12 (larvae and fry)	Synthesis	Diagnostic residues for reproductive impairment (deformity or mortality of larvae/fry); applies to centrarchids, fathead minnows, salmonids, percichthyids	Lemly, 1998
4–6 (whole-body) 7–13 (gonad/egg)	Synthesis	Reproductive impairment (10% effect level) in sensitive species (perch, bluegill, salmon)	USDOI, 1998; Presser et al., 2004
4–6.5 (whole-body)	Lab and synthesis	Growth and survival (swim-up Chinook salmon larvae)	Hamilton et al., 1990; Hamilton 2002, 2003
3.6–8.7 (whole-body)	Field	Survival (razorback sucker larvae)	Hamilton et al., 1996, 2005a, b; Hamilton, 2002, 2004
3.96–4.98 (whole body)	Field and lab	Reproductive impairment (deformities) in Northern Pike embryos (1% effect concentration or EC_{01}) as calculated from egg and muscle selenium concentrations	Muscatello et al., 2006
5.85 (whole-body)	Lab	40% overwinter mortality in juvenile bluegill (winter stress)	Lemly, 1993a

[1] Threshold value is based on the review/integration (synthesis) of results from several field and/or laboratory studies.
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Table 6-2
Threshold Values for Selenium Effects in Fish Based on Selenium Concentrations in Fish Tissue

Tissue Concentration (µg/g, dw)	Location	Effect/Threshold	Reference(s)
6 cold-water (whole-body) 9 warm-water (whole-body) 17 (ovary)	Synthesis	Recommended toxicity guidelines (10% effect level)	DeForest et al., 1999
10 (egg) 6–17 (egg)	Synthesis	Rapid rise in deformities (terata) for centrarchids	Lemly, 1993
12.5 (egg based on 52% moisture) 4.3 (muscle translation)	Field (eggs and milt) Lab (fish rearing)	Rapid rise in edema and deformities in rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*) fry (parental exposure)	Holm et al., 2003
18–22 (egg based on 52% moisture) 6.4–7.6 (muscle translation)	Field(eggs and milt) Lab (fish rearing)	Range of 15% effect level (edema, skeletal or craniofacial deformities) in rainbow trout swim-up fry	Holm et al., 2005
40–125 (whole-body) 25–200 (muscle) 20–170 (egg)	Field	16 species extirpated; 10–70% rates of teratogenesis	Cumbie and Van Horn, 1978; Lemly 1985, 1997, 1998, 2002
10 (egg)	Synthesis	Centrarchids (bluegills); Equivalent to a whole body value of 4 µg/g dw	Lemly, 1993 as reported in Chapman, 2007
17 (egg)	Synthesis	Threshold determined using 21 studies representing 8 fish species (warm-water and cold-water); using the procedure in USEPA (2004) to convert the 7.9 µg/g dw whole-body draft criterion value to an egg value	USEPA, 2004 as reported in Chapman, 2007
>16–18 (egg)	Lab	Cutthroat trout (*Oncorhynchus clarki*); mean values, no effects	Hardy, 2005 as reported in Chapman, 2007

Table 6-2
Threshold Values for Selenium Effects in Fish Based on Selenium Concentrations in Fish Tissue

Tissue Concentration (µg/g, dw)	Location	Effect/Threshold	Reference(s)
>20.6 (egg)	Field/Lab	Cutthroat trout; no selenium-related deformities; next highest concentration tested, 46.6 µg/g dw, did not produce viable fry	Rudolph et al., 2008; Chapman, 2007
21.2 (egg)	Field	Cutthroat trout; mean value; no effects found at egg selenium concentrations as high as 81.3 µg/g dw	Kennedy et al., 2000 as reported in Chapman, 2007
25.6 (egg)	Field/Lab	White sucker; mean value; corresponds to a mean frequency of deformity of 12.8%	de Rosemond et al., 2005 as reported in Chapman, 2007
>26.4–31.2 (egg)	Field	Brook trout; no increase in larval deformities at 6.6 and 7.8 µg/g ww; converted to dw based on 75% moisture	Holm et al. 2005, as reported in Chapman, 2007
32–40 (egg)	Field	Rainbow trout; threshold between 8-10 µg/g ww; converted to dw based on 75% moisture	Holm et al. 2005, as reported in Chapman, 2007
33.6 (egg)	Lab	Northern pike: EC_{20} for larval deformities relative to reference	Muscatello et al. 2006, as reported in Chapman, 2007
4–6 Marginal effects >6 Substantive effects	Synthesis	Whole-body thresholds	Presser et al., 2004
7.91 (whole-body) 5.85 (whole-body)	Synthesis	Draft criterion, winter stress conditions; a concentration of 5.85 µg/g dw measured in the summer or fall would trigger repeated monitoring in the winter	USEPA, 2004

Notes:
Source: Modified from Presser and Luoma (2006) and Chapman (2007)
µg/g = microgram per gram
dw = dry weight
EC_{20} = 20% effect concentration
ww = wet weight

6.2.2 Bird Egg Tissue SSO

For birds, a selenium concentration of 8 µg Se/g dw in egg tissue is being proposed as a site-specific objective for the Newport Bay watershed. Selenium concentrations in eggs are most useful for evaluating potential reproductive impairment (Skorupa and Ohlendorf, 1991). Many factors can influence the transfer of selenium from the food eaten by birds through their tissues (e.g., liver, blood) to the eggs, where effects occur in the developing embryo. Selenium concentrations in livers or blood are useful for assessing exposure at the time of sampling, but they are not nearly as useful for assessing potential reproductive impairment as the concentrations in eggs (CH2MHill, 2009).

Worldwide, mean background selenium concentrations (no effects level concentrations) in bird eggs are <3 µg Se /g on a dry-weight basis (typically 1.5-2.5 µg Se/g dw, with individual eggs <5 µg Se/g dw). Selenium concentrations that are associated with effects have been estimated from field studies of shorebirds and waterfowl and from laboratory studies with mallards, chickens, and Japanese quail (Heinz et al., 1989; CH2MHill, 2009). Reduced hatching success is considered the most sensitive, reliable endpoint for effects, with effect levels ranging from 6-7 µg Se/g dw to14 µg Se/g dw in black-necked stilts. Bird egg threshold values are summarized in Table 6-3.

Table 6-3
Threshold Values for Selenium Effects in Birds Based on Selenium Concentrations in Bird Eggs

Level/Status	Concentration (µg/g, dw)	Effects	Comments	References
Adequate	0.66-5.0 (0.20-1.5 ww)	Nutritional needs are met for poultry	Lower dietary concentrations are marginal or deficient, and diets must be fortified	Puls, 1988
High	5.0-16 (1.5-5.0 ww)	Levels are excessive and upper end of range may be toxic to poultry	Poultry are relatively sensitive to effects of selenium	Puls, 1988
Toxic	>8.2 (>2.5 ww)	Reduced egg hatchability and teratogenic effects in embryos/chicks	Poultry are relatively sensitive to effects of selenium	Puls, 1988
Background	Mean < 3.0 (typically 1.5-2.5); individual eggs <5	None	Concentrations may be higher in marine birds	Ohlendorf and Harrison, 1986; Skorupa and Ohlendorf, 1991; USDI, 1998; Eisler, 2000
Reproductive impairment	6-7 (about 1.8-2.1 ww)	EC_{10} on a clutch-wise (or hen-wise) basis and EC_{03} on egg-wise basis	Based on results of extensive field studies of black-necked stilts	Skorupa, 1998, 1999
Reproductive impairment	3.4-7.7	EC_{10} for reduced egg hatchability (Brain-Cousens model [3.4 µg/g] and log-logistic[2] model	Based on results of one laboratory study with mallards, assuming hormetic	Beckon et al., 2008

Table 6-3
Threshold Values for Selenium Effects in Birds Based on Selenium Concentrations in Bird Eggs

Level/Status	Concentration (µg/g, dw)	Effects	Comments	References
		[7.7 µg/g])	effects	
Reproductive impairment	9.0	$EC_{8.2}$ for impaired clutch viability	Based on results of one laboratory study with mallards, using linear regression analysis	Lam et al., 2005
Reproductive impairment	12 (95% CI = 9.7-14)	EC_{10} for reduced egg hatchability	Based on results of six laboratory studies with mallards, using hockey stick analysis	Adams (pers. comm.; see Ohlendorf 2007)
Reproductive impairment	12 (95% CI = 6.4-16)	EC_{10} for reduced egg hatchability	Based on results of six laboratory studies with mallards, using logistic regression analysis	Ohlendorf, 2003
Reproductive impairment	14	$EC_{11.8}$ for reduced egg hatchability	Based on results of extensive field studies of black-necked stilts	Lam et al., 2005
Teratogenicity	13-24	Threshold for teratogenic effects on population level	Sensitivity varies widely by species	Skorupa and Ohlendorf, 1991
Teratogenicity	23	EC_{10} for teratogenic effects in mallard	Mallard is considered a "sensitive" species	Skorupa, 1998; USDOI, 1998
Teratogenicity	37	EC_{10} for teratogenic effects in stilt	Stilt is considered an "average" species	Skorupa, 1998; USDOI, 1998
Teratogenicity	74	EC_{10} for teratogenic effects in American avocet	Avocet is considered a "tolerant" species	Skorupa, 1998; USDI, 1998

Notes:
[a]Typical moisture content is 65-80% moisture, varying with species and incubation stage; use 70% (i.e., factor of 3.3) for approximate conversion.
µg/g = microgram per gram
dw = dry weight
EC_{10} = 10% effect concentration
ww = wet weight

Mallards are found throughout the Newport Bay watershed and are considered to be more sensitive to the reproductive effects of selenium than the shorebirds that are commonly found in the watershed (e.g., black-necked stilts and American avocets). Beckon et al. (2008) calculated a potential range in 10% effect concentrations (EC_{10}) for selenium in mallards of 3.4 µg/g dw to 7.7 µg/g dw using two different logistic regression models (Figure 6-1). However, selenium-normal mallard eggs typically contain selenium concentrations of 1.5-3.0 µg/g dw, so the 3.4 µg/g of Beckon et al. (2008) cannot be an EC_{10} (J. Skorupa, electronic communicated dated July 7, 2009). This low concentration was calculated using a model that was designed to model classic hormesis[1] (Brain-Cousens model). Nutrients, such as selenium, while biphasic, do not display classic hormesis (Calabrese, 2008). None of Beckon et al.'s examined methods were specifically designed to estimate no effect concentrations (NECs).

In USFWS staffs' opinion, the range in selenium concentrations in mallard eggs (essentially 3-8 µg Se/g dw) modeled by Beckon et al. (2008) are reasonable NECs for egg selenium and mallard sensitivity. It has long been understood by toxicologists that the range of plausible EC_{10}s overlaps the true NEC for many data sets (J. Skorupa, electronic communication dated July 7, 2009). The upper end of this range of possible NECs (8 µg/g dw) has been judged by USFWS staff to represent sufficient conservatism based on the specific bird species requiring protection in the Newport Bay watershed, including the federally listed California least tern and light-footed clapper rail (J. Skorupa, electronic communications dated October 20, 2008). Studies of populations of the endangered California clapper rail (*Rallus longirostris obsoletus*) in San Francisco Bay found that egg tissue selenium concentrations averaging as high as 7.4 µg Se/g dw had no direct effect on reproduction (Lonzarich et al. 1992; Schwarzbach et al. 2006). The California clapper rail is a close relative of the light-footed clapper rail (*Rallus longirostris levipes*). The California least tern is a piscivorous bird, which are generally considered to be less sensitive to selenium than mallards or shorebirds (see discussion in Section 6.2.1 above re fish selenium).

[1] Hormesis is a biphasic response displayed by an organism when exposed to a stressor, such as a physical or chemical stressor. A hormetic effect can occur in an organism when exposure to a stressor results in a beneficial effect at low doses and increasingly harmful effects at higher doses. For hormetic stressors, zero exposure to the stressor is the normal, or control, condition for the organism. Selenium and other nutrients do not exhibit hormesis; the normal, or control, condition for a nutrient is any of the non-zero exposures that fall within the range of nutritional adequacy. Nutrients however, display a biphasic exposure-response curve in that low-dose toxic effects can result in an organism from nutritional deficiency as well as nutritionally excessive amounts.

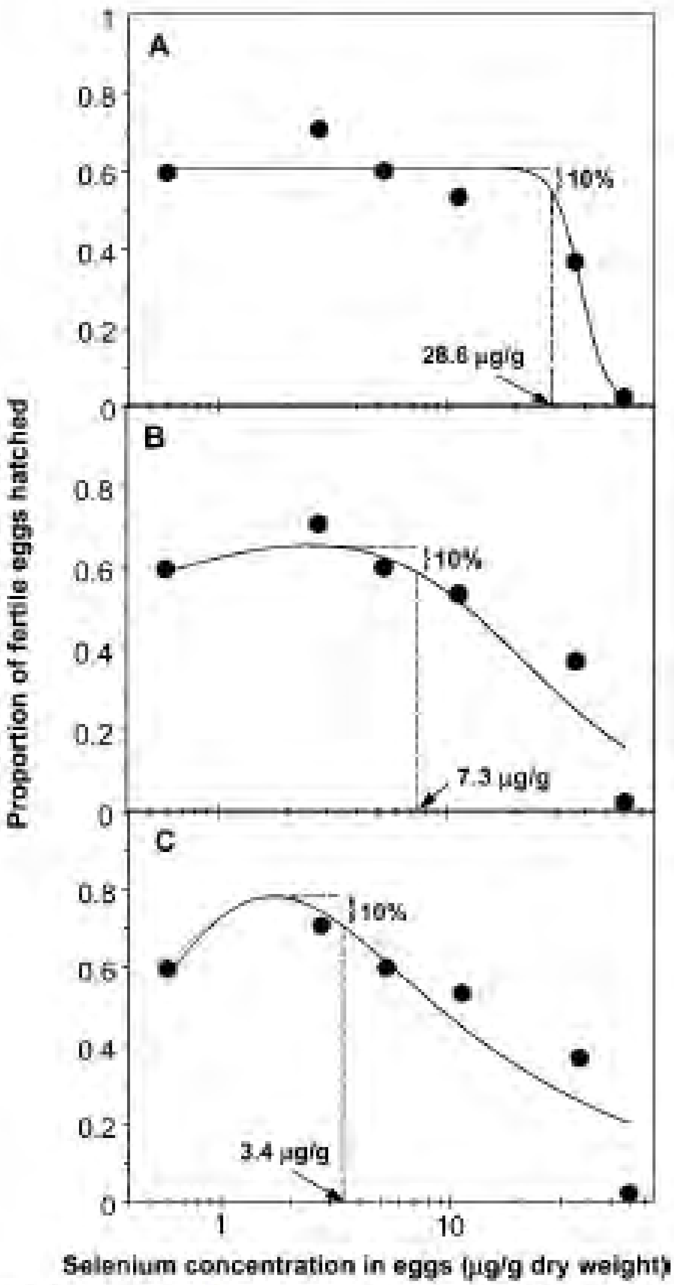

FIGURE 5. An example demonstrating the importance of model choice in the development of regulatory guidelines. Guidelines based on an estimated EC10 (allowing a concentration expected to adversely affect 10% of the population) would vary widely depending on the model employed. The data relate the hatchability of mallard eggs to the selenium concentration in the eggs (38). Curves fitted by least-squares nonlinear regression are (A) the log-logistic model (eq 3), (B) a log-logistic[2] model (eq 8), and (C) the Brain-Cousens model (eq 5). The estimate of EC10 based on the log-logistic model is more than eight times higher (less protective) than the estimate based on the Brain-Cousens model. The log-logistic[2] model yields an intermediate estimate.

Figure 6-1. Figure 5 from Beckon et al. (2008). The simple log-logistic model (A) cannot describe a biphasic relationship, such as that between selenium and hatchability. The Brain-Cousens model (C), which yields the most conservative estimate of possible EC_{10}s, is specifically designed to model hormetic effects; selenium is not a hormetic chemical. The log-logistic[2] model (multiplicative log-logistic model of Beckon et al., 2008) provides the most reasonable fit of the data and the best estimate of EC_{10}.

As a check on his recommendation that a bird egg tissue selenium SSO of 8 µg Se/g dw was an appropriate level of protection for the bird species in the Newport Bay watershed, Dr. Skorupa also reanalyzed his black-necked stilt egg hatchability database for selenium and effects, which contains 639 monitored and chemically sampled full-term nests, using USEPA's Toxicity Relationship Analysis Program (TRAP) (J. Skorupa, electronic communications dated October 28 and 29, 2008). TRAP includes a triangular tolerance distribution analysis option, which is specifically designed to statistically estimate X_0, the exposure value below which zero effects can be expected (i.e., the no effects concentration or NEC). X_0 was estimated by TRAP to be 5.8 µg Se/g dw (6 µg Se/g dw) with the 95% confidence interval ranging up to 15.8 µg Se/g dw (16 µg Se/g dw) (Figure 6-2). The NEC can also be estimated using this program by calculating the lower 95% confidence bound on the estimated EC_{10}, which yielded a result of 10.2 µg Se/g dw (10 µg Se/g dw) (Figure 6-2). The recommended bird egg tissue selenium SSO for the Newport Bay watershed of 8 µg Se/g dw falls between the two NEC TRAP estimates for selenium effects in black-necked stilts of 6 and10 µg Se/g dw (Skorupa, electronic communications dated October 28 and 29, 2008).

6.3 Alternatives to the Recommended Tissue SSOs Considered

Several alternatives were considered in developing site-specific objectives for selenium in the Newport Bay watershed.

Three standard procedures have been published by USEPA that can be used to establish site-specific objectives:

- The Water-effects Ratio (WER) Procedure, which can be used to adjust objectives to account for site-specific water chemistry;
- The Recalculation Procedure, which is used to adjust objectives based on the assemblage of species found at a particular site; and
- The Resident Species Procedure, which accounts for both site-specific water chemistry and the assemblage of resident species at the site.

USEPA's guidance for implementing these procedures can be found in their Water Quality Standards Handbook (USEPA, 1994). All of these procedures use methodologies designed to modify water quality objectives based on the typical approach of using traditional toxicity datasets (e.g., datasets based on the response of organisms that have been exposed to a toxic constituent in water in the laboratory for a specified period of time). Since selenium is a bioaccumulative compound that is accumulated primarily via diet, not water, none of these methods apply to developing objectives for selenium (Great Lakes Environmental Center, 2003).

For fish tissue, Regional Water Board staff could have elected to use USEPA's draft 304(b) aquatic life criterion for selenium. USEPA has proposed a tissue based standard of 7.91 µg Se/g dw in whole body fish based on juvenile bluegill toxicity studies incorporating overwinter stress, with a summer value of 5.85 µg Se/g dw (USEPA, 2004). However, USEPA's approach only considers protection of aquatic life, not aquatic-dependent wildlife (such as birds) and therefore, may not be protective of birds

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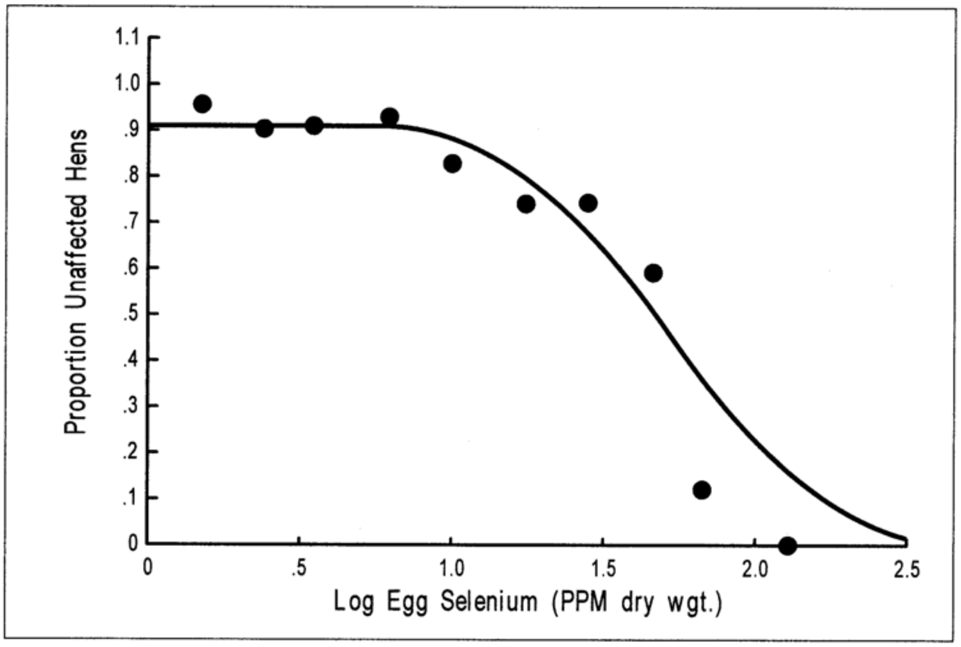

Parameter Summary (Triangular Tolerance Distribution Analysis)

Parameter	Guess	FinalEst	StdError	95%LCL	95%UCL
LogX50	1.5837	1.7204	0.0469	1.6269	1.8138
StdDev	0.4525	0.3898	0.0714	0.2877	0.6045
Y0	0.9249	0.9098	0.0171	0.8701	0.9406

Effect Concentration Summary

%Effect	Xp Est	95%LCL	95%UCL
50.0	52.53	42.36	65.14
20.0	23.41	17.79	30.81
10.0	15.580	10.234	23.719
5.0	11.681	6.731	20.272
0.0	5.828	2.153	15.780

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Figure 6-2. Declining portion of black-necked stilt hens hatching their full clutch of eggs as a function of increasing selenium exposure (total n = 639). Tolerance distribution analysis fitted to a triangular distribution as per USEPA (2002) Toxicity Relationship Analysis Program (TRAP). (From J. Skorupa, USFWS).

that consume fish. In accordance with the USFWS biological opinion on the CTR (Spear and McInnis, 2000), selenium criteria developed for California must be protective of both aquatic life and aquatic-dependent wildlife. USEPA's draft aquatic criterion is only applicable to freshwater systems and does not address estuarine and marine aquatic systems. Therefore, site-specific objectives for fish in Newport Bay, which is a saltwater estuary, would still have to be developed.

For bird egg tissue, Regional Water Board staff could have elected to follow the same process and method used to develop the State of Utah's proposed selenium standard for the Great Salt Lake (CH2MHill and CWECS, 2008). Utah has proposed to use a bird egg tissue concentration of 12.5 µg Se/g dw for the open waters of the Great Salt Lake; this value is a 10% effect level (EC_{10}) based on mallard studies (Ohlendorf, 2003). An objective based on an EC_{10} essentially allows 10 percent of a population (in this case, birds) to be at risk from reproductive effects due to selenium. However, USFWS staff has recently issued a letter (USFWS, 2009) that states that the State of Utah's proposed bird egg tissue objective for selenium could be in violation of the Migratory Bird Treaty Act (MBTA; 16 U.S.C. 703-712). The MBTA implements the United State's commitment to four bilateral treaties for the protection of migratory birds and includes most species commonly found in the Newport Bay watershed. The MBTA prohibits a "take" of migratory birds, their nests or eggs unless permitted by regulation (16 U.S.C. 703(a) as stated in Walsh, 2009). The MBTA is a strict liability statute, which means that no intent is required for there to be a violation (Walsh, 2009). As a result of this, even the unintentional take of migratory birds (such as by adopting a bird egg tissue criteria for selenium that is associated with known or observed effects such as Utah's proposed bird egg tissue standard of 12.5 µg Se/g dw) is prohibited. The bird egg tissue SSO of 8 µg Se/g dw proposed for the Newport Bay watershed is based on a no effects concentration (NEC) not an effects level concentration; therefore it would not be in violation of the MBTA.

7.0 EXISTING SOURCES AND LOAD ESTIMATES FOR SELENIUM IN THE NEWPORT BAY WATERSHED

7.1 Introduction

Selenium contributions to the Newport Bay watershed include both point and non-point sources. Point sources are those sources that discharge a pollutant through discrete pipes or other conveyances, such as storm water channels (USEPA, 2002). These sources are regulated under the National Pollutant Discharge Elimination System (NPDES) permit program. Non-point sources are generally those that discharge pollutants via diffuse runoff from land, primarily driven by rainfall events (USEPA, 2002).

Of these sources, groundwater appears to be the greatest contributor of selenium to the watershed (CH2MHill, 2009d). For example, Meixner et al. (2004) report that 96 percent of the selenium loads entering Newport Bay from the San Diego Creek subwatershed, which is the largest source of selenium to the Bay, are from groundwater sources in the watershed. A detailed description of the selenium sources and estimated contribution of each to selenium loads in the Newport Bay watershed follows. Note however, that while preliminary load estimates have been calculated for the Big Canyon Wash subwatershed, these are based on very limited data. The sources of selenium in Big Canyon have not yet been identified and while hydromodification has likely strongly influenced selenium concentrations in groundwater and surface waters in this area, the geology and biogeochemical cycling of selenium in Big Canyon varies dramatically from that observed in the San Diego Creek subwatershed (see Sections 3.5.2 and 4.1 of this report).

7.2 Estimation of Existing Selenium Loads

The estimated loads were generally based on a five-year period of record from July 2003 to July 2008, though some of the periods of record varied. Estimated loads (i.e., annual, winter season, and summer season) were calculated for the following categories of discharges[1]:

- Point Sources
  - Urban Runoff
  - Groundwater: Long-Term Dewatering
  - Groundwater: Short-Term Dewatering
  - Groundwater Clean-Up: Long Term
  - Groundwater Clean-Up: Short Term/Mobile Systems
  - Sewered Groundwater Discharges
  - Nursery Operations

[1] To address the uncertainty within the dataset, the values are rounded as follows: < 1 to the nearest tenth; 1-10 to the nearest one; > 10 to the nearest ten. Due to the rounding, the individual values do not always add up to the sum shown. The uncertainty is accounted for within the implicit TMDL margin of safety (MOS).

- Non-Point Sources
  - Agriculture Discharges
  - Atmospheric Deposition
  - Open Space
  - Rising Groundwater

For each category, the estimated loads are compared to the loads identified in the USEPA technical TMDLs for Toxic Pollutants, San Diego Creek and Newport Bay, California (USEPA, 2002) [hereinafter referred to as Toxics TMDLs] in order to provide context for the results and clarification (to the extent possible) as to why the load values may be different.

Although the calculations were generally based on the available data and qualitative knowledge regarding the discharge volumes and associated selenium concentrations, in reality, the available data and requisite assumptions used to generate the estimated loads of selenium varied widely for each source. In addition, while this is the most comprehensive selenium-based load estimate that has been calculated for the San Diego Creek subwatershed and the Newport Bay watershed as a whole to date, there may be sources that are not fully accounted for (e.g., discharges from mobile treatment units, utility vaults, desalters, nurseries) that should be accounted for in future load calculations.

Each source category section below describes the available data, assumptions made, and calculations used to generate the load estimates. The detailed spreadsheets are included in Appendix 7A.

7.2.1 Point Sources (PS)

Data used to calculate each point source's estimated selenium load are presented in this section. Summary information for the point source categories, including the average selenium concentrations used for the load calculations, is included below.

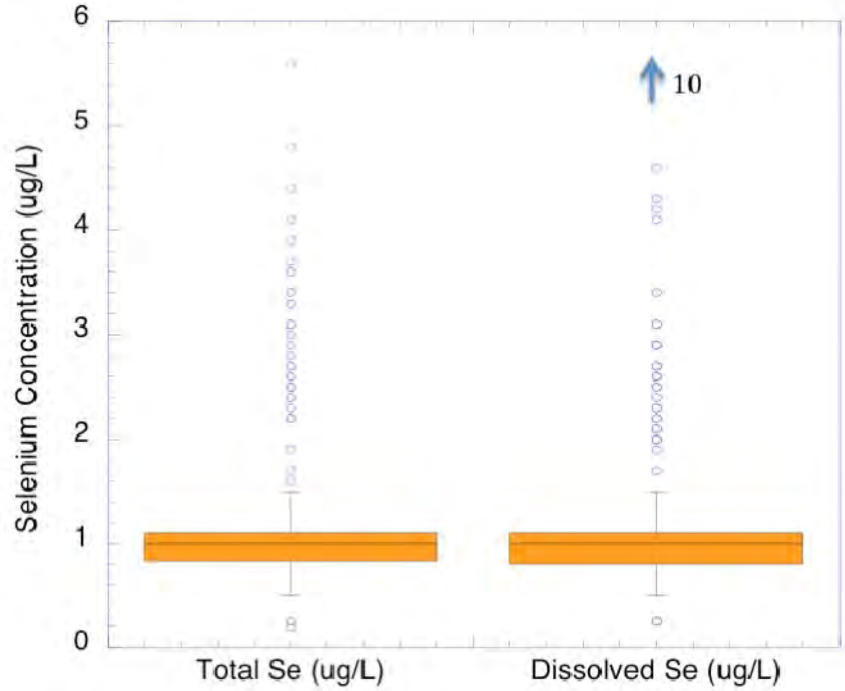
7.2.1.1 Urban Runoff

Sources of selenium in urban runoff may include atmospheric deposition, soils containing naturally occurring selenium, and imported water that may be used for irrigation or other purposes.

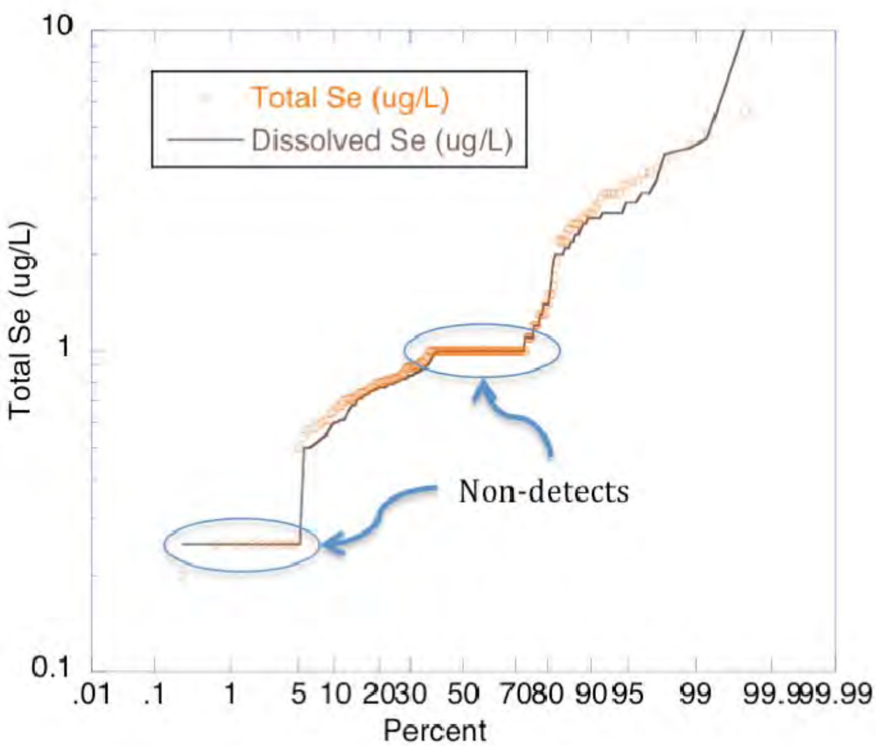
The County of Orange monitors flow and selenium concentrations in Costa Mesa Channel (CMCG02) along Westcliffe Drive. Stage measurements are taken in the channel about a block downstream of the mass emissions station. Costa Mesa Channel, which drains directly into Upper Newport Bay, was selected as a surrogate urban runoff site because its watershed is approximately one square mile in area, has predominately urban land uses, and is outside of the areas impacted by groundwater seepage. Because of these characteristics, load estimates for CMCG02 are extrapolated to represent urban runoff throughout the watershed.

The period of record for selenium concentration data is December 7, 2001 to June 30, 2008. However, the period of record for discharge data is shorter: July 1, 2005 to June 30, 2008. The available dataset is plotted for total and dissolved selenium in Figure 7-1a as box plots[2] and Figure 7-1b as log-normal probability distributions. Both figures indicate that in-channel concentrations are typically at the detection limit and almost all of it is dissolved. Probability distribution plots of environmental concentration data typically fall on a straight line, indicating a random distribution of concentrations. Not being log-normally distributed may have indicated anomalies in the dataset. Because non-detected samples were assumed at their detection limits, horizontal steps in the plot are clearly evident where several data points have the same value. The large proportion (~60%) of non-detected data notwithstanding, the detected data are reasonably log-normally distributed, meaning that they fall approximately along a straight line on the log-normally probability distribution plot. For this reason, no individual data points were excluded from the analyses presented herein.

[2] For box plots, each box encloses 50% of the data with the median value of the variable displayed as a line. The top and bottom of the box mark the limits of ± 25% of the variable population. The lines extending from the top and bottom of each box mark the minimum and maximum values within the data set that fall within a confidence interval (typically 95%). Any value outside of this interval, called an outlier, is displayed as an individual point.



a)



b)

Figure 7-1. Total and dissolved selenium concentrations in Costa Mesa Channel, 2002-2008 (n=209 for total Se; n=204 for dissolved Se), as a) box plots and b) log-normal probability distributions. In both figures, non-detected values have been replaced with their detection limit.

The CTR freshwater chronic criterion for selenium of 5 µg/L (as total recoverable selenium) is the current legally applicable water quality objective for the freshwater areas of the Newport Bay watershed. This criterion has not been exceeded at this station; therefore, selenium concentrations in urban runoff do not violate the CTR selenium criterion for freshwater.

These concentrations are also consistent with earlier findings. Lee and Taylor (2001) found urban runoff to contain very low selenium concentrations (typically <1.5 µg/L) and curbside urban runoff sampling conducted in the Urban Nutrient Best Management Practice Evaluation/Warner Channel Evaluation found no detected concentrations above 2 µg/L (County of Orange, 2005).

7.2.1.1a Seasonality and Speciation

The estimated urban runoff selenium loads are calculated both by annual averages and by season. The "winter season" is assumed to be from October 1 through March 31 and the "summer season" is assumed to be from April 1 through September 30. However, it must be noted that this seasonal delineation ignores the fact that even during the winter season, the majority of days (and associated flows) are quite similar to summer conditions. Nonetheless, for consistency with a seasonal distinction, concentrations and loads are segregated by these seasons.[3]

Although speciation is important, chemical analyses have typically measured only total and dissolved concentrations. USEPA's Source Analysis section in the selenium portion of the technical TMDLs for Toxics in the San Diego Creek/Newport Bay watershed (USEPA, 2002) states that "…water-borne selenium mostly existed in dissolved forms under low flow conditions [in the San Diego Creek sub-watershed]". Particulate fractions (i.e., total minus dissolved) of selenium during rain events fall in a wider range than those found in dry weather. Total metals concentrations are derived from the analyses of unfiltered samples; dissolved metals concentrations are derived from the analyses of filtered samples.

There are 111 winter season sample results and 102 summer season sample results for both total and dissolved analyses. Total and dissolved sample data are portrayed in box plots in Figure 7-2. Discrete pairs of samples are plotted against each other in Figure 7-3. Non-detected data are plotted at their detection limits (usually 1 µg Se/L). One sample recorded 10 µg/L for dissolved selenium, although the same sample measured 1.3 µg/L for total selenium—an obvious analytical error. No seasonal difference in selenium concentrations is observed in the dataset.

The median dissolved fraction indicates that 96% of selenium measured in this channel is dissolved. There is no statistically significant seasonal difference in either the total or dissolved form or in the dissolved fraction.

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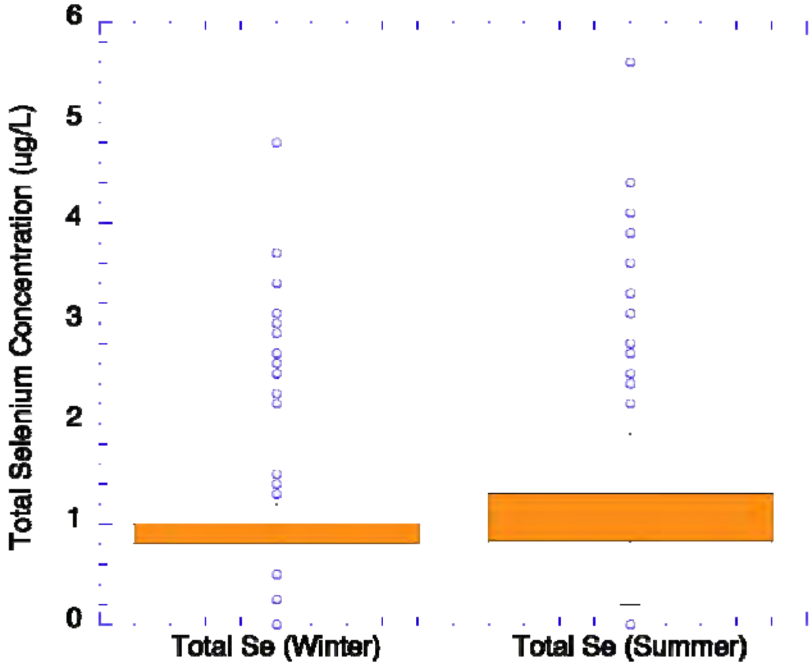
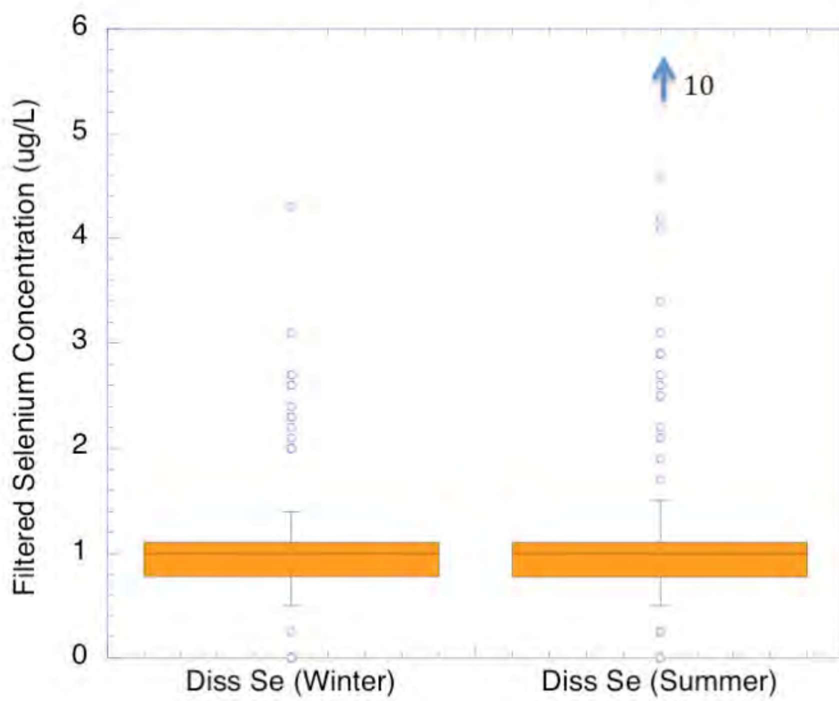
[3] To establish selenium loads, the calendar seasons of winter and summer are used to be consistent with the USEPA 2002 Toxics TMDLs (EPA, 2002). Other sections of the technical staff report (e.g. Allocations section) use dry verses wet weather periods instead of the winter and summer seasons because selenium concentrations in surface waters are highest and have the greatest impact on beneficial uses under dry weather flow conditions (see discussion under Section 11.0 in this report).



a)



b)

Figure 7-2. Box plots of a) total and b) dissolved selenium concentration data for Costa Mesa Channel, separated into winter and summer season samples.

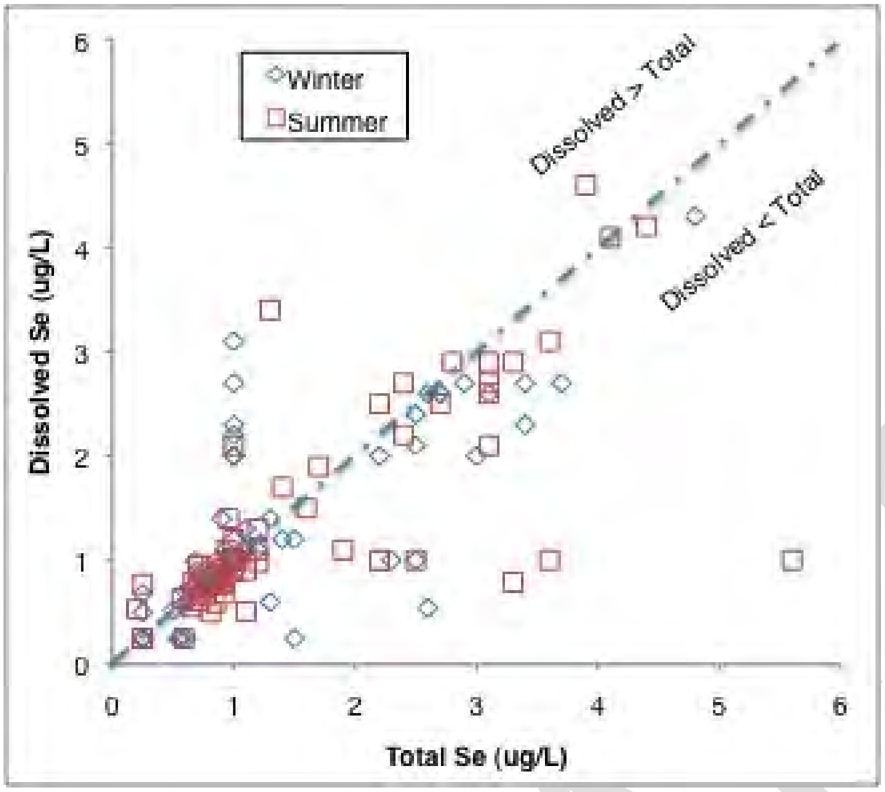


Figure 7-3. Paired total and dissolved selenium concentrations. The dashed line indicates 100% dissolved. Markers above this line indicate an analytical anomaly in which the dissolved concentration exceeds the total concentration.

7.2.1.1b Selenium Concentration as a Function of Discharge

Total, dissolved, and dissolved fraction Se concentrations are plotted against discharge in Costa Mesa Channel in Figure 7-4 in both linear and log scales. Very few samples were collected during high discharges, meaning the confidence in the total winter-season load is relatively low. Based on these data, there is no clear relationship between discharge and selenium concentrations.

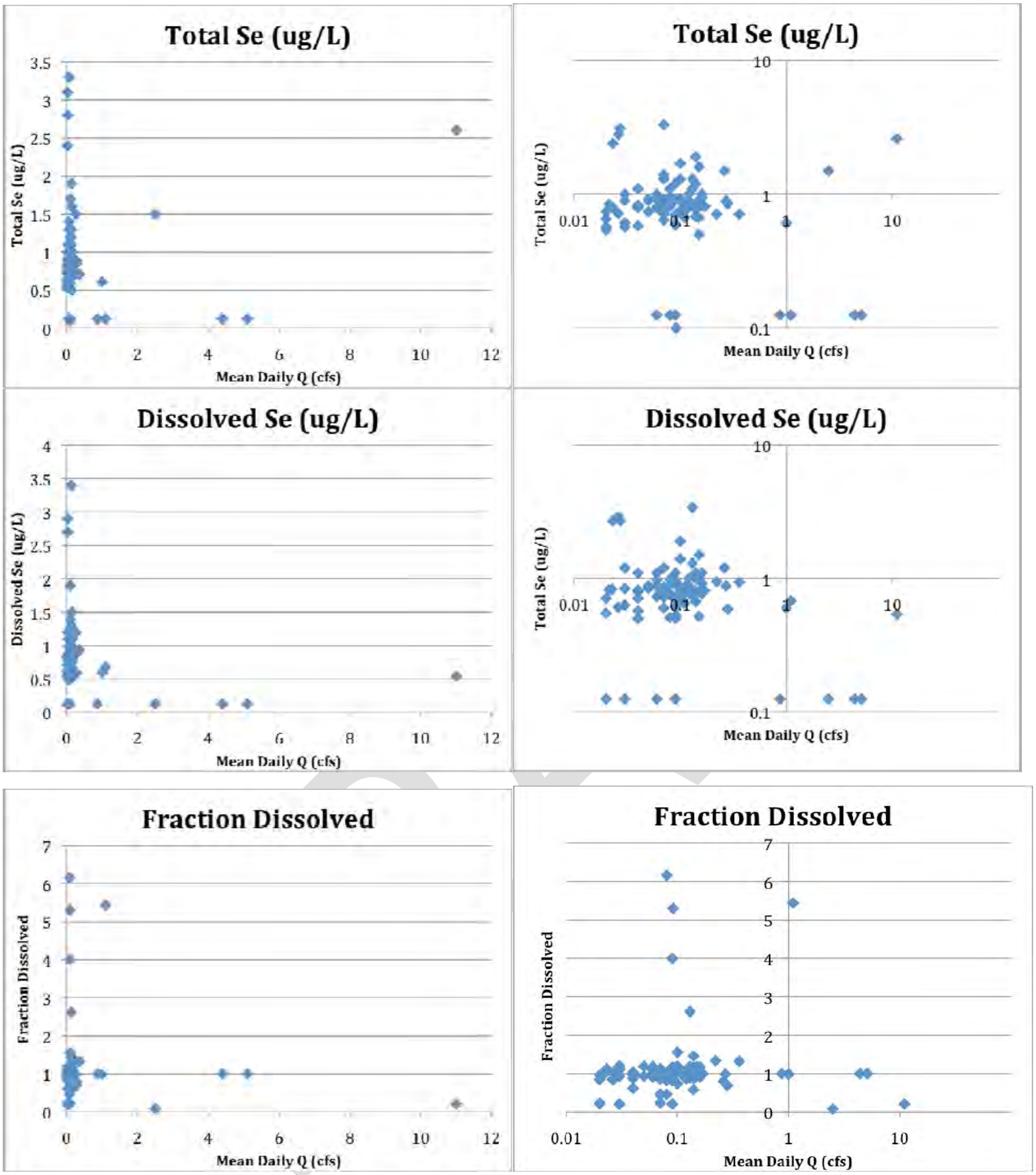


Figure 7-4. Total (top), dissolved (middle) and fraction dissolved selenium concentrations paired with daily mean discharge on linear (left) and log (right) scales. Non-detected data have been replaced with half the detection limit.

7.2.1.1c Rainfall Runoff Calculation

Average annual rainfall runoff was computed for urban land use areas as:

*Average annual runoff = runoff coefficient * annual average rainfall * land use area*

Input values were estimated as follows:

- Precipitation records for eight stations within and adjacent to the watershed were obtained for a 40-year period, from 1966 through 2005 (Appendix 7B). Annual average rainfall results were spatially-averaged for segments of the watershed using the Thiessen polygon method, and the spatial average was estimated to be 1.1 ft/year.
- The runoff coefficient was estimated as: 0.579, representing an area-weighted average by land use class (Coefficient was an area-weighted average by land use class and was taken from the Toxics TMDL, Appendix D [USEPA, 2002])
- The area in square feet for each land use type was calculated from the GIS data as Urban = 2,765,234,817 ft^2.

7.2.1.1d Urban Runoff Load Estimates

Total selenium loads in urban runoff are calculated for winter season and summer season. Values were taken from the dataset described above.

Urban Runoff Parameters and Assumptions	
Period of Record for Se Concentrations	December 7, 2001- June 30, 2008
Period of Record for Discharge Data	July 1, 2005 – June 30, 2008
Avg. Total Se Concentrations	0.9 - 1.3 µg/L
Decisions/Assumptions	- Costa Mesa Channel utilized as a surrogate sub-watershed

Seasonal average values are calculated based on measured concentrations. Loads are calculated separately for the San Diego Creek subwatershed and the rest of the Newport Bay watershed.

1. Summer season average flows and average concentrations are multiplied for the six-month period and scaled by relative watershed area from the flow rates measured at CMCG02:

- Average summer season flow rate at CMCG02, Q_{Summer} = 0.2 cfs
- Watershed area for the entire urban area relative to CMCG02, A_{Total}/A_{CMCG02} = total urban area / CMCG02 watershed area = 99 mi^2 / 1 mi^2 [72.7% of that urban area is in San Diego Creek subwatershed]
- Total summer season runoff volume, $V_{Summer} = Q_{Summer} * A_{Total}/A_{CMCG02} * 365/2$ seasonal days/yr = 0.2 cfs * (99/1) * (365/2) * 86400 s/day = 3.13×10^8 ft^3/yr [2.27×10^8 ft3/yr for San Diego Creek subwatershed only]
- Average summer season total Se concentration = 1.3 µg/L
- Summer season, non-stormwater load of total selenium, $L_{Summer} = V_{Summer} * C_{Summer}$ = 3.13×10^8 ft^3/yr * 1.3 µg/L * {conversion factors} = 26 lbs/yr [18.9 lbs/yr for San Diego Creek subwatershed only][4]

2. Winter season rainfall runoff loads are based on estimated runoff volumes (applying the Rational Method (Hayes and Young, 2005) for 40-year average precipitation) and average total selenium concentrations measured at CMCG02 during the highest 10% of winter-season discharges:

- Average rainfall runoff volume from all urban areas, V_{Rain} = 1.76×10^9 ft^3/yr [1.28×10^9 ft^3/yr for San Diego Creek subwatershed only]
- Average high-discharge total Se concentration measured at CMCG02, C_{Rain} = 0.9 µg/L
- Winter season, rainfall runoff load of total selenium, $L_{Rain} = V_{Rain} * C_{Rain}$ = 1.76×10^9 ft^3/yr * 0.9 µg/L * {conversion factors} = 99 lb/yr [72 lbs/yr for San Diego Creek subwatershed only][5]

3. Winter season loads are calculated as the sum of rainfall runoff loads and summer season non-stormwater loads, which assumes the same amount of non-stormwater runoff occurs throughout the year:

- Winter season urban runoff load of total selenium = $L_{Summer} + L_{Rain}$ = 26 lbs/yr + 99 lbs/yr = 125 lbs/yr [90.8 lbs/yr for San Diego Creek subwatershed only][5]

Based on these seasonal totals, the average total selenium load from urban areas is estimated to be 160 lbs/year [110 lbs/yr for San Diego Creek subwatershed only].

[4] Since there is some uncertainty in the estimation, the individual values were rounded to the nearest ten when summarized within the tables.

Watershed	Urban Runoff Selenium Load (lbs)[3,4]		
	Annual	Winter Season (10/1 – 3/31)	Summer Season (4/1 – 9/30)
San Diego Creek sub-watershed[1]	110	90	20
Newport Bay Watershed[2]	160	130	30

[1] The area tributary to San Diego Creek
[2] The area tributary to Newport Bay including San Diego Creek, Santa Ana Delhi Channel, Santa Isabel Channel, Big Canyon Wash and Costa Mesa Channel
[3] To address the uncertainty within the dataset, the values are rounded as follows: < 1 to the nearest tenth; 1-10 to the nearest one; > 10 to the nearest ten. Due to the rounding, the individual values do not always add up to the sum shown
[4] The average total selenium concentrations for the winter and summer seasons were 0.9 µg/L and 1.3 µg/L, respectively

These urban runoff load estimates are the first reported for this watershed. USEPA's Toxics TMDLs state that urban loads are insignificant (i.e., not calculated because all sample analytical results available at that time were below detection levels) (USEPA, 2002).

The approach for this estimated urban load uses the best available total selenium data for Costa Mesa Channel as a surrogate subwatershed that is representative of urban areas. Non-stormwater runoff loads for summer and winter season discharges are accounted for separately. The rainfall runoff load is estimated based on concentrations measured in higher flows and runoff volumes calibrated to watershed-wide totals. For example, the 40-year average record used for these precipitation estimates varied from -70 percent to +138 percent of the annual average at the Newport Bay station. It can be assumed that selenium load in the associated urban runoff varies among years by similar amounts. Although the estimated urban load is among the highest within the point source categories, the selenium concentrations are quite low (typically between 1-2 µg Se/L).

7.2.2 Groundwater: Long-term Dewatering

Long-term groundwater dewatering dischargers include the City of Irvine and the California Department of Transportation District 12 (hereafter Caltrans).

In 2002, the Regional Water Board issued Order No. R8-2002-0093 to Caltrans for their discharge of treated groundwater and filter backwash wastewater from the denitrification facility. The Eastern Transportation Corridor (ETC) is a 26-mile tollway connecting Interstate 5 to Route 91 in Orange County. During construction of the ETC, shallow groundwater was encountered within the section originating at Jamboree Road near Edinger Avenue. This section of the tollway is depressed below the existing ground surface. Because of this, a passive subdrain system was constructed to intercept groundwater and maintain the groundwater table at a level below the grade in the vicinity of the tollway. Groundwater dewatering is necessary to maintain and prevent flooding of the roadway. Although a denitrification facility was constructed to treat the pumped groundwater, the groundwater discharges have been sewered due to the elevated concentrations of selenium and the difficulties that were encountered with the denitrification facility.

In 2005, the Regional Water Board issued Order No. R8-2005-0079 to the City of Irvine for their groundwater dewatering facilities at the grade crossing at Culver Drive and BNSF railroad, the grade crossing at Jamboree Road and I-5 freeway; and the proposed undercrossing at Jeffrey Road and BNSF railroad. The City of Irvine has to pump/extract groundwater to lower the groundwater level at the two roadway crossings to prevent flooding of the roadway.

The data from the City of Irvine encompassed the entire June 2003 -June 2008 period of record. For Caltrans, the selenium load data were available for the periods from April 2003 to October 2004 and from February 2006 to August 2008. However, since all of Caltrans' discharges were sewered for the period of June 2003 through June 2008, the load from this source is discussed in a separate category with other sewered discharges below.

USEPA's Toxics TMDLs (2002) recognized the potential significance of the loads from both long-term and short-term groundwater cleanup and dewatering operations. However, no selenium information was available for these discharges at that time. Therefore, selenium load calculations for the groundwater-related operations in this document represent the first effort in quantifying this type of point source of selenium.

7.2.2.1 Load Calculation

Groundwater: Long-term Dewatering Parameters and Assumptions	
Period of Record for Concentration and Discharge Data	2003 - 2008
Decisions/Assumptions	- Seasonal loads summed to calculate the average annual selenium load

The City of Irvine metered its monthly discharges, and the selenium concentrations were monitored at various intervals. The discharges from its two operations had fairly constant monthly averaged selenium concentrations, which were 29.0 ± 6.7 µg Se/L and 21.3 ± 5.1 µg Se/L , respectively, for the Culver and Jamboree sites. The data were presented in monthly reports submitted to the Santa Ana Regional Water Quality Control Board (Regional Board).

The load calculations were carried out by multiplying the selenium concentrations and flow for each month during the period of record. Figure 7-5 shows an example of how this calculation was completed for the Culver site.

