

VOLUME II



DRAFT TECHNICAL REPORT FOR TENTATIVE CLEANUP AND ABATEMENT ORDER NO. R9-2012-0024

FOR THE SHIPYARD SEDIMENT SITE • SAN DIEGO BAY, SAN DIEGO, CA

March 14, 2012



STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

COVER PAGE

FOR

VOLUME 2 of 3

OF THE

Draft Technical Report for

**TENTATIVE CLEANUP AND ABATEMENT
ORDER NO. R9-2012-0024**

March 14, 2012

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SAN DIEGO REGION**

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Draft Technical Report for

TENTATIVE
CLEANUP AND ABATEMENT
ORDER NO. R9-2012-0024

For the Shipyard Sediment Site
San Diego Bay, San Diego, CA

Volume 2 of 3

Adopted by the
California Regional Water Quality Control Board
San Diego Region
on _____, 2012

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Acronyms & Abbreviations

AET	Apparent Effects Threshold	DFG	California Department of Fish and Game
AFFF	Aqueous Film Forming Foam	DRO	Diesel Range Organics
ASTM	American Society of Testing Material	DTSC	California Department of Toxic Substances Control
ANOVA	Analysis of Variance	DWQ	Division of Water Quality
AQUA	Aquaculture Beneficial Use	EC50	Median Effective Concentration
ARCO	Atlantic Richfield Company	EMC	Event Mean Concentration
ASTs	Aboveground Storage Tanks	EqP	Equilibrium Partitioning Approach
AT & SF	Atchison, Topeka, and Santa Fe Railroad	ERL	Effects Range Low
AVS/SEM	Acid Volatile Sulfide / Simultaneously Extracted Metals	ERM	Effects Range Medium
BAF	Biota Accumulation Factor	EST	Estuarine Habitat Beneficial Use
BAP	Benzo[a]pyrene	FACs	Fluorescent Aromatic Compounds
Bight 98	Southern California Bight 1998 Regional Marine Monitoring Survey	FSP	Field Sampling Plan
BIOL	Preservation of Biological Habitats of Special Significance	GRO	Gasoline Range Organics
BMPs	Best Management Practices	HPAH	High Molecular Weight Polynuclear Aromatic Hydrocarbons
BPJ	Best Professional Judgment	HQ	Hazard Quotient
BRI-E	Benthic Response Index for Embayments	IND	Industrial Service Supply Beneficial Use
BSAFs	Biota-to-Sediment Accumulation Factors	IR	Ingestion Rate
BTAG	U.S. Navy/U.S. EPA Region 9 Biological Technical Assistance Group	IRIS	Integrated Risk Information System
CAD	Confined Aquatic Disposal	Kp	Partition Coefficients
CCC	Criterion Continuous Concentration	LAET	Lowest Apparent Effects Threshold
CCR	California Code of Regulation	LC50	Median Lethal Concentration
CDFs	Confined Disposal Facilities	LOAELs	Low-Adverse-Effects-Levels
CEQA	California Environmental Quality Act	LOE	Lines of Evidence
CMC	Criterion Maximum Concentration	LPAH	Low Molecular Weight Polynuclear Aromatic Hydrocarbons
CNRSW	Commander Navy Region Southwest	LPL	Lower Prediction Limit
COCs	Contaminants of Concern	MAR	Marine Habitat Beneficial Use
COMM	Commercial and Sport Fishing Beneficial Use	MARCO	Marine Construction and Design Company
CoPC	Chemicals of Potential Concern	MEK	Methyl Ethyl Ketone
CSF	Cancer Slope Factor	MIGR	Migration of Aquatic Organisms Beneficial Use
CTR	California Toxics Rule	MS4	Municipal Separate Storm Sewer System
CWA	Clean Water Act	MTDB	Metropolitan Transit Development Board
CWC	California Water Code		

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NASSCO	National Steel and Shipbuilding Company	SQGs	Sediment Quality Guidelines
NAV	Navigation Beneficial Use	SQGQ	Sediment Quality Guideline Quotient
NAVSTA	Naval Station	SS-MEQ	Site-Specific Median Effects Quotient
NOAA	National Oceanic and Atmospheric Administration	SVOCs	Semi Volatile Organic Compounds
NOAELs	No-Adverse-Effects-Levels	S-W Diversity	Shannon-Weiner Diversity Index
NOV	Notice of Violation	SWAC	Surface-Area Weighted Average Concentration
NPDES	National Pollutant Discharge Elimination System	SWI	Sediment Water Interface
NRTAs	Natural Resource Trustees Agencies	SWM	Southwest Marine, Inc.
NTR	National Toxics Rule	SWCS	Storm Water Conveyance System
OHHEA	Office of Environmental Health and Hazard Assessment	SWPPP	Storm Water Pollution Prevention Plan
PAHs	Polynuclear Aromatic Hydrocarbons	SWPMP	Storm Water Pollution Monitoring Plan
PCBs	Polychlorinated Biphenyls	TBT	Tributyltin
PCTs	Polychlorinated Terphenyls	TMDL	Total Maximum Daily Load
PL	Prediction Limit	TOC	Total Organic Carbon
PPPAH	Priority Pollutant Polynuclear Aromatic Hydrocarbon	TPH	Total Petroleum Hydrocarbons
PRGs	Preliminary Remediation Goals	TR	Tissue Residue (biota-water-sediment equilibrium partitioning approach)
PW	Pore Water	TRGs	Tissue Residue Guidelines
QAPP	Quality Assurance Project Plan	TRI	Toxic Release Inventory
QA/QC	Quality Assurance/ Quality Control	Triad	Sediment Quality Triad
RAP	Remedial Action Plan	TRV	Toxicity Reference Value
RARE	Rare, Threatened or Endangered Species Beneficial Use	TSCA	Toxic Substances Control Act
REC1	Contact Water Recreation Beneficial Use	TSS	Total Suspended Solids
REC2	Non Contact Water Recreation Beneficial Use	TUc	Toxic Unit Chronic
RfD	Reference Dose	UPL	Upper Prediction Limit
RLs	Response Levels	U.S. EPA	U. S. Environmental Protection Agency
RME	Reasonable Maximum Exposure	U.S. FWS	U. S. Fish and Wildlife Service
RRO	Residual Range Organics	VOCs	Volatile Organic Compounds
SCCWRP	Southern California Coastal Water Research Project	WDRs	Waste Discharge Requirements
SDG&E	San Diego Gas and Electric	WILD	Wildlife Habitat Beneficial Use
SDMC	San Diego Marine Construction Company	WOE	Weight of Evidence
SDUPD	San Diego Unified Port District		
SHELL	Shellfish Harvesting Beneficial Use		

Preface

The Draft Technical Report (DTR) contained herein is the culmination of revisions over several years to the DTR first released to support to Tentative Cleanup and Abatement Order (TCAO) No. R9-2005-0126 in January 2005. This Technical Report provides the rationale and factual information supporting the findings of the tentative CAO No. R9-2012-0024. The text of each CAO finding is presented first, followed by a summary of the rationale and factual evidence supporting the finding. A copy of TCAO No. R9-2012-0024 and this DTR, as well as prior versions are posted on the San Diego Water Board website at <http://www.waterboards.ca.gov/sandiego>. TCAO No. R9-2012-0024 incorporates the Technical Report as a finding in support of TCAO No. R9-2012-0024 as if fully set forth therein.

12. Finding 12: Clean Water Act Section 303(d) List

Finding 12 of CAO No. R9-2012-0024 states:

The San Diego Bay shoreline between Sampson and 28th Streets is listed on the Clean Water Act section 303(d) List of Water Quality Limited Segments for elevated levels of copper, mercury, zinc, PAHs, and PCBs in the marine sediment. These pollutants are impairing the aquatic life, aquatic-dependent wildlife, and human health beneficial uses designated for San Diego Bay and are causing the Bay's narrative water quality objective for toxicity to not be attained. The Shipyard Sediment Site occupies this shoreline. Issuance of a CAO (in lieu of a Total Maximum Daily Load program) is the appropriate regulatory tool to use for correcting the impairment at the Shipyard Sediment Site.

12.1. Clean Water Act Section 303(d) List

CWA section 303(d) requires states to identify impaired waters that do not meet, or are not expected to meet by the next listing cycle, applicable water quality standards¹ after the application of certain technology-based controls, and schedule such waters for development of Total Maximum Daily Loads.² The states accomplish this by listing such waters and submitting an updated list from time to time (currently on a biennial basis in even numbered years) to U.S. EPA.

An impaired waterbody is one that does not attain and maintain water quality standards, due to an individual pollutant, multiple pollutants, pollution, or an unknown cause of impairment. A threatened waterbody is one that currently attains water quality standards but existing and readily available data and information on adverse declining trends indicate that water quality standards will likely be exceeded by the time the next list is required to be submitted to U.S. EPA.

The Shipyard Sediment Site, was added to the 2002 CWA Section 303(d) List under the name "San Diego Bay Shoreline between Sampson and 28th Streets" as an impaired waterbody segment due to elevated concentrations of copper, mercury, PAHs, PCBs, and zinc in bay bottom sediment. These pollutants are impairing the aquatic life, aquatic-dependent wildlife, and human health beneficial uses designated for San Diego Bay, and are causing the Bay's narrative water quality objective for toxicity to not be attained. Fact sheets prepared by the San Diego Water Board and submitted to the State Water Board in support of the listing are provided in the Appendix for Section **Error! Reference source not found.** The State Water Board adopted the 2002 CWA Section 303(d) list of water quality limited segments at a February 4, 2003 Board Meeting and the list was approved by the U.S. EPA in July 2003. No changes were made to the Shipyard Sediment Site listing in either the 2006 or 2010 CWA Section 303(d) list. In the 2010

¹ Water quality standards for a water body consist of its beneficial uses, criteria to protect those uses (referred to as water quality objectives in California), and an antidegradation policy. (40 CFR part 131).

² A TMDL is the sum of waste load allocations for point sources, load allocations for nonpoint sources, and natural background sources of an impairing pollutant. (40 CFR section 130.2(i)).

Integrated Report, however, the Shipyard Sediment Site was moved from Category 5 (TMDL required) to Category 4B (being addressed by actions other than TMDLs).

Regional Water Boards have wide latitude, numerous options, and some legal constraints that apply when determining how to address impaired waters. All violations of water quality standards should be addressed, and the San Diego Water Board may use any combination of existing regulatory tools to do so. Existing regulatory tools include individual or general waste discharge requirements (be they under Chapter 4 or under Chapter 5.5 (NPDES permits) of the Porter-Cologne Water Quality Control Act), individual or general waivers of waste discharge requirements, enforcement actions (e.g. cleanup and abatement order), interagency agreements, regulations, basin plan amendments, and other policies for water quality control.

The San Diego Water Board has determined that issuance of a cleanup and abatement order (in lieu of a Total Maximum Daily Load program) is the appropriate regulatory tool to use for correcting the impairment at the Shipyard Sediment Site based on the following considerations:

1. Pollutant discharges from NASSCO and BAE Systems, two primary sources of the marine sediment contamination at the Shipyard Sediment Site, have been significantly curtailed in recent years as the result of improvements in BMPs implementation.
2. Pollutant contributions to the Shipyard Sediment Site from Chollas Creek outflows will be gradually and significantly reduced over the 10-year period from October 2008 to October 2018 as the result of implementation of the Chollas Creek Metals TMDLs³ and future planned TMDLs for Chollas Creek.
3. Discharges from other sources to the Shipyard Sediment Site not described in Items 1 and 2 above are either entirely historical contributions and no longer occurring or can be controlled or terminated using existing San Diego Water Board regulatory tools such as waste discharge requirements or enforcement action.
4. The source control efforts summarized above will likely be sufficient to eliminate or significantly reduce continuing accumulation of pollutants at the Shipyard Sediment Site and ensure that remedial measures required under the cleanup and abatement order will not have to be repeated at a later date.
5. Attainment of the Cleanup Levels prescribed in Directive A of Cleanup and Abatement Order No. R9-2010-0002 will result in restoration of beneficial uses at the Shipyard Sediment Site and provide a basis for removing all of the primary and secondary constituents of concern listed for the Shipyard Sediment Site from the current CWA section 303(d) list.

³ See San Diego Water Board Resolution No. R9-2008-0054, A Resolution Adopting an Amendment to The Water Quality Control Plan for the San Diego Basin (9) to Incorporate Total Maximum Daily Loads for Dissolved Copper, Lead, and Zinc in Chollas Creek, Tributary to San Diego Bay, and to Revise the Toxic Pollutants Section Of Chapter 3 to Reference the California Toxics Rule. See also Regional Board Technical Report, *Total Maximum Daily Loads for Dissolved Copper, Lead, and Zinc in Chollas Creek, Tributary to San Diego Bay*, dated May 30, 2007.

13. Finding 13: Sediment Quality Investigation

Finding 13 of CAO No. R9-2012-0024 states:

NASSCO and BAE Systems conducted a detailed sediment investigation at the Shipyard Sediment Site in San Diego Bay within and adjacent to the NASSCO and BAE Systems leaseholds. Two phases of fieldwork were conducted, Phase I in 2001 and Phase II in 2002. The results of the investigation are provided in the Exponent report *NASSCO and Southwest Marine Detailed Sediment Investigation, September 2003 (Shipyard Report, Exponent 2003)*. Unless otherwise explicitly stated, the San Diego Water Board's finding and conclusions in this CAO are based on the data and other technical information contained in the Shipyard Report prepared by NASSCO's and BAE Systems' consultant, Exponent.

The Shipyard Sediment Site is exempt from the Phase I Sediment Quality Objectives promulgated by the State Water Board because a site assessment (the Shipyard Report) was completed and submitted to the San Diego Water Board on October 15, 2003. See State Water Board, *Water Quality Control Plan for Enclosed Bays and Estuaries – Part I Sediment Quality*, II.B.2 (August 25, 2009).

13.1. NASSCO and Southwest Marine Detailed Sediment Investigation

On February 21, 2001, the San Diego Water Board adopted Resolution Nos. 2001-02 and -03 directing the Executive Officer to issue Water Code section 13267 letters to NASSCO and BAE Systems requiring the submission of a site-specific study to develop sediment cleanup levels and identify sediment cleanup alternatives.

On June 1, 2001, the San Diego Water Board Executive Officer directed, under the authority provided in Water Code section 13267, NASSCO and BAE Systems to conduct a site-specific study to develop sediment cleanup levels and identify sediment cleanup alternatives. The study was conducted in accordance with the San Diego Water Board document, *Guidelines for Assessment and Remediation of Contaminated Sediments in San Diego Bay at NASSCO and Southwest Marine Shipyards, June 1, 2001*.

As a first step, NASSCO and BAE Systems developed and submitted to the San Diego Water Board a Work Plan (Exponent, 2001a) and time schedule for performance of a site assessment and development of sediment cleanup levels, sediment cleanup alternatives, and cleanup costs. Following San Diego Water Board concurrence with the work plan NASSCO and BAE Systems conducted the two phase sediment investigation at the Shipyard Sediment Site in San Diego Bay within and adjacent to the NASSCO and BAE Systems leaseholds. The results of the investigation are provided in the Shipyard Report.

13.2. Data Quality

The Work Plan for the Detailed Sediment Investigation included a field sampling plan (FSP) (Appendix A, Exponent, 2001a). The FSP presented the sampling methods that would be used during the investigation, including field sampling locations and procedures, the use of quality control samples, field data reporting and field custody procedures, and sample packaging and shipping requirements.

The Work Plan also included a quality assurance project plan (QAPP) (Appendix B, Exponent, 2001a) to ensure that the quality of the data was sufficiently high to support its intended use of determining the nature and extent of contamination, determining biological effects, assessing ecological and human health risks, and establishing remediation measures for the Shipyard Sediment Site. The QAPP described the procedures for field collection of samples, sample handling and custody (including preservation and holding time requirements), analytical methods, field and laboratory quality control, instrument maintenance and calibration, data validation methods, and data management. Data validation methods were provided for field procedures, chemical analyses, toxicity tests and laboratory bioaccumulation, and benthic macroinvertebrate identification.

The Shipyard Report presented a Quality Assurance Report for Chemistry Data that provided a data quality review (data validation and data quality assessment) of the data collected during the Detailed Sediment Investigation. The review verified that quality assurance and quality control (QA/QC) procedures were completed and documented as required by the QAPP. The data quality of chemistry data was determined by Exponent to be sufficiently high and no data were rejected. (Appendix F, Exponent, 2003)

Quality Assurance Reports were also provided for Toxicity Tests (Amphipod Toxicity, Echinoderm Toxicity, Sediment-Water Interface Toxicity, and Dilution Series Toxicity), Bioaccumulation Tests, and Benthic Macroinvertebrate Identification. The quality assurance reviews identified whether results met applicable performance standards, whether any deviations or inconsistencies with the specifications of the statement of work (with each contracted laboratory) occurred and then assessed whether there were any resulting effects on the quality of the data. Exponent determined that the data generated from the Detailed Sediment Investigation were acceptable for their intended use. (Appendices H, J, and L, Exponent, 2003)

13.3. Stakeholder Involvement

The San Diego Water Board conducted a series of stakeholder meetings and public workshops during the course of NASSCO's and BAE Systems' sediment investigation and received valuable input, which was factored into the investigation. At the meetings and workshops, experts, and interested parties representing the shipyards and a diverse group of stakeholders had the opportunity to provide critical input and share knowledge on various aspects of the Shipyard Sediment Site investigation, including review of the work plan. The stakeholder group included representatives from the Audubon Society; California Department of Fish and Game (DFG); City of San Diego, Environmental Health Coalition; National Oceanic and Atmospheric Administration (NOAA); San Diego Baykeeper; SDUPD; Sierra Club; Southern California

Coastal Water Research Project (SCCWRP); Surfrider Foundation; University of California, Davis, Marine Pollution Studies Laboratory; U.S. Fish and Wildlife (U.S. FWS); and U.S. Navy.

A summary of the meetings, workshops, and significant documents for the Shipyard Sediment Site investigation are listed in the Table 13-1 below.

Table 13-1 List of Meetings, Workshops, and Significant Documents

	Item or Event	Date
1	Adopt Resolution Nos. 2001-002 and 2001-003	2/21/2001
2	Issue CWC section 13267 letters to NASSCO and BAE Systems	6/01/2001
3	Issue Guidelines for Assessment and Remediation of Contaminated Sediments in San Diego Bay at NASSCO and BAE Systems Shipyards.	6/01/2001
4	Public Workshop #1	8/03/2001
5	Stakeholder Meeting #1	10/12/2001
6	Stakeholder Meeting #2	1/29 - 30/2002
7	Stakeholder Meeting #3	3/28 - 29/2002
8	Public Workshop #2	6/18/2002
9	Stakeholder Meeting #4	8/22/2002
10	Technical Meeting #1	12/12/2002
11	Technical Meeting #2	1/22 - 23/2003
12	San Diego Water Board Meeting – Status Report #1	9/10/2003
13	NASSCO and BAE Systems Detailed Sediment Investigation released for review.	10/10/2003
14	San Diego Water Board Meeting – Status Report #2	11/12/2003
15	Public Workshop #3	11/14/2003
16	Release Tentative CAO R9-2005-0126	5/1/2005
17	Public Workshop #4	6/29/2005
18	San Diego Water Board Meeting – Status Report #3	8/10/2005
19	Pre-Hearing Conference #1	8/26/2005
20	Pre-Hearing Conference #2	12/06/2005
21	Advisory Team / Cleanup Team public meeting	12/12/2005

It is anticipated that the San Diego Water Board will conduct additional prehearing conferences and workshops and at least one San Diego Water Board public hearing in considering the issuance of a final Cleanup and Abatement Order.

13.4. Conclusion

The San Diego Water Board's findings in the Tentative Cleanup and Abatement Order and conclusions in this Technical Report are based primarily on the data and other technical information provided in the Shipyard Report. The San Diego Water Board has reviewed the Quality Assurance Reports and found that the data reported in the Shipyard Report are found to be of sufficient quality to be used to develop the San Diego Water Board's findings and conclusions.

The San Diego Water Board's Technical Report identifies those instances where other data and technical information, in addition to that provided in the Shipyard Report, are used to support the Findings in the tentative Cleanup and Abatement Order and for the San Diego Water Board's management decisions.

14. Finding 14: Aquatic Life Impairment

Finding 14 of CAO No. R9-2012-0024 states:

Aquatic life beneficial uses designated for San Diego Bay are impaired due to the elevated levels of pollutants present in the marine sediment at the Shipyard Sediment Site. Aquatic life beneficial uses include: Estuarine Habitat (EST), Marine Habitat (MAR), and Migration of Aquatic Organisms (MIGR). This finding is based on the considerations described below in this *Impairment of Aquatic Life Beneficial Uses* section of the CAO.

14.1. Aquatic Life Beneficial Uses

There are three beneficial uses designated in the Basin Plan for San Diego Bay (RWQCB, 1994), which must be fully protected in order to provide for the protection of aquatic life. The three aquatic life beneficial uses are as follows:

- **Estuarine Habitat (EST)** – Includes uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).
- **Marine Habitat (MAR)** – Includes uses of water that support marine ecosystems including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).
- **Migration of Aquatic Organisms (MIGR)** – Includes uses of water that support habitats necessary for migration, acclimatization between fresh and salt water, or other temporary activities by aquatic organisms, such as anadromous fish.

The concentrations of the pollutants present in the marine sediment within and adjacent to the Shipyard Sediment Site cause or threaten to cause a condition of pollution or contamination that adversely impacts these three beneficial uses and thereby constitute a threat to aquatic life. Information supporting this conclusion is contained in Sections 15 through 19 of this Technical Report.

15. Finding 15: Multiple Lines of Evidence Weight-of-Evidence Approach

Finding 15 of CAO No. R9-2012-0024 states:

The San Diego Water Board used a weight-of-evidence approach based upon multiple lines of evidence to evaluate the potential risks to aquatic life beneficial uses from pollutants at the Shipyard Sediment Site. The approach focused on measuring and evaluating exposure and adverse effects to the benthic macroinvertebrate community and to fish using data from multiple lines of evidence and best professional judgment. Pollutant exposure and adverse effects to the benthic macroinvertebrate community were evaluated using sediment quality triad measurements, and bioaccumulation analyses, and interstitial water (i.e., pore water) analyses. The San Diego Water Board evaluated pollutant exposure and adverse effects to fish using fish histopathology analyses and analyses of PAH breakdown products in fish bile.

15.1. No Single Method Can Measure the Effects of Contaminated Sediment

Pollutants in sediment can cause adverse effects either through direct toxicity to benthic organisms or through bioaccumulation and food chain transfer to human and wildlife consumers of fish and shellfish. As noted by U.S. EPA (1992a), there is no single method that will measure all contaminated sediment effects at all times and to all biological organisms. For example, sediment chemistry provides unambiguous measurements of pollutant levels in marine sediment, but provides inadequate information to predict biological impact. Benthic communities can provide a direct measurement of community impacts, but are subject to disturbances that are not necessarily caused by pollutant driven sediment toxicity (e.g. low dissolved oxygen). Measurements of sediment toxicity directly measure biological impacts and integrate the effect(s) of various pollutant mixtures, but are subject to test imprecision and lack of consistent correlations with biological community effects. In addition, the toxicity test organisms may not adequately reflect the sensitivity of the full range of species comprising the benthic community. Reliance on any one of these measurement endpoints (chemistry, benthic communities and toxicity) to evaluate exposure and effects is problematic for characterizing risk from sediment pollutants. In contrast, a weight of evidence assessment using all three measurement endpoints gives the assessor much more information to reach conclusions.

15.2. Weight-Of-Evidence Approach

Based on these considerations, the assessment of potential adverse effects from contaminated sediment is best performed using a “weight-of-evidence approach.” The central tenet of a weight-of-evidence approach is that “multiple lines of evidence” should support decision-making. The corollary is that no single line of evidence should drive decision-making (unless a single line of evidence gives all the information necessary, and decision makers are willing to accept the outcome). The weight-of-evidence approach is commonly defined in the literature as a determination related to possible ecological impacts based upon multiple lines of evidence,

which contribute to an overall evaluation and conclusion. This determination incorporates judgments referred to as “best professional judgment” (BPJ) concerning the quality, extent, and congruence of the data contained in the different lines of evidence. BPJ comprises the use of expert opinion and judgment based on available data and site-situation specific conditions to determine, for example, environmental status or risk. BPJ can be initiated in cases where there are extensive data but few uncertainties and in cases where there are few data and many uncertainties.

15.3. San Diego Water Board Approach

The San Diego Water Board applied the weight-of-evidence approach principles to evaluate potential risks to aquatic life beneficial uses from the existing levels of pollutants at the Shipyard Sediment Site. The approach focused on evaluating the exposure and adverse impacts to the benthic macroinvertebrate community and to fish using multiple lines of evidence including sediment and pore water chemistry, laboratory studies of toxicity and bioaccumulation, benthic community evaluation, fish histopathology analyses and analyses of PAH breakdown products in fish bile. The details regarding pore water, fish histopathology, and fish bile analyses can be found in the Appendix for Section 15. The data used to establish these lines of evidence are contained in the NASSCO and BAE Systems’ report (Exponent, 2003) referenced in Section 13 of this Technical Report. The San Diego Water Board’s evaluation of these data and multiple lines of evidence are discussed in Sections 16 through 19 of this Technical Report.

15.4. State Water Resources Control Board’s Sediment Quality Objectives

The State Water Board’s *Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1. Sediment Quality* was effective on August 25, 2009 (SWRCB, 2009).

This plan contains sediment quality objectives (SQOs) for direct (benthic communities) and indirect (human health) effects, and a plan of implementation for direct effects. The SQOs are designed to provide the State and Regional Water Boards, stakeholders, and interested parties with a process to differentiate sediments impacted by toxic pollutants from those that are not. To protect benthic communities in bays and estuaries of California, the SQO describes a multiple lines of evidence (MLOE) approach that integrates sediment toxicity, sediment chemistry, and benthic community analysis into a station level assessment.

The State Water Board’s MLOE approach, sometimes referred to as the Triad approach, is similar to the San Diego Water Board’s approach identified in Section 15.3 above. Both methodologies evaluate the potential for the pollutants in the sediment to impact benthic communities by integrating sediment toxicity, sediment chemistry, and benthic community data.

The results of the station level MLOE assessment classify the impacts to the benthic communities into one of the following 6 categories:

- a. Unimpacted;
- b. Likely Unimpacted;
- c. Possibly Impacted;
- d. Likely Impacted;
- e. Clearly Impacted; or
- f. Inconclusive.

The SQO recommends a dividing line between “Likely Unimpacted” and “Possibly Impacted.” Protected sediments are defined by the categories “Unimpacted” and “Likely Unimpacted.” All other categories would be considered as not representing the protective condition.

The Principal Scientist on the project was Mr. Steve Bay, with SCCWRP. Mr. Bay evaluated a number of stations within San Diego Bay utilizing the MLOE approach in the SQO. This evaluation included 27 stations at the Shipyard Sediment Site, (Bay, 2007). The results are presented in Table 32-17 in Section 32.5.1 Analysis for Aquatic Life at Triad Stations.

The Shipyard Sediment Site is exempt from the Phase I Sediment Quality Objectives promulgated by the State Water Resources Control Board (State Water Board) because a site assessment (the Shipyard Report) was completed and submitted to the San Diego *Water Board on October 15, 2003*. See *State Water Board, Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality*, II.B.2 (August 25, 2009).

16. Finding 16: Sediment Quality Triad Measures

Finding 16 of CAO No. R9-2012-0024 states:

The San Diego Water Board used lines of evidence organized into a sediment quality triad, to evaluate potential risks to the benthic community from pollutants present in the Shipyard Sediment Site. The sediment quality triad provides a “weight-of-evidence” approach to sediment quality assessment by integrating synoptic measures of sediment chemistry, toxicity, and benthic community composition. All three measures provide a framework of complementary evidence for assessing the degree of pollutant-induced degradation in the benthic community.

16.1. Sediment Quality Triad Measures

The sediment quality triad (Triad) is one of the tools used by the San Diego Water Board to evaluate the potential risks to the benthic community from pollutants present at the Shipyard Sediment Site. These assessments are best performed using a “weight-of-evidence” approach that incorporates sediment chemistry, laboratory studies of toxicity or bioaccumulation, and evaluation of the benthic community. These lines of evidence can be organized into a Triad that provides the framework for a weight-of-evidence approach to sediment quality assessment by integrating results from sampling of the sediment chemistry, sediment toxicity, and benthic community composition within a defined area. All three measures provide complementary evidence for assessing the degree of contamination-induced degradation in the benthic community. Agreement or disagreement among these three measures at each sampling site or among sites may provide different interpretations of the ecological dynamics within an area. The Triad framework is used throughout the United States in sediment quality assessments of contaminated bay sediment and prospective dredge material. The Triad framework is recommended by the United States Environmental Protection Agency (U.S. EPA 2000b and 2000c) and is considered to be a standard method for qualitatively assessing the relationship between chemical concentrations and biological effects. The State Water Board is currently developing criteria for sediment quality based on the use of multiple lines of evidence including the Triad of measurements.

The Triad framework uses three independent lines of data in sediment quality assessment. The strength of using sediment chemistry, toxicity, and benthic community composition information in this approach is that it uses both chemical and biological measures from the same sediment sample to characterize sediment quality (Long, 1989). Sediment chemistry provides direct measurements of the pollutants found in the surficial sediment layer only. Sediment toxicity is the second component of the Triad and toxicity is determined in the laboratory with bioassay tests. If toxicity is observed in the bioassay tests, it can be assumed that there are pollutants in the sediment bioavailable at levels high enough to cause a significant response. Lastly, benthic data on community composition and structure provides evidence of the current condition of the benthic community response to its environment under in situ conditions. This benthic data provides confirmatory evidence concerning the potential impacts that contaminated sediment is having on the resident benthic community.

The data provided by each line of evidence for each sample is compared against pre-determined threshold values in order to rank the level of station impairment. Each line of evidence provided is then integrated into an overall weight-of-evidence evaluation that focuses on identifying the likelihood that the health of the benthic community is adversely impacted at a given station due to the presence of known CoPCs related to the site. Although the sediment chemistry, toxicity, and benthic community data should be complementary, the degree of impairment implied by each line of evidence may not be in complete agreement because they measure different properties of the surficial sediment (Long, 1989). Divergent findings in different lines of evidence may also indicate the presence of other stressors including physical disturbance and other non-chemical stressors.

A detailed description of the Shipyard Sediment Investigation decision matrices, individual station scores, and weight-of-evidence results are presented and summarized in Section 18 of this Technical Report.

17. Finding 17: Reference Sediment Quality Conditions

Finding 17 of CAO No. R9-2012-0024 states:

The San Diego Water Board selected a group of reference stations from three independent sediment quality investigations to contrast pollution conditions at the Shipyard Sediment Site with conditions found in other relatively cleaner areas of San Diego Bay not affected by the Shipyard Sediment Site: (1) Southern California Bight 1998 Regional Monitoring Program (Bight 98), (2) 2001 Mouth of Chollas Creek and Mouth of Paleta Creek TMDL studies, and (3) 2001 NASSCO and BAE Systems Detailed Sediment Investigation. Stations from these studies were selected to represent selected physical, chemical, and biological characteristics of San Diego Bay. Criteria for selecting acceptable reference stations included low levels of anthropogenic pollutant concentrations, locations remote from pollution sources, similar biological habitat to the Shipyard Sediment Site, sediment total organic carbon (TOC) and grain size profiles similar to the Shipyard Sediment Site, adequate sample size for statistical analysis, and sediment quality data comparability. The reference stations selected for the Reference Sediment Quality Conditions are identified below.

Reference Stations Used To Establish Reference Sediment Quality Conditions

2001 Chollas/Paleta Reference Station Identification Number	2001 NASSCO/BAE Systems Reference Station Identification Number	1998 Bight'98 Reference Station Identification Number
2231	2231	2235
2243	2243	2241
2433	2433	2242
2441	2441	2243
2238		2256
		2257
		2258
		2260
		2265

17.1. Guiding Principles for Determination of Reference Sediment Quality Conditions

The evaluation of benthic community impairment using the Triad weight-of-evidence approach requires information on both a contaminated marine sediment site and the general condition of the surrounding water body in terms of sediment chemistry, toxicity, and benthic community structure. This information is used to discriminate between pollution effects⁴ at the contaminated marine sediment site with that found in other relatively cleaner areas (referred to as reference sites) of the surrounding water body. When establishing a finding of benthic community impairment using the Triad approach, implicitly the assumption is made that pollution effects, in terms of chemistry, toxicity, and benthic community indices data, are more degraded in the localized contaminated marine sediment area of concern than the surrounding water body. The comparison of pollution conditions is used to identify areas within the contaminated marine sediment area of concern that may require remediation or cleanup to protect or restore aquatic life beneficial uses.

The choice of appropriate reference sites is critical in evaluating benthic community impairment. Reference stations for marine sediment quality investigations are best developed from a population of sites. Multiple reference sites are preferred and the number of background reference stations and the number of sample replicates per reference station depends on the statistical design of the sediment quality investigation. Generally, appropriate background reference stations are positioned in relatively clean areas remote from known pollution sources. The sediment in both reference and contaminated marine sediment sites should have the same gross physical and chemical characteristics, including such parameters as grain size, total organic carbon, and biological parameters (i.e., resident biota, particularly the benthos) should also be broadly similar in terms of the distribution of major taxa (e.g., family level) and biomass.

The term reference conditions (i.e. the sediment quality conditions described by the reference stations) are often used interchangeably with the terms “background reference conditions,” “background conditions,” and “ambient conditions.” Background conditions can be defined in terms of a “pre-industrial background” – the pristine, pre-industrial sediment quality conditions often reflected in deep native marine sediment. Alternatively, background can be defined in terms of an “ambient background” or “contemporary background” – the ambient sediment quality conditions in areas removed from sources of contaminants, recognizing that there may no longer be pristine surface marine sediment in a given geographic area of a waterbody.

The reference stations used to define background conditions also have an important role to play in determining the maximum extent of cleanup at a particular site. Water Code section 13304 authorizes the San Diego Water Boards to require complete cleanup of all waste discharged and restoration of affected water to background conditions (i.e., the water quality that existed before the discharge.) Under the terms of Resolution No. 92-49, *Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304*, the San Diego Water Board is obligated to have a presumptive cleanup goal to require cleanup to attain background water quality conditions (SWRCB, 1996). The San Diego Water Board may

⁴ An effect is defined as being significantly different from the condition at the reference site.

establish a cleanup level above background water quality conditions, only if the Board determines that it is technologically or economically infeasible to achieve background water quality conditions.⁵ Resolution No. 92-49 further provides that actions for cleanup and abatement should not be interpreted to require "... cleanup and abatement which achieves water quality conditions that are better than background conditions."⁶

Accordingly current practice in selecting a reference site inevitably requires some degree of compromise to meet the somewhat ambiguous requirements of a reference site "substantially free" of contaminants, yet having physical and chemical characteristics and biological parameters "broadly similar" to the contaminated marine sediment, and reflective of conditions "that existed before the discharge."

17.2. Shipyard Sediment Site Reference Sediment Quality Conditions

On June 9, 2003, the San Diego Water Board issued a letter titled "*Regional Board Final Position on a Reference Pool for the NASSCO, Southwest Marine, Mouth of Chollas Creek, and 7th Street Channel Sediment Investigations.*" The letter specified the "Final Reference Pool" (2003 Final Reference Pool) to be used in the Shipyard Sediment Site investigation for comparisons to determine statistically significant differences between site sediment quality conditions and reference sediment quality conditions (RWQCB, 2003b). Furthermore, this letter also outlined the statistical procedures and prediction limits to be generated with this data.

This pool of reference data, referred to in 2003 as the "Final Reference Pool," (2003 Final Reference Pool) were compiled from three independent sediment quality investigations:

- Southern California Bight 1998 Regional Monitoring Program (Bight 98) (SCCWRP, 2003),
- 2001 Mouth of Chollas Creek and Mouth of Paleta Creek TMDL studies (Chollas/Paleta TMDL study) (SCCWRP and U.S. Navy, 2005b), and
- Shipyard Report (Exponent, 2003).

The 2003 Final Reference Pool consisted of 2 stations from the Chollas/Paleta study, 3 stations from the Shipyard Sediment Site investigation, and 17 stations from the Bight 98 study for a total of 22 reference stations (see Appendix for Section 17). At the direction of the San Diego Water Board, Exponent (consultant for the Shipyards) used the 2003 Final Reference Pool as their basis for evaluating the sediment chemistry, toxicity, and benthic community conditions at the Shipyard Sediment Site. The results of this evaluation can be found in the Exponent report (Exponent, 2003).

⁵ Resolution 92-49, Section III.G.

⁶ Resolution 92-49, Section III.F.

The San Diego Water Board also considered two other alternative reference pools developed by NOAA and San Diego Bay Council for the Shipyard Sediment Site (See Appendix for Section 17). The 2003 Final Reference Pool was selected over these two reference pools based on the following considerations:⁷

- The 2003 Final Reference Pool had an adequate sample size (n=22) to improve the power of the statistical procedures for comparing the reference pool to the Shipyard Sediment Site stations. The San Diego Bay Council reference pool consisted of only a number of reference stations from the Bight '98 study (n=7) and thus lacked 1) an adequate sample size to conduct robust statistical analyses; 2) temporal comparability because the Bight 98 stations were sampled in 1998 several years prior to the initiation of the 2001 Shipyard Sediment Site investigation and 3) methodological comparability because the Bight 98 stations did not use the same toxicity tests used in the 2001 Shipyard Sediment Site Investigation.
- The 2003 Final Reference Pool included some reference stations from the two alternative reference pools (13 of 20 NOAA reference stations and 3 of 7 San Diego Bay Council reference stations were included in the 2003 Final Reference Pool).
- The three reference pools were generally not significantly different from one another with respect to the mean values of sediment chemistry, amphipod toxicity, and the Benthic Response Index Embayment (BRI-E) scores (See Appendix for Section 17). Two exceptions included total priority pollutant PAHs (PP-PAHs) for the 2003 Final Reference Pool and the mean BRI-E score for the Bay Council Pool. The San Diego Bay Council and NOAA reference pools were approximately 50% and 30% higher, respectively, in PP-PAH concentrations than the 2003 Final Reference Pool. The San Diego Bay Council reference pool had a lower BRI-E score, as expected, because it only included stations within the BRI-E Reference Level threshold, whereas the 2003 Final Reference Pool included stations within the BRI-E Response Level 1 threshold.

