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DRAFT REMEDIAL INVESTIGATION FOR TAYLOR BOULEVARD BRIDGE DISPOSAL SITE TIDAL AREA, NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD CONCORD, CALIFORNIA

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ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
AVS	Acid volatile sulfides
BAF	Bioaccumulation factor
bgs	Below ground surface
BTAG	Biological Technical Advisory Group
BW	Body Weight
Cal/EPA	California Environmental Protection Agency
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-term Environmental Action Navy
cm	Centimeter
COE	U.S. Army Corps of Engineers
COEC	Chemical of ecological concern
COPC	Chemical of potential concern
COPEC	Chemical of potential ecological concern
Cr(III)	Chromite
Cr(VI)	Chromate
CSM	Conceptual site model
CTO	Contract Task Order
DO	Dissolved oxygen
DQO	Data quality objective
DTSC	State of California Department of Toxic Substances Control
EC_{25}	Concentration at which 25 percent of the populations is effected
EC_{50}	Concentration at which 50 percent of the population is effected
EFA West	Engineering Field Activity West
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological risk assessment
ER-L	Effects-range low
ER-M	Effects-range median
ER-Mq	Effects-range median quotient
FS	Feasibility study
FSP	Field sampling plan
Hg(I)	Mercurous

ACRONYMS AND ABBREVIATIONS (Continued)

Hg(II)	Mercuric
HHRA	Human health risk assessment
HI	Hazard index
HQ	Hazard quotient
IR	Ingestion rate
IRIS	Integrated Risk Information System
IT	International Technology Corp.
J	Estimated data
km^2	Square kilometer
K_{sp}	Solubility products
LC_{50}	Lethal concentration for 50 percent of the population
LOAEL	Lowest-observed-adverse-effect level
μg/dL	Microgram per deciliter
μg/kg	Microgram per kilogram
μg/L	Microgram per liter
μm	Micrometer
mg/day	Milligram per day
mg/kg	Milligram per kilogram
mg/kg-day	Milligram per kilogram per day
mg/L	Milligram per liter
mL	Milliliter
mm	Millimeter
MBTA	Migratory Bird Treaty Act
msl	Mean sea level
NAS	National Academy of Science
Navy	U.S. Department of the Navy
NCEA	National Center for Environmental Assessment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAEL	No-observed-adverse-effect level
NWSSB	Naval Weapons Station Seal Beach
ORNL	Oak Ridge National Laboratory
PAH	Polynuclear aromatic hydrocarbon
PAS	Pacific Aerial Surveys

ACRONYMS AND ABBREVIATIONS (Continued)

PG&E	Pacific Gas & Electric
ppm	Parts per million
ppt	Parts per thousand
PRC	PRC Environmental Management, Inc.
PRG	Preliminary remediation goal
QA	Quality assurance
QAPP	Quality assurance project plan
QC	Quality control
R	Rejected data
RDA	Recommended Daily Allowance
Redox	Reduction-oxidation
RfD	Reference dose
RI	Remedial investigation
RME	Reasonable maximum exposure
RWQCB	California Regional Water Quality Control Board
SeIV	Selenite
SEM	Simultaneously extractable metals
SeVI	Selenate
SF	Slope factor
SMDP	Scientific management decision points
SUF	Site use factor
SVOC	Semivolatile organic compound
SWRCB	State of California Water Resources Control Board
TBB	Taylor Boulevard Bridge
TOC	Total organic carbon
TPH	Total petroleum hydrocarbons
TPH-d	Total petroleum hydrocarbons as diesel
TPH-mo	Total petroleum hydrocarbons as motor oil
TRV	Toxicity reference value
TtEMI	Tetra Tech EM Inc.
U	Nondetected data
UCL_{95}	95 percent upper confidence limit
USFWS	U.S. Fish and Wildlife Service
VOC	Volatile organic compound
WCV	Wetland Cover Value

ACRONYMS AND ABBREVIATIONS (Continued)

WP	Work plan

EXECUTIVE SUMMARY

The Department of the Navy (Navy), Engineering Field Activity West (EFA West) conducted a remedial investigation (RI) at the Taylor Boulevard Bridge (TBB) disposal site of the Naval Weapons Station Seal Beach Detachment Concord (NWSSB Detachment Concord), Concord, California.

The TBB Disposal Site when debris was discovered in late 1995 during an RI that was conducted at four nearby Tidal Area sites. The Navy collected sediment samples from borings in the TBB Disposal Site and the surrounding area in February 1996, March 1997, October 1997, February 1998, and June 1998 to assess the nature and extent of chemical contamination.

Based on preliminary evaluations of the spatial distribution of chemicals in sediments and soil and the small size of the site, it was clear that a removal action could be warranted to reduce the potential risk to human health and the environment. Preliminary evaluations indicated that concentrations of inorganic chemicals (primarily lead) at the center of the site were higher than concentrations detected in surrounding areas. The high concentrations of inorganic chemicals in soil in the center of the site were considered to pose a potential risk to both human health and the environment based on screening level assessments. Based on the results of these preliminary evaluations, the Navy proposed a removal action to remove the debris to mitigate the risk to the environment. However, based on discussions between the Navy and regulatory agencies, it was decided that an RI and feasibility study (FS) would be conducted for the TBB Disposal Site to better delineate areas that pose a significant risk and require remediation.

OBJECTIVES

Specific objectives of the RI for the TBB Disposal Site at NWSSB Detachment Concord were as follows:

- Characterize the nature and extent of soil and sediment contamination for the purpose of developing and evaluating effective remedial alternatives.
- Characterize spatial extent of debris for the purpose of developing and evaluating effective remedial alternatives.

- Identify potential contamination migration pathways and receptors potentially exposed to contaminants at the site.
- Assess risk to human health using a screening-level HHRA approach and delineate a risk footprint.
- Assess ecological risk using a baseline ERA approach and delineate a risk footprint.
- Collect data to support initial FS activities.

This RI report was prepared with these objectives in mind, in accordance with the revised National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and U.S. Environmental Protection Agency's (EPA) guidance for conducting RI/FSs under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (EPA 1988). Data gathered during the RI were used to evaluate whether the site poses a risk to human health or the environment and followed risk assessment guidance (EPA 1997a, 1997b).

METHODS

The TBB Disposal Site RI field investigation consisted of a series of five soil and sediment sampling events beginning in February 1996. These investigations served to characterize the site's soil and sediment chemistry and determine the nature and extent of chemicals likely to originate from on-site debris. Evaluation of these soil and sediment data indicated that concentrations of inorganic chemicals (primarily lead) at the center of the site were significantly higher than concentrations detected in surrounding areas. Based on screening level assessments, concentrations of inorganic chemicals in soil in the center of the site were determined a potential threat to both human health and ecological receptors. However, threats to ecological receptors were determined to be the primary risk drivers at the site because of the presence of wetlands and potential presence of special status species, and limited human access to the site. Additional sampling to address the data needs for a baseline ERA was conducted during February and March 2000. The ERA-focused sampling included collection of composite sediment samples for metals analysis and bioassays and collection of pickleweed and amphipods for tissue residue analysis. Also during the ERA-focused sampling, 22 holes were dug throughout the site in an effort to determine the depth and lateral extent of the site debris.

Screening Level Human Health Risk Assessment

For the HHRA, potential cancer risks and noncancer health hazards associated with sediment and soil were calculated using a screening-level approach. Specifically, soil and sediment chemical concentrations were compared with EPA Region IX preliminary remediation goals (PRG) (EPA 1999) for a residential scenario. PRGs based on target cancer risks of 1×10^{-6} and hazard quotients (HQ) of 1 were used. Although it is highly unlikely that the site will ever be developed for residential housing, residential PRGs were used as a very conservative benchmark to confirm that site conditions would be protective of human health for all possible future uses. Because the exposure and estimated risk for all other receptors are expected to be significantly less than those of a resident, the residential (or unrestricted) scenario was the only scenario evaluated in this risk assessment. The HHRA approach is consistent with the memorandum regarding the recommended outline for using EPA Region IX PRGs in screening risk assessments at military facilities (California Environmental Protection Agency [Cal/EPA] 1994). Chemicals of potential concern (COPC) were defined as all detected organic constituents and inorganic constituents detected in excess of ambient concentrations.

In view of the elevated concentrations of inorganic chemicals (primarily lead) detected in the center of the site, the site was divided into two subareas that were evaluated separately. All samples with detected lead concentrations greater than 400 mg/kg (the residential PRG for lead) were grouped into one area (hereafter referred to as Area A or, locations within the 400 mg/kg isopleth), and the remainder of the samples were grouped into another area (Area B, or locations outside the 400 mg/kg isopleth).

Baseline Ecological Risk Assessment

For the baseline ERA, five assessment endpoints, ranging from plants to higher-trophic-level receptors, were identified for specific evaluation. Assessment endpoints include the following:

- Maintenance and protection of wetland and upland transitional plants
- Protection of populations of benthic invertebrates
- Protection of populations of waterfowl

- Protection of populations of shorebirds
- Protection of individual salt marsh harvest mice

Chemicals of potential ecological concern (COPEC) for the TBB Disposal Area were identified separately for plants, invertebrates, and birds and mammals. For plants and benthic invertebrates, COPECs were identified based on a comparison of the 95th upper confidence limit of the mean (UCL_{95}) soil concentration compared to: 1) ambient values from site-specific sampling at the Tidal Area and from regional San Francisco Bay studies and 2) toxicity-based benchmarks. For birds and mammals, COPECs were identified based on a comparison of the UCL_{95} to ambient values.

Risks to each type of receptor from chemicals identified as COPECs were then characterized using a weight-of-evidence approach as described below to determine whether the site poses a significant risk to ecological receptors that warrants additional evaluation or a response action.

- **Lines of Evidence for Assessing Risk to Wetland and Upland Transitional Plants** - Within the context of the baseline ERA, maintenance and protection of wetland and upland transitional plants is defined as sufficient rates of survival, growth, and germination to sustain plant populations. The effect of chemicals on wetland and upland transitional plant populations was evaluated using the following lines of evidence:
  - Comparison of chemical concentrations in soil/sediment with Oak Ridge National Laboratory (ORNL) benchmarks for plants (Efroymson and others 1997).
  - Calculation of HQs (site concentration/ORNL benchmark) to evaluate the magnitude and extent of contamination.
  - Qualitative evaluation of site-specific bioaccumulation factors BAFs based on pickleweed tissue concentrations divided by collocated soil concentration.
  - Qualitative evaluation of toxicity based on a review of the primary literature.
- **Lines of Evidence for Assessing Risk to Populations of Benthic Invertebrates** - Within the context of the baseline ERA, protection of populations of benthic invertebrates is defined as sufficient rates of survival and growth to sustain populations of invertebrates at the site. The following lines of evidence were used to evaluate the effect of inorganic chemicals on populations of benthic invertebrates:
  - Comparison of chemical concentrations in sediment to effects-range low (ER-L) and effects range-median (ER-M [Long and others 1995]).

- Calculation of mean ER-M quotients (mean ER-Mq) to evaluate the magnitude and extent of contamination (Long and MacDonald 1998)

- Direct toxicity testing of sediment using the endpoints of survival and reburial of *Eohaustorius estuarius* amphipods

- An evaluation of factors affecting bioavailability (simultaneously extractable metals/ acid volatile sulfides, sediment grain size, pH, and total organic carbon)

- A qualitative evaluation of site-specific BAFs using amphipod tissue residues divided by sediment concentration.

- A qualitative evaluation of toxicity based on a review of the primary literature

- **Lines of Evidence for Assessing Risk to Populations of Aquatic Birds** - Within the context of the baseline ERA, protection of populations of aquatic birds is defined as sufficient rates of survival, growth, and reproduction to sustain populations of shorebirds. Risk to representative birds (Black-necked stilt and Mallard) considered to be ecological surrogates for the group at the TBB Disposal Site were evaluated quantitatively based on an HQ approach. In the HQ approach, site-specific daily doses estimated using a food-chain modeling approach were compared to toxicity reference values (TRV), where the HQ was equal to ingested dose divided by the TRV.

- **Lines of Evidence for Assessing Risk to Individual Salt Marsh Harvest Mice** - Within the context of the baseline ERA, protection of individual salt marsh harvest mice is defined as sufficient rates of survival, growth, and reproduction to sustain individual salt marsh harvest mice. Risk to the salt marsh harvest mouse at the TBB Disposal Site was evaluated quantitatively based on an HQ approach using food chain modeling to evaluate exposure through ingestion. Site-specific daily doses determined by food-chain modeling were compared to TRVs, where the HQ was equal to ingested dose divided by TRV.

CONCLUSIONS

The following subsections summarize the conclusions of the RI for the TBB Disposal Site. The nature and extent of contamination was characterized, the debris delineated, and a risk footprint identified based on the screening level HHRA and baseline ERA.

Human Health Risk Assessment

The screening-level HHRA conducted for the TBB Disposal Site indicated that COPCs are currently present at levels that could result in adverse health effects for residents. COPCs are present at higher concentrations at the center of the site within the 400-mg/kg lead isopleth (sample locations within the

400-mg/kg lead isopleth include 309SB05, 309SSCS, SB001, SB003, SB004, SB009, SB010, SB012, SB013, SB014, SB015, SB017, SB018, SB019, SB020, SB103, SS206). Soil and sediment within the 400-mg/kg lead isopleth also contains elevated levels of COPCs other than lead. If remediation was conducted to remove elevated concentrations of inorganics within the 400 mg/kg lead isopleth, concentrations of COPCs in the remaining soil and sediment would be within EPA target levels considered to be protective of human health. Potential exposures to COPC concentrations found outside the 400 mg/kg isopleth would not be expected to result in adverse health effects. Following remediation of soil and sediment within the 400-mg/kg lead isopleth, the only COPCs remaining at concentrations above EPA Region IX residential PRGs would be arsenic and iron.

The risk footprint for human health falls within the footprint for ecological risk.

Baseline Ecological Risk Assessment

Adequate information was available to evaluate the potential risk to receptors from chemicals at the TBB Disposal Site. One of the primary objectives of the ERA was to establish a risk footprint to help determine the boundary for remedial action.

The current level of inorganic chemical contamination at the site poses probable risk to plant, invertebrate, and bird and mammal receptors. In addition, the risk to the salt march harvest mouse, a threatened and endangered species, is significant. Areas with the highest levels of inorganic chemicals contamination are located where the debris is most concentrated, which is along the shoreline and in the center of the site. Removal of the debris would significantly reduce risk to both aquatic and wetland receptors.

Contaminants of Ecological Concern

Concentrations of some inorganic COECs at the site are very high, based on comparison with background and with available screening values. COECs that pose a risk to one or more of the assessment endpoint receptors at the TBB Disposal Site include arsenic, cadmium, copper, lead, mercury, selenium, and zinc. COECS to one or more receptors include arsenic, cadmium, copper, lead, mercury, selenium, and zinc. Copper and zinc are COECs to all receptors, while mercury is only

a COEC to aquatic birds and the salt marsh harvest mouse. Lead is a COEC to all receptors except plants. Cadmium is only a COEC to aquatic birds.

Risk to Ecological Receptors

For plants, concentrations of arsenic, copper, selenium, and zinc may be available for uptake at concentrations greater than required for healthy growth based on a comparison to ORNL. Pickleweed BAFs greater than one, provided another line of evidence for potential risk. A BAF greater than one indicates potential for contaminant uptake.

Risk to plants was indicated at locations SB001, SB003, SB004, SB009, SB010, SB012, SB013, SB014, SB015, SB017, SB018, SB019, SB020, and 309CSSS.

The risk to benthic invertebrates was evaluated based on the lines of evidence describe above in the Methods section. The determination of which inorganic chemicals were the principal risk drivers was based on a HQ approach. First, sampling locations where the mean ER-Mq was greater than 1.5 were determined. Then, across the nine sampling locations where mean ER-Mqs were greater than 1.5, COPECs with HQs greater than 1.0 were then identified. Lastly, mean HQs (across the nine locations) were calculated for each COPEC that had at least one HQ greater than 1.0. COECs identified using this process were copper, lead, selenium, and zinc. Copper had six HQs exceeding 1.0, lead had nine HQs exceeding 1.0, selenium had seven HQs exceeding 1.0, and zinc had nine HQs exceeding 1.0. Over all sampling locations (n=29), copper, lead, selenium, and zinc exceeded their respective ER-Ms at 21, 41, 62, and 41 percent of the sampling locations, respectively. Amphipod survival ranged from 77 to 88 percent in the three TBB Disposal Site samples and indicated minimal toxicity.

For benthic invertebrates, potential risk from exposure to copper, lead, selenium, and zinc may exist at locations 309CSPWSS, 309SSCS, SB013, SB014, SB015, SB018, SB019, SB020, and SB0205.

Risk to aquatic birds, as represented by the black-necked stilt and mallard, from exposure to arsenic, cadmium, copper, lead, mercury, selenium, or zinc exists at sampling locations 309SSCS, 309CSPWSS, SB001, SB003, SB004, SB009, SB010, SB014, SB015, SB017, SB018, SB019, SB020, SS205, and SB103.

Risk to the salt marsh harvest mouse from exposure to arsenic, copper, lead, mercury, selenium, or zinc at sampling locations 309CSPWSS, SB001, SB003, SB004, SB005, SB006, SB007, SB008, SB009, SB010, SB011, SB012, SB013, SB014, SB015, SB016, SB017, SB018, SB019, SB020, and SS206 was indicated.

A risk footprint showing the overlap of risk to each receptor by location was developed to determine areas of highest risk to help determine the boundary for remedial action.

SUMMARY OF RECOMMENDATIONS

Inorganic concentrations in the area of debris at the TBB Disposal Site are sufficiently high that they present a potential risk to human health and the environment. Given the small size of the site, the Navy recommends that debris be removed from all areas where risk is indicated, based on the results of the human and ecological risk assessments presented in Sections 7.0 and 8.0 of this RI report.

Risk management decisions must incorporate more than the technical basis for identifying risk from chemical contamination. Trade-offs in costs and benefits to different taxa must also be evaluated before decisions are made. Overall habitat quality at the site and the role of the site in the regional ecology of special status species must also be considered. Removal of the debris from the TBB Disposal Site would result in temporary ecological destruction of all of the wetland habitat; however, no salt marsh harvest mice were reported during surveys conducted at the TBB Disposal Site. Furthermore, compared to other areas in the Tidal Area that provide critical habitat to the salt marsh harvest mouse, the habitat area provided at the TBB disposal area is minimal

Based on CERCLA guidance, risk management decisions are made jointly by all parties involved in the risk assessment process at a site such as the TBB Disposal Site, including the Navy and its contractors, EPA, DTSC, RWQCB, USFWS, National Oceanic and Atmospheric Administration, California Department of Fish and Game, and the public. The Navy anticipates that the decisions made for this site will be based on a technical review of this document by those parties and on a collaborative and interactive process that includes meetings to identify goals and priorities. Thus, specific recommendations made in this document should serve as points of discussion for the risk management team.

1.0 INTRODUCTION

The Department of the Navy (Navy), Engineering Field Activity West (EFA West) is conducting a remedial investigation (RI) at the Taylor Boulevard Bridge (TBB) disposal site of the Naval Weapons Station Seal Beach Detachment Concord (NWSSB Detachment Concord), Concord, California (see Figure 1-1). EFA West has authorized Tetra Tech EM Inc. (TtEMI) to develop this RI report under the Comprehensive Long-term Environmental Action Navy (CLEAN) Contract No. N62474-94-D-7609 (CLEAN II), Contract Task Order (CTO) No. 0309. Work on the TBB Disposal Site was initiated under the CLEAN I contract, Contract No. N62474-88-D-5086, under CTO No. 0309.

The TBB Disposal Site (see Figure 1-2) was identified in late 1995 during an RI that was conducted at four nearby Tidal Area sites. The Navy collected sediment samples from borings in the TBB Disposal Site and the surrounding area in February 1996, March 1997, October 1997, February 1998, and June 1998 to assess the nature and extent of chemical contamination.

Based on preliminary evaluations of the spatial distribution of chemicals in sediments and soil, it was clear that a removal action would be necessary to reduce the potential risk to human health and the environment. Preliminary evaluations indicated that concentrations of inorganic chemicals (primarily lead) at the center of the site were higher than concentrations detected in surrounding areas. The high concentrations of inorganic chemicals in soil in the center of the site were considered to pose a potential risk to both human health and the environment. Based on the results of these preliminary evaluations, the Navy proposed a removal action to remove the debris to mitigate the risk to the environment. However, based on discussions between the Navy and regulatory agencies, it was decided that an RI and feasibility study (FS) would be conducted for the TBB Disposal Site.

In August 1999, a summary report and work plan (WP)/field sampling plan (FSP), presenting a synopsis of available data and screening-level human health and ecological risk assessments (ERA), was prepared (TtEMI 1999b). Although the site posed potential human health risks, the Navy's evaluation of the site to date suggested that the degree of exposure and therefore impact would be less on humans than ecological receptors. The site remediation necessary to mitigate the risk to animal receptors would also be expected to mitigate the risk to humans, even under the application of extremely conservative assumptions regarding human contact with the site. Therefore, field activities

in the summary report and WP/FSP were designed to complete the data requirements of a baseline ERA.

In February 2000, the Navy collected additional samples to complete the data requirements of a baseline ERA for the RI. Based on the results of the screening-level human health risk assessment (HHRA), additional data were not required to address risks to human health at the site. Although remediation of lead contamination is likely to be the primary objective of any cleanup action at the site, the purpose of the baseline ERA was to help define the limits of the excavation such that other site chemicals that pose a potential threat to ecological receptors were addressed simultaneously.

It is the Navy's intention to complete the RI phase and proceed through the FS and record of decision phases as rapidly as possible, so that site remediation can be conducted to minimize threats to the environment. Timely execution of all steps in this process is necessary to minimize the overall cost of remediation. Applicable or relevant and appropriate requirements for the TBB disposal site are discussed in Appendix J.

1.1 REMEDIAL INVESTIGATION OBJECTIVES

Specific objectives of the RI for the TBB Disposal Site at NWSSB Detachment Concord are as follows:

- Characterize the nature and extent of soil and sediment contamination for the purpose of developing and evaluating effective remedial alternatives.
- Characterize spatial extent of debris for the purpose of developing and evaluating effective remedial alternatives.
- Identify potential contamination migration pathways and receptors potentially exposed to contaminants at the site.
- Assess risk to human health using a screening-level HHRA approach and delineate a risk footprint.
- Assess ecological risk using a baseline ERA approach and delineate a risk footprint.
- Collect data to support initial FS activities.

This RI report was prepared with these objectives in mind, in accordance with the revised National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and U.S. Environmental Protection

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Agency's (EPA) guidance for conducting RI/FSs under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (EPA 1988). Data gathered during the RI are used to evaluate whether the site poses a risk to human health or the environment (EPA 1997a, 1997b). If a risk exists, the RI data will be used in the FS process to evaluate remedial alternatives.

1.2 REPORT ORGANIZATION

This report is organized into the following sections:

- Section 1.0, Introduction, introduces the project and presents background information.
- Section 2.0, Site Description and Background, describes the site, the history of the site, current operations occurring at the site, and previous investigations conducted at the site.
- Section 3.0, Environmental Setting, explains the physiography, topography, and regional geology; the regional hydrology and hydrogeology; the climate; and the ecological habitats at the site.
- Section 4.0, Investigation Rationale and Methods, describes investigation reconnaissance activities, sediment investigations, field quality assurance (QA)/quality control (QC) procedures, the analytical program, and the data validation process.
- Section 5.0, Nature and Extent of Site Chemicals and Debris: describes the distribution of debris at the site and the results of chemical analyses of sediment samples.
- Section 6.0, Contaminant Fate and Transport Evaluation, describes the physical and chemical processes that determine the chemical fate and toxicology of each metal at the site.
- Section 7.0, Human Health Risk Assessment, evaluates the risk to human health from chemicals at the site.
- Section 8.0, Baseline Ecological Risk Assessment, describes the conceptual site model; evaluates risk to plants, benthic invertebrates, and birds and mammals; weighs the various lines of evidence and assessment endpoints to characterize overall risk at the site; and considers how uncertainty influences the potential significance of the overall risk.
- Section 9.0, Conclusions and Risk Management Recommendations, summarizes overall risk to human health and ecological receptors, discusses the management implications of the human health and ecological risk, and makes recommendations regarding the overall risk from chemicals at the site.
- Section 10.0, References

2.0 SITE DESCRIPTION AND BACKGROUND

The following sections describe the TBB Disposal Site at NWSSB Detachment Concord. Descriptions of the site location, regional and site land use, history, and current operations are included.

2.1 SITE LOCATION AND DESCRIPTION

NWSSB Detachment Concord is located in the north-central portion of Contra Costa County, California, about 30 miles northeast of San Francisco. The facility encompasses about 13,000 acres and is bounded by Suisun Bay to the north and the City of Concord to the south and west (see Figures 1-1 and 1-2). Currently, the facility includes three principal areas: the Tidal Area, the Inland Area, and a radiography facility in Pittsburg, California. The Tidal Area encompasses about 6,800 acres (see Figure 1-2), the majority of which are wetlands. The TBB Disposal Site is located in the Tidal Area beneath Taylor Boulevard Bridge. Taylor Boulevard is the main access road to the Tidal Area.

Access to the TBB Disposal Site is through a guarded gate off of Port Chicago Highway, west of the main entrance to the Inland Area. Public access is restricted.

The TBB Disposal Site is a marsh adjacent to an upland transition area (see Figure 2-1). It has no paved areas, no buildings are present, and no physical evidence exists of any previous construction at the site. The nearest improvements are the Taylor Boulevard Bridge and the Taylor Boulevard Railroad Bridge, which span over the eastern side of the site. The elevation at the center of the site is 6 feet higher than the surrounding marsh. No portion of the site is higher than 12 feet above mean sea level (msl). The Santa Fe Railroad tracks are immediately south of the site, and Waterfront Road and the Southern Pacific Railroad tracks are immediately north of the site (see Figure 2-1).

The TBB Disposal Site is triangular in shape and is bordered by wetlands (referred to herein as Seal Creek Marsh) to the south and west (see Figure 2-1). Seal Creek Marsh, adjacent to the site, is mostly open water, although the water depth varies seasonally. Pickleweed borders most of the shoreline.

Debris consisting of broken glass, burned metal, and partially burned wooden railroad ties litter the ground surface at much of the site. Glass and metal debris cover a triangular area extending about 180 by 180 feet and extend into the open water and onto a peninsula (see Figure 2-1). The lateral and vertical distribution of the debris is detailed in Section 5.3. Surface vegetation covers the debris in most areas.

2.2 REGIONAL LAND USE

Land use at NWSSB Detachment Concord is diverse, including industrial and residential areas, rangeland, and open space. Railroad land holdings and utility easements cross through the Tidal Area. The Los Medanos Hills (see Figure 1-2) separate the Tidal and Inland Areas of NWSSB Detachment Concord. This land is privately owned and is leased to the Pacific Gas and Electric Company (PG&E) and to ranchers for cattle grazing. Land north of State Route 4 (see Figure 1-1) and west of NWSSB Detachment Concord is zoned for industrial development. Several industrial firms operate along Port Chicago Highway near the main gate to NWSSB Detachment Concord. Tosco Avon Refinery Company and Monsanto Chemical Company maintain facilities along Solano Way near Waterfront Road.

2.3 SITE HISTORY

The region encompassing NWSSB Detachment Concord was originally identified as Bay Point. The Tidal Area was originally occupied by the Pacific Coast Shipbuilding Company. The shipyard occupied the coastal area north of the TBB Disposal Site. Johnson Road was the only major road into the Tidal Area. In 1927, the Navy chose the site for naval ordnance operations because of its remote location and the availability of three major rail lines. Two of these rail lines bound the TBB Disposal Site to the north and south (see Figure 1-2). The rail lines were reportedly constructed before 1940. Construction of the waterfront handling facilities began in January 1942, and in April 1942, the facility was commissioned as the Naval Magazine Port Chicago. Around this time, the name Bay Point was changed to Port Chicago. The Inland Area, located in the Diablo Creek Valley, was subsequently acquired and linked to the Tidal Area by the Port Chicago and Clayton Railroads. In 1963, the base was officially renamed Naval Weapons Station Concord. In April 1998, the base became the Weapons Support Facility Seal Beach, Detachment Concord.

On July 7, 1944, two munitions ships, docked at a pier adjacent to the Tidal Area, exploded. The pier and both ships were destroyed, and 320 people were killed. Nearby residents in Port Chicago were injured. To protect the civilian population, the Navy acquired all land within a 2-mile radius of the loading piers. To provide a safety zone, the towns of Port Chicago and Nichols were purchased and demolished between 1968 and 1972. The former town sites are now in the Tidal Area.