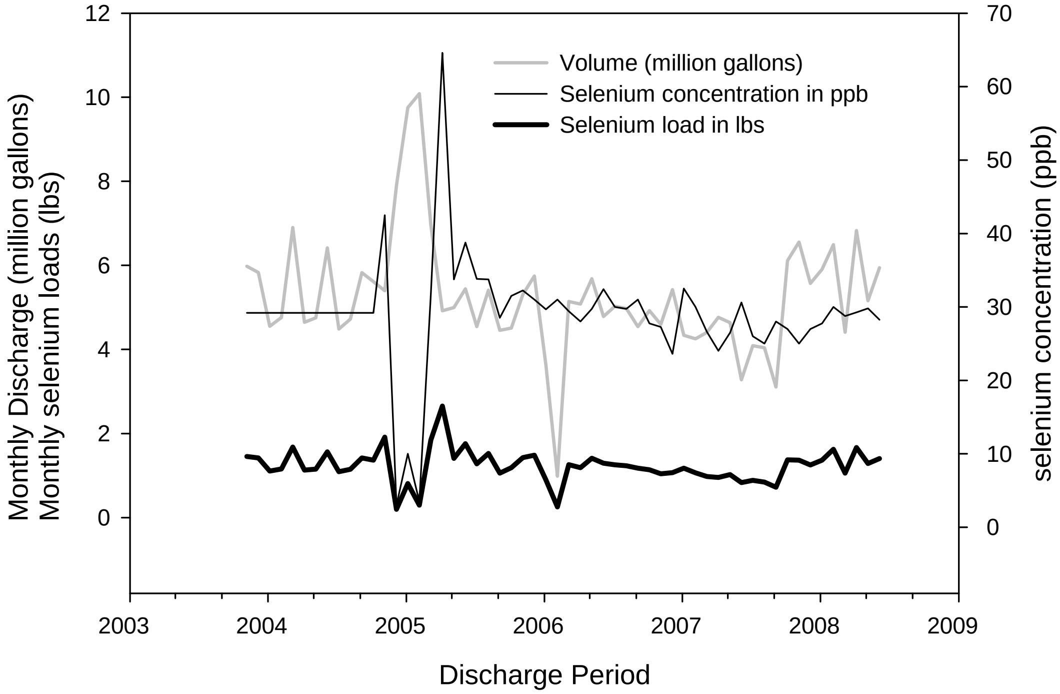


Figure 7-5. Monthly Discharges and Selenium Loads from City of Irvine at Culver Dewatering Operations

The equations that were used for the load calculations are provided below:

*Equation 1 Selenium load (lbs/time) = Flow * Selenium Concentration * Conversion Factor*

In Equation 1, the selenium loads are usually monthly loads in the unit of lbs selenium per month. A conversion factor is needed to reconcile the units for flow and selenium concentration and to convert the result into pounds of selenium per month. For example, during November 2004, a total of 5,398,920 gallons of groundwater was discharged with a selenium concentration of 42.5 µg/L. The monthly selenium load would therefore be calculated as follows:

*Selenium load=5,398,920 gallons*42.5 µg/L*(10^{-9} kg/ug÷0.454 lb/kg*3.785L/gal)=1.91 lbs*

The monthly loads were then aggregated for the winter (October 1 through March 31) and summer (April 1 through September 30) seasons. Finally, the seasonal loads were summed to calculate the average annual selenium load. The load to San Diego Creek subwatershed and Newport Bay watershed from the City of Irvine discharge is the same because the discharge only occurs in the San Diego Creek subwatershed.

Watershed	City of Irvine Groundwater: Long-Term Dewatering Selenium Load (lbs)[3]		
	Annual	Winter season (10/1 – 3/31)	Summer season (4/1 – 9/30)
San Diego Creek sub-watershed[1]	15	7	7
Newport Bay Watershed[2]	15	7	7

[1] The area tributary to San Diego Creek
[2] The area tributary to Newport Bay including San Diego Creek, Santa Ana Delhi Channel, Santa Isabel Channel, Big Canyon Wash and Costa Mesa Channel
[3] To address the uncertainty within the dataset, the values are rounded as follows: < 1 to the nearest tenth; 1-10 to the nearest one; > 10 to the nearest ten. Due to the rounding, the individual values do not always add up to the sum shown.

7.2.3 Groundwater: Short-term Dewatering

Short-term groundwater dewatering activities are covered by seventeen (17) individual discharge authorizations (initially issued under one general permit, Order No. R8-2004-0021, NPDES No. CAG998002), adopted by the Regional Water Board[5]. Individual orders issued to the dischargers are numbered 2004-0021-001 through 2004-0021-017[6]. Data for the five-year period of record (2003-2008) was obtained from monitoring reports provided by the Regional Water Board. Ten of the 17 permittees have reported data to the Regional Board, but only five of those provided data that could be used for the estimated loads. The other five dischargers either have negligible selenium loads (<0.01 lb) or have no selenium data. The remaining seven permitted dischargers have not reported data to the Regional Water Board, which may be because they are not discharging, or they may be sewering their discharges, or both.

In calculating the loads for short-term groundwater dewatering, it was assumed that all available data were obtained. However, this may not be the case if some of the dischargers did not submit data to the Regional Water Board. Thus, when the TMDLs are re-evaluated, the sources and loads should also be re-evaluated to reduce the uncertainty with the estimated loads.

[5] Order No. R8-2004-0021 has been replaced by Order No. R8-2007-0041, NPDES No. CAG918002, as amended.

[6] Discharge authorization for dischargers who require continuing authorization to discharge will be transferred to Order No. 2007-0041, as amended. The number and names of enrollees varies over time.

7.2.3.1 Load Calculation

Groundwater: Short-term Dewatering Parameters and Assumptions	
Period of Record for Concentration and Discharge Data	2003-2008
Decisions/Assumptions	- All available data were obtained - Selenium concentration of 5 µg/L was used for missing data or data reported below the reporting limit (half of the reporting limit)(see discussion below) - For Foothill Engineering a selenium concentration of 10 µg/L was used for missing data or data reported below the reporting limit (see discussion below) - Seasonal loads summed to calculate the average annual selenium load - Annual loads averaged for the five-year period in which the loads were calculated

The data for the groundwater short-term dewatering operations were often sporadic due to the nature of the operations. For all available paired selenium-flow data, the selenium loads were calculated for each month using Equation 1 (used in the *Groundwater: Long-term Dewatering Calculation* above). If there were multiple selenium data for a particular month, the load was calculated based on total flow volume and average total selenium concentration.

For discharges with no selenium data or where selenium was below the reporting limit, an assumed selenium concentration of 5 µg Se/L was used, which was half of the reporting limit of 10 µg Se/L for most of the monitoring reports. Using half of the reporting limit to substitute non-detect values is commonly used on environmental data (e.g. Wendelberger and Campbell, 1994). The exception is Foothill Engineering[7] where six (6) out of fifteen (15) measurements of selenium were above the reporting limits, which ranged from 10 µg Se/L to 50 µg Se/L. The reported concentrations were between 18-140 µg Se/L, with an average of 58.2 µg Se/L. Due to the fact that the reporting limits were not constant for Foothill Engineering, the generally accepted practice of using half of reporting limit to replace non-detect values was not used. Instead, 10 µg Se/L was used for all selenium concentrations below the reporting limit. For the Irvine Ranch Water District (IRWD), the selenium concentrations ranged from 0.59 to 17.6 µg Se/L, with an average of 7.5 µg Se/L. Eleven (11) out of 63 measurements were below reporting limits, which ranged from 0.25 to 10 µg Se/L. An assumed selenium concentration of 5 µg Se/L was used to substitute all values that were below the reporting limit and for those discharges where no selenium measurements were obtained.

[7] Foothill Engineering (full name Foothill Engineering and Dewatering Inc.) provides dewatering services for a number of construction sites within the Newport Bay watershed under permit No. R8-2004-0021-011. Only the site in Irvine located at Von Karman and DuPont yielded detectable amounts of selenium and this site was included in the load calculation.

The monthly selenium loads were summed to calculate the winter and summer season loads and then the seasonal loads were summed for each year to calculate the annual loads. The annual loads were then averaged (normalized) for the five-year period in which the loads were calculated. For example, if the permittee discharged groundwater for only one year in the five-year period, the annual load was divided by 5 to convert the load to a five-year average annual selenium load. This adjustment was necessary to make the selenium load calculations consistent throughout the period of record. However, it should be recognized that the short-term discharges and resulting loads are actually highly variable.

Due to the uncertainties associated with the assumed values for missing data and those below the reporting limit, the load calculations for some dischargers may be expressed as a range of reasonable values rather than a single fixed value. For example, for Foothill Engineering Company, 20 µg Se/L may be a reasonable upper limit estimate for the samples below the reporting limit, in view of the high reporting limits and high average concentrations for the detected samples. Similarly, 5 µg Se/L could be a reasonable lower limit for these samples. Therefore, a range of values could be used for this particular discharger.

Similar issues exist for other dischargers such as The Irvine Company and IRWD, but the differences in gross loads were insignificant (<1 lb). However, in order to provide clarity for the final load estimates, only single values based on best reasonable estimates are used. It should be understood that many data have intrinsic uncertainties due to the limited amount of available knowledge about the raw data and analytical methodologies.

Watershed	Groundwater: Short-Term Dewatering Selenium Load (lbs)[3]		
	Annual	Winter Season (10/1 – 3/31)	Summer Season (4/1 – 9/30)
San Diego Creek sub-watershed[1]	60	30	30
Newport Bay Watershed[2]	80	40	40

[1] The area tributary to San Diego Creek
[2] The area tributary to Newport Bay including San Diego Creek, Santa Ana Delhi Channel, Santa Isabel Channel, Big Canyon Wash and Costa Mesa Channel
[3] To address the uncertainty within the dataset, the values are rounded as follows: < 1 to the nearest tenth; 1-10 to the nearest one; > 10 to the nearest ten. Due to the rounding, the individual values do not always add up to the sum shown.

For San Diego Creek sub-watershed, the loads from this category were dominated by Foothill Engineering Company, which contributed about 50 lbs of selenium per year. For the entire watershed, Nexus is the only other significant contributor, accounting for about 18 lbs of selenium. The concentrations for these two dischargers were 58.2 ± 48.5 and 38.9 ± 2.7 µg Se/L, respectively. Selenium concentrations for the discharges from other dischargers varied considerably; however, the load contributions were relatively minor.

7.2.4 Groundwater Cleanup: Long-term[8]

Long-term groundwater cleanup activities are covered by eleven (11) individual discharge authorizations under general permit Order No. R8-2002-0007, NPDES No. CAG918001[9]. Regional Water Board staff provided the available data reports for the five-year period of record (2003-2008). Out of these permittees, only three had submitted data. The Marine Corp Air Station (MCAS) Tustin was the only discharger that provided a complete dataset.

7.2.4.1 Load Calculation

Groundwater Cleanup: Long-term Parameters and Assumptions	
Period of Record for Concentration and Discharge Data	2003 - 2008
Decisions/Assumptions	- All available data were obtained - Selenium concentration of 5 µg/L was used for missing data or data reported below the reporting limit (half of the reporting limit) - Only data from Marine Corp Air Station (MCAS) Tustin was utilized for this calculation - Summer and winter season discharges aggregated separately before being summed to yield annual loads

The load calculations and corrections for groundwater cleanup operations were carried out as for groundwater short-term discharges, as described above, and the period of record was consistent (2003-2008). For MCAS Tustin, the dominant discharger in this category, the dataset was in the same format as that submitted by the City of Irvine. Therefore, the calculation was identical to the one for the City of Irvine data (see Figure 7-5). For the other dischargers that did not have data that could be used, a selenium concentration of 5 µg Se/L was assumed, and the volumes of discharges were assumed to be the same as those permitted by the corresponding discharge authorization letters.

The annual loads from these discharges were evenly divided for summer and winter season loads. For example, Baxter Healthcare Corporation in Irvine (hereafter Baxter) had a permitted discharge of 57,600 gallons per day. Assuming this is the constant discharge rate, and assuming a 5 µg/L selenium concentration for the discharge, the annual selenium load from Baxter would be:

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[8] It should be noted that most permittees are not continuously discharging at the conservative levels used for this calculation, nor typically at the permitted levels.

[9] Order No. R8-2002-0007 has been replaced by Order No. R8-2007-0008, NPDES No. CAG918001 and, for groundwater cleanup discharges in the Newport Bay watershed, by Order No. R8-2007-0041, NPDES No. CAG918002.

*57600 lb/day * 365 day * 5 µg/L * (10^{-9} kg/ug÷0.454 kg/lb * 3.785L/gal) = 0.88 pounds*

The load was divided into 0.44 pounds of selenium for both summer and winter seasons.

For dischargers with monthly data, each monthly load was classified as either summer season (April 1-September 30) or winter season (October 1-March 31). The summer and winter season discharges were aggregated separately before being summed to yield the annual loads. The loads to the San Diego Creek subwatershed and Newport Bay watershed are the same because, based on the available data, it was necessary to assume that these discharges only occurred in the San Diego Creek sub-watershed.

Watershed	Groundwater Cleanup: Long Term Selenium Load (lbs)[3]		
	Annual	Winter Season (10/1 – 3/31)	Summer Season 4/1 – 9/30)
San Diego Creek sub-watershed[1]	30	20	20
Newport Bay Watershed[2]	30	20	20

[1] The area tributary to San Diego Creek
[2] The area tributary to Newport Bay including San Diego Creek, Santa Ana Delhi Channel, Santa Isabel Channel, Big Canyon Wash and Costa Mesa Channel
[3] To address the uncertainty within the dataset, the values are rounded as follows: < 1 to the nearest tenth; 1-10 to the nearest one; > 10 to the nearest ten. Due to the rounding, the individual values do not always add up to the sum shown.

The loads from this category were dominated by the discharge from MCAS Tustin, which contributed about 22 lb Se/yr until September 2007, when it started sewering its groundwater discharge. The selenium concentrations were 89.3 ± 49.2 µg Se/L. The variance was primarily based on the fact that MCAS has two locations with different average concentrations.

7.2.5 Groundwater Cleanup: Short Term/Mobile Systems[10]

Mobile groundwater cleanup activities are covered by eight (8) individual discharge authorizations under general permit, Order No. R8-2002-0007, NPDES No. CAG918001[11]).However, no data had been submitted to the Regional Board from this group of dischargers during the period of record (2003-2008).

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[10] It should be noted that most permittees are not continuously discharging at the conservative levels used for this calculation, nor typically at the permitted levels

[11] Order No. R8-2002-0007 has been replaced by Order No. R8-2007-0008, NPDES No. CAG918001 and, for groundwater cleanup discharges in the Newport Bay watershed, by Order No. R8-2007-0041, NPDES No. CAG918002.

7.2.5.1 Load Calculation

Groundwater Cleanup: Short-term/Mobile Systems Parameters and Assumptions	
Period of Record for Concentration and Discharge Data	2003 - 2008
Decisions/Assumptions	- No specific data available for these dischargers - Assume all dischargers are accounted for in the estimate - Selenium concentration of 5 µg/L was used for missing data - All dischargers discharged the permitted volume

The load calculation and corrections were carried out in a fashion similar to the long-term groundwater cleanup operations (see the previous example for Baxter). Since data were not available for the mobile operators, it was conservatively assumed that they discharged at the limit set forth by the corresponding discharging authorization letters, hence assuming all dischargers are accounted for in this estimate. The selenium concentration was assumed to be 5 µg Se/L for all discharges. The discharges for winter and summer seasons were also assumed to be the same.

Watershed	**Groundwater Cleanup: Short Term/ Mobile Systems Selenium Load (lbs)[3]**		
	Annual	**Winter Season (10/1 – 3/31)**	**Summer Season (4/1 – 9/30)**
San Diego Creek sub-watershed[1]	2	0.8	0.8
Newport Bay Watershed[2]	2	0.8	0.8

[1] The area tributary to San Diego Creek
[2] The area tributary to Newport Bay including San Diego Creek, Santa Ana Delhi Channel, Santa Isabel Channel, Big Canyon Wash and Costa Mesa Channel
[3] To address the uncertainty within the dataset, the values are rounded as follows: < 1 to the nearest tenth; 1-10 to the nearest one; > 10 to the nearest ten. Due to the rounding, the individual values do not always add up to the sum shown.

7.2.6 Sewered Groundwater Discharges

There are currently a number of dischargers that discharge their groundwater into the Orange County Sanitation District (OCSD) sewer lines under a Special Purpose Discharge Permit (SPDP). Caltrans has sewered its groundwater for the periods of September 1999 to June 2001 and April 2003 until present. The Marine Corps Air Station (MCAS) at Tustin started sewering its groundwater discharges on September 26, 2007. There are also a number of smaller dischargers in the Newport Bay watershed that sewer their groundwater. Even though sewered discharges do not constitute loads to the receiving waters, they were considered for potential future discharges due to regulatory uncertainties associated with the discharging cap for selenium for OCSD's ocean outfall. This discharge cap contains limits on both concentration and loading (WDR Order 2004-0062, NPDES # CA 0110604). Therefore, sewered dischargers are classified as a separate category that includes all sewered discharges for the period of June 2003 through 2008.

7.2.6.1 Load Calculation

Sewered Groundwater Discharges Parameters and Assumptions	
Period of Record for Concentration and Flow Data	2003 – 2008
Decisions/Assumptions	- Considered for potential future discharges - Assume all dischargers are accounted for in the estimate

The load calculation and corrections for sewered discharges were calculated as follows.

For MCAS Tustin and Caltrans, which have datasets that include discharge volume and selenium concentration, the load calculations follow the same procedure as that for the City of Irvine (see Figure 7-5 and Equation 1).

For other dischargers, the data submitted to OCSD included flow data in million gallons per day (mgd) and selenium concentrations in the discharges to OCSD. One of the discharge points had a flow of 0.04 mgd and a measured selenium concentration of 0.038 (mg/L). Therefore, the annual selenium load was calculated as follows:

$$0.04 * 10^{6}\ gal/d * 0.038\ mg/L * 365\ d/yr * 10^{-6}\ kg/mg * 3.785\ L/gal \div 0.454\ kg/lb = 4.75\ lb/yr$$

Selenium loads from the discharge points were similarly calculated and summed to be the aggregate load for this single discharger. The aggregate annual load was then divided evenly for summer and winter seasons. OCSD indicated that these dischargers were all long-term dischargers, and the number of dischargers remained stable. Therefore, the calculated annual loads were not normalized for the five-year period.

Watershed	Sewered Groundwater Discharges Selenium Load (lbs)[3]		
	Annual	Winter Season (10/1 – 3/31)	Summer Season (4/1 – 9/30)
San Diego Creek sub-watershed[1]	100	50	50
Newport Bay Watershed[2]	100	50	50

[1] The area tributary to San Diego Creek
[2] The area tributary to Newport Bay including San Diego Creek, Santa Ana Delhi Channel, Santa Isabel Channel, Big Canyon Wash and Costa Mesa Channel
[3] To address the uncertainty within the dataset, the values are rounded as follows: < 1 to the nearest tenth; 1-10 to the nearest one; > 10 to the nearest ten. Due to the rounding, the individual values do not always add up to the sum shown.

The loads were dominated by two major dischargers, Caltrans and MCAS Tustin.

7.2.7 Nursery Operations

USEPA's Toxics TMDLs included nursery operations (both permitted and unpermitted operations). This load was estimated to be about ~32 lbs/year (annual), ~4% of the total load (USEPA, 2002). USEPA's Toxics TMDLs point out that the nurseries were not considered major sources other than possibly during rain events; even then, the load could not be fully characterized.

For this effort, an evaluation of the nursery discharge data identified numerous non-detect values for the majority of samples and also found that the nurseries used a method detection limit of 10 µg Se/L. As a result, it is unclear whether their discharges exceeded the water quality criterion of 5 µg Se/L. This, combined with the limited total area in the watershed (~750 total acres) and the pending closure of the larger nursery operations, support consideration of the total selenium load from "Nursery Operations" (both permitted and un-permitted) as insignificant at this time. Therefore, the total load from the nurseries is being excluded as a point source load category. However, the Regional Monitoring Program for these TMDLs (see Section 12.5, Task 9) will require targeted monitoring with lower detection limits at the nurseries to better characterize selenium loads and to confirm the insignificant nature of the discharges. If monitoring results show that discharges from nurseries are significant, then nursery operations will be added as point source load category in a future TMDL revision.

7.2.8 Estimated Point Source Load Totals

The estimated totals for the point sources are summarized below. The point sources account for approximately 30% of the total selenium load within each of the watersheds.

Watershed	Point Source Combined Loads Selenium Load (lbs)[3]		
	Annual	Winter Season (10/1 – 3/31)	Summer Season (4/1 – 9/30)
San Diego Creek sub-watershed[1]	320	200	130
Newport Bay Watershed[2]	390	250	150

[1] The area tributary to San Diego Creek
[2] The area tributary to Newport Bay including San Diego Creek, Santa Ana Delhi Channel, Santa Isabel Channel, Big Canyon Wash and Costa Mesa Channel
[3] To address the uncertainty within the dataset, the values are rounded as follows: < 1 to the nearest tenth; 1-10 to the nearest one; > 10 to the nearest ten. Due to the rounding, the individual values do not always add up to the sum shown.

7.3 Non-Point Sources (NPS)

Data used to calculate the total selenium load from each non-point source are presented in this section.

7.3.1 Agriculture and Open Space

Loads were estimated based on multiplying the average total selenium concentrations in water, as measured in runoff from each NPS category, by the annual precipitation runoff from each representative NPS land use category of the watershed.

7.3.1.1 Runoff Calculation

Average annual rainfall runoff was computed for each land use type as:

*Average annual runoff = runoff coefficient * annual average rainfall * land use area*

Input values were estimated as follows:

- Precipitation records for eight stations within and adjacent to the watershed were obtained for a 40-year period, from 1966 through 2005. Annual average rainfall results were spatially-averaged for segments of the watershed using the Thiessen polygon method, and the spatial average was estimated to be 1.1 ft/year (Figure 7-6).
- Runoff coefficients were estimated as: Agriculture = 0.10 and Open Space = 0.10 (Coefficients were area-weighted averages by land use class within each category and were taken from the Toxics TMDL, Appendix D [USEPA, 2002])
- The area in square feet for each land use type was calculated from the GIS data as Agriculture = 254,400,059 ft^2 and Open Space = 1,070,122,554 ft^2

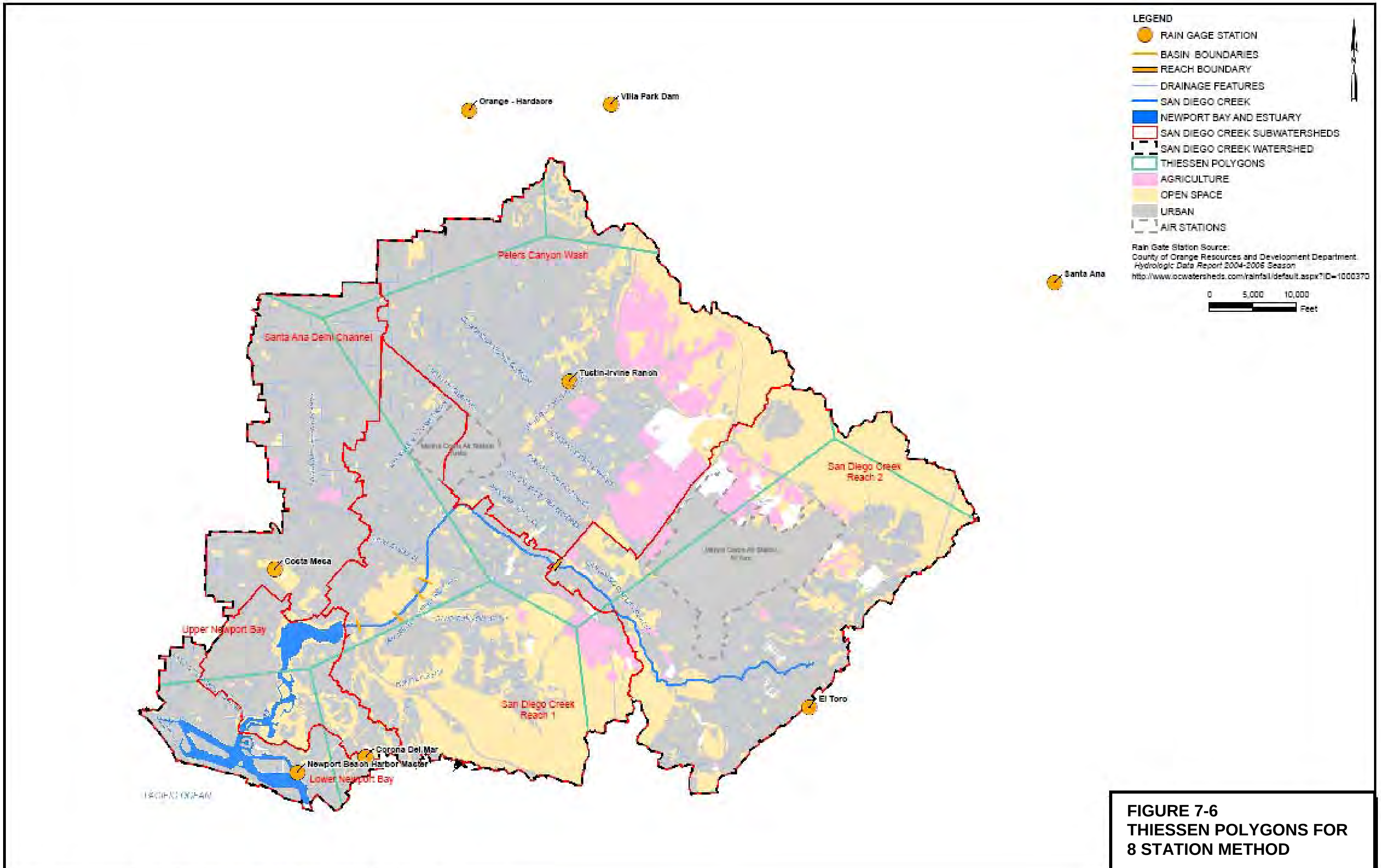

FIGURE 7-6
THIESSEN POLYGONS FOR 8 STATION METHOD

Figure 7-7 identifies the stations that were used to estimate the loads as well as the land use categories and their respective areas.

Land-use specific selenium concentrations and load in rainfall runoff

The Nitrogen and Selenium Management Program (NSMP) database was searched for water quality monitoring stations immediately downstream of areas in the watershed dominated by the individual NPS land use categories. The selenium concentrations during the winter season when discharges exceeded the low flow baseline for that station were assumed to represent active surface runoff at these stations. Those runoff-associated concentrations were averaged to yield geometric mean[12] selenium concentrations in runoff by land use type.

Agricultural land use geometric means were computed from ACWF18, Agua Chinon Channel; open space geometric means were computed from BCF04, Bonita Canyon, except for the Hicks Canyon portion, which was estimated to produce higher selenium concentrations (based on a March 2003 storm, [Meixner et al., 2004]). Load was computed as a geometric mean selenium concentration times total annual rainfall runoff (adjusting for units).

It is assumed that agricultural and open space land uses do not generate summer weather runoff in the same manner as does urban (i.e., any summer weather flows from those areas are from rising groundwater, not runoff, and were not averaged here) because many agricultural operators and the majority of the nurseries in the watershed recycle their irrigation water during the dry season.

Estimated annual NPS runoff and selenium concentrations and loads in the Newport Bay and San Diego Creek sub-watersheds by land use are summarized below.

NPS Category	Annual Runoff (ft^3/year)	Geometric Mean Selenium Concentration (µg/L) (range)	Annual Selenium Load (lb/yr) Newport Watershed[2]	Annual Selenium Load (lb/yr) San Diego Creek Sub-watershed[1]
Agricultural	27,984,006	1.5 (1 – 6.8)	3	3
Open Space (Hicks Canyon)	7,973,511	5.9 (NA)	3	3
Open Space (other)	109,739,970	1.8 (1 – 3.5)	10	10
Total Open Space	117,713,481	-	13	13

[1] The area tributary to San Diego Creek
[2] The area tributary to Newport Bay including San Diego Creek, Santa Ana Delhi Channel, Santa Isabel Channel, Big Canyon Wash and Costa Mesa Channel

[12] Environmental data, in general, tend to have a wide range and high outliers and central tendency is best represented by geometric mean (or median) rather than the arithmetic mean (Gilbert 1987).

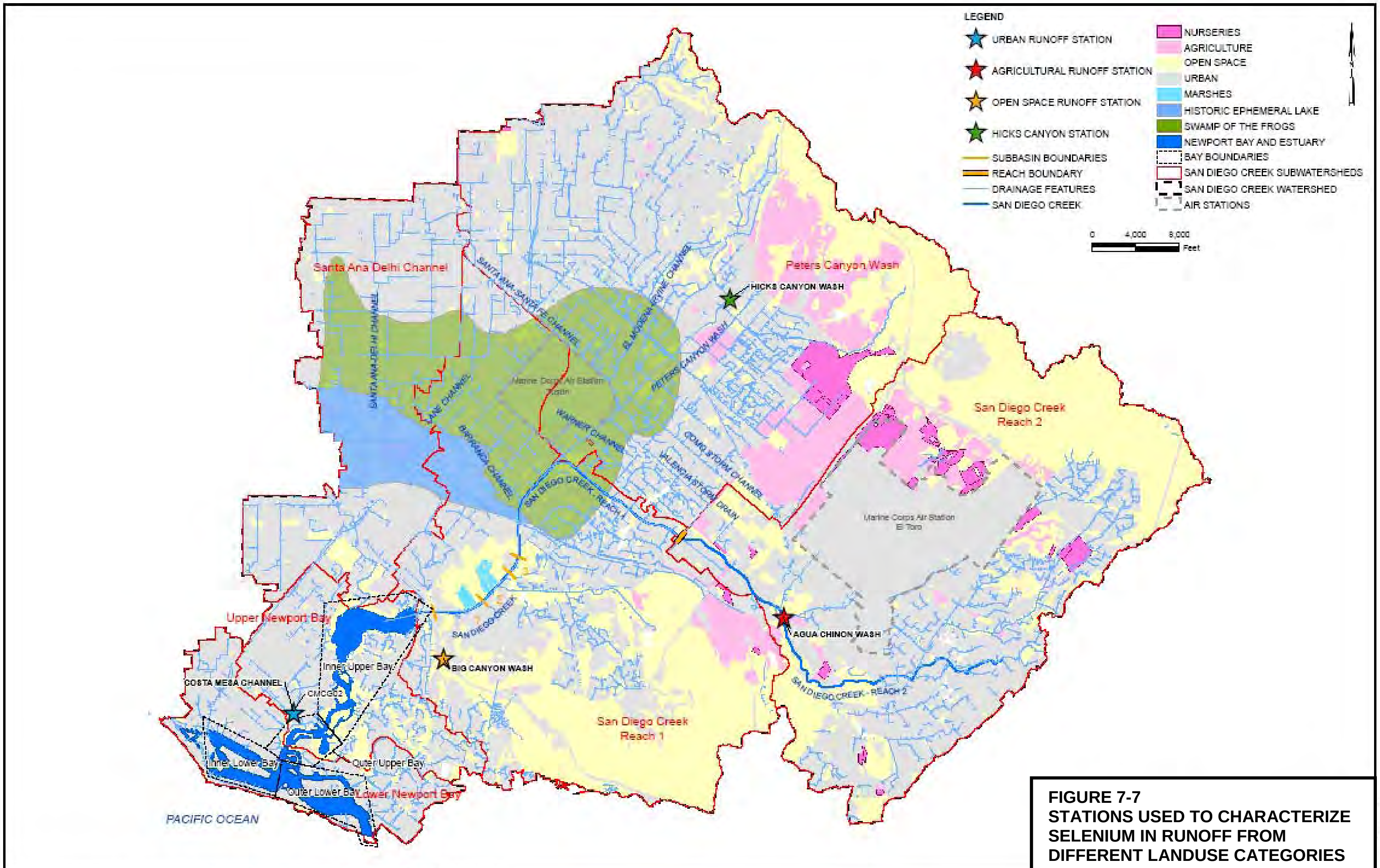

FIGURE 7-7
STATIONS USED TO CHARACTERIZE SELENIUM IN RUNOFF FROM DIFFERENT LANDUSE CATEGORIES

USEPA's Toxics TMDLs grouped NPS loads as agricultural (65.6 lbs Se/yr) versus "undefined total" runoff (621 lbs Se/yr) (USEPA, 2002). This "undefined total" estimate in the earlier TMDLs included groundwater from NPS as well as open space and urban runoff.

7.3.2 Rising Groundwater

Groundwater selenium loads are from groundwater seepage into drainage channels and creeks that are not part of permitted, point-source groundwater discharges. The sources are too diffuse to allow direct measurement of flow volumes or selenium concentrations. Loads were estimated using two methods, described below.

1) Groundwater loads were estimated to be 96% of total Se loads discharging into Newport Bay, following the method presented in the Sources and Loads report (CH2MHILL, 2009d), as based on the conclusions of Meixner et al. (2004). This factor acknowledges the preponderance of rising groundwater in total surface water loads. Additionally, San Diego Creek (SDC) is assumed to lose 40% of its selenium load to unknown processes prior to measurement at Campus Drive; the true load is assumed to be proportionally higher than what was measured (CH2MHILL, 2009d as per Meixner et al., 2004). In contrast, Santa Ana Delhi Channel (SADC) and Big Canyon Wash (BCW) were assessed for NPS groundwater Se loads by applying the 96% factor but not the additional 40% loss. Big Canyon Wash loads are roughly estimated from four paired data points of concentration and flow (CH2MHILL, 2008). All three subbasins drain areas of known, elevated Se concentrations in rising groundwater.

The estimated annual loads of total selenium from NPS groundwater sources to Newport Bay using Method 1 are:

- SDC = 870 lbs/year (2002-2007 average, adjusted upwards by 40%)[13]
- SADC = 80 lbs/year (2002-2007average)
- BCW = 90 lbs/year (estimate based on four data points collected in the period)
- Total NPS groundwater load (Method 1) = 1,040 lbs/year to Newport Bay

2) Individual estimates of point source and non- groundwater NPS loads for individual subbasins can be subtracted from the total loads. The difference represents rising groundwater. The same method can be applied to estimate groundwater loads in SDC and SADC, but separate land-use delineations were not available for BCW (and, therefore, this method was not applied to BCW)[14]. Using this subtraction technique:

> *NPS groundwater load = Measured watershed total load – (all point and non-groundwater NPS loads*)

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[13] Total annual loads at Campus Dr. (546) are divided by 0.6 to get total watershed loads (910) (including the "lost load") then multiplied times 0.96 to get the GW portion.

[14] It is recognized that this method may underestimate the loads from rising groundwater due to the conservative assumptions in the estimates. During the TMDL re-evaluation the sources and loads estimates should be re-calculated using the most recent data and information in order to refine these estimates.

For SDC, the total load estimate was 910 lbs Se/year with an estimated NPS groundwater component, by subtraction, of 580 lbs/year (64%). For SADC, the NPS groundwater load was estimated to be 60 lbs/year out of 80 lbs total (75%). These estimates are lower than the earlier Meixner et al. (2004) estimate of groundwater as 96% of total loads for SDC (the basis for Method 1, above). Using Method 2 (in combination with unchanged BCW load), the total NPS groundwater load was estimated to be 730 lbs/year to Newport Bay.

The average from Methods 1 and 2 for NPS groundwater load is 800 lbs Se/year to Newport Bay from SDC, SADC, and BCW. For SDC alone, the average total is estimated to be 730 lbs Se/year.

Separation by season was possible using method 2, for the San Diego Creek subwatershed because winter and summer season estimates were available for that drainage for the period 2002 through 2007. Since the seasonally-separated loads for rising groundwater were only estimated using method 2, they would not add to the annual total as presented in the table (i.e., the average of methods 1 and 2). Therefore, the percentages of winter and summer season loads from method 2 were applied to the annual average loads. This was computed as the average of methods 1 and 2 and those percentages (71% of the total as winter season and 29% of the total as summer season) and were applied to both the San Diego Creek subwatershed and the Newport Bay watershed as shown in the table below.

Watershed	Rising Groundwater Selenium Load (lbs)[4]		
	Annual	Winter Season (10/1 – 3/31)	Summer Season (4/1 – 9/30)
San Diego Creek sub-watershed[1,3]	730	520	210
Newport Bay Watershed[2,3]	800	570	230

[1] The area tributary to San Diego Creek
[2] The area tributary to Newport Bay including San Diego Creek, Santa Ana Delhi Channel, Santa Isabel Channel, Big Canyon Wash and Costa Mesa Channel
[3] Annual totals are averages of methods 1 and 2 (above) while winter and summer season values are the percentages as derived from method 2.
[4] To address the uncertainty within the dataset, the values are rounded as follows: < 1 to the nearest tenth; 1-10 to the nearest one; > 10 to the nearest ten. Due to the rounding, the individual values do not always add up to the sum shown.

USEPA's Toxics TMDLs estimate for NPS groundwater loads was incorporated as part of their "undefined total" load of 621 lbs Se/year (USEPA, 2002). In contrast, this document estimates that the comparable categories of agricultural and open space, plus NPS groundwater loads, total 820 lbs Se/year. The difference in load totals between the two TMDL summaries originates from both the uncertainty of loads from rising groundwater, estimated from different years of record, and the incorporation of more data and different techniques of estimation in the most recent load summary.

7.3.3 Atmospheric Deposition

Annual winter and summer atmospheric deposition directly onto open water was measured in the watershed using collectors that separately collected dry deposition to a water surface and also measure selenium concentration in rain water (CH2MHILL, 2009d). Atmospheric deposition onto the landscape should be accounted for as some portion of the other NPS loads, however this is assumed to be a very minor source of the total selenium measured in surface runoff. The total atmospheric deposition for the year was divided by the area of the collector surface to yield a spatially-averaged deposition rate. The deposition rate for the freshwater drainage was estimated as the spatially-averaged deposition rate multiplied by the surface area of the drainage channels and creeks (using an assumption of 15 feet as an average width over the measured channel lengths).

The surface area of Newport Bay was used for the estimate of direct atmospheric load to the bay itself. Total (winter and summer season) annual atmospheric deposition of selenium directly onto water surfaces in the San Diego Creek subwatershed and onto Newport Bay was estimated to be 4 lbs/year for water year 2003. In this dry, southern California climate, the summer season load of 3 lbs Se/year was greater than the winter season load of 0.8 lbs Se/year. USEPA's Toxics TMDLs listed winter and summer atmospheric deposition load to Newport Bay, alone, (not including channels) as 1.4 lbs Se/year (USEPA, 2002). The small portion from the channels of the San Diego Creek subwatershed drainage is estimated to be 0.3 lbs Se/year.

Watershed	Atmospheric Deposition Selenium Load (lbs)[3]		
	Annual	Winter Season (10/1 – 3/31)	Summer Season (4/1 – 9/30)
San Diego Creek sub-watershed[1]	0.3	0.1	0.2
Newport Bay Watershed[2]	4	0.8	3

[1] The area tributary to San Diego Creek
[2] The area tributary to Newport Bay including San Diego Creek, Santa Ana Delhi Channel, Santa Isabel Channel, Big Canyon Wash and Costa Mesa Channel
[3] To address the uncertainty within the dataset, the values are rounded as follows: < 1 to the nearest tenth; 1-10 to the nearest one; > 10 to the nearest ten. Due to the rounding, the individual values do not always add up to the sum shown.

7.3.4 Estimated NPS Load Totals

The estimated totals for the non-point sources are summarized below. The non-point sources account for approximately 70% of the total selenium load within each of the watersheds.

Watershed	Non-Point Source Combined Loads Selenium Load (lbs)[3]		
	Annual	Winter Season (10/1 – 3/31)	Summer Season (4/1 – 9/30)
San Diego Creek sub-watershed[1]	740	530	210
Newport Bay Watershed[2]	820	580	230

[1] The area tributary to San Diego Creek
[2] The area tributary to Newport Bay including San Diego Creek, Santa Ana Delhi Channel, Santa Isabel Channel, Big Canyon Wash and Costa Mesa Channel
[3] To address the uncertainty within the dataset, the values are rounded as follows: < 1 to the nearest tenth; 1-10 to the nearest one; > 10 to the nearest ten. Due to the rounding, the individual values do not always add up to the sum shown.

7.4 Summary

Table 7-1 and Figures 7-8 and 7-9 provide an overview of the total loads and estimated percentage of the load attributed to each source for selenium within both San Diego Creek subwatershed, which contributes the majority of the selenium loads, and the remaining subwatersheds (e.g., Santa Ana Delhi Channel subwatershed) that comprise the Newport Bay watershed.

Table 7-1. Selenium Sources and Estimated Loads for the Newport Bay Watershed[1]

Source	Se Load (lbs)					
	Annual		Winter Season (10/1-3/31)		Summer Season (4/1-09/30)	
Point Sources						
Urban Runoff	**160**		**130**		**30**	
San Diego Creek Sub-watershed		*110*		*90*		*20*
Remaining Sub-watersheds		*50*		*40*		*10*
GW Long-term Dewatering	**15**		**7**		**7**	
San Diego Creek Sub-watershed		*15*		*7*		*7*
Remaining Sub-watersheds		*---*		*---*		*---*
GW Short-term Dewatering	**80**		**40**		**40**	
San Diego Creek Sub-watershed		*60*		*30*		*30*
Remaining Sub-watersheds		*20*		*10*		*10*
GW Clean-up (Long Term) [2]	**30**		**20**		**20**	
San Diego Creek Sub-watershed		*30*		*20*		*20*
Remaining Sub-watersheds		*---*		*---*		*---*
GW Clean-up (Short Term/Mobile Systems)	**2**		**0.8**		**0.8**	
San Diego Creek Sub-watershed		*2*		*0.8*		*0.8*
Remaining Sub-watersheds		*---*		*---*		*---*
Sewered GW Discharges [3]	**100**		**50**		**50**	
San Diego Creek Sub-watershed		*100*		*50*		*50*
Remaining Sub-watersheds		*2*		*1*		*1*
Nursery Operations [4]	**N/A**		**N/A**		**N/A**	
Point Source Totals	**390**		**250**		**150**	
San Diego Creek Sub-watershed		*320*		*200*		*130*
Remaining Sub-watersheds		*70*		*50*		*20*

Table 7-1. Selenium Sources and Estimated Loads for the Newport Bay Watershed[1] (cont'd)

Source	Se Load (lbs)					
	Annual		Winter Season (10/1-3/31)		Summer Season (4/1-09/30)	
Nonpoint Source						
Agricultural Discharges	**3**		**3**		**N/A**	
San Diego Creek Sub-watershed		*3*		*3*		*N/A*
Remaining Sub-watersheds		---		---		---
Atmospheric Deposition	**4**		**0.8**		**3**	
San Diego Creek Sub-watershed		*0.3*		*0.1*		*0.2*
Remaining Sub-watersheds		*4.0*		*0.7*		*3.0*
Open Space	**15**		**15**		**N/A**	
San Diego Creek Sub-watershed		*10*		*10*		*N/A*
Remaining Sub-watersheds		*3*		*3*		*N/A*
Rising Groundwater	**800**		**570**		**230**	
San Diego Creek Sub-watershed		*730*		*520*		*210*
Remaining Sub-watersheds		*70*		*50*		*20*
Nonpoint Source Totals	**820**		**580**		**230**	
San Diego Creek Sub-watershed		*740*		*530*		*210*
Remaining Sub-watersheds		*80*		*50*		*20*
Total Estimated Load	**1,210**		**830**		**380**	
San Diego Creek Sub-watershed		*1,060*		*730*		*340*
Remaining Sub-watersheds		*150*		*100*		*40*

[1] To address the uncertainty within the dataset, the values are rounded as follows: < 1 to the nearest tenth; 1-10 to the nearest one; > 10 to the nearest ten. Due to the rounding, the individual values do not always add up to the sum shown. The uncertainty will also be accounted for within the TMDL margin of safety (MOS).

[2] Both City of Irvine Culver and Jamboree locations. *N/A Not Applicable*

[3] Special discharge permits were issued by OCSD for sewered discharged and it should be noted these discharges did not reach receiving waters in the Newport Bay watershed.

[4] Due to existing data results of non-detect for the majority of samples from nurseries, the limited total area in the watershed (~750 total acres), and the pending closure of the larger nursery operations, the total selenium load from "Nursery Operations" (both permitted and un-permitted) is considered insignificant at this time and is therefore being excluded as a point sourceload category. However, the TMDL implementation plan will require targeted monitoring with lower detection limits at the nurseries to better characterize selenium loads and to confirm the insignificant nature of the discharges. If monitoring results show that discharges from nurseries are significant, then nursery operations will be added as point source load category in a future TMDL revision.

Figure 7-8. Total Estimated % Load for Selenium in the San Diego Creek Sub-watershed

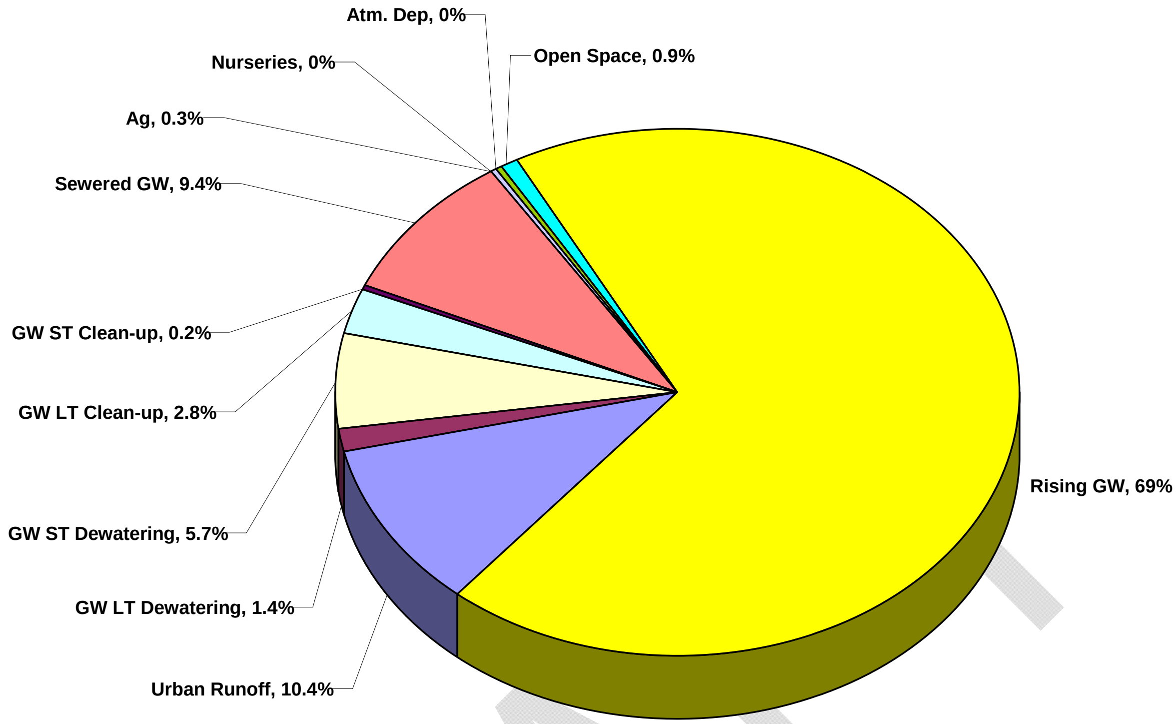
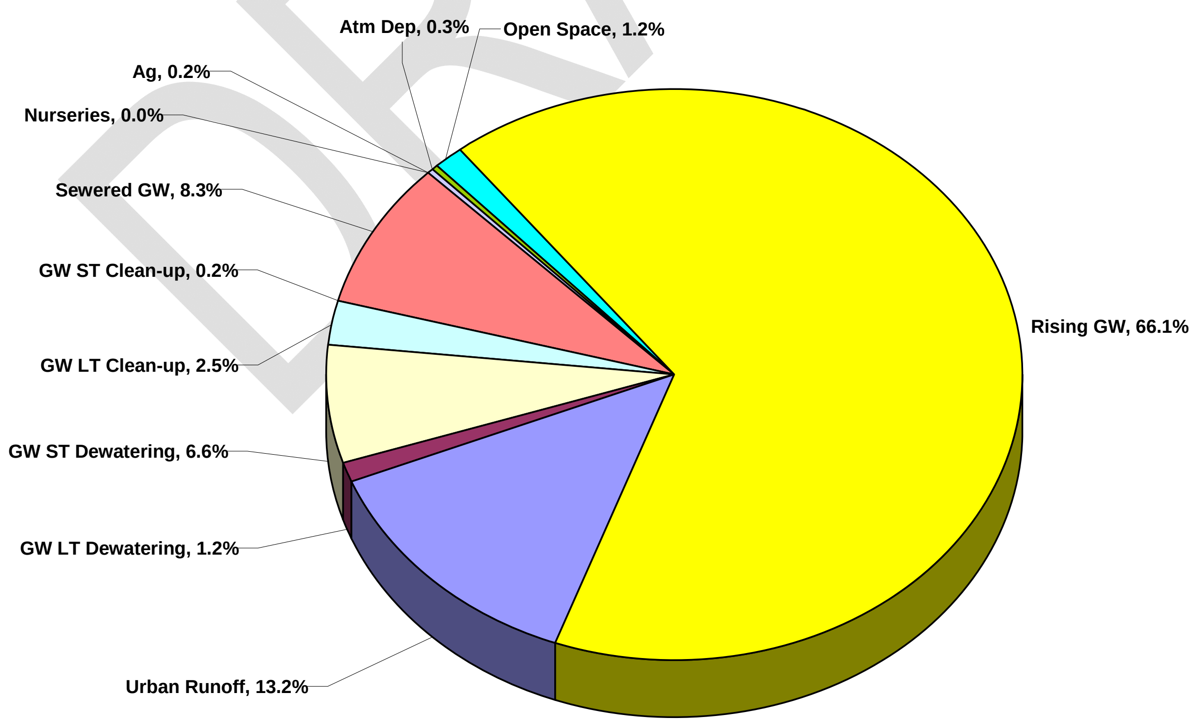


Figure 7-9. Total Estimated % Load for Selenium in the Newport Bay Watershed



A review of USEPA's Toxics TMDLs (USEPA, 2002) summary document and Technical Support Document, Part D, indicates that USEPA did not quantify the loads from each of the point and non-point sources identified in the table above; rather, discrete analyses were completed and qualitative conclusions were drawn based on the limited data available at that time. USEPA's major conclusions are summarized below:

- Selenium loadings are estimated to come primarily from erosion, runoff, and discharges of shallow groundwater (USEPA, 2002: Summary Document, page 12).
- An investigation of selenium sources shows that shallow groundwater is a significant and constant source of selenium to surface waters in the San Diego Creek watershed (Hibbs and Lee, 2000). Groundwater may seep into surface waters via natural processes, or it may be pumped as part of groundwater cleanup or dewatering operations that discharge into surface waters. Thus, selenium contributions to the watershed include both non-point sources (seepage) and point sources (cleanup and dewatering) (USEPA, 2002: Summary Document, page 34).
- Urban runoff has been found to contain very low selenium concentrations (< 1.5 μg/L) (Lee and Taylor 2001) (USEPA, 2002: Summary Document, page 35).
- Atmospheric deposition of selenium is not significant compared to loading from San Diego Creek and other freshwater tributaries (Mosher and Duce 1989) (Summary Document, page 35).
- Nursery runoff shows moderate concentrations (~10 μg Se/L) in dry weather and is a potential source during storms (Lee and Taylor, 2001) (USEPA, 2002: Summary Document, page 35).
- There is some evidence that runoff from open space, hillsides, and agricultural lands are significant sources during rain events, although this evidence is inconclusive. (USEPA, 2002: Summary Document, page 35).
- Groundwater seepage/infiltration, treated groundwater discharges, and groundwater dewatering discharges represent significant and constant sources (USEPA, 2002: Summary Document, page 35).
- The residential runoff reduction study results show that all samples were below detection limits of the analytical methods used (1.5 μg Se/L and 5 μg Se/L). This suggests that urban runoff is not a significant source of selenium (USEPA, 2002: Technical Support Document, Part D-13).
- Atmospheric deposition is insignificant compared to the load at Campus Drive in San Diego Creek (USEPA, 2002: Technical Support Document, Part D-13).
- Statistical analysis of the data has estimated the annual selenium load to be 2,443 lbs from 4/1/98 to 3/31/99 (USEPA, 2002: Technical Support Document, Part D-14).

A side-by-side comparison could not be made with the USEPA Toxics TMDLs for selenium, since these TMDLs did not have similar existing load estimates. This variance is to be expected since the USEPA estimate used a limited set of data, used a limited period of record, used a series of different assumptions, and did not appear to parse out the sources and loads in the detail that this effort did. It is expected that the load estimates will continue to be refined over time, as more data are collected and additional special studies are completed.

The selenium loads estimated for San Diego Creek at Campus Drive can vary from estimates based on source load data for several reasons, including the following:

- Water volumes for nonpoint sources are based on rainfall runoff, which does not account for imported water;
- The 40-year isohyetals used to estimate rainfall runoff may be different than the discharge record period; and
- A significant portion (>30%) of the rising groundwater load from the San Diego Creek subwatershed that is accounted for in the upper watershed is lost before it reaches the Campus Drive monitoring station;
- The Campus Drive monitoring station is located downstream of IRWD's San Joaquin Marsh, which can decrease selenium loads by the processes of bioaccumulation, sequestration and evasion, which may account for some of the lost selenium loads.

Although the above calculations provide a reasonable estimate of selenium loads in the San Diego Creek subwatershed and the Newport Bay watershed, a more discrete watershed model that links available spatial information (e.g., rainfall patterns, land cover and slope, land use) with selenium concentration information (e.g., levels in groundwater, unit loads by land use, BMP effectiveness) could be developed to estimate more accurate loads for each source category in the future. The model would include groundwater-surface water fate and transport mechanisms and link BMPs to specific sources. A calibrated model could then be used to compare and rank control options by predicting their effectiveness.

In addition, no model or monitoring estimates currently exist to measure either the selenium lost from the bay to the ocean (particularly during high runoff events) or the possible contributions to the bay from the ocean. Such estimates would have to be made as part of a future Newport Bay selenium mixing model that would incorporate loads to the bay (as discussed here) with tidal mixing and ocean exchange, as well as all aspects of sequestration, loss, and sediment re-mineralization and loss processes.

8.0 PROPOSED NUMERIC TARGETS FOR SELENIUM IN THE NEWPORT BAY WATERSHED

8.1 Introduction

TMDLs require quantitative numeric targets to implement existing water quality standards, including water quality objectives and beneficial uses. Numeric targets identify specific endpoints in sediment, the water column, or in tissue that, if met, equate to attainment of water quality standards, though they are not water quality standards themselves. Multiple targets may be appropriate where a single indicator is insufficient to protect all beneficial uses and/or to attain all applicable water quality objectives. Where applicable water quality objectives are numeric, TMDL targets are often set to those values. However, where applicable water quality objectives are in narrative form, it is necessary to develop quantitative target(s) through which narrative water quality objectives can be attained.

The established water quality objectives and beneficial uses for the Newport Bay watershed are discussed in Section 5.2 of this document. The range of beneficial uses identified in the Basin Plan for these waters makes clear that the targets must address the protection of aquatic organisms, wildlife (including federally listed threatened and endangered species) and human consumers of recreationally and commercially caught fish. As described in the Problem Statement (Section 5.0), selenium concentrations measured in fish collected in the Newport Bay watershed do not pose a risk to human consumers; however, the available data indicate ecological risk to fish and birds. The proposed numeric targets are intended to address this risk. Numeric targets/TMDLs intended to address beneficial uses related to aquatic life and aquatic-dependent wildlife will assure protection of other, potentially affected but less sensitive uses.