The 2003 Final Reference Pool was selected based in part on the assumption that most contaminants in San Diego bay sediments originate from land-based discharges.⁸ Following this assumption, contaminant concentrations in sediments should diminish with distance from land, and eventually reach levels consistent with ambient levels that could be used to approximate the San Diego Bay sediment quality conditions in the absence of the Shipyard Sediment Site discharges. The 2003 Final reference Pool was also selected based on specific thresholds of acceptability for toxicity and benthic community conditions (e.g., amphipod survival >85%) and thus did not reflect the variability in these conditions that can occur from other factors besides sediment contamination. Benthic community composition for example can be affected by stress factors that are not contaminant induced such as natural variations in habitat (e.g. sediment grain size and organic content) environmental factors (e.g. water depth, salinity, and temperature) and

⁷ See October 7, 2003 San Diego Water Board Letter to Ms. Laura Hunter, Environmental Health Coalition et al., SAR068566.

⁸ See Distance-from-shore approach to identify Bight98 reference sites in San Diego Bay, Steve Bay and Jeff Brown, January 8, 2003, SAR067944.

physical disturbance (e.g. anchor or prop wash). Measurements of sediment toxicity can also be influenced by variety of factors besides sediment contamination such as test imprecision, and the presence of natural factors such as hydrogen sulfide or ammonia. Sediment toxicity test results may also not have a consistent correlation with biological effects because the toxicity test species and species that compose the benthic communities may have different sensitivities to different contaminants. The 2003 Final Reference Pool did not represent an appropriate ambient background condition for San Diego Bay because it did not reflect the variability in sediment toxicity and benthic community conditions that can occur from factors other than sediment contamination.

The San Diego Water Board reconsidered its decision to use the 2003 Final Reference Pool following the submittal of the Exponent report and conducted a separate analysis of the sediment quality data to more accurately reflect a contemporary ambient background condition of San Diego Bay that excluded the effects of point source discharges, such as the Shipyard Sediment Site discharges and was representative of the typical variability in toxicity and benthic community conditions in San Diego Bay. This analysis led to the selection of a new pool of reference stations referred to as the “2005 Final Reference Pool” for the Shipyard Sediment Site. The 2005 Final Reference Pool was originally developed for the Chollas/Paletta TMDL investigation to establish a “Baseline Condition” for San Diego Bay (SCCWRP and U.S. Navy, 2005b, 2005). The Baseline Condition was defined as:

“...the existing ambient condition in the bay. This condition was based on a pool of reference stations selected to meet requirements of remoteness from source and similar habitat to the study sites. This condition acknowledges the potential presence of background contamination as well as natural variability in toxicity and benthic condition. Reference stations were excluded from this pool if there was an indication of contamination or toxicity that appeared to be related to a nearby source. However, stations were not excluded from this pool based on specific biological response thresholds.”

This Baseline Condition definition is consistent with the principles described in Section 17.1 and could be used to establish a reference condition reflective of the current sediment quality condition that would exist at the Shipyard Sediment Site absent the waste discharges. This contemporary ambient background condition is not representative of a pristine pre-industrial background condition as it acknowledges the presence of ambient background contaminant levels in San Diego Bay remote from known point source discharges. This Baseline Condition definition also incorporates the natural variability in toxicity and benthic conditions in San Diego Bay.

Factoring in low levels of pollutants at a reference site is consistent with U.S. EPA and U.S. Department of the Interior guidelines on selecting and establishing reference conditions:

“A reference sediment, on the other hand, is collected from a location that may contain low to moderate levels of pollutants resulting from both the global inputs and some localized anthropogenic sources, representing the background levels of pollutants in an area....” (U.S. EPA, 1992a)

“A general guidance is to select reference locations that reflect the overall conditions that can reasonably be expected in the site area given current uses other than those associated with the contamination under investigation.” (U.S. EPA, 1994b)

“Baseline data should not reflect conditions that would be expected at the assessment area had the discharge of oil or release of hazardous substances not occurred, taking into account both natural processes and those that are the result of human activities.”⁹

“The reference site need not be pristine.” (U.S. EPA, 1997a)

“Reference Site Criteria – The overall goal in establishing the reference condition from carefully selected reference sites is to describe the optimal biota that investigators may expect to find at the test sites of interest in the absence of stresses.” (U.S. EPA, 2000c)

The resulting 2005 Final Reference Pool of data consisted of 18 reference stations (Table 17-1). Nine of the reference stations were taken from the Bight 98 study (SCCWRP, 2003). The remaining nine reference stations originated from the Chollas/Paletta TMDL study and Exponent’s report. The 2005 Final Reference Pool is appropriate for the Shipyard Sediment Site investigation and was an improvement over the 2003 Final Reference Pool because:

- The 2005 Final Reference Pool most closely represents the current sediment quality condition that would exist at the Shipyard Sediment Site absent the waste discharges;
- The 2005 Final Reference Pool reflects the natural variability in toxicity and benthic conditions in San Diego Bay.
- The 2005 Final Reference Pool provides a better balance of the number of reference stations selected from each study;
- The 2005 Final Reference Pool provides a greater temporal and methodological comparability to the Shipyard Sediment Site data; and
- The 2005 Final Reference Pool provides improved comparability in habitat characteristics such as currents, water temperature, and fines content.

⁹ See 43 CFR Section 11.72.

Table 17-1 Reference Stations Used to Establish Reference Sediment Quality Conditions

2001 Chollas/Paleta Creeks Reference Stations	2001 NASSCO/BAE Systems Reference Stations	1998 Bight'98 Reference Stations
2231	2231	2235
2243	2243	2241
2433	2433	2242
2441	2441	2243
2238		2256
		2257
		2258
		2260
		2265

SCCWRP and U.S. Navy, 2005b

Thresholds for sediment toxicity and benthic community health were not used in the selection of stations in the 2005 Final Reference Pool (as was done in the 2003 Final Reference Pool) as representation of the typical variability in toxicity and benthic conditions in San Diego Bay was considered to be an important characteristic in the reference pool (SCCWRP and U.S. Navy, 2005b). To gain a better understanding on the overall effect of these criteria the San Diego Water Board further evaluated each station in the 2005 Final Reference Pool with respect to sediment chemistry, amphipod survival, and BRI scores. As shown in Table 17-2, all of the stations were (1) below the ERM and consensus-based guideline value for sediment chemistry, (2) above 80% amphipod survival (with the exception of 3 stations), and (3) classified as Reference Level or Response Level 1 – Greater than 5% of reference species absent based on the BRI scores (with the exception of 5 stations). The 2005 Final Reference Pool does include some amphipod and benthic community data indicating biological effects which are reflective of the natural variability in toxicity and benthic conditions that can occur from factors other than sediment contamination. The majority of the data in the 2005 Final Reference Pool falls within acceptable chemical and biological response threshold ranges. Additionally, only one station out of the 18 total stations in the 2005 Final Reference Pool assessed under the amphipod and benthic community lines of evidence had both metrics indicating biological effects. The 2005 Final Reference Pool is consistent with the San Diego Water Board's goal of establishing a reference condition that represents contemporary bay-wide ambient background contaminant levels that could be expected to exist in the absence of the Shipyard Sediment Site discharges and some level of natural variability in toxicity and benthic communities that could exist due to factors other than sediment contamination.

Table 17-2 Evaluation of the Reference Stations Used to Establish Reference Sediment Quality Conditions

Study	Station ID	San Diego Water Board Evaluation
Chollas/Paletta (CP) Study	2231	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival</u>:¹ 76%</p> <p><u>Benthic Community</u>: BRI Score = 39.5 (Response Level 1 – Greater than 5% of reference species absent). Atypical benthos due to high abundance of one species not previously recorded at this station.</p> <p><u>Location</u>: Mid Bay</p> <p><u>Comments</u>: Sediment chemistry and control adjusted toxicity data retained but benthic community data not used in the reference pool.</p>
	2243	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival</u>:¹ 84%</p> <p><u>Benthic Community</u>: BRI Score = 55.1 (Response Level 3 – Greater than 50% of reference species absent).</p> <p><u>Location</u>: Mid Bay</p> <p><u>Comments</u>: Retain all station data based on Triad results. Weight of evidence suggests that the high BRI score may be may be caused by factors other than pollution.</p>
	2433	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival</u>: 84%</p> <p><u>Benthic Community</u>: BRI Score = 22.8 (Reference Level).</p> <p><u>Location</u>: Northern Bay</p> <p><u>Comments</u>: Retain all station data based on Triad results</p>
CP Study	2441	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival</u>: 82%</p> <p><u>Benthic Community</u>: BRI Score = 30 (Reference Level).</p> <p><u>Location</u>: Northern Bay</p>

Study	Station ID	San Diego Water Board Evaluation
		<u>Comments:</u> Retain all station data based on Triad results.
	2238	<p><u>Sediment Chemistry:</u> No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival:</u> 90%</p> <p><u>Benthic Community:</u> BRI Score = 60.3 (Response Level 3 – Greater than 50% of reference species absent).</p> <p><u>Location:</u> Southern Bay</p> <p><u>Comments:</u> Retain all station data based on Triad results. Weight of evidence suggests that the high BRI score may be caused by factors other than pollution.</p>
NASSCO/BAE Systems Shipyards (SY Investigation)	2231	<p><u>Sediment Chemistry:</u> No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival:</u> 84%</p> <p><u>Benthic Community:</u> BRI Score = 31 (Reference Level). Atypical benthos due to high abundance of one species not previously recorded at this station. The non-native species, <i>Kalliapseudes crassus</i>, accounted for 85 to 90 percent of the total in this sample.</p> <p><u>Location:</u> Mid Bay</p> <p><u>Comments:</u> Sediment chemistry and control adjusted toxicity data retained but benthic community data not used in the reference pool.</p>
SY Investigation	2243	<p><u>Sediment Chemistry:</u> No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival:</u> 92%</p> <p><u>Benthic Community:</u> BRI Score = 45.1 (Response Level 2 – Greater than 25% of reference species absent).</p> <p><u>Location:</u> Mid Bay</p> <p><u>Comments:</u> Retain all station data based on Triad results.</p>
	2433	<p><u>Sediment Chemistry:</u> No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival:</u> 96%</p>

Study	Station ID	San Diego Water Board Evaluation
		<p><u>Benthic Community</u>: BRI Score = 16.8 (Reference Level)</p> <p><u>Location</u>: Northern Bay</p> <p><u>Comments</u>: Retain all station data based on Triad results.</p>
	2441	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival</u>: 95%</p> <p><u>Benthic Community</u>: BRI Score = 19.9 (Reference Level).</p> <p><u>Location</u>: Northern Bay</p> <p><u>Comments</u>: Retain all station data based on Triad results.</p>
Bight 98	2235	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival</u>: 71%</p> <p><u>Benthic Community</u>: BRI Score = 42.1 (Response Level 2 – Greater than 25% of reference species absent).</p> <p><u>Location</u>: Southern Bay</p> <p><u>Comments</u>: Retain all station data based on Triad results. Weight of evidence suggests that the high BRI score may be caused by factors other than pollution.</p>
	2241	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival</u>: 98%</p> <p><u>Benthic Community</u>: BRI Score = 34.7 (Response Level 1 – Greater than 5% of reference species absent).</p> <p><u>Location</u>: Mid Bay</p> <p><u>Comments</u>: Retain all station data based on Triad results.</p>
	2242	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus based guideline value.</p>

Study	Station ID	San Diego Water Board Evaluation
		<p><u>Amphipod Survival</u>: 92%</p> <p><u>Benthic Community</u>: BRI Score = 36.6 (Response Level 1 – Greater than 5% of reference species absent).</p> <p><u>Location</u>: Mid Bay</p> <p><u>Comments</u>: Retain all station data based on Triad results.</p>
Bight 98	2243	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival</u>: 96%</p> <p><u>Benthic Community</u>: BRI Score = 36.4 (Response Level 1 – Greater than 5% of reference species absent).</p> <p><u>Location</u>: Mid Bay</p> <p><u>Comments</u>: Retain all station data based on Triad results.</p>
	2256	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival</u>: 100%</p> <p><u>Benthic Community</u>: BRI Score = 37.9 (Response Level 1 – Greater than 5% of reference species absent).</p> <p><u>Location</u>: Mid Bay</p> <p><u>Comments</u>: Retain all station data based on Triad results.</p>
	2257	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival</u>: 91%</p> <p><u>Benthic Community</u>: BRI Score = 38.1 (Response Level 1 – Greater than 5% of reference species absent).</p> <p><u>Location</u>: Mid Bay</p> <p><u>Comments</u>: Retain all station data based on Triad results.</p>
Bight 98	2258	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus</p>

Study	Station ID	San Diego Water Board Evaluation
		<p>based guideline value.</p> <p><u>Amphipod Survival</u>: 92%</p> <p><u>Benthic Community</u>: BRI Score = 43.3 (Response Level 2 – Greater than 25% of reference species absent).</p> <p><u>Location</u>: Mid Bay</p> <p><u>Comments</u>: Retain all station data based on Triad results. Weight of evidence suggests that the high BRI score may be may be caused by factors other than pollution.</p>
	2260	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival</u>: 73%</p> <p><u>Benthic Community</u>: BRI Score = 39.1 (Response Level 1 – Greater than 5% of reference species absent).</p> <p><u>Location</u>: Mid Bay</p> <p><u>Comments</u>: Retain all station data based on Triad results.</p>
	2265	<p><u>Sediment Chemistry</u>: No chemical exceeded its ERM or consensus based guideline value.</p> <p><u>Amphipod Survival</u>: 85%</p> <p><u>Benthic Community</u>: BRI Score = 26.7 (Reference Level)</p> <p><u>Location</u>: Mid Bay</p> <p><u>Comments</u>: Retain all station data based on Triad results.</p>

Notes: Amphipod percent survival is control adjusted.

1. Potential outliers removed from data set and control adjusted.

18. Finding 18: Sediment Quality Triad Results

Finding 18 of CAO No. R9-2012-0024 states:

The San Diego Water Board categorized 6 of 30 sediment quality triad sampling stations at the Shipyard Sediment Site as having sediment pollutant levels “Likely” to adversely affect the health of the benthic community. The remaining triad stations were classified as “Possible” (13) and “Unlikely” (11). These results are based on the synoptic measures of sediment chemistry, toxicity, and benthic community structure at the Shipyard Sediment Site.

18.1. Sediment Quality Triad Results

Based on the results of the Triad lines of evidence, 6 of 30 stations sampled at the Shipyard Sediment Site are categorized as “Likely” impacted, which means it is likely that the CoPCs are adversely impacting the health of the benthic community (Table 18-1). The process used to assign the “Low,” “Moderate,” and “High” classifications to each line of evidence, and the “Unlikely,” “Possible,” and “Likely” categories for the weight-of-evidence conclusions are described below.

The results presented in Table 18-1 are based on a comparative analysis using a set of reference stations that characterize the Reference Sediment Quality Conditions described in Section 17 of this Technical Report. This reference condition can be used to represent contemporary background chemical and biological characteristics of San Diego Bay and is reflective of conditions that would exist in the marine sediment in the absence of the Shipyard Sediment Site discharges. This condition reflects the presence of existing background anthropogenic levels of pollutants from non-shipyard related discharges (e.g., urban watershed loading in San Diego Bay), as well as natural variability in marine sediment toxicity and benthic community condition. A description of the Reference Sediment Quality Conditions, including a list of the reference stations, is provided in Section 17 of this Technical Report.

Table 18-1 Results of the Sediment Quality Triad Lines-of-Evidence

Site	Station	Sediment Chemistry ¹	Toxicity ²	Benthic Community ³	Weight-of-Evidence Category ⁴
NASSCO	NA01	Moderate	Low	Low	Unlikely
	NA03	Moderate	Low	Low	Unlikely
	NA04	Moderate	Low	Low	Unlikely
	NA05	Moderate	Low	Low	Unlikely
	NA06	Moderate	Low	Low	Unlikely
	NA07	Moderate	Low	Low	Unlikely
	NA09	Moderate	Moderate	Low	Possible

Site	Station	Sediment Chemistry ¹	Toxicity ²	Benthic Community ³	Weight-of-Evidence Category ⁴
	NA11	Moderate	Moderate	Low	Possible
	NA12	Moderate	Moderate	Low	Possible
	NA15	Moderate	Low	Low	Unlikely
	NA16	Moderate	Moderate	Low	Possible
	NA17	High	Low	Low	Possible
	NA19	High	Moderate	Low	Likely
	NA20	Low	Low	Moderate	Unlikely
	NA22 ⁵	Moderate	Moderate	Moderate	Likely
BAE Systems	SW02	High	Low	Low	Possible
	SW03	Moderate	Low	Low	Unlikely
	SW04	High	Low	Moderate	Likely
	SW08	High	Low	Low	Possible
	SW09	High	Low	Low	Possible
	SW11	Moderate	Low	Low	Unlikely
	SW13	High	Moderate	Low	Likely
	SW15	Moderate	Moderate	Low	Possible
	SW17	Moderate	Moderate	Low	Possible
	SW18	Moderate	Low	Low	Unlikely
	SW21	High	Low	Low	Possible
	SW22	High	Moderate	Low	Likely
	SW23	High	Moderate	Low	Likely
	SW25	Moderate	Moderate	Low	Possible
SW27	Moderate	Moderate	Low	Possible	

1. Relative likelihood that the chemicals present in the sediment is adversely impacting organisms living in or on the sediment (i.e., benthic community).
2. Relative likelihood of toxic effects based on the combined toxic response from three tests: amphipod survival, sea urchin fertilization, and bivalve development.
3. Relative likelihood of benthic community degradation based on four metrics: total abundance, total number of species, Shannon-Wiener Diversity Index, and the Benthic Response Index.
4. Relative likelihood (Likely, Possible, or Unlikely) that the health of the benthic community is adversely impacted based on the three lines of evidence: sediment chemistry, toxicity, and benthic community.
5. NA22 was omitted from this analysis because it falls within an area that is being evaluated as part of the TMDLs for Toxic Pollutants in Sediment at the Mouth of Chollas Creek TMDL and is not considered part of the Shipyard Sediment Site for purposes of the CAO.

18.2. Sediment Chemistry Ranking Criteria

The low, moderate, and high classifications assigned to the sediment chemistry line-of-evidence are determined by comparing the bulk sediment chemical concentrations from each site station to sediment quality guidelines (SQGs) and to Reference Condition as follows:

- **Sediment Quality Guidelines** – Sediment quality guidelines (SQGs) are reference values above which sediment pollutant concentrations could pose a significant threat to aquatic life and can be used to evaluate sediment chemistry data. SQGs are considered one of the most effective methods for attempting to relate sediment chemistry to observed toxic effects and determine whether contaminants are present in amounts that could cause or contribute to adverse effects (Long et al., 1995; Long et al., 1998). SQGs have been used by regulatory agencies, research institutions, and environmental organizations throughout the United States to identify contamination hot spots, characterize the suitability of dredge material for disposal, and establish goals for sediment cleanup and source control (Vidal and Bay, 2005). SQGs are often used as a tool to interpret chemical data from analyses of sediment, identify data gaps, and screen CoPCs. SQGs are helpful in determining whether marine sediment contaminants warrant further assessment or are at a level that requires no further evaluation.

Several different approaches, based on empirical or causal correlative methodologies, have been developed for deriving SQG screening levels. Each of these approaches attempts to predict pollutant concentration levels that could result in adverse effects to benthic species, which are extrapolated to represent the entire aquatic community. Examples of empirical SQGs include the ERL and ERM values, which are concentrations corresponding to the 10th and 50th percentiles of the distribution observed in toxic samples, respectively (Vidal and Bay, 2005). Examples of causal SQGs include the equilibrium partitioning (EqP) approach which uses partitioning theory to relate the dry-weight sediment concentration of a particular chemical that causes an adverse biological effect to the equivalent free chemical concentration in pore water and to the concentration sorbed to sediment organic carbon or bound to sulfide. The theoretical causal resolution of chemical bioavailability in relation to chemical toxicity in different sediments differentiates equilibrium partitioning approaches from purely empirical correlative assessment methods (U.S. EPA 1998d). Causal SQGs have a greater ability relative to empirical SQGs to determine the specific contaminants responsible for toxicity. However causal SQGs require more extensive data sets and published values are not available for many contaminants relative to empirical SQGs. By comparison, empirical SQGs can be calculated for a large number of contaminants and only require routine chemical analyses (Vidal and Bay, 2005).

It is important to note that SQGs are not promulgated as regulatory sediment quality criteria or standards in California nor are they intended as cleanup or remediation targets (Buchman, 1999). The SQGs used to classify the Shipyard Sediment Site stations include:

- ERM for metals (Long et al., 1998),
 - Consensus midrange effects concentration for PAHs and PCBs (Swartz, 1999; MacDonald et al., 2000), and
 - Sediment Quality Guideline Quotient (SQGQ) for chemical mixtures (Fairey et al., 2001).
- **Reference Sediment Quality Conditions** – A key step to evaluating each line-of-evidence comprising the Triad of data is to determine if there are statistically significant differences between a contaminated marine sediment site and reference station sites. To accomplish this it is necessary to specify the appropriate statistical procedure to estimate the level of confidence obtained when differentiating between reference and the contaminated marine sediment site conditions. The statistical procedure used by the San Diego Water Board in the Shipyard Sediment Site investigation to identify stations where conditions are significantly different from the Reference Sediment Quality Conditions consisted of identifying station sample values outside boundaries established by the 95% upper predictive limit reference pool of data for each contaminant of concern. The 95% upper predictive limit allows a one-to-one comparison to be performed between a single Shipyard Sediment Site station and the pool of reference stations used to establish “Reference Sediment Quality Conditions” for the Shipyard Sediment Site (Reference Pool). Although multiple comparisons are made to the Reference Pool prediction limits, the San Diego Water Board made a decision to not correct for multiple comparisons so that the Shipyard Site/Reference comparisons would remain conservative and more protective. Metals characteristics and summary statistics for the Reference Pool are shown in Table 18-2. The 95% upper predictive limit for metals was dependent on the fines content at each station to help identify concentrations of metals that were enriched at the Shipyard Sediment Site (Table 18-3). In general, this means that stations with higher fines content will have a higher 95% upper predictive limit. For example, the 95% upper predictive limit for copper ranged from 85.9 mg/kg for a fines content of 25% to 159.5 mg/kg for a fines content of 75%. Summary statistics and the 95% upper predictive limits for organic contaminants and the SQGQ1 for the Reference Pool are shown in Tables 18-4 and 18-5, respectively.
 - **Tributyltin (TBT) Considerations** - TBT is not specifically considered in the sediment chemistry line of evidence (LOE) analysis because 1) it is not incorporated in the combination of chemicals used in the SQGQ1 calculation and 2) there are no published empirical SQGs or consensus MEC values for TBT effects on benthic community health. The SQGQ1 metric, documented in Fairey et. Al., (2001) and used in the analysis, is a central tendency indicator of the potential for adverse biological effects from chemical mixtures in a complex sediment matrix. Under the Fairey et. Al., (2001) methodology, the SQGQ1 value for a sediment is calculated by dividing concentrations of cadmium, copper, lead, silver, zinc, total chlordane, dieldrin, total PAHs (normalized by sediment organic carbon content), and total PCBs (sum of 18 congeners) in sediment by each chemical’s empirical SQG and subsequently averaging the individual quotients. The combination of

chemicals used in the SQGQ1 calculation, which does not include TBT, are assumed to be representative of, or the surrogates of, the toxicologically significant chemical mixture regardless of which chemicals were quantified in the sediment chemistry analyses. This is not only a well-accepted, but also a reasonable approach given the seemingly infinite number of chemicals present in marine sediment and for this reason it is not at all uncommon to exclude a specific chemical(s), such as TBT, in the chemistry LOE analysis for determining the likelihood of benthic community impairment. Furthermore, there is ample site specific data to evaluate the potential effects of tributyltin (TBT) on benthic community health. A site specific Lowest Apparent Effects Threshold (“LAET”) chemical threshold value for TBT described in DTR Section 32 was derived and applied at Site stations with only chemistry data to identify areas where benthic community impairment is likely. In addition the use of other chemicals as a surrogate for TBT is further supported by reference to the chemical correlation coefficients for TBT described in Table 29-4. TBT exhibits a particularly strong positive correlation with copper, HPAH, and total PCB as indicated by their correlation coefficients of 0.89, 0.80, and 0.79 respectively which are among the highest correlations observed at the Shipyard Sediment Site. These strong positive correlations indicate that decisions on the likelihood of benthic community impairment based on SQGQ1 values will address areas of the Site with elevated TBT values.

Table 18-2 Individual Station Characteristics and Summary Statistics for Physical Properties (%) and Metals (mg/kg) in the Reference Pool

Station	% Fines	%TOC	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
CP 2231	41.2	1.0	0.288	7.78	0.025	46.6	71.1	0.364	11.5	40.3	129
CP 2238	69.0	1.0	0.510	7.8	0.133	59.2	71.0	0.262	16.5	28.8	214
CP 2243	30.3	0.6	0.651	5.94	0.143	40.2	56.4	0.332	10.2	30.7	125
CP 2433	38.4	0.5	0.385	5.55	0.288	42.2	43.3	0.251	11.2	23.3	115
CP 2441	82.8	1.8	0.388	8.82	0.411	54.0	78.4	0.238	17.5	26.7	143
SY 2231	45.0	1.3	0.260	8.3	0.100	37.0	82.0	0.430	10.0	42.0	120
SY 2243	28.0	0.5	0.560	4.3	0.120	23.0	47.0	0.250	5.6	21.0	93.0
SY 2433	41.0	0.7	0.390	4.6	0.290	24.0	40.0	0.210	7.4	19.0	92.0
SY 2441	41.0	1.1	0.240	5.4	0.290	22.0	37.0	0.160	9.9	13.0	80.0
2235	45.0	0.6	0.476	6.4	0.095	37.5	58.2	0.239	10.7	21.3	136
2241	18.0	0.5	0.538	4.53	0.088	27.5	59.2	0.213	7.3	26.3	104
2242	31.0	0.7	0.493	4.27	0.096	25.4	42.0	0.300	6.8	17.8	89.8
2243	35.0	0.5	0.504	3.66	0.101	20.8	38.8	0.239	5.1	19.9	81.2
2256	67.0	1.3	1.29	7.47	0.200	54.3	128	0.632	14.3	54.1	197
2257	77.0	1.6	1.25	9.08	0.175	66.7	157	0.511	18.7	64.1	233
2258	71.0	1.4	0.954	7.75	0.161	60.0	143	0.664	16.4	53.0	211
2260	27.0	0.5	0.452	4.06	0.092	23.9	50.8	0.216	7.1	20.4	87.5
2265	13.0	0.4	0.192	2.48	0.069		18.0	0.065	1.5	12.0	43.2
N	18	18	18	18	18	18	18	18	18	18	18
Minimum	13.0	0.4	0.192	2.48	0.025	20.8	18.0	0.065	1.5	12	43.2
Maximum	82.8	1.8	1.29	9.08	0.411	66.7	157	0.664	18.7	64.1	233
Mean	44.5	0.9	0.546	6.01	0.160	39.1	67.8	0.310	10.4	29.6	127.4
Std Dev	20.5	0.4	0.315	1.98	0.100	15.4	38.3	0.158	4.7	15.0	53.4
RSD	46.1%	49.6%	57.8%	33.0%	62.5%	39.4%	56.4%	50.9%	45.5%	50.6%	41.9%
ERM	NA	NA	3.7	70	9.6	370	270	0.71	51.6	218	410

SCCWRP and U.S. Navy, 2005b

Table 18-3 Metal Threshold Values (mg/kg) Derived from the Fines-Metals Regression as a Function of Percent Fines for the Reference Pool

% Fines	Ag ¹	As ¹	Cd ¹	Cr ¹	Cu ¹	Hg ¹	Ni ¹	Pb ¹	Zn ¹
0	0.73	3.4	0.23	25.2	54.4	0.36	4.4	31.7	87.6
5	0.76	3.8	0.24	28.1	60.4	0.38	5.4	33.6	97.3
10	0.79	4.2	0.25	31.1	66.6	0.39	6.4	35.5	107.2
15	0.82	4.6	0.26	34.1	72.9	0.41	7.4	37.5	117.2
20	0.85	5	0.27	37.1	79.4	0.43	8.4	39.6	127.4
25	0.89	5.4	0.28	40.2	85.9	0.45	9.5	41.7	137.7
30	0.92	5.8	0.29	43.4	92.6	0.47	10.5	43.9	148.2
35	0.96	6.2	0.3	46.6	99.5	0.5	11.6	46.1	158.8
40	1	6.6	0.31	49.8	106.5	0.52	12.6	48.4	169.6
45	1.04	7.1	0.32	53.2	113.6	0.54	13.7	50.8	180.6
50	1.08	7.5	0.33	56.5	120.9	0.57	14.8	53.2	191.8
55	1.13	7.9	0.35	60	128.3	0.59	15.9	55.8	203.1
60	1.17	8.3	0.36	63.5	135.9	0.62	17	58.3	214.6
65	1.22	8.8	0.37	67	143.6	0.64	18.1	61	226.2
70	1.27	9.2	0.39	70.6	151.5	0.67	19.2	63.7	238.1
75	1.32	9.7	0.4	74.3	159.5	0.7	20.3	66.5	250
80	1.37	10.1	0.42	78	167.6	0.72	21.5	69.3	262.1
85	1.42	10.6	0.43	81.7	175.9	0.75	22.6	72.2	274.4
90	1.48	11	0.45	85.5	184.2	0.78	23.8	75.1	286.8
95	1.53	11.5	0.46	89.3	192.7	0.81	24.9	78.1	299.3
100	1.59	11.9	0.48	93.2	201.2	0.84	26.1	81.1	311.9

SCCWRP and U.S. Navy, 2005b

- Sediment metal concentrations exceeding these thresholds are considered enriched.

Table 18-4 Individual Station Characteristics, Summary Statistics, and 95% Upper Predictive Limits for Organic Contaminants in the Reference Pool

Station	PP-PAHs ¹ µg/kg	PCBs ² µg/kg	HPAHs ³ µg/kg	TBT ⁴ µg/kg
CP 2231	1,063	42.7	536.0	
CP 2238	199	11.4	199.0	
CP 2243	267	20.7	118.0	
CP 2433	780	27.1	415.0	
CP 2441	2,143	33.5	1,210.0	
SY 2231	687	77.1	235.0	15.0
SY 2243	204	22.4	56.0	2.6
SY 2433	486	20.8	169.5	3.3
SY 2441	343	10.5	117.2	3.7
2235	234	49.8	76.5	
2241	234	49.8	76.5	
2242	359	49.8	126.8	
2243	234	49.8	76.5	
2256	424	49.8	174.4	
2257	505	50.9	215.9	
2258	463	49.8	197.9	
2260	234	49.8	76.5	
2265	234	49.8	76.5	
N	18	9	18	4
Minimum	199	10.5	56	2.60
Maximum	2,143	77.1	1,210	15.00
Mean	505	29.6	231	6.15
Std Dev	471	20.5	275	5.92
RSD	93%	69%	119%	96%
95% PL⁵	1,264	84	663	21.7

1. PP-PAHs = Priority Pollutant Polynuclear Aromatic Hydrocarbons, sum of 16 PAHs: naphthalene, acenaphthylene, acenaphthene, fluorene, anthracene, phenanthrene, fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[123-cd]pyrene, dibenz[ah]anthracene, and benzo[ghi]perylene.
2. PCBs = Polychlorinated Biphenyls. "PCBs" is the sum of 41 congeners unless otherwise stated: 18, 28, 37, 44, 49, 52, 66, 70, 74, 77, 81, 87, 99, 101, 105, 110, 114, 118, 119, 123, 126, 128, 138, 149, 151, 153, 156, 157, 158, 167, 168, 169, 170, 177, 180, 183, 187, 189, 194, 201, and 206.
3. HPAHs = High Molecular Weight Polynuclear Aromatic Hydrocarbons, sum of 6 PAHs: Fluoranthene, Perylene, Benzo(a)anthracene, Chrysene, Benzo(a)pyrene, and Dibenzo(a,h)anthracene.
4. TBT = Tributyltin

5. The 95% upper predictive limits are calculated using the same methodology described in SCCWRP and U.S. Navy, 2005b. The supporting calculations are provided in the Appendix for Section 18.

Table 18-5 Calculated SQGQ1, Summary Statistics and 95% Upper Predictive Limit for the Reference Pool

Station	SQGQ1 ¹
CP 2231	0.18
CP 2238	0.20
CP 2243	0.18
CP 2433	0.15
CP 2441	0.19
SY 2231	0.21
SY 2243	0.15
SY 2433	0.13
SY 2441	0.10
2235	0.16
2241	0.16
2242	0.13
2243	0.13
2256	0.33
2257	0.37
2258	0.31
2260	0.14
2265	0.07
N	18
Minimum	0.07
Maximum	0.37
Mean	0.18
Std Dev	0.08
RSD	42%
95% PL²	0.35

1. SQGQ1 = Sediment Quality Guideline Quotient 1. The SQGQ1 value for a sediment is calculated by dividing concentrations of cadmium, copper, lead, silver, zinc, total chlordane, dieldrin, total PAHs (normalized by sediment organic carbon content), and total PCBs (sum of 18 congeners) in sediment by each chemical's empirical SQG and subsequently averaging the individual quotients. Individual quotients for total chlordane and dieldrin quotients are excluded in the SQGQ1 supporting calculations because these constituents were not included in the list of minimum analytes required to assess exposure at the Shipyard Sediment Site.
2. The 95% upper predictive limit is calculated using the same methodology described in SCCWRP and U.S. Navy, 2005b. The supporting calculations are provided in the Appendix for Section 18.

The relative potential for adverse effects attributable to sediment chemistry is classified as low, moderate, or high based on comparisons made to published sediment quality guidelines where increasing weight is given by the number and magnitude of chemicals exceeding a threshold, similar to the method used by Long et al. (1998). The breakpoints in the ranking levels are established using best professional judgment (BPJ) and followed Long et al. (1998) and Fairey et al., (2001). The San Diego Water Board's decision process for sediment chemistry evaluation is outlined in Figure 18-1 and the supporting calculations are provided in the Appendix for Section 18. The sediment chemistry line-of-evidence results for each Shipyard Sediment Site stations are shown in Table 18-6 and the supporting calculations are provided in the Appendix for Section 18.