Seven aerial photographs from 1952 to 1996 and recent site visits suggest that the TBB Disposal Site has not been graded for more than 45 years (Pacific Aerial Surveys [PAS] 1952, 1959, 1974 1984;

PRC 1996a). Slight changes in the site can be seen in each of the photographs, but there is no evidence of grading. The Taylor Boulevard Bridge and the railroad bridge immediately east of the disposal site were constructed sometime between 1939 and 1950. Changes in vegetation over time are apparent, but these changes may stem from photographs being taken in different seasons. The most notable change over time is the variation in the degree of inundation of Seal Creek Marsh. Although Seal Creek Marsh is readily identified as a marsh in the aerial photographs, the degree of site inundation varies significantly, probably with rainfall patterns. For example, marsh flooding is not apparent in photographs prior to August 6, 1996 (PAS 1952, 1959, 1974, 1984), but Seal Creek Marsh is inundated in the August 6, 1996, photographs (PRC 1996b).

The dates of debris disposal and the source of the debris at the site are unknown. The debris includes blue-colored glass bottles and ceramic fragments, suggesting that the waste is perhaps 40 to 50 years old or older.

2.4 CURRENT OPERATIONS

NWSSB Detachment Concord is the major naval, explosive ordnance transshipment facility on the West Coast. The facility provides storage, maintenance, and technical support for ordnance operations. Although daily operation of the facility is being transferred to the U.S. Army, responsibility for environmental cleanup will remain with the Navy into the near future. No plans currently exist for base closure.

The TBB Disposal Site has no other use.

3.0 ENVIRONMENTAL SETTING

The following sections describe the environmental setting of NWSSB Detachment Concord, including physiography, topography, geology, hydrology, and climate. Information herein was summarized from Section 2.5 of the "Draft Final, Remedial Investigation Report, Tidal Area Sites, Naval Weapons Station Seal Beach, Detachment Concord" (TtEMI 1999b).

3.1 PHYSIOGRAPHY AND TOPOGRAPHY

Contra Costa County consists of four physiographic regions, the Coast Range highlands, the intermountain valleys, the San Francsico Bay depression, and the Sacramento-San Joaquin Delta. The Diablo Range intercoastal highlands include both smooth rolling hills and relatively rugged mountains, ranging in elevation from 100 feet above msl along the San Francisco Bay depression to 3,849 feet above msl at Mt. Diablo. The intermountain valleys and San Francisco Bay depression consist of floodplains and low terraces, with gently rolling fans and old terrace remnants adjacent to the uplands. NWSSB Detachment Concord lies about 10 miles west of the confluence of the Sacramento and San Joaquin Rivers. This confluence forms the Delta region, which contains over 600 miles of interconnected and meandering tidal waterways. Drainage from NWSSB Detachment Concord is exclusively into Suisun Bay.

The Tidal Area originally consisted of three distinct land formations: (1) brackish marsh along the shore of Suisun Bay, (2) the upland colluvial slope, and (3) the sandstone hills farthest from the water. During construction of NWSSB Detachment Concord, much of the wetlands was filled. Most of the Tidal Area facilities were built on these filled areas (International Technology Corporation [IT] 1992). Between the Tidal Area and Los Medanos Hills, is a 0.5-mile-wide band of colluvial slope material. Colluvial slope materials form the eastern upland areas of the TBB Disposal Site, and Seal Creek Marsh borders the western area of the site.

3.2 REGIONAL GEOLOGY

The information herein was summarized from the Tidal Area site investigation report (IT 1992), geotechnical boring data obtained from the Navy, and published materials.

NWSSB Detachment Concord is located about 30 miles east of San Francisco Bay, within the geologically complex and tectonically active California Coast Range. The Tidal Area lies within the

southern part of a structural trough that is partially occupied by Suisun Bay. The trough is partially filled with unconsolidated and undifferentiated late Pleistocene and Holocene sediments. Glacial advances and retreats during the Quaternary period caused sea level fluctuations that caused changes in the depositional sedimentary environment. Glacial advances caused the sea level to drop 300 to 400 feet below its present level. This drop triggered the disappearance of estuarine depositional environments, including Suisun Bay, and caused the incision of the Sacramento River Valley. During glacial retreats, the sea level rose high enough to flood the Suisun Bay area, forming an estuary. As a result, sediments beneath Suisun Bay consist of estuarine sediments deposited during high sea level periods, alternating with alluvial and fluvial sediments that were deposited during periods of low sea level. These quaternary sediments underlie the Bay mud and younger alluvium.

The southern part of the Tidal Area includes the Los Medanos Hills. The Los Medanos Hills are composed of folded and faulted tertiary bedrock. The early to mid-teriary rocks are primarily marine in origin and consist of interbedded sandstones and mudstones. Marine formations include the Markley and Neroly formations that lie in a northwesterly direction that dips 30 to 40 degrees northeast. The Wolfskill formation (also called the Los Medanos formation) overlies the tertiary marine formations and occurs along the northeastern edge of the Los Medanos Hills.

Several active major faults occur near NWSSB Detachment Concord. The Concord Fault is a northwest-trending, right-lateral, strike-slip fault located about 1 mile southwest of the Inland Area. The Clayton Fault lies within the Inland Area, near the southwestern base of the Los Medanos Hills. This fault strikes northwest, dips northeast, and has a significant dip-slip separation (Dibblee 1980, 1981; Sims and others 1973). No major earthquakes have occurred on the Clayton Fault; however, this fault is believed to be the northwestern extension of the Greenville Fault. The Greenville Fault displays geomorphic evidence of Holocene displacements and experienced an earthquake with surface rupture in the eastern part of the Livermore Valley in January 1980 (Earth Science Associates 1982). The Antioch Fault is northwest-trending, located about 10 miles east of NWSSB Detachment Concord. No significant earthquakes have occurred on the fault; however, the 1889 Collinsville earthquake may have produced surface rupture in the City of Antioch (Toppozada and others 1981).

3.3 REGIONAL HYDROLOGY AND HYDROGEOLOGY

Regional and local hydrologic and hydrogeologic environments of the Tidal Area at NWSSB Detachment Concord are presented in this section. Hydrologic data stem from various surface and

subsurface field investigations. Hydrogeologic data are based on geologic maps, data from subsurface field investigations in the Suisun Bay and Carquinez Strait area, and published materials.

3.3.1 Hydrologic and Hydrogeologic Setting

Groundwater conditions at the Tidal Area are briefly summarized in this section (TtEMI 1998).

The Tidal Area is characterized by a highly irregular piezometric surface and very thin (or absent) vadose zone. Surface water features in the Tidal Area act to recharge local groundwater zones or as a point of groundwater discharge. Groundwater from the surrounding hills flows northward toward Suisun Bay and discharges to surface waters in the Tidal Area. Surface water from the surrounding hills flows northward, toward Suisun Bay, in creeks and artificial ditches, canals, and culverts.

Ground water at the Tidal Area occurs in a shallow, unconfined water-bearing zone that is composed of silty clays. As NWSSB Detachment Concord grew, site drainage was modified by addition of drainage channels and by filling both natural and manmade channels with sandy fill materials and silty clays. The result is a complex subsurface characterized by silty clays and linear bodies of sandy fill material.

Tidally influenced sloughs in the lowlands near Suisun Bay route bay water to and from the Tidal Area. Hastings Slough in the western portion of the Tidal Area extends from Suisun Bay to the Tosco Avon Refinery in Martinez, California. Mount Diablo Creek (called Seal Creek by NWSSB Detachment Concord) drains into Hastings Slough. Seal Creek and Hastings Slough are tidally influenced sloughs that are adjacent to the TBB Disposal Site. Although Seal Creek and Hastings Slough are tidally influenced, significant tidal fluctuation does not extend into Seal Creek Marsh. Based on repeated field observations, water levels at the TBB Disposal Site fluctuate less than 6 inches during daily tidal cycles.

In the Tidal Area, groundwater is generally a few feet below ground surface throughout the year. Groundwater elevations at the TBB Disposal Site are less than 1 foot below ground surface (bgs) at the margin of Seal Creek Marsh.

3.3.2 Lithology and Distribution of Hydrogeologic Units

Four major hydrogeologic units were identified beneath the Tidal Area within 100 feet of the surface. The four units were (1) bay sediments (clay with sand and peat stringers), (2) Yerba Buena mud (clay with minor sand lenses), (3) recent alluvium (including sands, silts, and clays), and (4) fluvial or estuarine sediments (predominantly micaceous sand). In addition, artificial fill is present in the upper

surface at several locations in the Tidal Area, particularly at the TBB Disposal Site. At the TBB Disposal Site, recent alluvium and bay sediments, consisting of silty clay, may be the only hydrogeologic units present. A description of the sediment and artificial composition, the relative thickness, and the distribution of each unit follows.

Bay Sediments

Bay sediments are currently being deposited within the San Francisco Bay estuary. These deposits typically consist of Bay mud, Bay peat, and Bay sand. Bay mud and Bay peat are the predominant lithologies at the Tidal Area; Bay sand occurs sparsely.

Silty clay is the predominant lithology of Bay mud. Bay mud silty clays contain organic matter and are typically dark gray to black, soft to medium stiff. These silty clays typically have very low permeabilities and retard groundwater migration.

Some facies of Bay mud contain appreciable amounts of peat, which is composed of partially decayed plant material deposited in a marsh environment. Hydrogeologic properties of the peat-rich portions of the Bay mud vary with the amount of clay present in the peat. In areas where the peat contains little or no clay, it has a relatively high permeability and acts as a preferred groundwater movement path.

Some portions of the Bay mud consist of fine- to coarse-grained sand lenses deposited in beach areas or in the channels of streams or rivers. Sand bodies within the Bay mud typically have high permeabilities and act as preferred pathways for groundwater movement. However, typically, the sand bodies are not laterally extensive.

Yerba Buena Mud

Yerba Buena mud (commonly called older Bay mud) consists of a medium stiff to very stiff clay that is gray, blue, or green in color, and contains significant organic matter (Sloan 1992). The Yerba Buena mud was deposited during the high sea level of the last interglacial period, about 120,000 to 125,000 years ago, in an estuary that predates the current San Francisco Bay.

Previous work in the Tidal Area found that Yerba Buena mud is not present at the western and southern portions of the Tidal Area (in the vicinity of the TBB Disposal Site). In these areas, the Yerba Buena mud is replaced by very stiff to medium stiff, predominantly brown and yellow-brown clays that are

locally interbedded with thin sands. These brown and yellow-brown clays are alluvial in origin and represent a localized facies change within the Yerba Buena mud. The depositional history is unknown.

Alluvium

Brown and yellow-brown clays and thin interbedded fine-grained alluvial sands, originating from the surrounding hills, occur in the southern and western portions of the Tidal Area. The alluvium contains sparse organic matter and has a relatively low permeability. Sands therein are typically interbedded at multiple horizons with clay or silt beds (TtEMI 1999a).

Fluvial or Estuarine Sediments

Borings in the northern Tidal Area indicate that at 50 to 70 feet below msl, a thick sand unit is present beneath both the Yerba Buena mud and the alluvium (TtEMI 1999a). This sand is typically brown or gray-green in color, is fine- to medium-grained, and contains sparse gravels. A significant percentage of mica is present in the sand, suggesting that the source is granitic rocks of the Sierra Nevada. If correct, this sand would have been deposited by the Sacramento River rather than by local streams. The presence of estuarine sand has not been confirmed at the TBB Disposal Site.

Artificial Fill

Clay, sandy silt, very fine-grained sands, silty gravels, and clean gravels from off-site sources characterize the artificial fill. Color varies from yellowish-brown to gray. The fine-grained silts and clay exhibit relatively low plasticity. The gravels are angular to subrounded and vary from poorly to well sorted. Artificial fill was used throughout the Tidal Area to construct road and railroad beds, channel levees, structural pads, and protective revetments. Sections of natural sloughs and artificial sluices were also backfilled using artificial fill. The TBB Disposal Site also contains a layer of artificial fill that consists of a combination of soil fill, old broken glass, metal scrap, and other debris. Beyond the debris fill area (not including nearby rail and roadway alignments), no evidence exists of soil fill near the Taylor Boulevard Bridge.

3.3.3 Surface Water Hydrology

The surface water bodies nearest to the TBB Disposal Site are Seal Creek Marsh, located immediately west of the site, and Hastings Slough, located about 1,000 yards west of the site, on the western edge of Seal Creek Marsh (see Figure 2-1). Suisun Bay is located about 1.25 miles north of the site (see

Figure 1-2). Surface water runoff from the TBB Disposal Site discharges to Seal Creek Marsh. Although originally the area was subject to tidal inundation, tidal fluctuation at Seal Creek Marsh adjacent to the TBB Disposal Site at this time is minimal. Based on observations (not direct measurements) at the TBB Disposal Site, shoreline water levels varied less than 6 inches during daily tidal cycles. However, during periods of heavy rainfall, the surface level of Seal Creek Marsh may vary as much as 4 feet because of freshwater inflow from Seal Creek by way of Diablo Creek.

In July 1999, salinity measurements at Seal Creek Marsh near the TBB Disposal Site ranged from 11 to 14 parts per thousand (ppt). Salinity measurements taken in May 2000 ranged from 5 to 10 ppt.

The drainage pattern of Seal Creek Marsh near the TBB Disposal Site has been altered through the years by manmade features. Active railroad lines border the TBB Disposal Site to the north and south (see Figure 2-1). In addition, drainage ditches dug by the Contra Costa County Mosquito Abatement District are present in Seal Creek Marsh. Aerial photographs of the Tidal Area from 1952 and 1959 show an east-west trending drainage ditch about 800 feet northwest of the TBB Disposal Site (PAS 1952, 1959). A 1974 aerial photograph shows additional excavation of north-south trending ditches west of the TBB Disposal Site (PAS 1974). These ditches are also evident in a 1984 aerial photograph of the area (PAS 1984). In a 1996 aerial photograph, the Seal Creek Marsh portion of the TBB Disposal Site is largely submerged, including much of the ditch region (TtEMI 1996c). Seal Creek Marsh was fully submerged during TBB Disposal Site visits in Spring 2000. Consequently, drainage ditches and other submerged features were not observed.

3.4 CLIMATE

Contra Costa Country normally has dry, warm summers and cool, moderately wet winters. Mean annual precipitation for NWSSB Detachment Concord is 14 inches (Ecology and Environment 1983). About 84 percent of the rainfall occurs from November through March. Regional rainfall varies from 13 inches in the eastern portion of Contra Costa County to more than 30 inches on the upper slopes of Mount Diablo.

The average local temperature varies from 45 °F in January to 75 °F in August. Record highs and lows of 106 and 16 °F were recorded near NWSSB Detachment Concord.

Prevailing winds blow from the west through the wind gap formed by San Francisco Bay and Carquinez Strait. As a result, the Pacific Ocean and Suisun Bay have a moderating effect on the

microclimate of NWSSB Detachment Concord. These westerly winds are dominant during the summer months and minimal from November through February. Wind directions and speed are monitored at a PG&E power plant in Pittsburg, a few miles east of NWSSB Detachment Concord. Sixty-five percent of the time, the wind blows from southwest to west-northwest at a mean speed of 12 miles per hour.

The geographic and urban setting of NWSSB Detachment Concord provides ideal conditions for urban air pollution. In recent years, Contra Costa County has not met federal Clean Air Act guidelines for carbon dioxide, particulates, and opacity (haze effect). Temperature inversion (an increase in ambient temperature with altitude) is common. Temperature inversion prevents airborne pollutants from dispersing vertically into the upper atmosphere, causing increased pollutant concentrations at ground level. The most common pollutants are sulfur dioxide, carbon monoxide, and particulates.

3.5 HABITAT

The TBB Disposal Site can be subdivided into two habitats (see Figure 3-1). The first is an open water aquatic habitat, and the second represents a wetland and upland transitional habitat that appears to be strongly influenced by soil moisture levels. Three dominant vegetation types are present in the wetland and upland transitional habitat; however, a true upland plant community is not present at the TBB Disposal Site.

3.5.1 Aquatic Habitat

The aquatic habitat consists of shallow, open water of varying salinities, interspersed with "islands" of vegetation; in the shallowest waters, dense pickleweed root systems and thick algal mats are abundant. The dominance of algal mats varies with season, as does the algal species composition. In deeper areas, cattail clumps occur. The bottom appears to be a rich organic matrix of decaying algae and detritus. This habitat may contain amphipod species, clams, polychaete worms, and other species of filter- and deposit-feeding benthic invertebrates.

3.5.2 Shoreline

The shoreline is the transition area between the aquatic and terrestrial habitats. The boundary of the shoreline fluctuates over time because of seasonal variation in the water level of Seal Creek Marsh, resulting from annual rainfall and tidal influence. For this reason, the shoreline is included as part of

both the aquatic and wetland and upland transitional habitats. The shoreline is shown in stippled colors on Figure 3-1.

The dominant plant along the shoreline is pickleweed, *Salicornia virginica*. The plant is a colonial halophyte that reproduces both vegetatively and by seed, resulting in dense stands. Pickleweed is adapted to high saline habitats; it absorbs salt and water through its roots and stores salt in aboveground tissues. The excess salt is transported to stem tips, which, when desiccated, fall off the plant, reducing the salt concentration in plant tissues (Ornduff 1974). Pickleweed, with its elaborate root system, traps detritus and sediment particles, which produce rich organic sediment; this sediment serves as a primary food source for many benthic invertebrates, particularly deposit and filter feeders. This moist, shaded pickleweed niche is the home for numerous benthic invertebrates, including various amphipod species.

3.5.3 Wetland and Upland Transitional Habitat

The shoreline comprises the lowest region of the wetland and upland transitional habitat (see Figures 3-1 and 3-2). On the tip of the peninsula and in the eastern portion of this lowest region (see Figure 3-2), gumplant (*Grindelia species*) grows in dense clumps interspersed among the pickleweed.

In the mid-region of the wetland and upland transitional habitat (see Figure 3-2); grasses such as saltgrass, *Distichlis spicata*, are abundant. Gumplant is also common. Gumplant often grows interspersed among the grasses forming loosely-spaced aggregations. Australian salt bush, *Atriplex semibaccata*, and spearscale, *Atriplex triangularis*, are also present, randomly growing among the grasses. Curly dock, *Rumex crispus*, occurs in small numbers. Alkali heath, *Frankenia salina*, also occurs sporadically.

In the upper region of the wetland and upland transitional habitat (see Figure 3-2), grasses are less abundant and shrubs dominate. Coyote brush (*Baccharis pilularis*), fennel (*Foeniculum vulgare*), and artichoke thistle (*Cynara caradunculus*) occur throughout this region. Gumplant is also present, but generally in smaller numbers, with the exception of a dense stand in the southwestern corner of the habitat.

The factor that probably controls plant distribution within the wetland and upland transitional habitat is soil moisture. As the site elevation increases from sea level to 10 feet and distance from the shoreline increases, the moisture content of surface soil declines, and the abundance of obligate wetland species decreases.

4.0 INVESTIGATION RATIONALE AND METHODS

The TBB Disposal Site RI field investigation consisted of a series of five soil and sediment sampling events beginning in February 1996. These investigations served to characterize the site's soil and sediment chemistry and determine the nature and extent of chemicals likely to originate from on-site debris. Additional sampling to address the ERA data needs was conducted during February and March 2000. The ERA-focused sampling included collection of composite sediment samples for metals analysis and bioassays and collection of pickleweed and amphipods for tissue residue analysis. Also during the ERA-focused sampling, 22 holes were dug throughout the site in an effort to determine the depth and lateral extent of the site debris.

This section briefly describes the rationale and methods for the field investigations at the TBB Disposal Site. Detailed information regarding field sampling and the related analytical program for the first five rounds of TBB Disposal Site soil and sediment sampling is contained in the FSP (PRC Environmental Management, Inc. [PRC] and Montgomery Watson 1994) and quality assurance project plan (QAPP) (PRC 1995) prepared for the NWSSB Detachment Concord Tidal Area RI. The field sampling and related analytical program for the ERA are detailed in the following TBB Disposal Site documents: (1) "Final Summary Report and Field Work Plan for Supplemental Sampling at Taylor Boulevard Bridge Disposal Site, Tidal Area, NWSSB Detachment Concord" (TtEMI 1999b), (2) "Final Field Sampling Plan for Supplemental Sampling at Taylor Boulevard Bridge Disposal Site Tidal Area, NWSSB Detachment Concord" (TtEMI 2000a), and (3) "Quality Assurance Project Plan for Taylor Boulevard Bridge Disposal Site, Tidal Area, NWSSB Detachment Concord" (TtEMI 2000b).

4.1 SOIL AND SEDIMENT INVESTIGATIONS

No clear distinction can be made between soil and sediment in most areas of the TBB Disposal Site because of the predominantly wetland nature of the site and the seasonal or periodic inundation of much of the shoreline area by winter storms or high tides. Although the area of the site above the 6-foot-above-msl contour likely contains upland *soils* that are rarely inundated, henceforth in this report, samples from all TBB Disposal Site areas are described as *sediment* samples. Therefore, "sediment samples" include those samples from the submerged Seal Creek Marsh portion of the site, as well as samples from the wetland and upland transitional habitat. The nature and extent of chemicals detected in sediment samples is described in Section 5.0. Appendix D contains analytical results for all TBB Disposal Site samples.

The initial sediment sampling investigation at the TBB Disposal Site was conducted in February 1996. Sediment samples were collected from three borings (SB01 through SB03) located in the central region of the site, in an area where scattered glass, metal, and wood debris were present. All sampling locations are illustrated on Figure 3-1. These early samples were collected to generally delineate chemical concentrations in TBB Disposal Site sediment. Two sediment samples were collected from each of the borings: one from 0.0 to 0.5 feet bgs, and one from 2.0 to 2.5 feet bgs. A total of six sediment samples were collected and analyzed for semivolatile organic compounds (SVOC), metals, total petroleum hydrocarbons (TPH)-purgeables (gasoline range compounds), and TPH-extractables (diesel fuel and motor oil range compounds). Samples were not analyzed for pesticides and polychlorinated biphenyls, because the large amount of glass debris at the site suggested a disposal area for household waste rather than industrial waste. Samples were also not analyzed for volatile organic compounds (VOC), because these constituents are not likely to be present in exposed shallow surface sediment.

Analytical results for the initial six samples from borings SB01 through SB03 indicated that TPH as diesel (TPH-d) and TPH as motor oil (TPH-mo) was present at the surface at SB01 and SB03. TPH-d and TPH-mo were not detected at SB02 or in any of the deeper samples from 2.0 to 2.5 feet bgs. The highest concentrations of metals were detected in surface samples at SB01 and SB03. Samples collected from 2.0 to 2.5 feet bgs contained lower concentrations of metals and SVOCs. Metals concentrations in the deeper samples appear to be within the estimated ambient limit range.

Based on the results of the initial sampling, a second round of sampling was conducted in March 1997. Nine borings (SB04 through SB12) were completed primarily to the east and south of borings SB01 through SB03 (see Figure 3-1) to evaluate the lateral extent of metals, TPH, and SVOC concentrations. The analytical data was also to be used in estimating the approximate volume of material to be removed as part of a future removal action. Samples were collected at each boring from the 0- to 0.5- and 1.0- to 1.5-foot bgs intervals. SVOCs and TPH were detected in the surface samples, but the pattern of detected organic chemicals did not suggest a significant spill, because deeper sediments were not involved. Consequently, SVOCs and TPH were not evaluated in subsequent sampling rounds.

Following the second round of sampling, the vertical extent of site chemicals in sediment was considered to be delineated; however, the lateral extent of elevated metals concentrations in TBB Disposal Site sediment was not defined. Three additional rounds of sampling were conducted to evaluate the lateral extent of metals concentrations in surface sediment in the adjacent submerged

region of Seal Creek Marsh. Surface sediment sampling events were conducted in October 1997 (including samples SB13 through SB20), March 1998 (including samples SB100 through SB106), and June 1998 (including samples SS200 through SS214). Sampling in the final two rounds extended laterally into areas where the concentrations of metals in sediment samples were lower.

4.2 DATA GAPS

Characterization of chemical concentrations in groundwater and surface water at the TBB Disposal Site has not been conducted. Although this is a data gap, no sampling of groundwater or surface water was proposed for the following reasons:

Groundwater

(1) The vertical extent of sediment contamination is well defined. Sediment samples below 1 foot bgs do not contain significant concentrations of chemicals. Although the disposal site has been in place for decades, no evidence exists that chemicals have migrated vertically by leaching, as evidenced by the lack of soil contamination at depths below 1 foot bgs.

(2) Debris removal will eliminate the primary source of contamination at the site. Even if groundwater impacts were detected, remedial actions performed at the site to address groundwater would likely begin and end with removal of the debris and contaminated sediment source.

Surface Water

(1) The size of the TBB Disposal Site, relative to the drainage area that discharges to the portion of Seal Creek Marsh adjacent to the site, is so small that it is not significant. As a result, potentially contaminated runoff from the site is unlikely to have a significant effect on water quality of the area.

(2) Because of the size of Seal Creek Marsh, the presence of nearby petroleum refineries to the west, and the transitory nature of surface water in the area, elevated concentrations of any surface water constituents cannot be assumed to have originated from the TBB Disposal Site.

(3) Even if it were possible to determine that surface water impacts within Seal Creek Marsh were attributable to the TBB Disposal Site, all remedial activities would be directed toward the removal of the debris and contaminated sources. Active remediation of surface water itself is unlikely.

(4) Establishing baseline conditions of surface water within Seal Creek Marsh is a complex task that could require establishment of reference areas for sampling and collection of multiple samples throughout the year. The cost would be difficult to justify, considering the presumably low risk of significant impact to surface water from a source area of such small size.

4.3 ECOLOGICAL RISK ASSESSMENT SAMPLING

Data provided from the sediment investigations was not sufficient to conduct a baseline ERA. The baseline ERA required data on the potential exposure to and effects of chemicals on representative receptors at the site. Accordingly, the following types of data were collected for evaluation during the months of February and March 2000: (1) concentrations of inorganic chemicals in tissues of pickleweed and benthic invertebrates on the site and (2) toxicity of site sediments to invertebrates under controlled laboratory conditions. Based on the findings of the screening-level ERA (TtEMI 1999b), elevated concentrations of metals (particularly lead and selenium) represent a greater risk to ecological receptors at the site than concentrations detected for a limited number of organic chemicals. Consequently, tissue and additional sediment samples were analyzed for inorganic chemicals only, because metals are the focus of the baseline ERA. The depth and extent of site debris was also determined during the February and March 2000 investigation.

The plans for collection of ERA data were based on the seven-step data quality objective (DQO) process, as presented in Section A1.2 of the TBB QAPP (TtEMI 2000b) and Section 9.2 of the WP (TtEMI 1999b). The DQO table from the TBB QAPP is included in Appendix A of this document.

4.3.1 Field Investigation Activities

The following field investigation activities were conducted at the TBB Disposal Site to evaluate the extent of debris, the concentration of inorganic chemicals, the toxicity of sediments, and the bioavailability of inorganic chemicals. These activities were conducted in accordance with the WP (TtEMI 1999b) and FSP (TtEMI 2000a). The activities are briefly described in the following sections.

4.3.1.1 Physical Delineation of Debris

A shovel was used to investigate the vertical and lateral extent of the debris. The offshore region of the site was probed using a shovel and 5-foot length of plastic pipe to estimate the offshore extent of glass debris. The debris cores and shovel waste was returned to the excavation hole from which it originated. The depth of debris and a description of the excavated material was recorded on boring

logs (see Appendix B). The vertical and lateral extent of glass and metal debris present at the site was mapped and is discussed in Section 5.3.

4.3.1.2 Sediment Collection

Sediment chemistry data from all TBB Disposal Site field investigations was pooled for use in this report. Inorganic chemical concentrations in sediment were used in three ways in the baseline ERA. Bulk sediment chemistry was used to: (1) delineate the nature and extent of contamination at the TBB Disposal Site, (2) evaluate sediment toxicity to plants and benthic invertebrates, and (3) estimate doses to mammalian and avian receptors that incidentally ingest sediment while feeding at the TBB Disposal Site.

As part of the ERA sampling, sediment was collected in the northern (three locations), central (three locations), and southern (three locations) portions of the marsh (see Figure 3-1), and the three samples from each geographic area were combined and homogenized. These composite sediment samples (309SSNS, 309SSCS, and 309SSSS) were placed into precleaned, 4-liter (L) glass jars with teflon-lined lids, stored in an ice chest, and transported to the laboratory. Samples were stored at 4 °C.