Where applicable water quality objectives are numeric, TMDL targets can be set to those values. As discussed in Section 5.2, the California Toxics Rule (CTR) water column criteria for selenium are the applicable numeric objectives at the present time. However, site-specific objectives (SSOs) for selenium, expressed as numeric concentrations in fish tissue and bird egg tissue, have been developed and are proposed to be adopted jointly with these selenium TMDLs by the Regional Water Board. The derivation of and justification for the selenium SSOs are summarized in Section 6.0 and in the CH2MHill report (2009a) included as Appendix 6A to this document. The proposed SSOs would assure the protection of beneficial uses and compliance with the narrative objectives for toxic substances established in the Basin Plan (Section 5.2). When, as anticipated, these SSOs are approved and promulgated by EPA, the SSOs will supersede the CTR criteria.

This section identifies the proposed numeric targets, which are based on the recommended SSOs, the CTR criterion for freshwater, and consideration of ambient quality conditions within the context of antidegradation policy provisions.

8.2 Proposed TMDL Numeric Targets

As stated above, the California Toxics Rule (CTR) criteria for selenium are the applicable numeric objectives at the present time. The CTR criteria are expressed as selenium concentrations in the water column. However, since selenium is primarily accumulated in organisms through diet, waterborne concentration-based criteria are viewed by many as inappropriate, especially for predicting chronic effects (Hamilton, 2003; Chapman et al., 2009).

As stated above, and as discussed in detail in Section 6.0, tissue-based SSOs for selenium for the Newport Bay watershed are recommended. Because the tissue-based SSOs are based on no effect concentrations (in birds) and no to low effects (in fish) (Section 6.0), the SSOs assure the reasonable protection of beneficial uses in both fresh and salt waters throughout the Newport Bay watershed. The proposed primary targets for both freshwater and saltwater areas in the Newport Bay watershed are set to the recommended SSO values.

The CTR chronic water column concentration for selenium in freshwater is used as the secondary numeric target for freshwater in the proposed TMDLs. Until the tissue-based SSOs are approved, the CTR chronic criterion for selenium in freshwater must legally serve as the final numeric target for selenium for the freshwater areas in the Newport Bay watershed. Once the CTR criteria are superseded by approved, tissue-based SSOs for selenium, the CTR-based secondary target will become ineffective and the primary tissue targets will also become the final numeric TMDL targets.

For saltwater, the applicable CTR chronic and acute criteria are substantially higher than the current median ambient water quality concentrations of selenium that have been measured in Newport Bay (Table 8-1). Using the CTR saltwater criteria as the basis for setting secondary numeric targets for saltwater would not comport with antidegradation provisions (see Appendix 1A), which preclude the lowering of water quality unless it can be demonstrated that beneficial uses would be protected and that the change in water quality is consistent with maximum benefit to the people of the state and necessary to accommodate important social or economic development. In the case of Upper Newport Bay, the first condition, protection of beneficial uses, is not met. Though the current median selenium concentrations are very low (less than 1 µg/L), selenium concentrations in some fish tissue samples collected from the Upper Bay exceed the marginal ecological risk guidelines of Presser et al. (2004), and on this basis, a finding of impairment for selenium in fish tissue was found (see Section 5.0). Therefore, neither the CTR chronic saltwater criterion for selenium nor existing median ambient quality is considered to be protective of the beneficial uses in

Upper Newport Bay. Accordingly, no secondary numeric target based on the CTR and applicable to saltwater is proposed.

Table 8-1. Comparison of CTR saltwater selenium criteria to ambient water column concentrations measured in Newport Bay

CTR Saltwater Criteria for Selenium (µg/L)		**Range in Ambient Water Column Selenium Concentrations in Newport Bay† (µg/L)**	
Chronic	Acute	Upper Bay	Lower Bay
71	290	0.011 – 9.1	0.015 – 9.8

† Based on data collected by Orange County from 2003-2008

The proposed numeric targets for selenium in the Newport Bay watershed are shown in Table 8-2. The proposed fish tissue target of 5 µg/g dw is applicable to both fresh and saltwater fish and also serves as a protective dietary target for piscivorous birds. The proposed bird egg tissue target of 8 µg/g dw will be protective of aquatic-dependent birds, including the federally listed Light-footed clapper rail and California least tern, in both fresh and saltwater areas of the Newport Bay watershed (see Section 6.2.1).

Table 8-2 Proposed Numeric Targets for Selenium in the Newport Bay Watershed

Primary Tissue Targets[1] (µg/g dry weight)		**Secondary Water Column Target[2] (µg/L)**
Fish Tissue	Bird Egg Tissue	Freshwater
5	**8**	**5**

1 Targets are based on the proposed tissue SSOs for the Newport Bay watershed and are applicable to both fresh and saltwater species.

2 Target is based on the current, legally-applicable CTR criterion for freshwater; this target will no longer be in effect once the CTR freshwater criterion has been replaced by approved tissue-based selenium SSOs for the Newport Bay watershed.

It is recognized that in some freshwater areas of the Newport Bay watershed, the ambient concentrations of selenium in the water column are better than the proposed secondary target based on the CTR value. This is the result of limited influence of selenium-laden rising groundwater on surface water flows in these areas. Where ambient freshwater quality is better than the secondary, CTR-based target, or where ambient quality is better than water column concentrations demonstrated to result in compliance with the primary tissue targets (see Section 9.0, Linkage Analysis for discussion of these water column guidelines), then conformance with antidegradation policy provisions will be required during the implementation of these TMDLs and regulation of discharges.

8.3 Alternatives to Proposed Numeric Targets

Several alternatives to the numeric targets approach delineated in the preceding discussion were considered. First, the numeric targets could be based solely on the CTR criteria, which is the approach used by USEPA in their technical TMDLs for Newport Bay and its watershed (USEPA 2002). As has been previously discussed, the CTR chronic exposure values of 5 µg Se/L in freshwater and 71 µg Se/L in saltwater (4-day averages, as total recoverable Se) are now the legally applicable water quality objectives. However, sole reliance on the CTR criteria as the basis for numeric targets would be inappropriate for a number of reasons.

First, as has also been discussed, there remains scientific and regulatory agency disagreement concerning the adequacy of the CTR criteria for the protection of wildlife, and there is an ongoing effort at the federal level to derive revised selenium criteria. (see Section 6.0) The CTR chronic criterion of 71 µg Se/L for saltwater is generally considered unrealistically under-protective of aquatic life exposure through the marine foodweb (e.g. Presser and Luoma, 2006; USEPA, 2004). The CTR criteria do not directly address the bioaccumulative nature of selenium toxicity or impacts to aquatic-dependent wildlife. The CTR criteria also do not reflect the highly site-specific nature of selenium chemistry, transformation and uptake and, therefore, the site-specific impacts of selenium on either aquatic or aquatic-dependent wildlife. It is for these reasons that site-specific objectives for selenium have been developed for the Newport Bay watershed and are proposed as part of this Basin Plan amendment package. Again, these SSOs are expected to supplant the CTR criteria upon their approval. The tissue-based SSOs provide a direct link to the protection of the aquatic and aquatic-dependent wildlife beneficial uses of principal concern in these TMDLs and therefore are the appropriate basis for establishing numeric targets.

Second, as discussed in Section 8.2 of this document, the CTR saltwater criteria for selenium are well above current ambient water quality concentrations in Newport Bay and application of these criteria as the basis for numeric targets would not be consistent with antidegradation policy provisions.

Another alternative to the selection of numeric tissue targets might be to use sediment concentrations as integrative measures of environmental contamination (CH2MHill, 2009a). Sediment concentrations could be compared to toxicology guidelines such as those recommended by the National Irrigation Water Quality program (USDOI, 1998). However, sediment is a surrogate measure of exposure; some invertebrates and fish live in close association with sediment and some invertebrates ingest it, but fish and wildlife exposure to sediment concentrations do not represent direct exposure to food or waterborne concentrations.

Sediment is not a reliable indicator of selenium exposure and risk and promulgated sediment selenium standards do not exist (Hamilton and Lemly, 1999). In addition, sediment selenium concentrations are heterogeneous on a small spatial scale and vary in relation to the relative accumulation of degraded biological fractions (organic carbon compounds) in the sediment. As such, they do not represent a clear link to selenium sources (CH2MHill, 2009). The resulting concentration of selenium in Newport Bay watershed sediments varies greatly with stream flow, ranging from sandy sediments with little organic content (and little selenium) to highly-organic wetland deposits, relatively more enriched in selenium. Concentration results vary strongly with sediment deposition characteristics in addition to their proximity to selenium sources.

For fish tissue, Regional Water Board staff could also have elected to use USEPA's draft 304(b) aquatic life criterion for selenium. USEPA has proposed a tissue based standard of 7.91 µg Se/g dw in whole body fish based on juvenile bluegill toxicity studies incorporating overwinter stress, with a summer value of 5.85 µg Se/g dw (USEPA, 2004). However the warmer winter waters of Newport Bay watershed preclude the need for winter stress considerations (CH2MHill 2009) and USEPA's draft fish tissue criterion only applies to freshwater, not estuarine or marine conditions. This would require the separate development of a tissue target for the estuarine and saltwater habitats in Newport Bay, or Regional Water Board staff would have to demonstrate that the draft tissue criterion would also be protective of aquatic life in non-freshwater conditions. In addition, USEPA's approach only considers protection of aquatic life, not aquatic-dependent wildlife (such as birds), and, therefore, may not be protective of birds that consume fish. In accordance with the USFWS biological opinion on the CTR (Spear and McInnis, 2000), selenium criteria developed for California must be protective of both aquatic life and aquatic-dependent wildlife. The recommended fish tissue selenium SSO of 5 µg/g dw for the Newport Bay watershed was selected by USFWS staff as protective of the freshwater and marine fish species, as well as piscivorous birds (as a dietary objective), that reside or forage in the Newport Bay watershed. The use of the recommended fish tissue SSO for the Newport Bay watershed as a primary TMDL numeric target is therefore both appropriate and more protective than USEPA's draft fish tissue criterion.

For bird egg tissue, Regional Water Board staff could have elected to follow the same process and method used to develop the State of Utah's proposed selenium standard for the Great Salt Lake (CH2MHill and CWECS, 2008). Utah has proposed to use a bird egg tissue concentration of 12.5 µg Se/g dw; this value is a 10% effect level (EC_{10}) based on mallard studies (Ohlendorf, 2003). However, as argued by Skorupa (personal electronic communication, October 20, 2008), and based on the biphasic modeling approach of Beckon et al. (2008), a no effect concentration (NEC or EC_0) for mallards lies somewhere between 3 and 8 µg Se/g. Dr. Skorupa, USFWD, recently reanalyzed his black-neck stilt egg hatchability database for selenium and effects, which contains 639 monitored and chemically sampled full-term nests, using USEPA's Toxicity Relationship Analysis Program (TRAP) (J. Skorupa, electronic communications dated October 28 and 29, 2008). The TRAP program generated two possible NEC for selenium in black-necked stilts: 5.8 (6) µg Se/g dw and 10.2 (10) µg Se/g dw. USFWS staff engaged in the consideration of site-specific objectives for the Newport watershed judged a value of 8 µg Se/g dw, which lies at the upper end of the range of possible NECs for mallards, and in the middle of the range of possible NECs for black-necked stilts, to be sufficiently protective of the federally listed bird species that reside or forage in the Newport Bay watershed. The use of this recommended bird egg tissue selenium SSO as a primary TMDL numeric target for the Newport Bay watershed is therefore both appropriate and more protective than the State of Utah's proposed draft criterion and, because it is considered to be a no effect concentration (NEC), it will not violate the Migratory Bird Treaty Act (see discussion under Section 6.2.2).

9.0 LINKAGE ANALYSIS

9.1 Introduction

Selenium has been extensively studied in aquatic systems since the mid-1980s, when observed toxic impacts to birds nesting at the Kesterson Reservoir (Merced County, California) were first associated with elevated selenium concentrations (see Section 2.1.1 of this report). Recently, several reviews and assessments of selenium have been published, including those by Hamilton (2004), Ohlendorf (2003), the Agency for Toxic Substances and Disease Registry (ATSDR, 2003), Luoma and Presser (2000), Presser and Luoma (2006), Eisler (2000), Frankenberger and Engberg (1998), U.S. Department of the Interior (USDOI, 1998), Frankenberger and Benson (1994), and Chapman et al. (2009). In addition to these recent reports, Lemly and Smith (1987) provided a detailed description of selenium cycling in aquatic systems.

The behavior of selenium in the environment is largely influenced by its oxidation state as well as physical factors such as geology, climate, and hydrology. Selenium occurs in several forms, including multiple oxidation states, which vary depending on ambient conditions (such as pH, Eh [oxidation/reduction potential], and microbial activity), as well as the environmental medium (such as water, sediment, or biological tissue). Biologically significant oxidation states include selenide (Se^{2-}), elemental selenium (Se^{0}), selenite (Se^{4+}), and selenate (Se^{6+}). Selenium is transported via rivers, streams, creeks, groundwater, and irrigation drainage water. Terminal waterbodies may become contaminated due to evaporative enrichment and sequestering over several seasons of runoff. These physical factors influence the fate and transport of selenium in various environmental media.

As outlined by Lemly and Smith (1987), dissolved selenium entering an aquatic system can 1) be absorbed or ingested by organisms, 2) bind or complex with particulate matter, or 3) remain free in solution. Although most selenium is either taken up by organisms or bound to particulate matter over time, selenium does not remain constant in the system. Instead, biological, chemical and physical processes move selenium through the system such that selenium stored in sediments can be cycled back into the biota and remain at elevated concentrations even when inputs of dissolved selenium in the water column are reduced or stopped.

The processes involved in the immobilization and mobilization of selenium in aquatic ecosystems are detailed in Lemly and Smith (1987), and are depicted in Figures 9-1 and 9-2. Selenium can be mobilized from sediment through oxidation and methylation processes and through direct uptake by plants and bottom-dwelling organisms (Figure 9-2). Selenium uptake by rooted plants, bottom-dwelling invertebrates, and detritus-feeding fish and wildlife contribute the most to the mobilization of selenium.

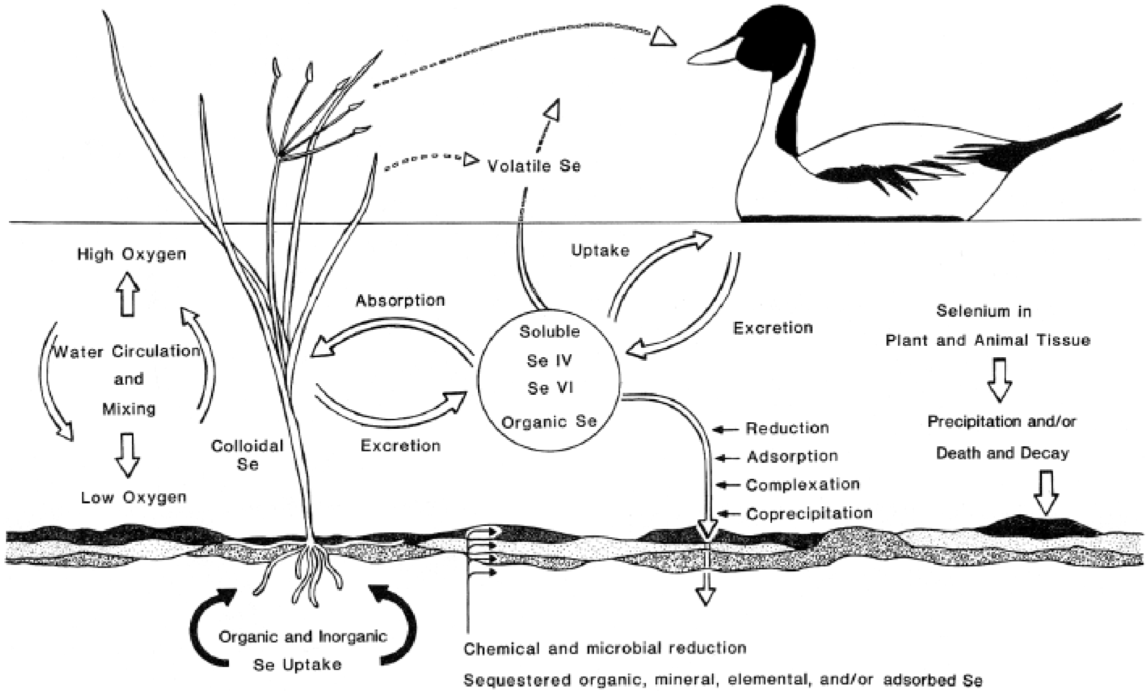


Figure 9-1. Selenium immobilization processes in an aquatic ecosystem (Source: Lemly and Smith, 1987).

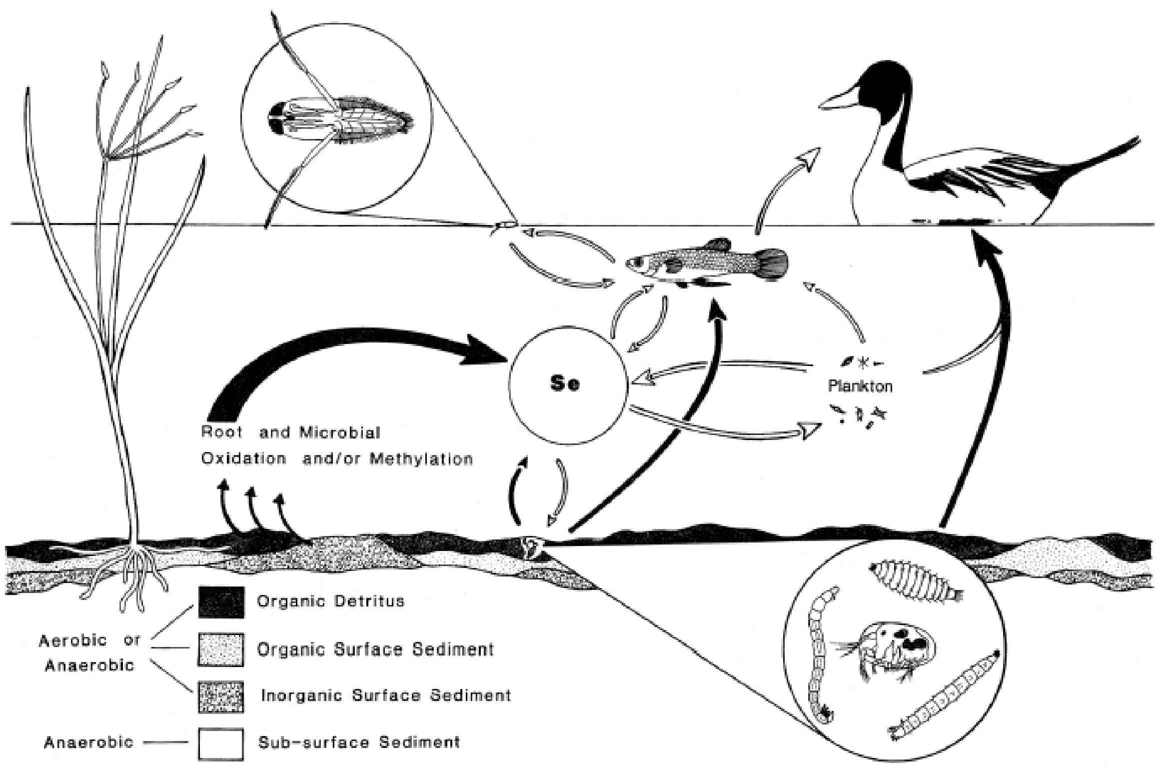


Figure 9-2 Selenium mobilization processes in an aquatic environment (Source: Lemly and Smith, 1987).

Conceptual models for selenium in the Newport Bay watershed were developed by the NSMP for San Diego Creek (freshwater habitat) and Newport Bay (saltwater habitat) (CH2MHill, 2009b). The San Francisco Bay Delta Estuary selenium conceptual model developed by the USGS was used as a basis for the Newport Bay watershed conceptual models.

The Newport Bay watershed fish and bird egg tissue SSOs need to be translated into corresponding water column concentrations in order to be able to set effluent limits and determine progress towards achieving the tissue SSOs. The biodynamic model developed by the USGS for the San Francisco Bay (Presser and Luoma, 2006) was adapted for use in the Newport Bay watershed to model possible water column concentrations using the tissue SSOs. The biodynamic model links waterborne concentrations of selenium to the fractions taken up as particulates and then follows selenium through the food web, taking into account species-specific transfer factors between trophic levels. The model provides a quantitative link between waterborne selenium concentrations and the selenium concentrations in the tissues of selected biota. In order to effectively model selenium transport, fate, exposure, and risk in the watershed, input values were needed for seasonal concentrations of selenium in water, waterborne particulates, surficial bed sediment, aquatic invertebrates, fish, and bird eggs. The conceptual models developed for the fresh and saltwater areas in the Newport Bay watershed provided information used in the biodynamic model on the selenium transfer pathways for the different hydrologic compartments and food webs in the watershed.

9.2 Conceptual Models for Selenium in the Newport Bay Watershed

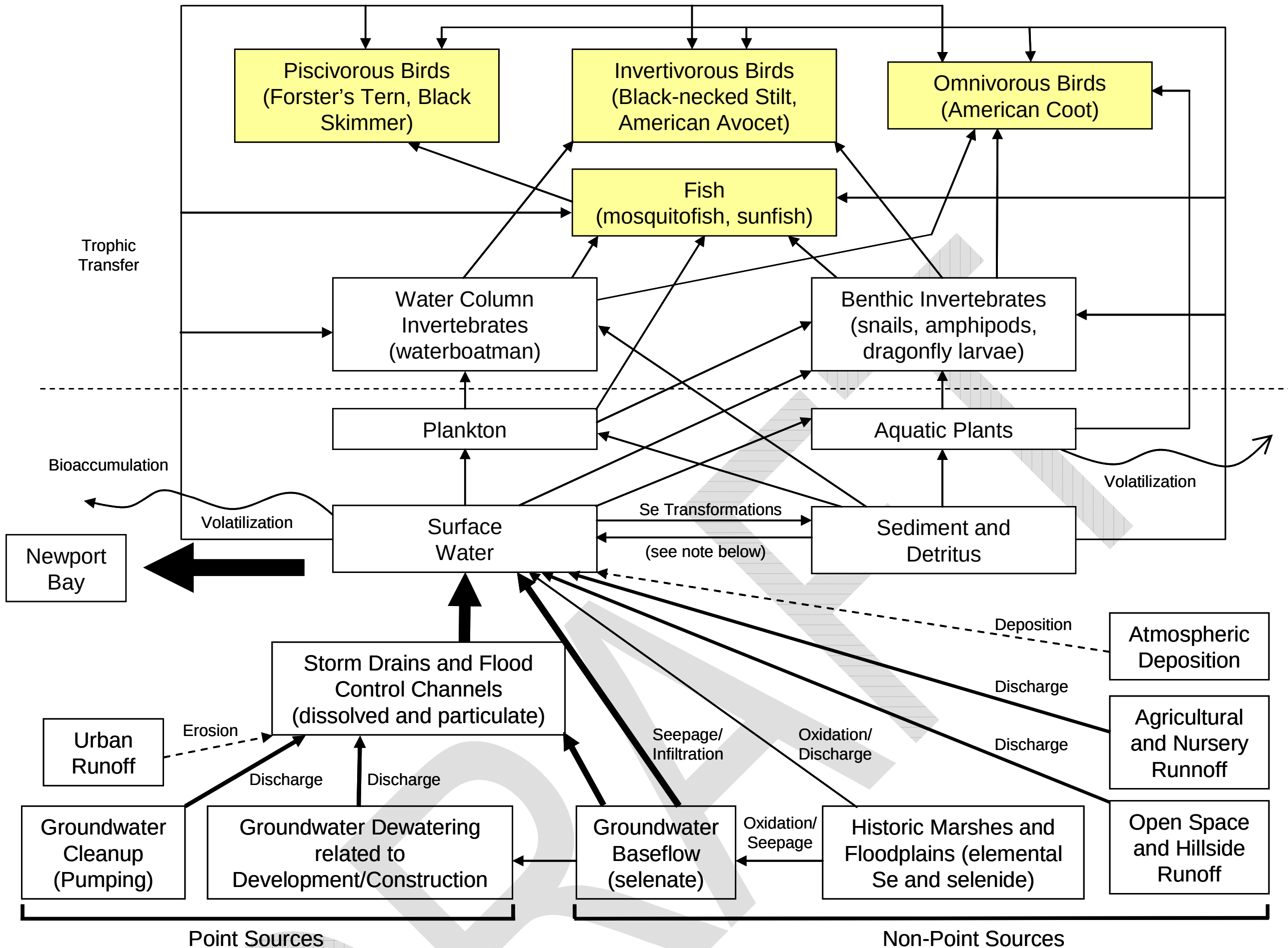
Although the Newport Bay watershed conceptual models were developed using the Luoma and Presser conceptual model for the San Francisco Bay Delta as a guide, there are some basic differences between the two models. The Bay Delta model does not include exposure or evaluate effects in the upstream freshwater reaches of the system. Instead, the focus is on modeling exposure to the estuarine/marine portions of the Bay-Delta. Bioaccumulation is determined for a single food item (clams), which is assumed to be representative of the major dietary exposure pathway to fish and aquatic birds utilizing the area. In contrast, for the Newport Bay watershed, development of adequate exposure models requires the assessment (and modeling) of selenium bioaccumulation in multiple food items and food webs (e.g., water column and benthic invertebrates) for both freshwater and saltwater habitats.

9.2.1 Conceptual Model for Freshwater Habitats in the Newport Bay Watershed

San Diego Creek is the largest freshwater drainage in the Newport Bay watershed and the major source of freshwater inputs and selenium to Newport Bay. Selenium enters the San Diego Creek watershed via many sources though groundwater sources (both point and non-point) account for most of the selenium discharge to surface waters (Figure 9-3). Once in surface water (dissolved and particulate), selenium may alternate between immobilization in sediments and mobilization from sediments through processes depicted in Figures 9-1 and 9-2. Selenium in surface water and sediment/detritus moves into the biota in the watershed via bioaccumulation into plankton and aquatic plants (CH2MHill, 2009b). This selenium is subsequently transferred to higher trophic level organisms such as invertebrates (benthic and water column), fish, and aquatic birds. Direct ingestion of surface water and sediment also represents a potential pathway for accumulation of selenium in invertebrates, fish, and aquatic birds (Figure 9-3).

9.2.2 Conceptual Model for Saltwater Habitats in the Newport Bay Watershed

San Diego Creek is the primary source of selenium to Newport Bay. Release mechanisms include surface water inflow, bedload sediment inflow, and suspended sediment discharge (Figure 9-4). The fate and transport of selenium once it enters the Bay is not well understood. Fish tissue data indicated that benthic invertebrates are likely the primary source for trophic transfer of selenium to higher trophic level organisms in Newport Bay (four of the five fish tissue composite samples that exceeded the fish tissue guideline of 5 µg/g dry weight were benthic-feeding fish). However, it appears that a crustacean-based food web, not a bivalve-based food web, lies at the base of the primary foodwebs of concern in this watershed. Site-specific bioaccumulation to topsmelt (*Atherinops affinis*) is included in the Newport Bay conceptual model (Figure 9-4). Topsmelt are a water-column/pelagic species that can be used to integrate selenium water column exposure into the model. Because topsmelt were used to integrate water column exposure into the model and benthic invertebrates are believed to be the primary mechanisms for trophic transfer to predators in Newport Bay, water column invertebrates were not included in the model (CH2MHill, 2009b).



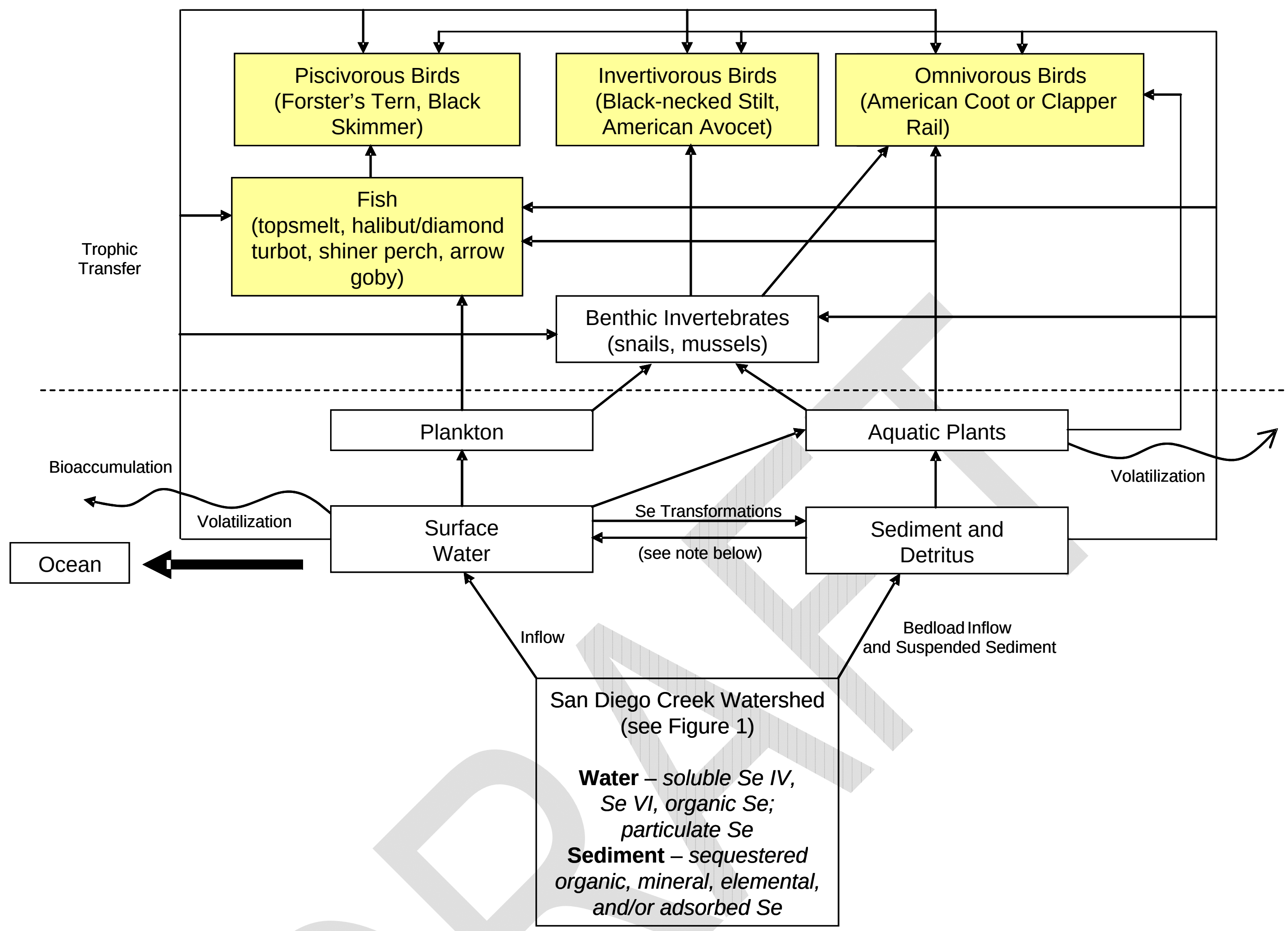
Notes:

Shaded Boxes = assessment species for effects

Weight of line from source indicates significance of contribution of selenium to the watershed (e.g., dotted line indicates insignificant contribution, whereas a heavy line indicates significant contribution).

Figures 1 and 2 provide details on selenium transformations between sediment and surface water (e.g., bacterial processes), as well as details on loss due to volatilization.

Figure 9-3: Conceptual Model, Exposure Pathways, and Food-Web Relationships for Freshwater Habitats in the Newport Bay Watershed (Source: CH2MHill, 2009b).



Notes:

Shaded Boxes = assessment species for effects

Figures 1 and 2 provide details on selenium transformations between sediment and surface water (e.g., bacterial processes), as well as details on loss due to volatilization.

Figure 9-4: Conceptual Model, Exposure Pathways, and Food-Web Relationships for Saltwater Habitats in the Newport Bay Watershed (Source: CH2MHill, 2009b).

9.3 Newport Bay Watershed Biodynamic Model

The Newport Bay watershed biodynamic model for selenium was developed using the same approach as used by the USGS for San Francisco Bay (Presser and Luoma, 2006). The biodynamic model provides a quantitative link between concentrations of selenium in the water column and in the tissues of selected biota. Toxicological literature data can be used to specify protective concentrations for tissues. Protective tissue concentrations can then be entered into the model to back-calculate the waterborne concentrations that would predict those values. In the case of the Newport Bay watershed model, the selenium tissue SSOs (Section 6.0 of this report) for fish and birds were used to back-calculate potential water column concentrations using a combination of site-specific data and literature values as key input parameters. USGS has published an open-file report (OFR) that documents how the Newport Bay watershed biodynamic model was developed, how the factors input into the model were derived, and the results of the different model runs that were used to model the freshwater and saltwater habitats in the watershed (Presser and Luoma, 2009). A copy of the USGS report is included as Appendix 9A.

In order to effectively model selenium transport, fate, exposure, and risk in the Newport Bay watershed, input values were needed for seasonal concentrations of selenium in water, waterborne particulates, surficial bed sediment, aquatic invertebrates, fish, and bird eggs. In addition, seasonal flow and loading data from the watershed to the bay were necessary inputs. The following specific inputs were needed to adapt the Presser and Luoma (2006) model for the Newport Bay watershed (CH2MHill, 2009a; Presser and Luoma, 2009):

- Conceptual model of selenium transfer pathways for all assessment areas and categories of the watershed including freshwater and saltwater, riparian and wetland habitats (Sections 9.2.1 and 9.2.2 of this report; CH2MHill, 2006);
- Seasonal pattern of waterborne selenium concentrations and loads, including dissolved and particulate fractions, throughout the watershed. Patterns of waterborne selenium chemical speciation (selenate, selenite, organic forms) (site-specific data from the Newport Bay watershed);
- Surficial sediment concentrations of selenium in areas of abundant receptors and primary food chain exposures (site-specific data from the Newport Bay watershed);
- Estimated assimilation efficiencies and transfer factors for selenium from inorganic sources to food chain bioaccumulation in tissues (site-specific data from the Newport Bay watershed and literature values);
- Food chain biota (dietary items) tissue concentrations of selenium (in algae, plants, aquatic invertebrates, small fish) (site-specific data from the Newport Bay watershed);

- Concentrations of selenium in larger/higher trophic level fish and in birds (predators/model end product) (site-specific data from the Newport Bay watershed);
- Choice (for model) of key species of dietary items and predators for predictions of uptake, exposure, and risk in the bay and freshwater habitats (site-specific data from the Newport Bay watershed).

The information listed above was provided by a series of reports prepared by CH2M HILL (for the NSMP) and others, starting with conceptual models for selenium transport and fate (USEPA, 2002; Meixner et al., 2004; CH2MHILL, 2009b), sampling and analysis to fill data gaps (CH2MHILL, 2006), and the summary of data on waterborne, particulate, sediment, and tissue selenium in the watershed (CH2MHILL, 2009b). A discussion of the primary model components and the data used in the different models runs follows.

9.3.1 <u>Partitioning Coefficients</u>

Partitioning of selenium between water column and particulates is a dynamic biogeochemical process and complex to model (Presser and Luoma, 2009). Selenium partitioning can be described by a distribution coefficient, which is the ratio

$$K_d = Se_{particulate} \text{ (ppb dry weight)}/Se_{water} \text{ (ppb)}^{1}$$

<u>or</u>

$$\mathbf{K_d = [Se_{particulate} \text{ (ppm dry weight)}/Se_{water} \text{ (ppb)}]*1000^{2}} \qquad \text{eq. 1}$$

A major factor in determining the partitioning coefficient (K_d) ("enrichment function" or EF of Chapman et al., 2009) is selenium speciation in water. Speciation of dissolved selenium ultimately controls transformation reactions between dissolved and particulate forms (e.g., sediments, detrital particles, and primary producers) and the transformation efficiency from dissolved to particulate ultimately determines food web concentrations of the element (Presser and Luoma, 2006). Most selenium transfer from primary producers to the next trophic level in an ecosystem takes place through particulate forms; dietary uptake and bioaccumulation of selenium in animals occurs to a much greater extent than uptake from water (Presser and Luoma, 2006). The hydraulic residence time of a particular water body plays an important role in selenium speciation and transformation. Selenium often enters a water body as selenate (Se^{+6}); if that water body, such as a marsh or pond, has a sufficiently long retention time, transformation and recycling of selenium may occur. Selenate may be taken up by bacteria or plants and converted to selenite (Se^{+4}) and organic selenium, and is then lost back to the water as these organisms die and decay. The more recycling, the more that chemically-reduced forms, such as selenite and organic selenium are produced, neither of which are easily re-oxidized to selenate (see discussion on selenium cycling in Section 4.0). This can result in the continued

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[1] Parts per billion (ppb) in sediment or particulates (µg/kg, ng/g) and in water (µg/L).
[2] Conversion factor for converting parts per billion to parts per thousand.

observation of selenium effects in biota long after the original selenium inputs have ceased or substantially declined.

Reactions between particles and dissolved selenium are dominated by biological uptake (Presser and Luoma, 2009). Of the three primary forms of selenium (selenate, selenite and organic selenium), selenate is the least reactive with particulate material. So, in water bodies where selenate is the only form of selenium, the K_ds tend to be low, reflecting low concentrations in particulate materials compared to concentrations in water (Presser and Luoma, 2009). Therefore, the species of selenium, particulate selenium concentrations, and the resultant biogeochemical transformations and accumulation in the food web can differ substantially even at similar dissolved concentrations. For instance, the total dissolved selenium concentrations measured in water in the lower part of San Diego Creek (Basin No. 2) are very similar those measured in Big Canyon Wash (15-19 µg/L); yet tissue and sediment selenium concentrations are more than 10 to 100 times higher in Big Canyon Wash than San Diego Creek (see Section 4.0 in this report). The presence of the relatively high proportions of selenite in the surface waters in Big Canyon Wash is the most likely reason for the high concentrations of selenium in sediment, algae, invertebrates, frogs and fish. The partitioning coefficient for these two sites is also approximately 10-fold different; a median K_d of 159 for lower San Diego Creek and a median K_d of 1,469 for Big Canyon Wash stream sites.

9.3.2 Trophic Transfer Factors

Many traditional models have attempted to quantify the link between contaminant concentrations in organisms, such as fish or birds, and those in the environment. Bioconcentration factors (BCFs), bioaccumulation factors (BAFs), and biota-sediment accumulation factors (BSAFs) have all been tried, mostly with mixed or variable results. BCFs are not appropriate for selenium since they are simply the ratio between selenium accumulated in tissue and selenium concentrations in water; dietary uptake and species of selenium are not considered. BAFs reflect the ratio between the concentration accumulated by the organism from all sources and concentration in water. Again, since selenium is accumulated primarily from diet, the selenium water column concentrations can be poor predictors of the selenium that an organism actually accumulates. Sediment is not a reliable indicator of selenium exposure and risk (Hamilton and Lemly, 1999). Sediment selenium concentrations are heterogeneous on a small spatial scale and vary in relation to the relative accumulation of degraded biological fractions (organic carbon compounds) in the sediment (CH2MHill, 2009a). As such, they do not represent a clear link to selenium sources; therefore BSAFs, which are the ratio of sediment pollutant concentrations to accumulation in an organism, are also not good or consistent indicators of selenium bioaccumulation in the real world.

Trophic transfer factors (TTFs) represent an organism's potential to bioaccumulate a contaminant from its diet. For selenium, dietary uptake is the primary route of accumulation for this contaminant (Presser and Luoma, 2009). The extent of bioaccumulation in an organism is dependent on the following species-specific physiological constants:

Assimilation efficiency (AE; usually expressed as %)
Ingestion rate (IR; grams per day)
Efflux (excretion) rate (K_e)
Growth

While organisms can accumulate metals from both water and food, for selenium, the contribution from water is usually considered to be insignificant. Therefore, the selenium concentration in an organism reflects the selenium concentration in its food, its ingestion rate and efficiency at assimilating selenium (uptake rate) and its loss rate:

$$C_{organism} = (AE)(IR)(C_{diet})/K_e$$

If rapid growth of the organism is not a concern, then the potential for an organism to bioaccumulate selenium can be expressed simply as:

$$TTF = (AE * IR)/K_e$$ [3]

or

$$\mathbf{TTF = C_{organism} / C_{diet}} \qquad \text{eq.2}$$

The species-specific TTF will remain constant even though the selenium concentrations to which the organism is exposed may change (Presser and Luoma, 2009).

Trophic transfer factors are species-specific and usually only vary within one order of magnitude in the field, though higher transfer factors have been measured in the laboratory (Chapman et al., 2009). The partitioning coefficient (K_d), or enrichment function (EF), begins at the base of the food web and is the first and largest transfer of selenium that occurs in the aquatic food web (Chapman et al., 2009) (Figure 9-5). The partitioning coefficient can vary by up to four orders of magnitude at different locations (Chapman et al., 2009).

[3] As defined by Reinfelder et al. (2008) and reviewed by Wang (2002)

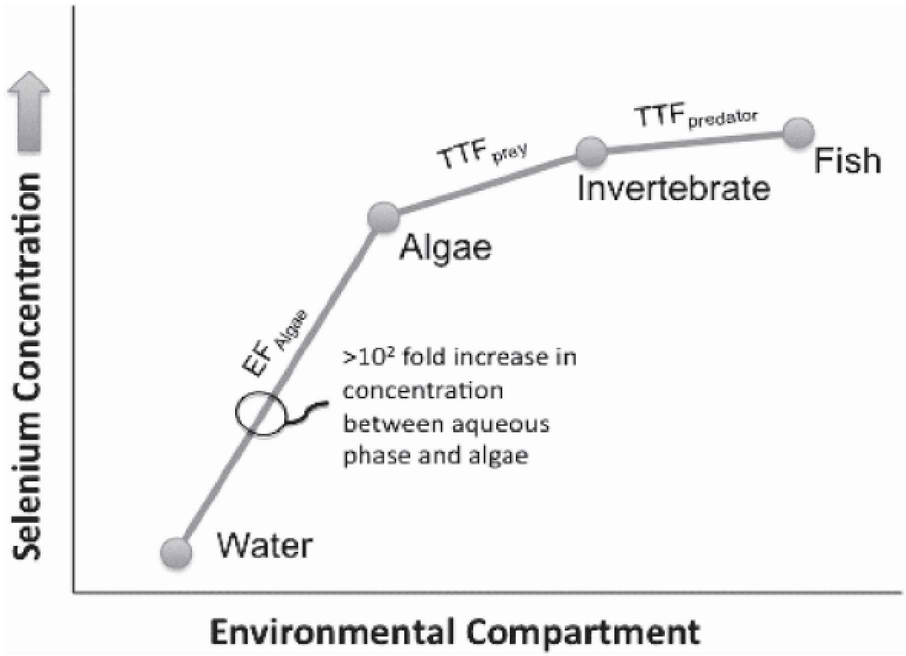

Figure 9-5. Diagram illustrating selenium enrichment and trophic transfer in aquatic food webs. The enrichment function (EF_{algae}) is equivalent to the partitioning coefficient (K_d); they represent the increase in selenium concentration between water and particulates, such as algae or sediment. (From Chapman et al., 2009).

9.3.3 Model Calculations

The Luoma-Presser model that the Newport Bay watershed model is based on is a biodynamic model that is mechanistically based, but empirically considers geochemical influences and biological differences (Luoma and Rainbow, 2005). For selenium, it provides a means to model site-specific food web structures by quantifying selenium transformation from dissolved to particulates (partitioning, K_d) and biodynamics (diet and tissue concentrations, TTFs). The model is an algorithm that can be used to predict what the selenium concentration would be in water starting with a specific tissue concentration, such as a guideline or SSO (Figure 9-6), or it can take a water column selenium concentration and use it to predict the probable selenium concentration in a target organism, such as fish or birds.

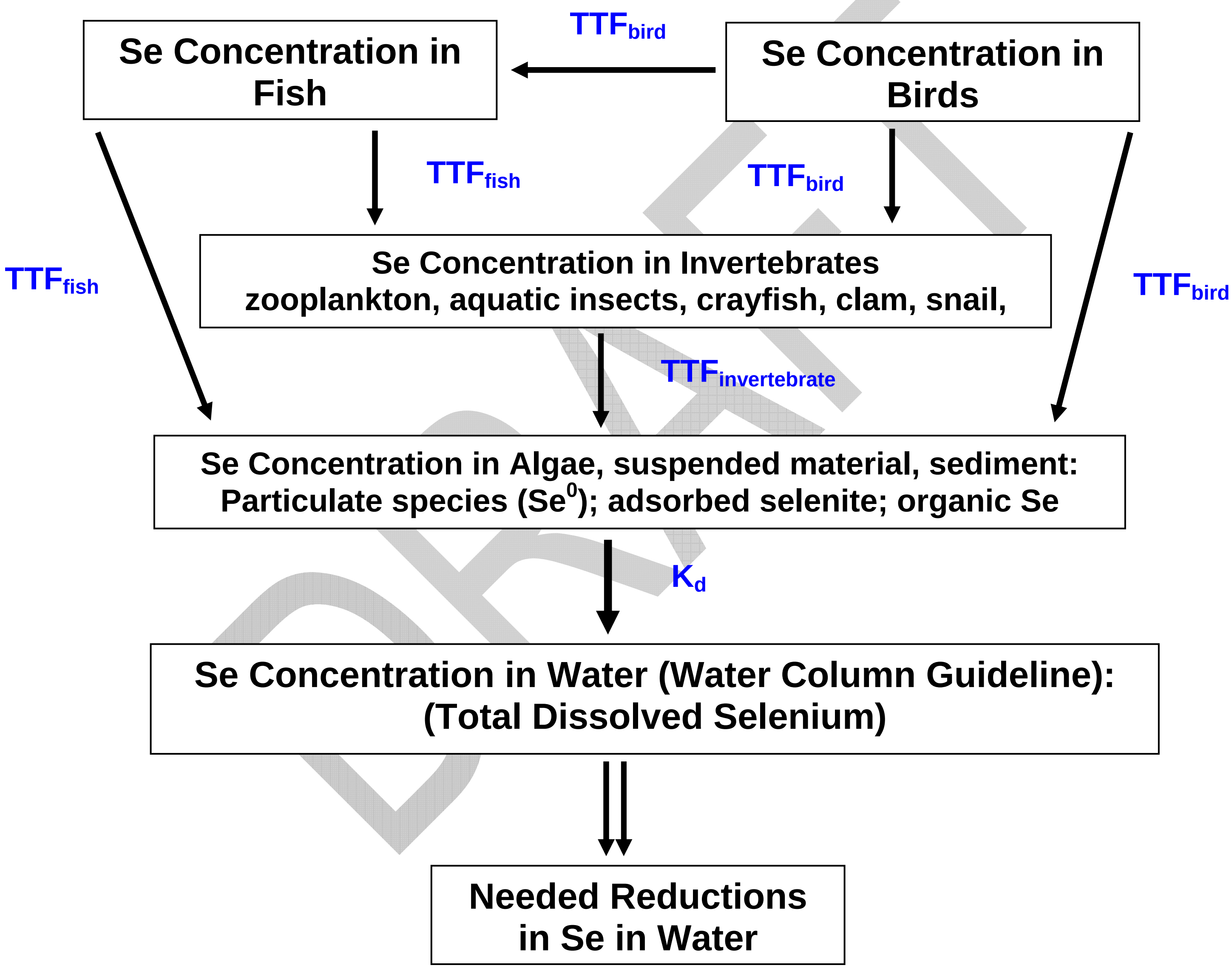

Figure 9-6. Biodyamic model links factors that determine the effects of selenium on the ecosystems in the watershed. For the Newport Bay watershed, a range in possible water column Se concentrations can be calculated using the tissue SSOs and appropriate trophic transfer factors and K_ds for the different food webs and hydrologic compartments in the watershed. (After Presser and Luoma, 2009).

For the Newport Bay watershed, SSOs for fish and bird egg tissue have been developed and incorporated into the TMDLs as primary numeric targets. However, for regulatory purposes, such as permit issuance, and for tracking reductions in selenium in surface waters through source control efforts or implementation of BMPs and treatment technologies, there is a need to be able to translate the selenium tissue SSOs into selenium concentrations in water. The model provides a means to generate potential water column selenium concentrations from the tissue SSOs for the different hydrologic compartments in the watershed using the following steps:

1. Calculate the partitioning coefficient (K_d) using equation 1:
   $K_d = [Se_{particulate}\ (\text{ppm dry weight})/Se_{water}\ (\text{ppb})]*1000$[1]

2. Calculate the trophic transfer factor for particulates to invertebrates (equation 2):
   $TTF_{invertebrate} = C_{invertebrate}/C_{particulate}$

3. Calculate the trophic transfer factor for invertebrates to fish[2]:
   $TTF_{fish} = C_{fish}/C_{invertebrate}$

4. Calculate the trophic transfer factor for fish to bird eggs[3]:
   $TTF_{bird} = C_{bird}/C_{fish}$

Then:

5a. Translate the target fish tissue concentration to a water column concentration (µg dissolved Se/L):

<u>Piscivorous fish food web</u>

$Water_{Se} = [(\text{predator fish}_{Se} \leftarrow\leftarrow\leftarrow \text{prey fish}_{Se} \leftarrow\leftarrow \text{invertebrate}_{Se} \leftarrow \text{particulate}_{Se}) \div K_d]$

$C_{water} = [(((C_{fishSSO}/TTF_{fishSSO})/TTF_{preyfish})/TTF_{invertebrate})))/K_d]*1000$

<u>Invertivorous fish food web (see Figure 9-7)</u>

$Water_{Se} = [(\text{fish}_{Se} \leftarrow\leftarrow \text{invertebrate}_{Se} \leftarrow \text{particulate}_{Se}) \div K_d]$

$C_{water} = ([(C_{fishSSO}/TTF_{fishSSO})/TTF_{invertebrate}))/K_d]*1000$

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[1] The multiplier of 1000 is only needed if the sediment or tissue is reported in ppm dry weight (e.g., µg/g or mg/kg) and the water concentration is reported in ppb (µg/L).

[2] For piscivorous fish, a second step is needed for calculating the TTF from prey fish to predator fish:

$TTF_{predator} = C_{predator}/C_{prey}$

[3] For non-piscivorous birds, calculate the TTF from invertebrates:

$TTF_{bird} = C_{bird}/C_{invertebrate}$

Or:

5b. Translate the target bird egg tissue concentration to a water column concentration (µg dissolved Se/L):

<u>Piscivorous bird food web</u>

$Water_{Se} = [(bird_{Se} \leftarrow\leftarrow\leftarrow fish_{Se} \leftarrow\leftarrow invertebrate_{Se} \leftarrow particulate_{Se}) \div K_d]$

$C_{water} = [(((((C_{birdSSO}/TTF_{birdSSO})/TTF_{fish})/TTF_{preyfish})/TTF_{invertebrate}))))/K_d]*1000$ ***<u>or,</u>***

$C_{water} = [((((C_{birdSSO}/TTF_{birdSSO})/TTF_{fish})/TTF_{invertebrate})))/K_d]*1000$

<u>Invertivorous bird food web</u>

$Water_{Se} = [(bird_{Se} \leftarrow\leftarrow invertebrate_{Se} \leftarrow particulate_{Se}) \div K_d]$

$C_{water} = (C_{birdSSO})/(TTF_{birdSSO})(TTF_{invertebrate})*K_d$

These same types of calculations can be done for herbivorous and omnivorous fish or bird food webs.

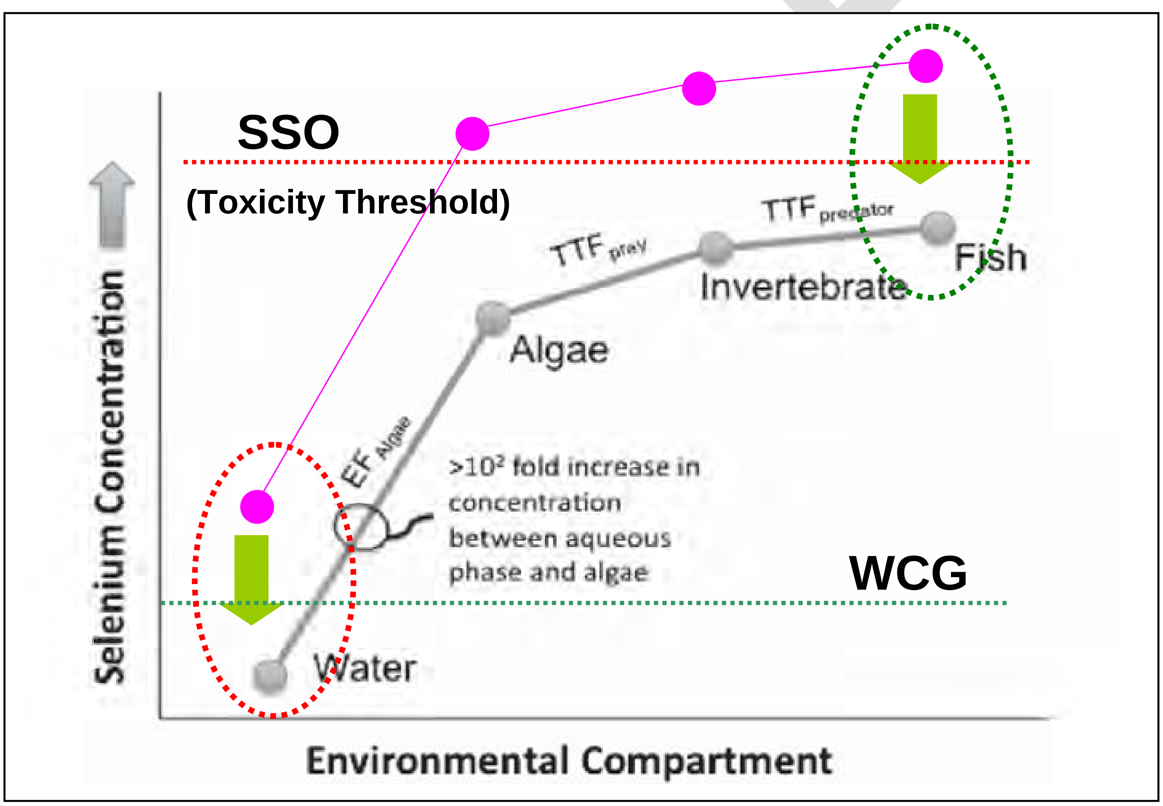

Figure 9-7. Diagram illustrating how water column concentrations (water column guidelines or WCGs) are back-calculated from the fish tissue or bird egg tissue SSOs using the Newport Bay watershed biodynamic model. EF (enrichment function) ≡ K_d (partitioning coefficient) (Adapted from Chapman et al., 2009).