Figure 18-1 Flow Diagram for the Sediment Chemistry Ranking Criteria (Low, Moderate, and High)

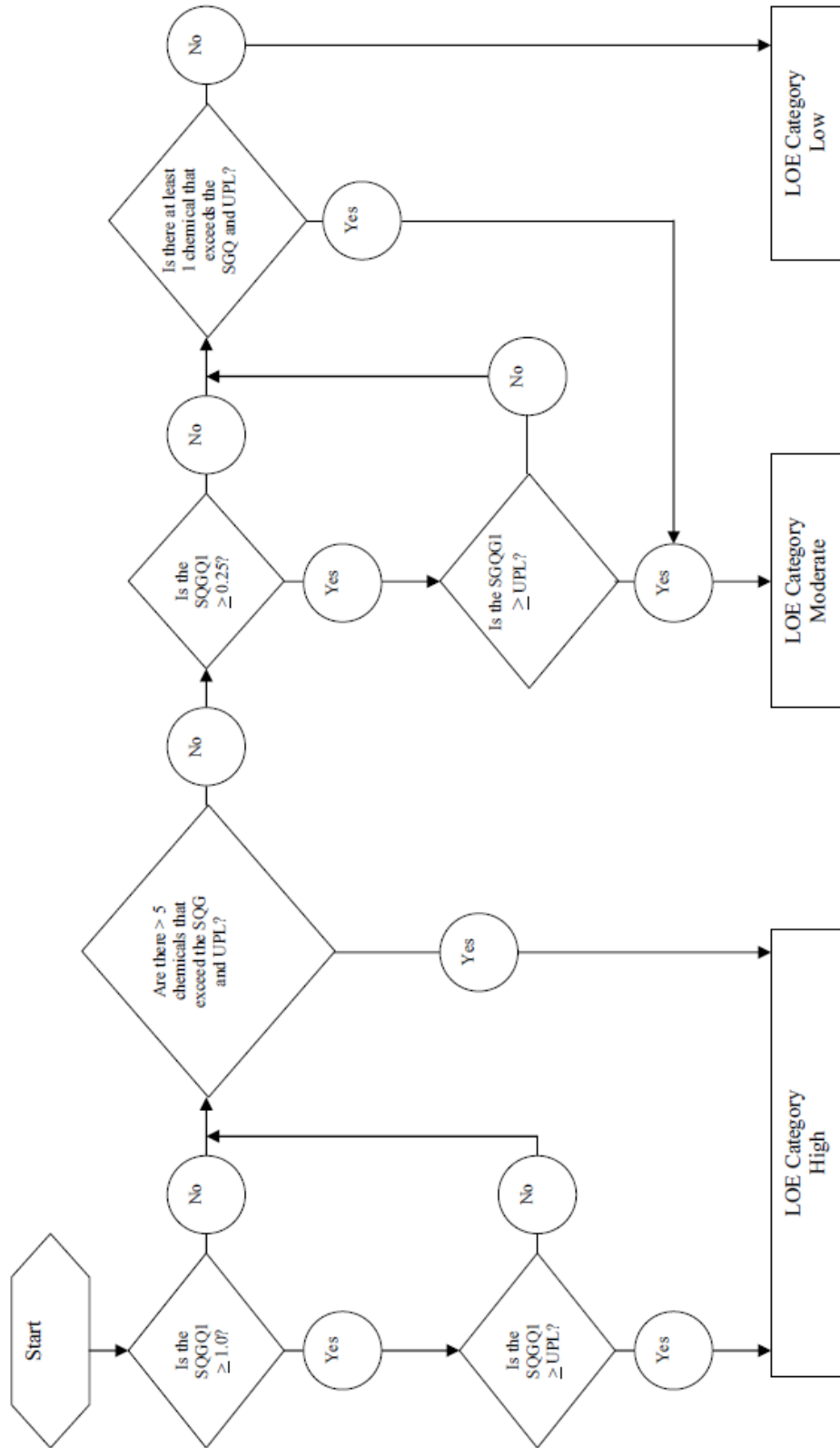


Table 18-6 Sediment Chemistry Line-of-Evidence Results

Site	Station	SQGQ1 ¹			SQGQ1 ≥ UPL	# Chemicals > SQG and UPL	LOE Category ²	
		< 0.25	0.25 to 1.0	≥1.0				
NASSCO	NA01		X		Yes	2	Moderate	
	NA03		X		Yes	2	Moderate	
	NA04		X		Yes	1	Moderate	
	NA05		X		Yes	0	Moderate	
	NA06		X		Yes	3	Moderate	
	NA07		X		Yes	2	Moderate	
	NA09		X		Yes	2	Moderate	
	NA11		X		Yes	1	Moderate	
	NA12		X		Yes	0	Moderate	
	NA15		X		Yes	2	Moderate	
	NA16		X		Yes	2	Moderate	
	NA17				X	Yes	4	High
	NA19				X	Yes	4	High
	NA20		X			No	0	Low
	NA22 ³		X			Yes	0	Moderate
BAE Systems	SW02			X	Yes	6	High	
	SW03		X		Yes	2	Moderate	
	SW04			X	Yes	6	High	
	SW08			X	Yes	5	High	
	SW09			X	Yes	5	High	
	SW11		X		Yes	1	Moderate	
	SW13			X	Yes	4	High	
	SW15		X		Yes	2	Moderate	
	SW17		X		Yes	3	Moderate	
	SW18		X		Yes	2	Moderate	
	SW21			X	Yes	2	High	
	SW22			X	Yes	2	High	
	SW23			X	Yes	3	High	
	SW25		X		Yes	2	Moderate	
	SW27		X		Yes	0	Moderate	

1. SQGQ1 = Sediment Quality Guideline Quotient 1 (Fairey et al., 2001)
2. The supporting calculations are provided in the Appendix for Section 18.
3. NA22 was omitted from this analysis because it falls within an area that is being evaluated as part of the TMDLs for Toxic Pollutants in Sediment at the Mouth of Chollas Creek TMDL and is not considered part of the Shipyard Sediment Site for purposes of the CAO.

The sediment chemistry ranking criteria was originally developed for the sediment quality site assessment work for the mouth of Chollas Creek and Paleta Creek TMDLs (SCCWRP and U.S. Navy, 2005b). The criteria were developed by SCCWRP, U.S. Navy, and the San Diego Water

Board with input from DFG, U.S. FWS, DTSC, and NOAA; collectively referred to as the Natural Resource Trustee Agencies (NRTAs), non governmental environmental groups, SDUPD, and the City of San Diego (City).

The low, moderate, and high sediment chemistry ranking criteria are based on the following two key assumptions (SCCWRP and U.S. Navy, 2005b):

1. A Shipyard Sediment Site sample station is ranked as having a low likelihood of impact from sediment CoPCs when all chemicals at a station are less than relatively low SQGs and less than the established Reference Condition; and
2. A Shipyard Sediment Site sample station is ranked as having a high likelihood of impact from sediment CoPCs when many of the chemicals at a station exceed a relatively high SQG, and exceed the Reference Condition sediment chemistry levels.

The specific sediment chemistry line of evidence category ranking from the SCCWRP and U.S. Navy (2005b) report are presented below and in Figure 18-1 of this report. The same sediment chemistry ranking criteria from the SCCWRP and U.S. Navy (2005b) report is used to evaluate the sediment chemistry data to the Shipyard Sediment Site sample stations.

Low Potential for Adverse Effects: The mean SQGQ1 is less than 0.25 or all chemicals were less than the 95% predictive limit calculated from the Reference Pool. Additionally, there must not be any single chemical that exceeded either its SQG or Reference Pool predictive limit value whichever was higher. To meet this category, all chemicals present at the site station, either individually or when summed, must be lower than a relatively low SQG and below the Reference Condition.

Moderate Potential for Adverse Effects: The mean SQGQ1 is between 0.25 and 1.0 and greater than the 95% predictive limit calculated from the Reference Pool. Additionally, a station is classified under this category if there are five or less individual chemicals that exceed their respective SQG and Reference Pool predictive limit. To meet this category, some (five or less) chemicals either individually or when summed exceed a moderate level SQG and/or the Reference Condition.

High Potential for Adverse Effects: The mean SQGQ1 for all chemicals is greater than or equal to 1.0 and is greater than the 95% predictive limit calculated from the Reference Pool. This category is also assigned if more than five chemicals exceed their individual SQG or the Reference Condition, whichever is higher. To meet this category, the Reference Condition as well as a relatively high SQG is exceeded when chemicals are considered as a group, or there are at least six individual chemicals exceeding a SQG or Reference Condition.

To determine the likelihood of impairment (Likely, Possible, or Unlikely) in the overall weight of evidence, each line of evidence ranking (Low, Moderate, or High) is put into the Weight-of-Evidence Analysis framework described in Section 18.5 below.

18.3. Toxicity Ranking Criteria

The low, moderate, and high classifications assigned to the toxicity line-of-evidence are determined by comparing the results of the three toxicity tests to their negative controls¹⁰ and to the Reference Pool described in Section 17 of this Technical Report:

- **Negative Controls** – The first key step in the toxicity line-of-evidence is to determine whether there are statistically significant differences between toxicity observed at the Shipyard Sediment Site and toxicity observed in the laboratory control condition. Three types of sediment toxicity tests were conducted at each Shipyard Site station: (1) 10-day amphipod survival test using *Eohaustorius estuarius* exposed to whole sediment, (2) 48-hour bivalve larva development test using the mussel *Mytilus galloprovincialis* exposed to whole sediment at the sediment-water interface, and (3) 40-minute echinoderm egg fertilization test using the purple sea urchin *Strongylocentrotus purpuratus* exposed to sediment pore water. The results of these toxicity tests were compared statistically to their respective negative controls using a one-tailed Student t-test ($\alpha = 0.05$). The supporting calculations are provided in the Appendix for Section 18.
- **Reference Sediment Quality Conditions** – The second key step in the toxicity line-of-evidence is to determine whether there are statistically significant differences between toxicity observed at the Shipyard Site and toxicity observed at the Reference Pool. The statistical procedure used to identify these differences consisted of the 95% lower predictive limit. The 95% lower predictive limit allows a one-to-one comparison to be performed between a single Shipyard Site station and the Reference Pool. The 95% lower predictive limit computes a single threshold value for each toxicity test in the Reference Pool (e.g., amphipod survival) from which each Shipyard Site station toxicity result is compared. Although multiple comparisons are made to the Reference Pool prediction limits, the San Diego Water Board made a decision to not correct for multiple comparisons so that the Shipyard Site/reference comparisons would be more conservative and protective. The 95% lower predictive limits for the three toxicity tests are shown in Table 18-7.

¹⁰ The term “controls” refers to a treatment in a toxicity test that duplicates all of the conditions of the exposure treatments but contains no test material. The control is used to determine the absence of toxicity of basic test conditions (e.g. health of test organisms, quality of dilution water). “Control sediment” is sediment that is (1) essentially free of contaminants, (2) used routinely to assess the acceptability of a test, and (3) not necessarily collected near the site of concern. Control sediment provides a measure of test acceptability, evidence of test organism health, and a basis for interpreting data obtained from test sediments. “Negative Control” is a type of control used to determine the inherent background effects in the toxicity test, such as effects related to the health of the test organisms and the quality of the dilution water. It provides a baseline and a point of correction for interpreting the sediment toxicity test results.

Table 18-7 Individual Station Characteristics, Summary Statistics, and 95% Lower Predictive Limits for Control Adjusted Amphipod Survival (%), Bivalve Development (% Normal), and Urchin Fertilization (%) in the Reference Pool

Station	Amphipod Survival	Bivalve Development ¹	Urchin Fertilization
CP 2231	76		66
CP 2238	90		36
CP 2243	84		97
CP 2433	84		100
CP 2441	82		102
SY 2231	84	93	99
SY 2243	92	66	92
SY 2433	96	101	79
SY 2441	95	70	90
2235	71		
2241	98		
2242	92		
2243	96		
2256	100		
2257	91		
2258	92		
2260	73		
2265	85		
N	18	4	9
Minimum	71	66	36
Maximum	100	101	102
Mean	88	82.5	85
Std Dev	8.4	17.1	22
RSD	10%	21%	26%
95% PL	72.9	37.4	41.9

SCCWRP and U.S. Navy, 2005b

- The 95% lower predictive limit for bivalve development is calculated using the same methodology described in SCCWRP and U.S. Navy, 2005b. The supporting calculation is provided in the Appendix to Section 18.

Similar to the chemistry line-of-evidence, the sediment toxicity ranking method employed a semi-quantitative assessment of the data that reflected both the presence and magnitude of toxicity. The category ranking criteria for sediment toxicity are summarized below and depicted in Figure 18-2. A comparison of the toxicity test results at each Shipyard Sediment Site station to the Reference Pool 95% lower prediction limits is shown in Table 18-8.

Figure 18-2 Toxicity Lines of Evidence

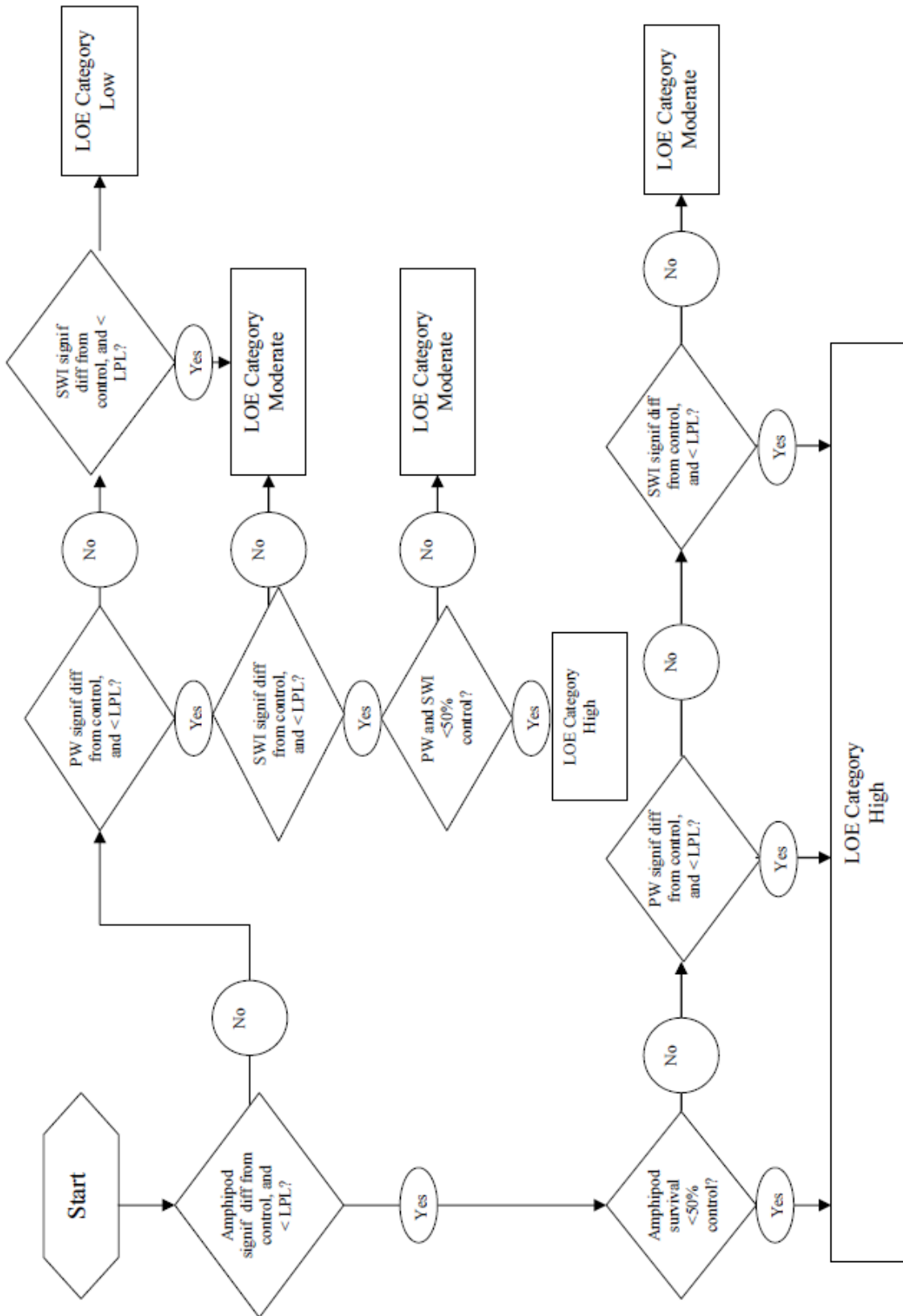


Table 18-8 Comparison of the Toxicity Data from the Shipyard Sediment Site Stations to the Reference Pool 95% Lower Predictive Limit

Site	Station	Amphipod Survival (95% LPL = 73%) ¹	Urchin Fertilization (95% LPL = 42%)	Bivalve Development (95% LPL = 37%) ¹
NASSCO	NA01	80	86	49
	NA03	84	84	94
	NA04	80	88	84
	NA05	89	95	94
	NA06	78	103	74
	NA07	74	102	88
	NA09	88	99	1
	NA11	70	101	80
	NA12	82	89	15
	NA15	97	88	93
	NA16	90	84	3
	NA17	95	88	80
	NA19	89	72	2
	NA20	90	78	80
NA22 ²	95	111	2	
BAE Systems	SW02	88	103	85
	SW03	92	103	88
	SW04	94	108	63
	SW08	91	103	93
	SW09	88	100	85
	SW11	77	89	83
	SW13	92	99	28
	SW15	92	103	9
	SW17	95	96	16
	SW18	74	83	64
	SW21	91	102	67
	SW22	90	104	1
	SW23	91	107	16
	SW25	86	103	10
SW27	73	91	22	

1. Toxicity values less than the 95% lower prediction limit values are bold faced and shaded.
2. NA22 was omitted from this analysis because it falls within an area that is being evaluated as part of the TMDLs for Toxic Pollutants in Sediment at the Mouth of Chollas Creek TMDL and is not considered part of the Shipyard Sediment Site for purposes of the CAO.

The toxicity ranking criteria was originally developed for the sediment quality site assessment work for the mouth of Chollas Creek and Paleta Creek TMDLs (SCCWRP and U.S. Navy, 2005b). The criteria were developed by SCCWRP, U.S. Navy, and the San Diego Water Board; with input from NRTAs, non-governmental environmental groups, Port, and the City of San Diego.

The low, moderate, and high toxicity ranking criteria are based on the following five key assumptions (SCCWRP and U.S. Navy, 2005b):

3. Toxic effects at Shipyard Sediment Site sample stations are classified as low or none when the results of all three toxicity tests were not significantly different from their controls or they had a statistically lower level of toxicity than observed at the Reference Condition sample stations;
4. The presence of significant toxicity in any one test was sufficient to classify a Shipyard Sediment Site sample station as moderately toxic. The three toxicity tests were given equal weight for classifying a sample station as moderately toxic;
5. If amphipod survival is less than 50 percent and significantly different from the control and Reference, a high rank of sediment toxicity was justified;
6. Toxic effects at Shipyard Sediment Site sample stations are classified as high when both of the sublethal toxicity tests measured a greater level of toxicity than the Reference Condition sample stations; and
7. The amphipod toxicity test result is given greater weight for the high toxicity category because the acute survival endpoint of this test was assumed to have a higher degree of association with ecological impacts than either the urchin fertilization or bivalve development tests. The sea urchin fertilization and bivalve embryo development test results are given less weight because these are sublethal critical life stage tests that are more susceptible to confounding factors, and their association with ecological impacts is less certain.

The toxicity line of evidence category ranking from the SCCWRP and U.S. Navy (2005b) report are presented below and in Figure 18-2. The same toxicity ranking criteria from the SCCWRP and U.S. Navy (2005b) report were used to evaluate the sediment toxicity data from the Shipyard Sediment Site investigation. The toxicity line-of-evidence results for each Shipyard Sediment Site station are depicted in Table 18-9.

Low Toxicity: Toxic effects are classified as low or none when results of all three bioassays were not significantly different from their controls or they have a statistically lower level of toxicity than observed at the Reference Condition sample stations.

Moderate Toxicity: Toxic effects are classified as moderately toxic if any one of the bioassay results is statistically different from its control and was less than the Reference Condition. Additionally, it is required for amphipod survival to have been greater than 50 percent, regardless of the result relative to controls or the Reference Condition.

High Toxicity: Toxic effects are classified as highly toxic when any one of the following criteria is met:

8. If survival of amphipods at a station is less than 50 percent and is statistically different than controls and statistically less than the Reference Condition sample stations.
9. If the amphipod test together with any one of the other bioassays both has a result that is statistically different from control and is statistically less than the Reference Condition sample stations.
10. If both the pore water and sediment-water interface test results are less than 50 percent of the control values and are statistically less than the controls and the Reference Condition sample stations.

To determine the likelihood of impairment (Likely, Possible, or Unlikely) in the overall weight of evidence, each line of evidence ranking (Low, Moderate, or High) is put into the Weight-of-Evidence Analysis framework described in Section 18.5 below.

Table 18-9 Toxicity Line-of-Evidence Results

Station	Amphipod Survival			Urchin Fertilization			Bivalve Development			LOE Category
	Different from Control	< 95% LPL	< 50% Control	Different from Control	< 95% LPL	< 50% Control	Different from Control	< 95% LPL	< 50% Control	
NA01	Yes	No	No	Yes	No	No	Yes	No	No	Low
NA03	No	No	No	Yes	No	No	No	No	No	Low
NA04	Yes	No	No	Yes	No	No	Yes	No	No	Low
NA05	Yes	No	No	No	No	No	No	No	No	Low
NA06	Yes	No	No	No	No	No	No	No	No	Low
NA07	Yes	No	No	No	No	No	No	No	No	Low
NA09	Yes	No	No	No	No	No	Yes	Yes	Yes	Moderate
NA11	Yes	Yes	No	No	No	No	No	No	No	Moderate
NA12	Yes	No	No	Yes	No	No	Yes	Yes	Yes	Moderate
NA15	No	No	No	Yes	No	No	No	No	No	Low
NA16	Yes	No	No	Yes	No	No	Yes	Yes	Yes	Moderate
NA17	No	No	No	Yes	No	No	Yes	No	No	Low
NA19	No	No	No	Yes	No	No	Yes	Yes	Yes	Moderate
NA20	Yes	No	No	Yes	No	No	Yes	No	No	Low
NA22 ¹	No	No	No	Yes	No	No	Yes	Yes	Yes	Moderate
SW02	Yes	No	No	No	No	No	No	No	No	Low
SW03	No	No	No	No	No	No	Yes	No	No	Low
SW04	No	No	No	Yes	No	No	Yes	No	No	Low
SW08	Yes	No	No	No	No	No	Yes	No	No	Low
SW09	No	No	No	No	No	No	Yes	No	No	Low
SW11	Yes	No	No	Yes	No	No	No	No	No	Low
SW13	Yes	No	No	No	No	No	Yes	Yes	Yes	Moderate
SW15	No	No	No	No	No	No	Yes	Yes	Yes	Moderate
SW17	No	No	No	Yes	No	No	Yes	Yes	Yes	Moderate

Station	Amphipod Survival			Urchin Fertilization			Bivalve Development			LOE Category
	Different from Control	< 95% LPL	< 50% Control	Different from Control	< 95% LPL	< 50% Control	Different from Control	< 95% LPL	< 50% Control	
SW18	No	No	No	Yes	No	No	Yes	No	No	Low
SW21	Yes	No	No	No	No	No	No	No	No	Low
SW22	Yes	No	No	No	No	No	Yes	Yes	Yes	Moderate
SW23	No	No	No	Yes	No	No	Yes	Yes	Yes	Moderate
SW25	Yes	No	No	No	No	No	Yes	Yes	Yes	Moderate
SW27	Yes	No	No	Yes	No	No	Yes	Yes	Yes	Moderate

1. NA22 was omitted from this analysis because it falls within an area that is being evaluated as part of the TMDLs for Toxic Pollutants in Sediment at the Mouth of Chollas Creek TMDL and is not considered part of the Shipyard Sediment Site for purposes of the CAO.

18.4. Benthic Community Ranking Criteria

The low, moderate, and high potential for benthic community degradation classifications used in the benthic community line-of-evidence were determined by comparing the benthic community structure indices at each Shipyard Sediment Site station to the thresholds developed for the Bight '98 Benthic Response Index for Embayments (BRI-E) (Ranasinghe et al., 2003) and to the Reference Pool described in Section 17 of this Technical Report:

- Benthic Response Index for Embayments – The BRI-E was developed by SCCWRP as a screening tool to discriminate between disturbed and undisturbed benthic communities in Southern California embayments, such as San Diego Bay. In order to give BRI-E values an ecological context and facilitate their interpretation and use for evaluation of benthic community condition, a reference threshold and four thresholds of response were defined by SCCWRP (Table 18-10). The reference threshold is defined as a value toward the upper end of the range of index values of samples taken at sites that had minimal known anthropogenic influence. The other four thresholds (Response Levels 1, 2, 3 and 4) involved defining levels of deviation from the reference condition. These thresholds are based upon a determination of the index values, above which species, or groups of species, no longer occurred along the pollution gradient.

Table 18-10 Characterization, Definition and BRI-E Thresholds for Levels of Benthic Community Condition

Level	Definition for Bays	BRI-E Threshold
Reference		< 31
Response Level 1	> 5% of reference species absent	31 to 42
Response Level 2	> 25% of reference species absent	42 to 53
Response Level 3	> 50% of reference species absent	53 to 73
Response Level 4	> 80% of reference species absent	> 73

(Ranasinghe et al., 2003)

- Reference Sediment Quality Conditions** – Four metrics were used to assess the benthic community structure: (1) Total abundance – the total number of individuals identified in each replicate sample, (2) Total taxa richness – the total number of distinct taxa identified in each replicate, (3) Shannon-Weiner Diversity Index – a measure of both the number of species and the distribution of individuals among species; higher values indicate that more species are present or that individuals are more evenly distributed among species, and (4) BRI-E – a quantitative index that measures the condition of marine and estuarine benthic communities by reducing complex biological data to single values. A key step in the benthic community line-of-evidence is to determine whether there are statistically significant differences between the benthic community structures observed at the site and the benthic community structure observed at the Reference Pool using the four metrics described above. The statistical procedure used in the Shipyard Sediment Site investigation to identify these differences consisted of the 95% lower predictive limit for total abundance, # of Taxa, and Shannon-Weiner Diversity index. A 95% upper predictive limit was used for the BRI-E. The 95% predictive limit computes a single threshold value for each benthic community metric in the Reference Pool (e.g., total abundance) from which each site station metric result is compared. Although multiple comparisons are made to the Reference Pool, the San Diego Water Board made a decision to not correct for multiple comparisons so that the Shipyard Site/Reference comparisons would be more conservative and protective. The 95% lower predictive limits for the four benthic community metrics and 95% upper predictive limit for BRI-E are shown in Table 18-11.

Table 18-11 Individual Station Characteristics, Summary Statistics, and 95% Lower Predictive Limits for Abundance, Number of Taxa, Shannon-Weiner Diversity Index and BRI-E in the Reference Pool

Station	Abundance	# Taxa	S-W Diversity	BRI-E	BRI-E Level
CP 2231					
CP 2238	419	32	2.6	60.3	III
CP 2243	691	41	2.3	55.1	III
CP 2433	421	57	2.8	22.8	Reference
CP 2441	476	66	2.9	30.0	Reference
SY 2231					
SY 2243	989	78	2.5	45.1	II
SY 2433	441	77	2.6	16.8	Reference
SY 2441	506	108	2.8	19.9	Reference
2235	551	29	2.1	42.1	II
2241	1526	44	2.3	34.7	I
2242	1117	28	1.8	36.6	I
2243	966	47	2.7	36.4	I
2256	237	28	2.7	37.9	I

Station	Abundance	# Taxa	S-W Diversity	BRI-E	BRI-E Level
2257	503	37	2.3	38.1	I
2258	826	36	2.3	43.2	II
2260	2263	49	1.8	39.1	I
2265	1543	48	2.4	26.7	Reference
N	16	16	16	16	
Minimum	237	28	1.8	17	
Maximum	2263	108	2.9	60	
Mean	842	50	2.4	37	
Std dev	544	22	0.3	12	
RSD	65%	44%	14%	32%	
95% PL	239	22	1.8	57.7	

SCCWRP and U.S. Navy, 2005b

The benthic community ranking criteria was originally developed for the sediment quality site assessment work for the mouth of Chollas Creek and Paleta Creek TMDLs (SCCWRP and U.S. Navy, 2005b). SCCWRP, U.S. Navy, and the San Diego Water Board developed the criteria with input from NRTAs, non-governmental environmental groups, the Port, and the City of San Diego.

The BRI-E threshold scores evidence are weighed higher because: (1) they are a comprehensive measure of benthic community health developed specifically for bays and harbors in Southern California, (2) the indices remove much of the subjectivity associated with interpreting the benthic community structure data, and (3) the indices provide a simple means of communicating complex benthic community structure data to the public and regulatory managers. The category ranking criteria for benthic community composition is depicted in Figure 18-3. A comparison of the benthic community metrics at each Shipyard Sediment Site station to the Reference Pool 95% prediction limits is shown in Table 18-12. The benthic community line-of-evidence results for each Shipyard Sediment Site station using the Reference Pool comparison are shown in Table 18-13 and the supporting calculations are provided in the Appendix for Section 18.

Figure 18-3 Benthic Community Lines of Evidence Characteristics

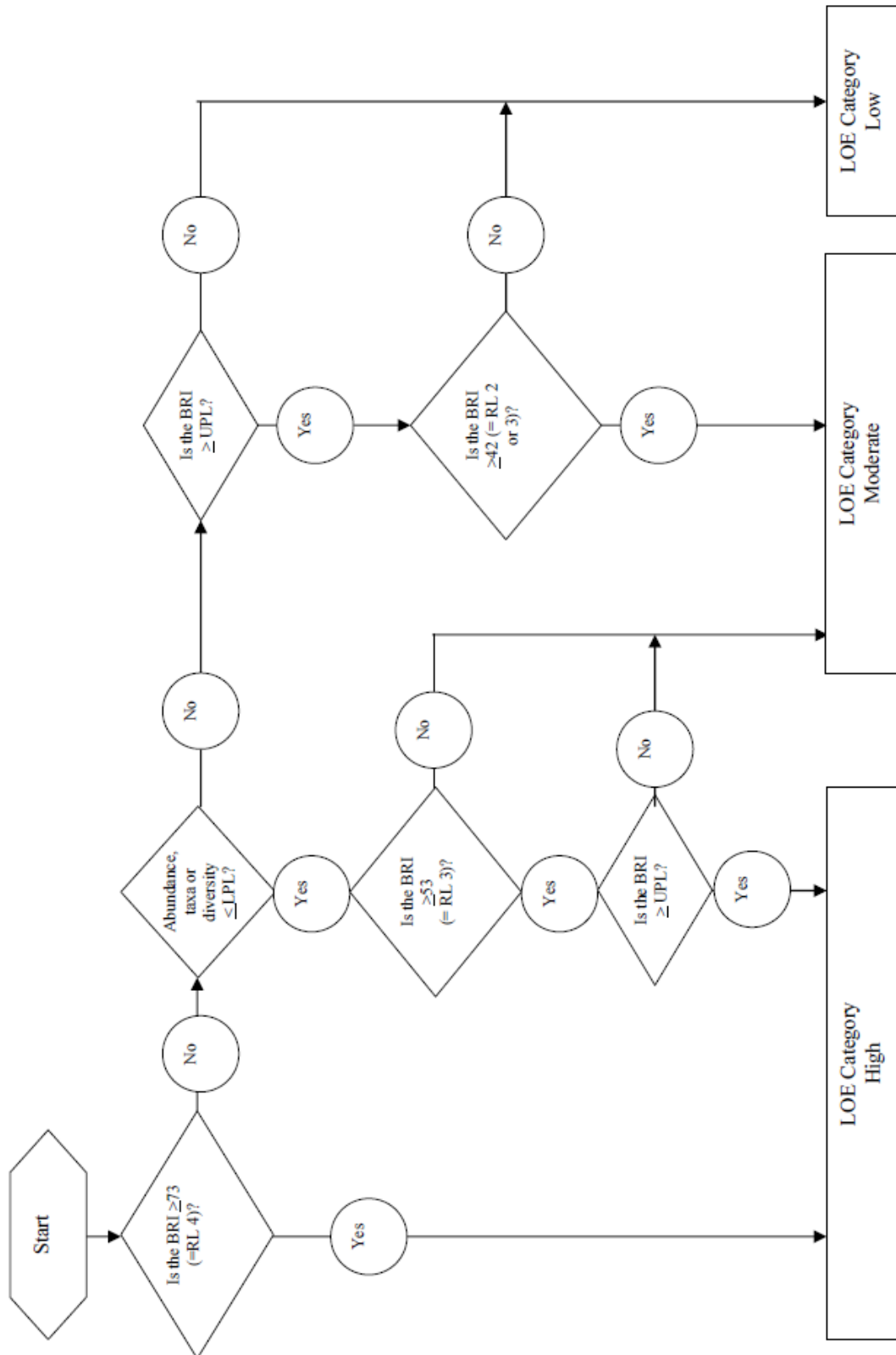


Table 18-12 Comparison of the Benthic Community Metrics Data from the Shipyard Sediment Site Stations to the Reference Pool 95% Predictive Limits

Site	Station	BRI (95% UPL = 57.7)	Abundance ¹ (95% LPL = 239)	# Taxa ¹ (95% LPL = 22)	S-W Diversity ¹ (95% LPL = 1.8)
NASSCO	NA01	42.2	447	33	2.8
	NA03	45.5	492	40	3.0
	NA04	49.6	285	25	2.5
	NA05	44.4	569	35	2.4
	NA06	54.4	611	37	2.7
	NA07	44.6	475	43	3.0
	NA09	51.1	862	44	2.6
	NA11	46.0	604	33	2.4
	NA12	42.6	538	37	2.7
	NA15	51.0	306	26	2.3
	NA16	48.0	522	33	2.6
	NA17	55.3	418	33	2.7
	NA19	46.7	828	43	2.7
	NA20	54.0	412	22	2.3
	NA22 ²	51.6	107	15	2.2
BAE Systems	SW02	52.1	976	39	2.4
	SW03	49.9	361	31	2.8
	SW04	41.1	3,175	36	1.6
	SW08	41.5	2,457	41	2.4
	SW09	53.2	572	39	2.7
	SW11	42.4	777	44	2.9
	SW13	43.6	742	53	3.2
	SW15	37.8	806	59	3.1
	SW17	45.7	621	30	2.4
	SW18	39.5	829	42	2.8
	SW21	53.2	315	24	2.4
	SW22	55.1	363	26	2.4
	SW23	50.0	316	27	2.6
	SW25	41.3	611	40	2.8
SW27	42.9	927	48	2.9	

1. For the BRI-E, index scores greater than the 95% upper prediction limit are bold faced and shaded. For the abundance, # taxa, and S-W diversity metrics, metric scores less than or equal to their respective 95% lower prediction limits are bold faced and shaded.
2. NA22 was omitted from this analysis because it falls within an area that is being evaluated as part of the TMDLs for Toxic Pollutants in Sediment at the Mouth of Chollas Creek TMDL and is not considered part of the Shipyard Sediment Site for purposes of the CAO.

Table 18-13 Benthic Community Line-of-Evidence Results

Station	Benthic Response Index				Abundance ≤ 95% LPL	# Taxa ≤ 95% LPL	S-W Diversity ≤ 95% LPL	LOE Category
	≥ 73	≥ 53	≥ 42	≥ 95% UPL				
NA01	No	No	Yes	No	No	No	No	Low
NA03	No	No	Yes	No	No	No	No	Low
NA04	No	No	Yes	No	No	No	No	Low
NA05	No	No	Yes	No	No	No	No	Low
NA06	No	Yes	Yes	No	No	No	No	Low
NA07	No	No	Yes	No	No	No	No	Low
NA09	No	No	Yes	No	No	No	No	Low
NA11	No	No	Yes	No	No	No	No	Low
NA12	No	No	Yes	No	No	No	No	Low
NA15	No	Yes	Yes	No	No	No	No	Low
NA16	No	No	Yes	No	No	No	No	Low
NA17	No	No	Yes	No	No	No	No	Low
NA19	No	No	No	No	No	No	No	Low
NA20	No	No	Yes	No	No	Yes	No	Moderate
NA22 ¹	No	No	Yes	No	Yes	Yes	No	Moderate
SW02	No	No	Yes	No	No	No	No	Low
SW03	No	No	No	No	No	No	No	Low
SW04	No	Yes	Yes	No	No	No	Yes	Moderate
SW08	No	No	Yes	No	No	No	No	Low
SW09	No	No	Yes	No	No	No	No	Low
SW11	No	No	No	No	No	No	No	Low
SW13	No	No	Yes	No	No	No	No	Low
SW15	No	No	No	No	No	No	No	Low
SW17	No	No	No	No	No	No	No	Low
SW18	No	No	No	No	No	No	No	Low
SW21	No	No	Yes	No	No	No	No	Low
SW22	No	No	Yes	No	No	No	No	Low
SW23	No	No	Yes	No	No	No	No	Low
SW25	No	No	Yes	No	No	No	No	Low
SW27	No	No	Yes	No	No	No	No	Low

1. NA22 was omitted from this analysis because it falls within an area that is being evaluated as part of the TMDLs for Toxic Pollutants in Sediment at the Mouth of Chollas Creek TMDL and is not considered part of the Shipyard Sediment Site for purposes of the CAO.

The low, moderate, and high ranking benthic community health classification criteria are based on the following two key assumptions (SCCWRP and U.S. Navy, 2005b):

- The assumption is made that no, or a low degree of benthic community degradation is present when the station BRI is Response Level 1 (< RL 2) or is statistically similar to the Reference Condition; and
- A high degree of benthic community degradation at a station is assumed to be present at BRI Response Levels (RLs) greater than 3 or when other indicators also show benthic community structure impacts.

The benthic community structure line of evidence category ranking from the SCCWRP and U.S. Navy (2005b) report are presented below and in Figure 18-3 of this report. The same ranking criteria from the SCCWRP and U.S. Navy (2005b) report are used to evaluate the benthic community indices from the Shipyard Sediment Site investigation.

Low Degree of Benthic Community Degradation: Benthic community degradation at each station is classified as none or a low if the BRI RL is less than 2 and when abundance, number of taxa, and the Shannon-Weiner Diversity Index are all statistically similar to the Reference Condition.

Moderate Degree of Benthic Community Degradation: The benthic community is classified as moderately degraded at stations exhibiting a BRI RL 2 or 3 and is statistically greater degradation than the Reference Condition, or, if any one of the other benthic community metrics is below the 95% PL established by the Reference Condition.

High Degree of Benthic Community Degradation: The benthic community is classified as highly degraded at stations with a BRI greater than RL 3. The benthic community is also classified as highly degraded at stations with BRI RL 2, the results are statistically greater than Reference Condition, and at least one of the other benthic community metrics is below the 95 percent PL established by the Reference Condition.

To determine the likelihood of benthic community impairment (Likely, Possible, or Unlikely), each line of evidence ranking (Low, Moderate, or High) is put into the Weight-of-Evidence Analysis framework described in Section 18.5 below.

18.5. Weight-of-Evidence Criteria

The three line of evidence (LOE) assessments for sediment chemistry, toxicity, and benthic community described in DTR Sections 18.2, 18.3 and 18.4, respectively, were integrated into an overall weight-of-evidence (WOE) assessment to identify the likelihood that the benthic community is adversely impacted at a given Shipyard Sediment Site station due to the presence of CoPCs in the sediment. This WOE assessment follows the general principles of the "Sediment Quality Triad Approach" described in a U.S. EPA compendium of "scientifically valid and accepted methods" used to assess sediment quality (U.S. EPA, 1992a). Potential combinations of the rankings for individual LOE were assessed and assigned a relative overall likelihood of benthic community impairment using three categories "Unlikely", "Possible" and "Likely" similar to the WOE

approach described in “Sediment Assessment Study for the Mouth of Chollas and Paleta Creek, Phase 1 Final Report, May 2005” (SCCWRP and U.S. Navy, 2005b).

The WOE framework used to interpret the various combinations is shown in Table 18-14, and is based on the consideration of four key elements:

- Level of confidence or weight given to the individual line of evidence
- Whether the line of evidence indicates there is an effect
- Magnitude or consistency of the effect
- Concurrence among the various lines of evidence.

The three categories of impairment are described below:

Unlikely - A station was classified as “Unlikely” if the individual LOE provided no evidence of biological effects due to elevated CoPCs (relative to the reference condition) at the site. This category was assigned to all stations with a “Low” chemistry LOE ranking, regardless of the presence of biological effects, because there was no evidence that effects were related to site-specific contamination. Similarly, stations having a “Moderate” ranking for chemistry and a “Low” ranking for biological effects were also classified as “Unlikely.” The category of “Unlikely” does not mean that there was no impairment, but that the impairment was not clearly linked to site related chemical exposure.