Amphipod Bioassay Method

An amphipod sediment bioassay, using amphipod survival and reburial as endpoints, was used to determine the potential acute impact of whole sediment contaminants on benthic organisms through short-term exposure. The three composite sediment samples from nine locations (see Figure 3-1) in Seal Creek Marsh were tested for toxicity to benthic invertebrates using the amphipod *Eohaustorius estuarius*, following American Society for Testing and Materials (ASTM) 1999. A summary of the method is provided below.

Based on a comparison of habitat, salinity tolerance, sediment tolerance, and sensitivity to contaminants of five species of freshwater, estuarine, and marine amphipods (WP, Section 9.3.4 [TtEMI 1999b]), *Eohaustorius estuarius* was chosen as the most appropriate organism for the sediment bioassay at the TBB Disposal Site. *Eohaustorius estuarius* is a free-burrowing amphipod found on protected and semiprotected beaches from the lower intertidal to shallow subtidal waters exclusively on the Pacific coast, from British Columbia south to central California (Environment Canada 1992, as cited in EPA 1994b). It is tolerant of various sediment grain sizes, has a wide range of salinity tolerance, and is highly sensitive to contaminants. Furthermore, other studies in San Francisco Bay using *Eohaustorius*

estuarius, including studies conducted at NWSSB Detachment Concord (Tidal and Litigation Areas), are available for comparison.

Amphipods (*Eohaustorius estuarius*) were collected from Lower Yaquina Bay, Oregon. This amphipod species lives in and on the sediment, making it an ideal organism to assess sediment toxicity. Furthermore, it is sensitive to metals and tolerates a wide range of sediment particle sizes (DeWitt and others 1989). The ambient salinity at Yaquina Bay was 8.5 ppt, and the amphipods were adjusted to a salinity of 11.5 ppt prior to shipment to California. Upon arrival at the laboratory, the salinity was increased to 20 ppt over 2 days at the rate of less than or equal to 5 ppt per day.

The sediment was removed from the refrigerator, allowed to reach room temperature, and was homogenized. An aliquot was centrifuged at 2,500 grams for 30 minutes to collect the supernatant. The supernatant was used for pore water pH, salinity, total ammonia, and sulfide concentration measurements. These parameters can affect the condition of the amphipods and may confound the results of the bioassay if they fall outside of specified values. Sediment aliquots were randomly allocated into five, 1-L glass beakers to produce a depth of about 2 centimeters (cm). Filtered (0.45 micrometer [μm]) seawater (artificial sea water "GP-2" [EPA 1988]) was diluted to 20 ppt salinity using deionized water passed through a reverse-osmosis unit. About 800 milliliters (mL) of the diluted seawater was poured into each replicate beaker. Beakers were placed into a temperature-controlled (15 ± 3°C) water bath under continuous illumination. Each beaker was aerated. A negative control using sediment from the field location where the amphipods were collected was also prepared.

Water quality parameters (pH, dissolved oxygen [DO], salinity, and temperature) were measured in water overlying the sediment in each replicate beaker the day after test initiation. Aeration was stopped, and 20 randomly selected *Eohaustorius estuarius* about 3 to 5 millimeters (mm) in length were randomly placed into each replicate beaker. The organisms were allowed to acclimate for 60 minutes, and the aeration was restarted.

The overlying water quality characteristics (pH, DO, salinity and temperature) were measured in one replicate each of the composite sediment and control treatments on each of the next 10 days. On days 2 and 8, a small aliquot of overlying water was collected from each replicate and pooled for measurement of total ammonia concentrations. After 10 days, final water quality parameters (pH, DO, salinity, and temperature) were determined for the overlying water in each replicate beaker. The sediment in each beaker was sieved, and all surviving amphipods were collected, enumerated, and

transferred into a small beaker containing clean sediment and fresh 20-ppt seawater for assessment of amphipod reburial.

To document that the amphipods in the definitive test were responding in a typical manner to toxic stress, a concurrent reference toxicant test (using cadmium) was performed (EPA 1994b). The 96-hour, static test using *Eohaustorius estuarius* had five cadmium concentrations, 0.75, 1.5, 3, 6, and 9 milligrams per liter (mg/L). The resulting effects concentration (EC_{25}) and effects concentration (EC_{50}) were 1.95 and 2.51 mg/L. The range of acceptable EC_{50} was 1.4 to 8.0 mg/L based upon the seven most recent reference tests performed at the laboratory. Therefore, the amphipods were responding to cadmium stress in a consistent and typical fashion.

4.3.2 Tissue Collection and Analysis

The following sections describe methods and procedures for collection of plant and invertebrate tissue samples. Tissues of selected plant and animal taxa were collected to provide site-specific prey concentrations used in food-chain modeling of chemical doses potentially ingested by vertebrate predators at the site (see Section 8-6). For invertebrates and pickleweed, tissue residues, coupled with chemical concentration data from collocated sediment samples, also provided an estimate of bioaccumulation of chemicals at the site (see Figure 3-1).

Pickleweed Tissue Collection

Pickleweed provides food and habitat for the endangered salt marsh harvest mouse (*Reithrodontomys raviventris halicoetes*) throughout the San Francisco Bay Area. At the TBB Disposal Site, patches of pickleweed potentially large enough to support the salt marsh harvest mouse occur, although no salt marsh harvest mice have been reported in the area.

Actively growing pickleweed tissue was collected from three locations in areas where pickleweed provides potentially suitable habitat for the salt marsh harvest mouse. Tissue samples and collocated sediment samples were analyzed for inorganic chemicals only. Tissue and collocated sediment sample concentrations were used to calculate doses to the salt marsh harvest mouse.

Pickleweed tissue samples were systematically collected within an approximate 3-meter radius of sampling location stakes. Samplers initially collected plant material within a 1-meter radius of the sampling location stake and then worked outward in 1-meter increments to the 3-meter radius limit, or

until the desired plant mass for the residue analysis was collected, whichever was reached first. Whenever possible, tissues were collected such that the entire 360° area around the sampling location stake (and within the specified radius) is represented in the sample.

Invertebrate Tissue Collection

As part of the characterization of the TBB Disposal Site, to provide data on the potential bioaccumulation and uptake of chemicals and for food-chain modeling, amphipod tissues from the shoreline region of the site were collected and analyzed for chemical residues. Amphipods are mostly marine organisms and can be either benthic or pelagic, but there are some freshwater and terrestrial species. Most amphipods are detritus feeders or scavengers and feed by filtering water or sediment through their appendages. Amphipods were collected, because they were the most abundant invertebrate taxa at the site and are a representative prey species for shorebird receptors. Amphipods collected at the TBB Disposal Site ranged in size from about 2 to 5 mm in length. Invertebrates, including amphipods, may accumulate chemicals in their tissues through contact with sediment and water, as well as through ingestion of chemicals in or on food items.

Benthic invertebrates are of interest, both as direct receptors of chemicals and as sources of chemicals to higher-trophic-level predators. Unfortunately, no action criteria are available against which to evaluate the effect of measured tissue concentrations in these taxa; that is, a given level of a chemical in the tissues of an amphipod cannot be said to be safe or unsafe for the amphipod. However, tissue concentrations can be evaluated as a source of chemicals to other animals through food-chain modeling. The Navy used the amphipod tissue concentration in the dose estimation for the Black-necked stilt and Mallard as representative receptors. Amphipod tissue samples were analyzed for inorganic chemicals.

Benthic invertebrate tissues were collected from three areas along the aquatic perimeter of the site (see Figure 3-1) that represent the northern, central, and southern sections of the shoreline. Amphipod collection was limited to those areas where the organisms were found during the time of field collection. One composite tissue sample per section was collected, for a total of three samples. Amphipod samples were collected using dip nets. Specimens were rinsed in the surface water to remove external sediment before being placed in the collection vessel.

5.0 NATURE AND EXTENT OF SITE CHEMICALS AND DEBRIS

The following sections describe the organic and inorganic chemicals detected in sediment and used to characterize the nature and extent of chemicals at the site. The vertical and lateral extent of debris was also characterized.

The TBB Disposal Site consists of two habitats: aquatic and "wetland and upland transitional" (see Figures 3-1 and 3-2). The shoreline region of the site is an area with seasonal variation in water level; this zone was considered to be part of both the wetland and upland transitional and aquatic habitats.

Figure 3-1 shows sampling locations for surface and subsurface sediment samples, composite sediment samples, and collocated tissue samples. Tissue residue data is discussed in Section 8.0. Sediment samples were collected from the interval 0 to 0.5 feet bgs, and subsurface sediment samples were collected from depths between 1.0 and 2.5 feet bgs. Samples from locations SB001 through SB012 were collected from both the surface and subsurface (see Section 4.0) and analyzed for metals, SVOCs, TPH-purgeable, and TPH-extractable. Only surface samples were collected at all other sediment locations, and these samples were analyzed only for metals. The three composite sediment samples were also used in an amphipod bioassay and analyzed for the following additional parameters: simultaneously extractable metals/acid volatile sulfides (SEM/AVS), total organic carbon (TOC), grain size, and pH. Pickleweed and amphipod tissue samples were analyzed for metals and percent moisture. Table 5-1 lists the analyses conducted for each sampling location.

Sections 5.1 and 5.2 summarize analytical results for inorganic and organic constituents, respectively. Appendix D includes complete tables that present the concentrations of chemicals in sediment samples.

5.1 INORGANIC CHEMICALS IN SEDIMENT SAMPLES

Metals were analyzed in 60 sediment samples, including 17 surface sediment samples collected in the aquatic habitat, 20 surface and 12 subsurface sediment samples from the "wetland and upland transitional" habitat, and 11 surface sediment samples collected from the shoreline (which is included in both aquatic and "wetland and upland transitional" habitats).

In the following subsections for each metal, the minimum and maximum detected sample concentrations are given for the aquatic and wetland and upland transitional habitats. Sampling results

are also summarized in Table 5-2. With the exception of aluminum and beryllium, the maximum detected concentrations of inorganic chemicals were detected in surface sediment samples.

5.1.1 Aluminum

Aluminum was detected in all 60 sediment samples analyzed for metals. The distribution of aluminum in site sediment samples is shown on Figures 5-1 and 5-22. Aluminum concentrations in the aquatic habitat ranged from 1,890 (SS205) to 23,300 (SS200) milligrams per kilogram (mg/kg). Aluminum concentrations in the wetland and upland transitional habitat ranged from 3.0 (SB017) to 19,000 (SB001, subsurface) mg/kg.

5.1.2 Antimony

Antimony was detected in 26 of 45 sediment samples analyzed for the metal. Fifteen of the original 60 sediment samples were either not analyzed for antimony, or the analyses were rejected during the data validation process. The distribution of antimony in site sediment samples is shown on Figures 5-2 and 5-22. Antimony concentrations in the aquatic habitat ranged from 0.37 (309SB106) to 26.3 (SB015) mg/kg. Antimony concentrations in the wetland and upland transitional habitat ranged from 0.37 (309SB106) to 84.2 (SB003, surface) mg/kg.

5.1.3 Arsenic

Arsenic was detected in 58 of 60 sediment samples analyzed for metals. The distribution of arsenic in site sediment samples is shown on Figures 5-3 and 5-23. Arsenic concentrations in the aquatic habitat ranged from 3.2 (SS207) to 106 (SB018) mg/kg. Arsenic concentrations in the wetland and upland transitional habitat ranged from 0.34 (SB017) to 142 (SB003, surface) mg/kg.

5.1.4 Barium

Barium was detected in all 60 sediment samples analyzed for metals. The distribution of barium in site sediment samples is shown on Figures 5-4 and 5-22. Barium concentrations in the aquatic habitat ranged from 56.8 (SB101) to 1,140 (SB014) mg/kg. Barium concentrations in the wetland and upland transitional habitat ranged from 5.6 (SB017) to 4,660 (SB001, surface) mg/kg.

5.1.5 Beryllium

Beryllium was detected in 37 of 60 sediment samples analyzed for metals. The distribution of beryllium in site sediment samples is shown on Figures 5-5 and 5-22. Beryllium concentrations in the aquatic habitat ranged from 0.010 (SS207) to 0.49 (SS200) mg/kg. Beryllium concentrations in the wetland and upland transitional habitat ranged from 0.01 (SS212) to 0.60 (SB001, subsurface) mg/kg.

5.1.6 Cadmium

Cadmium was detected in 23 of 60 sediment samples analyzed for metals. The distribution of cadmium in site sediment samples is shown on Figures 5-6 and 5-22. Cadmium concentrations in the aquatic habitat ranged from 0.31 (309SB106) to 7.8 (309CSPWSS) mg/kg. Cadmium concentrations in the wetland and upland transitional habitat ranged from 0.36 (SS212) to 13.4 (SB010, surface) mg/kg.

5.1.7 Chromium

Chromium was detected in all 60 sediment samples analyzed for metals. The distribution of chromium in site sediment samples is shown on Figures 5-7 and 5-23. Chromium concentrations in the aquatic habitat ranged from 0.89 (SB016) to 2,990 (SB015) mg/kg. Chromium concentrations in the wetland and upland transitional habitat also ranged from 0.89 (SB016) to 2,990 (SB015) mg/kg. Both locations SB016 and SB015 are located in the shoreline region shared by both habitats.

5.1.8 Cobalt

Cobalt was detected in 57 of 60 sediment samples analyzed for metals. The distribution of cobalt in site sediment samples is shown on Figures 5-8. Cobalt concentrations in the aquatic habitat ranged from 4.3 (SS207) to 27.8 (SB019) mg/kg. Cobalt concentrations in the wetland and upland transitional habitat ranged from 5.4 (SS211) to 37.5 (SB004, surface) mg/kg.

5.1.9 Copper

Copper was detected in 55 of 60 sediment samples analyzed for metals. The distribution of copper in site sediment samples is shown on Figures 5-9 and 5-23. Copper concentrations in the aquatic habitat ranged from 1.1 (SB016) to 1,980 (SB020) mg/kg. Copper concentrations in the wetland and upland transitional habitat ranged from 1.1 (SB016) to 12,500 (SB010, surface) mg/kg.

5.1.10 Iron

Iron was detected in all 60 sediment samples analyzed for metals. The distribution of iron in site sediment samples is shown on Figures 5-10. Iron concentrations in the aquatic habitat ranged from 63.2 (SB016) to 348,000 (SB019) mg/kg. Iron concentrations in the wetland and upland transitional habitat ranged from 63.2 (SB016) to 378,000 (SB017) mg/kg.

5.1.11 Lead

Lead was detected in all 60 sediment samples analyzed for metals. The distribution of lead in site sediment samples is shown on Figures 5-11 and 5-23. Lead concentrations in the aquatic habitat ranged from 1.7 (SB016) to 3,280 (SB014) mg/kg. Lead concentrations in the wetland and upland transitional habitat ranged from 1.7 (SB016) to 7,680 (SB003, surface) mg/kg.

5.1.12 Manganese

Manganese was detected in all 60 sediment samples analyzed for metals. The distribution of manganese in site sediment samples is shown on Figure 5-12. Manganese concentrations in the aquatic habitat ranged from 0.69 (SB016) to 2,480 (SS209) mg/kg. Manganese concentrations in the wetland and upland transitional habitat ranged from 0.69 (SB016) to 1,940 (309SB05) mg/kg.

5.1.13 Mercury

Mercury was detected in 14 of 60 sediment samples analyzed for metals. The distribution of mercury in site sediment samples is shown on Figure 5-13. Mercury concentrations in the aquatic habitat ranged from 0.18 (309CSPWSS) to 1.5 (SS204) mg/kg. Mercury concentrations in the wetland and upland transitional habitat ranged from 0.18 (309CSPWSS) to 26.4 (SB003, surface) mg/kg.

5.1.14 Molybdenum

Molybdenum was detected in 41 of 60 sediment samples analyzed for metals. The distribution of molybdenum in site sediment samples is shown on Figure 5-14. Molybdenum concentrations in the aquatic habitat ranged from 0.10 (SS208) to 301 (SB013) mg/kg. Molybdenum concentrations in the wetland and upland transitional habitat ranged from 0.08 (SS212 and SS213) to 301 (SB013) mg/kg.

5.1.15 Nickel

Nickel was detected in all 60 sediment samples analyzed for metals. The distribution of nickel in site sediment samples is shown on Figure 5-15. Nickel concentrations in the aquatic habitat ranged from 0.89 (SB016) to 126 (SB020) mg/kg. Nickel concentrations in the wetland and upland transitional habitat ranged from 0.89 (SB016) to 262 (SB003, surface) mg/kg.

5.1.16 Selenium

Selenium was detected in 31 of 60 sediment samples analyzed for metals. The distribution of selenium in site sediment samples is shown on Figures 5-16 and 5-24. Selenium concentrations in the aquatic habitat ranged from 0.10 (SS208) to 11.5 (SB019) mg/kg. Selenium concentrations in the wetland and upland transitional habitat ranged from 0.10 (309SB106) to 12.0 (SB017) mg/kg.

5.1.17 Silver

Silver was detected in 17 of 60 sediment samples analyzed for metals. The distribution of silver in site sediment samples is shown on Figures 5-17 and 5-24. Silver concentrations in the aquatic habitat ranged from 0.13 (309SB106) to 2.8 (SB015) mg/kg. Silver concentrations in the wetland and upland transitional habitat ranged from 0.13 (309SB106) to 6.7 (SS206) mg/kg.

5.1.18 Thallium

Thallium was detected in 22 of 60 sediment samples analyzed for metals. The distribution of thallium in site sediment samples is shown on Figures 5-18 and 5-24. Thallium concentrations in the aquatic habitat ranged from 0.11 (309SB106) to 3.5 (SS201) mg/kg. Thallium concentrations in the wetland and upland transitional habitat ranged from 0.11 (309SB106) to 2.1 (SB105) mg/kg.

5.1.19 Vanadium

Vanadium was detected in all 60 sediment samples analyzed for metals. The distribution of vanadium in site sediment samples is shown on Figures 5-19 and 5-24. Vanadium concentrations in the aquatic habitat ranged from 1.2 (SB016) to 80.5 (SS200) mg/kg. Vanadium concentrations in the wetland and upland transitional habitat ranged from 1.2 (SB016) to 62.2 (SB105) mg/kg.

5.1.20 Zinc

Zinc was detected in all 60 sediment samples analyzed for metals. The distribution of zinc in site sediment samples is shown on Figures 5-20 and 5-23. Zinc concentrations in the aquatic habitat ranged from 3.2 (SB016) to 4,980 (SS205) mg/kg. Zinc concentrations in the wetland and upland transitional habitat ranged from 3.2 (SB016) to 5,410 (SB009, surface) mg/kg.

5.2 ORGANIC CHEMICALS IN SEDIMENT SAMPLES

Twenty-four sediment samples were analyzed for organic chemicals, specifically petroleum hydrocarbons (as TPH-extractable) and SVOCs. Six sediment samples (those from locations SB001, SB002, and SB003) were also analyzed for TPH-purgeable. All samples were collected from the wetland and upland transitional habitat. Sediment samples from locations SB001 through SB003 were collected from 0 to 0.5 and 2.0 to 2.5 feet bgs. Sediment samples from SB004 through SB012 were collected from 0 to 0.5 and 1.0 to 1.5 feet bgs. The results of the sediment sample analyses for petroleum hydrocarbons and SVOCs are described in the following subsections.

5.2.1 Petroleum Hydrocarbons

The distribution of petroleum hydrocarbon concentration in surface and subsurface sediment samples is illustrated on Figure 5-25. Petroleum hydrocarbons detected in sediment samples analyzed for TPH-extractable were primarily from the motor oil range (TPH-mo). TPH-purgeable compounds were not detected in any sample. TPH-mo was detected in 11 of 12 surface sediment samples at concentrations ranging from 81 (SB007) to 2,900 (SB003) mg/kg. TPH-mo was detected in 9 of 12 subsurface sediment samples at concentrations ranging from 16 (SB007) to 45 (SB008) mg/kg. Petroleum hydrocarbons from the diesel fuel range (TPH-d) were detected in only 2 of 12 surface sediment samples and were not detected in any subsurface samples. TPH-d was detected in subsurface sediment samples from locations SB001 and SB003 at concentrations of 33 and 550 mg/kg, respectively.

The distribution of TPH in the sediment samples suggests a limited release of petroleum hydrocarbons, possibly caused by leakage of oil from construction vehicles and equipment dating from the construction of the Taylor Boulevard automobile and railroad bridges.

5.2.2 Semivolatile Organic Compounds

Twenty-four sediment samples were analyzed for SVOCs. The distribution of SVOC concentration in surface and subsurface sediment samples is illustrated on Figure 5-26. The highest concentration of SVOCs was detected in the surface sediment sample from location SB003 (see Figure 5-26). This sample contained 10 SVOC constituents, detected at concentrations ranging from 350 to 1,700 micrograms per kilogram (μg/kg). Nine of the SVOCs detected are polynuclear aromatic hydrocarbons (PAH), which are associated with TPH-d and TPH-mo.

With the exception of phenol, SVOCs were not detected in subsurface sediment samples (see Figure 5-26). Phenol was detected in three sediment samples collected from 2.0 to 2.5 feet bgs at concentrations of 450 (SB002), 790 (SB003), and 810 μg/kg (SB001).

5.3 EXTENT OF SITE DEBRIS

Holes were dug at 22 locations across the TBB Disposal Site to determine the vertical and lateral extent of the debris present at the site. These debris test hole locations are identified by triangular symbols on Figure 3-1 and are numbered DB001 through DB022. Figure 5-27 shows profiles of the debris test holes, with soil type and vertical extent of debris illustrated.

The peninsula section of the site contains the greatest amount of debris. The subsurface debris along the peninsula consisted primarily of glass fragments, intact glass bottles, and what appeared to be highly rusted metal debris (rust flakes and fragments). The rusted material was essentially mixed with the small amount of sediment that composed the debris matrix on the peninsula. No intact metal containers, or pieces of metal resembling containers were recovered in the peninsula debris test holes. Generally, in test holes where debris was found, the debris was contained in an approximately 50/50 matrix of soil and debris near the surface (0 to 0.5 foot bgs) and was graded to nearly 100 percent debris with depth. The debris in the peninsula area extends to greater than 3.0 feet bgs. Debris test holes on the peninsula could not be dug deeper than about 3 to 3.5 feet bgs because of difficulty in digging into debris at depth and extracting it through flooded holes.

Debris was not found in most of the debris test holes dug on the eastern side of the site, except in test holes DB001, DB011, DB012, and DB013 (see Figure 5-27). These locations are on the west-central portion of the site. Locations DB011 and DB013 contained lesser amounts of debris compared to the

test holes dug on the peninsula, and debris was not found at these locations below 1.5 feet bgs. Greater amounts of debris were found in test holes DB001 and DB012.

Based on test hole findings, surface and subsurface debris in the wetland and upland transitional habitat is found throughout the peninsula area, north to DB013, and extending southeast to just west of DB005. This area is delineated on Figures 3-1 and 5-27. Subsurface debris was generally found in those areas where debris was observed on the surface. However, subsurface debris was not found on the eastern side of the site where some scattered glass fragments and burned wood were found on the surface. Scattered wood debris on the eastern side of the site consisted mostly of a few railroad ties, a section of a utility pole, and some smaller charred pieces of wood.

The extent of debris in the aquatic portion of the site was estimated by probing the submerged sediments of the offshore area with a shovel and a 5-foot length of plastic pipe. Using this probing method, debris (particularly glass fragments) could be "felt" to determine its offshore extent. Shallow holes (approximately 0.5 foot below the sediment surface) were also dug in the submerged sediment, and sediment was brought to the surface to visually identify debris. Based on these methods, debris appears to extend about 10 to 20 feet offshore from the debris area identified on the "wetland and upland transitional" portion of the site (see Figures 3-1 and 5-27). This debris appears to extend down 1 to 2 feet below the sediment surface. In the area south of the peninsula, about 6 inches of sediment covers the debris. The debris appears to be heaviest close to the shoreline and is mixed with sediment in most areas. The stippled offshore area shown on Figure 3-1 delineates an area of scattered surface debris, based on sediment probing conducted while traversing this area.

6.0 CONTAMINANT FATE AND TRANSPORT EVALUATION

The following sections describe the (1) physical and chemical properties that determine the environmental fate of chemicals, (2) chemical transport processes, and (3) properties of specific inorganic chemicals.

6.1 CONTAMINANT FATE PROCESSES

Fate and transport of contaminants depend on the physical and chemical properties of the molecule; the physical, chemical, and biological features of the site; and the nature of the chemical release. This section summarizes physical and chemical processes that govern chemical fate and transport, reviews factors affecting chemical persistence in sediment and surface water, and discusses processes affecting site-specific chemical migration.

Physical and Chemical Processes

Most chemicals at the TBB Disposal Site are metals or metalloids that cannot be degraded. The following sections describe the chemical reactions metals undergo in the environment. Because organic chemicals are not present in significant concentrations at this site, chemical processes relating to organic chemicals are not discussed.

Solubility and Dissolution

Water solubility is a function of temperature and chemical species. Metals dissolve in water as +2 ions. Weathering occurs when some elements leach out of a mineral, leaving others behind. Metals released by leaching affect water quality (Stumm and Morgan 1981; Murarka and MacIntosh 1987).

The magnitude of weathering is estimated using solubility products (K_{sp}). Theoretically, a mineral dissolves in water to its solubility limit. However, minerals often dissolve so slowly that equilibrium does not occur, and maximum solubility is not reached (Morgan 1967).

Precipitation

Precipitates form when the concentration of a chemical in solution exceeds the saturation concentration (EPA 1989a). If the chemical concentration in solution falls below the solubility limit, the precipitate

redissolves. Inorganics in solution may precipitate when mixed with waters of differing mineral composition, temperature, or alkalinity (Williams 1985; Palmer 1989).

Complexation

A complex results from the reaction of metal cation with an anion. Transition metals, such as copper, nickel, and zinc, are typically involved in complexation reactions (Stumm and Morgan 1981). Alkaline earth metals, such as barium, beryllium, and magnesium, form weak complexes, and alkali metals, such as sodium and potassium, typically do not form complexes (Dempsey and O'Melia 1983).

Adsorption

Adsorption occurs when metals bind to specific sites on solid surfaces through coordination bonding. Metal adsorption is affected by sorption of other ions at the same binding site, reduction-oxidation (redox) potential, and metal speciation. Changes in metal concentration and pH affect adsorption (EPA 1989a).

Ion Exchange

Ion exchange occurs when two ions of differing binding affinities compete for the same binding site. The ion with the greater affinity will bind (displacing the ion with lesser affinity) through electrostatic forces to fixed charges on a solid matrix. Typically, alkali metals, alkaline earth metals, and some anions bind to clays and condensed humic matter by ion exchange (Helfferich 1962).

Reduction-oxidation

Reactions that transfer electrons between dissolved, gaseous, or solid constituents are called redox reactions. Oxidation refers to a loss of electrons, and reduction refers to a gain of electrons. If the oxidation state and number of electrons changes, a substance displays different reactivity, solubility, mobility, and toxicity characteristics (Fish 1993). For example, a dissolved substance that changes oxidation state may precipitate.

Environmental systems are described as oxidizing or reducing, depending on the availability of oxygen. Intertidal waters often are oxidized, because atmospheric oxygen is incorporated into the water through mixing, whereas marsh waters and sediments vary from oxidizing to reducing, depending on oxygen availability.

6.1.2 Biological Processes

Chemicals can be modified in two ways, biologically and chemically. An example of a biological process is the methylation of arsenic by diatoms. An example of a chemical process is adsorption of arsenic to iron oxide. While biological processes ultimately employ chemical reactions, the unique aspect of the biological process is that it is organism-mediated.

6.1.2.1 Biodegradation

Biological degradation is degradation of a molecule to its basic elemental composition, carbon dioxide and water. Typically bacteria degrade molecules. Many animals and plants can partially degrade chemicals through metabolic pathways normally used in food and energy metabolism. For example, many organisms transform arsenites to arsenates. However, most plants and animals lack the metabolic pathways to complete the degradation process.

6.1.2.2 Bioaccumulation

Bioconcentration is uptake of chemicals from water into the organism. Bioaccumulation is uptake of chemicals from all sources (water, sediment, and diet) into the organism. Biomagnification is bioaccumulation that increases in magnitude at higher trophic levels.

Metals dissolved in water as +2 ions enter aquatic organisms across the gills. Metals enter plants through their roots. Uptake depends on numerous chemical and biological factors that currently cannot be predicted. Mercury, selenium, and silver are examples of metals that are accumulated (Luoma and others 1995). Mercury also biomagnifies. Uptake of mercury depends on its chemical form; only methyl mercury is taken up and accumulated (Sadiq 1992f). How chemical form influences uptake of mercury in plants is not known.