For the Newport Bay watershed biodynamic model the following input parameters were used:

<u>Numeric targets (SSOs):</u>
Bird egg = 8 µg Se/g dw
Fish[1] = 5 µg Se/g dw

<u>TTFs (equation 2):</u>
Fish or invertebrate to bird eggs ($TTF_{\underline{bird}}$) = 1.4
Prey fish to predator fish (TTF_{fish}) = 1.1
Invertebrate to fish ($TTF_{\underline{preyfish}}$ or TTF_{fish}) = 1.1
Particulate to freshwater invertebrate ($TTF_{invertebrate}$) = 2.8
Particulate to saltwater water column invertebrate ($TTF_{invertebrate}$) = 2.05
Particulate to saltwater benthic invertebrate ($TTF_{invertebrate}$) = 4.5

<u>Median K_ds (equation 1):</u>
Peters Canyon Wash[2] = 178
Lower San Diego Creek[3] = 136
IRWD Wetlands = 226
UCI Wetlands = 786
San Diego Creek – all sites = 159
Santa Ana Delhi Channel[4] = 74
Big Canyon Creek (stream areas) = 1,469
Upper Newport Bay (water column food web) = 139
Upper Newport Bay (benthic food web) = 6,920
Lower Newport Bay (water column food web) = 359
Upper Newport Bay (benthic food web) = 18,513
All Bay Sites (water column food web) = 212
All Bay Sites (benthic food web) = 11,600

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[1] Both as a protective concentration for fish reproduction and as a dietary value for piscivorous fish and birds.
[2] Kds calculated by USGS for PCW ranged from 43 – 444. To represent both the upper and lower portions of PCW, a median K_d of 200 and a 75th percentile K_d of 400 were selected (upper PCW K_ds ranges from 43 – 281; lower PCW K_ds ranged from 132-444).
[3] This average K_d for Lower San Diego Creek does not include the IRWD and UCI marsh off-channel wetlands. If data from the marshes are combined with the San Diego Creek data, then the K_d increases slightly to 159 (All sites – San Diego Creek sub-watershed).
[4] Very limited data are available for the Santa Ana Delhi Channel; Regional Board staff calculated both a median and 75th percentile Kd for this waterbody; USGS only calculated a 75th percentile Kd.

75th percentile K_ds (equation 1):

Peters Canyon Wash[2] = 279
Lower San Diego Creek[5] = 238
IRWD Wetlands = 271
UCI Wetlands = 825
San Diego Creek – All Sites = 279
Santa Ana Delhi Channel = 127
Big Canyon Creek (stream areas) = 1,803
Upper Newport Bay (water column food web) = 188
Upper Newport Bay (benthic food web) = 8,423
Lower Newport Bay (water column food web) = 401
Lower Newport Bay (benthic food web) = 23,750
All Bay Sites (water column food web) = 353
All Bay Sites (benthic food web) = 17,770

9.3.4 Differences Between Model Parameters Selected by Regional Water Board Staff Compared to USGS Staff Selections

The trophic transfer factor for fish/invertebrates to bird eggs used in the model calculations for the Selenium TMDLs/SSOs technical staff report is different than that used by USGS staff in their modeling of the Newport Bay watershed (Presser and Luoma, 2009). USGS staff used a TTF of 1.8 for fish tissue to bird eggs based on three laboratory studies, as summarized by Ohlendorf (2003). Trophic transfer factors from laboratory studies tend to be higher than expected based on field data (Ohlendorf, 2008). In most laboratory studies, birds are exposed to a single form of selenium in their diets at a relatively constant concentration. Free-living birds however, are exposed to different dietary forms and concentrations of selenium. In most of these laboratory studies, birds are exposed to the most bioavailable form of selenium, so maximum transfer from diet to egg would be expected (CH2MHill, 2008). CH2MHill staff recommended a lower TTF of 1.4 based on field data as most appropriate for the Newport Bay watershed (Ohlendorf, 2008). USGS staff (Dr. Sam Luoma) orally concurred with this estimated TTF at the Resource Agency Meeting held in Davis, California on May 16, 2009, to discuss the final modeling for the Newport Bay watershed selenium SSOs. This option is also referenced in the USGS open-file report, though USGS staff elected not to use CH2MHill's recommended TTF (Presser and Luoma, 2009).

The K_ds selected by Regional Water Board staff as most appropriate for the bodies in the Newport Bay watershed differ slightly from those selected by USGS staff (Tables 9-1A and 9-1B). USGS staff calculated a variety of K_ds (mean, median, minimum, maximum, 75th percentile) for the different freshwater habitats in the watershed using available matched datasets. In selecting which K_ds to use in their model runs, they appear to have used their best professional judgment in their selection of K_ds for both the fresh and saltwater areas in the watershed.

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[5] This 75th percentile K_d for Lower San Diego Creek does not include the IRWD or UCI marsh off-channel wetlands.

USGS staff described different scenarios for selecting appropriate K_ds (as well as TTFs) but left it up to Regional Water Board staff to make the final decision as to which parameters would go into the final modeling runs.

Table 9-1A

***K_ds Used by Regional Water Board Staff in the Newport Bay Watershed Biodynamic Model*[1]**

Water Body	Median Kd	75th%ile Kd
Peters Canyon Wash	178	279
Lower San Diego Ck	136	238
IRWD wetlands	226	271
UCI wetlands	786	825
San Diego Ck- All Sites	159	279
Santa Ana Delhi Channel	74	127
Big Canyon Wash	1,469	1,803
Upper Bay water column*	139	188
Upper Bay benthic**	6,920	8,423
Lower Bay water column	359	401
Lower Bay benthic	18,513	23,750
All Bay Sites water column	212	353
All Bay Sites benthic	11,600	17,770

Table 9-1B

K_ds used in modeling by USGS*[2] *(Presser and Luoma, 2009; Tables 18-20)

SDC subwatershed (freshwater)	
Upper watershed	200
Lower San Diego Creek	320
IRWD wetlands	400
UCI wetlands	1,000
Newport Bay (saltwater)	
near mouth of estuary	200
upper bay	1,000
upper/lower bay	10,000
lower bay	20,000

[1] Most of the selected K_ds for the freshwater areas match the K_ds in Tables 2a and 2b in the USGS report (Presser and Luoma, 2009).

[2] USGS staff used their best professional judgment in selecting these K_ds.

* Water column particulate-based K_ds

** Bed sediment-based K_ds

The Basin Plan defines the water bodies in the Newport Bay watershed differently than in the manner used by USGS and CH2MHill in their modeling runs. Peters Canyon Wash is the main tributary to San Diego Creek, with lower Peters Canyon Wash having the highest concentrations of selenium in the area. San Diego Creek is divided into Reach 1 (the main stem portion of the creek located west of Jeffrey Road that extends downstream to Upper Newport Bay) and Reach 2 (the portion of the creek that is generally low in selenium (<5 µg Se/L) and located primarily outside of the influence of the Swamp of the Frogs that extends eastward to the foothills) (see Section 3.0, Figure 3-7). Newport Bay is divided into Upper Newport Bay, which contains the Upper Newport Bay Ecological Reserve and extends from the mouth of San Diego Creek to the Pacific Coast Highway. Lower Newport Bay, which is the largest pleasure craft harbor in the continental United States, extends from Pacific Coast Highway to the open ocean via Newport Channel (see Section 3.0, Figure 3-3).

USGS staff did not distinguish between upper and lower Newport Bay in their model runs and divided the freshwater portions of the watershed into the “upper watershed”, which appears to be somewhat equivalent to the Peters Canyon Wash subwatershed, and “lower San Diego Creek”, which also includes part of Reach 2 (Table 9-1B). USGS did not calculate K_ds for Big Canyon Wash (this was not part of their original scope of work and data from this area were not collected until June 2008) and only calculated a 75th percentile K_d for the Santa Ana Delhi Channel. Regional Water Board staff primarily used the same data as did USGS staff, but calculated K_ds based on the Basin Plan designations for the water bodies in the watershed. Regional Water Board staff also used data collected from Big Canyon Wash in June 2008 to develop K_ds for this small watershed and used additional data for the Santa Ana Delhi Channel to generate both median and 75th percentile K_ds. Further, Board staff divided the Newport Bay water column particulate selenium data and harbor bed sediment selenium data into upper and lower bay, then recalculated the K_ds for these salt water areas as well (Table 9-1A). Since the K_ds for the Delhi Channel and Big Canyon Wash are based on very limited data, they must be considered only preliminary.

There is a substantial difference between the water column particulate K_ds measured in the Bay and the benthic bed sediment K_ds estimated from data collected from several of the harbors in Newport Bay. Water column particulate K_ds vary from around 100 near the mouth of San Diego Creek to near 800 near the Bay’s confluence with the open ocean (Newport Channel). Partitioning coefficients calculated from bed sediment data collected from harbors in upper and lower Newport Bay vary from less than 6000 to greater than 40,000. USGS staff selected K_ds of 200, 1,000, 10,000, and 20,000 (Table 9-1B) to represent conditions from the estuarine portions of upper bay to the most isolated harbors in the bay.

Regional Water Board staff sorted the water column and bed sediment data according to whether the data had been collected from Upper Newport Bay or

Lower Newport Bay. Regional Water Board staff also added additional paired water column and bed sediment data collected from the Newport Dunes Resort marina in Upper Newport Bay by the City of Newport Beach in May 2006 to the bed sediment data to generate K_ds for Upper Newport Bay. This yielded median and 75th percentile water column particulate K_ds for Upper Newport Bay of 139 and 188 (respectively); for Lower Newport Bay, the K_ds were 359 and 401; for the entire Bay (for comparison to the USGS estimated K_ds), the K_ds were 212 and 353. The median and 75th percentile bed sediment-calculated K_ds for Upper Newport Bay were 6,920 and 8,423 (respectively); K_ds for Lower Newport Bay were 18,513 and 23,750, and for the combined upper and lower bay K_ds were 11,600 and 17,770. These numbers fall within the same range of K_ds used by the USGS but are specific to the basin plan-designated portions of Newport Bay.

9.3.5 Model Results

Table 9-2 shows the estimated water column concentrations generated by the equations as used in the Newport Bay biodynamic model for the different hydrologic units and TMDL numeric tissue targets combined into possible watershed scenarios. The watershed scenarios that were modeled using both the median and 75th percentile K_ds included:

invertebrates→fish (for lower trophic level fish such as fathead minnow)
invertebrates→fish→fish (for piscivorous fish such as large-mouth bass)
invertebrates→birds (for shorebirds such as black-neck stilts), and
invertebrates→fish→birds (for piscivorous birds such as terns)

The invertebrate→fish→ fish→birds (birds eating piscivorous fish) scenario was not modeled as the majority of the birds in the watershed feed on small fish that are either lower trophic level fish or juveniles of higher trophic level fish that feed primarily on plankton, zooplankton, or benthic invertebrates. While there are ospreys nesting in the area, one of their favorite prey is striped mullet, a lower trophic level fish that feeds on sediment, diatoms, and small benthic invertebrates, so they should be adequately represented by the invertebrate to fish to bird food web that was modeled. In addition, as was discussed previously (see Section 6.2.1), piscivorous birds appear to be less sensitive to selenium than mallards (one of the most sensitive birds to selenium; Smith et al., 1988 versus Heinz et al. 1987) and a fish-dominant diet may provide less exposure and risk from selenium than plant or invertebrate-based diets since "fish selenium" appears to be less bioavailable than selenium in other forms of food (Girling, 1984; Goede, 1993; Goede and Wolterbeek, 1993; Barceloux, 1999).

Piscivorous fish (invertebrate→fish→fish) were not modeled for either the IRWD or UCI offline wetlands or for Big Canyon Wash as only lower trophic level fish (e.g., mosquito fish and fathead minnows) have been observed in these areas.

Detailed explanations of the assumptions made and variables input into the model by USGS, as well as their validation runs, can be found in Appendix 9A..

The spreadsheets used by Regional Water Board staff to develop water column guidelines for the Newport Bay watershed using the Newport Bay watershed biodynamic model are included in Appendix 9B.

Table 9-2. Estimated Water Column Concentrations for Different K_ds, TTFs, and TMDL numeric tissue targets (SSOs) as Combined into Possible Watershed Scenarios.

Scenario	Tissue Target (µg Se/g dw)	TTF to bird eggs	TTF to whole-body fish	TTF to inverte-brates	K_d (Median)	K_d (75^{th} Percentile)	Estimated Median WCG (µg Se/L)	Estimated 75^{th} Percentile WCG (µg Se/L)
FRESHWATER AREAS								
PCW, insect to fish	Fish 5.0	NA	1.1	2.8	178	279	9.1	5.8
Lower SDC, insect to fish	Fish 5.0	NA	1.1	2.8	136	238	11.9	6.8
IRWD Wetlands, insect to fish	Fish 5.0	NA	1.1	2.8	226	271	7.2	6.0
UCI Wetlands, insect to fish	Fish 5.0	NA	1.1	2.8	786	825	2.1	2.0
SDC – All Sites, insect to fish	Fish 5.0	NA	1.1	2.8	159	279	10.2	5.8
SADC, insect to fish	Fish 5.0	NA	1.1	2.8	74	127	21.9	12.8
BCW creek, insect to fish	Fish 5.0	NA	1.1	2.8	1,469	1,803	1.1	0.9
PCW, insect to fish to fish	Fish 5.0	NA	1.1	2.8	178	279	8.3	5.3
Lower SDC, insect to fish to fish	Fish 5.0	NA	1.1	2.8	136	238	10.9	6.2
IRWD Wetlands, insect to fish to fish	Fish 5.0	NA	1.1	2.8	226	271	NA	NA
UCI Wetlands, insect to fish to fish	Fish 5.0	NA	1.1	2.8	786	825	NA	NA
SDC – All Sites, insect to fish to fish	Fish 5.0	NA	1.1	2.8	74	127	9.3	5.3
SADC, insect to fish to fish	Fish 5.0	NA	1.1	2.8	159	279	19.9	11.6
BCW creek, insect to fish to fish	Fish 5.0	NA	1.1	2.8	1,469	1,803	NA	NA

Table 9-2. Estimated Water Column Concentrations for Different K_ds, TTFs, and TMDL numeric tissue targets (SSOs) as Combined into Possible Watershed Scenarios.

Scenario	Tissue Target (µg Se/g dw)	TTF to bird eggs	TTF to whole-body fish	TTF to inverte-brates	K_d (Median)	K_d (75^{th} Percentile)	Estimated Median WCG (µg Se/L)	Estimated 75^{th} Percentile WCG (µg Se/L)
Lower PCW, insect to birds	Bird Eggs 8.0	1.4	NA	2.8	178	279	11.5	7.3
Lower SDC, insect to birds	Bird Eggs 8.0	1.4	NA	2.8	136	136	15.0	8.6
IRWD Wetlands, insect to birds	Bird Eggs 8.0	1.4	NA	2.8	226	271	9.0	7.5
UCI Wetlands, insect to birds	Bird Eggs 8.0	1.4	NA	2.8	786	825	2.6	2.5
SDC – All Sites, insect to birds	Bird Eggs 8.0	1.4	NA	2.8	74	127	12.8	7.3
SADC –insect to birds	Bird Eggs 8.0	1.4	1.1	2.8	74	127	27.6	16.1
BCW creek, insect to birds	Bird Eggs 8.0	1.4	NA	2.8	1,469	1,803	1.4	1.1
Lower PCW, insect to fish to birds	Bird Eggs 8.0	1.4	1.1	2.8	178	279	10.4	6.6
SDC, insect to fish to birds	Bird Eggs 8.0	1.4	1.1	2.8	136	238	13.6	7.8
IRWD Wetlands, insect to fish to birds	Bird Eggs 8.0	1.4	1.1	2.8	226	271	8.2	6.8
UCI Wetlands, insect to fish birds	Bird Eggs 8.0	1.4	1.1	2.8	786	825	2.4	2.2
SDC – All Sites, insect to birds	Bird Eggs 8.0	1.4	1.1	N2.8	74	127	11.7	6.6
SADC –insect to birds	Bird Eggs 8.0	1.4	1.1	2.8	74	127	25.1	14.6
BCW creek, insect to fish to birds	Bird Eggs 8.0	1.4	1.1	2.8	1,469	1,803	1.3	1.0

Table 9-2. Estimated Water Column Concentrations for Different K_ds, TTFs, and TMDL numeric tissue targets (SSOs) as Combined into Possible Watershed Scenarios.

Scenario	Tissue Target (µg Se/g dw)	TTF to bird eggs	TTF to whole-body fish	TTF to inverte-brates	K_d (Median)	K_d (75th Percentile)	Estimated Median WCG (µg Se/L)	Estimated 75th Percentile WCG (µg Se/L)
SALTWATER AREAS								
Upper Bay, water column (WC) invertebrate to fish	Fish 5.0	NA	1.1	2.05	139	188	16.0	11.8
Upper Bay, WC invert-ebrate to fish to fish	Fish 5.0	NA	1.1	2.05	139	188	14.5	10.7
Upper Bay, WC invertebrate to birds	Birds Eggs 8.0	1.4	NA	2.05	139	188	20.1	14.8
Upper Bay, WC invert-ebrate to fish to birds	Bird Eggs 8.0	1.4	1.1	2.05	139	188	18.2	13.5
Upper Bay, benthic (B) invertebrate to fish	Fish 5.0	NA	1.1	4.5	6,920	8,423	0.146	0.120
Upper Bay, B invert-ebrate to fish to fish	Fish 5.0	NA	1.1	4.5	6,920	8,423	0.133	0.109
Upper Bay, B invertebrate to birds	Bird Eggs 8.0	1.4	NA	4.5	6,920	8,423	0.184	0.151
Upper Bay, B invert-ebrate to fish to birds	Bird Eggs 8.0	1.4	1.1	4.5	6,920	8,423	0.167	0.137
Lower Bay, water column (WC) invertebrate to fish	Fish 5.0	NA	1.1	2.05	359	401	6.2	5.5
Lower Bay, WC invert-ebrate to fish to fish	Fish 5.0	NA	1.1	2.05	359	401	5.6	5.0
Lower Bay, WC invertebrate to birds	Birds Eggs 8.0	1.4	NA	2.05	359	401	7.8	7.0
Lower Bay, WC invert-ebrate to fish to birds	Bird Eggs 8.0	1.4	1.1	2.05	359	401	7.1	6.3
Lower Bay, benthic (B) invertebrate to fish	Fish 5.0	NA	1.1	4.5	18,513	23,750	0.055	0.043
Lower Bay, B invert-ebrate to fish to fish	Fish 5.0	NA	1.1	4.5	18,513	23,750	0.050	0.039

Table 9-2. Estimated Water Column Concentrations for Different K_ds, TTFs, and TMDL numeric tissue targets (SSOs) as Combined into Possible Watershed Scenarios.

Scenario	Tissue Target (µg Se/g dw)	TTF to bird eggs	TTF to whole-body fish	TTF to inverte-brates	K_d (Median)	K_d (75th Percentile)	Estimated Median WCG (µg Se/L)	Estimated 75th Percentile WCG (µg Se/L)
Lower Bay, Benthic invertebrate to birds	Bird Eggs 8.0	1.4	NA	4.5	18,513	23,750	0.069	0.053
Lower Bay, B invert-ebrate to fish to birds	Bird Eggs 8.0	1.4	1.1	4.5	18,513	23,750	0.062	0.049
All Bay Sites, water column (WC) invertebrate to fish	Fish 5.0	NA	1.1	2.05	212	353	4.8	2.9
All Bay Sites, WC invert-ebrate to fish to fish	Fish 5.0	NA	1.1	2.05	212	353	4.3	2.6
All Bay Sites, WC invertebrate to birds	Birds Eggs 8.0	1.4	NA	2.05	212	353	6.0	3.6
All Bay Sites, WC invert-ebrate to fish to birds	Bird Eggs 8.0	1.4	1.1	2.05	212	353	5.4	3.3
All Bay Sites, benthic (B) invertebrate to fish	Fish 5.0	NA	1.1	4.5	11,600	17,770	0.087	0.057
All Bay Sites, B invert-ebrate to fish to fish	Fish 5.0	NA	1.1	4.5	11,600	17,770	0.079	0.052
All Bay Sites, B invertebrate to birds	Bird Eggs 8.0	1.4	NA	4.5	11,600	17,770	0.109	0.071
All Bay Sites, B invert-ebrate to fish to birds	Bird Eggs 8.0	1.4	1.1	4.5	11,600	17,770	0.100	0.065

PCW = Peters Canyon Wash
SDC = San Diego Creek

SADC = Santa Ana Delhi Channel
BCW = Big Canyon Wash

IRWD = Irvine Ranch Water District offline wetlands
UCI = San Joaquin Freshwater Marsh Preserve (University of CA, Irvine offline wetlands)
UNB = Upper Newport Bay
LNB = Lower Newport Bay

WC = water column invertebrate
B = benthic invertebrate

NA = variable not applicable or insufficient data - cannot run model for that scenario

9.3.6 Discussion and Summary of Results

The partitioning coefficient (K_d) can vary greatly depending on location, type of particulate fraction measured, and the predominant selenium oxidation state (species of selenium). Trophic transfer factors can also vary significantly. For example, in the model, water column concentrations for Newport Bay (saltwater habitats) were derived using both a water column invertebrate (copepod) that had a TTF of 2.05 and a benthic invertebrate (polychaete worm) with a much higher TTF (4.5). Therefore, the resultant calculated water column concentrations are very sensitive to the food web being modeled as well as the K_d selected.

The K_d values used for the different hydrologic compartments in the Newport Bay watershed provide a range in possible water column concentrations for each hydrologic unit (Table 9-3). Because of this variability, and because the K_ds in many instances were calculated from bed sediment or algae since particulate selenium data were not available, the calculated water column guidelines shown in Table 9-3 below may change as additional data are collected during implementation of these TMDLs. The TMDL implementation plan includes a special study to refine the K_ds used in the Newport Bay watershed biodynamic model so that more accurate WCGs can be calculated for the different hydrologic units in the watershed (Section 12, Task 10).

Table 9-3. Range in Water Column Guidelines Predicted by the Newport Bay Watershed Biodynamic Model Using Fish (5 µg/g dw) and Bird Egg Tissue (8 µg/g dw) SSOs

Freshwater (µg/L)					
Lower Peters Cyn Wash	San Diego Creek (All Sites)	IRWD Wetlands	UCI Wetlands	Santa Ana Delhi Channel	Big Canyon Creek
5.0 – 11.5	5.0 – 13	6.0 – 9.0	2.0 – 2.6	12 - 28	0.9 – 1.4
Saltwater (µg/L)					
Upper Newport Bay (water column)	Upper Newport Bay (benthos)	Lower Newport Bay (water column)	Lower Newport Bay (benthos)	All Newport Bay (water column)	All Newport Bay (benthos)
11 – 20	0.109 – 0.184	5.0 – 8.0	0.04 – 0.07	2.5 – 6.0	0.06 – 0.110

9.4 Model Validation Results

USGS staff compared actual measured selenium concentrations in invertebrate, fish and bird species to those predicted by the Newport Bay watershed biodynamic model for San Diego Creek and Newport Bay (Presser and Luoma, 2009). The validation modeling for the freshwater areas showed the best agreement between the predicted and observed selenium concentrations. The modeling had more mixed results for Newport Bay. In almost all cases, the validation modeling over-predicted the bird egg tissue selenium concentrations for both San Diego Creek and Newport Bay. This may be a reflection of the greater variability in selenium concentrations in bird diet compared to fish. In the

Newport Bay watershed, birds are much more mobile and generally forage over a greater area than fish, especially freshwater fish, which are confined to the freshwater drainages in the watershed.

Of the sites and food webs modeled, San Diego Creek has the most robust data set. For this reason, the model is considered to generate the most reliable results when back-calculating from tissue concentrations to water column concentrations for this area. San Diego Creek is the primary source of freshwater and selenium to the IRWD and UCI wetlands and to Upper Newport Bay. Implementation actions based on the model predictions for this location should also result in selenium reductions in these other hydrologically connected areas.

9.5 Alternatives to the Newport Bay Watershed Biodynamic Model

Regional Water Board staff could have selected alternative methods of linking tissue selenium concentrations to waterborne selenium concentrations, rather than adapting the Luoma-Presser biodynamic model to the conditions in the Newport Bay watershed. One alternative would have been to simply use USEPA's (Peterson and Nebeker, 1992) simplified approach to bioaccumulation:

$$\text{Bioaccumulation} = \frac{[\text{concentration in organism}]}{[\text{concentration in environment}]}$$

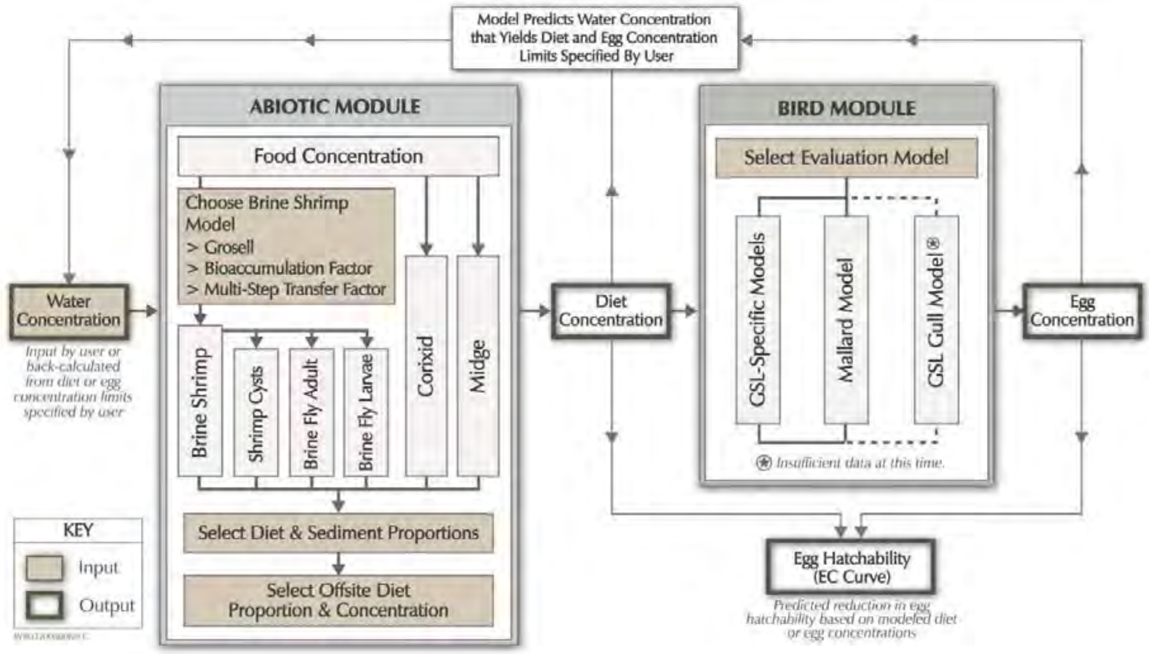
Environmental concentrations are either those in water (bioconcentration factors or BCFs), sediment (biota-sediment accumulation factors or BSAFs), or primarily from both diet and water (bioaccumulation factors or BAFs). However, one of the problems with this approach is that there is no mechanism to consider selenium speciation in water, which can dramatically affect the rate of bioaccumulation in an ecosystem. Bioaccumulation factors can vary significantly (as much as 50-fold) for a specific species in different environments and even more between different species of invertebrates, fish, or birds (Presser and Luoma, 2006). In contrast, the Newport Bay biodynamic model does consider species of selenium (through the use of a partitioning coefficient) and the differences between different species and different food webs (via trophic transfer factors).

Regional Water Board staff could also have elected to use the Bioaccumulation Model that was developed by CH2MHill and Center for Water, Ecosystems, and Climate Science (CWECS)(2008) for the Great Salt Lake. This model allows the user to estimate diet and egg selenium concentrations from an assumed waterborne selenium concentration. The model also allows the user to back-calculate a waterborne selenium concentration from an assumed diet or egg selenium concentration, as does the Newport Bay biodynamic model.

The Great Salt Lake Bioaccumulation Model is composed of a series of relationships that describe the transfer of selenium from water up through the food chain. The transfer factors and regression equations that represent these relationships were developed from data collected from Great Salt Lake as part of the research program. The user has the flexibility to select from numerous options to evaluate the sensitivity and results from alternative transfer relationships and bird diet combinations. Resulting waterborne, diet, and egg selenium concentrations are listed and plotted upon egg and diet toxicity curves to illustrate potential effects of selenium on egg hatchability (Ohlendorf, 2003). Figure 9-8 illustrates inputs, outputs, and the general flow of logic of the Great Salt Lake Bioaccumulation Model.

Like the Newport Bay watershed biodynamic model, the Great Salt Lake bioaccumulation model uses both site-specific data (where available) and literature values. However, the Great Salt Lake model was developed specifically for the foodwebs characteristic of the Great Salt Lake (brine shrimp and brine flies, birds, but no fish), which differ substantially from the foodwebs in the Newport Bay watershed. The relative simplicity of the GSL foodweb has led to a simplified bioaccumulation model, in which only two bioaccumulative processes were considered, i.e. from water/sediment to diet, and from diet to birds (CH2MHill and CWECS, 2008). T his simplistic approach is not applicable to the complex foodweb in the Newport Bay ecosystem (see Fig. 9-4). On the other hand, the unique geohydrology, aquatic chemistry, and biogeochemical cycling of selenium in GSL have limited the applicability of the bioaccumulation model to other environments, including Newport Bay watershed. While it may have been possible to adapt this model to the site-specific conditions in the Newport Bay watershed, the Luoma-Presser biodynamic model has been used to predict selenium concentrations under different scenarios for the San Francisco Bay Delta, which does contain species and foodwebs similar to those found in the Newport Bay watershed. The Luoma-Presser biodynamic model is also being used to revise the CTR selenium criteria so that both aquatic life and aquatic-dependent wildlife can be protected from the effects of selenium. For these reasons, USEPA and USFWS staff were supportive of the decision to adapt the Luoma-Presser biodynamic model to the site-specific conditions in the Newport Bay watershed.

Figure 9-8. Great Salt Lake Bioaccumulation Model (CH2MHill and CWECS, 2008)



10.0 LOADING CAPACITY

10.1 Introduction

The loading capacity is the maximum amount of a pollutant a water body can assimilate and still attain water quality objectives and protect beneficial uses. Loading capacity (and a TMDL) can be expressed in terms of "mass per time," "toxicity," or any other appropriate measure, depending on the circumstances of the impairment (Title 40, Code of Federal Regulations, §130.2[i]). For these selenium TMDLs, the water column guidelines back-calculated from the proposed fish and bird egg tissue numeric targets/SSOs are set as equivalent to the loading capacity for the waterbodies in the watershed, with certain exceptions. Attainment of the water column guidelines is expected to result in attainment of the tissue-based numeric targets/SSOs and thus the protection of beneficial uses. For the Santa Isabel Channel and Upper Newport Bay, insufficient data are available to apply the biodynamic model to calculate water column guidelines and thence loading capacities. For these waters, the loading capacities are set at the fish and bird egg tissue numeric targets/SSOs... Selenium loading capacity for the freshwater areas of the Newport Bay watershed are also based on the CTR chronic freshwater criterion, since it is the legally applicable water quality objective at the present time. However, once the SSOs are adopted, the CTR-based loading capacity will no longer be effective.

This water column concentration-based approach to determining the loading capacity (and TMDLs; see Section 11.0) of the watershed was utilized for several reasons: The water column concentrations (water column guidelines; see Section 9.0) generated using the Newport Bay watershed biodynamic model provide a direct link to meeting the recommended tissue-based SSOs and, thus, the protection of beneficial uses. The water column guidelines incorporate differences in selenium speciation and recycling that may occur in a water body through the use of particulate to water column partitioning coefficients (K_ds) and trophic transfer factors (TTFs) that represent how efficiently selenium transfers from primary producers to predators, the most important route for selenium bioaccumulation in tissue. Loading capacity (and TMDLs) based on the more typical mass-based approach do not provide this direct link to the protection of beneficial uses, and concentrations better address the watershed conditions, which are characterized by variations in stream flows and intermittent groundwater discharges that vary seasonally and from year to year.

10.2 Estimated Loading Capacity for the San Diego Creek Subwatershed

There is insufficient information to determine water column guidelines for each impaired freshwater channel in the San Diego Creek subwatershed. The loading capacity for freshwater tributaries within the San Diego Creek subwatershed will be based, in part, on the range in water column guidelines for lower San Diego Creek (San Diego Creek Reach 1) that were back-calculated from the fish and bird egg tissue SSOs/numeric targets using the biodynamic model. This range is 5.3 – 12.8 µg/L (5-13 µg/L). Lower San Diego Creek has the most robust data set of the sites and food webs modeled. For this reason, the biodynamic model is considered to generate the most reliable results when back-calculating from tissue concentrations to water column concentrations for this area. This range is similar to the range in water column guidelines calculated for lower Peters Canyon Wash (see Table 9-3) and it is reasonable to assume its applicability to other the tributary channels as well, given the predominance of rising groundwater, which is the primary source of selenium in these waters. The current applicable CTR freshwater chronic criterion for selenium is 5 µg/L. Therefore, the loading capacity for the subwatershed ranges between **5 and 13 µg/L.**

Since San Diego Creek is the primary source of freshwater flows and selenium to the IRWD and UCI (San Joaquin Freshwater Marsh Preserve) off-channel wetlands and to Newport Bay (Figure 10-1), reductions in selenium concentrations in the creek and attainment of its calculated water column guidelines are expected to reduce selenium in all of these hydrologically connected water bodies such that their loading capacity is not exceeded.

The median ambient water column selenium concentration in lower San Diego Creek at the Campus monitoring station is approximately 17 µg/L. Therefore, selenium concentrations in surface waters in the creek may have to be reduced by 25%, to as much as 70%, in order to meet the fish and bird egg tissue targets/SSOs. Adjustments to the loading capacity (and TMDLs and allocations;see Section 11.0) will be made on the basis of additional biodynamic modeling, using data and information provided by ongoing monitoring and special studies that are required by the recommended implementation plan (see Section 12.0). However, until the SSOs are approved, the final loading capacity will be based on the 2000 CTR freshwater selenium chronic criterion of **5 µg/L** (CTR-based loading capacity). Once the SSOs are approved, and the CTR is no longer in effect, the final SSO-based loading capacity for selenium in the San Diego Creek subwatershed will be set at the water column selenium concentration that results in compliance with the fish and bird egg tissue SSOs in all hydrologic units in the watershed.

10.3 Estimated Loading Capacity for Upper Newport Bay

Selenium loading capacity for Upper Newport Bay is difficult to define based on the data available at the present time and the factors discussed in more detail below.

Like most Southern California estuaries, circulation and mixing in Upper Newport Bay are predominantly tidally driven. Saltwater extends from Lower Newport Bay through Upper Newport Bay into the mixing basin or pre-basin located at the mouth of San Diego Creek (Figure 10-2). Salinity profiles in the pre-basin and Upper Newport Bay fluctuate with the tide, freshwater flow volumes, precipitation, and other seasonal effects. Under most conditions, freshwater from San Diego Creek proceeds through the pre-basin as a lens of freshwater overriding the underlying saltwater that then flows into inner Upper Newport Bay (Sevilla, 2003) (Figure 10-3). This vertical stratification in the pre-basin effectively acts as a conduit or pipe, delivering solutes and suspended solids (and associated pollutants) in the freshwater lens directly to Upper Newport Bay (Sevilla, 2003). The ambient water column selenium concentrations in Upper Newport Bay range from 0.15 μg Se/L (in harbor areas in the lower part of upper bay (Figure 10-4) to greater than 10 μg Se/L in the pre-basin. Selenium concentrations measured in the pre-basin and Upper Newport Bay can vary by an order of magnitude depending on where or at what depth the sample was collected and what tidal conditions were present during sample collection (Table 10-1 and Figure 10-4).

Figure 10-1. Google Earth™ image showing a portion of Lower San Diego Creek (Reach 1), in-line sediment basins, and the Campus Drive monitoring station, and their relationship to the off-channel wetlands and Upper Newport Bay.

Figure 10-2. Google Earth™ image showing the locations of the Santa Ana Delhi Channel, Upper Newport Bay, and San Diego Creek, including the pre-basin and weir that separate the sediment basins in the lower part of the creek from Upper Newport Bay.

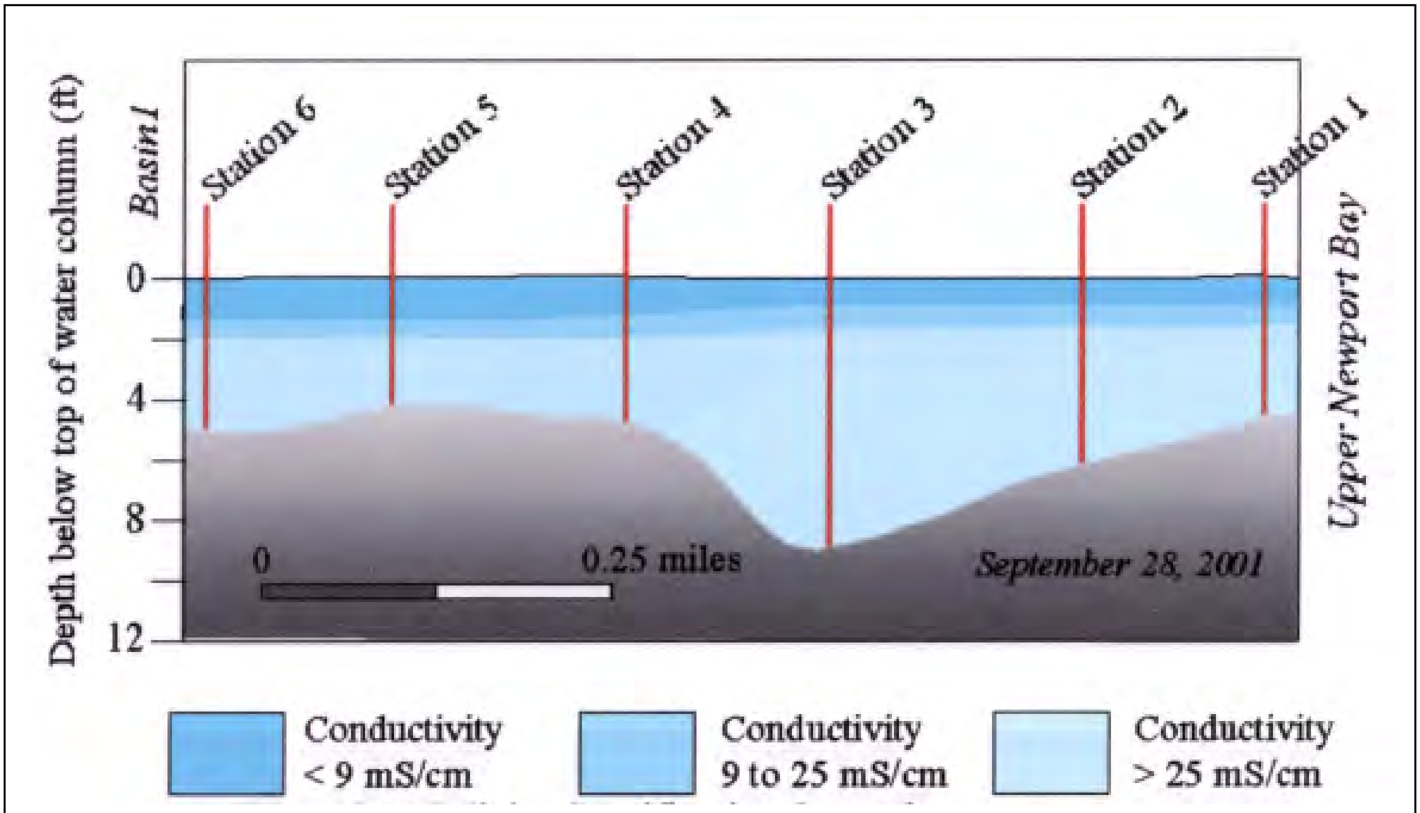


Figure 10-3. Typical sheet flow effect of freshwater lens from San Diego Creek as it enters the mixing pre-basin and flows along the top of the saltwater with only minimal mixing prior to entering Upper Newport Bay (From Sevilla, 2003).

Figure 10-4. Google Earth™ image showing the lower portion of Upper Newport Bay and City of Newport Beach water quality monitoring stations at the Newport Dunes Resort Marina and the De Anza Bayside Marina

Table 10-1 Fluctuations in Selenium Concentrations and Salinity in Upper Newport Bay with Location, Depth, and Distance from San Diego Creek

Location	Station Name	Date Sampled	Depth of Sample (ft)	Salinity (ppt)	Dissolved Se (µg/L)
Pre-basin	Mixing Pre-basin	Nov 2007	0.0	15.1	14.4
UNBER	NB1	Nov 2007	0.0	26.6	3.5
UNBER	NB1	Nov 2007	3.0	30.2	1.79
UNBER	NB2	Nov 2007	0.0	28.0	2.32
UNBER	NB2	Nov 2007	4.6	31.4	1.13
UNBER	NB3	Nov 2007	0.0	28.7	2.42
UNBER	NB3	Nov 2007	4.6	31.6	1.27
UNBER	NB4	Nov 2007	0.0	30.5	1.31
UNBER	NB4	Nov 2007	2.7	31.0	1.32
UNB	NB5	Nov 2007	0.0	30.8	1.18
UNB	NB5	Nov 2007	4.0	31.4	0.991
UNB	UNB-JAM (near NB2)	Sep 24, 2007	ID	NA	0.700
UNB	UNB-JAM (near NB2)	Sep 26, 2007	ID	NA	0.530
UNB	Newport Dunes Marina* (south of NB5)	May 2006	NA	NA	0.15
UNB	Newport Dunes Marina* (south of NB5)	Dec 2006	NA	NA	0.16
UNB	De Anza Bayside Marina* (northwest of NB5)	May 2006	NA	NA	0.12
UNB	De Anza Bayside Marina* (northwest of NB5)	Dec 2006	NA	NA	0.14

UNB = Upper Newport Bay
UNBER = Upper Newport Bay Ecological Reserve
ID = Integrated depth sample
NA = Not Available
* See Figure 10-5 for more detailed image of site locations.

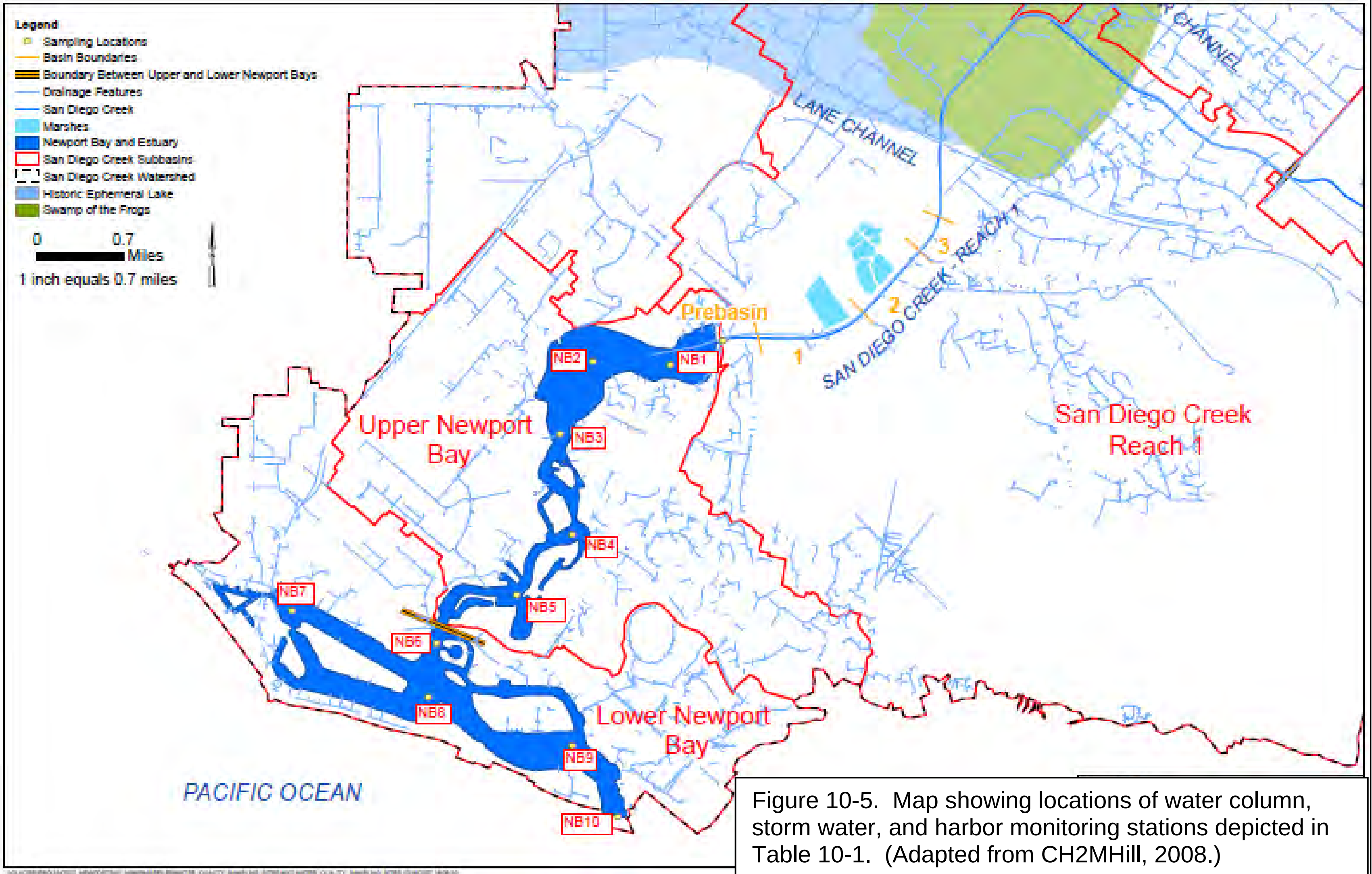


Figure 10-5. Map showing locations of water column, storm water, and harbor monitoring stations depicted in Table 10-1. (Adapted from CH2MHill, 2008.)

The CTR chronic saltwater criterion for selenium is 71 µg/L. Dissolved selenium concentrations in the upper bay and the pre-basin are well below this criterion[1]. However, Upper Newport Bay was found to be impaired when the fish tissue and bird egg tissue selenium levels are compared to relevant ecological risk thresholds (Presser et al, 2004). This indicates that the 2000 CTR saltwater criterion is under-protective of the beneficial uses in the Bay and that it should not be used to determine the bay's loading capacity.

The selenium WCGs back-calculated for Upper Newport Bay from fish and bird egg tissue-based SSOs using the Newport Bay watershed biodynamic model range from 11 to 20 µg/L when based on water column particulate data, and from around 0.11 to 0.18 µg/L when based on bed-sediment data from the harbors in the Bay. These data approximate the range in ambient water column concentrations measured in the upper bay up through the pre-basin (0.1 – 10+ µg Se/L). However, the Newport Bay watershed biodynamic model does not appear to work as well for the Bay as compared to the freshwater areas in the watershed.

While there is generally good agreement between selenium concentrations in sediment (used to calculate the K_d) with selenium concentrations in some benthic-feeding fish (e.g. striped mullet), there is not good agreement between particulate selenium (water column/suspended particulate-based K_ds) and water column fish (e.g. topsmelt). All but one of the fish tissue samples collected from Upper Newport Bay that exceeded the fish tissue selenium SSO/TMDL numeric target of 5 µg/g dw (11 samples) were benthic-dwelling or feeding fish (gobies, striped mullet, and killifish), and of those fish, 91% were collected from the portion of upper bay that lies closest to the mouth of San Diego Creek (at the upper end of Upper Newport Bay). This leads to the hypothesis that one mechanism of selenium cycling in the bay may be the flocculation of particulate selenium carried by the freshwater entering the bay, which then ends up in the bed sediments and ultimately in the benthic food webs in the bay.

The primary source of selenium to the Bay is the San Diego Creek subwatershed. As discussed above, based on the range in possible WCGs that would result in compliance with the selenium tissue SSOs, reductions in selenium on the order of between 25-70% will be needed in San Diego Creek. Under existing conditions, approximately 89% of the fish tissue samples, and 22% of the bird egg samples, collected from the San Diego Creek subwatershed exceed the recommended selenium fish and bird egg tissue SSOs. In Upper Newport Bay, a more limited number of tissue samples (approximately 18% of

[1] The CTR freshwater criteria apply at salinities of 1 part per thousand (ppt) and below at locations where this salinity occurs 95% or more of the time; the saltwater criteria apply at salinities of 10 ppt and above at locations where this occurs 95% or more of the time; and at salinities between 1 and 10 ppt, the more stringent of the two generally applies. The majority of the water in the pre-basin meets the CTR's definition of saltwater.

the fish samples, and 6% of the bird eggs sampled[2]), exceeded the recommended selenium tissue SSOs. The majority of the fish tissue samples that exceeded the recommended fish tissue SSO were collected from areas in the Upper Bay closest to the mouth of San Diego Creek (Figure 10-6). This evidence strongly indicates that it is highly likely that if water column selenium concentrations are reduced in the San Diego Creek subwatershed such that the selenium tissue SSOs are met, the tissue SSOs will also be met in Upper Newport Bay.

Given that (1) the range in water column guidelines predicted by the Newport Bay watershed biodynamic model using the tissue SSOs varies by an order of magnitude: (2) the range of ambient selenium concentrations in the Upper Bay also varies widely depending on location, tidal stage, and other factors; (3) the CTR saltwater criteria (both chronic and acute) are substantially higher than current ambient water column selenium concentrations in Upper Newport Bay, and (4) that reductions in selenium concentrations in San Diego Creek are expected to result in reductions in selenium concentration in the Upper Bay, the loading capacity for Upper Newport Bay will be set to the fish and bird egg tissue selenium SSOs of **5 µg/g dw and 8 µg/g dw**, respectively. These tissue concentrations have been also incorporated into the selenium TMDLs as primary numeric targets (see Section 8.0). As more data are provided to support more accurate biodynamic modeling of the Upper Bay, then a concentration-based loading capacity for Upper Newport Bay could be developed. However, since the ultimate goal of the selenium TMDLs is to protect the beneficial uses in the Newport Bay watershed, and selenium impacts to sensitive fish and bird species are of greatest concern, use of tissue concentrations for determining a range in loading capacities for Upper Newport Bay should be both appropriate and protective of the beneficial uses most at risk in the upper bay.

[2] While 6% of the bird eggs sampled in Upper Newport Bay exceeded the recommended bird egg tissue selenium SSO of 8.0 µg Se/g dry weight, a finding of impairment due to excessive selenium concentrations in bird eggs was not made. For a sample size of 62 eggs, the 2004 State Listing Policy requires a minimum of 8% of the eggs to exceed the criteria used to make a finding of impairment.

Table 10-2. Comparison of Existing Selenium Concentrations and Percent Exceedance of Bird Egg and Fish Tissue Guidelines* in San Diego Creek and Upper Newport Bay

Location	Percent (%) Exceedance		Range in Selenium Concentrations	
	SSO_{bird} (8 µg/g dw)	SSO_{fish} (5 µg/g dw)	Bird Eggs (µg/g dw)	Fish (whole body, µg/g dw)
Upper Bay[1]	6	18	1.6 – 10.7	1.39 – 9.5
San Diego Creek[2]	22	89	1.9 – 14.5	2.6 – 21.21
Location	**Median Selenium Concentration**		**Maximum Selenium Concentration**	
	Bird Eggs (µg/g dw)	Fish (whole body, µg/g dw)	Bird Eggs (µg/g dw)	Fish (whole body, µg/g dw)
Upper Bay[1]	3.4	3.4	10.7	9.5
San Diego Creek[2]	5.7	10.7	14.5	21.21

* The tissue guidelines (Presser et al., 2004) used in the impairment assessment (Section 5.0 of this report) for these TMDLs are the same as those recommended by USFWS staff as appropriate SSOs for the Newport Bay watershed (5 µg/g dw in fish and 8 µg/g dw in birds; see Section 6.0). The recommended SSOs have also been incorporated into these TMDLs as primary numeric targets (Section 8.0 of this report).
[1] Number of fish tissue samples = 62 (as composite samples); number of bird egg tissue samples = 62 (as individual eggs).
[2] Number of fish tissue samples = 18 (as composite samples); number of bird egg tissue samples = 18 (as individual eggs).

Since water column concentrations predicted by the Newport Bay watershed biodynamic model did not closely match observed selenium concentrations in Upper Newport Bay as well as it did for the San Diego Creek subwatershed, additional data will be needed to refine the model parameters for Upper Newport Bay (e.g., partitioning coefficients or K_ds). A special study is proposed as part of the recommended implementation actions to determine the fate and transport of selenium within the Bay (see Section 12.5, Task 11). While no selenium impairment was found in Lower Newport Bay, actions taken to reduce selenium concentrations in San Diego Creek and Upper Newport Bay should also result in selenium reductions in the Lower Bay. During implementation of these TMDLs/SSOs, data will continue to be collected from Newport Bay and San Diego Creek in order to assess whether upstream implementation actions are resulting in sufficient reductions in selenium concentrations in sediment, water, and biota in all of the hydrologic units in the Newport Bay watershed.

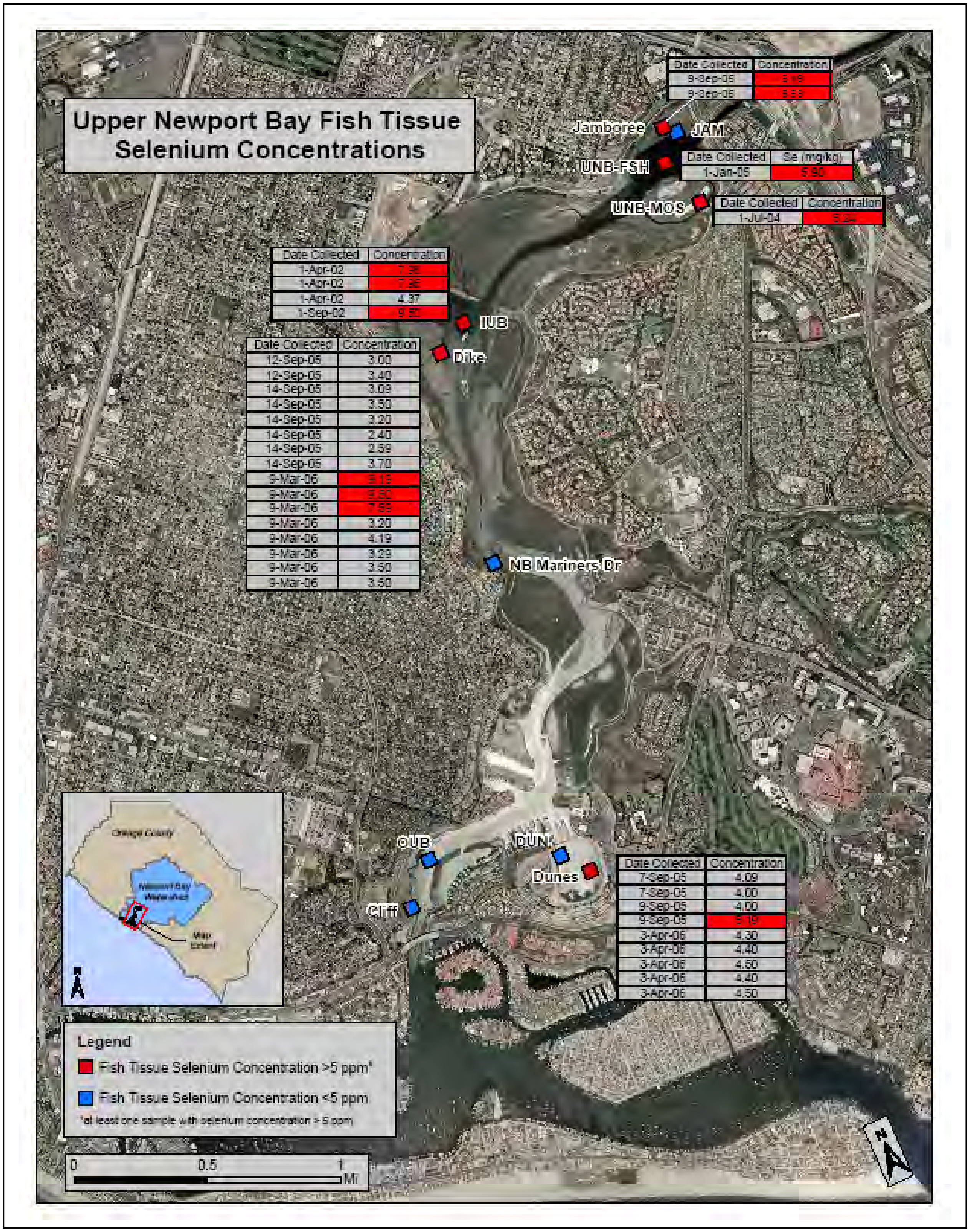


Figure 10-6. Google Earth™ image showing fish tissue concentrations in Upper Newport Bay and their proximity to the mouth of San Diego Creek.