Possible - A station was classified as “Possible” when there was a lack of concurrence among the LOE, which indicates less confidence in the interpretation of the results. This category was assigned to stations with moderate chemistry and a lack of concurrence among the biological effects LOE (i.e., effects present in only one of two LOE). Intermediate chemistry rankings have less certainty for predicting biological effects. The lack of concurrence between the toxicity and benthic community measures indicates a lower degree of confidence that the biological effects observed were due to CoPCs at the site; and that these effects could have been caused by other factors (e.g., physical disturbance or natural variations in sediment characteristics). The category of “Possible” represents situations where impairment was indicated, but there was less confidence in the reliability of the results. Of the three categories listed, stations in this group would be more likely to change their category as a result of natural variability, changes in the composition of the reference stations used for comparison, or to differences in the criteria used to classify each LOE.

Likely - A station was classified as “Likely” if there was a high level of agreement between observed biological effects and elevated CoPCs at the site. Concurrence among the three LOE (i.e., the presence of moderate or high rankings for chemistry, toxicity, and benthic community) always resulted in a classification of likely impairment. This classification was also assigned when the chemistry LOE was “High” and biological effects were present in either the toxicity or benthic community LOE.

For example, a station with a “High” ranking for chemistry, toxicity and benthic community would indicate a “High” likelihood of site-specific aquatic life impairment because each LOE indicates an effect, the magnitude of the effect is consistently high, and there is clear concurrence among the LOE. Alternatively, a station with a “Low” ranking for chemistry, and moderate or

high rankings for toxicity and benthic community would indicate unlikely site-specific aquatic life impairment from site CoPCs, because there is no concurrence with site CoPCs. This does not mean that there is no impairment, but that the impairment is not clearly linked to site related chemical exposure.

The WOE framework in Table 18 -14 was used to interpret the MLOE results and is consistent with other published WOE frameworks. The results of the WOE assessment for each Shipyard Sediment Site station are presented in Table 18-1.

Table 18-14 Weight-of-Evidence Analysis Framework for the Aquatic Life Impairment Assessment

Sediment Chemistry ¹	Toxicity ²	Benthic Community ³	Relative Likelihood of Benthic Community Impairment ⁴
High	High	High	Likely
High	High	Moderate	
High	Moderate	High	
Moderate	High	High	
High	High	Low	
High	Low	High	
High	Moderate	Moderate	
Moderate	High	Moderate	
Moderate	Moderate	High	
Moderate	Moderate	Moderate	
High	Moderate	Low	
High	Low	Moderate	
Moderate	High	Low	
Moderate	Low	High	
Moderate	Moderate	Low	
Moderate	Low	Moderate	
High	Low	Low	
Low	High	High	Unlikely
Low	High	Moderate	
Low	Moderate	High	
Low	Moderate	Moderate	
Low	Low	High	
Low	High	Low	
Low	Low	Moderate	
Low	Moderate	Low	
Moderate	Low	Low	
Low	Low	Low	

1. Relative likelihood that the contaminants present in the sediment is adversely impacting organisms living in or on the sediment (i.e., benthic community).
2. Relative likelihood of toxic effects based on the combined toxic response from three tests: amphipod survival, sea urchin fertilization, and bivalve development.
3. Relative likelihood of benthic community degradation based on four metrics: total abundance, total number of species, Shannon-Wiener Diversity Index, and the Benthic Response Index.
4. Relative likelihood that the health of the benthic community is adversely impacted based on the three lines of evidence: sediment chemistry, toxicity, and benthic community.

19. Finding 19: Bioaccumulation

Finding 19 of CAO No. R9-2012-0024 states:

The San Diego Water Board evaluated initial laboratory bioaccumulation test data to ascertain the bioaccumulation potential of the sediment chemical pollutants at the Shipyard Sediment Site. Examination of laboratory test data on the chemical pollutant concentrations in tissue of the clam *Macoma nasuta* relative to the pollutant concentrations in sediment indicates that bioaccumulation of chemical pollutants is occurring at the Shipyard Sediment Site. The data indicates for several chemical pollutants that concentrations in *Macoma nasuta* tissue increase proportionally as chemical pollutant concentrations in sediment increase. Statistically significant relationships were found for arsenic, copper, lead, mercury, zinc, tributyltin (TBT), PCBs, and high molecular weight polynuclear aromatic hydrocarbons (HPAHs). These chemical pollutants have a bioaccumulation potential at the Shipyard Sediment Site and are therefore considered bioavailable to benthic organisms. No statistically significant relationships were found for cadmium, chromium, nickel, selenium, silver, or PCTs.

19.1. Bioaccumulation Analyses

Sediment bioaccumulation tests were conducted to evaluate the bioaccumulation potential of the chemical pollutants present in sediment at the Shipyard Sediment Site and the degree to which these chemicals may enter the aquatic food web (Exponent, 2001a, 2002). The bioaccumulation tests involved the exposure of the clam *Macoma nasuta* to site and reference sediment for 28 days using the protocols specified by ASTM (2000). *Macoma* was selected as the test species for the bioaccumulation tests because it is native to the West Coast and actively ingests surface sediment (likely to be the most direct route of exposure to contaminants that accumulate in tissues). Bioaccumulation tests were conducted using sediment collected from four stations in the NASSCO leasehold (NA06, NA11, NA12, NA20), five stations in the BAE Systems leasehold (SW04, SW08, SW13, SW21, and SW28) and at five reference stations located in San Diego Bay (2441, 2433, 2440, 2231, and 2243). The site stations were positioned along a gradient of expected sediment concentrations of potentially bioaccumulative substances.

Evaluation of the chemical pollutant concentrations in *Macoma* tissue relative to the chemical pollutant concentrations in the sediment indicates that bioaccumulation of chemicals is occurring at the Shipyard Sediment Site (Exponent, 2003). For many chemical pollutants, concentrations in tissue increase as chemical pollutant concentrations in sediment increases, as shown in the regression plots provided in the Appendix for Section 19 of this Technical Report. Statistically significant tissue: sediment relationships (at $p = 0.05$) were found for arsenic, copper, lead, mercury, zinc, tributyltin (TBT), PCBs, HPAHs (Exponent, 2003). These chemical pollutants have a bioaccumulation potential at the Shipyard Sediment Site and are therefore considered bioavailable to benthic organisms. Bioavailability does not necessarily indicate the presence of adverse effects. It should be noted, however, that the relationships for arsenic and zinc, although statistically significant, are subject to some uncertainty because each are controlled by a single data point. No statistically significant relationships (at $p = 0.05$) were found for cadmium, chromium, nickel, selenium, silver, or polychlorinated terphenyls (PCTs).

20. Finding 20: Indicator Sediment Chemicals

Finding 20 of CAO No. R9-2012-0024 states:

The San Diego Water Board evaluated the relationships between sediment chemical pollutants and biological responses to identify indicator chemical pollutants that may be impacting aquatic life and would therefore be candidates for assignment of cleanup levels or remediation goals. A two-step process was conducted. The first step in the selection of indicator chemicals was to identify chemicals representative of the major classes of sediment pollutants: metals, butyltins, PCBs and PCTs, PAHs, and petroleum hydrocarbons. The second step was the evaluation of relationships between these chemicals and biological responses. Results of the three toxicity tests, benthic community assessment, and bioaccumulation testing conducted in Phase 1 of the Shipyard study were all used to evaluate the potential of such relationships. Chemical pollutants were selected as indicator chemicals if they had any statistically significant relationship with amphipod mortality, echinoderm fertilization, bivalve development, total benthic macroinvertebrate abundance, total benthic macroinvertebrate richness, or tissue chemical concentrations in *Macoma nasuta*. Chemical pollutants selected as indicator chemicals include arsenic, copper, lead, mercury, zinc, TBT, total PCB homologs, diesel range organics (DRO), and residual range organics (RRO).

20.1. Indicator Sediment Chemical Pollutants

A two-step approach was used to identify indicator chemical pollutants that may be impacting aquatic life beneficial uses as identified in Section 18 – Sediment Quality Triad Results. The first step consisted of selecting chemical pollutants representative of the major classes of sediment pollutants at the Shipyard Sediment Site and the second step evaluated those chemicals with observed relationships to biological responses.

The major classes of sediment chemical pollutants identified in Step 1 were metals, butyltins, polychlorinated biphenyls (PCB) and polychlorinated terphenyls (PCT), PAH, and petroleum hydrocarbons. Specific chemical pollutants were selected to represent each of these classes:

- **Metals** – All metals except for selenium were selected as indicator chemical pollutants. Selenium was excluded due to its relatively low detection frequency and because the detected values were equal to the quantitation limit;
- **Butyltins** – Tributyltin (TBT) was selected as an indicator chemical pollutant because it is commonly used in marine antifouling paints;
- **PCBs and PCTs** – The sum of PCB homologs was used because it more accurately represents total PCBs as opposed to the sum of congeners (not all congeners were measured) and the sum of Aroclors. The sum of PCT Aroclors measured was used to represent total PCTs;
- **PAH** – The sum of all high-molecular-weight PAHs (HPAH) was used to represent PAH compounds. The sum of low-molecular-weight PAHs (LPAH) and the sum of all PAH compounds were not used because most LPAH compounds were undetected; and

- **Petroleum Hydrocarbons** – Diesel-range organics (DRO) and residual-range organics (RRO) were used to represent petroleum hydrocarbons. Gasoline-range organics (GRO) was not used because it was undetected. Petroleum hydrocarbons, including TPH, RRO, DRO, and other PAHs, including BAP, were eliminated as indicator chemicals because HPAHs are considered to be the most recalcitrant, bioavailable, and toxic compounds present in the complex mixture of petroleum hydrocarbons.

In Step 2, the chemical pollutants identified above were selected as indicator chemical pollutants if they had any statistically significant relationship with any of the biological effects indicators. Amphipod mortality, echinoderm fertilization, bivalve development, total benthic macroinvertebrate abundance, total benthic macroinvertebrate richness, and tissue chemical concentrations in *Macoma nasuta* were used to evaluate the potential of such relationships. Based on the chemical and biological response comparisons (Table 20-1), the chemicals selected as indicator chemicals included arsenic, copper, lead, mercury, zinc, TBT, total PCB homologs, DRO, and RRO (Exponent, 2003). All of these indicator chemicals, except for DRO and RRO, are considered to have possible impacts on aquatic-dependent wildlife or human health because of their statistical relationship with the *Macoma* tissue bioaccumulation results. DRO and RRO are considered to have possible impacts on aquatic life because of their statistical relationship with the benthic community results as reported in the Shipyard Report. As noted above, potential impacts from DRO and RRO are assumed to be represented and addressed via HPAH risk evaluation.

Table 20-1 Relationships of Sediment Chemical Pollutants to Biological Effects

Chemical	Statistical Relationship to:						Selected as Indicator Chemical?
	Amphipod Toxicity	Echinoderm Toxicity	Bivalve Toxicity	Benthic Macroinvertebrate Total Abundance	Benthic Macroinvertebrate Total Richness	Macoma Tissue Bioaccumulation	
Arsenic	No	No	No	No	No	Yes ¹	Yes
Cadmium	No	No	No	No	No	No	No
Chromium	No	No	No	No	No	No	No
Copper	No	No	No	No	No	Yes	Yes
Lead	No	No	No	No	No	Yes	Yes
Mercury	No	No	No	No	No	Yes	Yes
Nickel	No	No	No	No	No	No	No
Silver	No	No	No	No	No	No	No
Zinc	No	No	No	No	No	Yes	Yes
TBT	No	No	No	No	No	Yes	Yes
HPAH	No	No	No	No	No	Yes	Yes
Total PCB homologs	No	No	No	No	No	Yes	Yes
PCTs	No	No	No	No	No	No	No
DRO	No	No	No	No	Yes	-- ²	Yes
RRO	No	No	No	Yes	Yes	-- ²	Yes

1. The relationship is controlled by a single point
2. Not evaluated

21. Finding 21: Aquatic-Dependent Wildlife Impairment

Finding 21 of CAO No. R9-2012-0024 states:

Aquatic-dependent wildlife beneficial uses designated for San Diego Bay are impaired due to the elevated levels of pollutants present in the marine sediment at the Shipyard Sediment Site. Aquatic-dependent wildlife beneficial uses include: Wildlife Habitat (WILD), Preservation of Biological Habitats of Special Significance (BIOL), and Rare, Threatened, or Endangered Species (RARE). This finding is based on the considerations described below in the *Impairment of Aquatic-Dependent Wildlife Beneficial Uses* section of this CAO.

21.1. Aquatic-Dependent Wildlife Beneficial Uses

There are three beneficial uses designated in the Basin Plan for San Diego Bay (RWQCB, 1994), which must be fully protected in order to provide for the protection of aquatic-dependent wildlife:

- **Wildlife Habitat (WILD)** – Includes uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources;
- **Preservation of Biological Habitats of Special Significance (BIOL)** – Includes uses of water that support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance (ASBS), where the preservation or enhancement of natural resources requires special protection; and
- **Rare, Threatened, or Endangered Species (RARE)** – Includes uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered.

The concentrations of the pollutants present in the marine sediment within and adjacent to the Shipyard Sediment Site cause or threaten to cause a condition of pollution or contamination that adversely impacts these three beneficial uses and thereby constitute a threat to the aquatic-dependent wildlife. Information supporting this conclusion is contained in Sections 22 through 24 of this report.

22. Finding 22: Risk Assessment Approach for Aquatic-Dependent Wildlife

Finding 22 of CAO No. R9-2012-0024 states:

The San Diego Water Board evaluated potential risks to aquatic-dependent wildlife from chemical pollutants present in the sediment at the Shipyard Sediment Site based on a two-tier approach. The Tier I screening level risk assessment was based on tissue data derived from the exposure of the clam *Macoma nasuta* to site sediments for 28 days using the protocols specified by American Society of Testing Material (ASTM). The Tier II baseline comprehensive risk assessment was based on tissue data derived from resident fish and shellfish caught within and adjacent to the Shipyard Sediment Site.

22.1. Two-Tiered Risk Assessment Approach

A two-tiered approach was used to evaluate potential risks to aquatic-dependent wildlife from chemical pollutants present at the Shipyard Sediment Site. Tier I was a screening level risk assessment that uses conservative exposure and effects assumptions to support risk management decisions. Tier II was a comprehensive risk assessment (i.e., baseline risk assessment) that more accurately characterizes potential risk to receptors of concern primarily by replacing the conservative assumptions required by Tier I with site-specific exposure parameters.

The approach used in Tiers I and II was conducted in accordance with U.S. EPA's "Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)" (U.S. EPA, 1997a) and with DTSC's "Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities" (DTSC, 1996). The approach consists of the following key elements:

- Selection of Receptors of Concern
- Exposure Characterization
- Effects Characterization
- Risk Characterization
- Risk Management
- Uncertainties Related to Risk Estimates

These elements are discussed in more detail in Section 23 – Tier I Screening Level Risk Assessment and Section 24 – Tier II Comprehensive Risk Assessment of this report.

23. Finding 23: Tier I Screening Level Risk Assessment for Aquatic-Dependent Wildlife

Finding 23 of CAO No. R9-2012-0024 states:

The Tier I risk assessment objectives were to determine whether or not Shipyard Sediment Site conditions pose a potential unacceptable risk to aquatic-dependent wildlife receptors of concern and to identify whether a comprehensive, site-specific risk assessment was warranted (i.e., Tier II baseline risk assessment). The receptors of concern selected for the assessment include: California least tern (*Sterna antillarum brownie*), California brown pelican (*Pelecanus occidentalis californicus*), Western grebe (*Aechmophorus occidentalis*), Surf scoter (*Melanitta perspicillata*), California sea lion (*Zalophus californianus*), and East Pacific green turtle (*Chelonia mydas agassizii*). Chemical pollutant concentrations measured in clam tissue derived from laboratory bioaccumulation tests were used to estimate chemical exposure to these receptors of concern. Based on the Tier I screening level risk assessment results, there is a potential risk to all receptors of concern ingesting prey caught at the Shipyard Sediment Site. The chemical pollutants in *Macoma* tissue posing a potential risk include arsenic, copper, lead, zinc, benzo[a]pyrene (BAP), and total PCBs. The results of the Tier I risk assessment indicated that a Tier II baseline comprehensive risk assessment was warranted.

23.1. Tier I Results

For the Tier I screening level risk assessment, six aquatic-dependent wildlife species were identified as potential receptors that could be at risk due to exposure to chemicals in prey caught at the Shipyard Sediment Site. The six receptors include: California least tern (*Sterna antillarum brownie*), California brown pelican (*Pelecanus occidentalis californicus*), Western grebe (*Aechmophorus occidentalis*), Surf scoter (*Melanitta perspicillata*), California sea lion (*Zalophus californianus*), and East Pacific green turtle (*Chelonia mydas agassizii*). Chemical concentrations measured in *Macoma nasuta* tissue derived from laboratory bioaccumulation tests were used to estimate chemical exposure for these receptors of concern.

Based on the Tier I results, as summarized in Table 23-1 below, the San Diego Water Board determined that there is a potential risk to all receptors of concern ingesting prey caught at the Shipyard Sediment Site and that a comprehensive, site specific risk assessment was warranted (i.e., Tier II baseline risk assessment). The chemical pollutants in *Macoma* tissue posing a potential risk include arsenic, copper, lead, zinc, BAP, and PCBs. The Tier I risk calculations and results are provided in the Appendix for Section 23.

Table 23-1 Summary of Tier I Aquatic-Dependent Wildlife Risk Assessment Results

Station	Receptor	Site Chemicals in <i>Macoma</i> Tissue Posing a Potential Risk ¹	Site Chemicals in <i>Macoma</i> Tissue Not Posing a Potential Risk ²
NA06	Brown Pelican	Lead	Benzo[a]pyrene (BAP), total polychlorinated biphenyls (PCBs), tributyltin (TBT), arsenic, chromium, copper, mercury, nickel, selenium, zinc
	Least Tern	Lead	BAP, PCBs, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
	Sea Lion	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Surf Scoter	Lead	BAP, PCBs, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
	Western Grebe	Lead	BAP, PCBs, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
	Green Turtle	Lead	BAP, PCBs, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
NA11	Brown Pelican	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Least Tern	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Sea Lion	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Surf Scoter	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Western Grebe	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Green Turtle	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc

Station	Receptor	Site Chemicals in <i>Macoma</i> Tissue Posing a Potential Risk ¹	Site Chemicals in <i>Macoma</i> Tissue Not Posing a Potential Risk ²
NA12	Brown Pelican	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Least Tern	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Sea Lion	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Surf Scoter	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Western Grebe	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Green Turtle	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
NA20	Brown Pelican	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Least Tern	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Sea Lion	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Surf Scoter	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Western Grebe	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Green Turtle	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc

Station	Receptor	Site Chemicals in <i>Macoma</i> Tissue Posing a Potential Risk ¹	Site Chemicals in <i>Macoma</i> Tissue Not Posing a Potential Risk ²
SW04	Brown Pelican	Copper, lead, zinc	BAP, PCBs, TBT, arsenic, chromium, mercury, nickel, selenium
	Least Tern	Copper, lead, zinc, BAP	PCBs, TBT, arsenic, chromium, mercury, nickel, selenium
	Sea Lion	Arsenic, zinc	BAP, PCBs, TBT, chromium, copper, lead, mercury, nickel, selenium
	Surf Scoter	Copper, lead, zinc	BAP, PCBs, TBT, arsenic, chromium, mercury, nickel, selenium
	Western Grebe	Copper, lead, zinc	BAP, PCBs, TBT, arsenic, chromium, mercury, nickel, selenium
	Green Turtle	Lead	BAP, PCBs, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
SW08	Brown Pelican	Copper, lead	BAP, PCBs, TBT, arsenic, chromium, mercury, nickel, selenium, zinc
	Least Tern	Copper, lead, zinc, BAP	PCBs, TBT, arsenic, chromium, mercury, nickel, selenium
	Sea Lion	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Surf Scoter	Copper, lead	BAP, PCBs, TBT, arsenic, chromium, mercury, nickel, selenium, zinc
	Western Grebe	Copper, lead	BAP, PCBs, TBT, arsenic, chromium, mercury, nickel, selenium, zinc
	Green Turtle	Lead	BAP, PCBs, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
SW13	Brown Pelican	Copper, total PCBs	BAP, TBT, arsenic, chromium, lead, mercury, nickel, selenium, zinc
	Least Tern	Copper, zinc, total PCBs	BAP, TBT, arsenic, chromium, lead, mercury, nickel, selenium
	Sea Lion	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc

Station	Receptor	Site Chemicals in <i>Macoma</i> Tissue Posing a Potential Risk ¹	Site Chemicals in <i>Macoma</i> Tissue Not Posing a Potential Risk ²
	Surf Scoter	Copper, lead	BAP, PCBs, TBT, arsenic, chromium, mercury, nickel, selenium, zinc
	Western Grebe	Copper	BAP, PCBs, TBT, arsenic, chromium, lead, mercury, nickel, selenium, zinc
	Green Turtle	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
SW21	Brown Pelican	Lead, total PCBs	BAP, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
	Least Tern	Lead, zinc, BAP, total PCBs	TBT, arsenic, chromium, copper, mercury, nickel, selenium
	Sea Lion	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Surf Scoter	Lead	BAP, PCBs, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
	Western Grebe	Lead	BAP, PCBs, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
	Green Turtle	Lead	BAP, PCBs, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
SW28	Brown Pelican	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Least Tern	Zinc, total PCBs	BAP, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium
	Sea Lion	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Surf Scoter	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Western Grebe	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc

Station	Receptor	Site Chemicals in <i>Macoma</i> Tissue Posing a Potential Risk ¹	Site Chemicals in <i>Macoma</i> Tissue Not Posing a Potential Risk ²
	Green Turtle	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc

1. A potential risk is defined if the hazard quotient (HQ) is greater than 1.0 **AND** greater than the reference 95% upper prediction limit *Macoma* tissue concentration.
2. Not posing a potential risk is indicated if the HQ is less than 1.0 **OR** if the HQ is greater than 1.0 **AND** less than the reference 95% upper prediction limit *Macoma* tissue concentration.

23.2. Tier I Approach

The San Diego Water Board conducted a Tier I screening level risk assessment to determine whether or not the current conditions at the Shipyard Sediment Site pose a potential unacceptable risk to aquatic-dependent wildlife receptors of concern and to identify whether a comprehensive, site-specific risk assessment was warranted (i.e., Tier II baseline risk assessment). Potential risks were characterized by: (1) quantifying the risks at the site using the hazard quotient (HQ) approach, and (2) comparing clam tissue concentrations exposed to site sediment to clam tissue concentrations exposed to reference sediment.

The approach used in the Tier I screening level risk assessment was conducted in accordance with U.S. EPA's "Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final" (U.S. EPA, 1997a), U.S. EPA's "Guidelines for Ecological Risk Assessment (EPA/630/R-95/002F)" (U.S. EPA, 1998b), and with DTSC's "Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities" (DTSC, 1996). The approach consists of the following key elements:

- Selection of Receptors of Concern
- Exposure Characterization
- Effects Characterization
- Risk Characterization
- Risk Management
- Uncertainties Related to Risk Estimates

These key elements are discussed in more detail below.

23.2.1. Selection of Receptors of Concern

For Tier I, fish-eating marine birds and mammals, mollusk-eating birds, and sea grass-eating reptiles were identified as important groups of aquatic-dependent wildlife that may be at risk due to exposure to chemicals in prey species at the Shipyard Sediment Site (Exponent, 2002). Six species were identified as suitable representative receptors for assessing potential risk to these groups as reviewed and approved by U.S. FWS, DFG, and NOAA (collectively known as the "Natural Resource Trustee Agencies"). The six species are shown in Table 23-2 below. These

receptors were selected based on characteristics such as their presence at the site, feeding habits, known adverse effects from exposure to bioaccumulative chemical pollutants, the availability of ample life history information in the literature, and federal or state listings of species as threatened or endangered.

Table 23-2 Receptors Selected for the Tier II Risk Assessment

Receptor	Scientific Name	Representative of	Comments
California least tern	<i>Sterna antillarum brownie</i>	Marine birds that may feed on small fish	Federal and California listed endangered species
California brown pelican	<i>Pelecanus occidentalis californicus</i>	Marine birds that may feed on small- to medium-sized fish	Federal and California listed endangered species
Western grebe	<i>Aechmophorus occidentalis</i>	Diving marine birds that may feed on small fish	
Surf scoter	<i>Melanitta perspicillata</i>	Diving marine birds that may feed on mollusks	
California sea lion	<i>Zalophus californianus</i>	Marine mammals that may feed on medium-sized fish	
East Pacific green turtle	<i>Chelonia mydas agassizii</i>	Marine reptiles that may feed on sea grasses	Listed as threatened wherever found and listed as endangered in Florida and on the Pacific coast of Mexico

23.2.2. Exposure Characterization

The primary routes of exposure to chemical pollutants at the Shipyard Sediment Site are through the ingestion of prey items and the incidental ingestion of sediment during foraging (Exponent, 2003). Separate chemical pollutant exposure estimates were developed for each receptor at each of the Shipyard Sediment Site stations where bioaccumulation tests were conducted. For Tier I, bioaccumulation tests were conducted using sediment from four stations in the NASSCO leasehold (NA06, NA11, NA12, and NA20) and five stations in the BAE Systems leasehold (SW04, SW08, SW13, SW21, and SW28). These stations were positioned along an expected gradient of sediment concentrations of potentially bioaccumulative substances at each shipyard leasehold. The bioaccumulation tests involved the exposure of the clam *Macoma nasuta* to bay sediment at the Shipyard Sediment Site for 28 days using the protocols specified by ASTM (2001). The tissue concentrations derived from these tests were used as the surrogate for prey tissue data, even though mollusks are not a major component of the diet for most of the receptors of concern selected for this risk analysis. Because *Macoma* actively ingests surface sediment (likely to be the most direct route of exposure to pollutants that accumulate in tissues), use of *Macoma* tissue data for all receptors of concern including those that exclusively feed on fish is considered a relatively conservative approach.

Exposure estimates for the six receptors were developed using the following general intake equation (DTSC, 1996):

$$\text{Daily Intake}_{\text{chemical}} \text{ (in mg/kg - day)} = \frac{(\text{CM} * \text{CR} * \text{FI} * \text{AF})}{\text{BW}}$$

where:

- CM = concentration of the chemical in a given dietary component or inert medium (mg/kg)
 CR = contact rate (i.e., ingestion rate) of dietary component or inert medium (kg/day)
 FI = fraction of the daily intake of a given dietary component or inert medium derived from the site (unitless area-use factor)
 AF = relative gastrointestinal absorption efficiency for the chemical in a given dietary component or inert medium (fraction)
 BW = body weight of receptor species (kg)

The intake equation was further expanded to account for the ingestion of prey items and the incidental ingestion of sediment:

$$\text{Daily Intake}_{\text{chemical}} \text{ (in mg/kg - day)} = \frac{[(\text{CM} * \text{CR} * \text{FI} * \text{AF})_{\text{prey}} + (\text{CM} * \text{CR} * \text{FI} * \text{AF})_{\text{sediment}}]}{\text{BW}}$$

The assumptions used by the San Diego Water Board in the expanded equation to estimate receptor exposure at each site stations are shown in Table 23-3 below and the exposure estimate calculations using these assumptions are provided in the Appendix for Section 23.

Table 23-3 Exposure Parameters for Tier I Screening Level Risk Assessment

Receptor	Prey Tissue Concentration (mg/kg dry wt)	Sediment Chemical Concentration (mg/kg dry wt)	Body Weight ¹ (kg)	Food Ingestion Rate ¹ (kg/day dry wt)	Sediment Ingestion Rate ² (kg/day dry wt)	Area Use Factor	Absorption Efficiency
California brown pelican	Maximum Detected Value	Maximum Detected Value	2.845	0.23	0.005	1	1
California least tern	Maximum Detected Value	Maximum Detected Value	0.036	0.044	0.0011	1	1
Western grebe	Maximum Detected Value	Maximum Detected Value	0.808	0.046	0.0031	1	1
Surf scoter	Maximum Detected Value	Maximum Detected Value	0.859	0.048	0.0028	1	1
California sea lion	Maximum Detected Value	Maximum Detected Value	45.0	0.99	0.0308	1	1
East Pacific green turtle	Maximum Detected Value	Maximum Detected Value	95	0.31	0.0186	1	1

1. Exponent, 2003
2. Exponent, 2002

23.2.3. Effects Characterization

Characterizing potential adverse effects to the receptors of concern requires a comparison of the receptor-specific exposure estimates to an appropriate toxicity reference value (TRV). As recommended by the Natural Resource Trustee Agencies, exposure estimates for the Tier I screening level risk assessment were compared to TRVs developed by the U.S. Navy/U.S. EPA Region 9 Biological Technical Assistance Group (BTAG) (DTSC, 2000). The BTAG TRVs were developed jointly by the U.S. Navy, Navy consultants, and regulatory agencies, including the U.S. EPA, DTSC – Human and Ecological Risk Division, San Diego Water Board, NOAA, U.S. FWS, Cal/EPA Office of Environmental Health Hazard Assessment (OEHHA), and DFG. The U.S. EPA, DTSC, and the other agencies endorse and recommend the use of the BTAG TRVs for ecological risk assessments conducted in California and in U.S. EPA Region IX.

The BTAG TRVs are presented as an upper and lower estimate of effects thresholds. The low-TRV is based on no-adverse-effects-levels (NOAELs) and represents a threshold below which no adverse effects are expected. The high-TRV is based on an approximate midpoint of the range of effects levels and represents a threshold above which adverse effects are likely to occur. The BTAG low and high TRVs for birds and mammals (site CoPCs only) are shown in Table 23-4 below. Because BTAG TRVs are not available for BAP for birds and chromium for birds and mammals, the NOAELs and low-adverse-effects-levels (LOAELs) identified by Exponent (2003) were used (Table 23-5). It should be noted that suitable reptilian TRVs were not found in the literature (Exponent, 2003). Therefore, avian TRVs were used to estimate potential adverse effects to the East Pacific green turtle.

Table 23-4 U.S. Navy/U.S. EPA Region 9 BTAG Toxicity Reference Values for Birds and Mammals (Shipyard Chemicals of Potential Concern Only)

Chemical	Birds		Mammals	
	Low TRV (mg/kg-day)	High TRV (mg/kg-day)	Low TRV (mg/kg-day)	High TRV (mg/kg-day)
Arsenic	5.5	22.0	0.32	4.7
Benzo[a]pyrene	Not Available	Not Available	1.31	32.8
Butyltins	0.73	45.9	0.25	15
Cadmium	0.08	10.4	0.06	2.64
Chromium	Not Available	Not Available	Not Available	Not Available
Copper	2.3	52.3	2.67	632
Lead	0.014	8.75	1.0	241
Mercury	0.039	0.18	0.027	0.27
	Not Available	Not Available	0.25	4.0
Nickel	1.38	56.3	0.133	31.6
PCBs	0.09	1.27	0.36	1.28

Chemical	Birds		Mammals	
	Low TRV (mg/kg-day)	High TRV (mg/kg-day)	Low TRV (mg/kg-day)	High TRV (mg/kg-day)
Selenium	0.23	0.93	0.05	1.21
Zinc	17.2	172	9.6	411

Table 23-5 NOAELs and LOAELs for Benzo[a]pyrene and Chromium Identified by Exponent

Chemical	Birds		Mammals	
	NOAEL (mg/kg-day)	LOAEL (mg/kg-day)	NOAEL (mg/kg-day)	LOAEL (mg/kg-day)
Benzo[a]pyrene	014	1.4	Not Used	Not Used
Chromium	0.86	4.3	3.3	69

(Exponent, 2003)

23.2.4. Risk Characterization

For the Tier I screening level risk assessment, the San Diego Water Board characterized potential risks of adverse effects to the receptors of concern by quantifying the risks at each of the site stations. Risks were estimated by integrating the exposure and effects assessments in Section 23.2.2 and 23.2.3 above using the hazard quotient approach:

$$HQ_{\text{low}} = \frac{IR_{\text{chemical}}}{TRV_{\text{low}}}$$

$$HQ_{\text{high}} = \frac{IR_{\text{chemical}}}{TRV_{\text{high}}}$$

where:

HQ	=	hazard quotient (unitless)
IR_{chemical}	=	total ingestion rate of the chemical (mg/kg body weight-day)
TRV	=	BTAG low or high toxicity reference value (mg/kg body weight-day)

An HQ value less than 1.0 indicates that the chemical is unlikely to cause adverse ecological effects to the receptor of concern. An HQ value greater than 1.0 indicates that the receptor's exposure to the chemical has exceeded the TRV, which could indicate that there is a potential that some fraction of the population may experience an adverse effect (Exponent, 2003). The HQ calculations and results for each receptor of concern at each assessment unit are provided in the Appendix for Section 23.

In addition to characterizing the risks at the Shipyard Sediment Site, the *Macoma* tissue concentrations at each site station were compared to the *Macoma* tissue concentrations derived from the reference station pool described in Section 17 of this Technical Report. The objective of this comparison was to determine whether or not the current Shipyard Sediment Site conditions pose a greater risk to the receptors of concern than the current reference conditions in San Diego Bay.

The 95% upper prediction limit (UPL) was calculated for the reference pool *Macoma* tissue concentrations. The 95% UPL allows a one-to-one comparison to be performed between a single Shipyard Sediment Site station (i.e., each of the nine bioaccumulation site stations) and a pool of “Reference Condition” stations (i.e., Reference Pool). Although multiple comparisons were made to the reference pool prediction limits, the San Diego Water Board made a decision to not correct for multiple comparisons so that the site/reference *Macoma* tissue comparisons would remain conservative and more protective. The 95% UPL for the reference pool *Macoma* tissue concentrations are provided in Table 23-6 below and the comparison results are provided in the Appendix for Section 23.

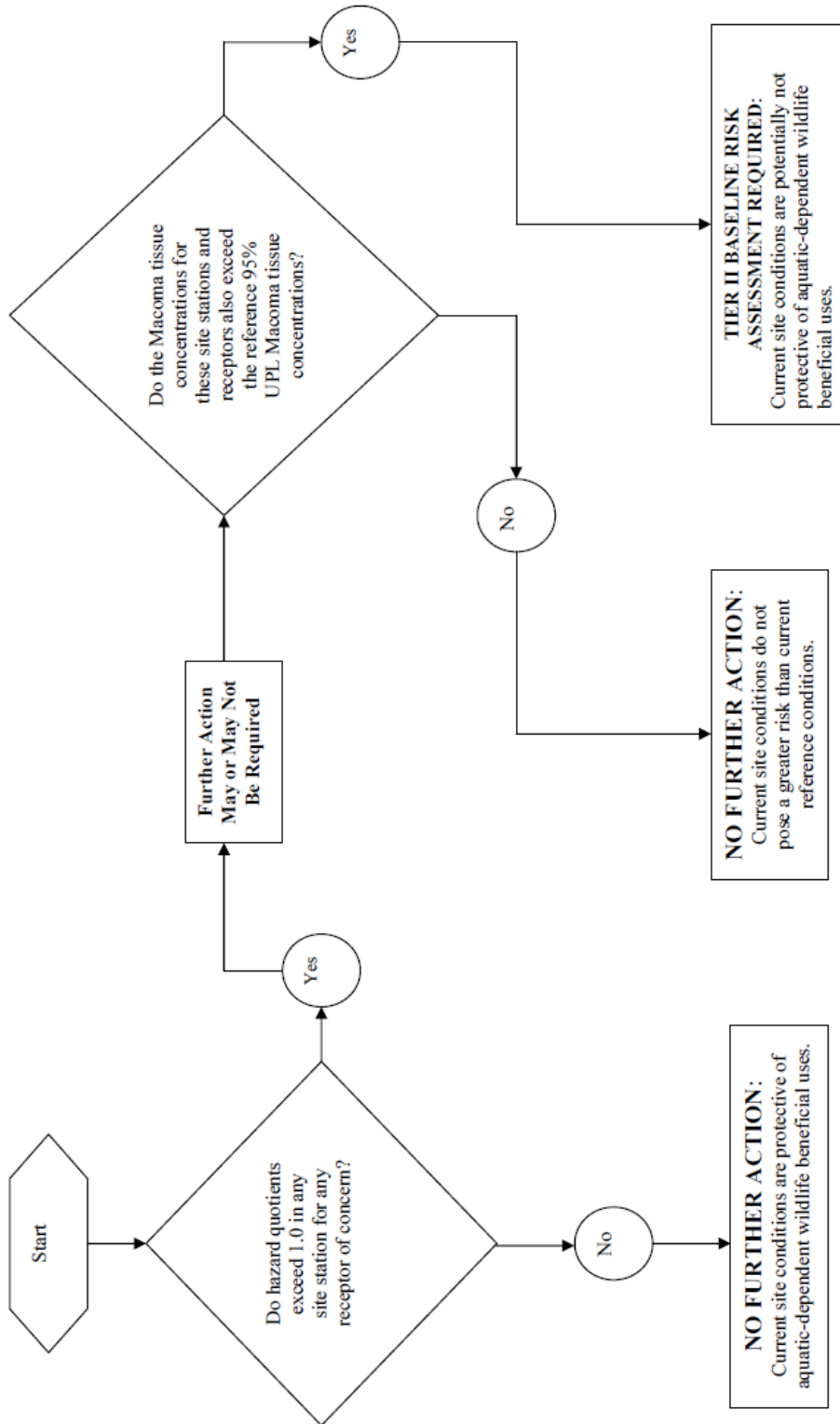
Table 23-6 Reference Pool 95% Upper Prediction Limits for *Macoma nasuta* Tissue Concentrations

Macoma Tissue Chemicals	95% Upper Prediction Limits
Metals	
Arsenic	22.8 mg/kg
Arsenic	22.8 mg/kg
Cadmium	0.39 mg/kg
Chromium	3.9 mg/kg
Copper	19.2 mg/kg
Lead	3.3 mg/kg
Mercury	0.15 mg/kg
Nickel	4.4 mg/kg
Selenium	4.9 mg/kg
Silver	0.57 mg/kg
Zinc	85.7 mg/kg
Organometallic Compounds	
Tributyltin	12 µg/kg
Organics	
Benzo[a]pyrene	132 µg/kg
Total Polychlorinated Biphenyls (PCB), as congeners	186 µg/kg
Total Polychlorinated Terphenyls (PCT)	All Reference Pool stations undetected

23.2.5. Risk Management

The San Diego Water Board identified two risk management decisions for the Tier I screening level risk assessment: (1) Current Shipyard Sediment Site conditions pose acceptable risks and no further action is warranted, and (2) Current Shipyard Sediment Site conditions pose a potential unacceptable risk that requires additional evaluation with a Tier II baseline risk assessment. These two management decisions are based on the risk characterization results at each Shipyard Sediment Site station and the *Macoma* tissue site/reference comparison results. A flow diagram (Figure 23-1) showing how each management decision is triggered is shown below and the results are presented in Table 23-1 above.