6.2 CONTAMINANT TRANSPORT PROCESSES

The following sections explain the physical transport processes that distribute inorganics in the environment.

6.2.1 Advection

Advection is the transportation of chemical by bulk motion of flowing water. In systems dominated by advection, the chemical front migrating from a contaminant source remains well defined, and the

chemical is transported as a slug. When dispersion or molecular diffusion occurs, the chemical front spreads out. The velocity of nonreactive contaminants is the same as the water velocity; reactive constituents migrate much more slowly (EPA 1989a).

6.2.2 Dispersion and Molecular Diffusion

Dispersion describes the tendency of a contaminant mass to spread through water. It is caused by spatial variations in velocity and hydraulic conductivity of the water (Freeze and Cherry 1979). Molecular diffusion occurs when chemicals move from areas of higher concentration to areas of lower concentration. The effect of diffusion on chemical transport is a function of the concentration gradient and the diffusion coefficient and is temperature-dependent (Huyakorn and others 1984).

6.2.3 Hydrodynamic Dispersion

Hydrodynamic dispersion is the combined effect of mechanical dispersion and molecular diffusion. Hydrodynamic dispersion increases linearly as water velocity increases (EPA 1989a). Mechanical dispersion is most significant in the direction of flow; transverse dispersion (perpendicular to the flow) is much smaller (Sudicky 1986).

6.2.4 Particulate Transport

Adsorbed contaminants, such as cadmium and zinc, are transported by surface waters. Particulate transport plays a key role in metal transport in marshes and intertidal areas, where the concentrations of particulates and detritus are very high. Chemicals adsorbed to soil particulates are transported as water-eroded sediments (for example, washload or bedload). Erosion is a function of (1) surface runoff rate, (2) raindrop impact, and (3) land surface features such as vegetation, roughness, slope, soil type, and infiltration capacity. Raindrop impact causes detachment of soil particles and varies with rain intensity, duration, and frequency.

6.2.5 Volatilization

Compounds with high vapor pressures and low solubilities change phases going from solutions to gases; that is, they volatilize. Selenium is a metal that volatilizes. Plant leaves release volatile forms of selenium into the atmosphere (U.S. Fish and Wildlife Service [USFWS] 1987). Bacteria in the sediments release volatile forms of selenium into the water column (USFWS 1987). Temperature, pressure, constituent concentration, area of the solution-air interface, and degree of sorption modify

volatilization rates. Gases released at the water surface enter the atmosphere; however, gases released into the water column follow a complex path or may be recycled before reaching the water surface. Volatility is described using the Henry's Law constant.

6.3 PROPERTIES OF SPECIFIC INORGANIC CHEMICALS

The chemical behavior and ecological toxicity of each metal detected at the site is briefly described below. A complete toxicity profile for each metal is found in Appendix C.

6.3.1 Aluminum

Aluminum occurs naturally and is ubiquitous. In soil, aluminum occurs principally as aluminosilicates (Sparling and Lowe 1996). Because aluminum solubility increases at pHs below 5.0, acid rain mobilizes aluminum in soils. In fresh water, aluminum occurs either as complexes or as Al^{3+}, depending on pH (Freda 1991). In seawater, insoluble ($AlOH_3$) is the principal species, and aluminum concentrations measured in seawater are therefore extremely low (about 1 microgram per liter [μg/L]) (Newman and Jagoe 1994).

Aluminum is very toxic to trees, although a few species are aluminum-tolerant. At low pH, aluminum reduces root growth rates and decreases the uptake of ions by tree roots {Heridasan 1982, as cited in Sparling and Lowe 1996). Many plants, such as pine trees, accumulate aluminum. The greatest aluminum concentrations occur in plant roots.

Evaluating toxic effects of aluminum to aquatic organisms is difficult. Low pHs are toxic to aquatic organisms; therefore, the effects of low pH and aluminum (which dissolves at low pHs) are confounded. For example, bioaccumulation factors for *Daphnia* ranged from 0 at pH 4.5 (where the daphnids died quickly) to 10,000 at pH 6.5 (Sparling and Lowe 1996). However, rather than being accumulated, the aluminum may be adsorbed to the daphnid's chitin exoskelton. For example, mayflies lost 70 percent of their accumulated aluminum when allowed to molt (Sparling and Lowe 1996). Other invertebrates without exoskeletons accumulate aluminum. Clams (*Macoma*) from San Francisco and Chesapeake Bays contained a mean aluminum concentration of 2,000 to 3,000 mg/kg (Sparling and Lowe 1996).

6.3.2 Antimony

Antimony enters plants through airborne deposition. Studies using potted grasses demonstrated that antimony in soil is immobile and unavailable for uptake (Ainsworth and Cooke 1990). Studies using grasses planted in control soil, placed at various distances from an antimony smelter, demonstrated that antimony deposited on plant leaves is the primary entry route into plants (Ainsworth and Cooke 1990). Animals accumulate antimony when they eat plant leaves and stems containing antimony (Ainsworth and Cooke 1991). However, bioaccumulation factors were low and toxicity was not observed in laboratory animals.

Antimony dissolves in water, and methylated antimony occurs in natural waters (Ainsworth and Cooke 1991). Antimony added to anaerobic, aquatic sediments is partially lost as unidentified volatile compounds (Ainsworth and Cooke 1991).

6.3.3 Arsenic

Arsenic speciation is influenced by redox-potential. In seawater, arsenic dissolves as an oxyanion. Arsenite, As(III), and arsenate, As(V), are most abundant (Sadiq 1992a). Organic complexes represent less than 2 percent of the total arsenic present in seawater. Marine sediments are the ultimate sink for arsenic. Precipitation and adsorption are major entry routes into sediments. Arsenic(III) sulfide formation and dissolution regulates arsenic concentrations in reduced interstitial, sediment waters (Sadiq 1992a).

Marine organisms accumulate more arsenic than do freshwater organisms. Inorganic species are taken up more readily than organic forms. The route of uptake affects the magnitude of accumulation. Aquatic organisms can convert arsenate into arsenite. Organisms rapidly excrete arsenic, suggesting that arsenic does not biomagnify. Marine plankton accumulates arsenates, transform them into organic arsenicals, and release them as arsenite and methylated arsenic. Similarly, plankton degrades organic arsenites and release arsenate into the seawater. In aquatic animals, 90 percent of the arsenic in the tissues is in an organic form (Sadiq 1992a).

Arsenite is more toxic than arsenate. Arsenates uncouple oxidative phosphorylation. Arsenites bind to protein sulfhydryl groups, thereby inactivating enzymes. Soluble organo-arsenical forms are less toxic than inorganic forms. Toxicity varies with species and life stage.

6.3.4 Barium

Barium is found mainly in inorganic complexes and is stable in the +2 valence state. Environmental conditions, such as pH, Eh, cation exchange capacity, and calcium carbonate levels in soil, will affect the movement of barium in the environment (Agency for Toxic Substances and Disease Registry [ATSDR] 1990a). In an aquatic environment, barium will most likely precipitate out of solution as a $BaSO_4$ or $BaCO_3$ insoluble salt, or the barium ion will absorb to particulate matter (ATSDR 1990a).

Barium accumulates in terrestrial and aquatic organisms (ATSDR 1990a). Marine plants accumulate barium at 1,000 times the concentration in water. Marine animals, plankton, and brown algae had bioaccumulation factors of 100, 120, and 260, respectively (Schroeder 1970, as cited in ATSDR 1990a). Little is known about the toxicity of barium.

6.3.5 Beryllium

Plants accumulate beryllium, with hickory trees accumulating the highest concentrations (Newland 1982). Leaves contain more beryllium than twigs or fruits. Romney and Childress (1965), as cited in Newland (1982), showed that beryllium inhibits growth of crop plants at concentrations above 2 mg/L. In aquatic animals, beryllium interrupts physiological processes such as ion regulation and gas exchange (Jagoe and others 1993). At low concentrations, beryllium damages gills. Higher beryllium concentrations cause chloride cell apical crypts, increased mucous production, epithelial hyperplasia, and primary lmamellar fusions (Jagoe and others 1993).

6.3.6 Cadmium

Cadmium dissolves in seawater as a +2 ion. Because binding to organic complexes is insignificant, inorganic cadmium is synonymous with total dissolved cadmium. Sediment is the ultimate sink for cadmium. Thermodynamic calculations suggest that cadmium forms hydroxides, sulfates, or carbonates in oxic sediments, with cadmium phosphate being the dominant form (Sadiq 1992b). Below pH 4, $CdHS^-$ is the dominant form (Sadiq 1992b).

Cadmium is taken up as a +2 ion across the gills. Biomagnification does not occur (Sadiq 1992b). Rate and extent of bioaccumulation vary with season. Marine invertebrates attain the highest cadmium body burdens, and these burdens are greatest in estuaries. When an organism is transferred into clean water, depuration of cadmium is rapid. Marine organisms accumulate less cadmium than freshwater

organisms (Saddiq 1992b). Similarly, marine organisms are less sensitive to cadmium (that is, it is less toxic). Toxicity is species-specific and varies with life stage, with larvae being the most sensitive.

6.3.7 Chromium

Chromium in seawater occurs primarily in two valence states, chromite (Cr[III]); and chromate, (Cr[VI]). Poulton and others (1988), as cited in Sadiq (1992d), measured the chromium present in five seawater fractions: (1) exchangeable, (2) carbonate-bound, (3) iron/manganese-bound, (4) organically bound, and (5) residual fraction. One percent was bound to the iron/manganese component, 11 percent was bound organically, and 88 percent occurred in the residual fraction.

Marine organisms accumulate chromium. Weerelt and others (1984), as cited in Sadiq (1992d), showed that barnacle soft tissues accumulated more chromate than chromite. Bioaccumulation decreases in a reducing environment. Toxicity in seawater decreases with increasing salinity and pH. Chromium is less toxic in seawater than in fresh water, because chromite is readily precipitated or oxidized to chromate, making it less available.

In fresh water, chromite (rather than chromate) is the available and toxic form. Uptake in rainbow trout is a passive process, with the gills being the major entry route. Only chromate crosses biological membranes. Trama and Beniot (1966), as cited in Sadiq (1992d), showed that $HCrO_4^-$ crosses membranes more easily than $CrO_4 2^-$.

6.3.8 Cobalt

Cobalt is an essential element. In fresh water, less than 2 percent of cobalt species occur in the dissolved form; the remainder precipitate or adsorb to suspended solids and sediments. Under acidic conditions and in the presence of excess chloride ions or chelating agents, some mobilization of cobalt from sediments may occur (ATSDR 1992).

Microorganisms, higher plants, and animals accumulate cobalt. Laboratory studies using the clam, *Macoma balthica*, demonstrated that whole body uptake of cobalt-60 from different sediment types showed little variation when compared with cadmium and zinc uptake (Luoma and Jenne 1977). Excessive cobalt uptake results in accumulation and toxicity (Considine 1976). Mollusks, crustaceans, and other bottom feeders have been reported to accumulate large quantities of cobalt (Jenkins 1980). However, a study of organisms in Ottawa River sediments showed no detectable bioaccumulation of

cobalt-60 (Evans and others 1988). Bioaccumulation factors for cobalt on a dry-weight basis were 100 to 4,000 for marine fish and 40 to 1,000 for freshwater fish (Smith and Carson 1981). The concentration of cobalt in normal rat tissues has been shown to range from 0.001 to 0.006 part per million (ppm) of dry matter (Considine 1976). Cobalt appears to not significantly bioaccumulate in benthic bottom feeders in comparison to its concentration in sediment (ATSDR 1992).

6.3.9 Copper

Copper occurs in seawater as two species, Cu(I) and Cu(II), depending on redox potential and pH. Copper can be dissolved in or associated with sediment, absorbed by organisms, or adsorbed to particulates. Unlike fresh water, where about 90 percent of the copper is complexed to humic materials, in seawater only, about 10 percent of the copper is complexed to humic materials (Sadiq 1992c). Sediment is the ultimate sink for copper.

Copper species in seawater or marine sediments are strongly influenced by redox potential. In seawater of pH 3.7 to 13, Cu(I) compounds occur. $CuCl^{2-}$ predominates, but $CuCl_3^{2-}$ and $CuCl^0$ are probably also present (Sadiq 1992c). Thermodynamics suggest that $CuFe_2O_4$ regulates copper concentrations in water above pH 6, whereas Cu_2S controls copper concentrations in anoxic interstitial waters (Sadiq 1992c).

Organisms can accumulate copper as a +2 ion from the water through their gills. Biomagnification does not occur.

6.3.10 Iron

The oxidation/reduction of iron from its ferrous (+2) to ferric states (+3) is pivotal in many metal reactions. Numerous metals bind or adsorb (on the surfaces) of iron complexes such as iron oxide. Davis-Colley and others (1984), as cited in Newman and Jagoe (1994), found 80 percent of cadmium in estuarine sediments associated with iron oxides. Often, these metal-iron oxide units regulate the concentration of dissolved metals in water or sediments. For example, easily extracted iron or hydrous iron oxides decreased the bioavailability of sediment-associated silver, arsenic, cobalt, copper, lead, and zinc (Newman and Jagoe 1994).

Two systems (sulfide precipitation capacity and free sulfide accumulation) determine whether precipitation/dissolution or adsorption/desorption control dissolved metal concentrations in natural

waters (Davies-Colley and others 1985, as cited in Hong and others 1994). If reducible iron is present, precipitation occurs. If SO_4^{2-} is abundant, desorption occurs, producing dissolved metal. Therefore, the redox state of iron plays a key role in determining whether metals are present in a dissolved form.

Oxygen and complexation influence the redox status of iron. Iron precipitates in the presence of oxygen and dissolves in the absence of oxygen (that is, reducing environment) (Sundby 1994). Complexing agents interact more strongly with Fe(III) than Fe(II), shifting equilibrium in favor of the reduced species (Meyer and others 1994). Iron sulfides present in sediments include amorphous FeS, mackinawite (tetragonal FeS), greigite (cubic Fe_3S_4), and pyrite (cubic FeS_2) (Newman and Jagoe 1994).

6.3.11 Lead

The major input of lead into seawater is from atmospheric deposition. Lead can be ionic, particulate, or complexed. Redox potential does not play a role in lead chemistry. Thermodynamics suggest that in seawater (1) lead oxides will be highly soluble and therefore unlikely, (2) lead carbonates and lead hydroxides will occur, (3) lead sulfates will not form, (4) $Pb_2CO_3Cl_2$ will form in shallow water, and (5) chlorophyromorphite, $Pb_5(PO_4)_3Cl$, will form in deep water (Sadiq 1992e).

Sediments represent the ultimate lead sink. Most lead enters the sediments associated with particulates. Methylation of lead occurs in sediments through a chemical reaction. Methylated lead is significant, because it is more toxic than other lead forms. In reducing (typically anoxic) environments, dissolved lead reacts with sulfides to form lead sulfides (PbS or galena), which regulate dissolved lead concentrations in interstitial water and waters directly overlying the sediment (Sadiq 1992e).

Lead bioaccumulates. It can be ingested as particulates or across the gills as a +2 ion. Low salinities decrease bioaccumulation. Alkyl lead is also water-soluble and available (Sadiq 1992e). Lead, however, is not biomagnified.

6.3.12 Manganese

Manganese occurs in five valence states (+2, +3, +4, +6, and +7) in an aqueous environment. Mn^{2+} and Mn^{4+} are most common. The concentration of Mn^{2+} is limited by the solubility of manganese carbonate; in water of low alkalinity and reducing conditions, solubility may be limited by manganese sulfide. Although manganese chelation may occur, free manganese ion is the predominant

form. At pHs greater than 9, soluble Mn^{2+} is chemically oxidized to the insoluble Mn^{4+}; at pHs less than 5.5, chemical reduction of Mn^{4+} will occur. Between these pHs, any transformation is biologically mediated (EPA 1983).

Manganese can bioaccumulate; however, biomagnification does not occur.

6.3.13 Mercury

Mercury enters the ocean from atmospheric deposition and discharges. Mercury exists in two forms, (1) mercuric (Hg[II]) or (2) mercurous (Hg[I]), with redox potential playing a significant role in determining which form of mercury is present. Because of the very low concentrations of mercury in seawater, predictions of how mercury behaves in seawater are based on thermodynamic calculations. In anoxic seawater or sediments, HgS_2^{2-} and $Hg(HS)^2$ occur (Sadiq 1992f). Dissolved mercury is at its lowest concentration at the suboxic/anoxic interface. Increases in dissolved mercury are caused by the formation/dissolution of HgS complexes and varies with pH (Sadiq 1992f). Conversion to volatile Hg^2 occurs chemically or biologically through microbial activity. The chemical process is extremely slow, making the biological process more important. Methylation rate increases with decreases in pH; however, methylation does not occur in anoxic sediments with a pH less than 5 (Sadiq 1992f). Methyl mercury (formed and degraded by bacteria) represents between 0.3 and 6 percent of the total dissolved mercury in seawater (Sadiq 1992f).

Mercury is accumulated and biomagnified by marine organisms. Mercury availability depends upon chemical form. Pentreath (1976a, 1976b), as cited in Sadiq (1992f), found that (1) uptake of inorganic mercury was proportional to its water concentration and (2) uptake of methyl mercury was more rapid through food. Similarly, Fowler and others (1978), as cited by Sadiq (1992f), showed with shrimp that methyl mercury is absorbed more efficiently than inorganic mercury, whereas elimination of methyl mercury is much slower than the elimination of inorganic mercury. Therefore, methyl mercury biomagnifies. Factors, such as age, size, and weight, influence mercury accumulation. Different body organs concentrate different forms of mercury. Mammals and fish cannot demethylate mercury (Sadiq 1992f).

6.3.14 Molybdenum

Molybdenum is an essential element. Molybdenum occurs in seawater as the molybdate ion, MoO_4^{2-} (Abbott 1977, as cited in USFWS 1989). Increasing the ratio of sulfate to molybdenum inhibits

molybdate uptake by marine algae, slows nitrogen fixation rates, and slows the growth of organisms that use nitrate as a nitrogen source (Howarth and Cole 1985, as cited in USFWS 1989). Toxicity to freshwater plants occurs at concentrations of 50 mg/L or higher; freshwater algae can accumulate up to 20 grams of molybdenum per kilogram dry weight without apparent effect. The hexavalent molybdenum is converted by green algae to pentavalent molybdenum and stored intracellularly (Sakaguchi and others 1981, as cited in USFWS 1989). Uptake is greater in fresh water than in seawater.

Bioaccumulation factors in invertebrates are low: 16 in amphipods, 3 in clams, 18 in crayfish muscle, and 32 in crayfish carapace (Short and others 1971, as cited in USFWS 1989). Whether biomagnification occurs is uncertain. Aquatic animals are resistant to molybdenum (USFWS 1989). Adverse effects on survival occurred at concentrations greater than 1,000 mg/L, and growth was altered at greater than 60 mg/L. One exception is known; the 28-day LC_{50} (concentration lethal to fifty percent of test organisms) for rainbow trout eggs was 0.79 mg/L (Birge and others 1980, as cited in USFWS 1989).

6.3.15 Nickel

Nickel is an essential element that dissolves in water as a +2 ion. In streams, nickel (3 to 98 percent) is particulate-bound (Moore and Ramamoorthy 1984). The nickel content of particulates relates inversely to particle size. In the Amazon and Yukon Rivers, precipitated or coprecipitated coatings and crystalline forms represent 80 percent of nickel transport followed by organic solids (15 percent) and soluble and sorbed species (5 percent) (Moore and Ramamoorthy 1984). Association of nickel with iron and manganese oxides is also an important mode of transport.

Nickel uptake is concentration-dependent. Exchange processes occur in most species; for example, calcium is displaced by nickel (Moore and Ramamoorthy 1984). The exchange rate depends on pH. Nickel is deposited in kidney, digestive organs, and in the exoskeleton of crustaceans. Nickel does not biomagnify. Nickel is less toxic to aquatic plants than mercury, copper, cadmium, silver, and thallium, but more toxic than lead and zinc (Moore and Ramamoorthy 1984). For fish and invertebrates, nickel is less toxic than copper, mercury, lead, zinc, cadmium, silver, chromium, and arsenic (Moore and Ramamoorthy 1984). Nickel is less toxic in seawater because of competitive interactions with cations. In fresh water, toxicity decreases with increasing water hardness.

6.3.16 Selenium

Selenium dissolved in water (1) absorbs to or is ingested by organisms, (2) binds or complexes with particulate matter, or (3) remains free in solution. These processes result in selenium deposition in sediments, the ultimate selenium sink. First, chemical and microbial action convert the selenate (Se[VI]) to selenite (Se[IV]); second, selenium adsorbs onto clay and organic carbon associated with particulates (binding and complexation); and third, selenium reacts with iron species, followed by coprecipitation or settling (USFWS 1987). Ninety percent of the total selenium may be present in the upper few centimeters of sediment (USFWS 1987).

Selenium availability is controlled by six processes (USFWS 1987): (1) selenium is converted by microorganisms or in plant roots into either the reduced organic or elemental form or from selenite into selenate; (2) biological mixing and associated oxidation of sediments occur when benthic organisms burrow and fish and wildlife feed; (3) physical perturbation and chemical oxidation associated with water circulation and mixing occurs; (4) sediments may be oxidized by plant photosynthesis; (5) rooted plants accumulate selenium; and (6) uptake occurs in bottom-feeding fish and wildlife. The relative contribution of each of the six processes varies from site to site. Aquatic habitats that accumulate the most selenium typically have shallow, standing, or slow-moving water; show high biological productivity; and flush slowly.

Selenium is both accumulated and biomagnified. Fish accumulate selenium to several thousand times the water concentration. Selenium concentrates in the eggs of birds and fish and is passed on to the developing embryo, where it can cause death or developmental abnormalities. Selenium in the water at 2 μg/L can result in toxicity and reproductive failure in fish (USFWS 1987). Predators at the top of the food chain accumulate selenium concentrations causing mortality or reproductive failure.

6.3.17 Silver

In fresh water, silver occurs as a +1 ion. The solubility limit for silver is very low ($10^{-9.7}$); therefore, if chloride ions are present, silver will precipitate as silver chloride (AgCl). Ferrous iron reduces silver to its metallic state. Silver sulfide has low solubility. Therefore, in fresh water, with chloride, iron, and sulfur present, stable solid forms of silver occur over the entire redox potential-pH range (Hem 1977). Thermodynamic models suggest that in seawater, silver will form chloro-complexes. $AgCl^{0}$, $AgCl^{2-}$, $AgCl_2^{2-}$ and $AgCl_4^{3-}$ are among the most abundant forms of silver (Cowan and others 1985, as cited in Luoma and others 1995).

Silver bioaccumulates. Cherry, and others (1983), as cited in Luoma and others (1995), concluded that using enrichment factors (ratio of concentration in clam digestive gland to concentration in seawater), silver accumulation exceeded that of all other elements. For example, in the clam (*Macoma balthica*) one unit of silver in water resulted in 56 units of silver in the organism (Luoma and others 1995). Apparently, the chloro-silver complex is available for uptake. The low polarity of the chloro-silver complex facilitates passage across biological membranes. Therefore, both free silver ions and neutral chloro-silver complexes accumulate. Silver bisulfide may also be accumulated (Cowan and others 1993, as cited in Luoma and others 1995). Plankton bioaccumulate silver, so ingestion may also contribute to silver accumulation by filter-feeding animals.

Silver is very toxic (1 to 14 μg/L). Early life stages of bivalve mollusks are the most sensitive to silver (Bryan and Langston 1992, as cited in Luoma and others 1995).

6.3.18 Thallium

Thallium occurs in the +1 and +3 oxidation states. The +3 state is much less stable in water than is the +1 state. Thallium +1 forms complexes with halogen, oxygen, and sulfur ligands (Cotton and Wilkson 1972). The Tl^{3+} ion present in oxidizing waters is a strong acid and hydrolyzes to form $Tl(POH)_3$. In reducing environments, thallium precipitates as metal, or, in the presence of sulfur, as sulfide (Lee 1971). In oxidizing environments, Tl^{1+} is highly soluble (EPA 1979).

Tl^{1+} forms insoluble sulfides and weak halide complexes (Lee 1971). At the redox potential and pH concentrations normally present in natural waters, Tl^{1+} should be the predominant species in both fresh water and seawater. Increases in pH decrease thallium-inorganic interactions, but cause increased thallium-humic acid interactions. Tl_2O and TlOH dissolve freely in water, and thallium salts (sulfate, nitrate, acetate, and carbonate) are moderately soluble. In reducing environments, precipitation of Tl_2S may be an important mechanism for removing thallium from solution (Bodek and others 1988). Biomethylation of Tl^{1+} occurs in anaerobic, mixed bacterial cultures. Biomethylation of thallium has not been verified under natural conditions (Bodek and others 1988).

6.3.19 Vanadium

Vanadium occurs in 65 naturally occurring minerals. Vanadium (as oxide) occurs in four oxidation states. VO, V_2O_3, VO_2, and V_2O_5. In nature, vanadium occurs in its trivalent state; it dissolves in water in its pentavalent state (Newland 1982). Organisms accumulate vanadium. Accumulation is

greater in marine organisms than in freshwater or terrestrial organisms. In ascidians, vanadium (in the trivalent state complexed to pyrrole rings) occurs in blood cells called vanadocytes or in plasma as hemovanadium (Newland 1982). Vanadium enters organisms directly from seawater (for ascidians) or by exposure to or ingestion of marine mud.

6.3.20 Zinc

Zinc occurs as a dissolved form, as a solid precipitate, or adsorbed to particle surfaces. Soluble zinc exists as free (hydrated) ions, as inorganic complexes (the primary form in the sea), or as organic complexes (Young and others 1980, as cited in USFWS 1993). At pH 8.1, the dominant soluble species are zinc hydroxide (62 percent), free ion (17 percent), monochloride ion (6.4 percent), and zinc carbonate (5.8 percent). When dissolved organic material is present, dissolved zinc occurs as organo-zinc complexes (EPA 1987, as cited in USFWS 1993). Zinc species composition varies with salinity. At low salinities, $ZnSO_4$ and $ZnCl^+$ predominate; at higher salinities, the aquo ion predominates (Spear 1981, as cited in USFWS 1993). As salinity decreases, the free ion concentration increases, and the concentration of zinc-chloro complexes decreases, resulting in increased bioavailability (Nugegoda and Rainbow 1989, as cited in USFWS 1993).

Zinc is eventually partitioned into sediments, where it occurs as zinc hydroxide precipitates, ferric and manganic oxyhydroxide precipitates, insoluble organic complexes, insoluble sulfides, and other forms (EPA 1987, as cited in USFWS 1993). As reduced sediments become oxidized, zinc is mobilized and released. However, the transfer mechanisms are poorly understood, and the bioavailability of different zinc forms is unknown. Sediment sorption is complete at pHs greater than 7, but is negligible at pHs less than 6 (EPA 1981, as cited in USFWS 1993). Sulfide precipitation in sediments controls zinc mobility in reducing environments; hydroxides, carbonates, or sulfates precipitate where zinc occurs in high concentrations [EPA (1980) as cited in U.S. Fish and Wildlife Service (1993)].

7.0 HUMAN HEALTH RISK ASSESSMENT

This section presents the HHRA for the TBB Disposal Site. The objective of this assessment was to evaluate potential risks to humans associated with exposure to chemicals detected in soils and sediments at the disposal site. The HHRA is based on the site characterization and soil and sediment sampling data presented in Section 5.0 of this report.

The media evaluated in the HHRA were soil and sediment. Potential cancer risks and noncancer health hazards associated with these media were calculated using a screening-level approach. Specifically, soil and sediment chemical concentrations were compared with EPA Region IX preliminary remediation goals (PRG) (EPA 1999) for a residential scenario. PRGs based on target cancer risks of 1×10^{-6} and hazard quotients (HQ) of 1 were used. Although it is highly unlikely that the site will ever be developed for residential housing, residential PRGs were used as a benchmark to confirm that site conditions would be protective of human health for all possible future uses. Because the exposure and estimated risk for all other receptors are expected to be significantly less than those of a resident, the residential (or unrestricted) scenario was the only scenario evaluated in this risk assessment. The HHRA approach is consistent with the memorandum regarding the recommended outline for using EPA Region IX PRGs in screening risk assessments at military facilities (California Environmental Protection Agency [Cal/EPA] 1994).

A preliminary evaluation of the spatial distribution of chemicals detected in soil and sediment at the disposal site indicated that inorganic chemical concentrations at the center of the site were significantly higher than concentrations at the periphery of the site. In view of the elevated concentrations of inorganic chemicals (primarily lead) detected in the center of the site, the site was divided into two subareas. All samples with detected lead concentrations greater than 400 mg/kg (the residential PRG for lead) were grouped into one area (hereafter referred to as Area A), and the remainder of the samples were grouped into another area (Area B).