10.4 Estimated Loading Capacities for Other Areas in the Newport Bay Watershed

10.4.1 San Diego Creek Subwatershed Off-channel Wetlands

Both the IRWD and UCI (San Joaquin Freshwater Marsh Preserve) wetlands are no longer groundwater-supported wetlands and instead rely on water pumped from San Diego Creek. Surface water in San Diego Creek is diverted and transported through the IRWD treatment wetlands and excess flows can be diverted through the Carlson Marsh to the UCI wetlands when available. The water column selenium concentrations generated by the Newport Bay watershed biodynamic model to meet the recommended fish and bird egg tissue SSOs ranges from 2.0 – 2.6 µg Se/L (2 - 3 µg Se/L) for the UCI wetlands and 6 – 9 µg Se/L for the IRWD wetlands. The current applicable CTR freshwater chronic criterion for selenium is 5 µg/L. Therefore, the range in loading capacity for the San Joaquin Freshwater Marsh Preserve is set at **2 - 5 µg Se/L** and for the IRWD wetlands (including Carlson Marsh) is set at **5 - 9 µg Se/L**.

The data used to calculate K_ds for these wetlands are very limited and may not be representative of the entire wetlands. Even though the CTR freshwater criterion is at or higher than the calculated water column guidelines for the UCI wetlands, it is still legally applicable until the SSOs are approved. On a best professional judgment basis, a lower selenium concentration may be necessary to comply with the narrative objectives for toxic substances and to protect the beneficial uses of these wetlands. Since these wetlands are hydrologically connected to lower San Diego Creek, it is expected that reductions in selenium concentrations in the creek will result in reductions in both off-channel wetlands such that the tissue SSOs will be met. Adjustments to the loading capacity (and TMDLs and allocations (see Section 11.0)) will be made on the basis of additional biodynamic modeling, using data and information provided by ongoing monitoring and special studies that are required by the recommended implementation plan (see Section 12.0). However, until the SSOs are approved, the final loading capacity for both the UCI and IRWD wetlands will be based on the 2000 CTR freshwater selenium chronic criterion of **5 µg/L** (CTR-based loading capacity). Once the SSOs are approved, and the CTR is no longer in effect, the final SSO-based loading capacity for selenium in the wetlands will be set at the water column selenium concentration that results in compliance with the fish and bird egg tissue SSOs.

10.4.2 Santa Ana Delhi Channel Subwatershed

The Delhi Channel is a small channel tributary to Upper Newport Bay (Figure 10-1) that also drains a portion of the high selenium area (Swamp of the Frogs), which is the main source of selenium in the San Diego Creek subwatershed (see Section 3.5). Although it is not tributary to San Diego Creek, it is often treated as part of this subwatershed due to its proximity and similar selenium issues. The Delhi channel however, drains a much smaller area (approximately 17 mi^2) than

San Diego Creek (approximately 119 mi^2) and primarily consists of a concrete- or rip-rap -lined channel with some earthen bank and soft bottom areas, such as the very lowermost portion of the drainage just before it enters Newport Bay (Figure 10-6).

The lower, wider and meandering part of the channel, which enters the saltwater marsh in Upper Newport Bay, is tidally influenced and contains only minimal flows during the dry season. To date, no bird eggs or freshwater fish have been collected from the freshwater portions of the lower Delhi Channel. A few crayfish, some algae and one sample of deployed freshwater clams (*Corbicula fluminea*) have been collected from the monitoring station in the lower part of the channel; however, only the clam and algae samples contained sufficient material for selenium analysis. The selenium concentration in the composite clam sample was 4.28 µg/g dw. The single algae sample had a selenium concentration of only 2 µg/g dw. The median ambient water column selenium concentration in the Delhi Channel is 10 µg/L (water column selenium concentrations in the Delhi Channel have ranged from 1 - 53 µg/L).

The Newport Bay biodynamic model over-predicts the selenium concentrations that would be expected in water when compared to existing selenium concentrations in the Delhi Channel. This is likely a result of the paucity of data available for this location. Therefore, a SSO-based loading capacity based on site-specific data cannot be calculated for the Santa Ana Delhi Channel (Delhi Channel). However, the Delhi Channel is often treated as part of the larger San Diego Creek subwatershed even though it is not tributary to San Diego Creek because it drains an area that is similar in topography, geology, land use and selenium concentrations. Since the Delhi channel provides another source of selenium to Upper Newport Bay, the loading capacity for the Delhi Channel will be set to the same range of loading capacities as the San Diego Creek watershed: **a SSO-based loading capacity range of 5-13 µg Se/L and a CTR-based loading capacity of 5 µg Se/L**.

Adjustments to this range in loading capacities for the Delhi Channel will be made, if and as necessary, based on the results of monitoring and additional biodynamic modeling required during implementation of these TMDLs/SSOs. While a finding of impairment due to selenium was not made for the Santa Ana Delhi Channel, actions taken to reduce selenium concentrations in the channel should also contribute to reductions in selenium in Upper Newport Bay.

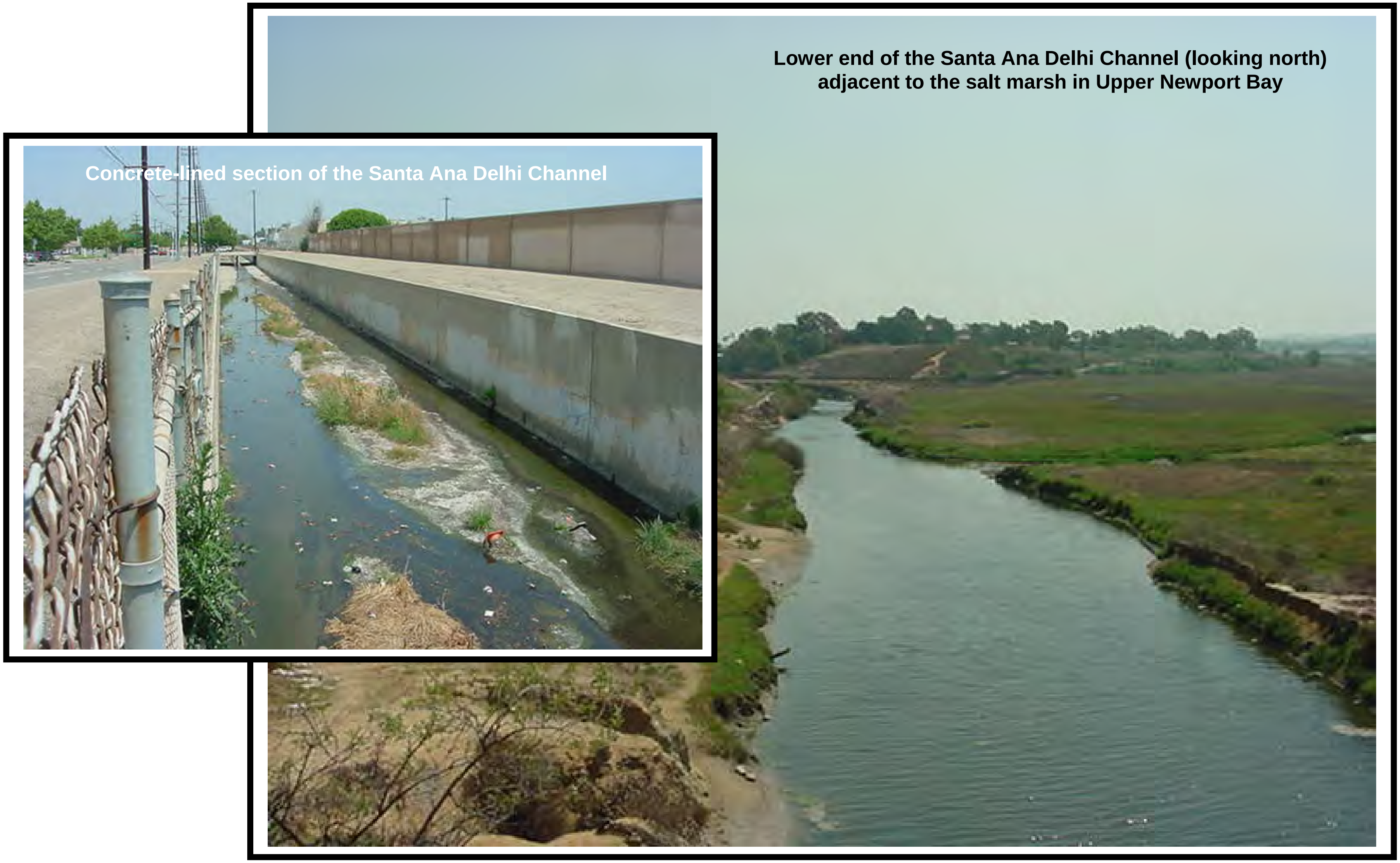


Figure 10-6. Photographs showing the lower portion of the tidally-influenced Santa Ana Delhi Channel (looking upstream) adjacent to the saltwater marsh in Upper Newport Bay and a concrete-lined freshwater section of the channel (inset photograph) located much further upstream.

<u>10.4.3 Santa Isabel Channel</u>

There are only limited water column data for selenium (only 24 samples collected in a 3 year period) for the Santa Isabel Channel; no sediment, algae, fish or bird egg tissue selenium data are available. The channel drains a very small area (less than 2 square miles) and is tributary to Upper Newport Bay (Figure 10-7). The median ambient water column selenium concentration is 2 µg Se/L, below either the CTR freshwater criterion or the SSO-based water column guidelines for the San Diego Creek subwatershed. A finding of impairment for this channel was made based on the minimum dataset required to determine impairment (2 of 24 samples equaled or exceeded the CTR freshwater chronic criterion of 5 µg Se/L). Given the small drainage area of this channel, its generally low selenium concentrations, and lack of suitable habitat for birds, it likely poses little ecological risk to fish or birds and it is not a significant source of selenium to Upper Newport Bay.

Because only limited data are available for the Santa Isabel Channel (water column data only), WCGs for this channel cannot be calculated at this time. For that reason, the SSO-based fish and bird egg tissue numeric targets will be used as the SSO-based loading capacities for this channel. In addition, though the CTR selenium freshwater criterion is higher than the median ambient selenium water column concentrations measured in this channel, given the limited dataset available, the criterion will be applied to the Santa Isabel Channel as the CTR-based loading capacity. Again, this CTR-based loading capacity will no longer be effective once the selenium SSOs are approved.

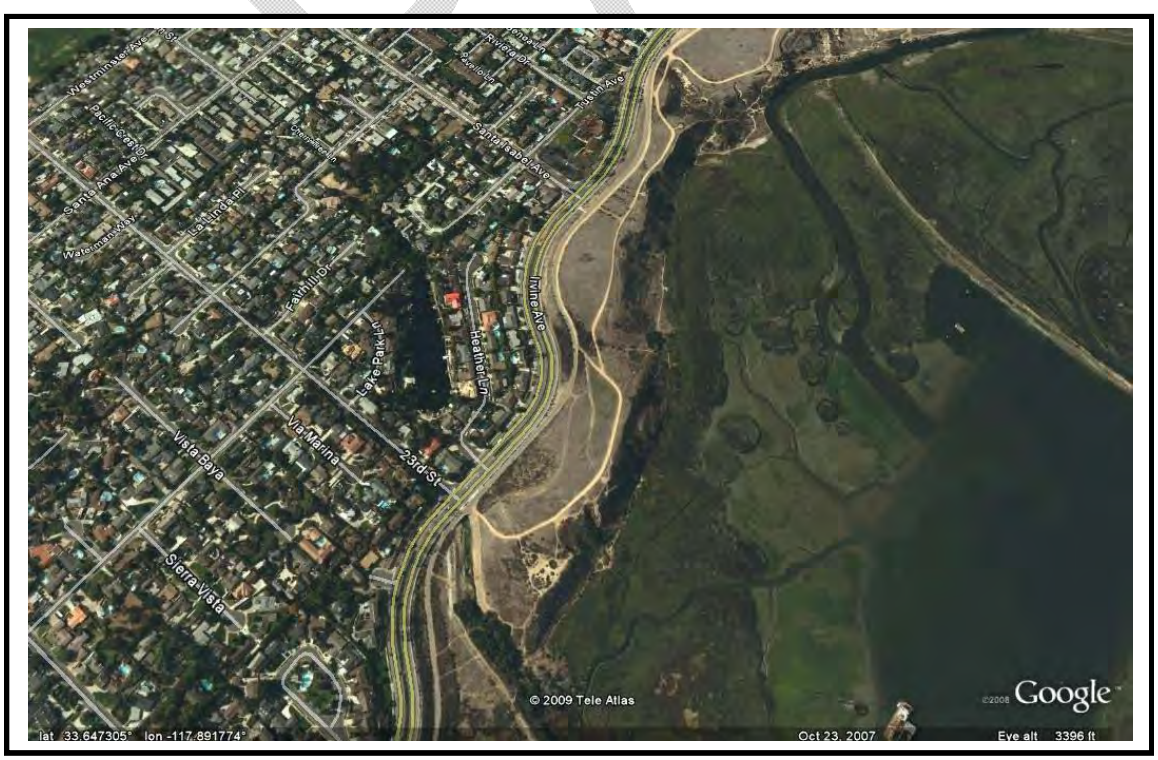


Figure 10-7. Location of the Santa Isabel channel in relation to Upper Newport Bay and the Santa Ana Delhi Channel.

10.4.4 Big Canyon Wash Subwatershed

The Big Canyon Wash subwatershed is a small watershed (approximately 2 mi^2) that is tributary to Upper Newport Bay and is another source of selenium to the Bay (Figure 10-8). Water column guidelines for Big Canyon Wash were calculated for the freshwater marsh ponds and riparian stream areas using the Newport Bay watershed biodynamic model and the fish and bird egg tissue selenium SSOs. Restoration of the lower part of the creek (Big Canyon Nature Park) is slated to begin in the fall of 2009. Current restoration plans call for the creation of an alternative low-selenium freshwater off-channel wetlands and the removal of the existing freshwater marsh and ponds (which contain high concentrations of selenium in sediment, algae, invertebrates and fish; see discussion under Section 3.5.2 of this report), once the off-channel wetlands have been established. Therefore, only the WCGs calculated for the stream areas of the canyon were used in determining a range in loading capacities for this subwatershed.

For Big Canyon Wash, the range in selenium WCGs that were calculated from the bird egg and fish tissue SSOs using the Newport Bay watershed biodynamic model is 0.9 – 1.4 µg/L (SSO-based loading capacity) based on the samples collected from the Big Canyon Nature Park. The current applicable CTR freshwater chronic criterion for selenium is 5 µg/L. While the CTR freshwater criterion for selenium is higher than the range in WCGs calculated from the tissue SSOs, the model calculations are based on very limited data (a one-time sampling event) taken from only one part of the Big Canyon Wash subwatershed. Until additional data are collected that can be used to confirm or revise the model results, it cannot be ascertained with certainty that the CTR freshwater chronic criterion of 5 µg/L would not be protective of the beneficial uses in Big Canyon Wash. For those reasons, the loading capacity for the Big Canyon Wash subwatershed is estimated to range between **1 and 5 µg/L**. However, since the back-calculated WCGs for Big Canyon Creek are based on limited data, and the restoration project will reset the baseline for the lower part of this watershed, the loading capacity for Big Canyon Wash will need to be reviewed and revised as new data are collected and analyzed. Special studies to provide the requisite information to improve and refine the biodynamic model results and the loading capacity for Big Canyon Wash are included as part of the proposed implementation plan for these TMDLs/SSOs (Section 12.0).

Figure 10-8. Google Earth™ image showing the Big Canyon Wash subwatershed. The 60-acre Big Canyon Creek Nature Park is located in the lower part of the canyon. This is the area being restored by the City of Newport Beach with the help of funds from the State of California.

10.5 Summary of Estimated Loading Capacities for the Newport Bay Watershed

A range in concentration-based loading capacities for selenium was derived using the Newport Bay biodynamic model and fish and bird egg tissue selenium SSOs for the San Diego Creek and Big Canyon Wash subwatersheds. The loading capacity for the Santa Ana Delhi Channel is currently assumed to be the same as the adjacent San Diego Creek subwatershed for the reasons outlined in Section 10.4.1. As previously stated, the current CTR saltwater criteria for selenium are well above current ambient water column selenium concentrations in Upper Newport Bay. Therefore, Regional Board staff cannot apply these criteria to the Bay as this would not conform to the state's antidegradation policy. Moreover, it is evident that the saltwater criteria are not sufficiently stringent to protect beneficial uses in the Bay. For the Upper Bay, and for the Santa Isabel Channel, loading capacities are based on the fish and bird egg tissue targets. Table 10-3 summarizes the estimated concentration-based loading capacities for the Newport Bay watershed.

Table 10-3. Range in Loading Capacities for Selenium in the Newport Bay Watershed

Water Body		**SSO-Based Loading Capacity**		**CTR-Based Loading Capacity[2]**
		Tissue concentrations	**WCG-based[1]**	
Salt Water	**Upper Newport Bay[3]**	**5-8 µg Se/g dw**		**NA**
Freshwater Streams	**San Diego Creek**		**5-13 µg Se/L**	**5 µg Se/L**
	Santa Ana/Delhi		**5-13 µg Se/L**	**5 µg Se/L**
	Santa Isabel	**5-8 µg Se/g dw**		**5 µg Se/L**
	Big Canyon Wash		**0.9-1.4 µg Se/L**	**5 µg Se/L**
Freshwater Marshes and Wetlands	**UCI Wetlands (San Joaquin FW Marsh Reserve)**		**2-3 µg Se/L**	**5 µg Se/L**
	IRWD Wetlands (incl. treatment ponds and Carlson Marsh)		**6-9 µg Se/L**	**5 µg Se/L**

[1] Numbers are rounded to the nearest one except for Big Canyon Wash, which are rounded to the nearest tenth.

[2] If the SSOs are approved, the CTR will no longer be in effect and the final loading capacity for selenium will be set at the water column selenium concentration that results in compliance with the fish and bird egg tissue numeric targets/SSOs in all hydrologic units in the watershed, as demonstrated by tissue monitoring (Section 12.5, Task 8). Adjustments to the calculated range in loading capacities will be made if and as necessary using data collected during implementation of these TMDLs/SSOs and the Newport Bay watershed biodynamic model. Such adjustments will be considered through a Regional Water Board public participation process.

[3] The loading capacity for selenium in Upper Newport Bay are currently set at the fish and bird egg tissue numeric targets, or in the future at the water column selenium concentration that results in compliance with the tissue targets, if future data collection efforts improve the predictive ability of the Newport Bay watershed biodynamic model for this area. Such adjustments to the biodynamic model will be considered through a Regional Water Board public participation process.

NA Not applicable: The CTR saltwater chronic and acute criteria for selenium are substantially higher than current ambient water column concentrations measured in Upper Newport Bay and are not appropriate for use in these TMDLs.

WCG Water column guideline; selenium water column concentration predicted from the tissue numeric targets/ SSOs by the Newport Bay biodynamic model (see Section 9.0).

Because the Newport Bay watershed biodynamic model creates a possible range of water column guidelines back-calculated from the bird egg and fish tissue SSOs, the loading capacities as currently defined for this watershed may need to be revised as new information is obtained and the model parameters are refined. As this occurs, the WCGs will be adjusted or re-calculated as needed, which may also then require re-calculation or re-assessment of the current loading capacities (and TMDLs and allocations) for the water bodies in the Newport Bay watershed. Any adjustments would be considered through a Regional Water Board public participation process. Both the minimum and maximum concentrations in the calculated range in loading capacities (and TMDLs and allocations), including those based on the SSOs and the CTR freshwater chronic criterion, for the hydrologic units in the Newport Bay watershed have been considered in the CEQA and economic analysis and also in the BMP Strategic Plan, which identifies the strategy for the development, testing, and implementation of BMPs/treatment technologies and source controls that will be required to reduce selenium concentrations in the watershed so that the recommended fish and bird egg tissue SSOs and TMDL numeric targets (including those based on the CTR freshwater chronic criterion) are met.

10.6 Alternatives to Concentration-Based Loading Capacity Estimates

Since existing loads for the Newport Bay watershed have been calculated, Regional Water Board staff could have elected to estimate mass-based loading capacities for the different water bodies in the watershed using water column selenium concentrations (WCGs) calculated from tissue SSOs with the Newport Bay watershed biodynamic model. However, as discussed previously under Section 10.1, the WCGs provide a direct link to meeting the recommended tissue-based SSOs and, thus, the protection of beneficial uses. Loading capacities based on the more typical mass-based approach do not provide this direct link to the protection of beneficial uses. In addition, this hybrid approach would compound the uncertainty in the loading capacity estimates. In particular, the calculation of selenium loads resulting from rising groundwater, the principal source of selenium inputs to surface waters in the watershed, is very difficult and imprecise.

For the San Diego Creek subwatershed, Regional Water Board staff could also have elected to use the recommended fish and bird egg tissue SSOs as the loading capacity. However, the habitat in most of the freshwater areas of the watershed is less stable and more fragmented than that of Upper Newport Bay. Fish species can change from year to year depending on how much flooding has occurred in the creeks, or whether someone has released fish into the creek[1]. Nesting habitat is also highly variable as a result of maintenance activities in the channels or changes in flow conditions. Selenium concentrations in water in the

[1] This is especially true for Peters Canyon Wash and Lower San Diego Creek; the fish species sampled one year may no longer be present the next year or new species (such as goldfish) may suddenly appear.

freshwater areas are much less variable. For these reasons, concentration-based loading capacities based on the WCGs predicted by the Newport Bay watershed biodynamic model, or based on the CTR freshwater chronic criterion, were considered to be more appropriate for the freshwater areas in the subwatershed.

For Newport Bay itself, no model or monitoring estimates currently exist to measure the selenium lost from the bay to the ocean (particularly during high runoff events). Such estimates would have to be made as part of a future Newport Bay selenium mixing model (see Section 12.5, Task 11) that would incorporate loads to the bay with tidal mixing and exchange, as well as all aspects of sequestration, loss, and sediment re-mineralization and loss processes. For the reasons discussed previously, the CTR saltwater selenium criteria cannot be applied to Newport Bay either to derive a concentration- or mass-based loading capacity due to antidegradation concerns (see discussion under Section 10.3). Dissolved selenium concentrations in the bay are well below both the CTR chronic and acute criteria (71 µg Se/L and 290 µg Se/L, respectively) for total dissolved selenium in saltwater. The CTR freshwater chronic criterion of 5 µg Se/L cannot legally be applied to the marine waters of Newport Bay.

11.0 TMDLs, Allocations, and Margin of Safety

A total maximum daily load (TMDL) is defined as the maximum amount of a pollutant that can be received by a water body while the loading capacity is not exceeded and water quality standards are achieved. The TMDL is expressed as:

$$TMDL = WLA + LA + MOS$$

Where: WLA = Waste Load Allocations for Point Sources
LA = Load Allocations for Nonpoint Sources
MOS = Margin of Safety

The allocations distribute the TMDL among all point and nonpoint sources. Various methods may be employed to determine how loads should be allocated, and numerous factors, including cost, technical achievability, and equity, should be considered (SWRCB, 2005). TMDLs can be expressed on a mass loading basis (e.g., grams of pollutant per year) or as a concentration in accordance with provisions in federal regulations [40 CFR 130.2(l)]. In addition, TMDLs and associated WLAs and LAs must be expressed in quantitative terms [40 CFR 130.2 (e-i) and 40 CFR 130.7 (c)]. For the Newport Bay Watershed[1], the TMDLs are set equivalent to the loading capacities (Section 10, Table 10-3), which, for most water bodies, are water column concentrations that are based on water column guidelines derived using the Newport Bay watershed biodynamic model and the CTR freshwater selenium chronic criterion. For Upper Newport Bay and the Santa Isabel Channel, loading capacities are based on fish and bird tissue concentrations equivalent to the numeric tissue targets/SSOs. (A CTR-based water column concentration loading capacity is also specified for the Santa Isabel Channel.) The WLAs and LAs are also expressed as concentrations.

While a mass-based approach is often considered more suitable for bioaccumulative substances such as selenium, in this case, selenium concentrations, and the application of the specifically tailored Newport Bay watershed biodynamic model (see Section 9.0, Linkage Analysis), provide a more direct link to adverse effects on aquatic life and aquatic-dependent wildlife in the watershed. As discussed in Section 9.0 Linkage Analysis and Section 10.0 Loading Capacity, selenium concentrations in water provide a direct link to meeting the recommended tissue-based SSOs and, thus, the protection of beneficial uses. The water column guidelines predicted by the Newport Bay watershed biodynamic model incorporate differences in selenium speciation and recycling that may occur in a water body through the use of particulate to water column partitioning coefficients (K_ds) and trophic transfer factors (TTFs) that represent how efficiently selenium transfers from primary producers to predators,

[1] Includes Newport Bay and the area tributary to Newport Bay including San Diego Creek, Santa Ana Delhi Channel, Santa Isabel Channel, Big Canyon Wash, and Costa Mesa Channel.

the most important route for selenium bioaccumulation in tissue. TMDLs and allocations based on the more typical mass-based approach do not provide this direct link to the protection of beneficial uses.

As discussed in Section 10.0 Loading Capacity, a concentration-based approach to TMDLs and allocations is expected to be protective of both the freshwater portions of the Newport Bay Watershed and Upper and Lower Newport Bay, which are estuarine and marine, respectively. The number and magnitude of exceedances of the TMDL numeric fish and bird egg tissue targets (SSOs) observed in Upper Newport Bay are fewer than those observed in the freshwater reaches draining to the Bay; no exceedances of the tissue targets were observed in Lower Newport Bay. The freshwater drainages in the Newport Bay watershed provide the majority of selenium to Newport Bay, with the largest contribution coming from the San Diego Creek subwatershed. Therefore, it is highly likely that if water column selenium concentrations are reduced in the freshwater drainages such that the selenium tissue numeric targets and SSOs are met, then the tissue targets and SSOs will also be met in Upper Newport Bay. Because of the linkage between reductions in selenium concentrations and attainment of the tissue numeric targets/SSOs (via the Newport Bay watershed biodynamic model), a concentration-based TMDL/allocation approach for selenium is considered to be more protective of the beneficial uses in Upper and Lower Newport Bay, than a mass-based approach.

Finally, the watershed conditions, which are characterized by variations in stream flows and intermittent groundwater discharges that vary seasonally and from year to year, are better addressed by concentration-based TMDLs and allocations. Non-point source rising groundwater is the largest source of selenium in the watershed. Because of the intermittent and variable nature of the stream flows and groundwater discharges in the watershed, which results in both spatial and temporal differences in selenium loads, calculating loads for rising groundwater is very difficult and imprecise. Areas of elevated selenium concentrations however, are more readily identified and can be targeted for remediation. Concentration-based effluent limits in waste discharge requirements facilitate both the permitting process and the determination of compliance. Concentration-based allocations are thus more practical to implement.

11.1 Seasonal Variations and Critical Conditions

TMDLs are required to contain an analysis of seasonal variation and critical conditions [40 CFR 130.7 (c)]. This analysis allows for a determination of when the TMDLs and the allocations should apply to ensure protection of beneficial uses and compliance with the numeric targets. For selenium, dry and wet weather conditions were evaluated along with seasonal variations to determine the critical conditions and period of applicability for the TMDLs and allocations.

11.1.1 Critical Conditions

Critical conditions are the conditions under which there is the greatest risk to the most sensitive beneficial use(s) due to selenium exposure. TMDLs developed to achieve water quality standards under critical conditions will also be protective of other conditions experienced in the subject waters. In addition, application of the TMDLs may be limited to the critical conditions, including a specific time and/or flow period.

Aquatic life (such as fish), as well as aquatic- dependent wildlife (such as birds), are the beneficial uses within the Newport Bay watershed that are most sensitive to selenium (Section 4.0). Aquatic life and aquatic- dependent wildlife are at the greatest risk of selenium exposure during embryonic and/or juvenile development. Most of the significant adverse effects of selenium in fish and birds are associated with reproduction. The most vulnerable period for fish and birds is maternal exposure to selenium immediately prior to egg laying (Cleveland, et al, 1993; Coyle, et al, 1993; Heinz, 1993). Selenium is a physiologically-regulated contaminant that both accumulates and depurates in organisms over short time periods (weeks). Thus, the concentration to which organisms are exposed immediately prior to egg laying significantly affects selenium bioaccumulation and the potential for reproductive effects. In the Newport Bay watershed, the reproductive period generally occurs in the late spring/early summer period, though the reproductive period varies among species and by year. Therefore, defining a critical period based on the breeding season would require consideration of these variations and would not necessarily ensure protection of the beneficial uses under all conditions. In addition, the TMDLs should be protective of the beneficial uses throughout the entire year.

Since a critical condition based strictly on protection of aquatic life and aquatic-dependent wildlife during the period of greatest risk of selenium exposure was not considered sufficiently protective of beneficial uses, an analysis was conducted to determine if other critical conditions exist. Critical conditions may also exist if there is a period of time or condition in the watershed that results in higher concentrations of selenium that may result in greater selenium exposure. To evaluate this condition, an analysis of selenium concentrations observed during dry weather flows as compared to selenium concentrations during wet weather flows was conducted (see Section 11.1.3, below). For this analysis, selenium concentration data and flow data from the San Diego Creek at Campus Drive monitoring station were separated into dry weather flow and wet weather flow data sets, according to the dry weather flow analysis described in Section 11.1.3. The results of the analysis are shown in **Error! Reference source not found.**.

The box plots of total selenium concentrations shows that dry weather flows (≤ 23 cubic feet per second [cfs]) have significantly higher median selenium concentrations than wet weather flows (**Error! Reference source not found.**1).

This is expected since the main source of selenium in the watershed is from rising groundwater (Section 7.0). During dry weather conditions, the proportion of groundwater in the creeks is relatively high, whereas during wet weather conditions the groundwater is diluted by rainfall and runoff, lowering the concentration of selenium. Thus, potential exposure of aquatic life and aquatic-dependent wildlife to selenium is greatest during dry weather conditions.

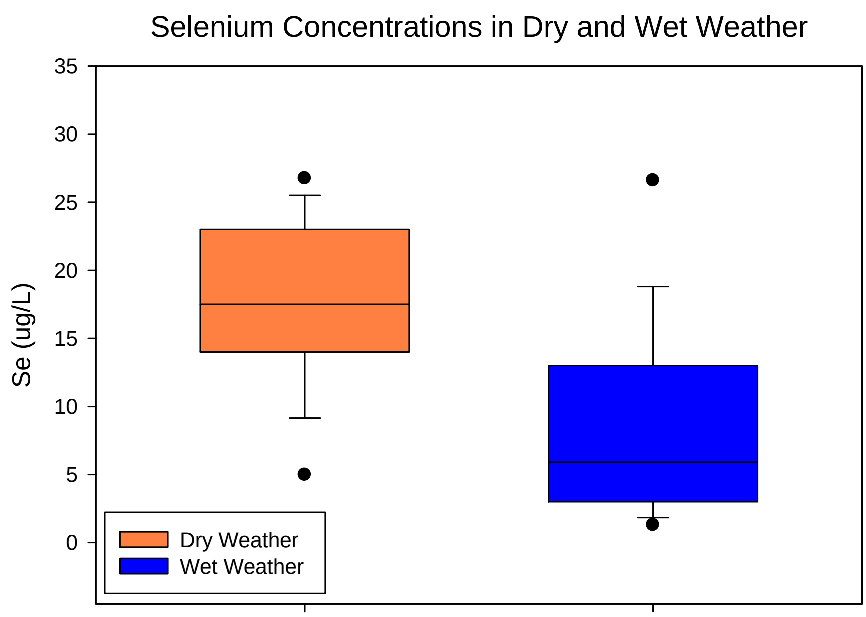


Figure 11-1. Box Plots of Total Selenium in Dry and Wet Weather at San Diego Creek at Campus (The line within the box plot represents the median concentration, the upper and lower bounds of the boxes represent the 75th and 25th percentile concentrations, the whiskers represent the 90th and 10th percentile concentrations, and the dots represent the 95th and 5th percentile concentrations.)

Based on this analysis, dry weather flows are considered to be a critical condition for these TMDLs. Since dry weather flows occur year-round, the application of the TMDLs and allocations will be protective of the period of potentially greatest risk to aquatic life and aquatic-dependent wildlife (i.e. the breeding season). During the late spring/early summer during which the breeding season typically occurs, flows in the Newport Bay watershed are typically low and contain elevated selenium concentrations dominated by inputs from rising groundwater. Utilizing dry weather flows as the critical condition and basis for determining the applicability of the TMDLs and allocations will ensure protection of beneficial uses by providing a year-round approach that will account for any variations in breeding season length from year to year and represent the flow conditions typically observed during the breeding season. Wet weather flows have lower concentrations, occur over short periods of time (hours to days) and generally occur in the winter, prior to the breeding season. As a result, not applying the TMDLs and allocations during wet weather flows will still be protective of beneficial uses.

11.1.2 Consideration of Seasonal Variations

As discussed in the Critical Conditions section, protection of beneficial uses requires consideration of both the periods of highest selenium exposure (dry weather flows) and the periods of greatest potential harm to the beneficial uses (breeding season and periods of embryonic and/or juvenile development). Dry weather flows occur year-round and therefore present potential periods of high selenium exposure during all periods of the year. The period of potential greatest harm due to selenium exposure occurs seasonally (spring and early summer). As a result, consideration of seasonal variations could include the development of different allocations for different periods of the year or the application of the allocations only during the breeding season. However, to ensure protection of beneficial uses both during the sensitive period and from the higher selenium concentrations that occur during dry weather flows, a year-round application of the TMDLs and allocations during dry weather flows was determined to be the most protective approach.

11.1.3 Dry Weather Flow Definition

Because the primary source of selenium in the watershed is rising groundwater, and groundwater dominates surface freshwater flows under dry weather conditions, it is necessary to determine how dry weather conditions in the Newport Bay watershed should be defined. Flow conditions in the freshwater drainages were evaluated to distinguish between flows that occurred in the watershed in the absence of precipitation (dry weather flows) as compared to flows that occur during precipitation events (wet weather flows). Dry weather flows occur year-round so the analysis is not truly seasonal, but differences between conditions and impacts between dry weather and wet weather flows were potentially different and considered separately. The definition of dry weather flow was determined by conducting an analysis of ten (10) years of flow data measured at San Diego Creek at Campus Drive by the County of Orange, Department of Public Works between 1998 and 2008 (Appendix 11A). San Diego Creek at Campus Drive was selected for the analysis because the San Diego Creek subwatershed is the largest subwatershed and provides the majority of the flow (approximately 78%) and selenium to Upper Newport Bay. Additionally, this site has a sufficient amount of flow data to allow for a comprehensive analysis.

In Figure 11-2, the flows in San Diego Creek at Campus drive are plotted by the percentile rank of each flow to yield a flow duration curve. A “knee” is present in the flow duration curve, indicating a sharp change in the flow rate between approximately the 85^{th} – 90^{th} percentile flow rates. This curve is characteristic of most southern California streams due to the Mediterranean climate pattern, which produces low or intermittent base flows during most of the year, and much higher flows during storm events. A mathematical analysis of the curve was conducted to determine at which point on the curve the greatest increase in slope takes place. The point on the curve with the greatest increase in slope is the percentile which corresponds to the maximum non-storm flow rate before precipitation driven runoff flow rates begin. The result of the analysis showed that the greatest increase in the slope of the curve happens at the 88th percentile. The 88th percentile flow rate for San Diego Creek at Campus Drive corresponds to a flow rate of 23 cfs[2].

To verify the appropriateness of San Diego Creek at Campus Drive as the point to determine dry weather flow conditions for the watershed, a flow duration curve was also developed for the Santa Ana-Delhi Channel (Figure 11-3) using flow data measured by the County of Orange, OC Public Works between 1998 and 2008 (Appendix 11B). The Santa Ana-Delhi Channel represents the other significant source of flow (approximately 18%) to Newport Bay. Combined with flows from San Diego Creek at Campus Drive, these two stations account for approximately 96% of the total freshwater flows in the watershed. A mathematical analysis of the duration curve to determine the greatest change in slope could not be conducted for Santa Ana-Delhi Channel due to limited data for the highest percent flows. However, visual analysis of Figure 11-3 shows that at the 88th percentile flow (the flow rate determined to be the cut-off point for dry weather flow at San Diego Creek at Campus Drive), flows in Santa Ana-Delhi Channel are representative of storm flow events and not dry weather.

Therefore, determining dry weather flow conditions based on flows at San Diego Creek at Campus drive is appropriate and is representative of dry weather conditions for the entirety of the watershed. If flows meet the requirements for dry weather flow as defined in this section at San Diego Creek at Campus Drive, the entire watershed will be considered to be experiencing dry weather flow.

[2] This approach has been used in other southern California TMDLs, including the Calleguas Creek Watershed Metals and Selenium TMDL.

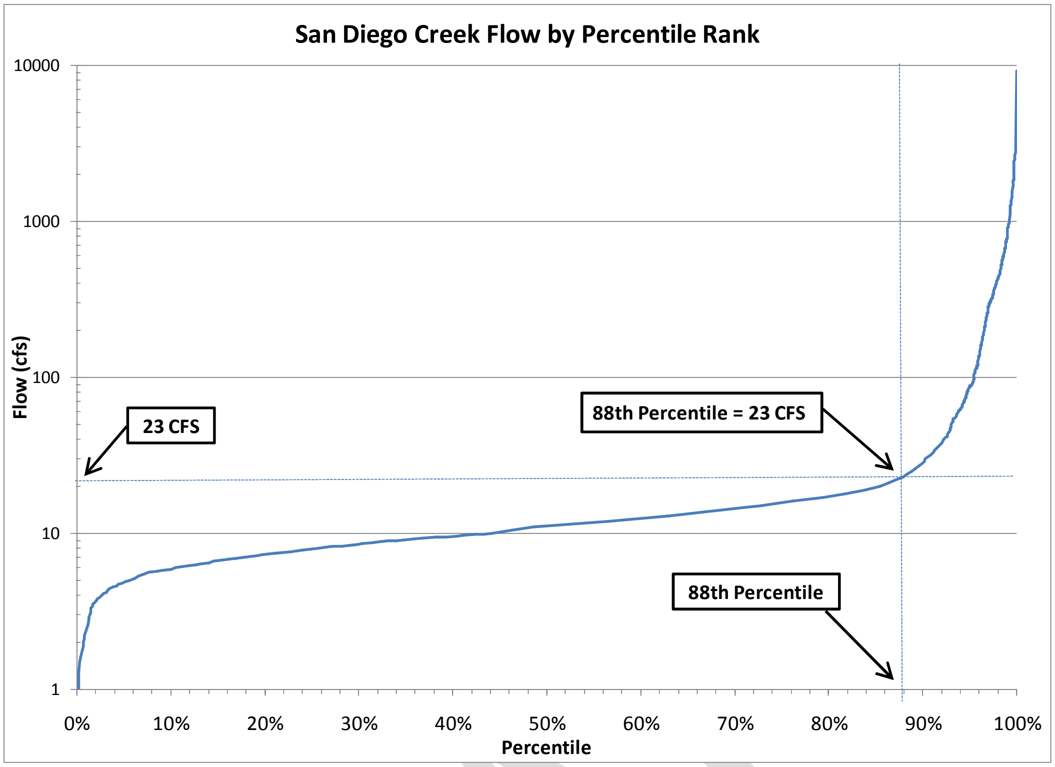


Figure 11-2. Flow Duration Curve for San Diego Creek at Campus

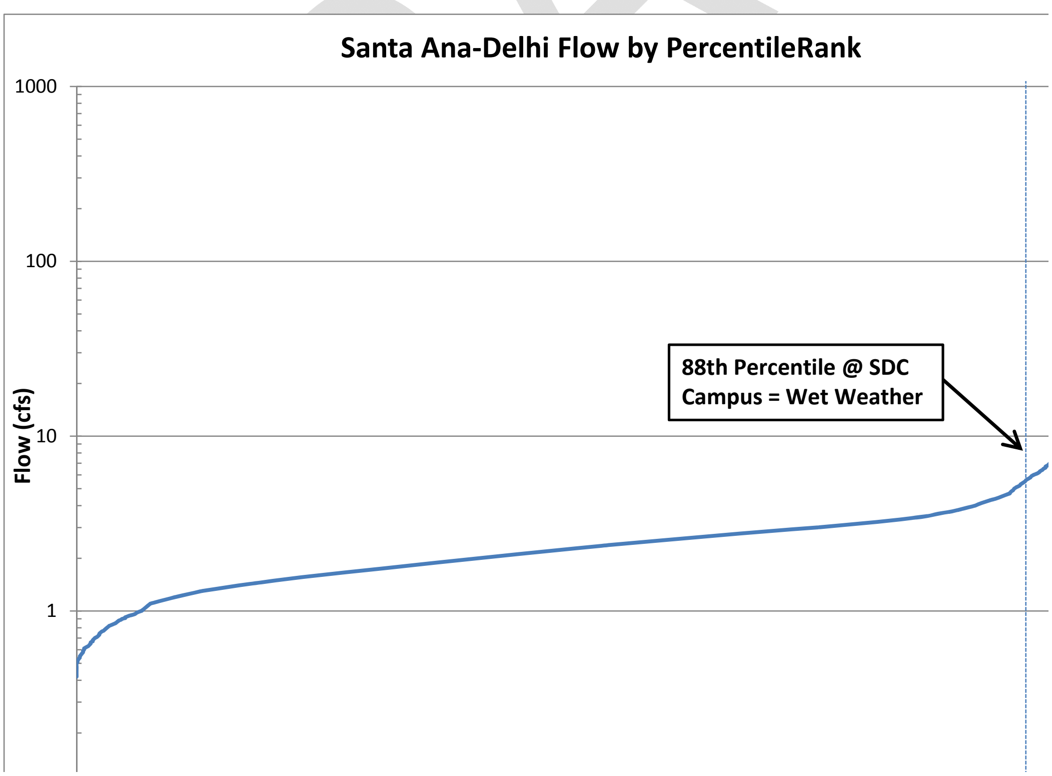


Figure 11-1. Flow Duration Curve for Santa Ana-Delhi Channel

It should be recognized that this definition of dry weather flow differs from the definition of dry weather flows employed in the Nutrient TMDLs for Newport Bay and San Diego Creek Watershed (Regional Water Board, 1998). For the Nutrient TMDLs, dry weather flow was defined as flows less than or equal to 50 cfs as measured at San Diego Creek at Campus Drive. This flow rate was selected because this is the flow rate necessary to create a freshwater lens through Newport Bay to the ocean without mixing (Regional Water Board, 1998). The Nutrient TMDLs defined the distinction between wet and dry weather in terms of ocean/bay mixing rather than by the presence of precipitation influenced flows, as is typically done. For the Nutrient TMDLs, Newport Bay itself was listed as impaired due to nutrients in the water column and was experiencing algae growth. Therefore, the objective of the Nutrient TMDLs was to address any inputs to Newport Bay that might be sequestered within the Bay and cause or contribute to the impairment. On that basis, the exclusion of flows that exit the Bay without mixing in the Bay was appropriate.

11.2 TMDL and Allocation Approach

The purpose of allocations is to assign the TMDL of the water body to the point source and non-point sources within the watershed. As previously noted, TMDLs and allocations can be concentration-based or load-based. As selenium concentrations provide a more direct link to adverse effects on aquatic life and aquatic-dependent wildlife in the watershed (as discussed above and in Section 9.0, Linkage Analysis and Section 10.0, Loading Capacity), the selenium TMDLs and allocations are concentration based. Given the consideration of seasonal variations and critical conditions (see preceding discussion), the TMDLs and allocations will be applied year-round during dry weather flows, i.e., the TMDLs and allocations will be applicable for all reaches of the watershed when flows in San Diego Creek at Campus Drive are below 23 cfs (as discussed above). Additional considerations concerning the expression of the TMDLs and determinations of the wasteload and load allocations are described in the following subsections.

11.2.1. Margin of Safety

A margin of safety for a TMDL addresses uncertainties associated with the analyses that may result in targets not being achieved. The margin of safety may be explicit, implicit, or both. For these selenium TMDLs, an implicit margin of safety is used.

Load-based TMDLs are typically derived from multiplying the numeric target (usually the applicable water quality objective) by a certain flow rate. The resulting load is assumed to protect beneficial uses. However, the technical link to protection of beneficial uses is most often in the actual standard (i.e. numeric target/water quality objective) and not the calculated load. Therefore, the choice of a flow condition, regardless of what flow rate is chosen, introduces an inherent margin of error in load-based TMDLs. In such TMDLs, an explicit margin of safety is typically and appropriately applied.

As discussed in Sections 6.0 and 8.0, there remains scientific and regulatory agency disagreement concerning the adequacy of the CTR criteria for the protection of wildlife, primarily because selenium is bioaccumulated via diet, not water. For the selenium TMDLs, the SSO-based numeric fish and bird egg tissue targets were recommended by USFWS to ensure protection of the bird and fish species that inhabit or forage in the Newport Bay watershed. The selenium tissue concentrations recommended by USFWS are considered to be either no effect (for birds) or no to very low effect (for fish) concentrations, and as such are conservative objectives that provide an implicit margin of safety for the selenium TMDLs. By selecting numeric targets that are tissue-based and designed to be protective of aquatic life and aquatic dependent wildlife, these selenium TMDLs are expected to be more protective of the beneficial uses in the watershed than TMDLs based solely on the CTR criteria.

The Newport Bay watershed biodynamic model provides a means to directly link the numeric tissue targets/SSOs to a range of possible water column selenium concentrations that if met, are expected to result in compliance with the tissue targets/SSOs. The assumptions used in the biodynamic model (e.g., selection of partitioning coefficients and trophic transfer factors) to derive the water column guidelines (WCGs) were selected based on both site-specific data and data in the literature and are directly linked to the beneficial uses within the watershed (see discussion under Section 9.0, Linkage Analysis). As these TMDLs (with the exception of Upper Newport Bay and Santa Isabel Channel) and allocations rely on the WCGs that are predicted from Newport Bay watershed biodynamic model, which included site-specific data in the selection of the model parameters and the use of the conservative tissue-based targets recommended by USFWS staff, the proposed TMDLs incorporate an implicit margin of safety.

As stated above, a TMDL is the sum of the wasteload and load allocations and the margin of safety. With an implicit margin of safety, the TMDL theoretically becomes the sum of the allocations. However, concentration-based wasteload and load allocations are not additive. Therefore, the concentration-based wasteload and load allocations are equivalent to the water column concentration-based TMDLs (see 11.4.1 and 11.4.2).

11.2.2 Statistical Expression of the TMDLs and Allocations

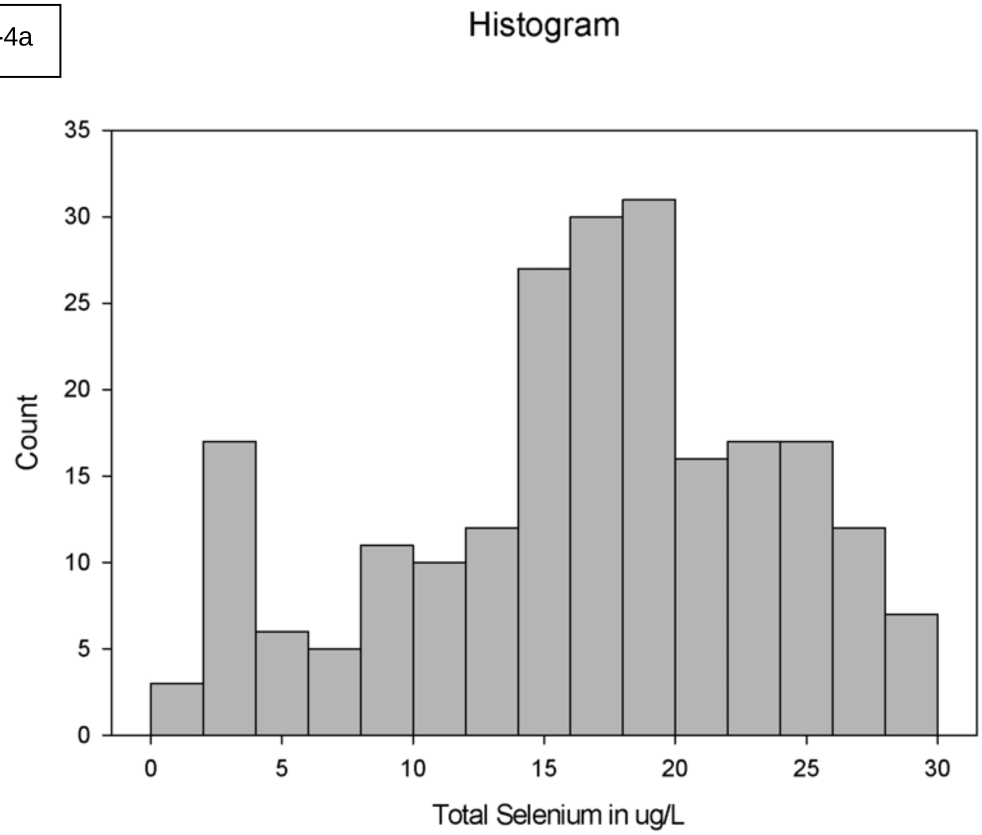
Averaging periods for the TMDLs and allocations were defined based on the potential impacts from selenium exposure and variability in observed receiving water data. Selenium is a bioaccumulative pollutant and chronic conditions are therefore the most appropriate time interval for assessment of beneficial uses. As a result, an averaging period is appropriate. Based on an analysis of ten years (1998-2008) of the dry-weather, low flow data measured at San Diego Creek at Campus Drive (Appendix 11A), large spikes in the concentrations of selenium in San Diego Creek are not expected. Data for San Diego Creek demonstrate the potential variability, where the 90th percentile selenium concentration is less than 10 µg Se/L greater than the geometric mean concentration and the 10th percentile selenium concentration is less than 10 µg Se/L lower than the geometric mean concentration (Table 11-1).

Table 11-1. Selenium Summary Statistics in San Diego Creek (µg/L)

Geomean	15.8	75th	23.0	25th	14.0
Mean	17.5	90th	25.0	10th	9.4
Median	17.5	Max	29.0	Min	2.0

A histogram and normal probability plot of the total selenium concentrations at the San Diego Creek at Campus Drive monitoring station show a near normal distribution (Figures 11-4a and b), instead of a log normal distribution. Since the protection of beneficial uses is linked to chronic not acute conditions, a semi-annual averaging period utilizing an arithmetic mean is appropriate for TMDLs and allocations based on water column concentrations. The semi-annual averaging periods are defined as April 1 through September 30 and October 1 through March 31 each year. For tissue samples, an annual averaging period is more appropriate since bird eggs are only available during a very limited time of the year, and fish tissue and other biota should also be collected during the same timeframe that the birds are breeding since they constitute a likely source of selenium input. Because selenium concentrations in fish and bird egg tissue are expected to be much more variable than those in water, a geometric mean statistical approach should be employed for evaluating compliance with the tissue-based TMDLs.

11-4a



11-4b

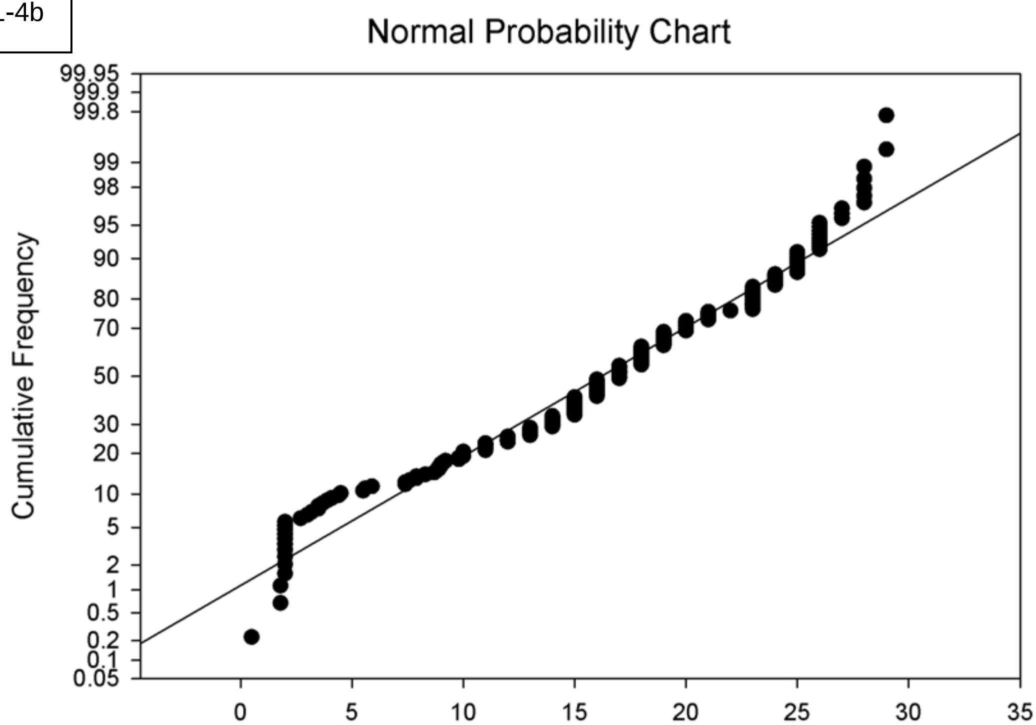


Figure 11-4a and b. Histogram and normal probability plot of selenium concentrations in San Diego Creek at the Campus Drive monitoring station.

11.3 TMDLs

The TMDLs are set at the loading capacities (see Section 10, Loading Capacity, Table 10-3), but, as discussed above, apply only during dry-weather flows year round (that is, when the flows measured in San Diego Creek at Campus Drive are less than or equal to 23 cfs). Given the limited variability of dry weather flow concentrations of selenium (see 11.1.1.), TMDLs based on water column concentrations are expressed as semi-annual arithmetic means (April 1 through September 30 and October 1 through March 31). Selenium tissue concentrations are expected to vary more widely (see 11.2.3.). Accordingly, these tissue-based TMDLs are expressed as annual geometric means. The TMDLs are shown in Table 11-2. In response to a decision by the D.C. Circuit Court of Appeals (*Friends of the Earth, Inc. v. EPA, et al.,* No. 05-5015 [D.C. Cir. 2006]), the water column concentration-based TMDLs are also expressed as daily maximum values (Table 11-2). Identifying daily maximum tissue-based TMDLs is neither meaningful nor practicable.

Compliance with the TMDLs is to be achieved as soon as possible but no later than 15 years from the effective date of the TMDLs, i.e., no later than [*insert date certain once TMDLs are approved*].