Figure 23-1 Flow Diagram for Tier I Aquatic-Dependent Wildlife Risk Management Decisions



23.2.6. Uncertainties Related to Risk Estimates

The process of evaluating aquatic-dependent wildlife risks involves multiple steps. Inherent in each step of the risk assessment process are uncertainties that ultimately affect the risk estimates. Uncertainties may exist in numerous areas such as estimation of potential site exposures and derivation of toxicity values. The most significant uncertainties in the Tier I risk analysis for the Shipyard Sediment Site are discussed below.

Tissue Chemical Concentrations. For this assessment, a 28-day laboratory bioaccumulation test using the clam *Macoma nasuta* was used to estimate exposure of prey items (fish and shellfish) to chemical pollutants of concern present at the Shipyard Sediment Site. For PCBs, dioxins, furans, PAHs, and metals, 80% of steady state generally occurs using the 28-day bioaccumulation test (U.S. EPA, 1998b; ASTM, 2001). Bioaccumulation testing protocols recommend that the bioaccumulation CoPCs reach approximately 80% of steady state tissue residues for a proper risk assessment. While attaining 100% steady state is ideal but not required in Tier I because it is a screening-level risk assessment, the San Diego Water Board recognizes that the observed tissue chemical concentrations in *Macoma nasuta* may be underestimated. Therefore, this may result in an underestimation of risk.

Surrogate for Fish-Eating Receptors. Chemical concentrations in *Macoma* tissue were used as a surrogate to estimate exposures to chemicals in food for all receptors of concern. Use of *Macoma* tissue for the receptors representing fish-eating marine birds and marine mammals (California least tern, California brown pelican, western grebe, and California sea lion) may result in an overestimation of risk because *Macoma* are more directly exposed to contaminants in the surface sediment than fish. *Macoma* actively ingests surface sediment to feed on detritus and also burrows into the sediment.

Exposure Parameters. The exposure parameters selected for Tier I are considered to be conservative values and therefore may result in an overestimation of risk.

Multiple Comparisons. Because multiple comparisons were made to the Baseline Pool, and each comparison carries with it a low probability (5%) of falsely identifying a statistical difference, there is a significant potential for multiple comparison error (SCCWRP and U.S. Navy, 2005b). This may result in an overestimation of risk.

TRV for Reptiles. For this risk assessment, avian TRVs were used as a surrogate for estimating risk to reptiles (specifically, East Pacific green turtle) because no appropriate reptile TRVs could be found for any site chemical of concern (Exponent, 2003). Avian TRVs were selected because birds are considered to be more taxonomically similar to reptiles than are mammals. This may underestimate or overestimate risks to the East Pacific green turtle.

24. Finding 24: Tier II Baseline Comprehensive Risk Assessment for Aquatic-Dependent Wildlife

Finding 24 of CAO No. R9-2012-0024 states:

The Tier II risk assessment objective was to more conclusively determine whether or not Shipyard Sediment Site conditions pose an unacceptable risk to aquatic-dependent wildlife receptors of concern. The receptors of concern selected for the assessment include: California least tern (*Sterna antillarum brownie*), California brown pelican (*Pelecanus occidentalis californicus*), Western grebe (*Aechmophorus occidentalis*), Surf scoter (*Melanitta perspicillata*), California sea lion (*Zalophus californianus*), and East Pacific green turtle (*Chelonia mydas agassizii*). Based on the Tier I screening level risk assessment results, there is a potential risk to all receptors of concern ingesting prey caught at the Shipyard Sediment Site and so a Tier II assessment was conducted. To focus the risk assessment, prey items were collected within four assessment units at the Shipyard Sediment Site and from a reference area located across the bay from the site. Chemical concentrations measured in fish were used to estimate chemical exposure for the least tern, western grebe, brown pelican, and sea lion and chemical concentrations in benthic mussels and eelgrass were used to estimate chemical pollutant exposure for the surf scoter and green turtle, respectively. Based on the Tier II risk assessment results, ingestion of prey items caught within all four assessment units at the Shipyard Sediment Site poses an increased risk above reference to all receptors of concern (excluding the sea lion). The chemicals in prey tissue posing a risk include BAP, PCBs, copper, lead, mercury, and zinc.

24.1. Tier II Results

For the Tier II risk assessment, six aquatic-dependent wildlife species were identified as potential receptors that could be at risk due to exposure to chemicals in prey caught at the Shipyard Sediment Site. The six receptors include: California least tern (*Sterna antillarum brownie*), California brown pelican (*Pelecanus occidentalis californicus*), Western grebe (*Aechmophorus occidentalis*), Surf scoter (*Melanitta perspicillata*), California sea lion (*Zalophus californianus*), and East Pacific green turtle (*Chelonia mydas agassizii*). Chemical concentrations measured in fish were used to estimate chemical pollutant exposure for the least tern, western grebe, brown pelican, and sea lion and chemical concentrations in benthic mussels and eelgrass were used to estimate chemical pollutant exposure for the surf scoter and green turtle, respectively.

Based on the Tier II results, as summarized in Table 24-1 and Table 24-2 below, the San Diego Water Board determined that ingestion of prey caught within all four assessment units at the Shipyard Sediment Site poses a risk to all aquatic-dependent wildlife receptors of concern (excluding the sea lion). The chemicals in prey tissue posing a risk include BAP, total polychlorinated biphenyls (PCBs), copper, lead, mercury, and zinc. NOAEL HQs exceeded 1.0 for some chemicals and receptors and there were no LOAEL HQs that exceeded 1.0 for any receptor or chemical (see Section 24.2.4 and Table 24-3). The Tier II risk calculations and results are provided in the Appendix for Section 24.

Table 24-1 Summary of Tier II Aquatic-Dependent Wildlife Risk Assessment Results for NASSCO Leasehold for NOAEL TRVs

Assessment Unit	Receptor	Site Chemicals in Prey Tissue Posing Risk ¹	Site Chemicals in Prey Tissue Not Posing Risk ²
Inside NASSCO Leasehold	Brown Pelican	PCBs, lead, mercury	BAP, tributyltin (TBT), arsenic, chromium, copper, nickel, selenium, zinc
	Least Tern	PCBs, lead, zinc	BAP, TBT, arsenic, chromium, copper, mercury, nickel, selenium
	Sea Lion	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Surf Scoter	copper, lead	BAP, PCBs, TBT, arsenic, chromium, mercury, nickel, selenium, zinc
	Western Grebe	lead	BAP, PCBs, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
	Green Turtle	lead	BAP, PCBs, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
Outside NASSCO Leasehold	Brown Pelican	PCBs, lead, mercury	BAP, TBT, arsenic, chromium, copper, nickel, selenium, zinc
	Least Tern	PCBs, lead, zinc	BAP, TBT, arsenic, chromium, copper, mercury nickel, selenium
	Sea Lion	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Western Grebe	PCBs, lead	BAP, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc

1. NOAEL HQ is greater than 1.0 and greater than the reference hazard quotient.
2. NOAEL HQ is less than 1.0 and less than the reference hazard quotient.

Table 24-2 Summary of Tier II Aquatic-Dependent Wildlife Risk Assessment Results for BAE Systems Leasehold for NOAEL TRVs

Assessment Unit	Receptor	Site Chemicals in Prey Tissue Posing Risk ¹	Site Chemicals in Prey Tissue Not Posing Risk ²
Inside BAE Systems Leasehold	Brown Pelican	PCBs, lead, mercury	BAP, TBT, arsenic, chromium, copper, nickel, selenium, zinc
	Least Tern	PCBs, lead, zinc	BAP, TBT, arsenic, chromium, copper, mercury, nickel, selenium
	Sea Lion	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Surf Scoter	BAP, copper, lead	PCBs, TBT, arsenic, chromium, mercury, nickel, selenium, zinc
	Western Grebe	PCBs, lead	BAP, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
	Green Turtle	lead	BAP, PCBs, TBT, arsenic, chromium, copper, mercury, nickel, selenium, zinc
Outside BAE Systems Leasehold	Brown Pelican	PCBs, lead, mercury	BAP, TBT, arsenic, chromium, copper, nickel, selenium, zinc
	Least Tern	PCBs, lead, zinc	BAP, TBT, arsenic, chromium, copper, mercury, nickel, selenium
	Sea Lion	NONE	BAP, PCBs, TBT, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc
	Western Grebe	PCBs, lead	BAP, TBT, arsenic, chromium, copper, mercury nickel, selenium, zinc

1. NOAEL HQ is greater than 1.0 and greater than the reference hazard quotient.
2. NOAEL HQ is less than 1.0 and less than the reference hazard quotient.

Table 24-3 Summary of Tier II Risk Assessment Hazard Quotients

Receptor Location	Arsenic		Chromium		Copper		Lead	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Brown Pelican								
Inside NASSCO	0.03	0.0076	0.18	0.035	0.3	0.013	14	0.023
Outside NASSCO	0.041	0.01	0.33	0.066	0.24	0.011	11	0.018
Inside SWM	0.037	0.0093	0.27	0.055	0.58	0.026	19	0.031
Outside SWM	0.038	0.0095	0.13	0.025	0.31	0.014	10	0.017
Reference	0.026	0.0064	0.1	0.02	0.16	0.0069	4.2	0.0068
Green Turtle								
Inside NASSCO	0.003	0.00075	0.057	0.011	0.33	0.015	6.3	0.01
Inside SWM	0.0042	0.0011	0.093	0.019	0.37	0.016	8.3	0.013
Reference	0.0019	0.00048	0.024	0.0047	0.06	0.0026	1.7	0.0028
Least Tern								
Inside NASSCO	0.058	0.015	0.26	0.053	0.48	0.021	18	0.028
Outside NASSCO	0.066	0.016	0.2	0.041	0.41	0.018	13	0.021
Inside SWM	0.077	0.019	0.27	0.054	0.93	0.041	33	0.052
Outside SWM	0.087	0.022	0.21	0.041	0.51	0.022	17	0.027
Reference	0.053	0.013	0.6	0.12	0.46	0.02	9.5	0.015
Sea Lion								
Inside NASSCO	0.14	0.0093	0.012	0.00057	0.068	0.00029	0.052	0.00022
Outside NASSCO	0.18	0.012	0.022	0.0011	0.054	0.00023	0.041	0.00017
Inside SWM	0.17	0.011	0.019	0.00089	0.13	0.00055	0.07	0.00029
Outside SWM	0.17	0.012	0.0085	0.00041	0.07	0.0003	0.038	0.00016
Reference	0.12	0.0078	0.0069	0.00033	0.035	0.00015	0.015	0.000064
Surf Scoter								
Inside NASSCO	0.15	0.038	0.5	0.099	1.8	0.079	38	0.061
Inside SWM	0.16	0.041	0.38	0.076	1.6	0.069	39	0.063
Reference	0.095	0.024	0.45	0.09	0.67	0.029	19	0.03
Western Grebe								
Inside NASSCO	0.0072	0.029	0.24	0.048	0.016	0.37	17	0.028
Outside NASSCO	0.031	0.0078	0.17	0.034	0.26	0.011	12	0.019
Inside SWM	0.038	0.0095	0.24	0.048	0.67	0.03	27	0.044
Outside SWM	0.04	0.01	0.17	0.034	0.31	0.014	14	0.022
Reference	0.025	0.0062	0.31	0.063	0.24	0.011	6.6	0.011

Table 24-3 Summary of Tier II Risk Assessment Hazard Quotients (continued)

Receptor Location	Mercury		Nickel		Selenium		Zinc	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Brown Pelican								
Inside NASSCO	1.3	0.28	0.076	0.0019	0.62	0.15	0.28	0.028
Outside NASSCO	1.2	0.26	0.076	0.0019	0.55	0.14	0.29	0.029
Inside SWM	1.1	0.24	0.086	0.0021	0.86	0.21	0.32	0.032
Outside SWM	1.1	0.24	0.067	0.0017	0.42	0.1	0.24	0.024
Reference	0.86	0.19	0.057	0.0014	0.19	0.047	0.25	0.025
Green Turtle								
Inside NASSCO	0.017	0.0036	0.013	0.00031	0.011	0.0028	0.078	0.0078
Inside SWM	0.031	0.0066	0.02	0.00048	0.011	0.0028	0.082	0.0082
Reference	0.0051	0.0011	0.0092	0.00022	0.01	0.0025	0.039	0.0039
Least Tern								
Inside NASSCO	0.32	0.07	0.078	0.0019	0.25	0.062	1.0	0.1
Outside NASSCO	0.31	0.068	0.071	0.0017	0.3	0.074	1.2	0.12
Inside SWM	0.34	0.074	0.11	0.0026	0.27	0.068	1.0	0.1
Outside SWM	0.38	0.081	0.077	0.0019	0.31	0.078	1.0	0.1
Reference	0.21	0.045	0.19	0.0047	0.52	0.13	0.82	0.082
Sea Lion								
Inside NASSCO	0.49	0.049	0.21	0.00086	0.75	0.031	0.13	0.003
Outside NASSCO	0.45	0.045	0.21	0.00087	0.67	0.027	0.14	0.0032
Inside SWM	0.41	0.041	0.23	0.00097	1.0	0.043	0.15	0.0035
Outside SWM	0.42	0.042	0.18	0.00077	0.5	0.021	0.11	0.0026
Reference	0.32	0.032	0.16	0.00065	0.23	0.0093	0.12	0.0028
Surf Scoter								
Inside NASSCO	0.21	0.046	0.32	0.0079	0.78	0.19	0.33	0.033
Inside SWM	0.22	0.047	0.19	0.0045	0.9	0.22	0.39	0.039
Reference	0.13	0.028	0.15	0.0038	0.84	0.21	0.26	0.026
Western Grebe								
Inside NASSCO	0.038	0.18	0.0013	0.053	0.029	0.12	0.047	0.47
Outside NASSCO	0.16	0.034	0.044	0.0011	0.14	0.034	0.55	0.055
Inside SWM	0.2	0.042	0.069	0.0017	0.13	0.032	0.5	0.05
Outside SWM	0.19	0.042	0.046	0.0011	0.15	0.036	0.48	0.048
Reference	0.1	0.022	0.09	0.0022	0.23	0.057	0.37	0.037

Table 24-3 Summary of Tier II Risk Assessment Hazard Quotients (continued)

Receptor Location	Benzo[a]pyrene		PCBs		TBT	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Brown Pelican						
Inside NASSCO	0.24	0.024	3.3	0.23	0.0094	0.00015
Outside NASSCO	0.2	0.02	1.5	0.11	0.018	0.00028
Inside SWM	0.35	0.035	3.5	0.25	0.015	0.00024
Outside SWM	0.2	0.02	2.1	0.15	0.014	0.00022
Reference	0.18	0.018	1.2	0.088	0.0044	0.00007
Green Turtle						
Inside NASSCO	0.029	0.0029	0.0033	0.00023	0.00007	1.1E-06
Inside SWM	0.09	0.009	0.0092	0.00065	0.00024	3.7E-06
Reference	0.014	0.0014	0.002	0.00014	0.000017	2.8E-07
Least Tern						
Inside NASSCO	0.29	0.029	2	0.14	0.0052	0.000082
Outside NASSCO	0.29	0.029	2.4	0.17	0.0069	0.00011
Inside SWM	0.52	0.052	3	0.21	0.012	0.00019
Outside SWM	0.32	0.032	2.3	0.16	0.02	0.00032
Reference	0.22	0.022	1.3	0.093	0.0052	0.000082
Sea Lion						
Inside NASSCO	0.0066	0.00026	0.22	0.061	0.0071	0.00012
Outside NASSCO	0.0055	0.00022	0.098	0.028	0.013	0.00022
Inside SWM	0.0099	0.00039	0.23	0.065	0.011	0.00019
Outside SWM	0.0057	0.00023	0.14	0.039	0.01	0.00017
Reference	0.0049	0.0002	0.081	0.023	0.0034	0.000056
Surf Scoter						
Inside NASSCO	0.75	0.075	0.37	0.026	0.032	0.00051
Inside SWM	2.1	0.21	0.57	0.04	0.04	0.00063
Reference	0.3	0.03	0.44	0.031	0.011	0.00017
Western Grebe						
Inside NASSCO	0.17	0.017	0.062	0.88	0.000043	0.0027
Outside NASSCO	0.15	0.015	1.0	0.074	0.0032	0.000051
Inside SWM	0.38	0.038	1.4	0.096	0.0064	0.0001
Outside SWM	0.16	0.016	1.0	0.073	0.0088	0.00014
Reference	0.1	0.01	0.57	0.041	0.0023	0.000036

Note: Reference HQs are based on samples collected in the vicinity of Station 2240.

24.2. Tier II Approach

The San Diego Water Board conducted a Tier II ecological risk assessment (i.e., baseline risk assessment) to more conclusively determine whether or not the current conditions at the Shipyard Sediment Site pose unacceptable risks to aquatic-dependent wildlife receptors of concern and to identify the need for remedial action. Risks were characterized by: (1) quantifying the risks at the site, and (2) comparing the site risks to the risks calculated at the reference areas.

The approach used in the baseline risk assessment was conducted in accordance with U.S. EPA's "Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)" (U.S. EPA, 1997a) and with DTSC's "Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities" (DTSC, 1996). The approach consists of the following key elements:

- Selection of Receptors of Concern
- Exposure Characterization
- Effects Characterization
- Risk Characterization
- Risk Management
- Uncertainties Related to Risk Estimates

These key elements are discussed in more detail below.

24.2.1. Selection of Receptors of Concern

For Tier II, fish-eating marine birds and mammals, mollusk-eating birds, and sea grass-eating reptiles were identified as important groups of aquatic-dependent wildlife that could be at risk due to exposure to chemicals in prey species at the Shipyard Sediment Site (Exponent, 2003). Six species were identified as suitable representative receptors for assessing potential risk to these groups as reviewed and approved by U.S. FWS, DFG, and NOAA (collectively known as the "Natural Resource Trustee Agencies"). The six species are shown in Table 24-4 below. These receptors were selected based on characteristics such as their presence at the site, feeding habits, known adverse effects from exposure to bioaccumulative contaminants, the availability of ample life history information in the literature, and federal or state listings of species as threatened or endangered.

Table 24-4 Receptors Selected for the Tier II Risk Assessment

Receptor	Scientific Name	Representative of	Comments
California least tern	<i>Sterna antillarum brownie</i>	Marine birds that may feed on small fish	Federal and California listed endangered species
California brown pelican	<i>Pelecanus occidentalis californicus</i>	Marine birds that may feed on small- to medium-sized fish	Federal and California listed endangered species
Western grebe	<i>Aechmophorus occidentalis</i>	Diving marine birds that may feed on small fish	
Surf scoter	<i>Melanitta perspicillata</i>	Diving marine birds that may feed on mollusks	
California sea lion	<i>Zalophus californianus</i>	Marine mammals that may feed on medium-sized fish	
East Pacific green turtle	<i>Chelonia mydas agassizii</i>	Marine reptiles that may feed on sea grasses	Listed as threatened wherever found and listed as endangered in Florida and on the Pacific coast of Mexico

24.2.2. Exposure Characterization

To focus the baseline risk assessment, the Shipyard Sediment Site was divided into four discrete assessment units to identify areas with a greater likelihood for adverse ecological effects to the receptors of concern (Exponent, 2003):

- Inside NASSCO – the area inside the NASSCO leasehold
- Outside NASSCO – the area between the NASSCO leasehold and the shipping channel
- Inside BAE Systems – the area inside the BAE Systems leasehold
- Outside BAE Systems – the area between the BAE Systems leasehold and the shipping channel.

The primary routes of exposure to pollutants at the Shipyard Sediment Site are through the ingestion of prey items and the incidental ingestion of sediment during foraging (Exponent, 2003). Separate chemical pollutant exposure estimates were developed for each receptor in each of the four assessment units using prey tissue and sediment chemical pollutant data collected at the Shipyard Sediment Site. The following prey items were used to estimate exposure to chemical pollutants in food for the receptors of concern:

Table 24-5 Prey Items Used in the Tier II Risk Assessment

Receptor	Prey Item	Scientific Name	Areas Collected
California least tern	Topsmelt	<i>Atherinops affinis</i>	Inside NASSCO
	Anchovies	<i>Engraulis mordax</i>	Outside NASSCO Inside/outside SWM
California brown pelican	Spotted sand bass	<i>Paralabrax masculatofasciatus</i>	Inside/outside NASSCO Inside/outside SWM
Western grebe	Topsmelt	<i>Atherinops affinis</i>	Inside NASSCO
	Anchovies	<i>Engraulis mordax</i>	Outside NASSCO Inside/outside SWM
Surf scoter	Benthic Mussels	<i>Musculista senhousi</i>	Inside NASSCO Inside SWM
California sea lion	Spotted sand bass	<i>Paralabrax masculatofasciatus</i>	Inside/outside NASSCO Inside/outside SWM
East Pacific green turtle	Eelgrass	<i>Zostera marina</i>	Inside NASSCO Inside SWM

Exposure estimates for the six receptors were developed using the following general intake equation (DTSC, 1996):

$$\text{Daily Intake}_{\text{chemical}} \text{ (in mg/kg - day)} = \frac{(\text{CM} * \text{CR} * \text{FI} * \text{AF})}{\text{BW}}$$

where:

- CM = concentration of the chemical in a given dietary component or inert medium (mg/kg)
- CR = contact rate (i.e., ingestion rate) of dietary component or inert medium (kg/day)
- FI = fraction of the daily intake of a given dietary component or inert medium derived from the site (unitless area-use factor)
- AF = relative gastrointestinal absorption efficiency for the chemical in a given dietary component or inert medium (fraction)
- BW = body weight of receptor species (kg)

The intake equation was further expanded to account for the ingestion of prey items and the incidental ingestion of sediment:

$$\text{Daily Intake}_{\text{chemical}} \text{ (in mg/kg - day)} = \frac{[(\text{CM} * \text{CR} * \text{FI} * \text{AF})_{\text{prey}} + (\text{CM} * \text{CR} * \text{FI} * \text{AF})_{\text{sediment}}]}{\text{BW}}$$

The assumptions used by the San Diego Water Board in the expanded equation to estimate receptor exposure at each assessment unit are shown in Table 24-6 below and the exposure estimate calculations using these assumptions are provided in the Appendix for Section 24.

Table 24-6 Exposure Parameters for Tier II Baseline Risk Assessment

Receptor	Prey Tissue Concentration (mg/kg dry wt)	Sediment Chemical Concentration (mg/kg dry wt)	Body Weight ¹ (kg)	Food Ingestion Rate ¹ (kg/day dry wt)	Sediment Ingestion Rate ¹ (kg/day dry wt)	Area Use Factor	Absorption Efficiency
California brown pelican	Mean Detected Value	Mean Detected Value	3.174	0.25	0.005	1	1
California least tern	Mean Detected Value	Mean Detected Value	0.045	0.0053	0.00011	1	1
Western grebe	Mean Detected Value	Mean Detected Value	1.2	0.062	0.0031	1	1
Surf scoter	Mean Detected Value	Mean Detected Value	1.05	0.056	0.0028	1	1
California sea lion	Mean Detected Value	Mean Detected Value	75	1.54	0.0308	1	1
East Pacific green turtle	Mean Detected Value	Mean Detected Value	95	0.35	0.0186	1	1

1. Exponent, 2003

24.2.3. Effects Characterization

Characterizing potential adverse effects to the receptors of concern requires a comparison of the receptor-specific exposure estimates to an appropriate toxicity reference value (TRV). As recommended by the Natural Resource Trustee Agencies, exposure estimates for the baseline risk assessment were compared to TRVs developed by BTAG (DTSC, 2000). The BTAG TRVs were developed jointly by the U.S. Navy, Navy consultants, and regulatory agencies, including the U.S. EPA, DTSC – Human and Ecological Risk Division, San Diego Water Board, NOAA, U.S. FWS, Cal/EPA Office of Environmental Health Hazard Assessment (OEHHA), and DFG. The U.S. EPA, DTSC, and the other agencies endorse and recommend the use of the BTAG TRVs for ecological risk assessments conducted in California and in U.S. EPA Region 9.

The BTAG TRVs are presented as an upper and lower estimate of effects thresholds. The low-TRV is based on no-adverse-effects-levels (NOAELs) and represents a threshold below which no adverse effects are expected. The high-TRV is based on an approximate midpoint of the range of effects levels and represents a threshold above which adverse effects are likely to occur. The BTAG low and high TRVs for birds and mammals (site CoPCs only) are shown in Table 24-7 below. Because BTAG TRVs are not available for BAP for birds and chromium for birds and mammals, the NOAELs and low-adverse-effects-levels (LOAELs) identified by Exponent (2003) were used (Table 24-8). It should be noted that suitable reptilian TRVs were not found in the literature (Exponent, 2003). Therefore, avian TRVs were used to estimate potential adverse effects to the East Pacific green turtle.

Table 24-7 U.S. Navy/U.S. EPA Region 9 BTAG Toxicity Reference Values for Birds and Mammals (Shipyard Chemicals of Potential Concern Only)

Chemical	Birds		Mammals	
	Low TRV (mg/kg-day)	High TRV (mg/kg-day)	Low TRV (mg/kg-day)	High TRV (mg/kg-day)
Arsenic	5.5	22.0	0.32	4.7
Benzo[a]pyrene	Not Available	Not Available	1.31	32.8
Butyltins	0.73	45.9	0.25	15
Cadmium	0.08	10.4	0.06	2.64
Chromium	Not Available	Not Available	Not Available	Not Available
Copper	2.3	52.3	2.67	632
Lead	0.014	8.75	1.0	241
Mercury	0.039	0.18	0.027	0.27
	Not Available	Not Available	0.25	4.0
Nickel	1.38	56.3	0.133	31.6
PCBs	0.09	1.27	0.36	1.28
Selenium	0.23	0.93	0.05	1.21
Zinc	17.2	172	9.6	411

Table 24-8 NOAELs and LOAELs for Benzo[a]pyrene and Chromium Identified by Exponent

Chemical	Birds		Mammals	
	NOAEL (mg/kg-day)	LOAEL (mg/kg-day)	NOAEL (mg/kg-day)	LOAEL (mg/kg-day)
Benzo[a]pyrene	0.14	1.4	Not Used	Not Used
Chromium	0.86	4.3	3.3	69

(Exponent, 2003)

24.2.4. Risk Characterization

For the baseline risk assessment, the San Diego Water Board characterized potential risks of adverse effects to the receptors of concern by quantifying the risks at each of the four assessments. Risks were estimated by integrating the exposure and effects assessments in Sections 24.2.2 and 24.2.3 above using the hazard quotient approach:

$$HQ_{low} = \frac{IR_{chemical}}{TRV_{low}}$$

$$HQ_{high} = \frac{IR_{chemical}}{TRV_{high}}$$

HQ	=	hazard quotient (unitless)
IR_{chemical}	=	total ingestion rate of the chemical (mg/kg body weight-day)
TRV	=	BTAG low or high toxicity reference value (mg/kg body weight-day)

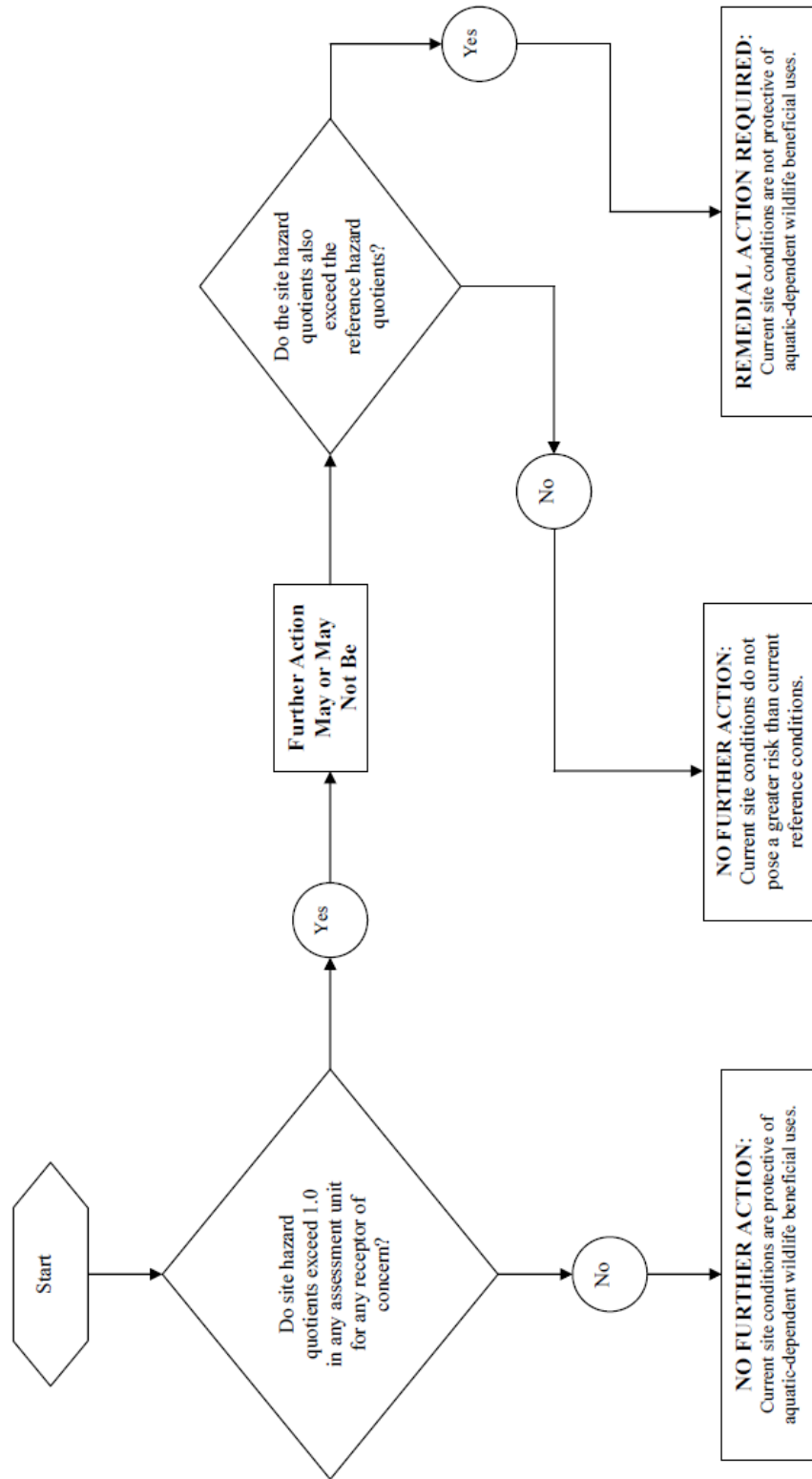
An HQ value less than 1.0 indicates that the chemical is unlikely to exceed the TRV for the receptor of concern. An HQ value greater than 1.0 indicates that the receptor's exposure to the chemical pollutant is predicted to exceed the TRV, which could indicate that there is a potential that some fraction of the population may experience an adverse effect (Exponent, 2003). The significance of any HQ greater than 1.0 depends in large part on the relevance of the TRV. In this assessment, HQs were calculated for two risk thresholds. The TRV_{low} is a no-effect level (i.e., a level at which no effects are predicted). The TRV_{high} is a demonstrated effect level. The actual threshold of adverse effects is predicted to lie somewhere between these two thresholds. The HQ calculations and risk characterization results for each receptor of concern at each assessment unit are provided in the Appendix for Section 24 and summarized in Table 24-3.

In addition to characterizing the risks at the Shipyard Sediment Site, risks were also characterized at a reference area to determine whether or not the site poses a greater risk to the receptors of concern than reference conditions in San Diego Bay. The reference area, located in the vicinity of Reference Station 2240, is located across the bay from the Shipyard Sediment Site (Exponent, 2003). Spotted sand bass, topsmelt, anchovies, benthic mussels, and eelgrass were collected from this reference area and the chemical concentrations from these prey items were used to estimate exposure to the receptors of concern. Risks at the reference area were calculated using the same CoPCs, exposure assumptions, and TRVs as those identified above for the Shipyard Sediment Site. The HQ calculations and risk characterization results for the reference area are provided in the Appendix for Section 24.

24.2.5. Risk Management

The San Diego Water Board identified two risk management decisions: (1) Current site conditions pose acceptable risks and no further action is warranted, and (2) Current site conditions pose unacceptable risks that require remedial action. These two management decisions are based on the risk characterization results at the Shipyard Sediment Site and at the reference area. A flow diagram showing how each management decision is triggered is shown below in Figure 24-1.

Figure 24-1 Flow Diagram for Tier II Aquatic-Dependent Wildlife Risk Management Decisions



24.2.6. Uncertainties Related to Risk Estimates

The process of evaluating aquatic-dependent wildlife risk involves multiple steps. Inherent in each step of the risk assessment process are uncertainties that ultimately affect the risk estimates. Uncertainties may exist in numerous areas such as estimation of potential site exposures and derivation of toxicity values. The most significant uncertainties in the Tier II risk analysis for the Shipyard Sediment Site are discussed below.

Area Use Factor. In the Shipyard Report, Exponent used area use factors for the aquatic-dependent wildlife risk assessment based on an analysis of the fraction of theoretical suitable foraging habitat represented by the Shipyard Site relative to San Diego Bay. This approach assumes that the Shipyards are equally attractive to foraging receptors as other potential foraging habitats throughout the Bay.

TRV for Reptiles. For this risk assessment, avian TRVs were used as a surrogate for estimating risk to reptiles (specifically, East Pacific green turtle) because no appropriate reptile TRVs could be found for any site chemical of concern (Exponent, 2003). Avian TRVs were selected because birds are considered to be more taxonomically similar to reptiles than are mammals. This may underestimate or overestimate risks to the East Pacific green turtle.

Fish Home Range. Spotted sand bass, topsmelt, and anchovies were collected in four discrete assessment units at the Shipyard Sediment Site: inside NASSCO leasehold, outside NASSCO leasehold, inside BAE Systems leasehold, and outside BAE Systems leasehold. It is assumed that the assessment units bound the home range for these fish and that the observed tissue chemical concentrations are based exclusively from exposure within these areas. This may, however, not be indicative of their actual exposures because these fish may feed beyond the assessment unit boundaries. Therefore, the estimated risk to the receptors of concern ingesting the fish may not characterize actual exposures to the Shipyard Sediment Site.

Composite Prey Samples. Forage fish and mussel samples were composited within each assessment unit to provide an adequate sample size for analytical purposes (Exponent, 2003). This is considered to be representative of the actual exposure received by the receptors of concern because they would typically catch and consume a wide range of prey across each unit. However, compositing may reduce the contribution of the most highly contaminated prey items ingested in the exposure assessment.

Mean Chemical Concentrations. The exposure estimates in this risk assessment are based on mean chemical concentrations in prey items and incidentally ingested sediment. This reflects spatial variation in chemical concentrations across each assessment unit and represents the actual exposure received by the receptors of concern utilizing the entire assessment unit while foraging for prey. This may, however, reduce the contribution of the most highly contaminated prey items ingested in the exposure assessment.

25. Finding 25: Human Health Impairment

Finding 25 of CAO No. R9-2012-0024 states:

Human health beneficial uses for Shellfish Harvesting (SHELL), and Commercial and Sport Fishing (COMM) designated for San Diego Bay are impaired due to the elevated levels of pollutants present in the marine sediment at the Shipyard Sediment Site. This finding is based on the considerations described below in this *Impairment of Human Health Beneficial Uses* section of the CAO.

25.1. Human Health Beneficial Uses

There are four beneficial uses designated in the Basin Plan for San Diego Bay (RWQCB 1994), which must be fully protected in order to provide for the protection of human health:

- **Contact Water Recreation (REC-1)** – Includes uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and SCUBA diving, surfing, white water activities, fishing, or use of natural hot springs;
- **Non-contact Water Recreation (REC-2)** – Includes the uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities;
- **Shellfish Harvesting (SHELL)** – Includes uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters and mussels) for human consumption, commercial, or sport purposes; and
- **Commercial and Sport Fishing (COMM)** – Includes the uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.

The concentrations of the pollutants present in the marine sediment within and adjacent to the Shipyard Sediment Site cause or threaten to cause a condition of pollution or contamination that adversely impacts two of these beneficial uses, SHELL and COMM, and thereby constitute a threat to the public health. Information supporting this conclusion is contained in Sections 26 through 28 of this Technical Report.