This section is organized to reflect the four basic steps of a risk assessment, as follows: Section 7.1, Data Evaluation and Chemicals of Potential Concern; Section 7.2, Exposure Assessment; Section 7.3, Toxicity Assessment; and Section 7.4, Risk Characterization. The summary and conclusions of the risk assessment are presented in Section 7.5.

7.1 DATA EVALUATION AND IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

This section describes the identification and evaluation of analytical data for use in the risk assessment. The data provide the basis for selecting chemicals of potential concern (COPC) for the TBB Disposal Site and estimating exposure point concentrations (EPC) for the risk assessment.

7.1.1 Data Evaluation

The available analytical data for this risk assessment include the results of the 57 sediment samples collected at a depth of 0 to 2.5 feet bgs from the disposal site, as presented in Section 5.0 of this report. Sediment samples were analyzed for inorganic chemicals (57 samples), SVOCs (24 samples), and extractable TPH (24 samples). The analytical data are presented in Appendix D.

All sediment samples collected at the disposal site were used in the HHRA, with the exception of three 3-point composite sediment samples. These samples were collected in February 2000 as part of the ERA investigation. These samples were not included in the data set for the HHRA because the sampling locations of the composite samples were generally co-located near existing discrete samples, so these locations are already characterized by existing discrete samples. Because chemical concentrations at those locations are already included in the data set used in the HHRA, inclusion of the composite samples would tend to overrepresent these areas.

As part of the data evaluation process, the analytical data were reviewed to verify that data quality was adequate for use in the risk assessment. No site-specific data quality issues were identified for the disposal site. Data validation of these samples followed EPA data validation guidelines, as described in the QAPP for the Concord Tidal Area Sites (PRC 1995). All data without qualifiers and all data qualified as estimated (J) were used in the risk assessment. Nondetected data (U) were also incorporated into the risk assessment by using a proxy value of one-half the sample quantitation limit. Only data qualified as rejected (R) were considered to be unusable for risk assessment purposes (EPA 1989b, 1992a).

7.1.2 Identification of Chemicals of Potential Concern

COPCs are those constituents present at a site that are carried through the risk assessment process and for which carcinogenic risks and noncarcinogenic hazards are estimated. COPCs at the disposal site were identified following a three-step process. First, validated soil and sediment analytical data were

assembled, and a preliminary list of all analytes detected in one or more soil or sediment samples was developed. Validated soil and sediment data are presented in Appendix D.

Second, some inorganic chemicals were removed from the list of COPCs on the basis of a comparison with ambient concentrations. Ambient metal concentrations were estimated, as described in Appendix E of the Tidal Area RI Report (PRC 1997). Inorganic chemicals were removed from the list of COPCs if the maximum detected concentration was below the 99th percentile of the ambient metal distribution (see Table 7-1). For Area A, aluminum and vanadium were removed from the COPC list based on the ambient screen. For Area B, aluminum, cobalt, nickel, and vanadium were removed.

As the third step in the identification of COPCs, elements considered to be essential human nutrients were removed from the list. EPA guidance states that these nutrients can be deleted because of their low toxicity when detected at environmental concentrations (EPA 1989b). Inorganic chemicals removed as COPCs using this step were calcium, magnesium, potassium, and sodium. Iron is also considered to be an essential nutrient; however, a PRG has recently been established for iron. Iron was therefore retained as a COPC.

All constituents remaining on the list after the above steps were completed were considered to be COPCs. COPCs identified based on the three-step process are listed in Tables 7-2 and 7-3 for Areas A and B, respectively. These tables also present COPC detection frequencies and the range of detected concentrations.

7.2 EXPOSURE ASSESSMENT

The exposure assessment evaluates the nature and magnitude of potential exposures associated with the disposal site. The assessment includes a description of the exposure setting and land use, identification of potential receptors and exposure pathways, and estimation of EPCs.

7.2.1 Exposure Setting and Land Use

The physical setting of the disposal site, including geology, climate, and topography, is described in Section 3.0 of this report. The disposal site is within a larger Tidal Area that includes diked wetlands, natural wetlands, and filled areas.

NWSSB Detachment Concord is an open naval base and is not scheduled to close. The majority of NWSSB Detachment Concord operations are in the Inland Area. Activities at the disposal area are

restricted to occasional grounds maintenance by base personnel and environmental restoration activities.

Infrequent and limited exposure may also occur if base personnel cross through the disposal site en route to an adjacent area. Land use in the area around NWSSB Detachment Concord is diverse, consisting of a mixture of military, industrial, residential, agricultural, and open space zones. No residential communities are located within the immediate vicinity of the disposal site. The closest residence is in the civilian community of Clyde, which is about 1 mile from the disposal site. The closest military residence is located more than 1 mile from the disposal site.

Future use at the TBB disposal site is not expected to change from its current use. Future residential, recreational, or private industrial or commercial use of the site is therefore not anticipated. Given the current sensitivity for development in a wetland environment, it is highly unlikely that residential development would be permitted at the disposal site, even if the Navy were to transfer the property to other owners. However, the residential exposure scenario is conventionally used to evaluate an unrestricted land-use exposure scenario, because the residential land-use scenario represents the greatest potential for exposure to site chemicals. This unrestricted (residential) land-use scenario generally characterizes a high potential for exposure to site chemicals. Sites found to have acceptable risk for this scenario will also have acceptable risk for other uses with lower exposure potential, such as industrial or recreational. Residential PRGs are used to evaluate this most conservative (health-protective) land-use scenario.

7.2.2 Receptors and Exposure Pathways

The residential (or unrestricted) scenario was the only scenario evaluated in this HHRA. Although it is highly unlikely that the site will ever be developed for residential housing, residential PRGs were used as a benchmark to confirm that site conditions are protective of human health for all possible future uses.

A recreational visitor is a more likely future receptor at the site. For example, a likely recreational visitor is a birder observing shorebirds. A utility worker would also occasionally access the site to conduct maintenance on the electrical pole at the site. Because the exposure and estimated risk for these and other possible receptors are expected to be significantly less than those of a resident, the risks for a recreational visitor and utility worker were not evaluated separately. It is expected that conditions considered to be protective of residents would also be protective of all other receptors.

Direct contact with groundwater was not evaluated in the HHRA. Groundwater from the Tidal Area is not considered to be suitable for use as a drinking water source (IT 1992). Most private and city municipal water in the region is supplied by treated surface water sources, although several wells are located in the industrial complex area to the west of NWSSB Detachment Concord. The wells are used primarily to supply process water and cooling water. Groundwater from a series of potable water wells surrounding Mallard Reservoir, also located west of NWSSB Detachment Concord, is used to augment aqueduct supplies of drinking water to the reservoir during drought periods; however, IT reports that these wells have been used only three times since the mid-1960s. Based on regional topography, the potable water wells are upgradient of the disposal site and therefore would not be affected by NWSSB Detachment Concord activities.

7.2.3 Exposure Points and Exposure Point Concentrations

Exposure points are defined as areas of potential human contact with a contaminated medium. They are typically defined on the basis of population activity patterns at a site and the relationship of those activities to the distribution of COPCs in soil and sediment. As discussed in the introduction to this section, based on an evaluation of the spatial distribution of chemicals in soil and sediment, two subareas of the disposal site were defined for the risk assessment. These subareas, Areas A and B, represent two separate exposure points. Review of the spatial distribution of COPC concentrations at the disposal site indicated vertical stratification of chemicals, with inorganic chemical concentrations in surface soils and sediments (0 to 1 foot bgs) significantly higher than those in deeper samples (greater than 1 foot bgs). Contaminants were also detected at higher concentrations at locations within Area A than outside of Area A. As a result, two sets of soil concentration terms (also referred to as EPCs) were developed for use in the HHRA, as described below.

The first set of soil concentration terms contains only the data from the 16 surface soil and sediment samples collected from 0 to 1 foot bgs in the 400-mg/kg lead isopleth (Area A). These soil concentration terms are presented in Table 7-2.

The second set of soil concentration terms contains data from all surface and subsurface soil and sediment samples collected outside of the 400-mg/kg lead isopleth (that is, all samples except the 16 samples located within the 400-mg/kg lead isopleth) (Area B). This set also includes samples taken from locations within the 400-mg/kg lead isopleth at depths greater than 1 foot. A total of 41 soil and sediment samples were used in this set of soil concentration terms. This data set was used to evaluate

potential human health risks associated with the site, assuming that soil within the 400-mg/kg isopleth is removed. These soil concentration terms are presented in Table 7-3.

The 95 percent upper confidence limit on the arithmetic mean (UCL_{95}) was generally used as the soil concentration term for each COPC. In cases where the UCL_{95} was greater than the maximum detected concentration, the maximum detected concentration was used as the soil concentration term. Methods used to calculate soil concentration terms are presented in Appendix J of the Tidal Areas RI (PRC 1997). Calculation of soil concentration terms was based on the data set distribution type (that is, normal, lognormal, or not tested). The distribution type was not tested if the data set contained three or fewer detected values. If the data set for a COPC was neither normal nor lognormal, it was assumed to have a lognormal distribution for purposes of calculating the UCL_{95}. Tables 7-2 and 7-3 also present COPC detection frequencies, sample quantitation limits, and range of detected concentrations.

Use of UCL_{95} concentrations is recommended by EPA (EPA 1992b) for evaluating reasonable maximum exposure (RME) conditions at a site and is consistent with State of California Department of Toxic Substances Control (DTSC) and EPA guidance for baseline HHRAs. RME is defined as the highest exposure that is reasonably expected to occur at a site. Typically, DTSC indicates that the maximum concentration of each chemical should be used as the EPC for comparisons against PRGs for screening-level risk assessments (Cal/EPA 1994). This policy is based on the assumption that few samples would be available for evaluation in a screening-level risk assessment. The 57 soil and sediment samples taken at the disposal site are adequate to characterize the nature and extent of chemical contamination. Consequently, UCL_{95} concentrations, rather than maximum detected concentrations, are used in this HHRA.

7.3 TOXICITY ASSESSMENT

A toxicity assessment typically includes two components: (1) brief descriptions of the major toxicological effects associated with COPCs identified at a site (toxicity profiles) and (2) a list of toxicity values (slope factors [SF] and reference doses [RfD]) used in the risk assessment for characterization of cancer risk and noncancer hazards. RfDs and SFs developed by EPA are the principal toxicity values used to estimate PRGs. Toxicity values are derived using data from both animal experiments and human epidemiological studies and can be used directly with EPA intake algorithms. Sources of toxicity values include the Integrated Risk Information System (IRIS)

(EPA 2000), which is a database containing EPA-verified, current toxicity values; and the Health Effects Assessment Summary Tables (EPA 1997a).

Toxicity values used in the calculation of chemical-specific PRGs are presented in the EPA Region IX PRG memorandum (EPA 1999). Toxicity profiles are not presented in this HHRA, because the EPA Region IX memorandum was used as the basis for assessing toxicity. Section 7.3.1 describes the source of specific toxicity values used to calculate PRGs selected for use in this risk assessment, and Section 7.3.2 identifies surrogate PRGs when a value is not available, because toxicity values have not been developed by EPA.

7.3.1 Toxicity Values

PRGs are health-based concentrations in soil for individual chemicals that correspond to an excess lifetime cancer risk of 1×10^{-6} or a noncarcinogenic HQ of 1. In most cases, when exposure to a specific chemical has been associated with both carcinogenic and noncarcinogenic effects, only the more stringent value (typically, the value corresponding to a cancer risk of 1×10^{-6}) is presented in the printed PRG table. The electronic version of the EPA Region IX PRGs includes PRGs corresponding to the noncarcinogenic effects of carcinogens. Both the carcinogenic and noncarcinogenic PRGs were used, when available.

For chromium, the toxicity is dependent on the ionic form of the metal (that is, whether chromium is present as the trivalent or the hexavalent form). Hexavalent chromium is a carcinogen by the inhalation route of exposure, whereas trivalent chromium is not a carcinogen by any route of exposure. Cal/EPA considers hexavalent chromium to be a carcinogen by both the ingestion and inhalation routes of exposure. In general, chromium is present in soil as either elemental chromium or trivalent chromium, unless industrial discharges of hexavalent chromium have occurred (Fetter 1993). However, because soil samples collected from the disposal site were not speciated for hexavalent chromium, it was conservatively assumed that chromium is present as both the hexavalent and the trivalent forms. The EPA Region IX PRG used to evaluate the cancer risks associated with potential exposure to chromium assumes a 1 to 6 ratio of hexavalent chromium to trivalent chromium. The PRG for chromium assumes that hexavalent chromium is only a carcinogen by the inhalation route.

7.3.2 Chemicals with No Toxicity Values

The EPA Region IX PRGs assume route-to-route extrapolation when no route-specific toxicity values were available. Oral RfDs and SFs are used to derive PRGs when dermal or inhalation toxicity values are not available (EPA 1999). In addition, inhalation toxicity factors are used to evaluate oral exposure when no oral toxicity values are available.

The following chemicals were detected at the TBB Disposal Site but do not have toxicity values: benzo(g,h,i)perylene and phenanthrene. The pyrene PRG was used as a surrogate for benzo(g,h,i)perylene, and the anthracene PRG was used as a surrogate for phenanthrene. Chemicals used as surrogates were chosen for their structural similarity to the chemicals without toxicity values and PRGs.

7.4 RISK CHARACTERIZATION

In this section, potential impacts to human health from residential exposure to COPCs are characterized for the disposal site. Section 7.4.1 presents the methods used to estimate carcinogenic risks and noncarcinogenic hazards associated with exposure to COPCs in soil and sediment. Section 7.4.2 presents the risk assessment results for the disposal site.

7.4.1 Risk Characterization Methodology

For the disposal site, the carcinogenic risk and noncarcinogenic hazard index (HI) was calculated based on the ratio of chemical concentrations to EPA Region IX residential PRGs for soil (1999).

7.4.1.1 Carcinogenic Risks

In its memorandum regarding the derivation of PRGs, EPA outlines an approach to estimate the cancer risk associated with exposure to carcinogens (EPA 1999). For COPCs that are classified as carcinogens, cancer risk associated with exposure to a single chemical is estimated by comparing the EPC (UCL_{95}) of the carcinogen to the cancer PRG, using the following equation:

$$Cancer\ Risk = (EPC/PRG) \times 10^{-6} \qquad (7\text{-}1)$$

where:

EPC = Exposure point concentration (mg/kg)

PRG = EPA Region IX residential PRG (mg/kg)

At a given site, individuals may be exposed to more than one substance. Carcinogenic risks associated with exposure to multiple chemicals can be assessed using an approach outlined by EPA in its memorandum regarding the PRGs derivation (EPA 1999). The total risk from exposure to multiple contaminants is calculated using the following equation:

$$Total\ Risk = 10^{-6} \times \{EPC_1/PRG_1 + EPC_2/PRG_2 + \ldots EPC_n/PRG_n\} \quad (7\text{-}2)$$

where:

Total risk	=	Total carcinogenic risk from exposure to all contaminants (unitless)
EPC_n	=	Exposure point concentration of contaminant n (mg/kg)
PRG_n	=	PRG for contaminant n (mg/kg)

To aid in the interpretation of risk assessment results, EPA guidance on the role of the risk assessment in supporting risk management decisions is considered. According to the EPA directive "Memorandum Regarding the Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (EPA 1991),

> Where cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4}, and the noncarcinogenic HQ is less than 1, action generally is not warranted unless there are adverse environmental impacts.

When action is warranted at a site (that is, site risks exceed 10^{-4}), remedial action goals defined by EPA are considered. In the NCP, EPA has defined general remedial goals for sites on the National Priorities List (40 *Code of Federal Regulations* Part 300.430). These goals include a target risk range, which is defined as "an excess upperbound lifetime cancer risk to an individual from exposure to site contamination of between 1×10^{-4} and 1×10^{-6}," or between 1 in 10,000 and 1 in 1,000,000.

In general, the EPA directive is used in interpreting the need for remedial action at a site, and action is not proposed when the risks associated with residential exposure at a site are below 10^{-4}. However, action may be proposed at sites where the risk is below 10^{-4} because of site-specific conditions. Consequently, carcinogenic risks within the target risk range of 10^{-4} and 10^{-6} are discussed in the risk assessment results section (see Section 7.4.2) of this report. In addition, when the risk for a chemical exceeds 1×10^{-6}, that chemical is identified as a "chemical risk driver". This information is reviewed

to confirm that no site-specific conditions (that is, localized contamination or potentially unidentified sources) warrant further investigation or remediation.

7.4.1.2 Noncarcinogenic Hazards

For COPCs that are not classified as carcinogens and for those carcinogens known to cause adverse health effects other than cancer, the potential for individuals to develop adverse health effects is evaluated by comparing EPCs (UCL_{95}) to noncancer PRGs. When calculated for a single chemical, this comparison estimates a HQ and is expressed in the following equation:

$$HQ = EPC/PRG \tag{7-3}$$

where:

PRG = EPA Region IX residential PRG (mg/kg)

EPC = Exposure point concentration (mg/kg)

To evaluate the potential for noncarcinogenic effects from exposure to multiple chemicals, the HQs for all chemicals are summed, yielding an HI as follows:

$$HI = EPC_1/PRG_1 + EPC_2/PRG_2 + \ldots + EPC_n/PRG_n \tag{7-4}$$

where:

EPC_n = Exposure point concentration of contaminant n (mg/kg)

PRG_n = PRG for contaminant n (mg/kg)

A total HI of less than 1 indicates no potential for adverse noncarcinogenic health effects. When the total HI exceeds 1, further evaluation in the form of a segregation of HI analysis is typically performed to determine whether noncarcinogenic hazards are a concern at the site. This is because the noncarcinogenic effects of chemicals with different target organs are generally not additive. If any one segregated HI exceeds 1, it may indicate that the potential exists for adverse noncarcinogenic health effects to occur (EPA 1989b). However, a segregation of HI analysis usually is not conducted if the HQ of any one chemical exceeds 1.

7.4.1.3 Lead Evaluation

The PRG for lead does not represent a soil concentration corresponding to an HQ of 1. Therefore, exposure to lead cannot be quantitatively evaluated in the same manner as other chemicals. Instead, the residential soil PRG for lead is derived by EPA using the EPA integrated Exposure Uptake Biokinetic Model (EPA 1994a). Applying this model, the PRG was calculated as a concentration of lead in soil that corresponds to an acceptable blood-lead concentration in a child. Blood-lead concentrations, expressed in micrograms of lead per deciliter of whole blood (μg/dL), are an integrated measure of an internal dose that reflects exposure from site-related and background sources. The EPA Region IX PRG for lead (400 mg/kg) corresponds to a blood-lead concentration in children of less than 10 μg/dL, the level of concern (EPA 1994a). For purposes of this assessment, lead is evaluated separately by comparing site soil concentrations to the lead PRG.

7.4.2 Risk Assessment Results

The results of the HHRA for the TBB Disposal Site are presented in Tables 7-4 and 7-5. These tables correspond to site conditions described in Section 7.2.3.

7.4.2.1 Area within the 400-Milligram per Kilogram Lead Isopleth (Area A)

Table 7-4 presents the carcinogenic risk and HI for a resident within the 400-mg/kg lead isopleth (Area A). The EPCs derived under this scenario assume that a resident is exposed only to soil and sediment within the 400-mg/kg lead isopleth. For a resident, the RME carcinogenic risk associated with potential exposure to COPCs in soil and sediment (4×10^{-4}) exceeds EPA's target risk range. Chemical risk drivers (that is, chemicals associated with a risk greater than 1×10^{-6}) are arsenic (4×10^{-4}), chromium (2×10^{-6}), benzo(a)pyrene (1×10^{-5}), and benzo(b)fluoranthene (3×10^{-6}). Arsenic was detected in all 16 samples, at concentrations ranging from 0.34 to 142 mg/kg. The maximum concentration (142 mg/kg) was used as the RME concentration. Benzo(a)pyrene was detected in three of six samples. The RME concentration of benzo(a)pyrene (0.6 mg/kg) is within the range of typical background concentrations in soils. Background concentrations of benzo(a)pyrene have been measured at 0.165 to 0.22 mg/kg in urban soils and 0.002 to 1.3 mg/kg in rural soils (ATSDR 1995). Benzo(b)fluoranthene was detected in five of six samples. The RME concentration of benzo(b)fluoranthene (2 mg/kg) is within the range of typical background concentrations. Background

concentrations of benzo(b)fluoranthene have been measured at 15 to 62 mg/kg in urban soils and 0.020 to 0.030 mg/kg in rural soils (ATSDR 1995).

The total HI for the resident is 22 and is attributable to arsenic (6), copper (2), and iron (10). Because individual HQs of these chemicals exceeded 1, no segregation of HI based on toxicological endpoint was performed.

The RME concentration for lead (3,470 mg/kg) exceeds the EPA Region IX residential PRG for lead (400 mg/kg). Assuming that the disposal site is developed for residential use, concentrations of lead in soil and sediment could result in a child blood-lead concentration greater than 10 μg/dL, the level of concern.

7.4.2.2 Area Outside of the 400-Milligram per Kilogram Lead Isopleth (Area B)

Table 7-5 presents the carcinogenic risk and HI for a resident exposed to the site outside of the 400-mg/kg lead concentration isopleth (Area B). This scenario assumes that remediation is conducted at the site to remove surface soil and sediment within the 400-mg/kg lead isopleth. For a resident, the RME carcinogenic risk associated with potential exposure to COPCs in soil and sediment (3×10^{-5}) is within EPA's target risk range. The chemical risk driver is arsenic (2×10^{-5}). Arsenic was detected in 39 of 41 samples, with concentrations ranging from 2.0 to 26.8 mg/kg, which is consistent with ambient values for arsenic in Tidal Area soils. The Tidal Area ambient value for arsenic (24 mg/kg) was exceeded in samples at only two locations in Area B (SB106 and SS205).

The total HI for the resident is 4. The chemical risk driver is iron (2). The RME concentration for iron (36,300 mg/kg), while above the EPA Region IX residential PRG, is within the range of background concentrations measured in California soils. Background concentrations for iron have been measured at 10,000 to 87,000 mg/kg in California soils (Bradford and Others 1996). Other than iron, no individual HQ exceeded 1.

Because no other individual HQ of iron exceeded 1, a segregation of HI based on the toxicological endpoint was performed for all COPCs other than iron. COPCs were grouped according to the target organ that would be affected by levels of exposure corresponding to the lowest-adverse-effects levels (LOAEL) (that is, the critical effects) identified by EPA (EPA 2000). The highest segregated HI is less than 1.

The RME concentration for lead (210 mg/kg) is below the EPA Region IX PRG for lead (400 mg/kg). Assuming that the disposal site is developed for residential use, the concentrations of lead in soil and sediment would not likely result in a child blood-lead level greater than 10 μg/dL.

7.4.3 Uncertainties

The risk estimates calculated in this HHRA are subject to varying degrees of uncertainty from a variety of sources. The uncertainties associated with the data evaluation, exposure assessment, and toxicity assessment will all directly affect the risk characterization.

7.4.3.1 Data Evaluation and Chemical of Potential Concern Selection Process

The primary uncertainty associated with the COPC selection process is the possibility that a chemical may be inappropriately identified as a COPC for evaluation in the risk assessment (that is, a detected chemical may be inappropriately excluded or included as a COPC). For the disposal site, the only analytes that were excluded from designation as COPCs were inorganic chemicals detected at concentrations below ambient levels and essential nutrients, with the exception of iron.

Site-specific ambient limits were not established for iron. The concentration of iron detected at the disposal site ranges from 63.2 to 378,000 mg/kg, with a mean of 64,400 mg/kg and a UCL_{95} of 123,000 mg/kg. The range of background California soil iron concentrations is 10,000 to 87,000 mg/kg (Bradford and Others 1996), and throughout the United States iron ranges from 7,000 to 550,000 mg/kg (Lindsay 1979). Although iron was likely correctly identified as a COPC, it is likely that background levels at the TBB Disposal Site exceed the residential PRG.

Consistent with EPA and DTSC guidance (EPA 1989b), ambient limits were not estimated for organic constituents detected in soils at the disposal site. However, studies have shown that there are ambient concentrations of PAHs in urban and rural soils (ATSDR 1995). PAHs are typically detected in soil samples from urban and rural areas at concentrations that may exceed a cancer risk of 1×10^{-6}. Natural sources of PAHs include emissions from volcanoes and forest fires. The primary manmade sources are wood-burning fires in homes, automobile and truck emissions, and other combustion sources. Background concentrations for benzo(a)pyrene have been measured at 0.165 to 0.22 mg/kg in urban soils and 0.002 to 1.3 mg/kg in rural soils (ATSDR 1995). Background concentrations for benzo(b)fluoranthene have been measured at 15 to 62 mg/kg in urban soils and 0.020 to 0.030 mg/kg in

rural soils (ATSDR 1995). At the TBB Disposal Site, the RME concentrations of benzo(a)pyrene and benzo(b)fluoranthene were within the range of typical background concentrations.

7.4.3.2 Exposure Assessment

Uncertainties exist in two areas of the exposure assessment process: (1) identification of receptors and (2) derivation of EPCs. Uncertainties in each of these areas are discussed in the following text.

Identification of Receptors

Receptors and exposure scenarios are identified based on observed and assumed land use and activity patterns of current and future receptors. To the degree that land use and activity patterns are not represented by those assumed, uncertainties are introduced. For example, future land use is assumed to be residential; however, such an assumption is unlikely given the proximity of the site to designated wetland areas and the tendency for significant portions of the site to be subject to flooding during the wet season.

Derivation of EPCs

As discussed in Section 7.2.3, the UCL_{95} was used as the EPC for each COPC, given the assumption that the large number of samples collected at the site adequately characterized the nature and extent of chemical contamination. The use of UCL_{95} concentrations is recommended by EPA for evaluating RME conditions. For small data sets, the UCL_{95} often exceeded the maximum detected concentration at a site, because the standard deviation associated with small data sets is high. Consequently, the maximum detected concentration (or the concentration of a single detected value) was often used as the RME concentration. The EPCs based on the maximum concentration or the UCL_{95} are likely to overestimate concentrations and associated risks at the site.

7.4.3.3 Toxicity Assessment

Primary uncertainties associated with the toxicity assessment are related to the derivation of toxicity values for COPCs. Standard toxicity values (RfDs and SFs) were used by EPA Region IX to derive the PRGs used in this risk assessment. Uncertainties associated with the unavailability of toxicity values for all COPCs and the chemical-specific factors for chromium and iron are described in the following text.

Unavailability of Toxicity Values

The carcinogenic risks and noncarcinogenic hazards can be assessed only for those COPCs for which relevant toxicity values are available. For fluorene and pyrene, for which an RfD was available for only one route of exposure, route-to-route extrapolations were made in the derivation of Region IX PRGs. These extrapolations will introduce some uncertainty into risk and hazard estimates.

Chromium Speciation

Selection of the appropriate toxicity value for chromium depends on the chemical species of chromium that is encountered; hexavalent chromium is a potent carcinogen by the inhalation route, whereas trivalent chromium is not a carcinogen. Chromium occurs primarily in the trivalent form in nature. Trivalent chromium has a more stable oxidation state than hexavalent chromium. Hexavalent chromium is easily transformed to trivalent chromium in reducing environments, such as those found in acidic soils or soils that contain iron or dissolved sulfides. Further, iron and dissolved sulfides in soil will reduce hexavalent chromium to trivalent chromium (Fetter 1993).

Because soil and sediment samples collected at the disposal site were not analyzed for hexavalent chromium, total chromium concentrations for each site were compared to the EPA Region IX residential PRG for chromium (210 mg/kg). This PRG for total chromium assumes that 1/6 of the total chromium is present in the form of hexavalent chromium. This assumption will likely introduce some uncertainty into risk and hazard estimates.

Iron

EPA recently established a PRG for iron based on the provisional oral RfD established by the National Center for Environmental Assessment (NCEA) (1999). The RfD represents a level that is both sufficient to protect against iron deficiency and insufficient to cause the toxic effects of iron overload. The RfD was derived using the upperbound value (0.27 milligram per kilogram per day [mg/kg-day]) in the range of average dietary intakes (0.15 to 0.27 mg/kg-day) from a National Health and Nutrition Examination Survey database. In this survey, biochemical indices of iron status (that is, serum ferritin levels) were used to confirm that blood-iron levels remained within a normal range when dietary intakes of iron were within the range of 0.15 to 0.27 mg/kg-day. It should be noted that the "Risk Assessment Issue Paper for Derivation of a Provisional RfD for Iron" (NCEA 1999) has not been through the formal EPA review process.