Table 11-2. Total Maximum Daily Loads for Selenium in the Newport Bay Watershed [0,1]

Water Body		SSO-Based TMDLs[2]		CTR-Based TMDLs[2]	
		TMDLs as Semi-annual Arithmetic or Annual Geometric Mean[3]	TMDLs as Daily Maximum[4]	TMDLs as Semi-annual Arithmetic[3] Mean (µg Se/L)	TMDLs as Daily Maximum (µg Se/L)[4]
Salt Water	Upper Newport Bay[5]	5-8 µg Se/g dw (tissue)	5-8 µg Se/g dw (tissue)[6]	NA	NA
Freshwater Streams	San Diego Creek	5-13 µg Se/L	10-27 µg Se/L	5	10
	Santa Ana Delhi	5-13 µg/L	10-27 µg Se/L	5	10
	Santa Isabel[5]	5-8 µg Se/g dw (tissue)	5-8 µg Se/g dw (tissue)[6]	5	10
	Big Canyon Wash	0.9-1.4 µg Se/L	1.9-2.9 µg Se/L	5	10
Freshwater Marshes and Wetlands	UCI Wetlands (San Joaquin FW Marsh Reserve)	2-3 µg Se/L	4-6 µg Se/L	5	10
	IRWD Wetlands (incl. treatment ponds and Carlson Marsh)	6-9 µg Se/L	12-19 µg Se/L	5	10

[0] TMDLs apply year-round during dry weather flows (i.e., when flow at San Diego Creek at Campus is ≤ 23 cfs).

[1] Numbers are rounded to the nearest one except for Big Canyon Wash, which are rounded to the nearest tenth.

[2] If the SSOs are approved, the CTR will no longer be in effect and the final TMDLs for selenium will be set at the water column selenium concentration that results in compliance with the fish and bird egg tissue numeric targets/SSOs in all hydrologic units in the watershed, as demonstrated by tissue monitoring (see subsection 4.c.4, Task 8 [and Section 12.5, Task 8, of the 2009 Selenium Staff Report]). Adjustments to the calculated range in TMDLs will be made if and as necessary using data collected during implementation of these TMDLs/SSOs and the Newport Bay watershed biodynamic model. Such adjustments will be considered through a Regional Water Board public participation process. If the SSOs are approved, the CTR-based TMDLs will no longer be in effect.

[3] A semi-annual (April 1 through September 30; October 1 through March 31) arithmetic mean is applied to water column concentrations; an annual geometric mean is applied to fish and bird egg tissue concentrations.

[4] For water column concentration-based TMDLs, daily maximum TMDLs are based on the scheme described in the Draft EPA Document "Options for Expressing Daily Loads in TMDLs" (USEPA, 2007). A factor of 2.064 is applied to the semi-annual arithmetic mean to calculate the daily maximum concentration.

[5] The TMDLs for selenium in Upper Newport Bay and Santa Isabel Channel are currently set at the fish and bird egg tissue numeric targets, or in the future at the water column selenium concentration that results in compliance with the tissue targets, if future data collection efforts improve the predictive ability of the Newport Bay watershed biodynamic model for these areas. Such adjustments to the biodynamic model will be considered through a Regional Water Board public participation process.

[6] Tissue-based daily maximum TMDLs are set as the same as the annual geometric mean TMDLs; it is not practicable or protective of beneficial uses to attempt to apply a daily concentration to fish or bird egg tissue selenium concentrations..

NA Not applicable: The CTR saltwater chronic and acute criteria for selenium are substantially higher than current ambient water column concentrations measured in Upper Newport Bay and are not appropriate for use in these TMDLs.

11.4 Allocations

As described in preceding sections, ranges of water column concentrations (water column guidelines or WCGs) necessary to achieve the tissue-based numeric targets were calculated for the freshwater areas of the watershed using the Newport Bay watershed biodynamic model. These water column guidelines are the basis, in part, of the water column concentration-based loading capacities and TMDLs, and, in turn the water column concentration-based wasteload and load allocations. Water column concentration-based TMDLs are also based on the CTR freshwater criterion. These TMDLs will no longer be in effect once the SSOs are approved.

While ranges of loading capacities and TMDLs are identified for Upper Newport Bay, certain freshwater streams and freshwater marshes and wetlands (see Table 10-3 and Table 11-2), a more focused approach to identifying applicable allocations is proposed. Specifically, for the purposes of establishing the wasteload and load allocations to implement the SSO-based TMDLs, the upper end of the range of TMDLs, i.e., 13 µg Se/L for the San Diego Creek subwatershed (including the IRWD and UCI wetlands and the Santa Ana Delhi Channel subwatershed) and 1 µg Se/L for Big Canyon Wash, are set initially as the final allocations.

Compliance with the wasteload allocations and load allocations for the freshwater areas in the Newport Bay watershed (which are the largest sources of selenium to the bay) is expected to result in compliance with the TMDLs established for Upper Newport Bay; no separate allocations for the Upper Bay are established. Likewise, reductions in selenium concentrations in San Diego Creek are also expected to result in reductions in both the UCI and IRWD off-channel wetlands such that the tissue SSOs will be met; again, no separate allocations for these wetlands are established. As discussed previously, the Santa Ana Delhi Channel is treated as part of the San Diego Creek subwatershed; therefore, with the exception of Big Canyon Wash and the Santa Isabel Channel, the allocations identified for the San Diego Creek watershed are considered to be applicable to the Newport Bay watershed as a whole. Assigning allocations to all discharges based on the water column guidelines, or the CTR chronic criterion unless and until superseded by the SSOs, for the freshwater reaches will be protective of the watershed, including the Bay.

At this time, there are insufficient data to determine allocations to meet the tissue-based TMDLs for the Santa Isabel Channel. Selenium limitations on discharges to this channel will take into consideration ambient water quality conditions (which, based on limited data, are better than the CTR criterion) and applicable standards, including antidegradation provisions[3].

Compliance with the allocations is to be achieved as soon as possible but no later than 15 years from the effective date of these TMDLs, i.e., no later than [*insert date certain once TMDLs are approved*].

11.4.1. Waste Load Allocations

All point sources (permitted discharges), are assigned waste load allocations (WLAs) for these TMDLs. Concentration-based allocations are assigned for both the current, applicable criterion (CTR) as well as for back-calculated water column guidelines for the proposed tissue-based SSOs (Section 9.0). If and when the SSOs are promulgated by USEPA, they will supersede the CTR criterion and allocations based on the water column guidelines derived from the SSOs will supersede the CTR-based allocations.

Waste load allocations are applicable year-round during dry weather flows as determined when flow measurements at San Diego Creek at Campus are ≤ 23 cfs. The allocations will be calculated as semi-annual arithmetic means. The semi-annual periods are defined as April 1st through Septmber 30th and October 1st through March 31st. each year. Compliance with the WLAs will be determined per the approach discussed in Section 12.0, Implementation Plan. The WLAs are presented in Table 11-3. The allocations are to be achieved as

[3] It should be noted that the finding of impairment in the Santa Isabel Channel is based on limited data and limited numbers of exceedances of the CTR freshwater criterion. Additional monitoring, including tissue-monitoring, if feasible, is expected to result in delisting of this water from the Clean Water Act section 303(d) list. In this case, neither TMDLs nor allocations would be necessary or appropriate for this Channel.

soon as possible but no later than 15 years from the effective date of these TMDLs, i.e., no later than [*insert date certain once TMDLs are approved*].

Table 11-3. Final Waste Load Allocations as a Semi-Annual Arithmetic Mean (for implementation purposes)[a]

Point Sources	CTR-Based Allocation (ug/L) [b, i, j]	SSO-Based Allocation (ug/L) [b, c, d, e, f, g, h, i, j]	
		Newport Bay Watershed	Big Canyon Wash
Urban Runoff [k]			
GW Long-term Dewatering			
GW Short-term Dewatering			
GW Clean-up (Long Term)	5	13	1
GW Clean-up (Short Term/ Mobile Systems)			
Nursery Operations			

(a) For semi-annual arithmetic mean: April 1 through September 30 and October 1 through March 31 each year.

(b) Allocations apply during dry weather flows (as determined when flow at San Diego Creek at Campus is ≤ 23 cfs).

(c) Concentration-based final allocations are based on the back calculated water column guidelines derived from the bird egg and fish tissue targets through the use of the biodynamic model represented by this equation: [[(((((fish tissue target)/TTFff)/TTFf)/TTFi)/Kd)*1000]+[(((((bird egg target)/TTFe)/TTFf)/TTFi)/Kd)*1000]]/2.

(d) TTFe = trophic transfer factor from predatory fish to egg, TTFff = trophic transfer factor from small fish to predatory fish, TTFf = trophic transfer factor from invertebrates to fish, TTFi = trophic transfer factor from particulates to invertebrates, Kd = uptake coefficient from dissolved Se in water to particulates.

(e) Initial values: TTFe = 1.4, TTFff = 1.1, TTFf = 1.1, TTFi = 2.8, K_d SDC = 159, K_d BCW = 1469. Additional K_d values may be incorporated for additional specific water bodies. TTF values may vary by specific water body. In water bodies where predatory fish are not present, the TTFf value in both equations should equal 1 to represent that one less step is occurring in the food chain. Such applications of the equation will be considered through a public participation process.

(f) During the development of the TMDLs, the derivation of the water column guidelines from the targets produced a range of possible water column guideline values based on the values assumed for the variables in the equation. The initial values selected included a rounded WCG of 1 ug/L for Big Canyon Wash and 13 ug/L for the rest of the Newport Bay watershed.

(g) Following the completion of studies to evaluate appropriate K_d and other variables (see Implementation Section) and based on the implementation of the BMP Strategic Plan, the model inputs and WCGs will be reevaluated and updated as necessary no later than 10 years from the effective date of the TMDLs. Subject to review and comment via a public participation process, updated values may then replace the initial values in the equations, resulting in revised allocations. The implementation plan, including the BMP Strategic Plan, and all the analyses required and completed for consideration of these Basin Plan amendments, including economics and CEQA, considered the full range of allocations.

(h) The allocations based on the back-calculated water column guidelines are to be achieved as soon as possible, but no later than 15 years from the effective date of the TMDLs, as discussed in Section 12.

(i) Assessed in the receiving water for members of the Cooperative Watershed Program. Compliance with allocations will be determined pursuant to the Compliance Approach outlined in the Implementation Plan (Section 12.0)

(j) Assessed at 'end of pipe' for Individual Action Plan point sources. Compliance with allocations will be determined pursuant to the Compliance Approach outlined in the implementation plan.

(k) Assessment location for Urban Runoff is the Costa Mesa Channel. This location was selected as a surrogate urban runoff site because the sub-watershed is approximately 1 square mile in area, it has predominately urban land uses, and it is outside of the areas impacted by groundwater seepage.

Consistent with the Friends of the Earth, Inc. decision regarding daily expression of Total Maximum Daily Loads (see section 11. 3), the waste load allocations for these TMDLs are also being expressed in average daily time increments (Table 11-).

Table 11-4 Final Waste Load Allocations expressed as a Daily Maximum (expressed on a "daily" basis to be consistent with the recent D.C. Circuit Court of Appeals decision in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015 [D.C. Cir.2006]) [a]

Point Sources	CTR-Based Allocation (ug/L) [b, i, j]	SSO-Based Allocation (ug/L) [b, c, d, e, f, g, h, i, j]	
		Newport Bay Watershed	Big Canyon Wash
Urban Runoff [k] GW Long-term Dewatering GW Short-term Dewatering GW Clean-up (Long Term) GW Clean-up (Short Term/ Mobile Systems) Nursery Operations	10	27	2

(a) Daily expression of the allocations was calculated based on the Draft EPA Document "Options for Expressing Daily Loads in TMDLs" (USEPA, 2007). Daily allocations were calculated using the following equation: Daily allocation=Semi-annual allocation * $e^{(Z\sigma - 0.5\sigma^2)}$,where Z = z-score associated with target recurrence interval of 90 days (2.291), $\sigma^2 = \ln((CV)^2 + 1)$ and CV = Coefficient of variation. The CV was calculated using dry weather data from San Diego Creek at Campus Drive and set equal to 0.352.

(b) Allocations apply during dry weather flows (as determined when flow at San Diego Creek at Campus is ≤ 23 cfs).

(c) Concentration-based final allocations are based on the back calculated water column guidelines derived from the bird egg and fish tissue targets through the use of the biodynamic model represented by this equation: [[(((((fish tissue target)/TTF_{ff})/TTF_f)/TFF_i)/K_d)*1000]+[(((((bird egg target)/TTF_e)/TTF_f)/TFF_i)/K_d)*1000]]/2.

(d) TTF_e = trophic transfer factor from predatory fish to egg, TTF_{ff} = trophic transfer factor from small fish to predatory fish, TTF_f = trophic transfer factor from invertebrates to fish, TTF_i = trophic transfer factor from particulates to invertebrates, Kd = uptake coefficient from dissolved Se in water to particulates.

(e) Initial values: TTF_e = 1.4, TTF_{ff} = 1.1, TTF_f = 1.1, TTF_i = 2.8, $K_{d\ SDC}$ = 159, $K_{d\ BCW}$ = 1469. Additional K_d values may be incorporated for additional specific water bodies. TTF values may vary by specific water body. In water bodies where predatory fish are not present, the TTF_f value in both equations should equal 1 to represent that one less step is occurring in the food chain. Such applications of the equation will be considered through a public participation process.

(f) During the development of the TMDLs, the derivation of the water column guidelines from the targets produced a range of possible water column guideline values based on the values assumed for the variables in the equation. The initial values selected included a rounded WCG of 1 ug/L for Big Canyon Wash and 13 ug/L for the rest of the Newport Bay watershed.

(g) Following the completion of studies to evaluate appropriate K_d and other variables (see Implementation Section) and based on the implementation of the BMP Strategic Plan, the model inputs and WCGs will be reevaluated and updated as necessary no later than 10 years from the effective date of the TMDLs. Subject to review and comment via a public participation process, updated values may then replace the initial values in the equations, resulting in revised allocations. The implementation plan, including the BMP Strategic Plan, and all the analyses required and completed for consideration of these Basin Plan amendments, including economics and CEQA, considered the full range of allocations.

(h) The allocations based on the back-calculated water column guidelines are to be achieved as soon as possible, but no later than 15 years from the effective date of the TMDLs, as discussed in Section 12.

(i) Assessed in the receiving water for members of the Cooperative Watershed Program. Compliance with allocations will be determined pursuant to the Compliance Approach outlined in the implementation plan.

(j) Assessed at 'end of pipe' for Individual Action Plan point sources. Compliance with allocations will be determined pursuant to the Compliance Approach outlined in the implementation plan.

(k) Assessment location for Urban Runoff is the Costa Mesa Channel. This location was selected as a surrogate urban runoff site because the sub-watershed is approximately 1 square mile in area, it has predominately urban land uses, and it is outside of the areas impacted by groundwater seepage.

11.4.2 Load Allocations

Load allocations are assigned to the non-point sources of selenium within the Newport Bay watershed. The non-point sources include agricultural discharges, atmospheric deposition, open space, and rising groundwater. Atmospheric deposition has not been assigned a separate load allocation since most of the atmospheric deposition is accounted for in allocations for runoff from the various land uses. Direct atmospheric deposition to the water bodies accounts for less than one percent of the total non-point source load. The load allocations are presented in Table 11-5. Like the wasteload allocations, the load allocations are to be achieved as soon as possible but no later than 15 years from the effective date of the TMDLs, ie., no later than [*insert date certain once the TMDLs are approved*].

Table 11-5. Final Load Allocations as a Semi-Annual Arithmetic Mean (for implementation purposes) [a]

Nonpoint Source	CTR-based Allocation (ug/L) [b, g, i]	SSO-based Allocation (ug/L) [b, c, d, e, f, g, h, i]	
		Newport Bay Watershed	Big Canyon Wash
Agricultural Discharges			
Open Space	5	13	1
Rising Groundwater			

(a) For semi-annual arithmetic mean: April 1 through September 30 and October 1 through March 31 each year.

(b) Allocations apply during dry weather flows (as determined when flow at San Diego Creek at Campus is ≤ 23 cfs).

(c) Concentration-based final allocations are based on the back calculated water column guidelines derived from the bird egg and fish tissue targets through the use of the biodynamic model represented by this equation: [[((((((fish tissue target)/TTF_{ff})/TTF_f)/TFF_i)/K_d)*1000]+[(((((bird egg target)/TTF_e)/TTF_f)/TFF_i)/K_d)*1000]]/2.

(d) TTF_e = trophic transfer factor from predatory fish to egg, TTF_{ff} = trophic transfer factor from small fish to predatory fish, TTF_f = trophic transfer factor from invertebrates to fish, TTF_i = trophic transfer factor from particulates to invertebrates, Kd = uptake coefficient from dissolved Se in water to particulates.

(e) Initial values: TTF_e = 1.4, TTF_{ff} = 1.1, TTF_f = 1.1, TTF_i = 2.8, $K_{d\ SDC}$ = 159, $K_{d\ BCW}$ = 1469. Additional K_d values may be incorporated for additional specific water bodies. TTF values may vary by specific water body. In water bodies where predatory fish are not present, the TTF_f value in both equations should equal 1 to represent that one less step is occurring in the food chain. Such applications of the equation will be considered through a public participation process.

(f) During the development of the TMDLs, the derivation of the water column guidelines from the targets produced a range of possible water column guideline values based on the values assumed for the variables in the equation. The initial values selected included a rounded WCG of 1 ug/L for Big Canyon Wash and 13 ug/L for the rest of the Newport Bay watershed.

(g) Following the completion of studies to evaluate appropriate K_d and other variables (see Implementation Section) and based on the implementation of the BMP Strategic Plan, the model inputs and WCGs will be reevaluated and updated as necessary no later than 10 years from the effective date of the TMDLs. Subject to review and comment via a public participation process, updated values may then replace the initial values in the equations, resulting in revised allocations. The implementation plan, including the BMP Strategic Plan, and all the analyses required and completed for consideration of these Basin Plan amendments, including economics and CEQA, considered the full range of allocations.

(h) The allocations based on the back-calculated water column guidelines are to be achieved as soon as possible, but no later than 15 years from the effective date of the TMDLs, as discussed in Section 12.

(i) Assessed in the receiving water

Per the Friends of the Earth decision, the load allocations for these TMDLs are also being expressed in average daily time increments (Table 11-6).

Table 11-6. Final Load Allocations expressed as a Daily Maximum (expressed on a "daily" basis to be consistent with the recent D.C. Circuit Court of Appeals decision in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015 [D.C. Cir.2006])[a]

Nonpoint Source	CTR-based Allocation (ug/L) [b, g, i]	SSO-based Allocation (ug/L) [b, c, d, e, f, g, h, i]	
		Newport Bay Watershed	Big Canyon Wash
Agricultural Discharges Open Space Rising Groundwater	10	27	2

(a) Daily expression of the allocations was calculated based on the Draft EPA Document "Options for Expressing Daily Loads in TMDLs" (USEPA, 2007). Daily allocations were calculated using the following equation: Daily allocation=Semi-annual allocation * $e^{(Z\sigma - 0.5\sigma^2)}$, where Z = z-score associated with target recurrence interval of 90 days (2.291); $\sigma^2 = \ln((CV)^2 + 1)$ and CV = Coefficient of variation. The CV was calculated using dry weather data from San Diego Creek at Campus Drive and set equal to 0.352.

(b) Allocations apply during dry weather flows (as determined when flow at San Diego Creek at Campus is ≤ 23 cfs).

(c) Concentration-based final allocations are based on the back calculated water column guidelines derived from the bird egg and fish tissue targets through the use of the biodynamic model represented by this equation: [[(((((fish tissue target)/TTF_{ff})/TTF_f)/TFF_i)/K_d)*1000]+[(((((bird egg target)/TTF_e)/TTF_f)/TFF_i)/K_d)*1000]]/2.

(d) TTF_e = trophic transfer factor from predatory fish to egg, TTF_{ff} = trophic transfer factor from small fish to predatory fish, TTF_f = trophic transfer factor from invertebrates to fish, TTF_i = trophic transfer factor from particulates to invertebrates, Kd = uptake coefficient from dissolved Se in water to particulates.

(e) Initial values: TTF_e = 1.4, TTF_{ff} = 1.1, TTF_f = 1.1, TTF_i = 2.8, $K_{d\ SDC}$ = 159, $K_{d\ BCW}$ = 1469. Additional K_d values may be incorporated for additional specific water bodies. TTF values may vary by specific water body. In water bodies where predatory fish are not present, the TTF_f value in both equations should equal 1 to represent that one less step is occurring in the food chain. Such applications of the equation will be considered through a public participation process.

(f) During the development of the TMDLs, the derivation of the water column guidelines from the targets produced a range of possible water column guideline values based on the values assumed for the variables in the equation. The initial values selected included a rounded WCG of 1 ug/L in Big Canyon Wash and 13 ug/L in the rest of the Newport Bay watershed.

(g) Following the completion of studies to evaluate appropriate K_d and other variables (see Implementation Section) and based on the implementation of the BMP Strategic Plan, the model inputs and WCGs will be reevaluated and updated as necessary no later than 10 years from the effective date of the TMDLs. Subject to review and comment via a public participation process, updated values may then replace the initial values in the equations, resulting in revised allocations. The implementation plan, including the BMP Strategic Plan, and all the analyses required and completed for consideration of these Basin Plan amendments, including economics and CEQA, considered the full range of allocations.

(h) The allocations based on the back-calculated water column guidelines are to be achieved as soon as possible, but no later than 15 years from the effective date of the TMDLs, as discussed in Section 12.

(i) Assessed in the receiving water

12.0 PROPOSED IMPLEMENTATION PLAN

12.1 Introduction

Federal regulations require states to incorporate Total Maximum Daily Loads (TMDLs) into water quality management plans (40 CFR 130.6). California's water quality management plan consists of the Regional Water Boards' Basin Plans (see Water Code Section 13240-13247) and statewide water quality control plans. While Section 13360 of the Water Code precludes Regional Water Boards from specifying methods of compliance with waste discharge requirements (WDRs), Water Code Section 13242 requires that basin plans include a program of implementation to achieve water quality objectives, including:

(a) A description of the nature of actions, which are necessary to achieve the objectives, including recommendations for appropriate action by any entity, public or private;
(b) A time schedule for the actions to be taken; and
(c) A description of surveillance to be undertaken to determine compliance with objectives.

A TMDL does not establish new water quality standards, including water quality objectives. Rather, a TMDL is essentially a strategy whereby existing narrative or numeric water quality objectives (and beneficial uses) are to be achieved and protected. An implementation plan must be developed to assure that the TMDL, and thereby water quality objectives, is achieved. This TMDL implementation plan fulfills the Water Code Section 13242 requirement.

The proposed selenium TMDLs include targets and other elements that are based on recommended site-specific objectives (SSOs) for selenium in fish tissue and bird eggs. Tissue-based objectives are considered to be a more appropriate way to regulate selenium than water column concentrations since selenium is primarily accumulated in organisms through diet (see Section 6.0). The proposed selenium TMDLs and SSOs are being proposed jointly as amendments to the Basin Plan, and the recommended implementation plan presented in this Section addresses both components.

The proposed selenium SSOs have been used in these TMDLs as the basis for numeric targets, along with the CTR freshwater chronic criterion of 5 µg/L for selenium (Section 8.0). The CTR saltwater selenium criteria cannot be used as numeric targets for Newport Bay as they are much higher than existing ambient selenium concentrations in saltwater and their implementation would not conform to the State's antidegradation policy (see discussion in Section 8.0). The selenium water column guidelines (WCGs) calculated from the tissue SSOs using the Newport Bay watershed biodynamic model were used in the TMDLs as the basis for estimating concentration-based TMDLs for the freshwater water bodies in the watershed, and to establish concentration-based TMDL waste load and load allocations (WLAs and LAs) for point sources and non-point sources of selenium (Sections 10 and 11 of this report). However, unless and until the SSOs have been approved by USEPA, the final TMDL numeric targets, loading capacities, TMDLs and allocations must be based on the current CTR freshwater criterion for selenium. As stated previously, the CTR saltwater criteria cannot be applied to Newport Bay due to antidegradation concerns. For Upper Newport Bay, the loading capacity, TMDLs and allocations are set equal to the recommended SSO tissue concentrations, since inadequate data are available to provide robust estimates, using the biodynamic model, of the water column concentrations needed to meet the tissue SSOs in the Upper Bay (see Section 9.0).

Accordingly, the recommended implementation plan includes actions that will result in compliance with both the CTR selenium freshwater criterion (unless and until supplanted by approved selenium SSOs) and the SSOs (if and when they are approved). This TMDL implementation plan includes a compliance schedule and milestones for meeting the final numeric targets (both the SSO-based numeric tissue targets and the CTR-based freshwater numeric target). [1]

This Implementation Plan identifies actions necessary to reduce water column and tissue selenium concentrations to below levels that may result in impairment in fish and birds that live or feed in the watershed.

Regional Water Board staff intends to coordinate TMDL implementation with the following agencies, programs, policies, and environmental groups:

- The Regional Water Board's Watershed Management Initiative (WMI) program for the Newport Bay watershed (http://www.waterboards.ca.gov/santaana/water_issues/programs/wmi/index.shtml)
- The Regional Water Board's permitting and enforcement sections
- The Regional Water Board's Storm Water compliance section
- The State Board's Nonpoint Source (NPS) Implementation and Enforcement Policy (http://www.waterboards.ca.gov/plans_policies/)
- The State Board's Policy for Implementation of Toxic Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (http://www.waterboards.ca.gov/plans_policies/)
- The California Department of Fish and Game
- The U.S. Fish and Wildlife Service

[1] It should be emphasized that the analyses conducted to fulfill other requirements for consideration of the Basin Plan amendment to incorporate these TMDLs/SSOs, including economic analysis, identification of reasonably foreseeable methods of compliance, and CEQA analysis of the potential environmental impacts of these methods and reasonably feasible alternatives, encompassed the TMDLs needed to implement the CTR criterion and the full range of Water Column Guidelines that may be found necessary to achieve the tissue-based SSOs (see Section 9.0, Linkage Analysis).

- The U.S. Environmental Protection Agency
- The Nitrogen and Selenium Management Program (NSMP) Working Group
- The Newport Bay Watershed Executive Committee
- The Newport Bay Watershed Management Committee
- The Newport Bay Watershed Stakeholder Committee
- The Toxics Reduction and Investigation Program (TRIP) Working Group
- The Integrated Regional Watershed Management Plan (IRWMP) for the Newport Bay Watershed
- Stop Polluting Our Newport
- Orange County Coast Keeper (http://www.coastkeeper.org/)
- Newport Bay Naturalists and Friends (http://www.newportbay.org/natwho.htm)
- Other watershed stakeholders.

Need for Phased TMDLs and Compliance Schedules

Staff proposes that the Newport Bay watershed selenium TMDLs be adopted as phased TMDLs. Phased TMDLs are used when, for scheduling reasons, the TMDLs need to be established despite significant data uncertainty and where the State expects that the loading capacity and allocation scheme will be revised in the near future as additional data are collected that will provide for more accurate TMDL calculations (USEPA, 2006). The phased approach provides time to:

- conduct further monitoring and assessment, including data collection to fill informational gaps;
- refine the parameters used in the Newport Bay biodynamic model to translate the proposed fish and bird egg tissue SSOs/numeric targets into water column concentrations that may differ from those now specified in the recommended TMDLs;
- complete the assessment of potential selenium sources in Big Canyon Wash and adjacent areas in the Newport Bay watershed; and
- conduct field demonstration-scale testing of potential selenium BMPs/treatment technologies.

The results of these studies are expected to provide the technical basis for any necessary future revisions to the TMDLs, WLAs, LAs, targets and/or other TMDL elements.

Controlling selenium discharges poses extraordinary challenges since there is no readily available, conventional selenium treatment technology that can be implemented in a reasonably practicable manner, given the watershed-scale of the selenium problem, its diffuse origin (largely rising groundwater) and the limited land available for facility placement given the high degree of urbanization in the watershed. In view of this difficulty, and in light of the need to implement phased TMDLs to address uncertainty and allow for appropriate refinement of the TMDLs, compliance schedules for meeting the TMDL numeric targets/SSOs have been identified. The compliance schedule/phased TMDL approach will allow for field testing and construction of demonstration-scale and, ultimately, full-scale selenium treatment BMPs that are expected to result in compliance with the TMDLs and attainment of water quality standards. As described below, the NSMP has conducted significant work to investigate and test potential BMPs. Based on the results of those efforts, a BMP Strategic Plan is being developed. (see Section 12.5, Task 5)

It is expected that the BMP Strategic Plan will also identify a phased approach toward BMP implementation, with highest priority given to those areas of greatest biological significance and/or of most concern due to selenium concentration and loading. The phased approach will accommodate investigation and demonstration testing of potential control measures and the completion of modeling efforts that will inform, in part, BMP site selection, while assuring early attention to areas of the watershed of most concern. The BMP Strategic Plan will also include "early action" measures that can be implemented in the near future to achieve selenium reductions while other, more comprehensive BMPs are investigated and considered for implementation.

12.2 Related TMDLs Efforts in the Watershed

There are numerous TMDLs that are under development and/or are currently being implemented within the Newport Bay watershed. In order to leverage limited resources, these other efforts must be considered so that the implementation of the selenium TMDLs/SSOs may, to the extent feasible, assist in meeting and/or providing information and data for these other TMDLs. Implementation of these selenium TMDLs and the schedule for implementation are very closely tied with other TMDLs that are currently being implemented in the watershed. In particular, the selenium TMDLs are closely tied to the revision of the Nutrient TMDL, a process that is expected to be completed in 2010. Rising groundwater, which is the source of the majority of the selenium loads in the watershed (Section 7.0), is also a significant source of nutrients (as nitrate) to surface waters in the watershed. Several of the selenium removal technologies/BMPs currently under consideration for implementation of the selenium TMDLs either (1) necessitate that nitrate be removed before any significant removal of selenium can occur (e.g., biological reduction systems), or (2) result in volume reductions in the watershed (e.g., diversions to the sanitary sewer). Therefore, most of the BMPs implemented to control selenium will also reduce the nitrogen loading within the watershed.

The TMDLs that are either being developed or implemented within the Newport Bay Watershed include the following[2]:

- Total Maximum Daily Loads for Toxic Pollutants, San Diego Creek and Newport Bay, California; U.S. Environmental Protection Agency[3]. Includes technical TMDLs for the following pollutants:

[2] Source: http://www.waterboards.ca.gov/santaana/water_issues/programs/tmdl/index.shtml#projects
[3] Promulgated by EPA in 2002. The Regional Board has adopted or will consider adoption of five separate Basin Plan Amendments to address each pollutant group. These TMDLs address selenium and will, once adopted, replace the EPA selenium TMDLs.

- Organophosphate (OP) Pesticides (Diazinon & Chlorpyrifos)
- Selenium
- Metals
- Organochlorine (OC) Compounds
- Chromium (Cr) and Mercury (Hg) *(specific to Rhine Channel only)*

- Total Maximum Daily Loads for Organochlorine Compounds, San Diego Creek and Upper andLower Newport Bay *(intended to replace EPA technical TMDLs; submitted to the State Water Resources Control Board for review in July 2009).* SARWQCB Resolution No. R8-2007-0024.
- Diazinon and Chlorpyrifos TMDL, Upper Newport Bay and San Diego Creek *(replaces EPA technical TMDLs; currently being implemented)*
- Total Maximum Daily Load for Nutrients in the Newport Bay/San Diego Creek Watershed *(currently being implemented)*. SARWQCB Resolution No. 98-9 as amended by Resolution No. 98-100. SARWQCB Resolution No. R8-2003-0039.
- Total Maximum Daily Load for Fecal Coliform in Newport Bay *(currently being implemented).* SARWQCB Resolution No. 99-10.
- Total Maximum Daily Load for sediment in the Newport Bay/San Diego Creek Watershed *(currently being implemented).* SARWQCB Resolution No. 98-101.

12.3 General Framework and Adaptive Management Approach

The implementation of the selenium TMDLs will utilize an adaptive management approach, which will be guided by monitoring, special studies, modeling, and ongoing stakeholder interaction, likely through the NSMP, and with funding likely provided through the Cooperative Watershed Program (CWP) funding agreement (see Section 12.5, Task 2).

This adaptive management approach is based on a series of tasks that are described further in this document. These tasks are meant to feed information back into the TMDL implementation and review processes on a continuous basis. The Regional Water Board will rely extensively on stakeholder input to guide and ultimately gauge the progress of the TMDLs in attaining water quality standards. The implementation tasks are focused on obtaining and utilizing information as a part of this adaptive approach as outlined below:

- Information obtained from the regional monitoring program (Task 9) will measure progress towards achieving water quality objectives and the protection of the designated beneficial uses.

- Information from the regional monitoring program will also measure progress towards achieving the TMDLs, waste load allocations (WLAs) and load allocations (LAs).

- Information obtained from the water column monitoring and special studies will assist in re-assessing the Newport Bay biodynamic model and the water column guidelines derived there from, as well determining progress towards attainment of the TMDL numeric targets/SSOs.

- Information from the ongoing investigations, special studies, and modeling will assist in the evaluation of the overall implementation and result in improved implementation strategies.

In addition, the implementation approach to reducing selenium concentrations in the Newport Bay watershed will consist of a series of step-wise, iterative actions. Source controls, treatment technologies and BMPs will first be implemented so that selenium concentrations will be reduced to meet the upper end of the range of water column guidelines (WCGs) predicted by the Newport Bay watershed biodynamic model for lower San Diego Creek. Achieving these guidelines is expected to result in compliance with the tissue SSOs/TMDL numeric targets in the watershed. Lower San Diego Creek (Reach 1) provides 85% of the freshwater flows and 96% of the selenium to Newport Bay. Reductions in selenium in this portion of the watershed should result in reductions in selenium loads and concentrations in Newport Bay as well as the off-channel UCI and IRWD wetlands. Compliance monitoring of fish and bird egg tissue (see Section 12.5, Task 9) will determine whether or not the tissue SSOs are being met at that WCG at that location. If the WCG has been met, but fish and/or bird egg tissue selenium concentrations continue to exceed the SSOs/numeric targets, then the Newport Bay watershed biodynamic model will be re-run utilizing a modified set of assumptions to determine a new WCG to achieve the SSO/numeric targets. Additional implementation actions (installation or expansion of BMPs, additional source controls, etc.) may need to be taken to continue to reduce selenium concentrations in surface waters in the watershed until compliance with either the tissue SSOs or the CTR freshwater chronic criterion is attained, whichever is applicable.

Implementation of the selenium TMDLs is expected to be an ongoing and dynamic process and may lead to future modifications to the TMDLs, including the impairment assessment, WLAs and LAs, monitoring requirements, implementation plan tasks and/or the schedule for implementation. The Regional Water Board will reevaluate these TMDLs consistent with Task 13.

The NSMP Working Group has made significant commitments to the development and implementation of these TMDLs. This level of commitment is expected to continue through the implementation and evaluation of the TMDLs. The NSMP will make recommendations for the revision and improvement of the TMDL tasks, as appropriate. Regional Water Board staff will continue to be active participants in the NSMP. This approach allows for the ongoing participation of the stakeholders for the duration of the TMDL implementation plan and greater transparency for the overall process. The NSMP stakeholders, including representatives from local environmental groups and Regional Water Board staff, will evaluate progress toward achieving the TMDLs, integrate the selenium TMDLs implementation tasks with other tasks already being conducted in response to other programs (e.g., permits, other TMDLs), and make recommendations for revisions to the TMDLs, including the implementation plan.

12.4 Relevant Monitoring Programs, Projects, and Special Studies Currently Underway in the Newport Bay Watershed

A number of investigations and monitoring programs have been established to assist with meeting TMDL goals. Some of the studies that are relevant to implementation of these TMDLs are listed below.

(1) County of Orange, OC Public Works, Water Quality Monitoring Program for Santa Ana Region.

In 2005, pursuant to specifications in the Monitoring and Reporting Program No. R8-2002-0010, NPDES No. CAS618030, the County revised the storm water monitoring program that is conducted under the 3rd Term Municipal Separate Storm Sewer System (MS4) Permit to incorporate monitoring elements for the toxics TMDLs (RDMD, 2003 DAMP, Exhibit 11.II). Watershed-specific issues relevant to the toxics TMDL were identified. Work to address these issues will be managed and funded by a group of permittees within the watershed, and coordination will occur through the NPDES monitoring program. The specific watershed issues identified by the permittees are listed below.

- Identification of in-bay sites with substantially elevated pollutant levels;
- An assessment of the current understanding of sediment and pollutant movements through the Newport Bay system;
- Long-term monitoring of fish tissue for pollutants above screening values for human and/or wildlife health;
- Assess the need for and design a benthic community monitoring effort;
- The design of future egg tissue studies.

(2) Tissue, sediment and water quality trend monitoring for bioaccumulative contaminants and metals in the Newport Bay watershed

This study is being conducted by the California Department of Fish and Game through a SWRCB contract with the San Jose State University Foundation. The primary objective of this contract is to conduct an annual tissue monitoring program for the Newport Bay watershed that can be used for TMDL development, implementation, trend analysis, listing/delisting, and beneficial use assessment. Water column, sediment and fish tissue samples are collected and bivalve samples are deployed annually at locations in San Diego Creek, the Santa Ana Delhi Channel (as funds are available), Upper Newport Bay, and Lower Newport Bay. Whenever possible, at least one and up to three species of fish are collected and analyzed for the constituents of concern (polychlorinated biphenyls [PCBs], polybrominated diphenyl ethers [PBDEs], chlorinated pesticides [e.g., chlordane, dieldrin, DDT, and toxaphene], pyrethroids, selenium, and trace metals) and general water quality parameters as needed (e.g., dissolved oxygen (DO), pH, conductivity, salinity, temperature, hardness, and dissolved and/or total organic carbon (DOC/TOC), etc.). In addition, sediments are analyzed for TOC and grain size. Analytical results can be used for comparison to TMDL numeric targets or appropriate sediment, human health or wildlife screening values. This monitoring program is currently in its fourth year Year 4). Funds to continue the program beyond Year 4 have not been secured.

(3) Cienega Filtration Facility Demonstration Project.

The Irvine Ranch Water District (IRWD) is currently performing a demonstration scale test of a subsurface anaerobic biological reduction reactor, known as the Cienega Filtration System, adjacent to Peters Canyon Channel upstream of Barranca Parkway in the City of Irvine. The primary objective of the demonstration scale test is to evaluate the ability of the system to reduce selenium and nitrogen concentrations in influent water from Peters Canyon Channel and to determine if the system is a viable selenium and nitrogen treatment technology. The demonstration scale test is also designed to evaluate the removal of other pollutants, and to identify permitting, site-configuration, construction details and constraints, start-up operations, and operational and maintenance concerns with the system. The demonstration scale system is capable of treating a flow of 0.3 cfs under optimal operating conditions. This project began operation in November 2008 and selenium removals to below the CTR freshwater chronic criterion of 5 µg/L have been obtained. If the demonstration scale system continues to be effective, IRWD plans to build a full scale system adjacent to the demonstration scale system that will have the capability of treating a flow of 3 cfs. Testing and evaluation of the demonstration scale system under a variety of operational conditions is planned for a two year period. The Cienega technology is a BMP under consideration for implementation of the selenium TMDLs and will be incorporated as a potentially viable BMP with preliminary locations identified in the NSMP BMP Strategic Plan.

(4) San Joaquin Freshwater Marsh Reserve Restoration.

The University of California, Irvine (UCI) and the University of California Natural Reserve System (UCNRS) plan to restore the San Joaquin Freshwater Marsh Reserve (SJFMR), targeting specific locations in two phases of work. The SJFMR is classified as a passive functioning natural system that receives limited management. UCI/UCNRS continues to pursue this goal as they enact their restoration plans. Based upon a 1997 conceptual plan, Phase I of the enhancement plan was implemented by the University of California with funding from the State Coastal Conservancy. The Phase I enhancement created a managed system of ponds to provide new habitat for wildlife and has been successfully completed. Phase II of the restoration plan is proposed to be constructed.

UCI consultants discussed with Regional Water Board staff that the Phase II design should allow improved hydrologic conditions and habitat diversity within those portions of the SJFMR. However, according to the analytical results of water quality monitoring submitted per Clean Water Act section 401 water quality certification application requirements, water entering the Phase I and Phase II portions of the marsh contains selenium. In addition, sediment and water column samples appear on occasion to exceed background selenium concentrations, but analysis of the bioavailability of the selenium was inconclusive due to the manner of sample collection. Tissue samples of macroinvertebrates, fish and some bird eggs collected from the Phase I area of the marsh exceeded guidelines for marginal or substantive ecological risk for diet, fish tissue, and bird egg tissue (Presser et al., 2004).

The concentrations in the marsh may be impacting beneficial uses both within the project area and as the water discharges downstream. Therefore, additional monitoring is needed. The UCI managers do not control the flows that enter the marsh. Water from local runoff and excess water from the IRWD treatment wetlands provide flows to the marsh. The project does not include plans to change the sources of the water that enter or exit the marsh system. Therefore, Regional Water Board staff has informed the UCI managers to coordinate with local partners in the watershed in order to reduce the bioavailable selenium within the SJFMR.

(5) Big Canyon Creek Nature Park Restoration.

The City of Newport Beach, in collaboration with the California Department of Fish and Game, plans to restore the reach of Big Canyon Creek located in the Big Canyon Creek Nature Park. The project includes several goals: restoration, preservation and/or creation of historic tidal marsh and rare/endangered species habitats; improvement to water quality in the Big Canyon Nature Park; opportunities for public participation and education; installation of erosion and sediment controls along Big Canyon.

Analytical results of sampling conducted in the freshwater riparian and marsh areas of Big Canyon Creek during June 2008 indicated water column samples that exceeded the California Toxics Rule freshwater chronic criterion of 5 µg/L; sediment, invertebrate, and fish tissue exceeded the substantive ecological risk guidelines for selenium established by the Department of the Interior (1998), as modified by Presser et al. (2004). As a result of these findings, the City of Newport Beach is reviewing how best to design several components of the restoration project such that selenium is made less bioavailable in water, sediment and benthic invertebrates throughout the project area, as well as in freshwater flows to Upper Newport Bay.

Those components may include the installation and operation of source controls such as a sediment capture pond to be located below Jamboree Road, and an offline freshwater pond system within the Nature Park designed to prevent selenium accumulation. In addition, regular monitoring will be required in the water column, sediment and tissue to track the success of the project to reduce selenium. The modifications will link the City of Newport Beach's Big Canyon Creek restoration effort to the broader effort to reduce selenium on a watershed-wide basis.

12.5 Proposed Implementation Tasks and Schedules

A maximum 15-year compliance timeframe is proposed for the selenium TMDLs. As noted previously, the basis for this schedule is that there is currently no practicable, best available technology (BAT) for selenium that can meet either the current CTR freshwater chronic criterion of 5 µg/L or the proposed SSOs of 5 µg Se/g (dry weight) in fish tissue and 8 µg Se/g (dry weight) in bird eggs (compliance with the SSOs is reflected by compliance with the identified Water Column Guidelines in the range of 5 -13 µg/L). The proposed schedules reflect recognition that time is needed to identify, evaluate the efficacy of and implement suitable selenium control measures. That said, aggressive efforts to comply with the TMDLs as soon as possible are expected. As described below, the NSMP has already made significant progress in identifying a BMP Strategic Plan that will assure compliance with the TMDLs in a timely manner. The Strategic Plan will include "early action" items to achieve selenium reductions that are feasible in the near term.

Based on consultation with stakeholders and review of the best available science, the most timely and effective course of action to assure appropriate implementation of the TMDLs as soon as possible is for all existing and potential dischargers in the Newport Bay watershed to participate in the NSMP through the CWP Funding Agreement (Task 2, below). Non-point source rising groundwater is the largest source of selenium in the watershed and the attainment of the SSOs and final TMDL numeric targets is contingent on the management of this significant source. A coordinated, regional watershed approach is necessary to achieve the selenium TMDLs efficiently. Absent a comprehensive, coordinated approach, it is less likely that this source could be managed in a timely and effective manner.

While participation in the NSMP and CWP Funding Agreement is strongly encouraged, it is also appropriate to recognize that individual dischargers may find it more appropriate and cost-effective to implement compliance strategies on an individual basis, including implementation of site-specific BMPs, such as sewering the discharge. However, it is recognized that the implementation of these strategies, including sewering, may require some time to implement and/or may have inherent limitations that render them a temporary rather than permanent option. Further, in consideration of fairness, any discharger who elects not to participate in the NSMP and CWP Funding Agreement should not necessarily be permitted to avail themselves of the significant effort and investment by NSMP stakeholders to identify and implement selenium controls on an individual and/or regional basis.

In light of the above, three compliance options are proposed:

Option 1. NSMP funded through the CWP Funding Agreement. Dischargers who elect to participate in the NSMP and CWP Funding Agreement will be required to fulfill specific requirements outlined below pursuant to an executed CWP Funding Agreement and to comply with the TMDLs and waste discharge requirements/waiver conditions necessary to implement the related provisions in accordance with the compliance schedules proposed in the TMDLs. Implementation of the selenium TMDLs is proposed to occur in two phases: the first phase is to take no more than seven (7) years to complete and the second phase is to take no more than eight (8) years to complete. Compliance is to be achieved as soon as possible, but no later than fifteen (15) years from the effective date of the TMDLs (i.e., upon OAL approval of the Basin Plan Amendment incorporating the TMDLs).

Option 2. Individual Action Plan. Existing dischargers may elect to identify and implement an alternative, acceptable means to comply with the final TMDLs WLAs, LAs, numeric targets, and/or with the waste discharge requirements or waiver conditions necessary to implement these TMDL components. Individual Action Plan dischargers would be required to achieve compliance ***as soon as possible*** but no later than **three** (**3)** years from the effective date of the selenium TMDLs in accordance with an Individual Action Plan and schedule approved by the Regional Water Board's Executive Officer. ***Further, these dischargers will be required to implement an acceptable offset for their selenium discharges in excess of their selenium limitations until final compliance is achieved.*** The NSMP CWP Funding Agreement is expected to include offset provisions to address such dischargers; however, other offset proposals may be considered. For new dischargers who elect not to participate in the NSMP and CWP Funding Agreement, the discharges would not be allowed to commence until an action plan and schedule, including a proposed offset and monitoring and reporting program, is approved by the Regional Water Board's Executive Officer.

Option 3. No Discharge. Absent participation in the NSMP and CWP Funding Agreement or implementation of an Individual Action Plan, existing dischargers would be required to immediately cease discharging and no new discharges would be authorized.

Board staff recommends that the actions identified in **Table 12-1** be undertaken by each respective responsible party in accordance with the recommended schedule.

Table 12-1. Proposed TMDL Tasks and Compliance Schedule

Task	Description	Responsible Party	Compliance Date – As Soon As Possible But No Later Than[1]
PHASE I IMPLEMENTATION			***Completion no later than 7 years from the date of OAL approval of BPA***
1.	Permit Revisions and Issuance a. Revise existing WDRs and NPDES permits: includes *Groundwater Dewatering and Remediation Permit, MS4 Permit, Other NPDES Permits*	Regional Water Board	a. Upon OAL approval of BPA and permit renewal
	b. Consider issuance of permits (NPDES, WDRs or conditional waivers of WDRs) for Individual Action Plan dischargers	Regional Water Board	b. As soon as possible upon OAL approval of BPA *(date)*
2.	NSMP and CWP Funding Agreement a. Submit NSMP Cooperative Watershed Program Funding Agreement and List of Dischargers to Regional Water Board	NSMP Dischargers	a. (*1 month after OAL approval of BPA*)
	b. Execute Cooperative Watershed Program Funding Agreement	NSMP Dischargers	b. Upon approval of the agreement by program participants
3.	Individual Action Plan a. Submit Individual Action Plan (identifying the offset plan/alternative means of compliance).	Individual Action Plan Dischargers	a. Upon *OAL approval of BPA* and permit renewal
	b. Implement Individual Action Plan	Individual Action Plan Dischargers	b. Upon EO approval with final compliance within 3 years of effective date of BPA
4.	Volume Reduction BMPs a. Implement Volume Reduction BMPs	All Dischargers	a. Ongoing
5.	BMP Strategic Plan a. Submit BMP Strategic Plan, including Early Action Items, and BMP Effectiveness Monitoring Program to Regional Water Board for review and approval b. Implement plans	NSMP Dischargers NSMP Dischargers	a. (*1 month after OAL approval of BPA*) b. Upon Regional Water Board

			approval.
	c. Submit annual progress/status reports to Regional Board for review and approval. Annual reports shall include assessment of the efficacy of the actions taken pursuant to the BMP Strategic Plan and recommendations for any modifications to the BMP Strategic Plan.	NSMP Dischargers	c. Annually
	d. Implement modified BMP Strategic Plan	NSMP Dischargers	d. Upon approval by the Regional Water Board
6.	Groundwater-Surface Water Model	NSMP Dischargers	
	a. Analyze existing data to determine if development of a groundwater-surface water model is reasonably feasible and submit results to the Regional Water Board		a. (*3 months after OAL approval of BPA*)
	b. If the Regional Water Board has determined that development of the model is reasonably feasible, develop groundwater-surface water model	NSMP Dischargers	b. *18 months after OAL approval of BPA*), submit completed groundwater surface water model to Regional Board
	c. Use groundwater-surface water model to identify locations of groundwater dependent demonstration scale projects as part of the BMP Strategic Plan	NSMP Dischargers	c. 6 months after groundwater-surface water model development completed
	d. Use model to identify data gaps, recommend additional implementation actions and/or special studies	NSMP Dischargers	d. 6 months after groundwater model development completed
	e. Submit any additional recommended implementation actions, schedules and special studies to Regional Water Board for approval	NSMP Dischargers	e. 12 months after groundwater model development completed; implement upon Regional Water Board approval
	f. Complete special studies to develop data needed to complete groundwater-surface water model	NSMP Dischargers	f. 24 months after approval of Regional Water Board of additional special studies.
	g. If necessary, as determined by the Regional Water Board, revise groundwater-surface water model based on special	NSMP Dischargers	g. 12 months after completion of special studies.

	studies data		
	h. Use groundwater-surface water model and results of the BMP Strategic Plan demonstration scale projects to re-evaluate the BMP Strategic Plan including the BMP Effectiveness Monitoring Plan, and the RMP	NSMP Dischargers	h. 12 months after any necessary revisions to the groundwater-surface water model have been completed.
	i. Submit any recommended revisions to the BMP Strategic Plan (and the BMP Effectiveness Monitoring Plan) and the RMP, other implementation actions, and special studies to the Regional Water Board for approval	NSMP Dischargers	i. 18 months after completion of revisions, if necessary, to the groundwater-surface water model.
	j. Implement revisions to the BMP Strategic Plan and RMP	NSMP Dischargers	j. Upon Regional Water Board approval
7.	Irrigation Reduction and Control Program		
	a. Per A.B. 1881, adopt updated Model Water Efficient Landscape Ordinance or one that is "at least as effective as" that Ordinance.	a. Local jurisdictions and/or NSMP Dischargers[4]	a. By January 1, 2010 or as required by A.B 1881.
	b. Assess whether additional irrigation reduction and control actions are necessary for areas with high selenium concentrations in soils, shallow groundwater, or surface waters.	b. Local jurisdictions and/or NSMP Dischargers.	b. Within 2 years of the adoption of a water efficient landscape ordinance, submit assessment of program and recommendations for any additional irrigation reduction/controls for high selenium areas to the Regional Water Board.
	c. Implement additional identified actions for areas with high selenium as described in b above.	c. Local jurisdictions and/or NSMP Dischargers	c. Upon Regional Water Board approval.
	d. Develop site specific program to reduce irrigation and control surface runoff for Big Canyon Wash subwatershed	d. City of Newport Beach and/or NSMP Dischargers	d. Within *1 month of OAL approval of the BPA*
	e. Implement Big Canyon Wash irrigation reduction and	e. City of Newport Beach	e. Upon Regional Water Board

[4] If the local jurisdiction participates in the NSMP then the NSMP will be the responsible party for this task

	control program f. Assess efficacy of Big Canyon Wash program and make adjustments as needed.	and/or NSMP Dischargers f. City of Newport Beach and/or NSMP Dischargers	approval. f. Annually.
8.	Regional Monitoring Program a. Submit regional monitoring program (RMP) for selenium to Regional Water Board for approval b. Implement monitoring program	a. NSMP Dischargers b. NSMP Dischargers	a. (*3 months after OAL approval of BPA*) b. Upon Regional Water Board approval
9.	Selenium Management Programs 1. Big Canyon Wash	1. City of Newport Beach and/or NSMP Dischargers[5]	
.	2. San Joaquin Marsh Freshwater Preserve (UCI Wetlands) 3. IRWD Carlson Marsh and Treatment Wetlands	2. UCI and/or UCNRS and/or NSMP Dischargers[6] 3. IRWD and/or NSMP Dischargers[7]	
	a. Develop a Work Plan for the management of selenium, including identification of sources, selenium fate and transport, and reduction strategies including source controls, operational changes, or BMPs b. Implement the Work Plan	Responsible Parties as identified above Responsible Parties as identified above	a. By (*1 month after OAL approval of BPA*) for Regional Water Board approval b. Upon Regional Water Board approval
10. .	Special Studies Plan a.Submit a plan to the Regional Water Board that describes the special studies that have been identified as needed to fill data gaps or provide additional data for implementation or revision of the TMDLs. The plan should also include a schedule for implementation of these	a. NSMP Dischargers	a. (*1 month after OAL approval of the BPA*) submit a proposed prioritized plan and schedule for the implementation of the identified special studies or alternative studies to the Regional Water Board for review and approval.

[5] If the City of Newport Beach participates in the NSMP then the NSMP will be the responsible party for this task.
[6] If the University of California, Irvine, or the Natural Reserve System participates in the NSMP then the CWP will be the responsible party for this task.
[7] If IRWD participates in the NSMP then the NSMP will be the responsible party for this task.

	studies. The plan should include the following recommended studies, or provide recommendations for alternative studies, including documentation of the justification of the selection of the alternative study(-ies) : 1. Water Translation/SSO Model Study - Conduct investigations to collect data from hydrologic units in watershed to refine water translation coefficient (Kd) in the Newport Bay watershed biodynamic model and corresponding water column guidelines. 2. Longitudinal Tracking Study Conduct study to confirm the fate, transport, and loss of selenium within the upper watershed. Determine Se mass balance. 3. Newport Bay Mixing Model study to determine the fate and transport of selenium once it enters the Bay. b. Implement Special Studies Plan c. Submit progress report, including any necessary revisions to the special studies plan to the Regional Water Board's Executive Officer for review and approval.	b. NSMP Dischargers c. NSMP Dischargers	b. Upon Regional Water Board approval. c. Annually.
PHASE II IMPLEMENTATION			***Completion no later than (15 years from the date of OAL approval of the BPA)***
11.	TMDL Reevaluation/Revision a. Review and recommend revisions (as necessary) to selenium TMDL and schedules, including BMP Strategic Plan, RMP, Big Canyon Wash Work Plan, and special studies b. Submit proposed revisions		a. No later than eight (8) years thirteen (13) years from the date of OAL approval of BPA. b. Within 12 months of initiation

	to Regional Water Board for approval		of review period
	c. Implement proposed revisions		c. Upon Regional Water Board approval or upon approval by the Regional Water Board, State Water Board and OAL, as applicable

[1] The Regional Water Board may, after a public hearing, and without need for a Basin Plan amendment, revise the schedules in this table, except for the final compliance date of (*15 years from OAL approval of the BPA*), if it determines good cause exists for such revisions.