26. Finding 26: Risk Assessment Approach for Human Health

Finding 26 of CAO No. R9-2012-0024 states:

The San Diego Water Board evaluated potential risks to human health from chemical pollutants present in the sediment at the Shipyard Sediment Site based on a two-tier approach. The Tier I screening level risk assessment was based on tissue data derived from the exposure of the clam *Macoma nasuta* to site sediments for 28 days using ASTM protocols. The Tier II baseline comprehensive risk assessment was based on tissue data derived from resident fish and shellfish caught within and adjacent to the Shipyard Sediment Site. Two types of receptors (i.e., members of the population or individuals at risk) were evaluated:

- a. Recreational Anglers – Persons who eat the fish and/or shellfish they catch recreationally; and
 - b. Subsistence Anglers – Persons who fish for food, for economic and/or cultural reasons, and for whom the fish and/or shellfish caught is a major source of protein in their diet.
-

26.1. Human Health Risk Assessment Approach

A two-tiered approach was used to evaluate potential risks to human health from chemical pollutants present at the Shipyard Sediment Site. The Tier I screening level risk assessment used conservative exposure and effects assumptions to support risk management decisions. The Tier II comprehensive risk assessment (i.e., baseline risk assessment) more accurately characterized potential risk to receptors of concern primarily by replacing the conservative assumptions required by Tier I with site-specific exposure parameters.

The approach used in Tiers I and II was conducted in accordance with U.S. EPA's "Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)" (U.S. EPA, 1989b). The approach consists of the following key elements:

- Identification of Chemicals of Potential Concern;
- Exposure Assessment;
- Toxicity Assessment;
- Risk Characterization;
- Risk Management; and
- Uncertainties Related to Risk Estimates.

These elements are discussed in more detail in Section 27 – Tier I Screening Level Risk Assessment for Human Health and Section 28 – Tier II Baseline Risk Assessment for Human Health of this Technical Report.

27. Finding 27: Tier I Screening Level Risk Assessment for Human Health

Finding 27 of CAO No. R9-2012-0024 states:

The Tier I risk assessment objectives were to determine whether or not Shipyard Sediment Site conditions potentially pose an unacceptable risk to human health and to identify if a comprehensive, site-specific risk assessment was warranted (i.e., Tier II baseline risk assessment). The receptors of concern identified for Tier I are recreational anglers and subsistence anglers. Recreational anglers represent those who eat the fish and/or shellfish they catch recreationally and subsistence anglers represent those who fish for food, for economic and/or cultural reasons, and for whom the fish and/or shellfish caught is a major source of protein in the diet. Chemical concentrations measured in *Macoma nasuta* tissue derived from laboratory bioaccumulation tests were used to estimate chemical exposure for these receptors of concern. Based on the Tier I screening level risk assessment results, there is a potential risk greater than that in reference areas to recreational and subsistence anglers ingesting fish and shellfish caught at the Shipyard Sediment Site. The chemicals in *Macoma* tissue posing a potential risk include arsenic, BAP, PCBs, and TBT.

27.1. Tier I Results

For the Tier I screening level risk assessment, recreational anglers and subsistence anglers were identified as potential receptors that could be at risk due to exposure of chemical pollutants in fish and shellfish caught at the Shipyard Sediment Site. Recreational anglers represent those who eat the fish and/or shellfish they catch recreationally and subsistence anglers represent those who fish for food, for economic and/or cultural reasons, and for whom the fish and/or shellfish caught is a major source of protein in the diet. Chemical concentrations measured in *Macoma nasuta* tissue derived from laboratory bioaccumulation tests were used to estimate chemical pollutant exposure for these receptors of concern.

Based on the Tier I results as summarized in Table 27-1 below, the San Diego Water Board determined that there was a potential risk to recreational and subsistence anglers ingesting fish and shellfish caught at the Shipyard Sediment Site and that a Tier II baseline risk assessment was warranted. The chemicals in *Macoma* tissue posing a potential risk include arsenic, BAP, PCBs, and TBT. The Tier I calculations and results are provided in the Appendix for Section 27.

Table 27-1 Summary of Tier I Human Health Risk Assessment Results.

Station	Receptor	Site Chemicals in <i>Macoma</i> Tissue Posing a Potential Risk ¹	Site Chemicals in <i>Macoma</i> Tissue Not Posing Risk ²
NA06	Recreational Angler	BAP, PCBs	TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
	Subsistence Angler	BAP, PCBs	TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
NA11	Recreational Angler	BAP	PCBs, TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
	Subsistence Angler	BAP	PCBs, TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
NA12	Recreational Angler	NONE	BAP, PCBs, TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
	Subsistence Angler	NONE	BAP, PCBs, TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
NA20	Recreational Angler	BAP	PCBs, TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
	Subsistence Angler	BAP	PCBs, TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
SW04	Recreational Angler	BAP, PCBs, arsenic	TBT, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
	Subsistence Angler	BAP, PCBs, TBT, arsenic	Cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
SW13	Recreational Angler	BAP, PCBs	TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
	Subsistence Angler	BAP, PCBs	TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc

Station	Receptor	Site Chemicals in <i>Macoma</i> Tissue Posing a Potential Risk ¹	Site Chemicals in <i>Macoma</i> Tissue Not Posing Risk ²
SW21	Recreational Angler	BAP, PCBs	TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
	Subsistence Angler	BAP, PCBs	TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
SW28	Recreational Angler	BAP, PCBs	TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc
	Subsistence Angler	BAP, PCBs	TBT, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, zinc

1. Site *Macoma* tissue concentration greater than risk-based tissue screening level and greater than the reference 95% upper prediction limit *Macoma* tissue concentration.
2. Site *Macoma* tissue concentration less than risk-based tissue screening level and less than the reference 95% upper prediction limit *Macoma* tissue concentration OR site *Macoma* tissue concentration greater than risk-based tissue screening level and less than the reference 95% upper prediction limit *Macoma* tissue concentration

27.2. Tier I Approach

The San Diego Water Board conducted a Tier I screening level risk assessment to determine whether or not the current conditions at the Shipyard Sediment Site pose a potential unacceptable risk to human health and to determine whether or not a comprehensive, site-specific risk assessment was warranted (i.e., Tier II baseline risk assessment). Potential risks were characterized by: (1) comparing clam tissue concentrations exposed to site sediment to tissue screening values published by the California Office of Environmental Health Hazard (OEHHA), and (2) comparing clam tissue concentrations exposed to site sediment to clam tissue concentrations exposed to reference sediment.

The approach used in the Tier I screening level risk assessment was conducted in accordance with U.S. EPA's "Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)" (U.S. EPA, 1989b) and in consultation with OEHHA. The approach consists of the following key elements:

- Exposure Assessment;
- Toxicity Assessment;
- Risk Characterization;
- Risk Management; and
- Uncertainties Related to Risk Estimates.

These key elements are discussed in more detail below.

27.2.1. Exposure Assessment

Human exposure to contaminated marine sediment can occur around three principal pathways:

- Direct contact of contaminated marine sediment by swimmers or divers;
- Incidental ingestion of contaminated marine sediment or associated waters by swimmers or divers; and
- Bioaccumulation and food chain transfer of sediment chemical pollutants to human consumers of contaminated fish and shellfish.

The most significant theoretical human health risk associated with contaminated marine sediment is considered to be the ingestion, over time, of fish and shellfish that may have bioaccumulated chemical pollutants either directly from marine sediment or through the food web (Long, 1989). U.S. EPA literature suggests that even when conservative assumptions about direct human exposure are used, risks associated with dermal contact and incidental ingestion of contaminated sediment are minimal and contribute less to the total risk than the fish and shellfish consumption pathway. The human health risks associated with fish and shellfish consumption often constitute the greatest proportion of the total risk, and sometimes drive the human health risk assessment (U.S. EPA, 1992b).

27.2.1.1. Shipyard Sediment Site Exposure Assessment

The most significant potential source of human exposure to chemical pollutants at the Shipyard Sediment Site is through consumption of fish and shellfish that may have bioaccumulated chemicals either directly from site sediment or through the food web (Exponent, 2003). Direct contact with sediment chemical pollutants at the Shipyard Sediment Site is not a likely exposure pathway to humans because the industrial nature of the site and the lack of a beach (shoreline at Shipyard Sediment Site consists almost exclusively of riprap, sheet-pile bulkhead, and piers) make swimming and wading a highly unlikely event. Therefore, two types of receptors (i.e., members of the population or individuals at risk) were identified and further evaluated in the Tier I screening level risk assessment:

11. Recreational Angler – represents those who eat the fish and/or shellfish they catch recreationally.
12. Subsistence Angler – represents those who fish for food, for economic and/or cultural reasons, and for whom the fish and/or shellfish caught is a major source of protein in the diet.

Exponent reported that public fishing and shellfish harvesting are currently unlikely events at the Shipyard Sediment Site due to the current security measures. Under the current site usage, there are security measures in place at both the upland property and the in-water leaseholds of NASSCO and BAE Systems due to the work performed on U.S. Navy ships (Exponent, 2003). Force protection measures, required for U.S. Navy vessels, prohibit non-mission-essential vessels from approaching U.S. Navy ships. A security boom prevents unauthorized vessels from

approaching closer than 300 feet in the NASSCO and BAE Systems leaseholds. Furthermore, armed personnel are present at all times to ensure that no trespassing occurs at the site.

Despite these factors the San Diego Water Board, as discussed with OEHHA, required a screening level risk assessment using the two theoretical receptors identified above based on the following recommended considerations (Brodberg, personal communication, 2004):

- Although fishing is currently prohibited, it is possible that NASSCO and BAE Systems employees or U.S. Navy personnel may fish off of the piers, bulkhead, riprap, ships, etc.;
- Although NASSCO and BAE Systems have long-term leases (NASSCO through 2040, BAE through 2034), it is possible that they may not occupy the site in the future and future site usage may allow for fishing. This scenario recently occurred at a former shipyard (Campbell Shipyard) located in San Diego Bay just north of the Shipyard Sediment Site;
- It is possible that sediment chemical pollutants within the NASSCO and BAE Systems leaseholds may migrate to areas outside the leasehold where fishing by boat and fishing at a nearby public pier (Crosby Street Park Pier located approximately ½ mile north of BAE Systems just past the Coronado Bridge) is accessible; and
- The San Diego Water Board's statutory responsibility is to protect the present and reasonably anticipated beneficial uses designated for San Diego Bay. The beneficial uses pertaining to human health are Commercial and Sport Fishing (COMM) and Shellfish Harvesting (SHELL). These beneficial uses are to be protected at all times regardless of the current site-access measures that prevent the uses from occurring.

For Tier I, the tissue concentrations derived from the laboratory bioaccumulation tests were used to represent the chemical pollutant exposures for the recreational and subsistence anglers. The bioaccumulation tests involved the exposure of the clam *Macoma nasuta* to site sediment for 28 days using the protocols specified by ASTM (2001). Sediment was collected from four stations in the NASSCO leasehold (NA06, NA11, NA12, and NA20) and five stations in the BAE Systems leasehold (SW04, SW08, SW13, SW21, and SW28). These stations were positioned along an expected gradient of sediment concentrations of potentially bioaccumulative substances at each shipyard. Because *Macoma* actively ingests surface sediment (likely to be the most direct route of exposure to sediment pollutants that accumulate in tissues), use of *Macoma* tissue data for estimating exposure to the receptors of concern is considered a conservative approach.

The *Macoma* tissue concentrations from each site station were compared to risk-based screening values developed by OEHHA (Brodberg and Pollock, 1999). These screening levels were developed for two California lakes, San Pablo Reservoir and Black Butte Reservoir, to determine whether additional sampling and health evaluations were warranted. While these screening levels were derived for two freshwater bodies, OEHHA (Brodberg, 2004) has indicated that the screening levels are applicable for chemicals in all fish and water bodies (i.e., freshwater, estuarine, and marine). For site chemical pollutants of concern that do not have screening values

published by OEHHA, the San Diego Water Board derived screening values for these chemical pollutants using the same equations and assumptions used by OEHHA. Additionally, because the screening value assumptions used by OEHHA were considered more applicable to recreational anglers (specifically due to the consumption rate of 21 g/day), the San Diego Water Board developed a separate set of screening values for subsistence anglers (using a consumption rate of 161 g/day).

For noncarcinogenic chemical pollutants, screening values were derived using the following equation:

$$SV_{\text{noncarcinogenic}} = \frac{(Rfd * BW)}{(CR * FI)}$$

where:

SV	=	tissue screening value for fish/shellfish tissue (µg/kg wet)
Rfd	=	reference dose (mg/kg-day)
BW	=	body weight of adult (kg)
CR	=	fish and shellfish consumption rate (g/day)
FI	=	fractional intake of seafood consumed that originates from site (unitless)

For carcinogenic chemicals, screening values were derived using the following:

$$SV_{\text{carcinogenic}} = \frac{(TRL * BW)}{(CSF * CR * FI * ABS)}$$

where:

SV	=	tissue screening value for fish/shellfish tissue (µg/kg wet)
TRL	=	target risk level (unitless)
BW	=	body weight of adult (kg)
CSF	=	carcinogenic slope factor (mg/kg-day) ⁻¹
CR	=	fish and shellfish consumption rate (g/day)
FI	=	fractional intake of seafood consumed that originates from site (unitless)
ABS	=	fraction absorbed (unitless)

The San Diego Water Board used the following exposure parameters (Table 27-2), in consultation with OEHHA, to develop the noncarcinogenic and carcinogenic screening values presented in the risk characterization section below.

Table 27-2 Exposure Parameters for Screening Level Development in the Tier I Human Health Risk Assessment

	Units	Recreational Angler	Subsistence Angler
Noncarcinogenic Chemicals			
Body Weight of Adult	kg	70	70
Consumption Rate (a)	g/day	21	161 ¹
Fractional Intake	kg/day dry wt	1	1
RfD	mg/kg-day	See Toxicity Assessment Section	See Toxicity Assessment Section
Carcinogenic Chemicals			
Target Risk Level	unitless	1 x 10 ⁻⁵	1 x 10 ⁻⁵
Body Weight of Adult	kg	70	70
Consumption Rate	g/day	21	161 ¹
Fractional Intake	unitless	1	1
Fraction Absorbed	unitless	1	1
CSF	(mg/kg-day) ⁻¹	See Toxicity Assessment Section 27.2.2	See Toxicity Assessment Section 27.2.2

1. SCCWRP and MBC, 1994

27.2.2. Toxicity Assessment

Reference doses (RfDs) for noncarcinogenic chemicals and cancer slope factors (CSFs) for carcinogenic chemicals were used when it was necessary to derive screening values for the Tier I risk analysis. The RfDs and CSFs were selected from U.S. EPA's Integrated Risk Information System (IRIS) with the exception of the carcinogenic PAHs (U.S. EPA, 2003a). For the carcinogenic PAHs, CSFs were used from the California Environmental Protection Agency (OEHHA, 2001). The RfDs and CSFs are listed in Table 27-3 below.

Table 27-3 Toxicity Criteria Used to Develop Human Health Tissue Screening Values

Chemical	CSF (mg/kg-day)	RfD (mg/kg-day)	Source
Metals			

Chemical	CSF (mg/kg-day)	RfD (mg/kg-day)	Source
Arsenic, inorganic	1.5	0.0003	U.S. EPA (2003a)
Cadmium	NA	0.0005	U.S. EPA (2003a)
Chromium	NA	0.003	U.S. EPA (2003a)
Copper	NA	0.037	U.S. EPA (2003a)
Mercury, total	NA	0.0001	U.S. EPA (2003a)
Nickel	NA	0.02	U.S. EPA (2003a)
Selenium	NA	0.005	U.S. EPA (2003a)
Silver	NA	0.005	U.S. EPA (2003a)
Zinc	NA	0.3	U.S. EPA (2003a)
Organometallic Compounds			
Tributyltin	NA	0.0003	U.S. EPA (2003a)
Polynuclear Aromatic Hydrocarbons			
Naphthalene	NA	0.02	U.S. EPA (2003a)
Acenaphthene	NA	0.06	U.S. EPA (2003a)
Fluorene	NA	0.04	U.S. EPA (2003a)
Anthracene	NA	0.3	U.S. EPA (2003a)
Fluoranthene	NA	0.04	U.S. EPA (2003a)
Pyrene	NA	0.02	U.S. EPA (2003a)
Benz[a]anthracene	1.2	NA	OEHHA (2001)
Chrysene	0.12	NA	OEHHA (2001)
Benzo[b]fluoranthene	1.2	NA	OEHHA (2001)
Benzo[k]fluoranthene	1.2	NA	OEHHA (2001)
Benzo[a]pyrene	12	NA	OEHHA (2001)
Indeno[1,2,3-cd]pyrene	1.2	NA	OEHHA (2001)
Dibenz[a,h]anthracene	4.1	NA	OEHHA (2001)

Chemical	CSF (mg/kg-day)	RfD (mg/kg-day)	Source
Polychlorinated Biphenyls			
Total PCBs ¹	2	NA	U.S. EPA (2003a)
Total PCBs (as Aroclor 1254) ²	NA	0.00002	U.S. EPA (2003a)

Notes: CSF – cancer slope factor, NA – not available, RfD – reference dose

- To be applied to the sum of Aroclors[®] 1248, 1254, and 1260, as in Brodberg and Pollock (1999). Aroclors[®] 1248 and 1254 were not detected in any sample, so the concentration of total PCBs reflects only Aroclor[®] 1260 in this assessment.
- RfDs are available only for Aroclors[®] 1254 and 1016, neither of which were detected in any sample. The RfD for Aroclor[®] 1254 was used as a surrogate.

27.2.3. Risk Characterization

For the Tier I screening level risk assessment, the San Diego Water Board characterized potential risks of adverse effects to recreational and subsistence anglers by comparing *Macoma nasuta* tissue concentrations from the nine Shipyard Sediment Site stations to tissue screening values published by OEHHA and to those derived by the San Diego Water Board. The tissue screening values are presented in Table 27-4 below. Site *Macoma* tissue pollutant concentrations greater than the screening values are considered to be a potential risk to recreational and/or subsistence anglers.

Table 27-4 Tissue Screening Values for Recreational and Subsistence Anglers

	Chemical	Screening Values for Recreational Angler(µg/kg wet)	Screening Values for Subsistence Angler(µg/kg wet)
Metals	Arsenic, total (non-cancer)	1,000	130
	Arsenic, inorganic (cancer)	22	0.29
	Cadmium	3,000	217
	Chromium	10,000	1,300
	Copper	120,000	16,000
	Mercury, total	300	44
	Nickel	67,000	9,000
	Selenium	20,000	2,000

	Chemical	Screening Values for Recreational Angler($\mu\text{g}/\text{kg}$ wet)	Screening Values for Subsistence Angler($\mu\text{g}/\text{kg}$ wet)
	Silver	17,000	2,174
	Zinc	1,000,000	130,000
Organometallic Compounds	Tributyltin	1,000	130
Polynuclear Aromatic	Naphthalene	67,000	9,000
	Acenaphthene	200,000	26,000
Hydrocarbons	Fluorene	130,000	17,000
	Anthracene	1,000,000	130,000
	Fluoranthene	130,000	17,000
	Pyrene	67,000	9,000
	Benz[a]anthracene	28	0.36
	Chrysene	280	3.62
	Benzo[b]fluoranthene	28	0.36
	Benzo[k]fluoranthene	28	0.36
	Benzo[a]pyrene	2.8	0.04
	Indeno[1,2,3-cd]pyrene	28	0.36
	Dibenz[a,h]anthracene	8.1	0.11
Polychlorinated Biphenyls	Total PCBs (cancer)	20	0.22
	Total PCBs (non-cancer)	67	8.70

Note: Screening values derived by the San Diego Water Board are bold faced and shaded.

In addition to characterizing the risks at the Shipyard Sediment Site, the *Macoma* tissue concentrations at each site station were compared to the *Macoma* tissue concentrations derived from the reference pool described in Section 17 of this Technical Report. The objective of this comparison was to determine whether or not the current site conditions pose a greater risk to the recreational and subsistence anglers than the current reference conditions in San Diego Bay.

The reference pool *Macoma* tissue concentrations were calculated using the 95% upper prediction limit (UPL). The 95% UPL allows a one-to-one comparison to be performed between

a single Shipyard Sediment Site station (i.e., each of the nine bioaccumulation site stations) and a pool of “Reference Condition” stations (i.e., Reference Pool). Although multiple comparisons were made to the reference pool prediction limits, the San Diego Water Board made a decision to not correct for multiple comparisons so that the site/reference *Macoma* tissue comparisons would remain conservative and more protective. The upper 95% UPL for the reference pool *Macoma* tissue concentrations are provided in Table 27-5 below and the comparison results are provided in the Appendix for Section 27.

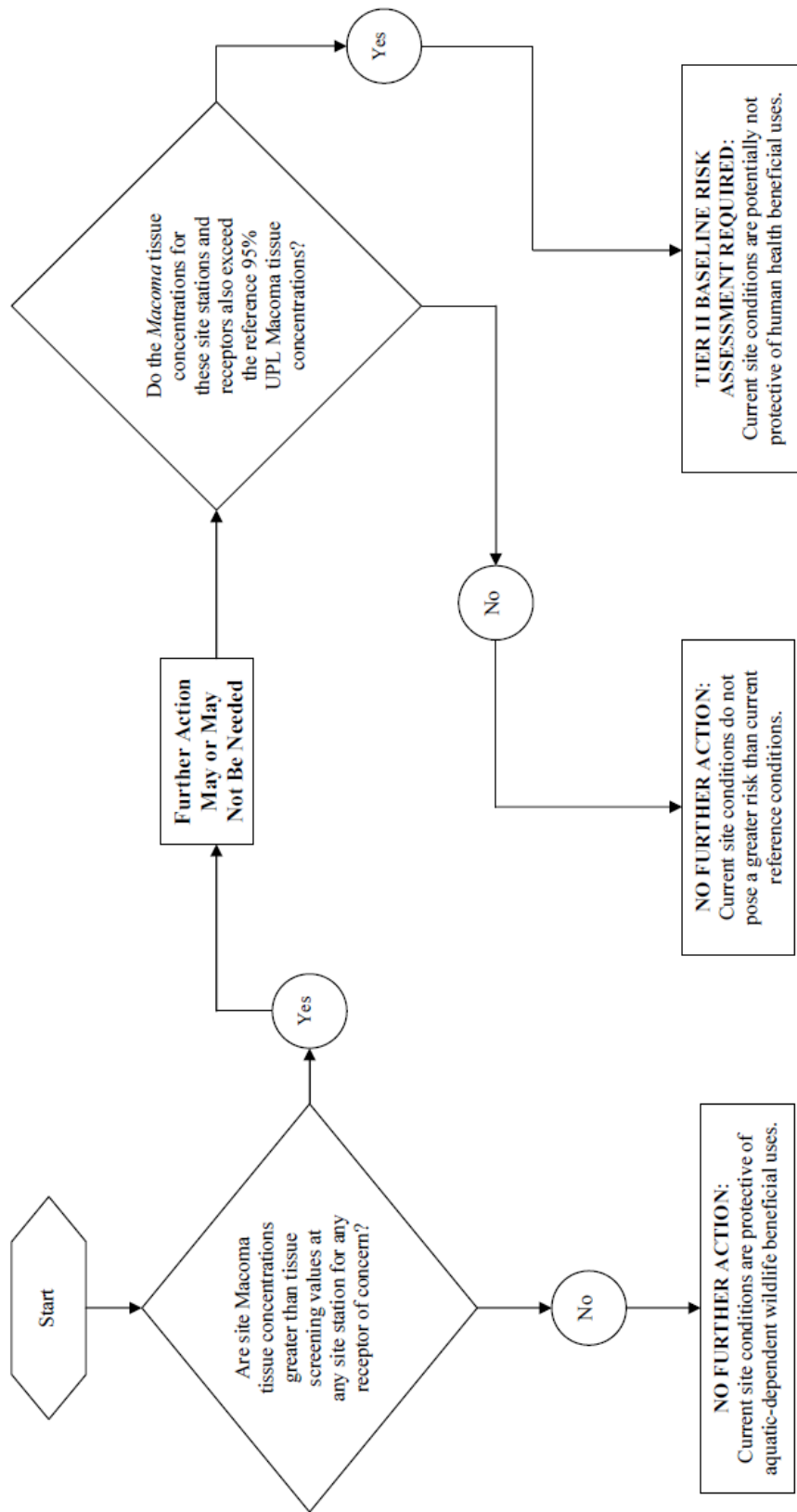
Table 27-5 Reference Pool Upper 95% Prediction Limits for *Macoma nasuta* Tissue Concentrations

<i>Macoma</i> Tissue Chemicals	95% Upper Prediction Limits
<i>Metals</i>	
Arsenic	22.8 mg/kg
Cadmium	0.39 mg/kg
Chromium	3.9 mg/kg
Copper	19.2 mg/kg
Lead	3.3 mg/kg
Mercury	0.15 mg/kg
Nickel	4.4 mg/kg
Selenium	4.9 mg/kg
Silver	0.57 mg/kg
Zinc	85.7 mg/kg
<i>Organometallic Compounds</i>	
Tributyltin	12 µg/kg
<i>Organics</i>	
Benzo[a]pyrene	132 µg/kg
Total Polychlorinated Biphenyls (PCB), as congeners	186 µg/kg
Total Polychlorinated Terphenyls (PCT)	All Reference Pool stations undetected

27.2.4. Risk Management

The San Diego Water Board identified two human health risk management decisions for the Tier I screening level risk assessment: (1) Current Shipyard Sediment Site conditions pose acceptable human health risks and no further action is warranted, and (2) Current site conditions pose a potential unacceptable human health risk that requires additional evaluation with a Tier II baseline risk assessment. These two management decisions are based on the human health risk characterization results at each site station and the *Macoma* tissue site/reference comparison results. A flow diagram showing how each management decision is triggered is shown below in Figure 27-1.

Figure 27-1 Flow Diagram for Tier I Human Health Risk Management Decisions



27.2.5. Uncertainties Related to Human Health Risk Estimates

The process of evaluating human health cancer and non-cancer risks involves multiple steps. Inherent in each step of the risk assessment process are uncertainties that ultimately affect the risk estimates. Uncertainties may exist in numerous areas such as estimation of potential site exposures and derivation of toxicity values. The most significant uncertainties in the Tier I risk analysis for the Shipyard Sediment Site are discussed below.

Tissue Chemical Concentrations. For this assessment, a 28-day laboratory bioaccumulation test using the clam *Macoma nasuta* was used to estimate exposure of fish and shellfish to CoPCs present in site sediment. For PCBs, dioxins, furans, PAHs, and metals, 80% of steady state generally occurs using the 28-day bioaccumulation test (U.S. EPA, 1998a; ASTM, 2001). Bioaccumulation testing protocols recommend that the bioaccumulation CoPCs reach approximately 80% of steady state tissue residues for a proper risk assessment. Attaining 100% steady state is ideal but not required in Tier I because it is a screening-level risk assessment. The San Diego Water Board recognizes that the observed tissue chemical concentrations in *Macoma nasuta* may be underestimated. Therefore, this may result in an underestimation of risk.

Surrogate for Fish and Shellfish. Chemical concentrations in *Macoma* tissue were used as a surrogate to estimate exposures to chemicals in seafood for recreational and subsistence anglers. While *Macoma* is not considered to be the primary seafood harvested from the Shipyard Sediment Site, use of *Macoma* tissue data for the Tier I risk analysis is considered a conservative approach because *Macoma* are directly exposed to contaminants in the surface sediment. *Macoma* actively ingests surface sediment to feed on detritus and also burrows into the sediment. Therefore, use of *Macoma* tissue may result in an overestimation of risk.

Exposure Parameters. The exposure parameters selected for Tier I are considered to be conservative values and therefore may result in an overestimation of risk.

Multiple Comparisons. Because multiple comparisons were made to the Reference Condition, and each comparison carries with it a low probability (5%) of falsely identifying a statistical difference, there is a significant potential for multiple comparison error (SCCWRP and U.S. Navy, 2005b). This may result in an overestimation of risk.

PCB Cancer Slope Factor. The PCB CSF used in this assessment was based on the upper-bound slope estimates for Aroclors 1254 and 1260 (Exponent, 2003). Use of the upper-end CSFs (i.e., highest) is conservative and may overestimate risks from PCBs.

Non-Cancer Risks from PCBs. Aroclors 1260 and 1254 were the only two Aroclors detected in *Macoma nasuta* tissue at all site and reference stations. U.S. EPA has only published RfDs for Aroclor 1254 (0.00002 mg/kg-day) and Aroclor 1016 (0.00007 mg/kg-day). For this assessment, the more conservative RfD for Aroclor 1254 was used for Aroclor 1260. This may overestimate risks from PCBs.

Inorganic Arsenic as a Percent of Total Arsenic. In order to account for the percentage of arsenic in *Macoma* tissue that is nontoxic, concentrations of inorganic arsenic were assumed to be 4 percent of total arsenic. Use of this percentage is considered to be conservative because some studies have reported much smaller percentages (Exponent, 2003). Therefore, this may result in an overestimation of risk.

28. Finding 28: Tier II Baseline Comprehensive Risk Assessment for Human Health

Finding 28 of CAO No. R9-2012-0024 states:

The Tier II risk assessment objective was to more conclusively determine whether Shipyard Sediment Site conditions pose unacceptable cancer and non-cancer health risks to recreational and subsistence anglers. Fish and shellfish were collected within four assessment units at the Shipyard Sediment Site and from two reference areas located across the bay from the Shipyard Site. Chemical concentrations measured in fish fillets and edible shellfish tissue were used to estimate chemical exposure for recreational anglers and chemical concentrations in fish whole bodies and shellfish whole bodies were used to estimate chemical exposure for subsistence anglers. Based on the Tier II risk assessment results, ingestion of fish and shellfish caught within all four assessment units at the Shipyard Sediment Site poses a theoretical increased cancer and non-cancer risk greater than that in reference areas to recreational and subsistence anglers. The chemicals posing theoretical increased cancer risks include inorganic arsenic and PCBs. The chemicals posing theoretical increased non-cancer risks include cadmium, copper, mercury, and PCBs.

28.1. Tier II Results

For the Tier II risk assessment, recreational anglers and subsistence anglers were identified as potential human receptors that could be at risk due to exposure to chemical pollutants in fish and shellfish caught at the Shipyard Sediment Site. Chemical pollutant concentrations measured in spotted sand bass and lobster tissues were used to assess the potential risks. Although the Tier I screening level risk assessment identified only four chemical pollutants as “possible” risks to recreational and subsistence anglers, all chemical pollutants of potential concern were analyzed in the spotted sand bass and lobster tissues and evaluated in the Tier II risk assessment.

Based on the Tier II results as summarized in Tables 28-1 and 28-2 below, the San Diego Water Board determined that human ingestion of seafood caught within all four assessment units at the Shipyard Sediment Site poses a cancer risk greater than 1×10^{-6} and non-cancer risk greater than 1 to both recreational and subsistence anglers. Additionally, the Shipyard Sediment Site poses a greater cancer and non-cancer risk to recreational and subsistence anglers than the risks posed at reference conditions in San Diego Bay. The carcinogenic CoPCs include inorganic arsenic and total polychlorinated biphenyls (PCBs). The non-carcinogenic CoPCs include cadmium, copper, mercury, and total PCBs. The Tier II risk calculations and results are provided in the Appendix for Section 28.

Table 28-1 Summary of Tier II Risk Assessment Results for Recreational and Subsistence Anglers (Cancer Risk)

Assessment Unit	Receptor	Diet	Carcinogenic Chemicals of Potential Concern	Cancer Risk		
				> 1x10 ⁻⁶	> Reference	Risk ¹
Inside NASSCO Leasehold	Recreational Angler	Fillet Sand Bass	Inorganic Arsenic	Yes	No	No
			PCBs	Yes	No	No
		Edible Lobster Tissue	Inorganic Arsenic	Yes	Yes	Yes
			PCBs	Yes	No	No
	Subsistence Angler	Whole Body Sand Bass	Inorganic Arsenic	Yes	Yes	Yes
			PCBs	Yes	Yes	Yes
		Whole Body Lobster	Inorganic Arsenic	Yes	No	No
			PCBs	Yes	Yes	Yes
Outside NASSCO Leasehold	Recreational Angler	Fillet Sand Bass	Inorganic Arsenic	Yes	Yes	Yes
			PCBs	Yes	Yes	Yes
	Subsistence Angler	Whole Body Sand Bass	Inorganic Arsenic	Yes	Yes	Yes
			PCBs	Yes	Yes	Yes
		Whole Body Lobster	Inorganic Arsenic	Yes	No	No
			PCBs	Yes	Yes	Yes
Inside BAE Systems Leasehold	Recreational Angler	Fillet Sand Bass	Inorganic Arsenic	Yes	Yes	Yes
			PCBs	Yes	Yes	Yes
		Edible Lobster Tissue	Inorganic Arsenic	Yes	Yes	Yes
			PCBs	Yes	Yes	Yes
	Subsistence Angler	Whole Body Sand Bass	Inorganic Arsenic	Yes	Yes	Yes
			PCBs	Yes	Yes	Yes
		Whole Body Lobster	Inorganic Arsenic	Yes	No	No
			PCBs	Yes	Yes	Yes
Outside BAE Systems Leasehold	Recreational Angler	Fillet Sand Bass	Inorganic Arsenic	Yes	Yes	Yes
			PCBs	Yes	Yes	Yes
	Subsistence Angler	Whole Body Sand Bass	Inorganic Arsenic	Yes	Yes	Yes
			PCBs	Yes	Yes	Yes

1. A cancer risk exists when the site risk is greater than 1x10⁻⁶ and greater than the risk calculated for the reference area.

Table 28-2 Summary of Tier II Risk Assessment Results for Recreational and Subsistence Anglers (Non-Cancer Risk)

Assessment Unit	Receptor	Diet	Non-carcinogenic Chemicals of Potential Concern	Non-cancer Risk		
				> 1	> Reference	Risk ¹
Inside NASSCO Leasehold	Recreational Angler	Fillet Sand Bass	PCBs	No	No	No
		Edible Lobster Tissue	Mercury	Yes	Yes	Yes
	Subsistence Angler	Whole Body Sand Bass	Mercury	Yes	Yes	Yes
			PCBs	Yes	Yes	Yes
		Whole Body Lobster	Cadmium	No	No	No
			Copper	Yes	Yes	Yes
			Mercury	Yes	No	No
			PCBs	Yes	Yes	Yes
	Outside NASSCO Leasehold	Recreational Angler	Fillet Sand Bass	PCBs	No	Yes
Subsistence Angler		Whole Body Sand Bass	Mercury	Yes	Yes	Yes
			PCBs	Yes	Yes	Yes
		Whole Body Lobster	Mercury	Yes	Yes	Yes
Inside BAE Systems Leasehold	Recreational Angler	Fillet Sand Bass	PCBs	Yes	Yes	Yes
		Edible Lobster Tissue	Mercury	No	No	No
	Subsistence Angler	Whole Body Sand Bass	Mercury	Yes	Yes	Yes
			PCBs	Yes	Yes	Yes
		Whole Body Lobster	Cadmium	Yes	Yes	Yes
			Copper	Yes	No	No
			Mercury	Yes	No	No
			PCBs	Yes	Yes	Yes
	Outside BAE Systems Leasehold	Recreational Angler	Fillet Sand Bass	PCBs	Yes	Yes
Subsistence Angler		Whole Body Sand Bass	Mercury	Yes	Yes	Yes
			PCBs	Yes	Yes	Yes

1. A non-cancer risk exists when the site hazard index is greater than 1.0 and greater than the hazard index calculated for the reference area.

28.2. Tier II Approach

The San Diego Water Board conducted a Tier II human health risk assessment (i.e., baseline risk assessment) to more conclusively determine whether or not the current conditions at the Shipyard Sediment Site pose unacceptable risks to human health and to identify the need for remedial action. Risks were characterized by: (1) quantifying the cancer and non-cancer risks at the site, and (2) comparing the site risks to the risks calculated for the reference areas.

The baseline risk assessment was conducted in accordance with U.S. EPA's "Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)" (U.S. EPA, 1989b) and in consultation with California Office of Environmental Health Hazard (OEHHA). The approach consists of the following key elements:

- Identification of Chemicals of Potential Concern;
- Exposure Assessment;
- Toxicity Assessment;
- Risk Characterization;
- Risk Management; and
- Uncertainties Related to Risk Estimates.

These key elements are discussed in more detail below.

28.2.1. Identification of Chemicals of Potential Concern

Chemical pollutant concentrations in fish and shellfish caught at the Shipyard Sediment Site were compared with tissue screening concentrations to identify chemical pollutants of potential concern that require further evaluation in the baseline risk assessment. Tissue screening concentrations were developed for carcinogenic and non-carcinogenic chemical pollutants using the same equations as those used in the California Lakes Study by the Office of Environmental Health Hazard Assessment (Brodberg and Pollock, 1999). For carcinogenic chemicals, screening concentrations were derived as follows (Exponent, 2003):

$$\text{TRG}_{\text{carcinogenic}} = \frac{(\text{TRL} * \text{BW})}{(\text{CSF} * \text{CR} * \text{FI} * \text{ABS})}$$

where:

TRG	=	tissue screening level for fish and/or shellfish tissue (µg/kg)
TRL	=	target risk level (unit-less)
BW	=	body weight (kg)
CSF	=	carcinogenic slope factor (mg/kg-day) ⁻¹
CR	=	fish and shellfish consumption rate (kg/day)
FI	=	fractional intake of seafood consumed that originates from site (unit-less)
ABS	=	fraction absorbed (unit-less)

For non-carcinogenic chemicals, screening concentrations were derived as follows (Exponent, 2003):

$$\text{TRG}_{\text{non-carcinogenic}} = \frac{(\text{RfD} * \text{BW})}{(\text{CR} * \text{FI})}$$

where:

TRG	=	tissue screening level for fish and/or shellfish tissue (µg/kg)
RfD	=	reference dose (mg/kg-day)
BW	=	body weight (kg)
CR	=	fish and shellfish consumption rate (kg/day)
FI	=	fractional intake of seafood consumed that originates from site (unit-less)

As discussed in Section 28.2.2 below, the receptors of concern identified for the baseline risk assessment are recreational anglers and subsistence anglers. Separate screening concentrations were developed for these two anglers using highly conservative assumptions. The assumptions used to derive screening concentrations for carcinogenic and non-carcinogenic chemicals are shown below in Table 28-3 and Table 28-4.