The National Academy of Sciences (NAS) (1989) has determined that the Recommended Dietary Allowance (RDA) for iron is 10 milligrams per day (mg/day) for children over the age of 1 and adult males and 15 mg/day for females aged 11 to 50 years. These RDA values correspond to intakes of 0.14 mg/kg-day for children over the age of 1 and adult males and 0.24 to 0.33 mg/kg-day for females. These values do not represent a level that is associated with adverse health effects, but rather a level required for proper nutrition. While chronic iron toxicity has been observed in people with metabolic disorders resulting in excessive iron absorption, a LOAEL for normal individuals consuming western diets has not been quantitatively determined. Therefore, it is likely that individuals may be exposed to iron at levels significantly higher than the PRG without experiencing adverse health effects.

7.5 HUMAN HEALTH RISK ASSESSMENT SUMMARY AND CONCLUSIONS

This risk assessment has been prepared as part of an RI for the TBB Disposal Site at NWSSB Detachment Concord. It is based on data collected from the disposal site and surrounding area in February 1996, March and October 1997, February and June 1998, and February 2000. The data were compared to EPA Region IX residential PRGs, which are equal to a cancer risk of 1×10^{-6} or an HQ of 1. COPCs are defined as all detected organic constituents and inorganic constituents detected in excess of ambient concentrations.

Currently, the disposal site is only accessible to Navy authorized personnel. There are no current plans for base closure, and the site use is not expected to change in the near future. For this HHRA, potential carcinogenic risks and noncarcinogenic hazards were calculated based on the ratio of detected contaminant concentrations to residential PRGs. Although it is highly unlikely that the site will ever be developed for residential housing, residential PRGs were used as a benchmark to confirm that postremediation site conditions will be protective of human health for all possible future uses. As previously discussed, it is anticipated that a removal action will occur at the site to protect ecological receptors. For purposes of the risk assessment, the site was divided into two subareas: the area in the center of the site where lead concentrations exceeded the residential PRG of 400 mg/kg and the area outside of the 400-mg/kg lead isopleth.

For the resident, the carcinogenic risk (4×10^{-4}) from soil and sediment within the 400-mg/kg lead isopleth at the disposal site (Area A) under current conditions exceeds EPA's target risk range of 1×10^{-6} to 1×10^{-4}. Chemical risk drivers are arsenic, chromium, benzo(a)pyrene, and

benzo(b)fluoranthene. The HI is 22, indicating the potential for adverse health effects from residential use of the site. HQs for arsenic, copper, and iron are greater than 1.

The Area A RME concentration for lead (3,470 mg/kg) exceeds the EPA Region IX PRG for lead. Assuming that the disposal site is developed for residential use and no remediation is conducted at the site, the concentrations of lead in soil and sediment could result in a child blood-lead concentration greater that 10 μg/dL, the level of concern. However, because it is anticipated that soil and sediment within the 400-mg/kg lead isopleth will be removed to protect ecological receptors, it is highly unlikely that residents will be exposed to COPCs at levels expected to result in adverse health effects.

The carcinogenic risk (3×10^{-5}) from soil and sediment outside of the 400-mg/kg lead isopleth (Area B) is within the target risk range of 1×10^{-6} to 1×10^{-4}. Arsenic is the only COPC with a cancer risk (2×10^{-5}) greater than 1×10^{-6}. The HI is 4, indicating the potential for adverse health effects from residential use of the site. Iron is the only COPC with an individual HQ (2) greater than 1.

The Area B RME concentration for lead (210 mg/kg) is below the EPA Region IX PRG for lead. Assuming soil and sediment within the 400-mg/kg lead isopleth is removed, the risks identified at the disposal site would be within EPA target levels considered to be protective of human health, and potential exposures to COPCs in soil would not be expected to result in adverse health effects.

The screening-level HHRA conducted for the disposal site indicates that COPCs are currently present at levels that could result in adverse health effects for residents. COPCs are present at higher concentrations at the center of the site, and it is likely that soil and sediment within the 400-mg/kg lead isopleth will be removed to protect ecological receptors. Soil and sediment within the 400-mg/kg lead isopleth also contains elevated levels of COPCs other than lead. Concentrations of COPCs in soil and sediment remaining after remediation of the 400-mg/kg lead isopleth would be within EPA target levels considered to be protective of human health. Potential exposures to remaining COPCs would not be expected to result in adverse health effects. Following remediation of soil and sediment within the 400-mg/kg lead isopleth, the only COPCs remaining at concentrations above the EPA Region IX residential PRGs would be arsenic and iron. The remaining levels of both benzo(a)pyrene and iron would be within background ranges, and it is unlikely that further remediation would result in levels below the PRGs.

8.0 BASELINE ECOLOGICAL RISK ASSESSMENT

This section describes the methodology and results of the baseline ERA conducted as part of the RI for the TBB Disposal Site. Ecological risk assessment within the Superfund Program is intended to fulfill three basic functions:

1. Document whether actual or potential ecological risks exist at a site.
2. Identify which contaminants at a site pose an ecological risk.
3. Generate data to be used in evaluating cleanup options.

Guidance for the design and conduct of ERAs under CERCLA is provided in EPA (1997b, 1999). While existing guidance provides a general framework for the conduct of ERAs, it recognizes that approaches and methodologies must be tailored to assessment scenarios at individual sites. EPA (1997b) characterizes ERA as a complex, nonlinear process that involves many parallel activities and emphasizes that the ERA framework was designed to be flexible, thereby allowing scaling of studies in a manner appropriate to the requirements of and conditions at each site.

EPA (1997b) separates the ERA process into eight steps:

Step 1: Screening-level problem formulation and evaluation of ecological effects

Step 2: Screening-level preliminary exposure estimate and risk calculation

Step 3: Baseline risk assessment problem formulation

Step 4: Study design and data quality objectives

Step 5: Field verification of sampling design

Step 6: Site investigation and analysis of exposure and effects

Step 7: Risk characterization

Step 8: Risk management

Steps 3 through 7 are required only for those sites for which the screening-level assessment (Steps 1 and 2) indicates a need for further evaluation of ecological risk. Steps 2, 3, 4, 5, 6 (only if changes to the field sampling plan are necessary), and 8 have associated scientific management decision points (SMDP). SMDPs are significant communication points that require meetings between the risk

manager, risk assessment team, and other involved parties to evaluate and approve or redirect work up to that point. All involved parties should agree to SMDPs before the risk assessment process is continued.

A screening level ERA (Steps 1 and 2) was completed for the TBB Disposal Site in 1999 using available sediment chemistry data (TtEMI 1999a). Preliminary evaluations of the data recommended remediation of all soil containing more than 250 mg/kg lead from the site; therefore, the screening-level ERA assumed remediation of lead-contaminated soil and evaluated only residual site conditions in the absence of lead contamination exceeding 250 mg/kg.

Screening Level ERA (Steps 1 and 2)

In the screening-level ERA, data were screened against literature-derived toxicity values for benthic receptors, using an HQ approach to identify chemicals of potential ecological concern (COPEC). Two HQs were calculated for each chemical that exceeded the Concord tidal area ambient (PRC 1996a) and for which screening values were available. HQs were calculated using the 1992 Wetland Cover Values (WCV) (California Regional Water Quality Control Board [RWQCB] 1992) and effects-range median (ER-M) (Long and others 1995).

Regulatory guidance indicates that benthic receptors may be at risk if the HQ exceeds 1.0 (EPA 1989b). In the screening-level ERA, sediments were assumed to have the highest potential for toxic effects where the $HQ_{ER\text{-}M}$ was above 1.0. The potential for toxic effects was assumed to be low where the HQ_{WCV} was less than 1.0. The potential for toxic effects was assumed to be moderate where HQ_{WCV} was greater than 1.0, but the $HQ_{ER\text{-}M}$ was not. The screening-level ERA concluded (1) potential risk based on WCVs for copper, lead, mercury, selenium, and zinc; and (2) high risk based on ER-Ms for mercury, selenium, and zinc. Although none of the HQs were high enough to warrant immediate action, these results indicated a potential for adverse ecological effects to benthic invertebrates.

The screening-level ERA also identified receptors potentially at risk, fate and transport mechanisms, exposure pathways, and endpoints to screen for ecological risk. Based on the results of the screening-level ERA, it was determined that a baseline risk assessment would be required.

8.1 PROBLEM FORMULATION FOR BASELINE ECOLOGICAL RISK ASSESSMENT (STEP 3)

Conclusions set forth in screening-level ERA (TtEMI 1999a) and the need to better define risk were the basis for undertaking additional evaluation of ecological risk at the TBB Disposal Site. In Step 3, the goals and focus of the baseline ERA (EPA 1997b) were established, and the screening-level ERA problem formulation was further developed based on the results of the screening-level ERA and stakeholder input. Problem formulation for the baseline ERA is presented in Table 8-1.

The baseline ERA (Steps 3 to 8) is a refinement of the screening-level ERA and includes a more detailed conceptual site model (CSM). The CSM identifies natural resources potentially at risk, fate and transport processes, and complete exposure pathways for receptors. The CSM includes the following components:

- **Stressors:** identification of site stressors in an ecological context. Stressors can be defined as any factor causing adverse ecological impacts on natural resources at the site; in this ERA, only inorganic chemical stressors are addressed directly. However, other types of stressors will be mentioned when relevant.

- **Exposure Pathways and Critical Receptors:** identification of complete ecological exposure pathways, such as ingestion and dermal contact, and the critical receptors that may be exposed. Critical receptors usually include representatives of important feeding guilds and may include special status species.

- **Fate and Transport:** description of potential pathways of chemical transport and the ultimate fate of site chemicals, including the potential for biogeochemical transformation of the chemicals, potential for on- and off-site migration of chemicals, and biotic transfer.

- **Assessment and Measurement Endpoints:** identification of assessment and measurement endpoints that will be used to characterize risk at the site. Assessment endpoints are environmental characteristics or values which, if found to be significantly affected, would indicate a need for action by risk managers. Measurement endpoints more closely reflect technical considerations in the risk assessment process; that is, measurement endpoints are focused on more direct measures of ecological effects that allow for an evaluation of risk to assessment endpoints.

The following sections review the first two components of the CSM. Fate and transport of chemicals for all habitats are discussed in Section 8.1.3. A detailed discussion of assessment and measurement endpoints used to evaluate risk at the TBB Disposal Site is presented in Section 8.1.4. An overall CSM is presented on Figure 8-1. Complete exposure pathways in the TBB Disposal Site aquatic and wetland habitats are identified on Figure 8-2.

8.1.1 Stressors

Inorganic chemicals are the primary stressors to both the aquatic and wetland and upland transitional habitats at the TBB Disposal Site. Metal concentrations are highest in the wetland and upland transitional habitat in areas of debris. Organic chemicals were evaluated in the screening-level ERA (TtEMI 1999a) and were determined to pose negligible risk in comparison with inorganic chemicals. Therefore, only inorganic chemicals were further evaluated in the baseline ERA. However, the nature and extent of all chemicals evaluated at the site was provided in Section 5.1 (inorganic chemicals) and 5.2 (organic compounds). Although not all inorganic chemicals are metals, the terms "inorganic chemical" and "metal" are used interchangeably throughout the text of this document.

In addition to chemical stressors, other types of stressors in the wetland habitat include historical changes in hydrologic dynamics resulting from construction activities at the site and the presence of introduced and invasive plant species. Although these factors will not be addressed in the risk assessment, they may be important in risk management decisions.

8.1.2 Exposure Pathways and Critical Receptors

Receptors residing in or migrating through the aquatic or wetland and upland transitional habitat at the TBB Disposal Site may be exposed to site-related chemicals through surface waters, sediments and soils, or plant and animal material.

Bioavailable chemicals accumulated in prey can be transferred to higher trophic levels through the food chain and may biomagnify. A food web for the TBB Disposal Site is provided on Figure 8-1. Mercury, selenium, and arsenic, detected at the TBB Disposal Site, have been shown to biomagnify in some cases (Eisler 1988; Saiki and Lowe 1987, as cited in Taylor and others 1992; Suedel and others 1994).

Plants may take up chemicals directly from the soil or surface water and suffer direct or indirect effects of exposure. The plants adapted to conditions of inundation also provide critical habitat for special status animals such as the salt marsh harvest mouse. Protection of plant species such as pickleweed (*Salicornia virginica*) is critical for the maintenance of salt marsh harvest mice populations. Contaminants in plants may be transferred to herbivores, including insects, rodents, and granivorous birds; if these chemicals bioaccumulate in tissues of herbivores, higher-level predators will also be exposed.

Many species ingest sediment or soil particles and detritus directly while feeding (oligochaetes, filter feeders, demersal fish, and shorebirds) or indirectly while capturing sediment or soil-covered prey (herons, egrets, waterfowl, and raptors). Predators may also ingest chemicals within the tissues of their prey; this is especially important for chemicals that biomagnify. Mammals and birds may incidentally ingest soil with preening or grooming (Beyer and others 1994). Many types of animals, such as benthic invertebrates, fish, wading birds, amphibians, aquatic mammals, and burrowing mammals, are subject to dermal exposure to chemicals in soil, sediment, or surface water.

Ingestion of site sediments and prey by receptors is considered to be the main exposure pathway. The size of the site relative to the drainage area that discharges to Seal Creek Marsh is so small that it is insignificant. As a result, contaminated runoff from the site is unlikely to have a significant effect on water quality of the area.

8.1.3 Fate and Transport

Potential pathways for chemical mobilization and transport within the site and to Seal Creek Marsh include:

1. Groundwater-surface water interactions, including discharge of chemicals dissolved in groundwater to surface water in Seal Creek Marsh or direct subtidal discharge of chemicals dissolved in groundwater into the Bay.

2. Surface transport, including advective transport of chemicals dissolved in surface water or absorbed to suspended sediments and wind-driven transport of soil particles

3. Biotic transport such as movement of chemicals in tissues of plants or animals at the site

These transport pathways and the potential for migration of site chemicals will be discussed in the following sections. A schematic of exposure routes and potential receptors at the TBB Disposal Site is provided on Figure 8-3. A detailed discussion of the fate of chemicals detected at the site was provided in Section 6.0.

8.1.3.1 Groundwater-Surface Water Interactions

Groundwater surface water interactions at the site were not evaluated. However, field observations indicated that boreholes created to characterize the nature and extent of debris filled with water at sediment depths ranging from 0.5 to 3 feet, depending on elevation. These observations indicate a

mixing of groundwater and surface water, particularly at the lower elevations of the wetland and upland transitional habitat and in the aquatic habitat.

8.1.3.2 Surface Transport Pathways

The main mechanism of surface transport of chemicals is through surface water movement, including movement of suspended sediments with adsorbed chemicals. Wind transport of contaminated soil is potentially important in the drier upland habitats at the site during the dry season.

Tidal exchange and overland flow of surface runoff are considered to be the main routes of potential migration of site chemicals within the site and to Seal Creek Marsh. Contaminants in sediments may be present as both dissolved fractions in the interstitial water and as solid-phase adsorptions to surfaces or organic material (Campbell 1988). Although daily tidal action is minimal, extreme precipitation events could result in a net movement of dissolved chemicals and contaminated soils and sediments across the site.

Chemicals adsorbed to soil particles can be borne by wind, which blows primarily from the west-northwest through Carquinez Strait; as a result, airborne particles may be moved primarily to the east-southeast. The potential movement of chemicals as airborne particles is not considered to be a significant transport process in permanently wet habitats. However, wind may transport particulates in the wetland and upland transitional habitat during annual dry periods (late summer and early fall) when the surface soil is desiccated.

8.1.3.3 Biotic Transport

Chemicals may also be transported in plant and animal tissues. Chemicals in the bodies of mobile receptors such as fish, migrating birds, flying insects, and far-ranging predators, may be carried off site and deposited in other locations in the form of feces or corpses. In addition, distribution and partitioning of chemicals are affected by the activities of burrowing animals, such as amphipods, and fish in wetland environments (Greene and Chandler 1994).

8.1.4 Assessment and Measurement Endpoints

Assessment and measurement endpoints identified for the TBB Disposal Site and rationale for their selection are shown in Table 8-2. A flow diagram showing trophic linkages among assessment and measurement endpoints can be found on Figure 8-3. Five assessment endpoints, ranging from plants to

higher-trophic-level receptors, were identified for specific evaluation during the TBB Disposal Site baseline ERA. Assessment endpoints include the following:

- Maintenance and protection of wetland and upland transitional plants
- Protection populations of benthic invertebrates
- Protection of populations of waterfowl
- Protection of populations of shorebirds
- Protection of individual salt marsh harvest mice

Further discussion regarding selection of assessment and measurement endpoints is provided in the following sections (see also Tables 8-1 and 8-2).

8.1.4.1 Rationale for Selection of Endpoints

Taxa reported to use habitats at the TBB Disposal Site or observed during site visits were considered to be possible assessment endpoints. Protection of the population was used as the endpoint for all species, except those for which the individual is the unit of protection because of their federal or state threatened or endangered status. By definition, assessment endpoints have ecological, toxicological, and societal importance (EPA 1992b). Several site-specific factors influenced the selection of endpoints, including the occurrence, ecological significance, conservation status, life and natural history characteristics, and potential toxicological susceptibility of receptors; known and potential chemicals present and their mechanisms of toxicity; and spatial and temporal patterns of potential exposure.

Taxa selected as assessment endpoints were chosen to represent surrogates for ecologically important groups of receptors. For example, the potential for risk to the Mallard can indicate potential risks for other waterfowl having similar exposure routes and physiology.

Species that inhabit NWSSB Detachment Concord all or part of the year were selected over migratory species within a feeding guild; it is reasonable to assume that if resident species are shown not to be at risk, migrants are safe from chemicals at the site, as well. For example, migratory ducks and other waterfowl are important ecologically and socially; the Mallard was chosen as a surrogate for this group based on its occurrence in Seal Creek Marsh throughout the year.

Native taxa representative of important ecological guilds were chosen as endpoints for the protection of major ecological niches in TBB Disposal Site habitats. For example, pickleweed, which is part of the plant community found at the site, is not only an important primary producer and food source for the salt marsh harvest mouse, but also functions as a structural element in wetland habitats.

Some taxa selected as assessment endpoints are valued by society, as evidenced by their conservation status. The salt marsh harvest mouse is a federal and state endangered species. Waterfowl are protected under the Migratory Bird Treaty Act and are harvested by humans. These taxa also have recreational value for birdwatchers and naturalists across the state and country.

Toxicological concerns also guided the selection of endpoints; the presence of metals and metalloids requires that exposure to plants and lower-trophic-level receptors should be evaluated. Some bioaccumulating chemicals, such as arsenic, mercury, and selenium, warrant concern about exposure of higher-level receptors. Factors considered included the sensitivity of receptors to effects of specific types of chemicals, the potential fate of chemicals in terms of biogeochemical processes and bioaccumulation, and dominant exposure routes of ingestion of contaminated prey and media. Endpoints were chosen to represent risk posed through all major exposure pathways considered to be important at this site.

8.1.4.2 Natural History of Assessment Endpoint Species

Receptor-specific natural and life history characteristics influencing potential risk, such as diet, trophic relationships, residency, foraging range, and possible exposure pathways, were evaluated during selection of assessment endpoints. These features are presented for each receptor in Table 8-3. Additional natural history information was gathered through literature reviews and will be discussed where relevant to evaluation of exposure and effects.

8.2 RELATIONSHIP BETWEEN ASSESSMENT AND MEASUREMENT ENDPOINTS AND RISK CHARACTERIZATION METHODS

Assessment and measurement endpoints were selected to function together in models for characterization of risk at the TBB Disposal Site. Risk to some assessment endpoints (such as the plants and benthic invertebrate communities) was measured directly. For assessment endpoints that could not be measured directly, measurement endpoints were selected based on dominant exposure pathways for each assessment endpoint, as defined in the CSM. The relationships between assessment

and measurement endpoints are shown in Table 8-4 and are discussed in more detail in the following section.

Risk to assessment endpoint taxa was evaluated based on multiple lines of evidence. Lines of evidence include measurement endpoints and other qualitative evaluations. Measurement endpoints are quantitative and include such things as comparison of site data to toxicity benchmarks, bioassays, and food-chain modeling using site-collected data. Qualitative evaluations take into account such things as literature evaluations and bioaccumulation factor (BAF) calculations. The lines of evidence used to assess the risk to each assessment endpoint are detailed in the following sections and are summarized in Table 8-5.

8.2.1 Lines of Evidence for Assessing Maintenance and Protection of Wetland and Upland Transitional Plants

Within the context of the baseline ERA, maintenance and protection of wetland and upland transitional plants is defined as sufficient rates of survival, growth, and germination to sustain plant populations. The effect of chemicals on wetland and upland transitional plant populations was evaluated using the following lines of evidence:

- Comparison of chemical concentrations in sediment with Oak Ridge National Laboratory (ORNL) benchmarks for plants (Efroymson and others 1997). ORNL benchmarks are a measure for growth and yield for terrestrial plants. Growth and yield are ecologically significant responses both in terms of plant populations and the ability of vegetation to support higher trophic levels. One of the uncertainties associated with ORNL benchmarks is that they were developed for terrestrial plants; however, data specific to wetland plants is limited. The methodology by which ORNL benchmarks were developed has proven to be extremely conservative in practice (Efroymson and others 1997); therefore, the estimate of risk is also conservative.

- Calculation of HQs (site concentration/ORNL benchmark) to evaluate the magnitude and extent of contaminants.

- Qualitative evaluation of site-specific BAFs based on pickleweed tissue concentrations.

- Qualitative evaluation of toxicity based on a review of the primary literature.

8.2.2 Lines of Evidence for Assessing Protection of Populations of Benthic Invertebrates

Within the context of the baseline ERA, protection of populations of benthic invertebrates is defined as sufficient rates of survival and growth to sustain populations. The following lines of evidence were used to evaluate the effect of inorganic chemicals on populations of benthic invertebrates:

- Comparison of chemical concentrations in sediment to effects-range low (ER-L) and ER-M (Long and others 1995). The ER-L is the concentration at which 10 percent of the studies showed effects; sediment concentrations below the ER-L are interpreted as being "rarely" associated with adverse effects. The ER-M is the concentration at which 50 percent of the studies showed effects. Concentrations above the ER-M are "frequently" associated with adverse effects (Long and others 1995). ER-Ls and ER-Ms are guidelines developed to identify concentrations of chemicals in sediment associated with biological effects in the laboratory, field, or modeling studies (Long and others 1995).

- Calculation of mean ER-M HQs (mean ER-Mq) to evaluate the magnitude and extent of contaminants (Long and MacDonald 1998)

- Direct toxicity testing of sediment using the endpoints of survival and reburial of *Eohaustorius estuarius* amphipods

- Factors affecting bioavailability (SEM/AVS, sediment grain size, pH, and TOC)

- A qualitative evaluation of site-specific BAFs using amphipod tissue residues

- A qualitative evaluation of toxicity based on a review of the primary literature

8.2.3 Lines of Evidence for Assessing Protection of Populations of Aquatic Birds

Within the context of the baseline ERA, protection of populations of aquatic birds is defined as sufficient rates of survival, growth, and reproduction to sustain populations of shorebirds such as the Black-necked stilt and aquatic omnivores like the Mallard. Risk to representative birds (Black-necked stilt and Mallard) at the TBB Disposal Site were evaluated quantitatively based on an HQ approach. In the HQ approach, site-specific daily doses determined by food-chain modeling were compared to toxicity reference values (TRV), where the HQ was equal to ingested dose divided by the TRV. The derivation of avian TRVs and the use of food-chain analysis in the HQ approach were described in detail in a technical memorandum (EFA West 1998). Food-chain analysis was conducted for each avian COPEC and receptor pair for which a TRV was available. For COPECs that did not have a TRV, a qualitative assessment of risk was performed based on available information in the scientific literature.

8.2.4 Lines of Evidence for Assessing Protection of Individual Salt Marsh Harvest Mice

Within the context of the baseline ERA, protection of individual salt marsh harvest mice is defined as sufficient rates of survival, growth, and reproduction to sustain individual salt marsh harvest mice. Risk to the salt marsh harvest mouse at the TBB Disposal Site was evaluated quantitatively based on an HQ approach. Site-specific daily doses determined by food-chain modeling were compared to TRVs, where the HQ was equal to ingested dose divided by TRV. The derivation of TRVs for mammals and the use of food-chain analysis in the HQ approach were described in detail in a technical memorandum (EFA West 1998). Food-chain analysis was conducted for each small mammal COPEC for which a TRV was available. For COPECs that did not have a TRV, a qualitative assessment of risk was performed based on available information in the scientific literature.

8.3 DATA QUALITY ASSESSMENT

Once sampling data were collected and validated, a data quality assessment was conducted. The data quality assessment process involved evaluation of the following information:

- Compliance with DQOs. Data were evaluated to determine whether the requirements of DQOs and the assumptions under which DQOs were prepared were met. See Section 8.3.1 for a detailed description.
- Data quality. Data were evaluated to determine whether the total study error in the data was small enough to allow decision-makers to use the data to support a decision (see Section 8.3.2).

8.3.1 Compliance with Data Quality Objectives

DQOs are qualitative and quantitative statements developed through the seven-step DQO process (EPA 1994c). "The DQO process is intended to facilitate the development of sampling plans by targeting data needed to make decisions, including risk management decisions. The DQO process specifically focuses on the importance of, and methods for, developing a sampling plan for collecting data with a known level of statistical error to ensure that the data can be used as intended and that the level of decision error is known. The EPA also recognizes that not every environmental sampling initiative lends itself to the use of statistical techniques" (EPA 1994c). The plans for collection of data for the baseline ERA were based on the seven-step DQO process, as presented in Section A1.2 of the TBB QAPP (TtEMI 2000a) and Section 9.2 the WP (TtEMI 1999b). The DQO table from the TBB QAPP is included in Appendix A of this document.

Except for Step 1 of the DQO process, the data meets DQO requirements and the assumptions under which the DQOs were prepared. Step 1 of the DQO process involved a description of the problem to be studied and a review of prior studies and existing information to gain sufficient understanding to define the problem. The following problem statement was made in the TBB Disposal Site WP (TtEMI 1999b) and QAPP (TtEMI 2000b):

> Soils at the site contain levels of several inorganic chemicals that may pose risk to ecological receptors under conservative exposure and effects scenarios. Site-specific factors affecting actual exposure and effects have not been investigated. A baseline ERA must be performed in order to make reasonable decisions about what remedial actions are protective of receptors at the site. Lead concentrations at some locations are high enough (>250 ppm) that remediation is expected to be necessary to reduce risk to human health. New data from additional sampling will be evaluated with the original data to determine if lead concentrations in the area outside of the 250 mg/kg lead isopleth pose a risk to ecological receptors. Wetland and aquatic habitat could be adversely affected by remedial actions.
>
> The results of the screening-level human health risk assessment for the TBB Disposal Site indicate that the risks associated with potential residential exposure to chemicals detected in soil and sediment within the 250 mg/kg lead isopleth are greater than the EPA target risk range considered protective of human health. Remediation of soil and sediment within the 250 mg/kg lead isopleth is therefore proposed to bring the risks to within the EPA target risk range. After remediation is completed to remove the surface soil and sediment from within the 250 mg/kg lead isopleth, the remaining lead concentrations (137 mg/kg) would be below the residential soil PRG, indicating that adverse noncarcinogenic health effects would not be expected. Because human health concerns will be alleviated, the focus of the future evaluation will be placed on the evaluation of risk to ecological receptors once the significantly contaminated surface soils are removed. Thus, human health concerns are not considered further in the DQO process evaluation.

Based on a reconsideration of the TBB Disposal Site data, the problem statement was amended prior to the preparation of this report (May 17, 2000, NWSSB Detachment Concord Meeting Minutes). The 250-mg/kg lead isopleth was considered to be arbitrary with respect to estimating ecological risk and considering site habitats. For this report, the site is not discussed in terms of areas inside and outside of a 250-mg/kg lead isopleth. The TBB Disposal Site is viewed as a single area with respect to evaluating risk to ecological receptors. For human health, all samples with detected lead concentrations greater than 400 mg/kg (the residential PRG for lead) were grouped into one area (hereafter referred to as Area A, or area within 400 mg/kg lead isopleth), and the remainder of the samples were grouped into another area (Area B, or area outside 400 mg/kg lead isopleth). The results of the baseline human health and ERAs will determine the area of the site to be remediated.