Table 12-2 outlines the primary TMDL milestones and their estimated completion dates.

Table 12-2. TMDL Milestones and Estimated Completion Dates

Milestone	Estimated Completion Date (as soon as possible but no later than)
Submittal of Annual Regional Monitoring Program Reports to Regional Water Board assessing compliance with the TMDLs, applicable WLAs (applies to both IAP dischargers and NSMP dischargers), and BMP Strategic Plan Annual Progress Reports, including assessment of progress towards attainment of the water column guidelines and TMDL numeric targets/SSOs, successes and failures of the program, and the need and schedule for any proposed course changes.	Annually, to commence the first Oct after [*insert date certain, once BPA is approved]*. Reports will be submitted for review and approval by the Regional Board and to ensure public participation and input into the TMDL implementation process
Implement Cooperative Watershed Program Funding Agreement	Upon approval by participating dischargers
Implement BMP Strategic Plan, including Early Action Items, and BMP Effectiveness Monitoring, and annual assessment and reporting requirements.	Upon approval by the Regional Water Board
Implement Groundwater-Surface Water Model Development	Upon approval by the Regional Water Board
Implement Irrigation Reduction and Control Program	Upon approval by the Regional Water Board
Implement Regional Monitoring Program	Upon approval by the Regional Water Board
Implement Selenium Management Programs for Big Canyon Wash, San Joaquin Freshwater Marsh Preserve, IRWD Wetlands (including Carlson Marsh).	Upon approval by the Regional Water Board
Assess Efficacy of the Irrigation Reduction and Control Program	Yearly, upon approval by the Regional Water Board

Complete Early Action Items identified in the BMP Strategic Plan	As soon as possible, but no later than 5 years after Regional Water Board approval of the BMP Strategic Plan
Complete Phase I of the TMDL - Pilot Testing and/or Field Demonstration Testing of Potential Selenium Treatment BMPs	As soon as possible but no later than 7 years from OAL approval of the BPA
Complete Selenium Management Programs for Big Canyon Wash, San Joaquin Freshwater Marsh Preserve, and IRWD Wetlands	As soon as possible, but no later than 7 years from OAL approval of the BPA,
TMDL Reevaluation/Revision - Assess progress in attainment of the water column guideline(s) and the TMDL numeric targets. Determine if further load reductions are necessary. Review and revise (as necessary) the TMDLs (including implementation plan, BMP Strategic Plan, Regional Monitoring Program, Selenium management programs and special studies).	As soon as possible, but no later than 8 years from OAL approval of the BPA,
Begin Implementation of Phase II (Full Scale Implementation) of the BMP Strategic Plan	As soon as possible, but no later than 8 years from OAL approval of the BPA,
TMDL Reevaluation/Revision - Assess progress in attainment of the TMDL numeric targets and secondary water column guideline(s). Determine if further load reductions are necessary. Review and revise (as necessary) theTMDLs (including the TMDL implementation plan), BMP Strategic Plan, Regional Monitoring Program, selenium management plans, special studies status and needs, etc.	As soon as possible, but no later than 13 years from OAL approval of the BPA or 5 years from the implementation of Phase II.
Completion of Phase II of the TMDLs: Final compliance with TMDL numeric tissue targets (SSOs) or 2000 CTR chronic freshwater chronic criterion, whichever is legally applicable at the end of the TMDL compliance period	As soon as possible but no later than 15 years from OAL approval of the BPA,

12.5 TMDL Implementation

12.5.1 Phase I Implementation Tasks

TASK 1. PERMIT REVISIONS AND ISSUANCE

The Regional Water Board will review and revise, as necessary, the existing NPDES permits, including the area's MS4 permit, groundwater dewatering and groundwater remediation permits, and WDRs for commercial nurseries, specified in **Table 10-4**, to incorporate the appropriate TMDL WLAs, LAs and monitoring program requirements. New permits (NPDES, WDRs or conditional waivers of WDRs may also be issued to implement the approved TMDLs.

The proposed TMDLs allow for the inclusion of a compliance schedule in new or existing permits for dischargers who participate in the NSMP Cooperative Watershed Funding Program. If a discharger elects not to participate in the NSMP Cooperative Watershed Funding Program, or is not fulfilling their obligations pursuant to the NSMP Cooperative Watershed Funding Program agreement in an effective or timely manner, then the discharger will be required to either (a) cease or not initiate the discharge, or (b) develop and implement an Individual Action Plan that identifies an acceptable method for achieving compliance with the final WLAs/LAs specified in the approved TMDLs (Section 12.5). These different requirements are discussed in more detail below:

1. NSMP Cooperative Watershed Funding Program Dischargers: Provisions in NPDES permits/WDRs revised or issued to implement the TMDLs will specify the following for dischargers who are members of the NSMP Cooperative Watershed Funding Program:

   a) Allocations. Participation in the NSMP Cooperative Watershed Funding Program and timely and effective implementation of the related TMDL implementation plan tasks, including the BMP Strategic Plan and the Regional Monitoring Program, will constitute compliance withthe requirement to achieve compliance with the TMDLs and associated WLAs "as soon as possible". The NPDES permits/WDRs will specify further that the status of compliance will be reviewed on an annual basis and that no discharger may exceed their individual WLA.

   b) Final allocations. Final WLAs will also be specified, with a schedule requiring compliance as soon as possible, but no later than 15 years after the effective date of the TMDL[8].

Dischargers who join the NSMP Cooperative Watershed Funding Program will be required to implement the following tasks as identified in Table 12-1:

- Continue to implement the Nitrogen and Selenium Management Program (Task 2)
- Implement volume reduction BMPs (Task 4)
- Develop and implement a BMP Strategic Plan, which will include a BMP Effectiveness Monitoring Plan (Task 5)
- If feasible, as determined by the Regional Water Board, develop a groundwater-surface water model (Task 6)
- Develop and implement an irrigation reduction and control plan (Task 7)
- Develop and implement a Regional Monitoring Program (RMP) (Task 8)
- Develop and implement special studies as needed (Task 10)

[8] It is recognized that this schedule will exceed the five year term of WDRs/NPDES permits. This schedule will be reflected in subsequent renewals of these permits.

- Provide periodic review and revision (as necessary) of the selenium TMDLs, BMP Strategic Plan, Regional Monitoring Program, and special studies status and needs (Task 11)

Other tasks identified in Table 12-1 may also be implemented by NSMP dischargers. Some tasks may be implemented on an individual basis by responsible parties (e.g., Task 9, Selenium Management Programs) or through other regulatory vehicles (e.g., MS4 permits may incorporate irrigation reduction and control [Task 7]).

For NSMP dischargers, compliance with the TMDLs is expected to be achieved as the result of the iterative implementation of source controls and effective BMPS to manage the discharge of selenium, along with monitoring to measure BMP effectiveness. Compliance with the final TMDLs, WLAs, and LAs is to be achieved as soon as possible, but no later than (fifteen) 15 years from the effective date of the TMDLs (upon approval by OAL).

2. Individual Action Plan Dischargers: Dischargers not participating in the NSMP Cooperative Watershed Funding Program, or who are participating in the Program but fail to implement their Program-related responsibilities in a timely or effective manner, will be required to comply with the TMDLs, final WLAs and numeric targets within three years of the effective date of the TMDLs (i.e., upon approval by OAL) in accordance with an Individual Action Plan and schedule approved by the Regional Water Board's Executive Officer. Alternatively, these parties must cease any ongoing discharges and not initiate any proposed discharges.

Individual Action Plan dischargers will be required to implement the following tasks as identified in Table 12-1:

- Develop and implement an individual action plan (Task 3)
- Implement volume reduction BMPs (Task 4)
- Provide recommendations for and participate in periodic review and revision (as necessary) of the selenium TMDLs, BMP Strategic Plan, Regional Monitoring Program, and special studies status and needs (Task 11)

Individual Action Plan dischargers will be required to submit and implement upon Regional Water Board approval, a selenium offset program for selenium discharges in excess of their selenium limitations until final compliance is achieved. As the NSMP CWP moves towards implementing regional controls for selenium reductions, it is expected to include offset opportunities for Individual Action Plan dischargers. IAP dischargers that choose to participate in an offset opportunity provided by the NSMP CWP will need only to offset the actual amount of selenium that exceeds their WLA(s) since they will be contributing to the regional, watershed-wide approach. However, any IAP dischargers that do not offset their discharge through the NSMP CWP will be required to provide an additional increment of selenium removal that equals 2X greater than the amount of the exceedance of their selenium WLA(s) in their discharge. This is because discharges of selenium above their assigned WLA can have long-term adverse effects on biota because selenium is bioaccumulative. Regional Water Board staff encourages a regional, watershed-wide approach to reducing selenium concentrations in water and biota, such as that being implemented through the NSMP CWP, since it is expected to provide the quickest and most cost-effective route to meaningful selenium reductions in the watershed.

As previously described, an adaptive approach to implementation of the TMDLs is recommended. As the TMDL tasks are implemented, including BMP installation, monitoring and special investigations, and relevant data and information are compiled, revisions to the TMDLs, including implementation strategies, may be recommended and considered. Subsequent issuance/revisions of the NPDES permits/WDRs will implement any such changes.

Permit revision/issuance will be accomplished as soon as possible upon approval of these TMDLs. Given Regional Water Board constraints and the need to consider other program priorities, permits requiring revision will likely be revised during renewal. The NPDES permits/WDRs that may be revised include those identified in Table 12-3 below.

Table 12-3. Existing NPDES Permits and WDRs Regulating Discharges in the Newport Bay Watershed.

Permit Title	Order No.	NPDES No.
Waste Discharge Requirements for the United States Department of the Navy, Former Marine Corps Air Station Tustin, Discharge to Peters Canyon Wash in the San Diego Creek/Newport Bay Watershed	R8-2006-0017	CA8000404
Waste Discharge Requirements for the County of Orange, Orange County Flood Control District and the Incorporated Cities of Orange County within the Santa Ana Region - Area-wide Urban Storm Water Runoff - Orange County	R8-2002-0010	CAS618030
General Waste Discharge Requirements for Discharges to Surface Waters that Pose an Insignificant (de minimus) Threat to Water Quality	R8-2009-0003	CAG998001
General Groundwater Cleanup Permit for Discharges to Surface Waters of Extracted and Treated Groundwater Resulting from the Cleanup of Groundwater Polluted by Petroleum Hydrocarbons, Solvents and/or Petroleum Hydrocarbons mixed with Lead and/or Solvents	R8-2007-0041, as amended by Order No. R8-2009-0045	CAG918002
General Waste Discharge Requirements for the Re-injection/percolation of Extracted and Treated Groundwater Resulting from the Cleanup of Groundwater Polluted by Petroleum Hydrocarbons, Solvents and/or Petroleum Hydrocarbons Mixed with Lead and/or Solvents within the Santa Ana Region	R8-2002-0033	
Waste Discharge Requirements for City of Irvine, Groundwater Dewatering Facilities, Irvine, Orange County	R8-2005-0079	CA8000406
Waste Discharge Requirements for Bordiers Nursery, Inc.	R8-2003-0028	
Waste Discharge Requirements for Hines Nurseries, Inc.	R8-2004-0060	
Waste Discharge Requirements for El Modeno Gardens, Inc., Orange County	R8-2005-0009	
Waste Discharge Requirements for Nakase Bros. Wholesale Nursery, Orange County	R8-2005-0006	

TASK 2 THE NITROGEN AND SELENIUM MANAGEMENT PROGRAM COOPERATIVE WATERSHED PROGRAM FUNDING AGREEMENT

Non-point source rising groundwater is the largest source of selenium in many areas of the Newport Bay watershed. The final TMDL numeric targets cannot be achieved unless comprehensive measures are taken to reduce selenium loads to surface waters from groundwater. A regional watershed approach is necessary to achieve these load reductions in the groundwater and the groundwater-supported baseflows in the creeks. In order to provide reasonable assurance that these TMDLs will be implemented appropriately, effectively, and in a timely manner so that water quality standards will be attained as soon as possible, the selenium TMDLs strongly encourage all existing and potential dischargers in the Newport Bay watershed to participate in the NSMP Cooperative Watershed Program Funding Agreement (NSMP CWP).

Dischargers who elect not to participate in the NSMP CWP must either not discharge (e.g., by sewering the discharge), or provide an Individual Action Plan that identifies an acceptable means to comply, within three years of the effective date of the TMDLs, with the TMDL WLAs, LAs, and numeric targets and with waste discharge requirement limitations/waiver conditions necessary to implement these TMDL components (Section 12.4).

Those dischargers who elect to participate in the NSMP CWP will be expected to enter into the NSMP CWP Funding Agreement with the other dischargers, and must provide an executed watershed agreement to the Regional Water Board within one month of the effective date of the TMDLs.. A draft agreement for the Cooperative Watershed Program was submitted to the Regional Water Board on [date] (Appendix 12A).

The NSMP stakeholders will be expected to continue to hold regular meetings to oversee the implementation of the TMDL-related tasks and report the status and/or results to the Regional Water Board on an annual basis. The NSMP will continue to operate in accordance with its approved Memorandum of Procedures and Public Participation Program (Appendix 12B).

TASK 3 DEVELOPMENT AND IMPLEMENTATION OF AN INDIVIDUAL ACTION PLAN

The proposed implementation plan for the selenium TMDLs provides a compliance option for those dischargers who want to implement an alternative, acceptable means to comply with the TMDLs WLAs, LAs, numeric targets, and/or with the waste discharge requirements or waiver conditions necessary to implement these TMDL components. As indicated above, the Individual Action Plan (IAP) dischargers will be required to comply with the TMDLs (WLAs, LAs, and numeric targets) no later than **three years** from the effective date of the TMDLs in accordance with an action plan and schedule approved by the Executive Officer. Alternatively, ongoing discharges must cease and no new discharges may commence.

Those dischargers who elect to develop and implement an individual action plan will be expected to submit the completed plan to the Regional Water Board's Executive Officer for review and approval 3 months prior to the anticipated discharge (see **Table 12-1**). IAP dischargers that choose to participate in an offset opportunity provided by the NSMP CWP will need only to offset the actual amount of selenium that exceeds their WLA(s) since they will be contributing to the regional, watershed-wide approach. However, any IAP dischargers that do not offset their discharge through the NSMP CWP will be required to provide an additional increment of selenium removal that equals 2X greater than the amount of the exceedance of their selenium WLA(s) in their discharge. Selenium is bioaccumulative; therefore discharges of selenium above the assigned WLA(s) can have long-term adverse effects on biota. Regional Water Board staff encourages a regional, watershed-wide approach to reducing selenium concentrations in water and biota, such as that being implemented through the NSMP CWP, since it is expected to provide the quickest and most cost-effective route to meaningful selenium reductions in the watershed.

The individual action plans should include, at a minimum, the following information:

- Project timeline, including duration of project, discharge locations, and schedule of discharge activities;
- Volume of water that is expected to be discharged (in gallons per day, and total for project) for the duration of the project and expected selenium concentrations;
- An estimate of the concentrations and loads of Se that are expected to be discharged during the life of the project (in µg/L and pounds per day/week/month, respectively);
- The monitoring approach including locations, frequencies, constituents, and methodologies;
- If the concentrations are anticipated to exceed the applicable TMDL WLA(s), identify the means by which the portion of the discharge that exceeds the WLA(s) will be offset (which program and/or BMP, and confirmation that there is capacity with that program and/or BMP that will be utilized for the offset)[9].

The IAP dischargers will be expected to implement their approved action plans and report the status and/or results to the Regional Water Board on a monthly and/or annual basis, depending upon the reporting requirements approved as a part of their IAP.

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[9] Participation by an IAP discharger in the offset opportunities provided though the NSMP CWP requires only that the discharger(s) offset the amount of selenium that exceeds their WLA(s). If the IAP discharger chooses not to participate in the NSMP CWP, then they must also provide an additional increment of selenium removal that equals 2X greater than the amount of the exceedance of their selenium WLA(s) in their discharge.

TASK 4 IMPLEMENTATION OF VOLUME REDUCTION BMPS

All dischargers are required to submit documentation with their notice of intent (NOI) to discharge that the feasibility of eliminating or reducing the volume of the discharge has been evaluated. Discharges to surface waters will be considered for permit authorization only provided that it is demonstrated that the reduction/elimination of the discharge is not reasonably feasible. Potential volume reduction measures were evaluated by the NSMP Working Group as part of the implementation of the approved NSMP Work Plan.

Three volume reduction BMPs were deemed feasible by the NSMP Working Group for the Newport Bay watershed. These are: (1) discharge to land; (2) discharge to sewer; and (3) offsite transport and disposal. Specifications and limitations of the three methods were listed in the NSMP report *Volume Reducing Best Management Practices for Short-Term Groundwater Related Discharges within Orange County – August 2005*[10]. Volume reduction BMP fact sheets are included in Appendix 12C; a brief summary of each of these BMPs is provided below.

<u>Discharge to Land</u>

A discharge to land consists of collecting water from the project site, potentially transporting it and then spreading water over another project site. The water that is discharged is infiltrated or evaporated at the project site. In addition, water may be used for dust control purposes. No discharge to the surface waters may occur. The discharger must submit in advance of their discharge a request to the Regional Water Board that defines how they will be discharging to land and whether or not waste discharge requirements and/or monitoring would be necessary.

<u>Discharge to Sewer</u>

A discharge to the sanitary sewer system consists of discharging water directly to the sewer system instead of surface waters. This BMP requires obtaining permission from the appropriate sanitary sewer agency and complying with any monitoring and/or pre-treatment requirements, such as the removal of sediments. Discharges will likely be limited during wet weather periods, and water quality and flow estimation may be required throughout the duration of the discharge. Discharge to Orange County Ground Water Replenishment System (GWRS) may also be an option (please also see discussion under Task 5, BMP Strategic Plan).

<u>Offsite Transportation and Disposal</u>

Offsite transportation and disposal includes working with a licensed transport, storage and disposal (TSD) contractor who may remove, transport, store and dispose or treat the water as necessary. Offsite transportation would be most applicable to discharges classified as “hazardous” or “designated” as defined in

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[10] “Short term Ground-water Discharges” are considered 1 year or less in duration.

Title 22 CCR, Section 66261 and California Water Code Section 13173. Title 22 CCR identifies concentrations of selenium of 0.16 mg/L or greater to be considered “hazardous”. Offsite transportation can also be used for non-hazardous concentration water. Several requirements may apply before water can be transported offsite, including analytical testing to determine the levels of constituents and an analysis of the feasibility of onsite collection and storage.

Other volume reduction BMPs that may be considered by dischargers include percolation or evaporation basins and groundwater reinjection. However, these options present their own potential problems and may not be cost- or space-effective or provide sufficient volume reduction for some projects

Any discharger wishing to discharge groundwater containing selenium to surface waters, whether on a short-term or long-term basis, must submit a Report of Waste Discharge (ROWD) with their NOI. The ROWD must include a demonstration that the discharge cannot be avoided, reduced or eliminated. Approval of the NOI is dependent on the timely submittal of a ROWD that fulfills the demonstration requirements discussed in Appendix 12D.

TASK 5 DEVELOP AND IMPLEMENT A SELENIUM BEST MANAGEMENT PRACTICES (BMP) STRATEGIC PLAN, INCLUDING EARLY ACTION PLAN, AND BMP EFFECTIVENESS MONITORING PLAN

NSMP dischargers will be required to develop a proposed BMP Strategic Plan and BMP Effectiveness Monitoring Plan for submittal to the Regional Water Board no later than one month after approval of the TMDLs by the Office of Administrative Law (OAL), and to implement those Plans upon approval by the Regional Water Board at a public hearing.

The BMP Strategic Plan will include the following elements:

1. A description of the approach to implement pollution prevention, source control and treatment control BMPs to meet TMDL targets for selenium ;
2. Identification of BMP implementation priority areas considering the level of biological significance and selenium concerns;
3. Candidate source and/or treatment controls necessary to meet TMDL targets (Phase I) including:
    a. type and approximate locations of controls;
    b. timing for implementation;
    c. treatment capacity;
    d. cost of implementation; and
    e. constraints on implementation, such as permitting, brine disposal, diversion/removal of surface water flows that could impact instream beneficial uses; and
    f. anticipated removal rates and/or load reductions for both selenium and nitrogen

4. Early Action Tasks to be completed within the first 5 years[11] including:

[11] As soon as possible, but no later than 5 years from the effective date of the TMDLs.

   a. type and approximate locations of controls;
   b. timing for implementation;
   c. treatment capacity;
   d. anticipated removal rates and/or load reductions; and
   e. relation of Early Action Tasks to control of selenium in implementation priority areas (#2, above)
5. A BMP Effectiveness Monitoring Program;
6. A contingency plan for selection and implementation of alternative BMPs for evaluation/implementation should one or more of the control measures evaluated fail to achieve expectations;
7. A plan and schedule for Final Control Technology Implementation (Phase II of the TMDLs)

The NSMP Working Group has evaluated various source and treatment controls for their feasibility to address selenium discharges to surface waters in the Newport Bay Watershed. The key technical documents that have been developed include the following:

- Volume Reduction BMP Fact Sheets, August 2005
- Quick Start BMP Program Final Report, September 2005
- BMP Data Needs Final Report, November 2005
- Identification and Assessment of Selenium and Nitrogen Treatment Technologies and Best Management Practices Interim Report, March 2006
- BMP Selection and Pilot-Scale Testing Considerations Interim Report, November 2006
- BMP Testing Protocol, November 2006
- Pilot Test Report for Nitrogen and Selenium Removal Technologies, March 2007
- Identification and Assessment of Selenium and Nitrogen Treatment Technologies and Best Management Practices Report, March 2007
- Simple Treatment-Related Model Final Report, June 2007
- NSMP BMP Implementation Plan Alternatives, December 2007
- NSMP BMP Implementation Plan Modified Alternatives, April 2008
- BMP Strategic Plan Framework, November 2008
- Draft BMP Strategic Plan, July 2009

Due to the large contribution of non-point source rising groundwater to the total selenium load, effectively reducing selenium concentrations will require utilizing regional treatment BMPs and regional source control BMPs. Although several selenium treatment BMPs have been identified as potentially feasible, additional demonstration-scale testing is necessary before full-scale implementation can occur. The BMP Strategic Plan will include include technology validation and demonstration-scale testing of candidate BMPs. Where these demonstration-scale BMPs prove successful in removing selenium, they are expected to remain in operation, achieving selenium reductions while full-scale implementation of BMPs are constructed/installed. A Draft BMP Strategic Plan developed by the

NSMP Working Group is included in Appendix 12E. The final BMP Strategic Plan must be submitted to the Regional Water Board for review and approval within one month of the effective date of the TMDLs.

The BMP Strategic Plan that will be submitted to the Regional Water Board for approval will be considered a dynamic document, subject to review and revision based on the data and knowledge gained during the implementation process. For example, changes to the BMP implementation strategy may be necessary if a given BMP proves to be ineffective and/or inefficient, and/or if a new treatment technology is developed.

The draft BMP Strategic Plan (and the Plan that will be submitted to the Regional Water Board for approval) addresses compliance with the full range of proposed numeric targets and allocations, including those based on the CTR and those based on the SSOs. This includes identifying the BMPs that may be employed to achieve the full range of water column guidelines (5-13 µg/L) calculated using the biodynamic model. These are the water column concentrations that may be necessary to achieve the tissue-based numeric targets, and the selenium SSOs (Section 9.0, Linkage Analysis).

The Draft BMP Strategic Plan outlines several types of selenium treatment BMPs that will be evaluated though demonstration-scale (field-scale) testing within the watershed. The results of these evaluations will assist in identifying those BMPs that provide effective and consistent reductions in selenium (and nitrate), are space and resource efficient, and are economically viable for implementation in the watershed. Any treatment BMPs that are implemented for the selenium TMDLs must not discharge identified pollutants of concern in greater concentrations than are present in the inflows to the BMPs. Details of these potential treatment BMPs can be found in referenced reports listed above and in the Draft BMP Strategic Plan (Appendix 12E). A brief discussion of the current most promising selenium treatment BMPs follows.

The BMP Strategic Plan must include a discussion of the technologies, BMPs, and/or source controls that are being evaluated, including an analysis of any potential constraints or issues (such as permitting or brine disposal) that might prevent, or inhibit the use of the device in some areas or under certain circumstances. The BMP Strategic Plan should also have in place a contingency plan that outlines when and what actions will be taken if a BMP does not perform as planned, including alternatives to that BMP, and how decommissioning of the BMP will be conducted. The BMP Strategic plan must also include a schedule and plan for determining which BMPs/source controls will be scaled up to their full capacity, where they will be located, and when they will begin operations and selenium and/or nitrogen removals will be fully optimized. The plan also must include a discussion of any Early Action Items that can be implemented within 5 years or less of the effective date of the selenium TMDLs that will provide reductions in selenium and/or nitrogen while testing of additional/alternative source controls and BMPs progresses. Annual progress reports on the implementation of the BMP Strategic Plan should be submitted. These reports should include an assessment of the status of implementation of the tasks identified in the Strategic Plan, the results of BMP effectiveness monitoring, and an assessment of the effectiveness of the actions implemented. Based on this assessment, recommendations for changes in the BMP Strategic Plan, including changes in the controls to be employed, placement of these controls and/or scheduling of implementation of these controls, should be identified. Changes to the BMP Strategic Plan will be considered by the Regional Water Board utilizing a public participation process and the revised Strategic Plan would be implemented upon approval by the Regional Water Board.

BMPs Under Consideration for Implementation

Anaerobic Biological Reduction Reactors
Anaerobic biological treatment involves the use of anaerobic bacteria that chemically reduce selenium from selenate to selenite or elemental forms of selenium. By supplying an organic carbon source as an electron donor, selenium (in the form of selenate, which would be the electron acceptor) can be reduced to selenite and then to elemental selenium, which is a particulate form that can be removed from the water stream. The general chemical reaction is shown in Figure 12-1, below.

Figure 12-1 Generalized Anaerobic Bacteria Reduction Process (SJVDIP, 1999)

Se (+ VI) + Bacteria + Organic Carbon Selenate (soluble)	→	Se(+IV) Selenite (soluble)	→	Se(0) Elemental Se (particle)

The reduction process illustrated above can be inhibited by other constituents present in the water that may act as electron donors. For example, nitrate, which is present in groundwater within the Newport Bay watershed, would also be reduced through bacterial denitrification. Since nitrate is present in much higher concentrations than selenium, most of the carbon is used for nitrate reduction (SJVDIP, 1999).

Two types of anaerobic biological reduction reactor systems are being considered as potential selenium treatment BMPs and are included in the draft BMP Strategic Plan:

Cienega Filtration Facility Demonstration Project
The Cienega Filtration facility is a type of anaerobic biological reduction reactor and is located at the southwest corner of Peters Canyon Wash and Barranca Parkway, beneath the athletic fields at the site of the Irvine Unified School District's high school campus, which is currently under construction (Figure 12-2).

The system will provide load reductions for the reaches downstream of this location. The subsurface design allows for secondary use of the land above the system (the high school's athletic fields in this case), which is important in a highly urbanized area where space is at a minimum and property costs are high.

Figure 12-2. Location of Cienega Filtration Facility Demonstration Cell

The first cell of a planned future full-scale facility has been constructed and is in demonstration-phase testing. The current field demonstration portion of this project consists of a subsurface, geomembrane-lined cell filled with an inert crushed rock media or biofilter (Figures 12-3 and 12-4). Surface water containing selenium at concentrations of approximately 20 to 40 µg/L, and nitrate of approximately 10-13 mg/L, is diverted from Peters Canyon Wash and pumped through the biofilter. The source water is inoculated with local bacteria followed by addition of electron donor materials to promote reducing conditions in the chamber. Sodium benzoate is being used as the feedstock for the bacteria during start up operations. Methane is being considered for long-term operation, if viable. Both selenium and nitrate are treated since the reduction process needed to remove selenium also results in biologically mediated denitrification. A post-treatment oxygenation system restores aerobic conditions in the treated flows before they are returned to Peters Canyon Wash to comply with permitted discharge requirements for dissolved oxygen concentrations of 5 mg/L or greater.

Waste streams of the collected elemental selenium/microbial product (a sludge mixture) have a potential market niche as an animal feed supplement (MSE, 2001). If a commercial or other beneficial use for the waste sludge can't be identified, disposal would be either to a conventional or hazardous waste landfill depending on the levels of selenium and other constituents in the sludge.

Figure 12-3. Schematic of Field Demonstration-scale Project

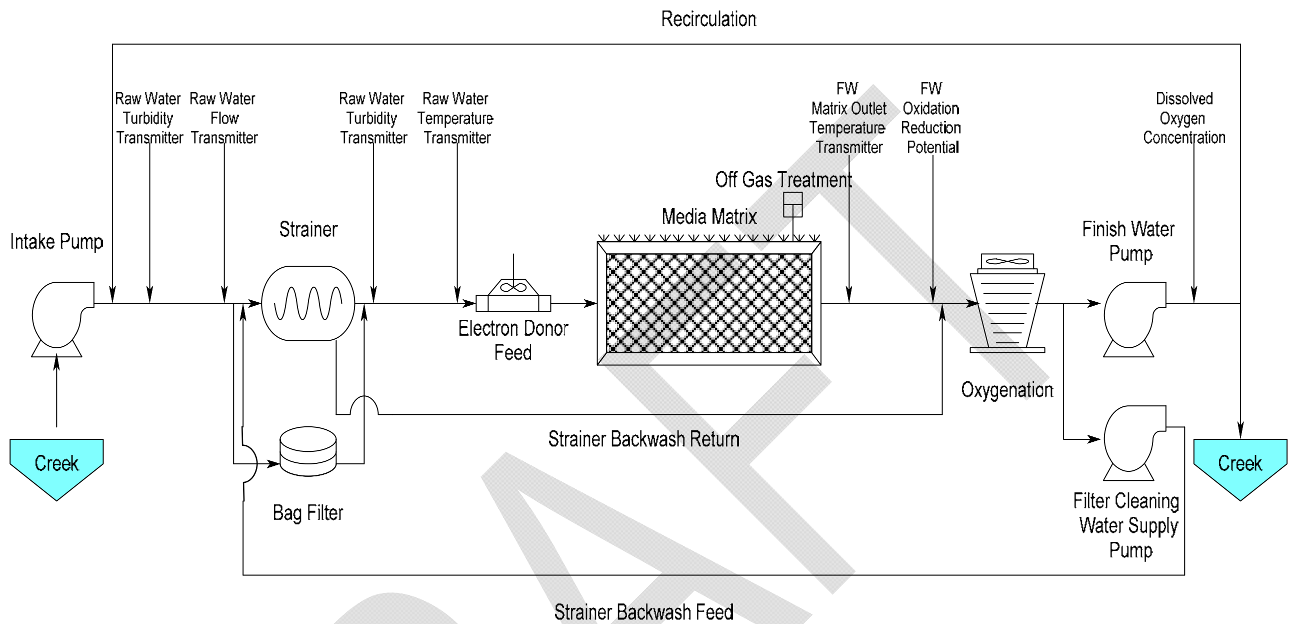


Figure 12-4 Photograph of media matrix demonstration cell under construction

The demonstration project is currently operational and is being tested and evaluated to refine and optimize its performance. The performance evaluation includes comparison of influent data with both effluent data and in-stream data collected just downstream of the demonstration cell to determine the project's effectiveness in removing selenium and nitrate. The evaluation also includes an analysis of the processes that took place during the planning, construction, and operation of the facility, including site acquisition, permitting, site configuration, start-up operations, and long-term operations and maintenance. At present, potential issues for the Cienega project include the detection of low-levels of selenite (up to 1.5 µg/L) in the effluent, waste sludge disposal, and system stability. If effective, a full-scale system that is projected to be able to treat approximately ¾ of the dry weather flows (about 3 cfs) in Peters Canyon Wash will be implemented. The demonstration cell is capable of treating 0.3 cfs under optimal operating conditions.

The system is currently removing significant amounts of nitrate (nitrate concentrations in effluent are less than 1 mg/L) and selenium (approximately 70% of the selenium is being removed from the influent flows) but has not yet reached its full operational potential due to periodic shutdowns for trouble shooting and storm events. Testing and evaluation under a variety of operational conditions is ongoing to ensure the long-term viability of the design before moving forward with construction of the full-scale facility.

ABMet® Technology

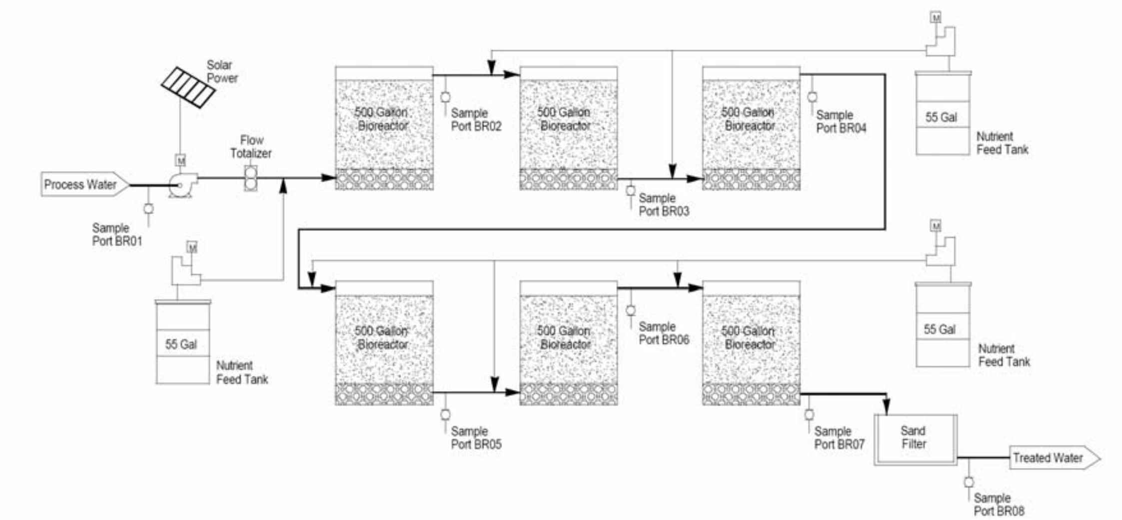
Researchers at Applied Biosciences (now General Electric Water and Process Technologies) of Salt Lake City, Utah, developed a process using anaerobic solids bed reactors in which selenium was reduced to elemental selenium by specially developed biofilms containing specific proprietary microorganisms. This process is described in the final report for the U.S. Environmental Protection Agency's (USEPA) Mine Waste Technology Program (MSE, 2001). In the USEPA report, the process was referred to as the BSeR™ process, but it is now referred to as ABMet® technology. This process is engineered and uses a very controlled biological process for the removal of heavy metals, metalloids, and other inorganic compounds (Salton Sea, 2005). Source water is pumped into a series of bioreactors containing carbon/biosolids/biofilm combination or carbon/biofilm, depending on the test series. Nutrients (e.g. molasses, as a food source for the bacteria) are supplied to the reactors at three locations in the process. Prior to discharge, the effluent water is run through a sand filter to remove particulates. The process results in a precipitate of elemental selenium (Figure 12-5).

In the test conducted for USEPA (MSE, 2001) the ABMet® selenium reduction process consistently achieved final concentrations below 5 µg/L, and often below 2 µg/L (MSE, 2001). A separate study also quantified nitrate removals using this process from about 30 mg/L to about 1 mg/L (Pickett, 2006).

The ABMet® process produces a waste consisting of the collected elemental selenium/microbial product (a sludge mixture). Therefore, an additional step is required to remove and dispose of this waste stream. The waste generated by the ABMet® process may have a potential market niche as an animal feed supplement (MSE, 2001). If a commercial or other beneficial use for the waste sludge cannot be identified, disposal would be either to a conventional or hazardous waste landfill depending on the levels of selenium and other constituents in the sludge.

The NSMP Working Group has pilot tested the ABMet® anaerobic biological reduction reactor on a small scale (1-5 gallons per minute). The system brought down selenium and nitrogen levels from 21 µg/L and 13 µg/L down to as low as 1.7 µg/L and 0.3 µg/L, respectively. A larger field demonstration-scale of this process may be built and evaluated as part of Phase I of the BMP Strategic Plan. Full-scale ABMet® facilities have most commonly been installed in remote mining areas or in industrial complexes. Facilities generally included large treatment tanks and piping/control mechanisms. Siting an ABMet® facility within a suburban residential setting within the Newport Bay watershed may be difficult. Though this system is not designed as a subsurface system, it may have the potential to be deployed underground, however the additional costs for this modification have not yet been determined.

Figure 12-5. ABMet® Process Flow Diagram (MSE 2001)

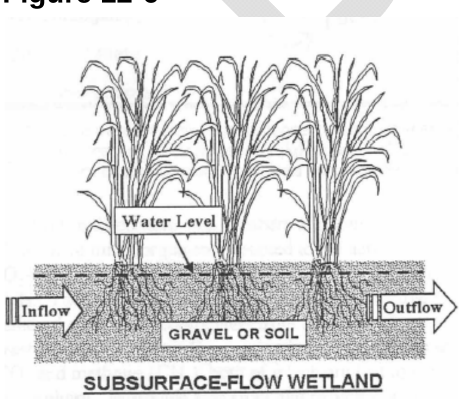


Subsurface Flow Wetlands

A constructed wetland is an engineered system that has been designed and constructed to use natural processes involving wetland vegetation, soils, and associated microbial activity to provide treatment of storm water and wastewater. Natural wetlands act as biofilters, removing sediments and pollutants from water, and constructed wetlands are designed to capitalize on this feature. There are two basic types of constructed wetlands: surface-flow (SF) and subsurface-flow (SSF) wetlands. SF systems typically have water flowing at shallow depths over the soil surface and through plants, while SSF systems keep the water below the soil surface (Figure 12-6).

The large land area footprint required to balance flow capacity and treatment residence time requirements in constructed wetlands may limit the applicability of this treatment option in the Newport Bay watershed.

Figure 12-6



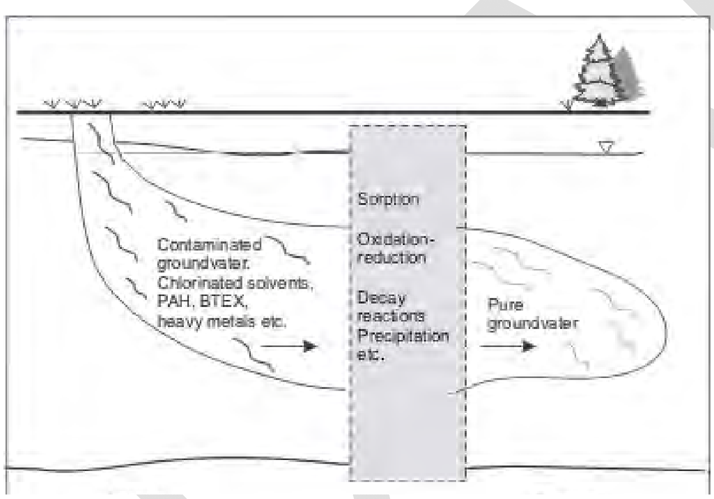
Constructed wetlands remove selenium by reduction to insoluble forms (selenide (Se2-), elemental selenium (Se0))that are deposited in sediments, accumulated in plant tissues, and volatilized to the atmosphere through biological processes facilitated by plants, plant/microbe associations, and microbes alone. Because fish and wildlife could potentially be exposed to selenium that has accumulated in plants and invertebrates in a surface water (SF) constructed wetlands system, SSF systems are preferred for selenium treatment.

Permeable Reactive Barriers

Permeable Reactive Barriers (PRBs) are a passive in-situ treatment technology that uses natural groundwater flow conditions at a site for remediation. Methods of installation include constructing a trench across the contaminated groundwater flow path by using either a funnel-and-gate system or a continuous reactive barrier. The gate or reactive cell portion is filled with a treatment media of typically zero-valent granular iron, which is derived from treated scrap metal to remove its valence electrons. As groundwater passes through the reactive barrier (**Figure 12-7**), contaminants are either immobilized or chemically transformed to a less toxic or more biodegradable state. PRBs are generally limited to depths of 50-70 feet or less.

Before implementation of PRBs, a detailed groundwater model is necessary to identify potential locations where PRBs can achieve the maximum removal efficiency (refer to Task 5 of this Plan for more details). The main challenge to the use of PRBs is identifying appropriate and effective locations and potential conflicts with the current use of the location (i.e., development on the site).

Figure 12-7. Permeable Reactive Barrier (Source: http://www.p2pays.org/ref/14/13983.htm))



Sewer Diversion

This approach consists of the identification of high selenium areas within the surface waters and/or groundwater and diverting all or a portion of the water to the sanitary sewer. Diverted flows could be sent to either the Orange County Sanitation District (OCSD) or the Orange County Water District Groundwater Replenishment System (GWRS). Flows sent to OCSD would receive secondary treatment (once the secondary treatment facilities are complete) prior to discharge via the ocean outfall. The GWRS is a system that treats secondary treated wastewater with microfiltration, reverse osmosis, ultraviolet light and hydrogen peroxide and then uses the effluent to replenish the groundwater aquifer, a significant source of potable water supply. (Note: the Maximum Contaminant Limit (MCL) for selenium in drinking water of 50 µg/L is an order of magnitude higher than the CTR freshwater chronic criterion of 5 µg/L for protection of wildlife). While sewer diversion is a well-known treatment technology, both diversion options face significant limitations. Until a groundwater/surface water model is completed, the most efficient locations for sewer diversions cannot be accurately identified. Additionally, any diversion is limited by both trunk line and treatment plant capacity. OCSD already accepts significant amounts of urban runoff diversions into its system and any additional diversions must be coordinated with existing trunk line and plant capacity limitations. The GWRS system has not reached its full treatment capacity and currently cannot accept any additional flows. Investigations are being carried out in order to determine if a direct line can be connected to the GWRS once the system is built to its full capacity and if a treatment system would have to be used to treat the brine. Developing a direct line to the GWRS is desirable so that water diverted would be available as drinking water in the future. If the evaluation determines that this option is feasible, a demonstration scale project may be developed and evaluated as part of Phase I of the BMP Strategic Plan.

Groundwater Interception and Treatment (Pump and Treat)
Groundwater interception and treatment options are traditionally associated with groundwater contamination by man-made contaminants. This technology could be used to prevent high selenium groundwater from seeping into reaches in the watershed, thus reducing the volume of the surface water requiring treatment. However, a detailed groundwater model will be necessary to identify potential locations where groundwater can be intercepted/pumped out (refer to Task 5 of this Plan for more details about the model). After interception, the groundwater can be treated with one of the BMPs identified above or diverted to the sewer or GWRS. If an appropriate location to implement a groundwater interception and treatment option is identified, a demonstration scale groundwater interception and treatment project may be developed and evaluated as part of Phase I of the BMP Strategic Plan.

Changes in Wetland Operation
Operation of the UCI Wetlands could be modified to allow for increased "flow through" dynamics. This is one change that may limit the biological uptake of selenium. Other operational options for both the UCI and IRWD off-channel wetlands could be explored to limit the biological uptake of selenium either through improving pass-through of selenium in the wetlands by increasing flows or absorption and removal of selenium from the water column into sediments in areas where biological uptake and recycling are expected to be limited. Any type of operational changes would require extensive discussions with both UCI and IRWD staff.

BMP Simple Treatment Model

The NSMP Working Group has developed a selenium and nitrogen simple treatment model (CH2MHill, June 2007) that will be used primarily as a tool to prioritize locations for potential BMPs so that the maximum water quality and ecological benefit can be gained from implementation of BMPs. The model is a pollutant mass balance calculator that divides the San Diego Creek/ Newport Bay watershed into important concentration points and predicts seasonal pollutant concentrations as flow weighted averages of sources that contribute selenium and nitrate. Sources include surface water flows in creeks and storm drains, groundwater exfiltration, and point sources such as groundwater treatment and dewatering facilities.

The model contains a tool that allows the user to select any source and evaluate the cost and water quality improvements from implementing any one of three BMP treatment technologies at that source. Data incorporated into the model include stream flow data, water quality sampling and analysis data, and BMP technology pilot testing performance data. Model runs using existing data and some of the above-described potential BMPs predicted total selenium and nitrate-nitrogen concentrations at several locations in the watershed within 5-15% of observed seasonal values. This is an acceptable level of accuracy for a model of this type (CH2MHill, June 2007). The model has been designed as a modular tool that can be revised and updated as additional water quality, hydrology, surface water/groundwater interaction, and BMP performance data are collected over time. In particular, the data collected from the BMP demonstration testing, monitoring, and special studies that will be completed during Phase I of implementation of the selenium TMDLs will be used to update and revise the model prior to determining the most optimal location for selenium and nitrate BMPs.

BMP Effectiveness Monitoring

The effectiveness of the different BMPs that may be implemented to reduce selenium and nitrogen concentrations in surface waters or groundwater must be understood in order to determine whether or not the BMP is performing as designed, and to ensure that the BMP is not causing or contributing to water quality impairment as a result of the change in flows (e.g., surface flows diverted to the BMP might be reduced to the extent that the beneficial uses of the surface water are adversely affected) or the treatment process itself (e.g., the treatment process produces a contaminant, such as bacteria, that either exceeds or contributes to the exceedance of a water quality objective for that water body). A Draft BMP Effectiveness Monitoring Plan prepared by the NSMP Working Group is shown in Appendix xx.

BMP effectiveness monitoring has two primary purposes:

1. To assess the performance of the BMP with regards to its engineering design (performance monitoring);

2. To assess the performance of the BMP with regards to potential impacts to water quality and beneficial uses (water quality monitoring).

Engineering parameters such as inflow and outflow volumes, electrical/plumbing/mechanical performance, data transmission, energy use, etc., require monitoring to ensure that the BMP is operating efficiently and as designed.

Monitoring of influent and effluent water quality, upstream and downstream ambient water quality, and pounds of selenium or nitrate removed/volume of water diverted is required to ensure that the BMP is resulting in measured benefits to water quality and that it is not potentially contributing to or causing water quality and/or beneficial use impairment.

Monitoring of the environment within and external to the BMP should be designed so that the inter-related goals of good engineering performance and water quality improvement can be tracked over the lifetime of the BMP. The primary purpose of the BMP effectiveness monitoring is to identify viable BMP technologies for removal of selenium that may be implemented in the watershed. The monitoring is also expected to help assess whether additional implementation measures may be needed and it should provide information for the TMDL compliance monitoring program (see Task 9).

The draft BMP Effectiveness Monitoring Plan will be reviewed and approved by the Regional Water Board at a public meeting, and is required to be implemented upon that approval (see Task 5, **Table 12-1**).

Early Action Items for Implementation
While many of the selenium reduction technologies/BMPs have not yet been tested at the field scale, and some implementation actions may take years to complete because of permitting issues, costs associated with land acquisition and/or construction, CEQA review, or other issues, it is appropriate and necessary to require consideration of implementation actions that could be completed within less than 5 years of OAL approval of the selenium TMDLs and that would result in reductions in selenium concentrations in some areas of the watershed.

These actions could include demonstration projects, such as a sewer diversion demonstration, that could be used to more fully understand the benefits and constraints on this type of BMP; partial or full implementation of the Cienega Filtration Facility, which is in its first year of field demonstration-scale testing, or demonstration testing of the ABMet® system; or local ordinances to reduce irrigation in high selenium areas.

An Early Action Plan should be submitted as part of the BMP Strategic Plan to the Regional Water Board for review and approval as soon as possible, but no later than 1 month after OAL approval of the BPA implementing these TMDLs. The early action plan items should include projects that have been identified that are suitable for early implementation and that will result in measurable reductions in selenium concentrations in the watershed. The plan should also include a schedule that clearly outlines when these actions will be initiated and completed, a monitoring program that is structured so that the efficacy of the actions implemented and the amount of selenium (and nitrate) reductions that are being achieved can be quantified, and that can be used to both assess progress towards meeting the selenium TMDLs and/or aid in necessary revisions to these TMDLs.

TASK 6 DEVELOP GROUNDWATER-SURFACE WATER MODEL

The principal source of selenium loading in the Newport Bay watershed is shallow groundwater discharge to surface channels. A groundwater-surface water interaction model may be needed to better understand the hydrogeologic and hydrologic transport of selenium through the watershed. In addition, in order to assess the feasibility of reducing selenium and nitrate in stream baseflows, a groundwater-surface water interaction model may need to be developed to test strategies to manage groundwater discharge and potential remediation methods.

The primary purpose of the groundwater-surface water model would be assist in determining the location(s) and type of BMP(s) best suited to help minimize seepage of high concentration selenium groundwater into surface waters so that the volume of surface water requiring treatment can be reduced. If it appears that interception and treatment of groundwater (through the use of Permeable Reactive Barriers and/or traditional pump and treat methods) before it reaches surface waters may be a successful implementation approach for the selenium TMDLs, the BMP Strategic Plan will be revised accordingly. The groundwater-surface water model could also be used to determine whether source control measures, such as reductions in irrigation, would result in measurable reductions in selenium loadings to groundwater and surface waters. The model would also be expected to provide calculations of potential reductions in selenium loads based on the locations and expected performances of proposed selenium treatment BMPs. The model may also be used to identify data gaps, recommend additional implementation actions and/or special studies, and provide information that may be used to revise the RMP and the TMDL.

TASK 7 DEVELOP AND IMPLEMENT IRRIGATION REDUCTION AND CONTROL PROGRAM

Landscape over-irrigation is a significant source of discharges to the MS4 system. It is currently unknown whether and to what extent this type of discharge affects the perched groundwater underlying the San Diego Creek subwatershed and discharges of selenium from this aquifer. However, over-irrigation is suspected to exacerbate the discharge of high selenium groundwater in the Big Canyon Wash area. To address the potential for surface irrigation to impact selenium groundwater discharges, irrigation reduction and control programs may be necessary.

Statewide, this issue is being addressed through Assembly Bill 1881. To improve the efficiency of water use in new and existing urban irrigated landscapes in California, the Department of Water Resources (DWR) is updating the Model Local Water Efficient Landscape Ordinance. AB 1881 requires local agencies by no later than January 1, 2010, to adopt the updated model ordinance or equivalent. If the local agencies don't take action by that date, the ordinance will be adopted automatically by statute. Also, the bill requires the Energy Commission, in consultation with DWR, to adopt, by regulation, performance standards and labeling requirements for landscape irrigation equipment, including irrigation controllers, moisture sensors, emission devices, and valves to reduce the wasteful, uneconomic, inefficient, or unnecessary consumption of energy or water.

Adoption and implementation of the updated Model Local Water Efficient Landscape Ordinance throughout the Newport Bay watershed will provide an efficient mechanism to reduce over-irrigation in the area. However, additional irrigation control reduction measures may be necessary in areas underlain by high selenium soils, shallow groundwater, or geologic formations. Monitoring and/or special studies in these areas should be undertaken to ensure that the ordinances, once they are in place, are sufficient in and of themselves to reduce the mobilization of selenium into groundwater and/or surface waters.

TASK 8 DEVELOP REGIONAL MONITORING PROGRAM FOR SELENIUM

The proposed implementation plan requires that the Cooperative Watershed Program participants submit a proposed watershed (regional) monitoring and reporting program within 3 months of the effective date of the TMDLs, and that the program be implemented upon approval by the Regional Board. Appropriate monitoring and reporting requirements for discharges by the Individual Action Plan participants will be determined on a case-by-case basis, taking into consideration the objectives of the Regional Monitoring Program (in particular, the compliance monitoring requirements) and reasonable contributions by these dischargers to fulfill these objectives.

Previous selenium monitoring efforts were designed to build on the information in the selenium TMDLs promulgated by the USEPA and to fill data gaps in understanding the transport and fate of selenium, as well as the ecological risk of selenium contamination in the Newport Bay watershed (USEPA, 2002). Monitoring data for selenium concentrations and speciation in water, selenium concentrations in particulate fractions of water, and selenium concentrations in surface sediments and a variety of biological tissue samples (plants, invertebrates, fish, and bird eggs) have been collected throughout the watershed since the time the USEPA TMDLs were established in 2002. A comprehensive summary of selenium concentrations and loading within the watershed (for all media) is provided in the Sources and Loads Report (CH2MHILL, 2008) and discussed in Section 7 of this report.

Expectations regarding the content and focus of an approvable regional monitoring and reporting program are discussed below. In short, the program must satisfy several fundamental goals: (1) provide data needed to determine compliance with the selenium TMDLs, including the wasteload allocations, load allocations and numeric targets, and with the SSOs (upon approval); (2) provide data for the evaluation and future refinement of the TMDLs/SSOs; and (3) integrate the program with other ongoing or proposed monitoring in response to permit and other TMDL requirements (including the BMP effectiveness monitoring (Task 5), selenium management programs (Task 9), and special studies (Task 10) required by the proposed Implementation Plan for these selenium TMDLs). The framework for the regional, integrated approach has already been established in response to other TMDLs and MS4 permit requirements (e.g., nutrients, bacteria) and will likely serve as the basis for development of a Regional Monitoring Program that addresses selenium monitoring and data needs.

The regional, integrated monitoring and reporting approach offers the most effective and efficient method for gathering and evaluating data that can be used to develop and revise these or other TMDLs. While it may not be possible to fully integrate all of the data collection that is occurring in the watershed, analyses of multiple contaminants can be performed on many of the samples that are being collected.

A good example of this is the current trend monitoring program for bioaccumulative compounds that is being performed by DFG under contract to the SWRCB (see discussion under Section 12.4). This program collects water, sediment, bivalves and fish samples from a variety of locations in the fresh and salt water areas of the Newport Bay watershed. Samples are analyzed for multiple constituents of concern (polychlorinated biphenyls [PCBs], polybrominated diphenyl ethers [PBDEs], chlorinated pesticides [e.g., chlordane, dieldrin, DDT, and toxaphene], pyrethroids, selenium, and trace metals) and general water quality parameters (e.g., dissolved oxygen (DO), pH, conductivity, salinity, temperature, hardness, and dissolved and/or total organic carbon (DOC/TOC), etc.). Analytical results are used for comparison to TMDL numeric targets or appropriate sediment, human health or wildlife screening values. Selenium is already monitored as part of the trend monitoring program, but the program’s future is uncertain due to a lack of dedicated funding. However, the trend monitoring program could be used as a framework that can be expanded to meet the needs of the compliance monitoring required to track progress in the implementation of the selenium TMDLs.

While some monitoring efforts may be focused of necessity on the collection of data for specific, limited purposes (e.g., assessing biomagnification of PCBs in fish tissue), there should remain opportunities to extend such programs so that multiple purposes and needs can be addressed. A comprehensive, fully integrated Regional Monitoring Program should result in significant cost savings over the long term, and should facilitate more rapid and appropriate consideration of refinement of existing and/or future TMDLs.

For the selenium TMDLs, the Regional Monitoring Program should also integrate pertinent aspects of the required TMDL compliance monitoring program (discussed below), BMP effectiveness monitoring (described in Task 5), the selenium management programs (see Task 10), and special studies (discussed in Task 12). The data collected from these three programs will help to prioritize source controls, BMP implementation, refine the TMDLs, and assess progress towards compliance with the TMDLs/SSOs as implementation of the selenium TMDLs proceeds.