Table 28-3 Assumptions Used to Derive Tissue Screening Concentrations for Carcinogenic Chemicals

Parameter		Units	Recreational Angler	Subsistence Angler
Target risk level	TRL	none	1 x 10 ⁻⁶	1 x 10 ⁻⁶
Body Weight	BW	kg	70	70
Carcinogenic slope factor	CSF	(mg/kg-day) ⁻¹	See Toxicity Assessment Section 28.2.3	See Toxicity Assessment Section 28.2.3
Fish or shellfish consumption rate	CR	kg/day	0.021 ¹	0.161 ²
Fractional intake of seafood consumed from site	FI	none	1	1
Fraction absorbed	ABS	none	1	1

1. OEHHA, 2001
2. SCCWRP and MBC, 1994

Table 28-4 Assumptions Used to Derive Tissue Screening Concentrations for Non-Carcinogenic Chemicals

Parameter		Units	Recreational Angler	Subsistence Angler
Reference dose	RfD	(mg/kg-day)	See Toxicity Assessment Section 28.2.3	See Toxicity Assessment Section 28.2.3
Body Weight	BW	kg	70	70
Fish or shellfish consumption rate	CR	kg/day	0.021 ¹	0.161 ²
Fractional intake of seafood consumed from site	FI	none	1	1

1. OEHHA, 2001
2. SCCWRP and MBC, 1994

As a further conservative assumption, the maximum chemical pollutant concentrations in fish (spotted sand bass) and shellfish (spiny lobsters) caught from the Shipyard Sediment Site were compared to the tissue screening concentrations. Maximum chemical pollutant concentrations in fillets of spotted sand bass and in edible tissue portions of spiny lobsters were used to identify CoPCs for the recreational angler. Chemical pollutant concentrations in whole bodies of spotted sand bass and in whole bodies of spiny lobsters were used to identify CoPCs for the subsistence angler. The comparisons are shown below in Table 28-5 and Table 28-6.

Table 28-5 Screening of Chemicals of Potential Concern in Fish and Lobster Tissue for Recreational Angler

Chemical	Maximum Fillet Spotted Sand Bass Concentration (µg/kg)	Maximum Edible Tissue Lobster Concentration (µg/kg)	Human Health Tissue Screening Concentration (µg/kg)
Metals			
Arsenic, inorganic (non-carcinogenic)	28	532	1,000
Arsenic, inorganic (carcinogenic)	28	532	2.2
Cadmium	2.5 U	50	1,667
Chromium	50 U	50 U	10,000
Copper	460	17,900	123,333

Chemical	Maximum Fillet Spotted Sand Bass Concentration (µg/kg)	Maximum Edible Tissue Lobster Concentration (µg/kg)	Human Health Tissue Screening Concentration (µg/kg)
Mercury, total	224	521	333
Nickel	20 U	50 U	66,667
Selenium	500	300	16,667
Silver	2 U	21	16,667
Zinc	4,900	32,400	1,000,000
Organometallic Compounds			
Tributyltin	23	9.6	1,000
Polycyclic Aromatic Hydrocarbons			
Naphthalene	5 U	5 U	66,667
Acenaphthene	5 U	5 U	200,000
Fluorene	5 U	5 U	133,333
Anthracene	5 U	5 U	1,000,000
Fluoranthene	5 U	5 U	133,333
Pyrene	5 U	5 U	66,667
Benz[a]anthracene	5 U	5 U	2.8
Chrysene	5 U	5 U	28
Benzo[b]fluoranthene	5 U	5 U	2.8
Benzo[k]fluoranthene	5 U	5 U	2.8
Benzo[a]pyrene	5 U	5 U	0.3
Indeno[1,2,3-cd]pyrene	5 U	5 U	2.8
Dibenz[a,h]anthracene	5 U	5 U	0.8
Polychlorinated Biphenyls			
Total PCB Aroclors (carcinogenic)	400	21	1.7

Chemical	Maximum Fillet Spotted Sand Bass Concentration (µg/kg)	Maximum Edible Tissue Lobster Concentration (µg/kg)	Human Health Tissue Screening Concentration (µg/kg)
Total PCB Aroclors (noncarcinogenic)	400	21	67

Notes: Chemical concentrations exceeding a tissue screening concentration are bold faced and shaded. Inorganic arsenic concentration was estimated assuming that 4 percent of total arsenic was inorganic. Chemicals not detected in any sample from a station are qualified with a “U” and one-half the quantitation limit is listed.

Table 28-6 Screening of Chemicals of Potential Concern in Fish and Lobster Tissue for Subsistence Angler

Chemical	Maximum Whole Body Spotted Sand Bass Concentration (µg/kg)	Maximum Whole Body Lobster Concentration (µg/kg)	Human Health Tissue Screening Concentration (µg/kg)
Metals			
Arsenic, inorganic (non-carcinogenic)	36	260	130
Arsenic, inorganic (carcinogenic)	36	260	0.3
Cadmium	40	230	217
Chromium	700	200 U	1,304
Copper	6,100	67,000	16,087
Mercury, total	200	59	43
Nickel	440	110	8,696
Selenium	1,000	400	2,174
Silver	41	260	2,174
Zinc	22,000	28,000	130,435
Organometallic Compounds			
Tributyltin	63	27	130
Polycyclic Aromatic Hydrocarbons			
Naphthalene	10 U	10 U	8,696
Acenaphthene	10 U	10 U	26,087
Fluorene	10 U	16	17,391
Anthracene	10 U	18	130,435
Fluoranthene	10 U	13	17,391
Pyrene	10 U	10 U	8,696
Benz[a]anthracene	10 U	10 U	0.4
Chrysenes	10 U	10 U	3.6

Chemical	Maximum Whole Body Spotted Sand Bass Concentration (µg/kg)	Maximum Whole Body Lobster Concentration (µg/kg)	Human Health Tissue Screening Concentration (µg/kg)
Benzo[b]fluoranthene	10 U	10 U	0.4
Benzo[k]fluoranthene	10 U	10 U	0.4
Benzo[a]pyrene	10 U	10 U	0.04
Indeno[1,2,3-cd]pyrene	10 U	10 U	0.4
Dibenz[a,h]anthracene	10 U	10 U	0.1
Polychlorinated Biphenyls			
Total PCB Aroclors (carcinogenic)	2,100	76	0.2
Total PCB Aroclors (noncarcinogenic)	2,100	76	8.7

Notes: Chemical concentrations exceeding a tissue screening concentration are bold faced and shaded. Inorganic arsenic concentration was estimated assuming that 4 percent of total arsenic was inorganic. Chemicals not detected in any sample from a station are qualified with a “U” and one-half the quantitation limit is listed.

The following chemical pollutants exceeded their respective tissue screening concentrations for the recreational angler and were further evaluated in the baseline risk assessment:

- Fish Fillet – Inorganic arsenic (carcinogenic) and PCBs (carcinogenic and non-carcinogenic); and
- Edible Lobster Tissue – Inorganic arsenic (carcinogenic), mercury, and PCBs (carcinogenic).

The following chemical pollutants exceeded their respective tissue screening concentrations for the subsistence angler and were further evaluated in the baseline risk assessment:

- **Whole Body Fish** – Inorganic arsenic (carcinogenic), mercury, and PCBs (carcinogenic and non-carcinogenic); and
- **Whole Body Lobster** – Inorganic arsenic (carcinogenic and non-carcinogenic), cadmium, copper, mercury, and PCBs (carcinogenic and non-carcinogenic).

28.2.2. Exposure Assessment

The objective of the exposure assessment is to evaluate the type and magnitude of human exposures to CoPCs that are present at or migrating from the Shipyard Sediment Site (U.S. EPA,

1989b). Human exposure to contaminated marine sediment can occur around the following three principal pathways:

- Direct contact of contaminated marine sediment by swimmers or divers;
- Incidental ingestion of contaminated marine sediment or associated waters by swimmers or divers; and
- Bioaccumulation and food chain transfer of sediment pollutants to human consumers of contaminated fish and shellfish.

The most significant theoretical human health risk associated with contaminated marine sediment is considered to be the ingestion, over time, of fish and shellfish that may have bioaccumulated chemical pollutants either directly from marine sediment or through the food web (Long, 1989). U.S. EPA literature suggests that even when conservative assumptions about direct human exposure are used, risks associated with dermal contact and incidental ingestion of contaminated sediment are minimal and contribute less to the total risk than the fish and shellfish consumption pathway. The human health risks associated with fish and shellfish consumption often constitute the greatest proportion of the total risk, and sometimes drive the human health risk assessment. (U.S. EPA, 1992b)

28.2.2.1. Shipyard Sediment Site Exposure Assessment

The most significant potential source of human exposure to pollutants at the Shipyard Sediment Site is through consumption of fish and shellfish that may have bioaccumulated chemicals either directly from site sediment or through the food web (Exponent, 2003). Direct contact with sediment pollutants at the Shipyard Sediment Site is not a likely exposure pathway to humans because the industrial nature of the site and the lack of a beach (shoreline at Shipyard Sediment Site consists almost exclusively of riprap, sheet-pile bulkhead, and piers) make swimming and wading a highly unlikely event. Therefore, two types of receptors (i.e., members of the population or individuals at risk) were identified and further evaluated in the baseline risk assessment. The two receptor types are as follows:

- **Recreational Angler** – represents those who eat the fish and/or shellfish they catch recreationally; and
- **Subsistence Angler** – represents those who fish for food, for economic and/or cultural reasons, and for whom the fish and/or shellfish caught is a major source of protein in the diet.

Exponent reported that public fishing and shellfish harvesting are currently unlikely events at the Shipyard Sediment Site due to the current security measures. Under the current site usage, there are security measures in place at both the upland property and the in-water leaseholds of NASSCO and BAE Systems due to the work performed on Navy ships (Exponent, 2003). Force protection measures are required for Navy vessels and prohibit non-mission-essential vessels from approaching Navy ships. A security boom prevents unauthorized vessels from approaching

closer than 300 feet in the NASSCO and BAE Systems leaseholds. Furthermore, armed personnel are present at all times to ensure that no trespassing occurs at the site.

Despite these factors the San Diego Water Board required a baseline risk assessment using the two theoretical receptors identified above based on the following recommended considerations (Brodberg, personal communication, 2004):

- Although fishing is currently prohibited, it is possible that NASSCO and BAE Systems employees or U.S. Navy personnel may fish off of the piers, bulkhead, riprap, ships, etc.;
- Although NASSCO and BAE Systems have long-term leases (NASSCO through 2040, BAE through 2034), it is possible that they may not occupy the site in the future and future site usage may allow for fishing. This scenario recently occurred at a former shipyard (Campbell Shipyard) located in San Diego Bay just north of the Shipyard Sediment Site;
- It is possible that sediment chemical pollutants within the NASSCO and BAE Systems leaseholds may migrate to areas outside the leasehold where fishing by boat and fishing at a nearby public pier (Crosby Street Park Pier located approximately ½ mile north of BAE Systems just past the Coronado Bridge) is accessible; and
- The San Diego Water Board's statutory responsibility is to protect the current and reasonably anticipated beneficial uses designated for San Diego Bay. The beneficial uses pertaining to human health are Commercial and Sport Fishing (COMM) and Shellfish Harvesting (SHELL). COMM and SHELL are to be protected at all times regardless of the current site-access measures that prevent the uses from occurring.

To focus the baseline risk assessment, the Shipyard Sediment Site was divided into the following four discrete assessment units (Exponent, 2003):

- Inside NASSCO – the area inside the NASSCO leasehold;
- Outside NASSCO – the area between the NASSCO leasehold and the shipping channel;
- Inside BAE Systems – the area inside the BAE Systems leasehold; and
- Outside BAE Systems – the area between the BAE Systems leasehold and the shipping channel.

This was done for the following reasons: (1) chemical pollutant concentrations in sediment vary at the NASSCO and BAE Systems leasehold portion of the Shipyard Sediment Site due to the differences in historical activities/operations conducted at the two shipyards, (2) access restrictions differ inside versus outside the leaseholds, (3) the types of fishing that could occur from piers/shoreline are different from those via boat access, and (4) the relative size of the four assessment units will affect the amount of fish and shellfish that could potentially be consumed from each unit. Therefore, risks to the recreational and subsistence anglers were evaluated separately in each of the four assessment units to identify areas with greater likelihood for adverse health effects.

Separate chemical pollutant exposure estimates were developed for each angler in each of the four assessment units using tissue concentrations from the following two types of fish and shellfish caught at the Shipyard Sediment Site:

- **Spotted Sand Bass (*Paralabrax masculatofasciatus*)** – Chemical concentrations in sand bass fillets and whole bodies were used to estimate exposure to chemicals in food for the recreational angler and subsistence angler, respectively; and
- **Spiny Lobsters (*Panulirus interruptusi*)** – Chemical concentrations in edible tissue (all soft tissue, including hepatopancreas) and the entire organism, including the shell, were used to estimate exposure to chemicals in food for the recreational angler and subsistence angler, respectively.

Human exposure to contaminants in fish and shellfish collected at the Shipyard Sediment Site was estimated using the following simple exposure model consistent with U.S. EPA (1998b) guidance (Exponent, 2003):

$$\text{Intake (in mg/kg - day)} = \frac{(C * CR * FI * ED * EF)}{(BW * AT * CF)}$$

where:

C	=	tissue chemical concentration in spotted sand bass and spiny lobster (µg/kg-wet weight)
CR	=	fish consumption rate (kg/day)
FI	=	fraction ingested from the site (unitless)
ED	=	exposure duration (years)
EF	=	exposure frequency (days/year)
BW	=	body weight (kg)
AT	=	averaging time (days)
		- non-carcinogens: exposure duration x 365 days
		- carcinogens: 70-year lifetime x 365 days
CF	=	conversion factor (1,000 µg/mg)

According to U.S. EPA guidance, exposures should be based on an estimate of the reasonable maximum exposure (RME) expected to occur under both current and future conditions at the site. The RME is defined as the highest exposure that is reasonably expected to occur at a site. The assumptions used by the San Diego Water Board to estimate the RME at the Shipyard Sediment Site are shown below in Table 28-7 and the exposure estimate calculations using these assumptions are provided in the Appendix for Section 28.

Table 28-7 Reasonable Maximum Exposure (RME) Assumptions for Recreational and Subsistence Anglers

Parameter		Units	Recreational Angler	Subsistence Angler
Tissue Chemical Concentration	C	µg/kg-wet wt	Maximum	Maximum
Fish or Shellfish Consumption Rate	CR	kg/day	0.021 ¹	0.161 ²
Body Weight	BW	kg	70	70
Exposure Duration	ED	years	30	30
Exposure Frequency	EF	days/year	365	365
Fraction Ingested from Site or Reference	FI	unitless	1	1
Averaging Time for Carcinogens	AT _c	days	25,550	25,550
Averaging Time for Noncarcinogens	AT _n	days	10,950	10,950
Conversion Factor	CF	µg/mg	1,000	1,000

1. OEHHA 2001
2. SCCWRP and MBC 1994

28.2.3. Toxicity Assessment

The toxicity assessment identifies toxicity values for each chemical pollutant of concern and discusses their potential adverse effects to humans (U.S. EPA, 1989b). Two types of toxicity values are evaluated: CSFs for carcinogenic chemicals and RfDs for non-carcinogenic chemicals.

CSFs and RfDs from U.S. EPA's Integrated Risk Information System (IRIS) were used in the baseline risk assessment (U.S. EPA, 2003a). The CSFs and RfDs for the CoPCs identified in Section 28.2.1 are listed in Table 28-8 below.

Table 28-8 Cancer Slope Factors and Reference Doses for Chemicals of Potential Concern

Chemical	CSF (mg/kg-day) ⁻¹	RfD (mg/kg-day)	Source
Metals			
Arsenic, inorganic	1.5	0.0003	U.S. EPA (2003a)
Cadmium	NA	0.0005	U.S. EPA (2003a)

Chemical	CSF (mg/kg-day) ⁻¹	RfD (mg/kg-day)	Source
Copper	NA	0.037	U.S. EPA (2003a)
Mercury, total	NA	0.0001	U.S. EPA (2003a)
Polychlorinated Biphenyls			
Total PCBs	2	NA	U.S. EPA (2003a)
Total PCBs (as Aroclor 1254)	NA	0.00002	U.S. EPA (2003a)

28.2.4. Risk Characterization

Risk characterization is the final step of the baseline risk assessment process, which combines the information from the exposure assessment and toxicity assessment to yield estimated cancer risks and non-cancer health hazards from exposure to the CoPCs (U.S. EPA, 1989b).

For the baseline risk assessment, the San Diego Water Board characterized potential health risks to the recreational and subsistence anglers by quantifying the cancer and non-cancer risks at each of the four assessment units. Risks from exposure to the carcinogenic CoPCs were estimated using the following equation:

$$\text{Risk} = \text{Intake} * \text{CSF}$$

where:

$$\begin{aligned} \text{Intake} &= \text{human exposure to chemical concentrations in fish and shellfish} \\ &\quad \text{tissue (mg/kg-day)} \\ \text{CSF} &= \text{cancer slope factor (mg/kg-day)}^{-1} \end{aligned}$$

The San Diego Water Board selected a target cancer risk level of 1×10^{-6} (one-in-a-million) to screen for potential beneficial use impairment consistent with federal and state water quality criterion that protects human health. The 10^{-6} cancer risk level has historically formed the basis of human health protective numerical water quality objectives in California (RWQCB, 2003a). It is generally recognized by California and U.S. EPA as the *de minimis* or negligible level of risk associated with involuntary exposure to toxic chemicals in environmental media. The 10^{-6} risk level used in water-related health-protective regulatory decision-making in California includes the following:

- CWA water quality criteria promulgated for California waters by U.S. EPA in the *National Toxics Rule and the California Toxics Rule* state that “[t]he human health criteria shall be applied at the State-adopted 10^{-6} risk level.” These criteria, when combined with beneficial use designations in state Water Quality Control Plans (SWRCB, 1997) are water quality standards for California’s inland and estuarine surface waters.

- Functional Equivalent Documents adopted by the State Water Board that provide background and justification for the *California Ocean Plan* (SWRCB, 2001) and the former *California Inland Surface Waters and Enclosed Bays and Estuaries Plans* (SWRCB, 2000) cite the 10^{-6} risk level as the basis for human health protective water quality objectives for carcinogens.

Risks from exposure to non-carcinogenic CoPCs were estimated using the following equation:

$$\text{Hazard Index} = \frac{\text{Intake}}{\text{RfD}}$$

where:

Intake = human exposure to chemical concentrations in fish and shellfish tissue (mg/kg-day)
RfD = reference dose (mg/kg-day)

A hazard index less than 1.0 indicates that human exposure to chemical pollutant concentrations in fish and shellfish is below the level that is expected to result in a significant health risk. A hazard index greater than 1.0 indicates unacceptable exposures may be occurring, and there may be an increased concern for potential non-cancer effects (TAMS/Gradient Corporation, 2000). However, the relative values of a hazard index greater than 1.0 cannot be used to describe the severity of the risk. The cancer and non-cancer risk calculations for the recreational and subsistence angler at each assessment unit are provided in the Appendix for Section 28.

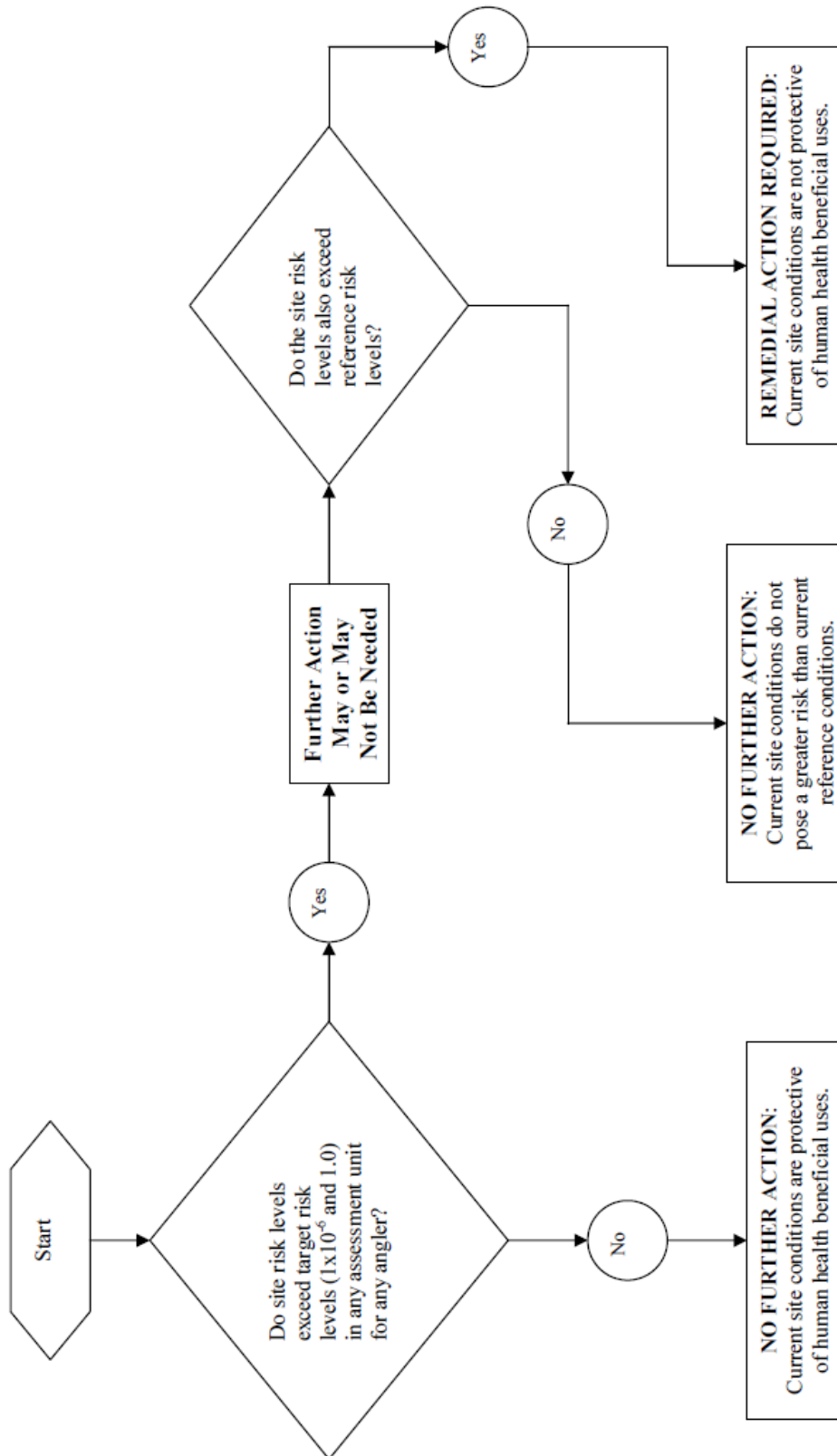
In addition to characterizing the risks at the Shipyard Sediment Site, risks were also characterized at two reference areas to determine whether or not the site poses a greater risk to recreational and subsistence anglers than reference conditions in San Diego Bay. The two reference areas are located across the bay from the Shipyard Sediment Site (Exponent, 2003). Spotted sand bass were collected from a reference area located in the vicinity of Reference Station 2240 and the chemical concentrations in fillets and whole bodies were used to estimate exposure to recreational and subsistence anglers, respectively. Spiny lobsters were collected from a reference area located in the vicinity of Reference Station 2230 and the chemical concentrations in edible tissue and the entire organism were used to estimate exposure to recreational and subsistence anglers, respectively. Carcinogenic and non-carcinogenic risks at the reference areas were calculated using the same chemical pollutant of concern, exposure assumptions, toxicity values, and risk equations as those identified above for the Shipyard Sediment Site. The calculations and risk characterization results for the two reference areas are provided in the Appendix for Section 28.

28.2.5. Risk Management

The San Diego Water Board identified two risk management decisions: (1) Current site conditions pose acceptable cancer and non-cancer risks and no further action is warranted, and (2) Current site conditions pose unacceptable cancer and/or non-cancer risks and remedial action is required. These two management decisions are based on the risk characterization results at the

Shipyards Sediment Site and at the reference locations. A flow diagram showing how each management decision is triggered is shown below in Figure 28-1.

Figure 28-1 Flow Diagram for Human Health Risk Management Decisions



28.2.6. Uncertainties Related to Risk Estimates

The process of evaluating human health cancer risk and non-cancer hazard indices involves multiple steps. Inherent in each step of the risk assessment process are uncertainties that ultimately affect the risk estimates. Uncertainties may exist in numerous areas such as estimation of potential site exposures and derivation of toxicity values. The most significant uncertainties in the Tier II risk analysis for the Shipyard Sediment Site are discussed below.

Fractional Intake. Exponent (2003) used the following fractional intake assumptions for the human health risk assessment: Inside NASSCO = 0.034 (or 3.4 percent), Outside NASSCO = 0.005 (or 0.5 percent), Inside BAE Systems = 0.023 (or 2.3 percent), and Outside BAE Systems = 0.002 (or 0.2 percent). In contrast, the San Diego Water Board initially used a conservative fractional intake of 1 based on the assumption that 100% of the fish and shellfish caught and consumed by recreational and subsistence anglers is from the Shipyard Sediment Site. Since it is likely that anglers catch at least a portion of their seafood from other locations in San Diego Bay and/or the fish caught from the Shipyard Sediment Site comes from elsewhere, the actual site fractional intake is likely to be less than 100 percent.

Exposure Concentration. U.S. EPA guidance recommends that the tissue chemical concentrations used in the intake equation be either the 95 percent upper confidence limit (UCL) on the arithmetic average concentration or the maximum concentration, whichever is lesser (U.S. EPA, 1989b). In order to simplify the risk calculations, the San Diego Water Board only used the maximum concentration observed in spotted sand bass (fillet and whole body) and lobster (edible tissue and whole body) to estimate risks at each of the four assessment units and at the two reference areas. This may result in an under- or overestimation of risks at the Shipyard Sediment Site.

Spotted Sand Bass Home Range. Spotted sand bass were collected in four discrete assessment units at the Shipyard Sediment Site: inside NASSCO leasehold, outside NASSCO leasehold, inside BAE Systems leasehold, and outside BAE Systems leasehold. It is assumed that the assessment units bound the home range for these spotted sand bass and that the observed tissue chemical concentrations are based exclusively from exposure within these areas. This may, however, not be indicative of their actual exposures because these fish may feed beyond the assessment unit boundaries. Therefore, the estimated risk to the recreational and subsistence anglers ingesting the fish is considered conservative and does not characterize actual exposures to the Shipyard Sediment Site.

PCB Cooking Losses. Numerous studies have evaluated the loss of PCBs from fish during preparation and cooking (Exponent, 2003). Reductions of PCBs ranged from 26 to 90 percent using cooking methods such as microwaving, boiling, and frying. For this assessment, a 50 percent reduction factor for PCBs in spotted sand bass fillets was used to assess potential risks to recreational anglers (Brodberg, 2004). A PCB cooking loss factor was not applied to spotted sand bass whole bodies because of the various preparation and cooking methods (such as boiling the entire fish to make a soup) and other related habits (such as consuming pan drippings from frying) potentially used by subsistence anglers. These cooking loss factor assumptions may underestimate or overestimate PCB cancer risks and PCB non-cancer hazards.

PCB Cancer Slope Factor. The PCB CSF used in this assessment was based on the upper-bound slope estimates for Aroclors 1254 and 1260 (Exponent, 2003). Use of the upper-end CSFs (i.e., highest) is conservative and may overestimate risks from PCBs.

Non-Cancer Risks from PCBs. Aroclors 1260 and 1254 were the only two Aroclors detected in spotted sand bass and lobster caught at the Shipyard Sediment Site. Aroclor 1260 was detected in spotted sand bass (whole body and fillet) and lobster (whole body and edible tissue). Aroclor 1254 was detected in spotted sand bass (whole body and fillet). U.S. EPA has only published RfDs for Aroclor 1254 (0.00002 mg/kg-day) and Aroclor 1016 (0.00007 mg/kg-day). For this assessment, the more conservative RfD, Aroclor 1254, was used as a surrogate for Aroclor 1260. This may overestimate risks from PCBs.

Inorganic Arsenic as a Percent of Total Arsenic. In order to account for the percentage of arsenic in fish tissue that is nontoxic, concentrations of inorganic arsenic were assumed to be 4 percent of total arsenic (Exponent, 2003). Use of this percentage is considered to be conservative because some studies have reported much smaller percentages. Therefore, this may result in an overestimation of risk.

28.3. Comparison to Fish Advisories

The U.S. EPA and U.S. Department of Health and Human Services issued an advisory in 2004 for safe consumption of fish (U.S. EPA, 2004a).¹¹ The 2004 U.S. EPA advisory, recognizing that fish and shellfish are a part of a healthy diet, as well as recognizing that nearly all fish and shellfish contain some amounts of mercury, recommends that women¹² and young children limit their exposure to the harmful effects of mercury by limiting fish consumption

The 2004 U.S. EPA advisory recommends that people avoid eating fish and shellfish with the highest levels of mercury. For example, king mackerel is on the U.S. EPA list of fish with the highest levels of mercury with an average concentration of 0.73 mg/kg.¹³ Fish listed as having lower levels of mercury include fresh salmon (0.01 mg/kg), Pacific mackerel (0.09 mg/kg), and light canned tuna (0.12 mg/kg). For comparison, the average mercury concentrations of the fish, both fillets and whole body, from the four shipyard areas and the reference areas ranged from 0.12 to 0.19 mg/kg (Table 28-9).

The 2004 U.S. EPA advisory recommends that "...women and young children will receive the benefits of eating fish and shellfish and be confident that they have reduced their exposure to the harmful effects of mercury... [if they] ...eat up to 12 ounces a week of a variety of fish and shellfish that are lower in mercury." For comparison, the consumption rates used in this Technical Report and the Shipyard Report are approximately 5.2 ounces per week (21 g/day) and 39.8 ounces per week (161 g/day) for the recreational and subsistence anglers, respectively. Therefore, assuming that the Shipyard Sediment Site fish fall within the U.S. EPA definition of

¹¹ <http://www.cfsan.fda.gov/~dms/admeHg3.html>

¹² Women who might become pregnant, women who are pregnant, nursing mothers, and young children.

¹³ <http://www.cfsan.fda.gov/~frf/sea-mehg.html>

fish lower in mercury, the subsistence angler consumption rate is over three times the recommended levels for women and young children.

A 2004 U.S. EPA Technical Memorandum provides details on the origin of a national advisory for fish consumption based on mercury exposure (U.S. EPA, 2004b). For fish with mercury concentrations in the range of those reported for the shipyards and reference areas (i.e. 0.12 to 0.23 mg/kg), they advise no more than 6 ounces per week. For comparison, the consumption rates used in this Technical Report and the Shipyard Report are approximately 5.2 ounces per week (21 g/day) and 39.8 ounces per week (161 g/day) for the recreational and subsistence anglers, respectively. Therefore, the recreational angler consumption rate is within the recommendation, but the subsistence angler consumption rate is over six times the recommended levels.

Regarding exposure to PCBs from fish consumption, the California Office of Environmental Health Hazard Assessment's (OEHHA) website¹⁴ states, "In certain areas in California, PCBs have been measured in sport-caught fish at levels well above 100 ppb." These elevated levels may pose a health concern. OEHHA advises you to limit how much you eat of fish taken in these locations" (OEHHA, 2005). As indicated in Table 28-9 all four of the shipyard areas reported mean whole body concentrations above 100 ppb¹⁵ and one of the areas reported mean fillet concentrations above 100 ppb with two others very close to 100 ppb.

Table 28-9 Spotted Sand Bass Data – Mean Concentration (Wet Weight)

	Reference	Inside NASSCO	Outside NASSCO	Inside BAE Systems	Outside BAE Systems
Fillet Data					
Mercury (total, mg/kg)	0.19	0.12	0.15	0.18	0.16
PCB Congeners (µg/kg)	67.4	44.4	99.4	193	99.8
Whole Body Data					
Mercury (total, mg/kg)	0.12	0.16	0.15	0.13	0.14
PCB Congeners (µg/kg)	490	760	544	430	544

¹⁴ <http://www.oehha.ca.gov/fish/pcb/index.html>

¹⁵ ppb = parts per billion = µg/kg = micrograms per kilogram

29. Finding 29: Chemicals of Concern and Background Sediment Quality

Finding 29 of CAO No. R9-2012-0024 states:

The San Diego Water Board derived sediment chemistry levels for use in evaluating the feasibility of cleanup to background sediment quality conditions from the pool of San Diego Bay reference stations described in Finding 17. The background sediment chemistry levels based on these reference stations are as follows:

Background Sediment Chemistry Levels

Chemicals of Concern	Units (dry weight)	Background Sediment Chemistry Levels ¹
Primary COCs		
Copper	mg/kg	121
Mercury	mg/kg	0.57
HPAHs ²	µg/kg	663
PCBs ³	µg/kg	84
Tributyltin	µg/kg	22
Secondary COCs		
Arsenic	mg/kg	7.5
Cadmium	mg/kg	0.33
Lead	mg/kg	53
Zinc	mg/kg	192

1. Equal to the 2005 Reference Pool's 95% upper predictive limits shown in Section 18 of the *Technical Report for Cleanup and Abatement Order No. R9-2012-0024*. The background levels for metals are based on the %fines:metals regression using 50% fines, which is conservative because the mean fine grain sediment at the Shipyard Investigation Site is 70% fines.
2. HPAHs = sum of 6 PAHs: Fluoranthene, Perylene, Benzo[a]anthracene, Chrysene, Benzo[a]pyrene, and Dibenzo[a,h]anthracene.
3. PCBs = sum of 41 congeners: 18, 28, 37, 44, 49, 52, 66, 70, 74, 77, 81, 87, 99, 101, 105, 110, 114, 118, 119, 123, 126, 128, 138, 149, 151, 153, 156, 157, 158, 167, 168, 169, 170, 177, 180, 183, 187, 189, 194, 201, and 206.

The San Diego Water Board identified constituents of primary concern (primary COCs), which are associated with the greatest exceedance of background and highest magnitude of potential risk at the Shipyard Sediment Site. A greater concentration relative to background suggests a

stronger association with the Shipyard Sediment Site, and a higher potential for exposure reduction via remediation. Secondary contaminants of concern (secondary COCs) are contaminants with lower concentrations relative to background, and are highly correlated with primary COCs and would be addressed in a common remedial footprint. Based on these criteria, the primary COCs for the Shipyard Sediment Site are copper, mercury, HPAHs,¹⁶ PCBs, and TBT, and the secondary COCs are arsenic, cadmium, lead, and zinc.

29.1. Guiding Principles for Designating Background Sediment Quality Conditions

The San Diego Water Board must apply Resolution No. 92-49 when setting cleanup levels for contaminated sediment if such sediment threatens beneficial uses of the waters of the state and the contamination or pollution is the result of a discharge of waste. Contaminated sediment must be cleaned up to background sediment quality unless it would be technologically¹⁷ or economically¹⁸ infeasible to do so.

Background conditions for evaluating the feasibility of cleanup to background in marine sediment remediation projects are defined in terms of sediment chemistry, toxicity, and benthic community structure rather than water column chemical pollutant concentrations. This is because protection of water quality involves far more than just water chemistry considerations. Protection of water quality includes protection of the multiple elements which together make up aquatic systems including the aquatic life, wildlife, wetlands, and other aquatic habitat, vegetation, and hydrology required to maintain the aquatic system. Marine sediment provides habitat for many aquatic organisms and functions as an important component of aquatic ecosystems. Adverse effects on organisms in or near sediment can occur even when chemical pollutant levels in the overlying water are low. Various toxic contaminants found only in barely detectable amounts in the water column can accumulate in sediment to much higher levels. Benthic organisms can be exposed to chemical pollutants in sediment through direct contact, ingestion of sediment particles, or uptake of dissolved contaminants present in the interstitial (pore) water. In addition, natural and human disturbances can release pollutants to the overlying water, where pelagic (open-water) organisms can be exposed. Chemical pollutants in sediment

¹⁶ Petroleum hydrocarbons, including TPH, RRO, DRO, and other PAHs were eliminated as primary and secondary COCs for the following reasons. HPAHs, a primary COC, are considered to be the most recalcitrant, bioavailable, and toxic compounds present in the complex mixture of petroleum hydrocarbons. Other measures of petroleum hydrocarbons are generally correlated with HPAHs such that remedial measures to address HPAHs will also address environmental concerns associated with elevated levels of low molecular weight PAHs (LPAHs), total PAHs, TPH, RRO and DRO.

¹⁷ Technological feasibility is determined by assessing available technologies, which have been shown to be effective in reducing the concentration of the pollutants of concern.

¹⁸ Economic feasibility is an objective balancing of the incremental benefit of attaining further reductions in the concentrations of constituents of concern as compared with the incremental cost of achieving those reductions. The evaluation of economic feasibility includes consideration of current, planned, or future land use, social, and economic impacts to the surrounding community including property owners other than the discharger. Economic feasibility does not refer to the dischargers' ability to finance cleanup. Availability of financial resources is considered in the establishment of reasonable compliance schedules.

can also cause adverse effects either through bioaccumulation and food chain transfer to human and wildlife consumers of fish and shellfish. The accumulation of pollutants in sediment, the toxicity and bioaccumulation of sediment pollutants, and the diversity and composition of the aquatic species are all relevant water quality issues that need to be considered in decisions dealing with contaminated marine sediment cleanup

For the current study, background sediment quality is defined for existing “surface” marine sediment in terms of an “ambient background” or “contemporary background,” which means the average surface sediment quality conditions in areas removed from sources of chemical pollutants, recognizing that there may no longer be pristine surface marine sediment in a given geographic area of a waterbody. Ideally, surface sediment station sites used to define “ambient” or “contemporary” background sediment quality conditions should be collected from a field site that is appreciably free of chemical pollutants and has grain size, total organic carbon, sulfide and ammonia levels, and other characteristics similar to the contaminated marine sediment site.