8.3.2 Data Quality

Data used for this project were determined to be of sufficient quantity and known quality to be useable in the assessment of human and ecological risk. A comparison of achieved detection limits was conducted to ensure that they were less than screening values such as ambient, ER-L, and ORNL. Achieved detection limits for inorganic chemicals for all samples were less than screening benchmarks.

8.4 ASSESSMENT OF RISK TO WETLAND AND UPLAND TRANSITIONAL PLANTS

The evaluation of risk to plants at the TBB Disposal Site focused on the maintenance and protection of wetland and upland transitional plants. The following paragraphs provide an overview to introduce the process by which risk to wetland and upland transitional plants at the TBB Disposal Site was assessed. COPECs are identified in Section 8.4.1, exposure and effects are assessed in Sections 8.4.2 and 8.4.3, the risk to plants is characterized in Section 8.4.4, and a summary of risk drivers or chemicals of ecological concern (COEC) and areas of the site posing risk to plants is provided in Section 8.4.5.

For exposure to take place, plants must be growing in a medium where chemicals are in a bioavailable form. The wetland and upland transitional plant habitat supports a diversity of plants, as described in Section 3.5. Because the distributions of metals and plants at the wetland and upland transitional plant habitat overlap, exposure has likely occurred.

To identify which metals were COPECs to plants, the UCL_{95} of the mean for each metal in the wetland and upland transitional habitat was compared against an ambient- and a toxicity-based benchmark. The ambient benchmark was the lower of either the San Francisco Bay (RWQCB 1998) or the Concord Tidal Area ambient metal concentrations (PRC 1996b). Toxicity-based benchmarks were from ORNL (Efroymson and others 1997). COPECs were identified based on exceedance of the San Francisco Bay *or* Tidal Area ambient concentrations *and* the ORNL plant toxicity benchmark.

Plant COPECs were then further evaluated to determine chemicals of ecological concern (COECs) and to identify areas of the site that pose a risk to plants. The process included calculation and evaluation of the following:

- **HQs:** HQs (sediment concentration/ORNL) were used to assess how often metals at each sampling location exceeded a benchmark concentration above which metal toxicity may occur. As explained in EPA regulatory guidance (EPA 1989b), an HQ greater than 1.0 is an indicator that receptors may be at risk. By tabulating the number of sampling locations at which the HQ exceeded 1.0, the frequency of occurrence of locations with potential toxicity was evaluated.

- **Mean HQs:** Mean HQs were calculated across sampling locations for each COPEC. By determining the COPECs for which the mean HQ exceeded 1.0, the overall magnitude of exceedance across the site was evaluated.

- **BAFs:** BAFs were calculated to see if pickleweed had been exposed to metals. If the BAF was greater than 1.0, it was concluded that metal uptake or accumulation (exposure) had occurred.

- **Literature Review:** A review of the literature was made to identify routes of exposure and potential toxicological effects of inorganic chemicals on plants was conducted.

8.4.1 Chemicals of Potential Ecological Concern Screening for Plants

Nineteen inorganic chemicals present at the TBB wetland and upland transitional plant habitat (n = 30; includes shoreline samples) were evaluated as potential COPECs (see Table 8-6). Iron, magnesium, potassium, and sodium were also present, but were not considered to be potentially toxic. Each occurs naturally and is either an essential element or plays a key role in metabolism. Sediment samples across the wetland and upland transitional habitat were combined to calculate a UCL_{95} of the mean (n=30). The UCL_{95} were then compared against an ambient- and a toxicity-based benchmark to identify COPECs for wetland and upland transitional plants. Chemicals were considered to be COPECs if the UCL_{95} of the mean exceeded both benchmarks. The overall screening process by which COPECs for wetland and upland transitional plants were determined is shown on Figure 8-4.

The ambient benchmark consisted of the lower of the ambient, UCL_{95} metal concentrations for San Francisco Bay sediments (RWQCB 1998) or the ambient, 99th percent UCL (UCL_{99}) metal concentrations for Concord Tidal Area sediments (PRC 1996a). If the TBB Disposal Site UCL_{95} concentration for a metal exceeded either the San Francisco Bay *or* the Concord Tidal Area ambient concentrations (whichever was lower), that metal was then screened against the second benchmark.

The second benchmark was the ORNL plant toxicity benchmarks (Efroymson and others 1997). If the UCL_{95} concentration for a metal at the TBB wetland and upland transitional plant habitat exceeded the ambient benchmark described above *and* the ORNL benchmark, that metal was considered to be a COPEC in plants (see Table 8-6). An ambient metal value and ORNL benchmarks existed for each

metal at the wetland and upland transitional plant habitat, all 19 inorganic chemicals underwent the COPEC screening process.

Nine inorganic chemicals were identified as plant COPECs (see Table 8-6); antimony, arsenic, barium, chromium, copper, lead, mercury, selenium, and zinc.

Table 8-7 summarizes the various benchmarks (San Francisco Bay ambient metal concentrations, Concord Tidal Area ambient metal concentrations, and ORNLs) used to evaluate COPECs. Also included are the number of individual sampling locations with metal concentrations exceeding (1) San Francisco Bay ambient metal benchmarks, (2) Concord Tidal Area ambient metal benchmarks, and (3) ORNL plant toxicity benchmarks.

Metals that were not selected as COPECs were reviewed to ensure that significant metal exposure or toxicity had not been overlooked. This process involved evaluating the data to determine if high concentrations existed that may pose a risk, even if the UCL_{95} of the mean was less than the benchmark. Because the maximum concentration of cadmium (13.4 mg/kg) exceeded the UCL_{95} by two orders of magnitude, best professional judgment suggested that cadmium be reclassified as a COPEC. Remaining inorganic chemicals were not evaluated further.

8.4.2 Exposure Assessment

A plant must be exposed to a chemical before uptake, accumulation, or toxicity can occur. Because distributions of inorganic chemicals and plants at the wetland and upland transitional plant habitat overlapped, exposure may have occurred. To evaluate if metal exposure had occurred, (1) complete metal exposure pathways for plants were developed, (2) spatial variation in the EPC in the wetland and upland transitional plant habitat was evaluated using HQs and mean HQs, and (3) BAFs were employed to determine if pickleweed tissues contained metal concentrations greater than those in the sediment, suggesting that uptake or accumulation (exposure) had occurred.

8.4.2.1 Complete Exposure Pathways

Plants are exposed to inorganic chemicals by: (1) root uptake of chemicals dissolved or bound in the soil and (2) root absorption of chemicals deposited on foliage or stems.

Plant roots take up available inorganic chemicals. Metals are either sequestered within the root or translocated through the vascular system into other plant parts such as the foliage. Exposure to volatile

inorganic chemicals or deposition on foliage also occurs. Dissolved inorganic chemicals penetrate the cuticle and enter the free spaces of the leaves or stems (Hughes 1981). Once inside the leaf or stem, inorganic chemicals can be bound or cross sieve cell membranes and be translocated to other plant parts (Hughes 1981). Fate and rate of transport of inorganic chemicals in the plant vary with age of the vegetative part, chemical form of the metal, and the plant species unique biochemistry.

Saline, brackish, and freshwater marshes have unique features that influence exposure pathways. Inundation, salinity gradients, and varying amounts of rain cause changes in the chemical form and availability of inorganic chemicals for uptake. Detritus quantity and type influence metal availability. When certain plant species are inundated, metals cross the cuticle present in leaves and enter the plant tissues. However, uptake of chemicals from the water column is insignificant in partially submerged plants such as cattails and salt marsh cord grass (Bretela and others 1981; Duskenko and others 1995). Therefore, the most important pathway for metal uptake at the TBB wetland and upland transitional plant habitat is through plant roots.

In the more upland areas, salt stress is reduced, and soils are more oxidized. Inundation is rare. Soil organic matter often differs in quantity and composition from that closer to the shoreline. Here, root uptake is also the dominant route of metal entry into plants. Bioavailability of inorganic chemicals for root uptake varies with soil oxidation state and organic composition.

8.4.2.2 Spatial Variation in Exposure

To describe which sampling locations at the wetland and upland transitional plant habitat had inorganic chemical concentrations above ORNL benchmarks (Efroymson and others 1997), an HQ approach was used.

HQs

An HQ was calculated by dividing the metal concentration at each sampling location by the ORNL benchmark (Efroymson and others 1997) for that metal. HQs for each COPEC and sampling location appear in Table 8-8. If an HQ exceeds 1.0, toxicity may occur. By evaluating the number of sampling locations where HQs exceeded 1.0 and the number of HQs exceeded for each location, the magnitude and frequency of exceedance was assessed.

Mean HQs

The mean HQ was calculated by summing HQs for one COPEC across sampling locations and dividing that sum by the number of sampling locations at which the COPEC was present (see Table 8-8). Because a HQ greater than 1.0 indicates potential for toxicity at a sampling location, it was assumed that a mean HQ greater than 1.0 demonstrated potential for toxicity across the site that may affect populations of plants. Using this rationale, antimony, arsenic, chromium, copper, lead, selenium, and zinc occurred at the TBB wetland and upland transitional plant habitat at concentrations that may cause ecological harm at the population level.

8.4.2.3 Bioaccumulation

Bioaccumulation describes the movement of chemicals from sediment into plant tissues. Bioaccumulation and factors that influence the process are explained in detail in Appendix E. The BAF is the ratio of the plant tissue concentration divided by the sediment chemical concentration. If the BAF equals 1.0, it implies that the chemical concentration in the sediment equals that in the tissues of the plant (that is, no uptake has occurred). If the BAF exceeds 1.0, it implies that the chemical concentration in the plant tissues exceeds that in the sediment (that is, chemical uptake has occurred). The BAF does not imply either the presence or absence of toxicity.

To evaluate whether pickleweed at the wetland and upland transitional plant habitat was accumulating inorganic chemicals in its tissues, pickleweed BAFs were calculated for each COPEC.

Collocated pickleweed and soil samples were collected from three locations; northern, central, and southern sections of the site. These three samples were considered to be representative of the wetland and upland transitional plant habitat at the site (see Figure 3-1). BAFs (tissue [mg/kg of dry weight]/soil [mg/kg of dry weight]) were calculated at each of these three locations. Pickleweed BAFs are shown in Table 8-9.

The sediment sample collected in the central region of the site (309CSPW) yielded pickleweed BAFs greater than 1.0 for selenium (3.7). The sediment sample collected in the southern region (309SB05PW) yielded no BAFs greater than 1.0. The sediment sample collected in the northern region of the site (309SB106PW) yielded pickleweed BAFs greater than 1.0 for arsenic (4.6), cadmium (1.69), copper (1.1), mercury (13.1), selenium (3.2), and zinc (1.4).

Six COPECs had maximum BAFs greater than 1.0 (see Table 8-9). They were antimony (4.6), cadmium (1.69), copper (1.1), mercury (13.1), selenium (3.7), and zinc (1.4). These BAFs suggest that pickleweed is taking up these six inorganic chemicals from wetland and upland transitional plant habitat sediments.

8.4.2.4 Identification of Plant Chemicals of Ecological Concern

The procedure used to identify risk drivers or COECs from COPECs is illustrated on Figure 8-5. A three-step process was used to identify risk drivers and locations of highest concern.

All COPECs with mean HQs greater than 1.0 were retained. COPECs with mean HQs greater than 1.0 represent inorganic chemicals that may cause adverse effects to plant populations across the site. Antimony, arsenic, chromium, copper, lead, selenium, and zinc had mean HQs that exceeded 1.0 and were therefore retained (see Figure 8-5). Barium, cadmium, and mercury were excluded.

In the second step of the process, locations with numerous chemicals exceeding ORNL benchmarks were identified. Locations where five or more HQs exceeded 1.0 were identified as locations of concern. ORNL benchmarks provide a very conservative estimate of risk; therefore, locations at which at least five HQs exceeded 1.0 were considered to pose a significant risk to wetland and upland transitional plants (see Figure 8-5 for a list of locations).

In the third step, BAFs were used to assess metal uptake; BAFs were only evaluated for COPECs identified in Step 1 at locations determined in Step 2 above (see Figure 8-5). If a BAF was less than 1.0, metal uptake and accumulation had not occurred, suggesting that the metal was not available and exposure had not occurred. Arsenic, copper, selenium, and zinc were retained (see Table 8-10). Antimony, barium, chromium, and lead were excluded (see Table 8-10).

Using the process outlined above (see Figure 8-5), COECs to plants were arsenic, copper, selenium, and zinc. These four chemicals were considered to be major risk drivers to plant populations in the wetland and upland transitional habitat. Not retained as COECs were antimony, chromium, and lead, because BAFs were less than 1.0 (see Table 8-9), and barium, cadmium, and mercury because mean HQs were less than 1.0.

In summary, arsenic, copper, selenium, and zinc were identified as plant COECs in the wetland and upland transitional habitat.

8.4.3 Effects Assessment

In the following sections, the likelihood that the four COECs, arsenic, copper, selenium, and copper, could cause toxicity to plants is assessed. First, the published plant toxicity literature for arsenic, cadmium, copper, selenium, and zinc was reviewed. Second, bioavailability of the four inorganic chemicals in sediments at the TBB wetland and upland transitional plant habitat was evaluated.

8.4.3.1 Potential Effects of Chemicals of Ecological Concern

General information on adverse effects of COECs on plants is presented in toxicological profiles in Appendix C. No specific information on most plants, plant assemblages, or soil conditions found at the TBB Disposal Site is available that would allow an evaluation of the direct relevance of literature studies. Maximum concentrations in sediment, summarized in Table 5-2, are not likely to be bioavailable to plants, although some portion will be.

Arsenic: Arsenic was found at maximum concentration of 142 mg/kg; the UCL_{95} was 37.6 mg/kg (see Tables 5-2 and 8-6). For freshwater cattail, arsenic can cause decreases in root growth at a root concentration of 1.0 ppm and can terminate root growth at 3.0 ppm; at sediment concentrations of 300 ppm, arsenic caused reductions in vegetative growth (Peterson and others 1981; Duskenko and others 1995; Tamaki and Frankenberger 1992). In general, arsenic stunts plant growth, but does not bioaccumulate in higher-level receptors (Peterson and others 1981; Tamaki and Frankenberger 1992).

Copper and Zinc: Copper and zinc are essential trace metals for plants. The maximum concentration of copper was 12,500 mg/kg in wetland sediment and 1,690 mg/kg for the UCL_{95}; comparable zinc maxima and UCL_{95} were 5,410 and 1,660 mg/kg, respectively (see Tables 5-2 and 8-6). Reported background levels are 81 for copper and 264 ppm for copper and zinc in the Tidal Area (see Table 8-5). The exact amounts plants require of these two elements are not known, but are considered to be relatively small. Minimum soil concentrations toxic to plants also are not known. High levels of copper in soil have reduced root length and enzyme activity and produced chlorosis (Lepp 1981; Foy and others 1978). Zinc in acidic soils was toxic to corn crops at concentrations of 450 to 1,400 ppm available zinc; 180 to 700 ppm available zinc caused toxicity to cowpeas (Gall and Barnette 1940, as cited in Adriano 1986). Zinc toxicity causes growth retardation, chlorosis, membrane "leakiness," and reduced photosynthesis (Collins 1981). No increase in toxicity of zinc with increasing salinity was shown for salt marsh cord grass (Mrozek and Funicelli 1982). Levels of copper and zinc above background levels may therefore pose a risk for plants at certain locations at the TBB Disposal Site.

Selenium: Selenium was found at a maximum concentration of 12 mg/kg; the UCL_{95} was 3.8 mg/kg (see Tables 5-2 and 8-6). Selenium is not proven to be essential for plant growth. It is absorbed by plants as selenite, selenate, or in organic form, and the selenate may be the more toxic. It is believed that selenate is taken up actively, while selenite uptake is largely passive (Peterson and others 1981). Selenium is translocated to all parts of the plant. Toxicity symptoms include chlorosis, stunting, and yellowing of the leaves. Some plants concentrate selenium at concentrations in excess of 1,000 mg/kg, even on soils with less than 1 mg/kg selenium, while others do not accumulate appreciable amounts, even on seleniferous land (Newland 1982). Wan and others (1988) investigated the effects of selenium on alfalfa grown in three soils. In the sandy loam soil (pH 6.7, 13 percent organic matter), shoot weight was reduced 83, 33, and 56 percent by the addition of 1.5 Se(VI), while 0.5 ppm had no effect.

8.4.3.2 Bioavailability

For a metal to be taken up, accumulated, or be toxic to a plant, it must be available. The pHs of sediments at the wetland and upland transitional plant habitat ranged from 7.56 to 8.22; TOC ranged from 43,600 to 102,000 mg/kg. These data suggested that inorganic chemicals at the wetland and upland transitional plant habitat might not be available to plants, because metals typically are soluble and mobile only in sediments at pHs less than seven. Similarly, TOC concentrations are high enough to provide sufficient binding sites for metals to make the inorganic chemicals at the habitat unavailable. However, such conclusions must be considered speculative because of the very small sample size (n=3) and the pickleweed BAFs discussed below.

No data specifically describing metal availability to TBB plants were collected, so potential metal availability was evaluated using existing TBB Disposal Site data and information from published literature on metal plant toxicity. A indirect measure of bioavailability is the BAF. If a BAF exceeds 1.0, then chemical uptake and accumulation has occurred. If chemical uptake and accumulation have occurred, then those metals must be available to the plant. Arsenic, copper, selenium, and zinc all had BAFs greater than 1.0 (see Table 8-9), indicating that they are available to pickleweed in the TBB wetland and upland transitional plant habitat.

8.4.4 Risk Characterization for Wetland and Upland Transitional Plants

The following sections discuss the significance of each of the lines of evidence associated with protection and maintenance of wetland and upland transitional plants, describe which inorganic chemicals at the TBB Disposal Site are the principal drivers of risk to plants, and describe the sampling

locations at the TBB Disposal Site where the potential risk of inorganic chemicals to plants is greatest. Table 8-10 summarizes data inputs and COPEC screening, and COEC selection processes for plants.

8.4.4.1 Summary of Lines of Evidence for Evaluating Risk to Plants

The effect of chemicals on wetland and upland transitional plant populations was evaluated using the following lines of evidence:

- Comparison of chemical concentrations in sediment to ORNL toxicity-based benchmarks for plants
- HQs to evaluate the spatial distribution of chemicals.
- Qualitative evaluation of site-specific BAFs
- Qualitative evaluation of toxicity based on a review of the primary literature

8.4.4.2 Chemicals Driving Risk to Plants

Determining which inorganic chemicals were the principal drivers of potential risk to plants was based on an evaluation of HQs, mean HQs, and BAFs. The plant COECs, arsenic, copper, selenium, and zinc, were identified based on the process described in Section 8.4.2.4. Across the wetland and upland transitional plant habitat, arsenic had 12 HQs greater than 1.0, copper had 14 HQs greater than 1.0, selenium had 12 HQs greater than 1.0, and zinc had 14 HQs greater than 1.0.

Over all sampling locations (n = 30), arsenic, copper, selenium, and zinc exceeded their respective ORNLs at 50, 53, 43, and 90 percent of the sampling locations, respectively (see Table 8-7).

However, total sediment metal concentrations do not necessarily indicate potential toxicity. Only that portion of the total metal concentration that is available to the plant can cause potential toxicity. The BAF is a qualitative assessment of bioavailability; if the BAF is greater than 1.0, exposure has occurred (that is, the metal is likely to be available). Arsenic, copper, selenium, and zinc had BAFs greater than 1.0 (see Table 8-9), indicating that pickleweed had been exposed to these inorganic chemicals. While antimony, chromium, and lead also had numerous sampling locations with HQs greater than 1.0, pickleweed was not exposed to these inorganic chemicals (that is, their BAFs were less than 1.0) (see Table 8-9).

The principal drivers of risk to plants were the four COECs, arsenic, copper, selenium, and zinc.

8.4.4.3 Areas Posing Risk to Plants

During the process of determining COECs, the number of sampling locations with five or more HQs greater than 1.0 was tabulated to identify sampling locations with significant risk to plants (see Figure 8-5). Because ORNL benchmarks provide a very conservative estimate of risk, locations where at least five HQs exceeded 1.0 depict areas expected to pose the greatest risk to wetland and upland transitional plants. These sampling locations were 309CSPWSS, SB001, SB003, SB004, SB009, SB010, SB012, SB013, SB014, SB015, SB017, SB018, SB019, and SB020.

Figure 8-6 shows the location of each sediment sample with five or more HQs greater than 1.0. The portion of the wetland and upland transitional plant habitat at risk from metal exposure roughly coincides with the area where debris is distributed, plus sampling locations SB003, SB010, SB013, and SB020.

8.4.5 Summary of Chemicals of Ecological Concern and Areas Posing Risk to Plants

Potential risk to wetland and upland transitional plants from exposure to arsenic, copper, selenium, and zinc exists at the site (sampling locations 309CSPWSS, SB001, SB003, SB004, SB009, SB010, SB012, SB013, SB014, SB015, SB017, SB018, SB019, and SB020).

8.5 ASSESSMENT OF RISK TO BENTHIC INVERTEBRATES

The evaluation of risk to benthic invertebrates at the TBB Disposal Site focused on the protection of populations of benthic invertebrates. The following paragraphs provide an overview of the process by which risk to benthic invertebrates was assessed at the TBB Disposal Site. COPECs are identified in Section 8.5.1, exposure and effects are assessed in Sections 8.5.2 and 8.5.3, the risk to populations of benthic invertebrates is characterized in Section 8.5.4, and a summary of COECs and areas of the site posing risk to benthic invertebrates is provided in Section 8.5.5.

Invertebrates are important prey items for fish, birds, and mammals and play an important role in nutrient recycling in wetland and upland systems. Exposure occurs when benthic invertebrates are exposed to inorganic chemicals in sediment and dissolved in the water or exposed through ingestion of contaminated sediment.

To identify which metals were COPECs to benthic invertebrates, the UCL_{95} of the mean for each metal detected in the aquatic habitat was compared against an ambient- and toxicity-based benchmark. The

ambient benchmark was the lower of either the San Francisco Bay (RWQCB 1998) or the Concord Tidal Area ambient metal concentrations (PRC 1996a). Toxicity-based benchmarks were ER-Ls (Long and others 1995). COPECs were identified based on exceedance of the San Francisco Bay *or* Tidal Area ambient concentrations *and* the ER-L.

COPECs were further evaluated to identify risk drivers or COECs at the TBB Disposal Site. COPECs were identified based on the ER-L. The ER-L represents a concentration below which effects rarely occur, and therefore estimates the low end of the effects range. In contrast, the ER-M represents concentrations toward the middle of the effects range and above which effects would be likely to occur (Long and others 1995). Because the probabilities of effects are much higher when concentrations exceed the ER-Ms than when they exceed only the ER-L, the ER-M is more indicative of adverse effects (Long and MacDonald 1998). Therefore, risk drivers were identified based on exceedances of the ER-M.

A process for evaluating the data included calculation and evaluation of the following:

- **HQs:** HQs (sediment concentration/ER-M) were calculated to assess how often inorganic chemicals at each sampling location exceeded a benchmark concentration above which metal toxicity would occur. By tabulating the number of sampling locations at which the HQ exceeded 1.0, the frequency at which each metal causes potential toxicity was determined.

- **Mean ER-Mqs:** By determining the number of sampling locations with mean mean ER-Mqs exceeding 1.5, the proportion of sampling locations with metal concentrations that could cause potential toxicity was determined. Long and MacDonald (1998) reported that when the mean ER-Mq was greater than 1.5, more than 50 percent of ER-Ms were exceeded, and more than 74 percent of samples showed high toxicity. By determining the locations for which the mean ER-Mq exceeded 1.0, areas of highest risk were identified.

- **Mean HQs:** Mean HQs were calculated across sampling locations for each COPEC. By determining the COPECs for which the mean HQ exceeded 1.0, the overall magnitude of exceedance across the site was evaluated.

- **BAFs:** BAFs were calculated to see whether benthic invertebrates had been exposed to inorganic chemicals. If the BAF was greater than 1.0, it was concluded that metal uptake or accumulation (exposure) had occurred. BAFs were calculated using site-collected data (amphipod tissue concentration/sediment concentration).

- **Bioavailability:** Using equilibrium partitioning (Di Toro, and others 1991), one can determine if a divalent metal ion is available. SEM/AVS concentrations in anoxic sediment samples were measured. If the difference between SEM and AVS concentrations was zero or less (that is, a negative number), divalent metals were assumed not to be available.

- **Amphipod Bioassays:** Ten-day, solid-phase bioassays (ASTM 1999) using the amphipod *Eohaustorius estuarius* were conducted to assess sediment toxicity. Endpoints evaluated were survival and reburial.

- **Literature Review:** A review of the literature was made to identify routes of exposure and potential toxicological effects.

8.5.1 Chemicals of Potential Ecological Concern Screening for Benthic Invertebrates

Nineteen inorganic chemicals present at the TBB aquatic habitat were evaluated to determine COPECs (see Table 8-11). Iron, magnesium, potassium, and sodium were also present, but were not considered to be potentially toxic. Because each occurs naturally and is either an essential element or plays a key role in metabolism, they were not evaluated further. Sediment samples across the aquatic habitat were combined to calculate a UCL_{95} of the mean (n=29, includes shoreline samples). The UCL_{95}s were then compared against an ambient- and toxicity-based benchmark to identify COPECs for benthic invertebrates. Chemicals were considered to be COPECs if the UCL_{95} exceeded both benchmarks. The overall screening process by which COPECs for benthic invertebrates were determined is shown on Figure 8-7.

The ambient benchmark consisted of the lower of the ambient, UCL_{95} metal concentrations for San Francisco Bay sediments (RWQCB 1998) or the ambient, UCL_{99} metal concentrations for the Concord Tidal Area sediments (PRC 1996a). If the TBB Disposal Site UCL_{95} concentration for a metal exceeded either the San Francisco Bay *or* the Concord Tidal Area ambient concentrations (whichever was lower), that metal was then screened against the ER-L.

The toxicity benchmark was the ER-L (Long and others 1995). If the UCL_{95} concentration for a metal at the TBB aquatic habitat exceeded the ambient benchmark described above *and* the ER-L, that metal was considered to be a COPEC for benthic invertebrates (see Figure 8-7).

No ER-L, or ambient San Francisco Bay, benchmarks exist for aluminum, barium, beryllium, cobalt, manganese, molybdenum, thallium, and vanadium. These inorganic chemicals were therefore only screened against the Concord Tidal Area ambient metal concentrations (PRC 1996a). Aluminum, barium, beryllium, cobalt, manganese, and vanadium had UCL_{95} concentrations that were less than the Concord Tidal Area metal concentrations; these inorganic chemicals were therefore excluded from the screening process. Because molybdenum and thallium exceeded the Concord Tidal Area ambient concentrations, both molybdenum and thallium were identified as COPECs.

Eleven inorganic chemicals were identified as benthic invertebrate COPECs (see Table 8-11). They were antimony, arsenic, cadmium, chromium, copper, lead, molybdenum, selenium, silver, thallium, and zinc.

Inorganic chemicals not selected as COPECs were reviewed to ensure that high concentrations had not been overlooked. Because mercury exceeded the ER-L by an order or magnitude at location SS203 and because of its potential to bioaccumulate, mercury was also considered to be a COPEC. Remaining inorganic chemicals were not evaluated further.

Table 8-12 summarizes benchmarks used in the screening and evaluation process and the number of individual sampling locations with metal concentrations exceeding benchmarks.

8.5.2 Exposure Assessment

An organism must be exposed to a chemical before uptake, accumulation, or toxicity can occur. Because distributions of inorganic chemicals and benthic invertebrates at the aquatic habitat overlap, exposure may have occurred. To evaluate if metal exposure had occurred: (1) complete metal exposure pathways for benthic invertebrates were developed; (2) inorganic chemicals present at the aquatic habitat were screened using two benchmarks to select COPECs; (3) spatial variation in metal distributions at the aquatic habitat was evaluated using HQs, mean ER-Mqs, and mean HQs; and (4) BAFs were employed to determine if amphipod tissues contained metal concentrations greater than those in the sediment, suggesting uptake or accumulation (exposure) had occurred.

8.5.2.1 Complete Exposure Pathways

Receptors and chemicals must co-occur for exposure to take place. Benthic invertebrates are likely to be exposed to chemicals in anoxic interstitial water (of deep burrows), oxic interstitial water, water at the sediment-water interface, and overlying surface water. Some kinds of benthic invertebrates, such as deposit feeders and detritivores, can directly ingest sediment. For these organisms, digestive processes may allow the uptake of some inorganic and organic chemicals bound to sediments (Campbell and Tessier 1989; Luoma and others 1992). Many deposit-feeding organisms selectively ingest certain particle sizes; taxa that readily ingest small particles may be subject to higher exposure. Aquatic invertebrates respire large volumes of water, which may allow for uptake of soluble chemicals across gills and other specialized membranes or the integument of the organism (Hawker 1990).