Compliance Monitoring Program

Section 13242 of the California Water Code specifies that Basin Plan implementation plans must contain a description of the monitoring and surveillance programs to be undertaken to determine compliance with water quality objectives. Therefore, monitoring designed to assess compliance with the proposed Newport watershed Selenium SSOs, and the TMDLs designed to achieve them (and other relevant narrative and numeric water quality objectives), must be implemented as part of the Basin Plan amendment to incorporate the SSOs and TMDLs. As indicated above, compliance monitoring is expected to be an integral part of the Regional Monitoring Program to be submitted by the Cooperative Watershed Program Participants and will be implemented upon Regional Board approval. (Again, requirements for compliance and other monitoring by the Individual Action Plan dischargers will be established on a case-by-case basis as individual permit requirements are considered.)

The principal goals of the Compliance Monitoring Program for the selenium TMDLs/SSOs are to:

- Measure progress toward the protection of aquatic life and aquatic-dependent wildlife (e.g., aquatic birds) beneficial uses.
- Measure progress toward achievement of the waste load allocations (WLAs) and load allocations (LAs).
- Measure progress toward attainment of the TMDL numeric targets/SSOs.

In addition to the above stated goals, the data collected from the Compliance Monitoring Program will help to identify priority areas in the watershed for BMP implementation and areas needing additional study or more focused monitoring.

Monitoring Parameters and Target Species

The nature and scope of the Regional Monitoring Program, including the Compliance Monitoring Program, for these TMDLs are complicated by the fact that the TMDLs include both tissue-based targets for selenium and water-column concentrations (water column guidelines) back-calculated from the tissue targets [12].

Tissue and water column monitoring will be integral to the selenium TMDLs monitoring effort since the TMDL numeric targets (see Section 8.0 in this report) are both water column- and tissue based[1] and the allocations are based on the translation of the tissue targets to water column guidelines (WCGs) using the Newport Bay watershed biodynamic model (Section 11.0). Water column monitoring will provide a direct mechanism for measuring progress towards achieving the TMDL allocations. In addition, water column concentrations can be compared to current CTR freshwater chronic criterion for selenium[13]. Water column monitoring will also provide an indirect means, via the translated WCGs, of measuring progress toward reaching the tissue targets and tissue-based SSOs. Monitoring of biota (whole-body fish and bird eggs) will provide a direct measure of progress toward achieving the tissue-based TMDL numeric targets and should help to refine the WCGs and TMDL allocations. Monitoring of selenium concentrations in sediment will provide a measure of longer-term, integrated selenium concentrations in the environment and can be used to help track the sources and fate of selenium as well as other sediment-associated contaminants.

The compliance monitoring program will need to include, at a minimum, the sampling and analysis of water column, sediment, whole-body fish and bird eggs. Fish tissue sampling will serve three purposes: (1) to monitor selenium concentrations in fish to assess potential reproductive effects; (2) to monitor selenium concentrations in fish to protect fish-eating birds; and (3) to monitor compliance with the fish tissue numeric targets. Bird egg tissues should be monitored to assess compliance with bird egg numeric targets and to evaluate potential reproductive effects to local birds. Water column samples are necessary to determine compliance with the allocations in the selenium TMDLs and to determine progress toward achieving the TMDL numeric targets. Sediment sampling will provide additional information on selenium cycling and mass balance in the different compartments in the watershed. Particulate or bivalve monitoring (as future studies or regional monitoring program modifications) may also be necessary to track progress in meeting the selenium TMDLs.

The monitoring locations should be selected based on the concentrations of selenium present, the sensitivity of the habitat, the type of hydrologic unit (e.g.,

[12] The final TMDL numeric target must be based on the current CTR criteria until the tissue-based Selenium SSOs are approved by USEPA. At that time, the TMDL numeric tissue targets, which are based on the SSOs, will become the final numeric targets for the TMDLs, and the targets based on the CTR criterion will become ineffective.

[13] As discussed previously (and in detail in Sections 8 and 10 of this report) the CTR saltwater criteria for selenium cannot legally be applied to the marine waters of Newport Bay due to antidegradation concerns.

lentic, lotic, wetlands) and hydrologic connections, and a reasonable assurance that the targeted samples will be present in sufficient numbers for the necessary analyses. The monitoring locations should be as representative as possible of the habitat and hydrologic units being monitored. The fish and bird species selected should include those that are likely to be either sensitive to selenium effects and/or the most exposed to selenium. Fish specimens will also need to be selected based on their importance in the diet of the targeted bird species. Bird species selected should include species that can act as surrogates for threatened and endangered species (e.g., Forster's tern as a surrogate for the endangered California least tern) and that are known to nest and feed in the watershed. Marine fish species selected for monitoring should be resident species, not migratory, to ensure that selenium concentrations in their tissues are representative of the conditions in the watershed.

The proposed monitoring program should include a method for determining when compliance with the selenium TMDLs has been achieved. The proposed methodology must be based on a statistically significant population of samples that accurately reflect the uncertainty associated with the analysis. The monitoring and compliance methodology must be designed so as to assure the long-term protection of both the most sensitive and most exposed species of fish and birds in the watershed.

Given the year-to-year differences in habitat, species availability and abundance, potential nesting sites, surface flows (in freshwater systems) and selenium concentrations in the watershed that are likely to occur, the monitoring program must be adaptable and flexible. The program should include a discussion of alternatives that can be used if the target species/sampling locations are not present or conditions for sample collection are not optimal. A decision tree should be developed to identify the triggers for the selection of the alternatives.

While flexibility is necessary because of changing environmental circumstances, the program must be designed and implemented to assure that the monitoring program provides the data necessary to assess compliance with the TMDLs. The inherent variability in the availability of fish and of bird eggs at specific locations and variations in the degree of selenium exposure must be considered in defining an appropriate collection and analytical program. Sampling sites for fish and for bird eggs should be selected based on their foraging range and their potential exposure to selenium.

Once fish or bird eggs have been sampled, water and sediment can be sampled at the nearest, precisely located monitoring station that lies within the foraging range of the target species[14]. If a precisely located monitoring station does not

[14] Birds and fish are mobile and may not be found in the same location from year to year. However, birds in particular tend to forage as close as possible to their nesting sites, if sufficient food items are present; some fish also have limited foraging ranges. Therefore, in order to correlate the selenium concentrations in the bird egg/ fish tissue, to water, sediment or food item

lie within the foraging range of the species being sampled, food items, water and sediment should be collected from within the foraging range of the targeted species, and the location of samples collected identified as accurately as possible. However, locations with limited habitat (e.g., Peters Canyon Wash, Santa Ana Delhi Channel) may not reliably provide any fish or bird eggs for collection, although water and sediment can always be sampled and food items or potential surrogates for fish, such as amphibians or upper trophic level macroinvertebrates may also be available for sampling.

<u>Suggested Routine Monitoring Parameters</u>

- Water: flow volume, selenium (total and dissolved; general water quality parameters – TDS, DOC, TOC, TSS, general anions and cations, total nitrogen, etc.).
- Sediment: upper 2 cm, target fine, organic-rich sediment where possible (total selenium as dry weight, percent solids, total organic carbon, grain size).
- Tissues: Fish (whole-body analyses) and bird eggs (egg contents only); total selenium, percent solids, percent lipids.
  Target biota by location:
  - Fish:
    - Freshwater = Juvenile and adult fish in the Centrarchidae (sunfish) family (e.g., bluegill, largemouth bass) for compliance with the fish tissue target; juveniles of bluegill or largemouth bass, or smaller fish such as red shiners or fathead minnows for assessment of risk to fish-eating birds and for contaminant trend monitoring.
    - Saltwater = Topsmelt or anchovies (water column feeding species) and various goby species (benthic species) for assessment of selenium concentrations in bird food items. Both juvenile and adult specimens of larger, water column species such as jacksmelt or kelp bass and bottom-dwelling species such as halibut, turbot, or various surfperch species for determining compliance with the fish tissue target.
  - Bird Eggs:
    - Freshwater = Shorebirds (avocet, stilt; invertivorous birds), grebes (omnivorous or insectivorous birds), coots (omnivorous or herbivorous birds)
    - Marine = Terns or skimmers (piscivorous birds), shorebirds

Fish Collection

As there are no native fish species in the freshwater areas of the watershed, introduced species of fish from the Centrarchidae (sunfish) family are suggested

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selenium concentrations it is important that the media that are sampled are collected from within the foraging range of the species of bird or fish being targeted. Sediment, water, and food items must be collected from within this range even if the next, precisely-located monitoring station is outside of this range.

for monitoring to determine compliance with the TMDL fish tissue target. Of the non-native warm water fish species found in the freshwater creeks, fish of this family are the most sensitive to selenium effects. Bluegills are more sensitive to selenium than other sunfish; therefore, both adult and juvenile bluegill should be collected in preference to other sunfish species (e.g., pumpkinseed, green sunfish, black crappie, largemouth bass) that may be present. However, if bluegills are not present, then other sunfish species should be targeted for collection, including largemouth bass. Juveniles of these species or other smaller fish such as red shiners or fathead minnows should be sampled to monitor selenium tissue concentrations in fish that are most likely to be preyed on by aquatic-dependent bird species. Red shiners and fathead minnows have also been used for monitoring contaminant trends in the watershed as part of the Toxic Substances Monitoring Program and the current bioaccumulative trend monitoring program. Since not all species of fish are expected to be available in any given year within the freshwater areas, the monitoring program must be flexible with regard to the species targeted; ideally, the alternative fish species should still be in the same general taxonomic group as the targeted fish species (e.g., centrarchids/sunfish). Collection methods may include electro-shocking, kick nets, dip nets, or beach seines.

For saltwater (marine) areas, targeted fish should include resident small water column feeding fish such as topsmelt or anchovies (prey for piscivorous birds such as terns and skimmers) or small benthic dwelling fish such as gobies (prey for wading herons). Larger juvenile and adult fish (both water column and benthic feeding species) such as jacksmelt, kelp bass, halibut, turbot, or surfperch should also be collected and analyzed for selenium for comparison to the TMDL numeric fish tissue target, but care should be taken to ensure that the fish collected are resident to in the Bay. Some fish species, such as halibut, spend their larval and juvenile stages in the Bay, but may migrate in and out of the Bay as adults. The marine fish species targeted in the Bay for tissue monitoring should be collected using trawl and/or beach seines.

Bird Egg Collection
The frequency of bird egg sampling should be coordinated with Orange County flood control channel maintenance activities in order to collect bird eggs in years when there is optimal nesting habitat. In the spring of some years, abundant sandbars and vegetation in the main channel of San Diego Creek support nesting pairs of shorebirds, coots, and grebes. However, if those sandbars and vegetation have been removed before the nesting season as part of flood control maintenance, very minimal nesting habitat remains and few nests would be available. It is suggested that egg sampling be conducted annually but that sampling should take advantage of years with maximal nesting habitat in the lower creek. The nesting habitat on the islands and shoreline in Upper Newport Bay is expected to be more consistent on a yearly basis than the freshwater areas. However, this nesting habitat is changing over the next few years as dredging proceeds to complete the Upper Newport Bay Ecosystem Restoration

Project. Current plans call for the removal of one of the main nesting islands for terns and skimmers, Skimmer Island. A new island has been created for California least terns further down in the bay near the western segment of the salt dike. It is not yet clear how successful the new island will be at attracting nesting birds. If Skimmer Island is removed as currently planned, then this may represent a significant, if temporary, loss in suitable nesting habitat for aquatic-dependent birds in this part of the watershed. However, it is hoped that this will be offset by the construction of the new island and the planned improvements to the nesting habitat on the other islands in the upper bay.

<u>Suggested Monitoring Locations</u>
While specific, recommended sampling sites for monitoring selenium in water and sediment can be established, sampling sites for monitoring selenium in some biota (such as fish and birds) may vary depending on flow conditions in the creeks (for fish), and nesting site availability (for birds). Compliance monitoring sites must provide sufficient target biota biomass for tissue sample analysis and confirmatory waterborne selenium concentrations for comparison to the water column guidelines.

Selected monitoring locations should include:

1. <u>Peters Canyon Wash (PCW) upstream of its confluence with San Diego Creek</u>

   This area lies within the historic Swamp of the Frogs, the primary source of selenium in the watershed, and receives the highest selenium groundwater inputs. This site will be representative of selenium concentrations in upstream tributary creeks and storm channels and provides some low to moderate quality habitat. Some invertebrates and small fish are usually available year-round. Suitable bird nesting habitat is both sparse and sporadic in this area due to the highly channelized nature of the wash and lack of adjacent wetlands or habitat areas.

2. <u>San Diego Creek (SDC) Reach 1 just upstream of Newport Bay</u>

   This area has moderate to good quality habitat and includes a riparian strip along the east bank of the creek. A series of in-line sedimentation basins extend from Culver Drive to the Bay. Water is pumped from the middle basin (Basin #2) to the IRWD off-channel treatment wetlands. Some of this pumped water is passed through to the University of California, Irvine (UCI) wetlands (San Joaquin Freshwater Marsh Reserve). Therefore, monitoring this area of the creek provides data on the selenium concentrations in water, sediment and biota in the creek and also provides a baseline selenium concentration for water entering the IRWD and UCI wetlands. The basins and riparian habitat in the downstream portion of Reach 1 are also likely to provide the most readily available freshwater tissue samples for TMDL compliance monitoring.

3. IRWD Treatment Wetlands and Carlson Marsh

While the treatment wetlands have been shown to be effective in removing both nitrate and selenium from the water column, the impairment assessment performed for these TMDLs found impairment in the wetlands from selenium in water, fish tissue, and bird eggs (see Section 5). At the time, a distinction between samples collected from the treatment pond and the Carlson Marsh area could not be accurately determined. Water is pumped from San Diego Creek Basin #2 and sent through IRWD's treatment ponds. Approximately 30% of the selenium, and up to 60% of the nitrate, is removed from the water before flows are returned to the creek or passed through the Carlson Marsh to the UCI wetlands. High selenium concentrations have been found in sediment and biota collected from the Carlson Marsh (Sutula et al., 2008; Horne et al., 2006). The treatment ponds are managed to optimize nitrate removals by raising and lowering water levels in different ponds; as a result, bird prey organisms in these wetlands are limited primarily to fish and some benthic invertebrates. However, the wetlands provide nesting habitat for birds and it is not known how much of the selenium found in bird eggs collected in the wetlands is from consumption of food items from the marsh verses the creek, or how much of the selenium that is removed by the treatment ponds is absorbed to sediment, volatilized by plants, or enters the wetlands food web. Actions taken to reduce selenium concentrations in San Diego Creek are expected to result also in reductions in selenium in the treatment wetlands. Monitoring is needed to confirm that this is in fact occurring.

4. UCI San Joaquin Freshwater Marsh Reserve

The San Joaquin Freshwater Marsh Reserve supports a variety of wetland habitats, including freshwater marshlands, shallow ponds, and channels confined by earthen dikes. Dry upland habitats with a remnant coastal sage scrub community rise on the margins of the reserve. The marsh is a critical stopping place for 100 migratory bird species using the Pacific Flyway. Altogether, more than 200 bird species (20 nesting) have been sighted in the reserve, including two resident endangered bird species: the light-footed clapper rail and the California least tern. The wetlands receive seasonal flows, primarily from storm water runoff from adjacent urban areas, and from overflows from the IRWD treatment wetlands via Carlson Marsh. A finding of impairment due to selenium was made for fish and bird egg tissue collected from the reserve. Though portions of the reserve are currently scheduled for restoration, it is not clear what, if any impact this may have on selenium concentrations in biota in the existing marsh ponds. A routine monitoring program will be required to be developed and implemented in the marsh to measure selenium in the various media on a regular basis to establish that selenium does not continue to adversely impact beneficial uses and overall water quality.

5. <u>Big Canyon Wash (BCW) and Freshwater Wetlands</u>

   Big Canyon Wash is a small (about 2 mi^2), highly urbanized watershed. However, the 60-acre Big Canyon Creek Nature Reserve lies in the most downstream portion of the watershed, adjacent to Upper Newport Bay. Recent monitoring (June 2008) found very high concentrations of selenium in water, algae, sediment, and fish collected from both the riparian and freshwater marsh areas. No bird eggs were found during the June 2008 sampling event, but it is expected that birds nesting and feeding in the canyon may also be at risk due to selenium. Monitoring in Big Canyon should include collection and analysis of water column samples for selenium speciation as well as the collection of sediment, fish, and bird eggs for selenium analysis. The City of Newport Beach has plans to restore the Big Canyon Creek Nature Reserve.

   When the plans for the Reserve are initiated, the monitoring program developed for the nature park will need adjustment as the restoration progresses. For example, periodic revision to the monitoring locations in the canyon will likely be required. Construction activities associated with the restoration of the nature park would likely affect the availability of both fish and of bird eggs until the restoration is completed. The monitoring program for the nature park will need adjustment as the restoration progresses. At least three or four monitoring stations are needed in the canyon to collect water column samples and to record flows. These samples should be collected on at least a quarterly basis at the following locations: at the downstream end of the canyon where freshwater flows enter Upper Newport Bay; at the upstream end of the nature park where water first flows into the park, west of Jamboree Road; and upstream of the Big Canyon Golf Course, adjacent to MacArthur Boulevard (the canyon splits into two main, and one minor, tributary at this location).

6. <u>Santa Ana Delhi Channel (SADC)</u>

   The Santa Ana Delhi Channel traverses a highly urbanized area and is mostly concrete-lined. The lower, downstream portion of the channel that flows into Upper Newport Bay is more natural, with a sandy bottom and dirt sides. This portion of the channel is tidally influenced and sample collection must occur when the flows in the channel are composed primarily of fresh water, since the freshwater flows are the primary source of selenium in the channel. Generally, only limited invertebrates, sediment, and water are available for sampling in this part of the channel. Fish are generally present in sufficient numbers for sampling only when the tidal surge enters the creek, so they are marine fish and not representative of the fresh water conditions in the channel. There may be areas located further upstream in the watershed, but that are still within the high selenium areas, that contain fish and/or nesting habitat for birds. If this is the case, an additional monitoring location should be established in the upstream reaches of the Delhi Channel.

7. Upper Newport Bay

   The impairment assessment performed for these TMDLs (Section 5.0) found impairment due to selenium in Upper Newport Bay. Water column, whole-body fish, and bird eggs should be sampled and analyzed for selenium. The upper bay nesting islands offer the best opportunities for egg sampling, and such samples should be collected from as many species as practicable. Marine fish targeted for tissue sampling should be collected in upper bay using trawl and/or beach seines. Both water column and benthic feeding resident fish should be targeted for collection.

8. Lower Newport Bay

   While a finding of impairment due to selenium was not found for Lower Newport Bay, it is hydrologically connected to Upper Newport Bay and baseline monitoring should be continued to ensure that selenium concentrations in biota in this waterbody do not increase. Water column, sediment and fish tissue monitoring are recommended. Marine fish targeted for tissue sampling in lower bay should be collected using trawl and/or beach seines. No bird nesting sites are available in this part of the Bay, so collection of bird eggs in this area is not necessary. Both water column and benthic feeding resident fish should be targeted for collection.

Specific compliance monitoring sites (biota) and confirmatory water sampling sites that should be considered in a proposed monitoring program are shown in Figure 12-8.

Numbers of Samples and Reporting Frequency
Fish and sediment should be collected annually in the late spring/early summer at all sites. Bird eggs and bird food items (such as invertebrates) should also be collected annually in late spring; however, the number of eggs in any given year may vary significantly depending on the availability of nesting sites, and the number of eggs produced. Water samples should be collected concurrently with biota and sediment samples. Compliance reports should be submitted to the Regional Board's Executive officer on an annual basis.

The targeted numbers of samples for analysis should be as follows:

- Bird eggs - Up to eight bird eggs per site for up to three species, to be analyzed individually (up to 24 bird eggs per site). Very few sites will yield that many eggs, but if they are available they should be collected.
- Fish - Up to three samples of composited, whole-body fish, consisting of five similar-sized, same-species fish per sample for up to three fish species, should be collected per site (nine or more composited fish samples per site).
- Surrogate Tissue Sampling – If no fish or bird eggs are present at a site, amphibians, such as frogs, and/or upper trophic level macroinvertebrates, such as crayfish, may need to be collected from a site as a surrogate for the fish and birds. Tissue samples (amphibian or invertebrate) should be

composited with a minimum of 3-5 individual, similar-sized organisms per composite per site.

- Sediment - Quarterly sampling; one sample from each of the 8 sites identified above and shown on Figure 12-8. Samples should be taken from the upper 2 cm of the bed sediment and sampling should target areas with abundant detrital materials/organics.

In general, for both bird eggs and fish, the total number of tissue samples per year is expected to be much less than the theoretical maximum of 240 samples because many of the sites are extremely limited in biota availability. A total of 32 water and sediment samples will be collected annually (4 quarters times 8 sites) from the general areas identified on Figure 12-8.

Field Methods and Data Management
Water, sediment, and biota collection and handling methods and data management should be conducted in accordance with the applicable Surface Water Ambient Monitoring Program (SWAMP) protocols and as provided in the NSMP sampling and analysis plan (CH2M HILL, 2006). A Quality Assurance Project Plan (QAPP) must be submitted with the compliance monitoring program.

Assessing Compliance with Tissue Targets
As described in Section 5.0 (Problem Statement), the assessment of impairment of water quality standards due to selenium in Newport Bay and the Newport watershed relied on the 303(d) listing methodology and criteria identified in the 2004 State Listing Policy. Where water quality standards are attained in impaired waters as the result of the implementation of TMDLs or other actions, those waters can be removed from the 303(d) list, i.e., they can be de-listed. The Listing Policy also identifies delisting criteria. Meeting the proposed numeric targets for selenium, including those based on the SSOs, and TMDLs is expected to result in the attainment of water quality standards. It is reasonable and appropriate to apply the delisting methodology/criteria identified in the Listing Policy to the determination of compliance with the proposed numeric targets and SSOs and, thereby, the attainment of water quality standards.

Pursuant to the State Listing Policy, water segments or toxic pollutants can be removed from California's section 303(d) list if the numeric water quality objectives, criteria, or standards tor toxic pollutants are not exceeded as follows:

- Using the binomial distribution, waters shall be removed from the section 303(d) list if the number of measured exceedances supports rejection of the null hypothesis as presented in Table 4.1.
- The binomial distribution cannot be used to support a delisting with sample sizes less than 28.

Table 4.1 from the State Listing Policy is reproduced below.

Table 4.1

MAXIMUM NUMBER OF MEASURED EXCEEDANCES NEEDED TO REMOVE A WATER SEGMENT FROM THE SECTION 303(d) LIST FOR TOXICANTS.[1]

Null Hypothesis: Actual exceedance proportion ≥ 18 percent.
Alternate Hypothesis: Actual exceedance proportion < 3 percent.
The minimum effect size is 15 percent.

Sample Size	Delist if the number of exceedances equal or is less than
28 – 36	2
37 – 47	3
48 – 59	4
60 – 71	5
72 – 82	6
83 – 94	7
95 – 106	8
107 – 117	9
118 – 129	10

For sample sizes greater than 129, the maximum number of measured exceedances allowed is established where α and β ≤ 0.10 and where |α - β| is minimized.

α = Excel® Function BINOMDIST(k, n, 0.18, TRUE)
β = Excel® Function BINOMDIST(n-k-1, n, 1 – 0.03, TRUE)

where n = the number of samples,
k = maximum number of measured exceedances allowed,
0.03 = acceptable exceedance proportion, and
0.18 = unacceptable exceedance proportion

[1] SWRCB 2004

As shown above, the State Listing Policy requires that for toxic pollutants, a minimum of 28 samples be used to determine if a water body can be removed from the 303(d) list (it may be noted that this is almost twice the number of samples required to place a water body on the 303(d) list). As can be seen in Table 4.1, the ability to delist is actually determined by the number of exceedances per a range in sample numbers, with roughly 6-8% of the samples not to exceed the delisting criteria when compared to the total number of samples used in the delisting assessment (e.g., in Table 4.1, for a sample size of 28-36 samples, only 2 samples can exceed the criteria used to assess compliance with water quality standards. In this example, if 2 of 28 samples exceed the criteria, then the rate of exceedance is 7%. If 2 of 36 samples exceed the criteria, then the rate of exceedance is reduced to 5.6% [or rounded to 6%]). Though the listing/delisting policy does not specifically address bird egg tissue, it is not excluded either; therefore, in Regional Board staffs' opinion the delisting criteria should also be used to determine compliance with the bird egg tissue numeric target/SSO.

Assessing compliance with both the proposed fish and bird egg tissue targets at all locations in the watershed will be difficult. It may not be possible in a given year (or even, in some locations, over multiple years) to collect sufficient numbers of samples, particularly bird eggs, to meet the Listing Policy criterion. As discussed previously, no fish or bird eggs have been collected from the lower portion of the Santa Ana Delhi Channel. There appears to be little suitable bird nesting habitat in this part of the channel. Locations further upstream in the channel that still lie within the high selenium area but they may contain fish and/or potential nesting habitat should be considered for future monitoring.

To date, no bird eggs have been found in Peters Canyon Wash or Big Canyon Wash. There is not sufficient habitat in Peters Canyon (and likely to be less in the future due to ongoing channel modification activities). In Big Canyon, vector control activities taking place in the freshwater marsh in the canyon appear to be keeping birds from nesting there. In addition, restoration construction activities are planned to begin this fall in the Big Canyon Nature Park, which will also likely inhibit potential nesting birds. There have also been very few nesting birds found in the IRWD treatment wetlands, likely as a result of how the wetlands are managed, which reduces the available food items (water levels are raised or lowered periodically in the different treatment ponds to maximize nitrate removals; this results in less biotic productivity in this area compared to San Diego Creek located adjacent to the wetlands).

As a result of these limitations, it is recommended that the eight sites identified above be grouped by drainages to provide a better probability of attaining adequate tissue samples that could be considered representative of a defined portion of the watershed. These four Compliance Assessment Areas (CAAs) are shown on Figure 12-9 and are grouped as follows:

- Swamp of the Frogs Drainage area: PCW, SDC, and SADC sites (SOF-CAA).
- Off-channel wetlands: UCI and IRWD/Carlson marsh wetlands (WET-CAA)
- Big Canyon Wash (BCW-CAA)
- Upper and Lower Newport Bay (BAY-CAA)

Tissue chemistry results from any given year of monitoring could be grouped by these assessment areas for assessing compliance with the TMDL tissue targets.

In addition to this spatial aggregation, it may be necessary, particularly for bird eggs, to collect data over more than one year to achieve the requisite number of samples per the Listing Policy. In such cases, compliance assessments would take place once the minimum number of samples is collected. In those areas where bird egg (and/or fish tissue) collection is particularly problematic, it may be necessary to identify an invertebrate surrogate. The use of surrogate tissue data would need to be justified by site-specific demonstration of a reliable relationship between selenium tissue concentrations in the surrogate organism and that of bird target species.

For each area, results from individual bird egg or whole-body composite fish samples would be compared separately against the criteria in Table 12-3 to identify appropriate follow-up actions. Table 12-3 presents a list of three tiers that increase in severity of exceedance of the tissue targets. For any given tier, exceedance of the tissue target concentrations by a certain percentage of either bird eggs <u>or</u> fish samples qualifies for that tier. As the degree of exceedance increases, the number and intensity of proposed actions increases in response. The proposed actions focus on the review of the monitoring program, its results, and the design and implementation of BMPs. The actions must remain flexible to address non-compliance conditions on a site/area-specific basis. Exceedances in different areas of the freshwater habitats or of the bay in different types of biota may require different responses. The degree of exceedance (if any) is expected to vary among these assessment area groupings and the proposed actions would focus on the specific areas showing tissue exceedances.

Because the State Listing Policy allows an exceedance rate of the tissue targets of 6-8%, it is appropriate to ensure that compliance based on the delisting policy is not allowing extreme exceedances of the tissue targets/SSOs. Definition of a ceiling for these types of low frequency exceedances would be used simply to trigger additional investigation to determine why a few tissue samples may be well above the criteria yet still fall within the State Listing Policy's requirements to delist. For instance, if 28 bird eggs were collected and only two of them exceeded the bird egg tissue target of 8 ug/g dw, but one of the eggs was 3-4 times higher than the target (e.g., had a selenium concentration of 24-32 ug/g dw), this would automatically indicate that there may be a problem that could potentially result in non-compliance and that would then set in motion further investigations before a final determination of compliance could be made (instead of remaining in Tier 1 in Table 12-3, exceedance of the ceiling concentration for bird egg or fish tissue would automatically trigger Tier 2).

No effects concentrations for most bird species fall within a range. The bird egg tissue selenium SSO of 8 µg/g dw that is proposed to be adopted for the Newport Bay watershed is a mallard-based no effect concentration or NEC (see detailed discussion under Section 6.0 in this report and Skorupa e-mail dated 10-20-08) that is at the upper range of possible no effects concentrations of 3 – 8 µg/g dw for mallards (Skorupa, e-mail dated 10-20-08; Beckon et al., 2008). The upper 95^{th} confidence limit for the same dataset used to establish the mallard NEC is calculated as 9.4 µg/g dw (notes from conversation with Dr. Skorupa on 5-28-09). However, the mallards in this dataset were farm-raised mallards that were fed selenomethionine. If USEPA's 2002 Toxicity Relationship Analysis Program (TRAP) is used on the USFWS black-neck stilt egg hatchability database (which is based on wild bird data and field selenium) to calculate a range of possible NECs for selenium in stilt eggs, the lower 95^{th} confidence limit is 2 µg/g dw and the upper 95^{th} confidence limit is 16 µg/g dw. This yields an estimated EC_0 of about 6 µg/g dw and and an EC_{10} of 10 µg/g dw. (Note that the 8 µg/g dw Se bird egg SSO falls within this range).

Shorebirds, such as stilts which feed primarily on benthic invertebrates, are more likely to get all of their food from the freshwater areas in the watershed (they are therefore more exposed) than primarily herbivorous birds such as mallards (which are more sensitive to selenium effects) or piscivorous birds such as terns, (which also feed in the Bay) (notes from conversation with Dr. Skorupa on 5-28-09). In addition, the selenium available to birds in the wild is not pure selenomethionine as is used in laboratory experiments for determining selenium effects in birds. The stilt field data set is much larger (n=639) and more robust than the mallard dataset (n=X). Since the Se SSO of 8 µg/g dw falls within both the possible ranges of NECs for mallards and stilts, analysis of both datasets provides scientific support of this as a protective criterion for the majority of the bird species that are expected to feed and nest in the Newport Bay watershed. Given the more robust nature of the stilt dataset and the fact that these birds are likely to be more exposed to selenium effects (via their diet) than other species in the Newport Bay watershed, a low-frequency exceedance ceiling of 16 µg/g dw, which is the upper 95^{th} confidence limit for the stilt dataset, is recommended.

Since the bird egg tissue ceiling concentration of 16 µg/g dw is double the proposed selenium SSO of 8 µg/g dw, a simple doubling of the selenium fish tissue numeric target/SSO of 5 ug/g dw to 10 ug/g dw is recommended as an appropriate low-frequency exceedance ceiling concentration for fish. As previously discussed, exceedance of these ceiling concentrations will trigger additional investigations with the intent to confirm compliance with the tissue targets in accordance with the State Listing Policy.

Until the fish and bird egg tissue SSOs are approved by USEPA, compliance with the CTR criteria will be used to assess final compliance with the TMDLs and attainment of water quality standards. Once the SSOs have been approved, the tissue-based SSOs for selenium will be used to assess final compliance (instead of the CTR criteria).

Table 12-3. Tiered Compliance Assessment and Proposed Actions Approach; Selenium TMDLs Monitoring Program, Newport Bay Watershed. Whole-body Fish Tissue and Bird Egg Tissue considered separately for exceedance of targets for each Compliance Assessment Site/Area.

Tier	**Frequency of Exceedance of Tissue Targets***	**Proposed Action**
1: Compliance	Less than 8%* (no egg to exceed 16 ug Se/g dw; no fish tissue composite to exceed 10 ug Se/g dw)†	Continued monitoring Continue BMP Strategic Plan
2: Non-compliance	8-18%**	All actions in Tier 1, plus: Identify sites for increased sampling Identify potential sources/causes for outlier results Reassess the Newport Bay biodynamic model parameters and results (partitioning coefficients, trophic transfer factors, water quality guidelines, etc.) Identify options for focused BMP enhancements, need for and nature of additional BMPs or other implementation actions; implement appropriate measures in a timely manner
3: Non-compliance	Over 18%***	All actions in Tier 2, plus: Resample biota Increase sampling (include selenium speciation in water column samples) Institute special studies as needed Assess need for additional source controls Early/timely implementation of additional BMPs

* This is based on the State Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List, September 2004 (State Listing Policy). The Listing Policy determination for findings of impairment is based on a binomial distribution and varies depending on the total number of samples from 6-8%. However, the number of tissue samples per year is expected to be highly variable. If the data meet the Listing Policy delisting criteria and fall into the Tier 1 category, the compliance assessment area is considered to be in compliance with the TMDLs.
† These not-to-exceed concentrations will ensure compliance with the Migratory Bird Treat Act and protection of the beneficial uses in the Newport Bay watershed.
** Tier 2 represents progress towards achieving compliance, but recognizes that additional actions are necessary to ensure that compliance is achieved by the end of the implementation period. The upper end of the frequency of exceedance range is based on the unacceptable exceedance proportion identified in Table 4.1 within the Listing Policy. The lower end of the frequency of exceedance range is just above the upper end of the allowable frequency of exceedance range.

*** Tier 3 represents an assessment area for which meeting the tissue targets requires more significant actions than Tier 2. The frequency of exceedance range is based on the unacceptable exceedance proportion identified in Table 4.1 within the Listing Policy.

Phase I TMDL Monitoring
For the projects listed under Phase I in Table 12-1, monitoring will be required to measure effectiveness and assist in management decisions made by the Cooperative Watershed Program (CWP). These projects include volume reduction (both short- and long-term discharges) projects, all BMP effectiveness demonstration projects, compliance monitoring, and identified special studies associated with Phase I. The specific monitoring requirements for each project will be outlined as projects are developed and implemented.

Phase II TMDL Monitoring
For the Phase II tasks, monitoring will be required (or continued) to measure effectiveness and assist in management decisions made by the CWP. These projects include all BMP effectiveness demonstration projects and full scale implementation projects, and any newly identified special studies or studies continued from Phase I, and compliance monitoring. The specific monitoring requirements for each project will be outlined as projects are developed and implemented.

TASK 9. DEVELOP AND IMPLEMENT SELENIUM MANAGEMENT PROGRAMS
Selenium management programs are needed for Big Canyon Wash, the San Joaquin Freshwater Marsh Preserve, and the IRWD treatment wetlands, in particular, the Carlson Marsh, to determine the fate and transport of selenium in these hydrologic units, and in the case of the UCI and IRWD wetlands, to also assess how flows are managed. Either the local jurisdiction or property owner, or the CWP stakeholders, shall develop and submit a detailed Work Plan to the Regional Water Board for approval. The Work Plan will assist in developing a comprehensive understanding of and management plan for selenium discharges and cycling within these water bodies. Within 1 month of the effective date of the TMDLs, the Work Plans shall be submitted to the Regional Water Board. Upon approval of the Work Plans by the Regional Water Board, the responsible party or CWP shall implement the Work Plan. Completion of the Work Plan is expected to assist in the reevaluation/revision of the TMDL implementation plan and/or BMP Strategic Plan.

1. Big Canyon Wash (City of Newport Beach and/or CWP dischargers)
A combination of stream gauging, and sediment and water quality sampling is needed in the Big Canyon Wash subwatershed to evaluate the potential sources and loads of selenium. Since it appears that the golf course ponds may play an important role in the conversion of selenate to the more bioavailable selenite before the surface flows enter the nature park, the selenium source tracking investigation should focus on identifying the following:

- Sources of water that may enter the golf course grounds, both as surface flows and subsurface flows (former Ford plant, Spyglass Hill area, tributary drainages to Big Canyon creek);
- Volume of baseflows that enter the golf course (e.g., cubic feet per second, gallons per day);
- Volume of surface water that exits the golf course at Jamboree Road;
- Surface water flow paths through the golf course to Big Canyon Creek;
- Selenium concentrations and selenium species in surface flows before they enter the golf course;
- Selenium concentrations and selenium species in the creeks and ponds on the golf course;
- Selenium concentrations and selenium species in the surface waters that enter the golf course (Big Canyon Wash north, middle, and south branches).

While some of the above tasks may have already been completed as part of studies conducted concurrently with the restoration effort, additional studies are needed to continue to track selenium sources and cycling upstream of the Big Canyon golf course and within the nature park itself. Oxygen and hydrogen isotope analyses and water chemistry fingerprinting may be needed to determine the different sources of water in the watershed (irrigation flows, leakage from Big Canyon Reservoir, groundwater, etc.).

The components of the Work Plan should include, but not be limited to, the following, provided that some of these tasks have not already been completed as part of the current studies that the City of Newport Beach is conducting:

- Reconnaissance Survey of Sources of Water and Selenium, Big Canyon Golf Course
- Big Canyon Nature Park and Big Canyon Golf Course Preliminary Hydrology and Source Investigation
- Hydrology and Source Investigation of Big Canyon Creek Upland Tributaries, Big Canyon Reservoir, and Irrigation Sources
- Identification of potential BMPs that may be implemented within the sub-watershed
- Implementation of BMPs within key areas of the watershed and/or to address critical sources of selenium

The Work Plan must include a time line and scope to develop a selenium management program for the Big Canyon Wash sub-watershed and a task to develop a Quality Assurance Project Plan (QAPP) that meets SWAMP requirements. In addition, samples must be collected and processed in accordance with SWAMP protocols.

2. San Joaquin Freshwater Marsh Preserve/UCI Wetlands (UCI and/or UCNRS and/or CWP dischargers).

Very few co-located samples have been collected from the UCI wetlands Phase I area and none have been collected from the Phase II area. Only the Phase II area is currently scheduled for restoration and the project itself will not result in any change in the sources of flows that enter or exit the marsh system, but will effect how these flows are circulated and retained in the marsh (WRA, 2007). It appears that the restoration will not affect the flows in the Phase I ponds. Selenium concentrations measured in fish tissue and bird eggs collected from the UCI wetlands continue to exceed the TMDL numeric targets/SSOs, even though most water column measurements indicate that selenium concentrations in water are relatively low (generally less than 5 µg/L). Preliminary estimates of the partitioning coefficient for the Phase I ponds yield K_ds of around 600 to near 1000 indicating that selenium conversions to more bioavailable forms is occurring in the ponds. In order to determine how selenium is cycling under the current conditions in the marsh, the following data/information needs to be collected.

Phase I Marsh Ponds

- Co-located water column, particulate, algae, sediment, invertebrates, and fish tissue samples should be collected from at least two of the ponds within the Phase I area (the pond located closest to the inlet water source, and the pond located furthest from the inlet water source) during the spring nesting season. All samples should be analyzed for selenium concentrations; water column samples will also be analyzed for selenium species, total nitrogen (including nitrate, nitrite, and ammonia), pH, dissolved oxygen, dissolved organic carbon, and other parameters as needed. Sediment samples will also be analyzed for grain size, total organic carbon, nutrients (including ammonia), and Pyrethroids (the marsh is sprayed periodically for mosquito control).
- Water column samples should be collected from the inlet, where water is pumped from San Diego Creek, and the outlet, where excess flows are diverted from the ponds to the lower marsh in the Phase II area. Samples should be collected at least one week prior to the collection of the samples from the ponds, as well as at the time of collection of the pond samples.
- Water column samples from the inlet, ponds, and outlet shall be sampled at least two times (one during the beginning of pumping and another just prior to the pump being shut off) and analyzed for total selenium, dissolved selenium, and selenium species, during the period when flows are pumped from San Diego Creek into the marsh ponds.

Phase II Area

- Baseline monitoring consisting of co-located water column, particulate, sediment, and biological samples (algae, invertebrates, fish, and bird eggs, if available) will need to be conducted during the nesting season in the Phase II area to determine whether selenium concentrations or other constituents currently pose a risk to wildlife foraging in the wetlands.

Samples should be collected from the seasonal marsh and upper, middle, and lower marshes in the Phase II area. Samples collected from the Phase II area should be analyzed for the same constituents as those listed above for the Phase I ponds.

- Water column samples should be collected from where water enters the Phase II area (from the inlet from Carlson Marsh as well as areas where concentrated urban runoff enters the marsh) and where it may exit the marsh at least two times (2X) during the period when flows enter the marsh. Samples should be separated by at least 24 hours, if possible, and analyzed for total selenium, dissolved selenium, and selenium species, and other pertinent constituents, during the period when these flows are entering the wetlands.

A Work Plan must be submitted to the Regional Water Board within one month of OAL approval of the selenium TMDLs/SSOs that includes, at a minimum, the above suggested tasks and sampling parameters. Samples must be collected and processed in accordance with SWAMP protocols. The Work Plan should include a time line and scope to develop a selenium management program for the San Joaquin Freshwater Marsh Reserve, including a task to develop a Quality Assurance Project Plan (QAPP) that meets SWAMP requirements. Samples from different media must be co-located and collected within same time frame (within a 24-hour period). All baseline samples must be collected within a 5-day period and under dry season conditions. Analytical laboratory results must be reported in SWAMP database format. Original analytical laboratory reports, including quality assurance/quality control reports and chain-of-custody documents, should also be submitted in electronic format such as Microsoft Excel® spreadsheets and/or Adobe Acrobat® pdf files. If the identified locations do not have sufficient water or biota for sampling, another location in the same general area can be substituted for, or sampled in conjunction with, the identified location provided that it can be demonstrated that the habitats and hydrology are similar.

The Work Plan should also include a task to develop a simple model that can be used to determine how selenium is cycling in the wetlands (including flows into and out of the marsh) and how it may change if the hydrology of the site is altered or selenium BMPs are needed to reduce concentrations so that the fish and bird egg tissue targets can be met throughout the wetlands.

Long-term monitoring will also be necessary in both the Phase I and Phase II portions of the San Joaquin marsh to track selenium concentrations – as well as other contaminants of potential concern – in water, sediment and biota after the restoration has been completed in order to ensure that the restoration is functioning as intended and that contaminants are not accumulating at concentrations that may impair beneficial uses. Therefore, the Work Plan should also include a task to develop a long-term monitoring plan for selenium and other constituents of concern for the Phase I and II areas in the wetlands. The long-term monitoring plan could be included in the Regional Monitoring Program if UCI chooses to join or work with the NSMP Working Group. Regional Water Board staff encourages UCI to work with IRWD and the NSMP Working Group in the development of their selenium management programs, since their wetlands are hydrologically connected and efforts to reduce selenium in San Diego Creek and the IRWD wetlands should have a beneficial effect on selenium concentrations in UCI's San Joaquin Freshwater Marsh Reserve.

3. IRWD Treatment Wetlands and Carlson Marsh (IRWD and/or CWP dischargers)

A finding of impairment due to selenium was made for water, fish and bird egg tissue collected from the IRWD Treatment wetlands and Carlson Marsh. There was not sufficient information available to definitively separate samples collected from Carlson Marsh from the treatment ponds in the main wetlands area. A sediment sample collected from IRWD's Carlson marsh indicates that selenium is accumulating in this area (Sutula et al., 2008). Selenium in the sediment sample exceeded the substantial ecological risk guideline of Presser et al. (2004) for selenium in sediments. The sediment sample contained more than 20 µg Se/g dry weight (dw); the substantial ecological risk guideline is 4 µg Se/g dw. Excess water from IRWD's treatment wetlands passes through Carlson Marsh prior to entering the UCI wetlands (SJFMR).

As water from San Diego Creek passes through the IRWD treatment ponds, approximately 30% of the selenium is removed before flows are returned to the creek. It is not clear how this loss is occurring (biological uptake, volatilization, and/or sequestration) and how much of the selenium is available to the food webs in the wetlands. Both fish and bird eggs collected from the pond areas exceed the proposed numeric targets/SSOs of 5 µg Se/g dw and 8 µg/g dw, respectively; therefore it is necessary to determine the forms, fate and transport of selenium in the wetlands from where it enters the wetlands from San Diego Creek, through the treatment ponds and then back to the creek, and/or through Carlson Marsh to the UCI wetlands.

Within one month of the effective date of the Selenium TMDLs, IRWD will submit a Work Plan to the Regional Water Board that addresses the fate and transport of selenium from San Diego Creek as it is transported and routed through IRWD's different wetlands areas, as described above, and that includes the following (or similar) tasks and items:

- A map showing how flows move through the wetlands under the following conditions:
  - Normal operations
  - Periodic shutdowns during storm events
  - Flow diversions to Carlson Marsh and UCI wetlands;

- A sampling plan that includes co-located water, particulates, algae, invertebrates, and fish samples collected during the conditions outlined above, from the inlet and outlets, and each pond and/or riparian area in the wetlands (including Carlson Marsh), and the collection of bird eggs, as available. All samples should be analyzed for selenium concentrations; water column samples will also be analyzed for selenium species, total nitrogen (including nitrate, nitrite, and ammonia), pH, dissolved oxygen, dissolved organic carbon, and other parameters as needed. Sediment samples will also be analyzed for grain size, total organic carbon, nutrients (including ammonia);
- Development of a simple model that can be used to determine how selenium is cycling in the wetlands (including flows into and out of the marshes and riparian areas) under the conditions specified above (normal operations, shutdowns, etc.) and how it may change if the hydrology of the site is altered or selenium BMPs are needed to reduce concentrations so that the fish and bird egg tissue targets can be met throughout the wetlands;
- A long-term sampling plan that will indicate the effectiveness of any selenium reductions made in San Diego Creek or IRWD's wetlands as implementation of the TMDLs and the BMP Strategic Plan progresses (this may be incorporated into the Regional Monitoring Program).

Samples must be collected and processed in accordance with SWAMP protocols. The Work Plan should include a time line and scope to develop a selenium management program for IRWD's wetlands, including a task to develop a Quality Assurance Project Plan (QAPP) that meets SWAMP requirements. Samples from different media must be co-located and collected within same time frame (within a 24-hour period). Analytical laboratory results must be reported in SWAMP database format. Original analytical laboratory reports, including quality assurance/quality control reports and chain-of-custody documents, should also be submitted in electronic format such as Microsoft Excel® spreadsheets and/or Adobe Acrobat® pdf files. If the identified locations do not have sufficient water or biota for sampling, another location in the same general area can be substituted for, or sampled in conjunction with, the identified location provided that it can be demonstrated that the habitats and hydrology are similar.

Regional Water Board staff encourages IRWD to work with UCI in the development of their selenium management programs, since their wetlands are hydrologically connected and efforts to reduce selenium in San Diego Creek and/or the IRWD wetlands should have a beneficial effect on selenium concentrations in both offline wetlands.

TASK 10. CONDUCT SPECIAL STUDIES

Special studies may be needed to assist with program implementation and for the refinement of the TMDLs.Board staff recommends that the following special studies be conducted in addition to the studies already underway in the watershed as funding allows and as deemed necessary. These recommendations are based, in part, on input from the Resource Agencies (USGS, USFWS, USEPA), the Selenium Technical Review Committee (STRC), and consultants for the NSMP. The potential special studies that have been identified at this time include:

- Water Translation/SSO Model Study
  More information is needed on the particulate fractions of selenium in the water column for both fresh and saltwater areas of the watershed and bay. The data are needed for field estimates of uptake factors (K_d) in the translation models (see Section 9.0, Linkage Analysis).

  Within 6 months of the effective date of the TMDLs, the Cooperative Watershed Program stakeholders shall submit a proposed special study of the particulate fractions of selenium in the water column in both fresh and saltwater areas of the watershed and Newport Bay to the Regional Water Board's Executive Officer (EO) for approval. The proposal must include a task to develop a QAPP that meets SWAMP requirements. Once approved, the Cooperative Watershed Program stakeholders must implement the special study.

- Longitudinal Tracking Study
  This study is needed to confirm the concept of the 40% loss of upper watershed Se in the Se mass balance as measured in the water column. For the freshwater areas, a study is needed to refine the loading estimates from surfacing groundwater, which currently incorporate a generic and imprecise 40% load-loss term (as per Meixner and Hibbs, 2004; see Section xx) so that a selenium mass balance for the watershed can be estimated. The study would entail quarterly, detailed measurements of waterborne selenium concentrations and flow longitudinally down Peters Canyon Wash and San Diego Creek, to assess areas where waterborne selenium loads decrease, likely due to a mix of biological and chemical sequestration and loss processes.

- Newport Bay Selenium Mixing Model
  The fate and transport of selenium once it enters the marine waters of Newport Bay are not well understood. If fish and bird egg tissue concentrations indicate impairment in the Bay after selenium reductions have been achieved in the freshwater areas of the watershed, additional modeling of selenium processes within the Bay may be necessary. The Newport Bay watershed biodynamic model did not perform as well for the bay as it did for the freshwater bodies in the watershed. However, the model did better at predicting selenium concentrations in the bay for the benthic food webs than it did for the water column food webs. The model used bed sediment data for the benthic food web; only one set of water column particulate data was available to model the water column food

webs. Additional particulate data, information on flocculation of particulates, selenium bioavailability in bed sediments, and selenium transfer from particulates and sediment to biota may be needed.

Reporting Requirements
It is recognized that as the TMDLs are implemented, the need for or type of special studies may change and that alternative studies may be more appropriate. Thus, this implementation plan takes an adaptive approach towards special studies as well. A special studies plan that prioritizes and outlines the initial special studies that will be conducted is to be submitted to the Regional Water Board for approval within 6 months of the effective date of the selenium TMDLs. Annually, in conjunction with other reporting requirements established by these TMDLs, an assessment of the progress made, results of, or any recommended revisions to, the special studies plan are to be submitted to the Regional Water Board for review and approval. These provisions are necessary and appropriate to provide flexibility to adapt to changing conditions or requirements as implementation of these TMDLs proceeds.

12.5.2 Phase II Implementation

TASK 13 TMDL REEVALUATION/ REVISION
These TMDLs will be reevaluated no later than upon completion of Phase I of implementation (within eight years of OAL approval of the BPA) and then at least once every 5 years[15] after that (the second review would occur no later than thirteen years after OAL approval of the BPA). Earlier review and revision may also occur if conditions warrant it.

All new data and information collected during Phase I will be evaluated to determine whether modifications to the TMDLs, including the implementation tasks, are necessary. Specifically, it is expected that Phase I will provide data and information necessary to evaluate the following:

a) Impairment findings: A revised impairment assessment may result in recommendations for modifications to the TMDLs and implementation priorities and schedules;
b) Wasteload/load allocations, targets and/or water column guidelines;
c) The effectiveness and placement of BMPs. It is also possible that, over time, new BMPs will be developed to address selenium discharges in a effective/efficient manner. Any such new BMPs should be incorporated in the BMP Strategic Plan;
d) The efficacy of the environmental and BMP effectiveness monitoring programs;
e) Potential data gaps;
f) The need for and nature of additional special studies;

[15] A five year time frame is considered necessary to allow for the collection and analysis of the data and information. This includes collection and evaluation of bird egg and fish tissue data and the results of the monitoring program and special studies.

g) Other implementation tasks, priorities, and schedule;
h) Revision of the responsible parties identified in the TMDLs.

As discussed in Section 12.2, a number of TMDLs are being, or are expected to soon be implemented, in the Newport Bay watershed. As implementation and review of the selenium TMDLs and these other TMDLs takes place, additional opportunities to integrate BMP, monitoring and other TMDL-related efforts will be identified and implemented. It is possible that changes to these (or other) TMDLs will be necessary to accommodate this integrated approach.

Figure 12-8.
TMDL Compliance Monitoring Sites for Biota, Sediment, and Water

Audra Bardsley, OC Watersheds Program

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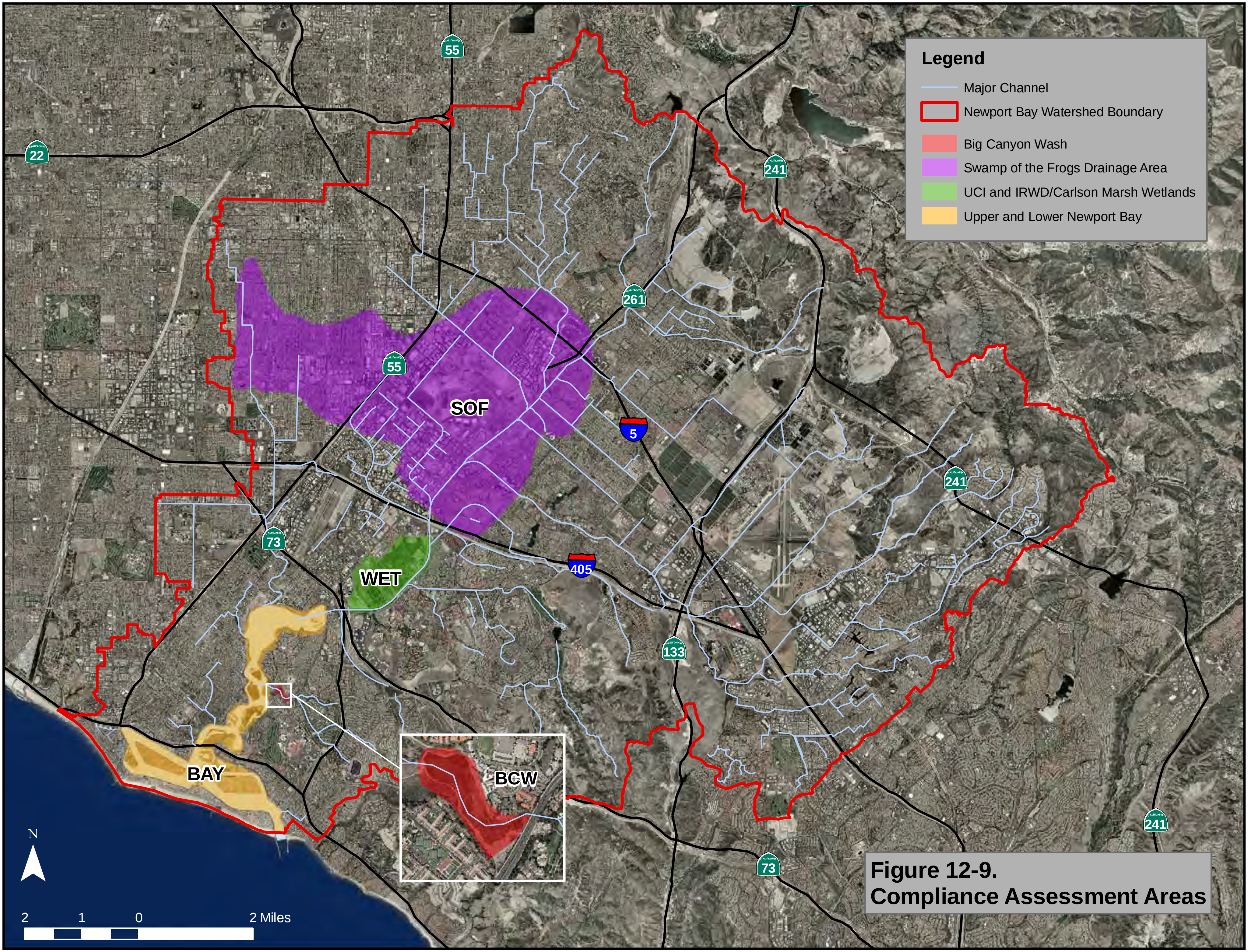

Figure 12-9. Compliance Assessment Areas

Audra Bardsley, OC Watersheds Program

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Newport Bay Watershed Selenium TMDLs/SSOs

California Least Tern
Sterna antillarum browni

Light-footed Clapper Rail
Rallus longirostris levipes

Western Pond Turtle
Actinemys marmorta pallida