29.2. Background Sediment Quality and the Reference Condition

The San Diego Water Board derived sediment chemistry levels for use in evaluating the feasibility of cleanup to background sediment quality conditions from the pool of San Diego Bay reference stations as described in Section 17. The background sediment chemistry levels at these reference stations are described below.

Table 29-1 Background Sediment Chemistry Levels

Chemicals of Concern	Units (dry weight)	Background Sediment Chemistry Levels ¹
Primary COCs		
Copper	mg/kg	121
Mercury	mg/kg	0.57
HPAHs ²	µg/kg	663
PCBs ³	µg/kg	84
Tributyltin	µg/kg	22
Secondary COCs		
Arsenic	mg/kg	7.5
Cadmium	mg/kg	0.33
Lead	mg/kg	53
Zinc	mg/kg	192

1. Equal to the 2005 Reference Pool's 95% upper predictive limits shown in Section 18 of the Technical Report. The background levels for metals are based on the %fines:metals regression using 50% fines, which is conservative because the mean fine grain sediment at the Shipyard Investigation Site is 70% fines.
2. HPAHs = High Molecular Weight Polynuclear Aromatic Hydrocarbons, sum of Fluoranthene, Perylene, Benzo(a)anthracene, Chrysene, Benzo(a)pyrene, and Dibenzo(a,h)anthracene.
3. PCBs = Polychlorinated Biphenyls, sum of 41 congeners: 18, 28, 37, 44, 49, 52, 66, 70, 74, 77, 81, 87, 99, 101, 105, 110, 114, 118, 119, 123, 126, 128, 138, 149, 151, 153, 156, 157, 158, 167, 168, 169, 170, 177, 180, 183, 187, 189, 194, 201, and 206.

The background sediment quality conditions presented in Table 29-1 provide an appropriate bench mark to evaluate the cleanup to background sediment quality conditions, given the San Diego Water Board's remediation goal for the Shipyard Sediment Site of reducing sediment pollutant levels to attain reasonable protection of beneficial uses.

The background sediment quality condition represents the condition of San Diego Bay away from known sources of chemical pollutants. A detailed description of the reference station selection process is described in the Appendix for Section 17.

The San Diego Water Board believes the background sediment quality conditions presented in this Section will provide reasonable protection of San Diego Bay beneficial uses because:

- From the list of 18 chemicals or combination of chemicals listed in Table 29-1, 11 have published sediment quality guideline values. A comparison of the 11 chemicals to their respective ERMs¹⁹ and ERLs²⁰ show that all 11 CoPCs are below their ERM and 3 of the 11 are also below the ERL. The ERL and ERM values identify ranges in sediment chemistry that are predicted to be rarely (below ERL), occasionally (above ERL but less than ERM), or frequently (above ERM) associated with adverse effects. The Background Sediment Chemistry concentrations fall into the "rare" or "occasional" categories of predicting effects. See Table 29-2 below.
- Mean survival for the amphipod toxicity test for the stations used to define background conditions (i.e. the Reference Condition) is 88 % control adjusted survival. For the 10-day amphipod test, a 72% survival threshold value (80% of the minimum acceptable control survival (90%)) can be used to detect survival significantly less than control (Thursby et al., 1997). This threshold value is very similar to a later published threshold value of 75% survival for the same test using *E. estuarius* (Phillips et al., 2001). The mean Reference Condition is significantly greater than the two threshold values and is close to the minimum acceptable control survival.

¹⁹ Effects Range – Median (ERM) is the median or 50th percentile of effects data for each chemical identified (Long et al., 1995).

²⁰ Effects Range – Median (ERM) is the median or 50th percentile of effects data for each chemical identified (Long et al., 1995).

- The mean BRI value for the background condition is 37 (RL 1). From the 16 reference stations used, 11 (69%) of the stations have BRI scores that fall into the “Reference” or “RL 1” categories. RL 1 is defined as > 5% of reference species absent and is considered a marginal change in relative abundance of species. RL 2 through RL 4 is considered to show clear evidence of benthic community disturbance (Ranasinghe et al., 2003). See Table 29-3 below.

Table 29-2 Background Sediment Chemistry Levels Compared to Sediment Screening Values

Chemicals of Concern	Units (dry weight)	Background Sediment Chemistry Levels ¹	Effects Range Low ²	Effects Range Median ²
Primary COCs				
Copper	mg/kg	121	34	270
Mercury	mg/kg	0.57	0.15	0.71
HPAHs ³	µg/kg	663	1700	9600
PCBs ⁴	µg/kg	84	22.7	180
Secondary COCs				
Arsenic	mg/kg	7.5	8.2	70
Cadmium	mg/kg	0.33	1.2	9.6
Lead	mg/kg	53	46.7	218
Zinc	mg/kg	192	150	410

- Equal to the 2005 Reference Pool’s 95% upper predictive limits shown in Section 18 of the Technical Report. The background levels for metals are based on the %fines:metals regression using 50% fines, which is conservative because the mean fine grain sediment at the Shipyard Investigation Site is 70% fines.
- From Buchman, 1999
- HPAHs = High Molecular Weight Polynuclear Aromatic Hydrocarbons, sum of Fluoranthene, Perylene, Benzo(a)anthracene, Chrysene, Benzo(a)pyrene, and Dibenzo(a,h)anthracene.
- PCBs = Polychlorinated Biphenyls, sum of 41 congeners: 18, 28, 37, 44, 49, 52, 66, 70, 74, 77, 81, 87, 99, 101, 105, 110, 114, 118, 119, 123, 126, 128, 138, 149, 151, 153, 156, 157, 158, 167, 168, 169, 170, 177, 180, 183, 187, 189, 194, 201, and 206.

Table 29-3 Characterization, Definition and BRI-E Thresholds for Levels of Benthic Community Condition

Level	Definition for Bays	BRI-E Threshold
Reference		< 31

Level	Definition for Bays	BRI-E Threshold
Response Level 1	> 5% of reference species absent	31 to 42
Response Level 2	> 25% of reference species absent	42 to 53
Response Level 3	> 50% of reference species absent	53 to 73
Response Level 4	> 80% of reference species absent	> 73

(Ranasinghe et al., 2003)

Justification for each station used in establishing the Reference Condition is provided in Section 17, Table 17-2 and the data and descriptive statistics are provided in the Appendix for Section 17.

Establishing and applying the reference condition as described in Sections 17 and 18 acknowledges the potential for low levels of contamination that is dispersed throughout San Diego Bay and takes into account the natural variability of sediment toxicity and the benthic community condition. The reference or San Diego Bay background condition establishes the current condition that would exist in San Diego Bay minus the influence from Shipyard Sediment Investigation Site.

Although the Reference Condition recognizes some low level of sediment contamination, the levels should remain protective of the beneficial uses.

29.3. Identification of Chemicals of Concern

The San Diego Water Board identified the following nine COCs with the potential to affect the benthic invertebrate community, aquatic-dependent wildlife, or human health beneficial uses (Sections 18-28): arsenic, cadmium, copper, HPAHs, lead, mercury, PCBs, TBT, and zinc.²¹ The nine COCs were separated into two groups, primary COCs and secondary COCs:

- **Primary COCs** were defined as COCs meeting the following criteria:
 - ▶ Greatest exceedance of background suggesting a strong association with the Shipyard Sediment Site;
 - ▶ Highest magnitude of potential risk at the Shipyard Sediment Site; and
 - ▶ Higher potential for exposure reduction via remediation.

²¹ Alternative cleanup levels for chromium, nickel, and silver were not included as COCs in this analysis because they did not have a statistically significant relationship with biological effects on benthic invertebrates (Section 20), they did not pose a risk to aquatic dependent wildlife based on the Tier II Baseline Comprehensive Risk Assessment for Aquatic-Dependent Wildlife (Section 24), and they did not pose a cancer or non-cancer human health risk based on the Tier II Baseline Comprehensive Risk Assessment for Human Health (Section 28).

- **Secondary COCs** were defined as COCs meeting the following criteria:
 - ▶ Lower concentrations relative to background suggesting a lower degree of association with the Shipyard Sediment Site;²² and
 - ▶ Highly correlated with primary COCs and would be addressed in a common remedial footprint.

COCs with a strong Shipyard Sediment Site association were identified via comparison of current, or pre-remedial, surface-area weighted average concentration (SWAC)²³ values to background concentrations. COCs with a SWAC approximately twice that of background were considered to have a high degree of association with the Shipyard Sediment Site, and included copper, HPAHs, PCBs,²⁴ and TBT. Correlation coefficients were generated for COC-by-COC comparison to identify the COCs that had strong positive correlations (see Table 29-4). Among the other five COCs, arsenic, cadmium, lead, and zinc exhibited a strong positive correlation with copper, HPAHs, PCBs, and/or TBT, suggesting that areas of the Site exhibiting high concentrations of these COCs also contained high concentrations of the Site-associated COCs. Only mercury was not highly correlated with copper, HPAHs, PCBs and/or TBT.

Table 29-4 Correlation Coefficients (r values) for COC-by-COC Comparisons of Concentrations in Surface Sediment Samples Collected for the Detailed Sediment Investigation)

COC	As	Cd	Cu	Hg	HPAHs	Pb	PCBs	TBT	Zn
As	1.00	0.66	0.92	0.63	0.68	0.86	0.73	0.81	0.97
Cd	0.66	1.00	0.61	0.42	0.52	0.66	0.64	0.51	0.71
Cu	0.92	0.61	1.00	0.78	0.76	0.90	0.83	0.89	0.94
Hg	0.63	0.42	0.78	1.00	0.73	0.77	0.87	0.63	0.61
HPAHs	0.68	0.52	0.76	0.73	1.00	0.84	0.87	0.80	0.67
Pb	0.86	0.66	0.90	0.77	0.84	1.00	0.92	0.87	0.89
PCBs	0.73	0.64	0.83	0.87	0.87	0.92	1.00	0.79	0.75

²² Secondary COCs with a low degree of association with the Site are suggestive of COCs derived from watershed or regional sources, rather than dischargers specific to the Site. The San Diego Water Board has limited authority to order Site cleanup of pollution conditions that has a low degree of association with named dischargers.

²³ Surface-area weighted average concentrations (SWACs) are discussed in Section 32.2.

²⁴ Total PCBs was defined as the sum of 41 congeners.

COC	As	Cd	Cu	Hg	HPAHs	Pb	PCBs	TBT	Zn
TBT	0.81	0.51	0.89	0.63	0.80	0.87	0.79	1.00	0.85
Zn	0.97	0.71	0.94	0.61	0.67	0.89	0.75	0.85	1.00

Notes: Pearson correlations using ln-transformed data. Correlation is significant if less than -0.433 or greater than 0.433 (correlations > 0.70). Bolded, shaded values indicate a strong correlation between COCs.

Source: Exponent, 2003

The high degree of correlation between Shipyard Sediment Site-associated COCs (copper, TBT, HPAHs, and PCBs) and arsenic, cadmium, lead, and zinc suggests that alternate cleanup levels for Shipyard Sediment Site-associated COCs would also achieve a high degree of exposure reduction for arsenic, cadmium, lead, and zinc. However, an alternate cleanup approach based on copper, TBT, HPAHs, and PCBs would not likely address the highest concentrations of mercury due to the lack of correlation between mercury and any of the four Site-associated COCs. Therefore, mercury was added as a primary COC. The final list of primary COCs includes copper, mercury, TBT, HPAHs, and PCBs, as summarized in Table 29-5. The secondary COCs include arsenic, cadmium, lead, and zinc.

Table 29-5 Identification of Primary Chemicals of Concern

Chemicals of Concern	Units (dry weight)	Pre-Remedial SWAC	Bkgd	Multiple	Site-Associated COCs (Multiple \geq 2)	Strong Correlation with Site-Associated COCs	Selection as Primary COC
Metals							
Arsenic	mg/kg	9.4	7.5	1.3	No	Yes	No
Cadmium	mg/kg	0.28	0.33	0.8	No	Yes	No
Copper	mg/kg	187	121	1.5	Yes ¹		Yes
Lead	mg/kg	73	53	1.4	No	Yes	No
Mercury	mg/kg	0.75	0.57	1.3	No	No	Yes
Zinc	mg/kg	252	192	1.3	No	Yes	No
Organics							
Tributyltin	μ g/kg	162	22	7.3	Yes		Yes
HPAHs	μ g/kg	3,509	663	5.2	Yes		Yes

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Chemicals of Concern	Units (dry weight)	Pre-Remedial SWAC	Bkgd	Multiple	Site-Associated COCs (Multiple ≥ 2)	Strong Correlation with Site-Associated COCs	Selection as Primary COC
PCBs	$\mu\text{g}/\text{kg}$	308	84	3.6	Yes		Yes

1. The multiple of 1.5 was rounded up to 2 to be conservative.

30. Finding 30: Technological Feasibility Considerations

Finding 30 of CAO No. R9-2012-0024 states:

Although there are complexities and difficulties that would need to be addressed and overcome (e.g. removal and handling of large volume of sediment; obstructions such as piers and ongoing shipyard operations; transportation and disposal of waste), it is technologically feasible to cleanup to the background sediment quality levels utilizing one or more remedial and disposal techniques. Mechanical dredging, subaqueous capping, and natural recovery have been successfully performed at numerous sites, including several in San Diego Bay, and many of these projects have successfully overcome the same types of operational limitations present at the Shipyard Sediment Site, such as piers and other obstructions, ship movements, and limited staging areas. Confined aquatic disposal or near-shore confined disposal facilities have also been employed in San Diego Bay and elsewhere, and may be evaluated as project alternatives for the management of sediment removed from the Shipyard Sediment Site.

30.1. Technological Feasibility to Cleanup to Background Conditions

Technological feasibility is determined by assessing available technologies which have been shown to be implementable and effective in either reducing pollutant levels in contaminated marine sediments or isolating contaminated marine sediment from the marine environment.

The feasibility study in the Shipyard Report (Exponent, 2003) identifies and evaluates natural recovery, subaqueous capping, dredging, and treatment as candidate remedial options. Exponent's screening of these candidate remedial options retains natural recovery and dredging for further evaluation, and does not retain subaqueous capping and in situ treatment. However, the parties subject to the cleanup and abatement order have evaluated other remedial options and determined that those remedial alternatives screened out in the Shipyard Report (Exponent, 2003) may be appropriate for certain areas within the site, especially those areas where piers or other over-water structures prevent or make it difficult to implement traditional remedial measures such as dredging. Note that remedial measures may be used in combination since a given remedial measure may be enhanced by other measures to achieve the desired cleanup goal.

The evaluation of remedial measures must also consider the short and long term impacts associated with its implementation. In this regard, a remedial strategy should include an evaluation of impacts to the local community and beyond. The San Diego Water Board evaluated whether or not it is technologically feasible to cleanup to background using the three readily employable and proven remediation strategies: natural recovery, subaqueous capping, and dredging. Other alternatives that may be available, in whole or in part, for management of the dredge material include confined aquatic disposal (CAD) or near-shore confined disposal facility (CDF). And, while these alternatives may be less desirable than removal of the contaminated sediment from San Diego Bay, these alternatives may mitigate impacts resulting from off-site transportation and disposal.

Natural recovery, subaqueous capping, and dredging alternatives are discussed below.

30.1.1. Monitored Natural Recovery

The National Research Council defines Monitored Natural Recovery (MNR) as a contaminated sediment remedy that depends on un-enhanced natural processes to reduce risk to human and environmental receptors to acceptable levels (NRC 2000). Natural recovery involves leaving the contaminated sediment in place and allowing the ongoing aquatic processes to contain, destroy, or otherwise reduce the bioavailability of the sediment pollutants in order to achieve site specific remedial action objectives (U.S. EPA, 2005a; NRC, 1997; Magar et al., 2009). Underlying MNR processes may include biodegradation, biotransformation, bioturbation, diffusion, dilution, adsorption, volatilization, chemical reaction or destruction, resuspension, and burial by clean sediment. Monitoring is fundamental to the remedy in order to assess whether risk reduction and ecological recovery by natural processes are occurring as expected. Successful implementation of MNR requires that (1) natural recovery processes are actively transforming, immobilizing, isolating, or removing chemical contaminants in sediments to levels that achieve acceptable risk reduction within an acceptable time period, and (2) source control has been achieved or sources are sufficiently minimized such that these natural recovery processes can be effective. Source control is common to all sediment remedies but particularly to MNR because slow rates of recovery could be outpaced by ongoing releases (Magar et al., 2009).

Monitored natural recovery is not a passive, no-action, or no-cost remedy. While it does not require active construction, effective remediation via MNR relies on a fundamental understanding of the underlying natural processes that are occurring at the site. MNR remedies require extensive risk assessment, site characterization, predictive modeling, and monitoring to verify source control, identify natural processes, set expectations for recovery, and confirm that natural processes continue to reduce risk over time as predicted (Magar et al., 2009). The remedial investigation and feasibility study are used to establish lines of evidence to verify acceptable rates and relative permanence of risk reduction measured and/or predicted for MNR.

Natural recovery processes occur at all contaminated sediment sites, and the extent to which these processes can be relied upon to achieve acceptable risk reduction must be determined by the results of the remedial investigation and feasibility study (Magar and Wenning, 2006; U.S. EPA, 2005a; NRC, 2001). The following conditions that are particularly conducive to MNR include (U.S. EPA, 2005a):

- Assessment indicates that natural recovery processes will continue at rates that contain, destroy, or reduce the bioavailability or toxicity of contaminants within an acceptable time frame.
- Short-term exposure can be reasonably limited by institutional controls during the recovery period.
- Contaminant exposures in biota and the biologically active zone of sediment are moving toward risk-based goals.
- For sites relying on natural isolation, the sediment bed is reasonably stable.

Because they are always present to varying degrees, natural recovery processes should be considered in every remedial action, even in cases when MNR is not expected to be the sole or primary remedy for a contaminated site (Magar and Wenning, 2006; U.S. EPA, 2005a; NRC, 2001). Natural recovery processes are often combined with other engineering approaches to increase the overall success of the remedial action (Magar et al., 2009). Many sites utilize hybrid remedies that combine dredging, capping, and MNR. For example, MNR may be used to control risk from areas of widespread, low-level sediment contamination following dredging or capping of more highly contaminated areas where analysis reveals that MNR cannot achieve acceptable risk reduction within targeted time frames, or MNR may be combined with thin-layer placement of clean sediment at sites where the natural rate of sedimentation is insufficient to bury contaminants in a reasonable time frame (U.S. EPA, 2005a).

Based on the available lines of evidence from the assessment (Exponent, 2003) a range of natural recovery processes are active at the Shipyard Sediment Site. Sedimentation rates in the range of 1-2 cm/year suggest that the surface sediment layer will be actively improved by natural deposition (see Section 5.8). Active efforts are underway to control sources. Elevated chemical concentrations are generally restricted to a limited spatial area within the pier areas. Bioavailability of site chemicals to benthic organisms appears to be limited based on lack of observed toxicity or benthic community degradation relative to reference conditions in most areas. Current site use for shipbuilding and repair activities may lead to sediment disturbances due to ship launching and other ship movements. Complete control of site sources has not been fully demonstrated to a level that would assure adequate rates of recovery. While NASSCO and BAE Systems propose that monitored natural recovery or attenuation is an appropriate exclusive remedy, none of the dischargers has demonstrated, and there is insufficient evidence in the record, to support a conclusion that, monitored natural attenuation has a substantial likelihood of achieving compliance with the alternative cleanup levels established in this CAO within a reasonable time frame. Therefore, based on current site use and site characteristics, while natural recovery processes are active at the site, it has not been demonstrated that the remedy has a substantial likelihood of achieving compliance with the CAO within the sediment management Units of the Shipyard Sediment Site. For this reason, as well as the reasons discussed in the San Diego Water Board Cleanup Team's Response to Comments Report²⁵ (August 23, 2011), monitored natural recovery is not recommended as the primary remedy for the Shipyard Sediment Site, but is likely to provide an additional level of effectiveness and margin of safety in combination with more active remedial measures located within areas designated as sediment management Units.

30.1.2. Subaqueous Capping

Subaqueous capping (i.e., in-place capping) is the placement of clean material on top of the contaminated sediment. Capping effectiveness can be achieved through three primary mechanisms including (1) physical isolation of the contaminated sediment from the benthic environment, (2) stabilization of contaminated sediments, preventing resuspension and transport to other sites, and (3) reduction of the flux of dissolved contaminants into the water column (U.S. EPA, 2005a; U.S. EPA, 1998c). The capping material is typically clean sand, silty to gravelly

²⁵ Response to Comments Report, August 23, 2011, pp. 1-26 through 1-28 and 30-1 through 30-4 and 32-4 through 32-6.

sand, and/or armoring material, or may involve a more complex design with geotextiles, liners and multiple layers. To achieve these results, an in-situ capping project must be treated as an engineered project with carefully considered design, construction, and monitoring (Palermo et al., 1998). Effective capping requires sufficient cap thickness, careful cap placement to avoid disturbance, and cap integrity maintenance from disturbances. Capping also requires monitoring to ensure integrity and effectiveness. Capping is a procedure that can be used at appropriate sites, and its success depends on careful design and implementation.

Sediment capping, when properly designed, has been demonstrated to be effective in remediating sediment contamination at a broad range of sites (U.S. EPA, 2010). For the Shipyard Sediment Site, available lines of evidence indicate that some areas may be suitable for in-situ capping (Exponent, 2003). In most areas, water depth is adequate to accommodate at least a moderate thickness cap with anticipated uses for navigation and shipbuilding. Naturally driven hydrodynamic conditions in the region, including tidal currents and wind waves, are generally not likely to compromise a properly designed cap. Long-term risk reduction is likely to outweigh habitat disruption, particularly in areas of higher chemical concentrations. Rates of groundwater flow at the site are likely to be low and not likely to create unacceptable contaminant releases. The sediment at the site generally has sufficient strength to support a moderate thickness cap. Elevated levels of contamination generally cover contiguous areas. Other lines of evidence from the site indicate potential limits to the applicability of capping in certain areas of the Site. There is evidence of physical disturbance from ship movements, ship testing, and ship launching activities. These physical disturbances would require a thicker or more physically resistive capping design which could limit water depth at the site or degrade the benthic habitat. Evidence of well developed benthic communities existing at the site may be a concern both due to potential cap failure via burrowing and bioturbation, as well as the impact to these communities that may occur through cap placement. In general, the major limitation of in-situ capping for the site is that the contaminated sediment remains in place where contaminants could become exposed or be dispersed if the cap is significantly disturbed or if contaminants move through the cap in significant amounts. Based on current site use for shipbuilding and repair activities, and the potential for sediment disturbances due to ship launching and other ship movements, portions of the Shipyard Sediment Site are subject to sediment disturbance that potentially limits the applicability of in-situ capping.

For these reasons, while in-situ capping is not recommended as the primary remedy for the site, it will be considered for application in specific areas. These include areas that are shielded to a degree from physical disturbance and where mechanical dredging is not feasible (e.g., under piers or adjacent to structures). In addition, clean, thin-layer backfill will be considered in areas where dredge residual contamination, following one or more dredge passes, does not resolve contaminate concentration at the upper-most surface layer as a result of fall-out from mechanical dredging. Based on current site use, placement of a sand layer is considered technologically feasible for under-structure areas, areas adjacent to structures, and in certain isolated areas near shore where mechanical dredging may undermine structures. Sand layering may also be appropriate to help manage residuals following the dredging process.

30.1.3. Environmental Dredging

Historically, dredging is one of the most common methods employed at contaminated sediment sites. Dredging is the physical removal of sediment from a water body. Environmental dredging, as opposed to navigational or construction dredging, is performed specifically for the removal of contaminated sediment. Environmental dredging is intended to remove sediment contaminated above certain action levels while minimizing the spread of contaminants to the surrounding environment during dredging (NRC, 1997). According to the U.S. EPA, 150 sites on National Priorities List involved contaminated sediment and approximately 30 percent of the sites included a decision that specified dredging or excavation as the sediment cleanup method (U.S. EPA, 2005a). Key design considerations for effective implementation of environmental dredging as a cleanup method include sediment removal, transport, staging, treatment (pretreatment, treatment of water and sediment, if necessary), and disposal of liquids and solids (U.S. EPA, 2005a; U.S. ACE, 2008a).

Because of its extensive use in previous cleanups, a broad range of technologies exist to implement environmental dredging across a range of conditions (U.S. ACE, 2008a). For the Shipyard Sediment Site, available lines of evidence indicate that most areas are suitable for environmental dredging (Exponent, 2003). Water depth at the site is deep enough for dredge equipment, yet not too deep for operations. Contaminated sediment is generally underlain by clean, more resistant sediment to facilitate identification of dredge limits. Suitable disposal sites are available. Long-term risk reduction of sediment removal is likely to outweigh sediment disturbance and habitat disruption in areas of elevated chemical levels.

Other lines of evidence from the site indicate potential limits to the feasibility of environmental dredging. The presence of infrastructure, such as piers and pilings, makes dredging more difficult due to access constraints. Site operations such as ship berthing and ship movements increase the complexity of planning and executing a dredging operation. Technical limitations include the following:

- Ability to effectively contain and remove all of the target material;
- Potential to expose much more highly contaminated material that was previously buried;
- Absence of identified area for staging equipment and handling and transporting dredged materials;
- Potential impacts to the local community related to handling and transportation of dredged material;
- Potential for debris that could impede dredging;
- Potential alteration of habitat and impacts to the existing benthic community; and
- Potential water quality impacts from resuspension of sediment and the associated release of pollutants.

Based on the available data, it appears that the total amount of sediment “lost” to resuspension can be as low as 0.1% to over 5% of the in situ volume (U.S. ACE, 2008b). However, this small percentage does not necessarily mean that sediment resuspension is not a concern. The loss of even 1 percent of certain pollutants could be a substantial problem. However, specialty dredges have been designed to reduce resuspension during dredging operations and are effective in removing sediment with a minimum of resuspension. In addition, field tests indicate that conventional dredges, if operated with care, can also remove sediment with low levels of resuspension (NRC, 1997).

Disposal of dredged material needs to be considered when evaluating dredging as a remedial alternative. Dredged material may be deposited via aquatic disposal (e.g. in-bay or at open ocean disposal sites); transported to inland sites (e.g., landfill); or placed in CDFs, preferably within or near the remediation site.

Suitability for ocean disposal of dredge material is evaluated using effects-based testing as described in the “Green Book” national testing manual (U.S. EPA/Corps, 1991). Although sediment testing of the material at the Shipyard Sediment Site in accordance with the Green Book has not been accomplished, given the nature and extent of chemistry for most of the sediment expected to require remediation, ocean disposal is not retained for further consideration.

Offsite disposal of dredged sediment can be in approved landfills, following chemical screening to ensure compatibility with landfill requirements. If the dredged material is classified as hazardous waste under the Resource Conservation and Recovery Act (42 USC §6901 et seq.) or Title 22 of the California Code of Regulations (Division 4.5, Chapter 11), it may be disposed only in Class I waste management units. Offsite disposal is an effective remedial alternative as it permanently removes the waste from the site. Considerations associated with disposal include:

- The identification of an upland sediment management site with sufficient space and access to stockpile, dewater, and ship removed dredge material;
- Potential impacts to the local community near where the sediment is managed; and
- Potential impacts to the community associated with the anticipated numerous truck trips to transport the sediment to the disposal location.

Alternatives to offsite disposal include confinement of sediment within or adjacent to the bay. CAD is a submerged area where dredge material is placed, followed by the placement of capping material. This technique has been employed in San Diego Bay and elsewhere in the country and can simultaneously be enhanced to provide aquatic habitat. A nearshore CDF is similar to a CAD except that it is created adjacent to the shoreline, where the sediment is confined using retaining structures such as sheetpile or dike structures. The use of a CAD or CDF can significantly reduce the potential community impacts associated with offsite disposal, including the need for an on-shore dewatering and sediment management site and the truck trips through the local community.

Given that adequate consideration for the factors described above is applied during the design phase of the remediation, environmental dredging is recommended as the preferred remedial method for the site. Because of the limitations of conducting dredging in all areas targeted for remediation, the design should incorporate targeted application of capping and backfill to supplement the effectiveness of dredging where needed. Natural recovery processes outside the dredge footprint should be considered in the context of overall site recovery. They also provide an additional margin of safety for the protection of beneficial uses that could not be achieved by dredging alone. Exposure scenarios, risk levels, protection of beneficial uses, and economic feasibility for the proposed remedy are discussed in further detail in the following sections.

30.2. Conclusion

Although there are complexities and difficulties that would need to be addressed and overcome (e.g. removal and handling of large volume of sediment; obstructions such as piers and ongoing shipyard operations; transportation and disposal of waste), the San Diego Water Board concludes that it is technologically feasible to cleanup to the background sediment quality levels defined in Section 29 utilizing one or more of the above remedial and disposal techniques. Mechanical dredging, subaqueous capping, and natural recovery have been successfully performed at numerous sites, including several in San Diego Bay, and many of these projects have successfully overcome the same types of operational limitations present at the Shipyard Sediment Site, such as piers and other obstructions, ship movements, and limited staging areas. CAD and near shore CDF have also been employed in San Diego Bay and elsewhere and are considered technically feasible alternatives to be evaluated for the management of sediment removed from the Shipyard Sediment Site.

31. Finding 31: Economic Feasibility Considerations

Finding 31 of CAO No. R9-2012-0024 states:

Under State Water Board Resolution No. 92-49, *Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304*, determining “economic feasibility” requires an objective balancing of the incremental benefit of attaining further reduction in the concentrations of primary COCs as compared with the incremental cost of achieving those reductions. Resolution No. 92-49 provides that “[e]conomic feasibility does not refer to the dischargers’ ability to finance cleanup.” When considering appropriate cleanup levels under Resolution No. 92-49, the San Diego Water Board is charged with evaluating “economic feasibility” by estimating the costs to remediate constituents of concern at a site to background and the costs of implementing other alternative remedial levels. An economically feasible alternative cleanup level is one where the incremental cost of further reductions in primary COCs outweighs the incremental benefits.

The San Diego Water Board evaluated a number of criteria to determine risks, costs, and benefits associated with no action, cleanups to background sediment chemistry levels, and alternative cleanup levels greater than background concentrations. The criteria included factors such as total cost, volume of sediment dredged, exposure pathways of receptors to contaminants, short- and long-term effects on beneficial uses (as they fall into the broader categories of aquatic life, aquatic-dependent wildlife, and human health). The San Diego Water Board then compared these cost criteria against the benefits gained by diminishing exposure to the primary COCs to estimate the incremental benefit gained from reducing exposure based on the incremental costs of doing so. As set forth in detail herein, this comparison revealed that the incremental benefit of cleanup diminishes significantly with additional cost beyond a certain cleanup level, and asymptotically approaches zero as remediation approaches background. Based on these considerations, cleaning up to background sediment chemistry levels is not economically feasible.

31.1. Evaluation of Economic Feasibility of Cleaning Up to Background

Economic feasibility is a term of art under Resolution No. 92-49, and refers to the objective balancing of the incremental benefit of attaining more stringent cleanup levels compared with the incremental cost of achieving those levels. Economic feasibility does not refer to the subjective measurement of the discharger’s ability to pay the costs of a cleanup. The benefits of remediation are best expressed as the reduction in exposure of human, aquatic wildlife, and benthic receptors to site-related COCs.

Economic feasibility was assessed by ranking the 66 shipyard sediment stations based on the contaminant levels for the five primary COCs found in surficial sediment samples.²⁶ A series of cumulative cost scenarios was then evaluated by starting with the six most contaminated stations, then adding the six next most contaminated stations, progressing sequentially down the list until the entire Shipyard Sediment Site was included in the scenario (see Appendix for Section 31). For each scenario, the required dredging volume and associated cost of remediation for the set of Thiessen polygons²⁷ included in the step was estimated. The estimated post-remedial surface-area weighted average concentrations (SWAC) and exposure reduction for the primary COCs was also estimated for each cost scenario. Exposure reduction was defined for this purpose as the reduction in sediment SWAC for the shipyard site, relative to background, where the pre-remedial SWAC is considered zero reduction and background is considered 100 percent reduction. As chemical concentrations are reduced and mass removed, the SWAC for each COC decreases, which is equivalent to an expected exposure reduction for the target receptors. The following equation represents the relationship of exposure reduction to post-remedy SWAC.

$$\text{Exposure Reduction} = \text{SWAC}_{\text{current}} - \text{SWAC}_{\text{post-remedy}}$$

To estimate the relative exposure reduction of a cost scenario, it is appropriate to normalize the exposure reduction to background. For example, current conditions represent 0 percent exposure reduction, whereas as post-remedial SWAC equal to background represents 100 percent exposure reduction. This equation is the calculation of the percent of exposure reduction relative to background.

$$\% \text{ Exposure Reduction} = \frac{\text{SWAC}_{\text{current}} - \text{SWAC}_{\text{post-remedy}}}{\text{SWAC}_{\text{current}} - \text{Background}} \times 100$$

The following equation is an example of quantifying exposure reduction. This example assumes a current SWAC of 10 ppm for COC1 and a final SWAC of 2 ppm. The background concentration used in this example is 1 ppm for COC1.

$$\frac{10 \text{ ppm} - 2 \text{ ppm}}{10 \text{ ppm} - 1 \text{ ppm}} \times 100 = 89\%$$

In this example, the exposure reduction relative to background when cleaning up a current SWAC of 10 ppm to a post-remedial SWAC of 2 ppm is 89 percent. An average exposure reduction for each cost scenario was calculated by averaging the percent exposure reduction for each primary COC (copper, mercury, HPAHs, PCBs, and TBT; see Appendix for Section 31).

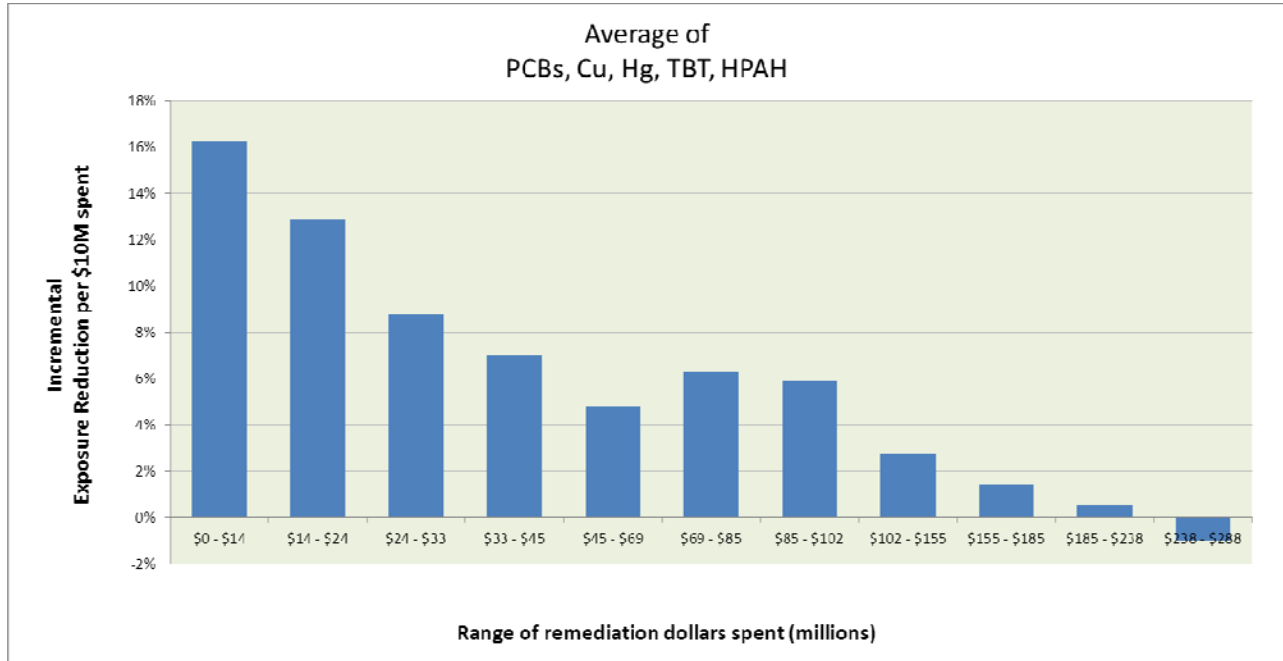
²⁶ The ranking methodology is discussed in Section 32.2.3.

²⁷ To calculate surface-area weighted average concentrations for COCs at the Shipyard Sediment Site, a geospatial technique (Thiessen polygons) was used to represent the area represented by each sediment sample. This methodology is discussed in Section 32.2.

31.2. Comparison of Incremental Cost versus Incremental Benefit

A cost-benefit relationship became readily apparent in the San Diego Water Board’s analysis. Initial expenditures return a relatively high exposure reduction benefit, but additional expenditures yield progressively lower returns per dollar spent on remediation. Further expenditures eventually reach a point where exposure reduction benefits become negligible. For additional significant sums of money spent, the environmental condition is not substantially improved. Figure 31-1 illustrates this relationship.

Figure 31-1 Percent Exposure Reduction versus Remediation Dollars Spent



Note: See Appendix for Section 31 for supporting calculations

The highest net benefit per remedial dollar spent occurs for the first \$24 million (12 polygons), based on the fact that initial exposure reduction is 16 to 13 percent per \$10 million spent. Beyond \$24 million, however, exposure reduction drops consistently as the cost of remediation increases. Exposure reduction drops to 7 percent or below per \$10 million spent after \$33 million, and below 3 percent after \$102 million. Based on these incremental costs versus incremental benefit comparisons, cleanup to background sediment quality levels is not economically feasible.