Biological factors that affect exposure include feeding mode, selectivity in diet, position in the food chain, foraging depth, organism size, assimilation efficiency, and detoxifying mechanisms (Connell 1990c; Fisher 1995). Variability in exposure results from the mobility of organisms; some invertebrates are relatively immobile after a planktonic larval phase, while others remain highly mobile throughout their lifespan. Complete exposure pathways for benthic invertebrates in or on wetland sediments include dermal contact with sediment, surface water, pore water, and dietary exposure to sediment, detritus, or prey (Hawker 1990; Luoma and Jenne 1977). Pathways evaluated in the baseline ERA include dermal contact with sediment and dietary exposure to sediment or prey. In general, it is common practice in ERAs to focus on ingestion of contaminated prey and sediment (Pascoe and others 1996), although ignoring other sources may slightly underestimate risk.

Exposure to benthic organisms typically occurs through a metal dissolved in water as a +2 ion that enters the organism across its gill membranes. Understanding of how metals dissolved in the pore water (= interstitial water) of sediments cause toxicity to benthic organisms is explained by equilibrium partitioning (DiToro and others 1991). Metals associated with particles exist in equilibrium with metals dissolved in the sediment pore water (the metal sorbs or desorbs from/to the particle in an equilibrium process). Particle size, composition, and, in particular, the amount and type of organic carbon in the particle, play important roles in regulating this equilibrium.

The other route through which benthic organisms accumulate metals is by ingestion of particles with associated metals. This ingestion route has received very limited exploration to date and is currently the focus of much research. While existing data show this route exists, it is not clear what percentage of the total metal body burden is achieved through ingestion of metal-associated particulates (Nalepa and Lundrum 1988; Mayer and others 1996). The rate at which accumulation occurs and the quantity of metal in the tissues required to cause toxicity are interrelated. This relationship is poorly understood; therefore, explaining precisely how this route causes toxicity is not yet possible.

8.5.2.2 Spatial Variation in Exposure

A HQ approach was employed to assess sampling locations in the aquatic habitat that had metal concentrations likely to cause adverse effects to benthic invertebrates.

HQs

A HQ was calculated based on the metal concentration at a sampling location divided by the ER-M for that metal. HQs for each COPEC and sampling location appear in Table 8-13. If a HQ exceeds 1.0, toxicity may occur if that chemical is bioavailable. By evaluating the number of sampling locations where HQs exceeded 1.0 and the number of HQs that were exceeded for each COPEC, the magnitude and frequency of exceedances was assessed.

Mean ER-Mqs

A mean ER-Mq was calculated for each sampling location. Long and MacDonald (1998) concluded that when the mean ER-Mq exceeded 1.5, the "... .probability... .of toxicity in amphipod tests equals 74%." To calculate the mean ER-Mq, HQs for all COPECs at each sampling location were summed and divided by the number of HQs at that location. Nine sampling locations (309CSPWSS, 309SSCS, SB013, SB014, SB015, SB018, SB019, SB020, and SS205) had mean ER-Mqs greater than 1.5, demonstrating potential for ecological harm (see Table 8-13).

Mean HQs

For all sampling locations in the aquatic habitat, a mean HQ was calculated for each COPEC (see Table 8-13). HQs for each COPEC were summed across all sampling locations and divided by the number of sampling locations. An ER-M for molybdenum and thallium does not exist; therefore, HQs for molybdenum and thallium were not calculated.

Because an HQ greater than 1.0 demonstrates potential for toxicity, it was assumed that a mean HQ greater than 1.0 also demonstrated potential for toxicity across the site that may affect invertebrate populations. Using this rationale, copper, lead, selenium, and zinc occurred at the aquatic habitat at concentrations that may cause ecological harm. Mean HQs were also calculated using only the locations at which mean ER-Mqs were greater than 1.5. These results were the same, with copper, lead, selenium, and zinc all greater than 1.0 (see Figure 8-8).

8.5.2.3 Bioaccumulation Factors

Bioaccumulation describes the movement of chemicals from water or sediment across the gills or skin and ingestion of chemicals associated with sediment particles into the organism (termed "uptake"). If uptake exceeds excretion, the chemical is stored in the tissues of the organism (termed

"accumulation"). Bioaccumulation and factors that influence the process are explained in detail in Appendix E. The BAF is the ratio of the tissue chemical concentration divided by the sediment chemical concentration. If the BAF equals 1.0, it implies that the chemical concentration in the sediment equals that in the tissues of the organism (that is, no chemical uptake has occurred). If the BAF exceeds 1.0, it implies that the chemical concentration in the tissues of the organism exceeds that in the sediment (that is, chemical uptake has occurred). The BAF does not imply either the presence or absence of toxicity.

To determine if amphipods at the aquatic habitat were accumulating metals in their tissues, amphipod BAFs were calculated for each COPEC. Because of the mass of amphipod tissue required for analysis (10 grams), amphipods were collected over a broad area (as opposed to a specific location) in each of three regions at the TBB aquatic habitat (northern, central, and southern). The northern, central, and southern region samples were considered to be representative of the available amphipod habitat (see Figure 3-1). One composite sediment sample was also collected from each of the three regions (sample numbers 309SSNS, 309SSCS, and 309SSSS). BAFs were calculated by pairing the appropriate amphipod tissue and composited sediment sample (for example, the northern amphipod tissue sample was paired with the northern composite sediment sample, and so on).

BAFs appear in Table 8-14. Sediment sample 309SSCS yielded amphipod BAFs greater than 1.0 for arsenic, copper, mercury, molybdenum, selenium, silver, and zinc. Sediment sample 309SSNS yielded amphipod BAFs greater than 1.0 for antimony, arsenic, cadmium, copper, mercury, molybdenum, selenium, silver, and zinc. Sediment sample 309SSSS yielded amphipod BAFs greater than 1.0 for antimony, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, selenium, silver, thallium, and zinc.

All 12 COPECs had maximum BAFs (see Table 8-14) greater than 1.0. They were antimony (8.9), arsenic (14.4), cadmium (5.5), chromium (1.8), copper (10.0), lead (2.0), mercury (11.2), molybdenum (3.4), selenium (12.0), silver (47), thallium (2.6), and zinc (32). These BAFs suggested that amphipods are taking up these 12 inorganic chemicals from aquatic sediments.

8.5.2.4 Identification of Benthic Invertebrate Chemicals of Ecological Concern

The procedure used to identify risk drivers or COECs from COPECs is illustrated on Figure 8-8. A three-step process was used to identify risk drivers and locations of highest concern.

Sample locations with mean ER-Mqs greater than 1.5 were retained. Nine sampling locations or composite samples had mean ER-Mqs greater than 1.5, 309CSPWSS, 309SSCS, SB013, SB014, SB015, SB018, SB019, SB020, and SS205. These are locations where significant risk is indicated from one or more COPECs.

In the second step of the process, COPECs with HQs greater than 1.0 were identified to determine metals most significant in causing the mean ER-Mqs to exceed 1.5 (see Figure 8-8). In this step, only locations where the mean ER-Mq exceeded 1.5 were evaluated. COPECs with HQs greater than 1.0 included: antimony, arsenic, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc (see Figure 8-8).

Because molybdenum and thallium do not have ER-M benthic invertebrate toxicity benchmarks (Long and others 1995), they were evaluated qualitatively.

Molybdenum is an essential element. While much literature describes the potential toxicity of molybdenum to plants, few data describe the potential toxicity of molybdenum to animals. While it is recognized that animals that consume plants or soil containing excess molybdenum may become diseased, no data describe molybdenum toxicity for benthic invertebrates or other aquatic organisms. Using best professional judgment, it was concluded that molybdenum did not significantly contribute to potential ecological toxicity. Molybdenum was therefore not considered to be a COEC.

Thallium occurs in water in +1 and +3 oxidation states. The +3 state is much less stable in water than is the +1 state (Cotton and Wilkson 1972). No literature describes thallium uptake and bioaccumulation, nor has the aquatic toxicity of thallium been described. Thallium is assumed to be nontoxic, but data to support this conclusion were not located. Using best professional judgment, it was concluded that thallium did not contribute significantly to potential ecological toxicity. Thallium was therefore not considered to be a COEC.

In Step 3, the mean HQ was calculated by summing HQs for one COPEC and dividing by the number of sampling locations (see Figure 8-8). Because an HQ greater than 1.0 demonstrates potential for ecological toxicity, it was assumed that a mean HQ greater than 1.0 also demonstrated potential for ecological toxicity. Using this rationale, copper, lead, selenium, and zinc occurred at the aquatic habitat at concentrations that may cause adverse effects to populations of benthic invertebrates. Six COPECs, antimony, arsenic, cadmium, chromium, mercury, and silver, had mean HQs less than 1.0

(see Figure 8-8), and therefore were not retained as COECs. In Step 3, only locations where the mean ER-Mq exceeded 1.5 were included in the calculation of the mean HQ. This results in a more conservative estimate, as shown by a comparison of mean HQs in Table 8-13 and Figure 8-8.

Final COEC Selection

In summary, using results from Steps 1 through 3 explained above and a review of the metal toxicity literature for benthic invertebrates, copper, lead, selenium, and zinc were retained as COECs for benthic invertebrates.

8.5.3 Effects Assessment

In the following sections, the likelihood that the four COECs at the TBB aquatic habitat could cause toxicity to benthic invertebrates was assessed. First, the results of amphipod bioassays were reviewed to determine if sediment samples collected at the TBB aquatic habitat caused significant amphipod mortality. Second, the published aquatic toxicity literature for copper, lead, selenium, and zinc was reviewed. Third, SEM and AVS concentrations in sediment samples were evaluated to assess whether these four inorganic chemicals were available in sediment samples from the TBB aquatic habitat.

8.5.3.1 Amphipod Bioassays

Ten-day, solid-phase, sediment toxicity bioassays using the amphipod, *Eohaustorius estuarius*, were conducted to see if sediment-associated metals were toxic to amphipods (ASTM 1999). Methods used in the bioassays are described in Section 4.2.1.3

Amphipod survival was 98 percent in the control (see Table 8-15). Survival ranged from 77 to 88 percent in the three TBB Disposal Site samples (see Table 8-15). Successful reburial in the control was 97 percent (see Table 8-15). Amphipod reburial in TBB Disposal Site sediments ranged from 95 to 100 percent (see Table 8-15). Amphipod survival data was compared with the San Francisco Bay Basin "reference envelope" of 68 percent, which represents the response that would be expected from amphipods living in San Francisco Bay ambient sediments (RWQCB 1998). Data were also evaluated using the "detectable difference" approach (Thursby and others 1997; State of California Water Resources Control Board [SWRCB] 1998). The detectable difference is the difference from the control that a given protocol is capable of detecting as statistically significant in 90 percent of the samples tested. The State of California Bay Protection and Toxic Cleanup program established a 90th percentile

minimum significant difference of 75 percent of the control for the *Eohaustorius estuarius* sediment toxicity. Using these two benchmarks none of the TBB Disposal Site sediments caused a significant reduction in amphipod survival.

8.5.3.2 Potential Toxic Effects of Chemicals of Ecological Concern

Toxicological profiles of COECs are presented in Appendix C. Most inorganic chemicals at the site can cause direct effects on aquatic invertebrates at high levels. Screening benchmarks, such as ER-Ls and ER-Ms, are based on toxicity tests using a variety of test organisms. Although these screening values are not based on site-specific information, they represent the best regulatory tools available to evaluate contamination concentrations. Studies supporting ER-Ls and ER-Ms include a variety of endpoints such as mortality in toxicity tests, changes in community composition, and physiological effects (Long and others 1995). These studies focused primarily on effects of specific contaminants on molluscs, amphipods, and other crustaceans.

Copper: The maximum sediment concentration of copper in the aquatic habitat was 1,980 mg/kg; the UCL_{95} of the mean was 418 mg/kg (see Tables 5-2 and 8-11). Copper is an essential ion. Many marine crustaceans and mollusks accumulate copper in their blood, where it has a role in respiratory pigments (Suedel and others 1994). Aquatic animals accumulate copper directly from the water through their gills. Accumulation is independent of rank in the food chain, and biomagnification across the food chain does not occur (Hawker 1990; Suedel and others 1994). In situ experiments with experimentally enhanced levels of copper in sediments altered abundance of invertebrates (Morrisey and others 1996).

Lead: The maximum concentration of lead in the aquatic habitat was 3,280 mg/kg; the UCL_{95} of the mean was 747 mg/kg (see Tables 5-2 and 8-11). Lead can be ingested as particulates or can cross the gills as a +2 ion. Either route leads to lead bioaccumulation. Lead is toxic to most aquatic organisms; however, adverse effects are modified by environmental conditions, such as low salinities, which decrease bioaccumulation (Sadiq 1992e). Fish continuously exposed to toxic concentrations of waterborne lead show various signs of lead poisoning, including spinal curvature; anemia; degeneration of the caudal fin; destruction of spinal neurons; reduced ability to swim against a current; destruction of the respiratory epithelium; muscular atrophy; paralysis; renal pathology; growth inhibition; retardation of sexual maturity; testicular and ovarian histopathology; decreased survival rate of fry; and death (Eisler 1988). Potential for biological effects of sediment-sorbed lead is highest where sediment

concentrations exceed the ER-M (218 mg/kg). Long and others (1995) reported a percent incidence of effects of 90.2 for concentrations above the ER-M.

Selenium: The maximum concentration of selenium in the aquatic habitat was 11.5 mg/kg; the UCL_{95} of the mean was 3.7 mg/kg (see Tables 5-2 and 8-11). Selenium is both accumulated and biomagnified. Where sediments contain 6 to 15 mg/kg selenium, invertebrates may have up to 50 mg/kg selenium, which is a concentration that would be directly toxic to adult fish and waterfowl (USFWS 1991). Aquatic sediments containing more than 3 mg/kg selenium usually cause selenium levels in benthic invertebrates to exceed safe concentrations; the toxic threshold for selenium transferred to consumer species of fish and wildlife is 3 mg/kg (Lemly 1993). Toxic effects have been documented in fish consuming diets containing 10 to 33 mg/kg selenium (Besser 1993). Predators at the top of the food chain accumulate selenium through their diet; if concentrations are high enough, mortality or reproductive failure occur.

Zinc: The maximum concentration of zinc in the aquatic habitat was 4,980 mg/kg; the UCL_{95} of the mean was 1,040 mg/kg (see Tables 5-2 and 8-11). Zinc is an essential nutrient and invertebrates, such as bivalves, accumulate zinc. Amphipods, however, do not accumulate significant zinc concentrations, particularly when compared to mollusks (Rainbow 1996). Food chain uptake of zinc is more important than aqueous uptake; no evidence suggests that zinc biomagnifies in aquatic food chains (Suedel and others 1994). Potential for biological effects of sediment-sorbed zinc is highest where sediment concentrations exceed the ER-M (410 mg/kg). Long and others (1995) reported a percent incidence of effects of 69.8 for concentrations above the ER-M.

8.5.3.3 Bioavailability

For a metal to be accumulated or toxic to benthic invertebrate, it must be available. One technique to assess bioavailability of metals in the field is equilibrium partitioning (Hare and others 1994), through which it can be demonstrated whether a metal is bound (unavailable) or unbound (available). Divalent metals (copper, cadmium, lead, and zinc) bind to sulfides present in anoxic sediments. One mole of sulfide binds one mole of divalent metal. SEM and AVS concentrations in the sediment are measured, and the difference between the molar SEM and AVS concentrations is then calculated. This technique works only for divalent metals and cannot be used with arsenic, selenium, and other metals that exist in multiple valence states. Handling and storage of the sediment sample must be done correctly; if the sediment becomes oxic, it cannot be used.

Initially, the ratio of SEM to AVS to assess bioavailability was calculated (Hare and others 1994; Carlson and others 1991). If that ratio was 1 or less, it was concluded that the metal was completely bound by the sulfide and was not available (that is, the metal was not toxic). Recently, Berry and others (1998) suggested that calculating the difference between the SEM and AVS is more appropriate (SEM – AVS = X). If X is zero or less than zero (that is, a negative number), the metal is bound by the sulfide and is not available (that is, the metal cannot be toxic). If X is greater than zero, some metal remains unbound and is available for uptake or accumulation (that is, the metal is potentially toxic).

SEM/AVS concentrations were measured in the three composite sediment samples used to calculate amphipod BAFs were measured (see Table 8-16). In sample 309SSCS, the SEM/AVS difference was -1445. In sample 309SSNS, the SEM/AVS difference was – 273. In sample 309SSSS, the SEM/AVS difference was – 411. Clearly, in all three composite sediments and regardless of the calculation method, divalent metals were bound by sulfide. Therefore, divalent metals were not available or likely to be toxic to benthic invertebrates.

Other factors, such as pH, salinity, TOC, and grain size, influence bioavailability. Metals may become more bioavailable as pH decreases (Meyer and others 1994). At the TBB Disposal Site, pH ranges from 7.5 to 7.9 (see Table 8-16). Because of the relatively neutral pH at the TBB Disposal Site, major changes in bioavailability from acidic or alkaline conditions are not likely, except as associated with changing redox conditions.

Salinity varies seasonally and annually at the TBB Disposal Site and is strongly tied to precipitation patterns. In September 1999, salinity readings collected from the shoreline ranged from 10 to 14 ppt. In May 2000, salinity readings ranged from 3 to 10 ppt. In general, marine and freshwater taxa have similar sensitivities to most inorganic and organic contaminants, and bioavailability of chemicals may be similar in both environments (Knesovich 1994). One exception is cadmium, which is generally more toxic to freshwater organisms; this may be caused by differences in speciation of cadmium, which exists in the ionic form in fresh water and as a complexed form ($CdCl_2$) in seawater. Bivalves have been shown to increase bioaccumulation of cadmium as salinity decreases (Hawker 1990).

The surface area of the particles within a unit mass of sediment increases as sediment particle size decreases. As surface area increases, the number of charged binding sites increases, resulting in more sites for adsorption. Grain size is therefore an important variable, because smaller particles carry

greater contaminant loads and organic carbon fractions. Sediment TOC consists primarily of humic matter and fulvic acids resulting from the breakdown of plant and animal material. When natural organic ligands form complexes and chelates with metals, the solubility of metals is increased (Hawker 1990). Although many metals form bonds and aggregations with an organic matrix, no simple relationship between TOC and bioavailability can be predicted. In general, TOC is assumed to increase with increasing proportion of fine particles.

Grain size and TOC were measured on the three composite sediment samples. Percent fine sediment was calculated as the percent of the sample with grain size less than 75 μm. Samples at the TBB Disposal Site were not predominantly fines, with samples less than 75 μm ranging from 48 to 64 percent (see Table 8-16). TOC values at the TBB Disposal Site ranged from 104,000 to 123,000 mg/kg (see Table 8-16). Although data were insufficient to determine if a strong relationship between grain size and TOC existed at the TBB Disposal Site, a positive relationship between these two variables has been shown in other studies in San Francisco Bay (Thomson-Becker and Luoma 1985). The small grain size in the Bay muds and upland soils indicates a high potential for particulate-bound contaminant loads.

8.5.4 Risk Characterization

The following sections discuss the significance of each of the lines of evidence associated with protection of populations of benthic invertebrates, describe which inorganic chemicals at the TBB aquatic habitat are the principal drivers of potential risk to benthic invertebrates, and describe sampling locations at the TBB aquatic habitat where potential risk of inorganic chemicals to benthic invertebrates is greatest. Table 8-17 summarizes data inputs and the COPEC screening process and COEC selection processes for benthic invertebrates.

8.5.4.1 Summary of Lines of Evidence for Evaluating Risk to Populations of Benthic Invertebrates

The effect of chemicals on populations of benthic invertebrates was evaluated using the following lines of evidence:

- Comparison of chemical concentrations in sediment with ER-Ls and ER-Ms (Long and others 1995)
- Mean ER-Mqs (Long and MacDonald 1998) to evaluate the potential cumulative effect of inorganic chemicals at each location
- Mean HQs to evaluate the overall magnitude of exceedance of each COPEC across the site
- Direct toxicity testing (evaluation of survival and reburial [*Eohaustorius estuarius*])
- Factors affecting bioavailability (SEM/AVS, sediment grain size, pH, and TOC)
- A qualitative evaluation of site-specific BAFs using amphipod tissue
- A qualitative evaluation of toxicity based on a review of the primary literature

8.5.4.2 Chemicals Driving Risk to Populations of Benthic Invertebrates

The determination of which inorganic chemicals were the principal risk drivers to benthic invertebrates was based on the three-step process described in Section 8.5.1.5. First, sampling locations where the mean ER-Mq was greater than 1.5 were determined. Then, across the nine sampling locations where mean ER-Mqs were greater than 1.5, COPECs with HQs greater than 1.0 were then identified. Lastly, mean HQs (across the nine locations) were calculated for each COPEC that had at least one HQ greater than 1.0 (see Figure 8-8). COECs identified using this process were copper, lead, selenium, and zinc. Copper had six HQs exceeding 1.0, lead had nine HQs exceeding 1.0, selenium had seven HQs exceeding 1.0, and zinc had nine HQs exceeding 1.0. Over all sampling locations (n=29), copper, lead, selenium, and zinc exceeded their respective ER-Ms at 21, 41, 62, and 41 percent of the sampling locations, respectively (see Table 8-12).

The principal drivers of risk to benthic invertebrates were the four COECs, copper, lead, selenium, and zinc.

8.5.4.3 Areas Posing Risk to Populations of Benthic Invertebrates

During the process of determining COECs, the number of sampling locations with mean ER-Mqs greater than 1.5 was tabulated to identify sampling locations with significant risk to benthic invertebrates (see Figure 8-8). Because these locations of concern were identified using mean ER-Mqs that were calculated (in part) by summing HQs across all the COPECs at each sampling location (see Table 8-11), the locations of concern depict where the aquatic habitat risk to benthic invertebrates from

inorganic chemicals is greatest. These sampling locations were 309CSPWSS, 309SSCS, SB013, SB014, SB015, SB018, SB019, SB020, and SS205.

Figure 8-6 shows the location of each sediment sample with mean ER-Mqs greater than 1.5. In summary, the portion of the aquatic habitat at risk from metal exposure roughly coincides with the area where debris is distributed, plus sampling locations SB013 and SB020.

8.5.5 Summary of Chemicals of Ecological Concern and Areas Posing Risk to Populations of Benthic Invertebrates

Potential risk to populations of benthic invertebrates from exposure to copper, lead, selenium, and zinc exists at sampling locations 309CSPWSS, 309SSCS, SB013, SB014, SB015, SB018, SB019, SB020, and SS205.

8.6 ASSESSMENT OF RISK TO BIRDS AND MAMMALS

The evaluation of risk to birds and mammals focused on selected assessment endpoints identified in Section 8.1.4 and used an approach that evaluated exposure through the ingestion pathway. Risk to representative birds and mammals at the TBB Disposal Site was evaluated quantitatively based on a HQ approach. In the HQ approach, site-specific daily doses determined by food-chain modeling were compared to TRVs, where the HQ was equal to ingested dose divided by TRV. TRVs are screening level benchmark values for higher-trophic-level receptors such as birds and mammals. A TRV is a daily dose level with known biological effects on laboratory animals. TRVs derived from peer-reviewed literature studies were compared to site-specific estimated doses and used to evaluate risk due to ingested contaminants. TRVs were derived for COPECs and receptors specific to Navy installations by a work group through a collaborative effort involving the Navy and its contractors and the EPA Region IX Biological Technical Advisory Group (BTAG). BTAG includes federal, state, and local regulatory agencies and resource trustees. The derivation of TRVs and the use of food-chain analysis in the HQ approach were described in detail in a technical memorandum (EFA West 1998).

For the TBB Disposal Site baseline ERA, food-chain analysis was conducted for each COPEC and receptor pair for which a TRV was available. For COPECs that did not have a TRV, a qualitative assessment of risk was performed based on available information in the scientific literature.

Ingestion of contaminated material was considered to be the most important exposure pathway for vertebrate receptors. Inhalation and dermal exposure routes were not addressed quantitatively, because

they are considered to be less important and limited data exists concerning exposure and absorption rates. Uncertainty associated with not considering inhalation and dermal routes of exposure is addressed in the uncertainty analysis in Section 8.8.

The evaluation of exposure through ingestion was limited to ingestion of chemical-affected environmental media (sediment) and chemical-affected food sources (prey). Ingestion of surface water was not considered, because the contribution of chemical concentrations in surface water would be negligible to the total dose. In cases where TRVs were unavailable, information from the literature was used to support the effects assessment and risk characterization.

Representative receptors selected for food-chain modeling were the Black-necked Stilt, the Mallard, and the salt marsh harvest mouse. Selection of these species was based on assessment endpoints identified in Tables 8-1 through 8-3, the food web summarized on Figure 8-2, and discussions with regulatory and trustee agencies. The representative mammalian receptor was the salt marsh harvest mouse. Representative avian receptors are the Mallard duck and Black-necked Stilt.

Section 8.6.1 summarizes COPECs that were evaluated for birds and mammals. Section 8.6.2 discusses the exposure assessment, including site-specific doses calculated using food-chain models. Section 8.6.3 summarizes the TRVs used and potential effects of COPECs. Section 8.6.4 presents the risk characterization, including HQs calculated for each receptor. Section 8.6.4 also summarizes the results of the evaluation of risk to birds and mammals, including COECs that were identified and the spatial extent of areas posing a risk.

8.6.1 Chemicals of Potential Ecological Concern for Birds and Mammals

The following sections describe the screening process for identifying COPECs for birds and mammals. Because the habitat and potential chemical concentrations to which receptors are exposed is different based on life history and foraging behavior, COPECs were determined separately for birds and mammals. For aquatic birds, the data set included data collected in both the aquatic and wetland and upland transitional habitats. Because the salt marsh harvest mouse would not be exposed to chemicals in the aquatic habitat, the data set included only data collected in the wetland and upland transitional habitat (includes shoreline samples).

8.6.1.1 Screening Methodology for Birds and Mammals

The screening process for birds and mammals placed site concentrations within the context of regional ambient concentrations. For the salt marsh harvest mouse, sediment samples from the wetland and upland transitional habitat were combined to calculate a UCL_{95} of the mean (n=30). For the Mallard and Black-necked Stilt, sediment samples from both the aquatic and wetland and upland transitional habitat were used to calculate the UCL_{95} of the mean (n=48). The UCL_{95}s were then compared against ambient values to identify COPECs for each receptor group. Chemicals were considered to be COPECs if the UCL_{95} exceeded ambient. The overall screening process by which COPECs for birds and mammals were determined is shown on Figure 8-9.

8.6.1.2 Identification of Chemicals of Potential Ecological Concern

COPECs evaluated for birds and mammals were those for which the UCL_{95} exceeded ambient values (see Tables 8-18 and 8-19). The list of COPECs for aquatic birds included antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, molybdenum, selenium, silver, and zinc (see Table 8-18). For the salt marsh harvest mouse, chemicals that exceeded ambient included antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, molybdenum, selenium, silver, and zinc (see Table 8-20).

8.6.2 Exposure: Food-chain Model

Food-chain modeling integrates ecological information, such as life history and feeding behavior of receptors, and spatial variation in chemical concentrations in prey and soil into the risk assessment process. Food-chain modeling is an accepted method for estimating site-specific doses of chemicals to birds and mammals through trophic transfer (Linder and others 1993; Pascoe and others 1994). The use of food-chain analysis and TRVs in the HQ approach was described in detail in a technical memorandum prepared by EFA West (1998). The quantification of ecological risks was associated with several uncertainties, including the limitations of closed-system modeling. Uncertainty is discussed in Section 8.8.

8.6.2.1 Dose Model

Estimates of site-specific exposures for higher-trophic-level organisms were based on daily dose estimates modeled from measurements of chemical concentrations in soil or sediment and food sources

(Pascoe and others 1994, 1996; Pastorok and others 1996). For the salt marsh harvest mouse, a special status species, a food-chain model was used to calculate high and low daily dose estimates to provide a range of site-specific doses for evaluation. For the Black-necked Stilt and Mallard duck, for which the assessment endpoint was protection of the species of a population level, a "typical" dose using average life history parameters was calculated.

Site-specific doses were calculated as the sum of the daily dietary exposure estimates for ingestion of food items and incidentally ingested sediment. The following equation was adapted for each receptor:

$$Dose_{total} = \frac{\left(\left[IR_{prey} \times C_{prey}\right] + \left[IR_{soil} \times C_{soil}\right]\right) \times SUF}{BW} \qquad (8\text{-}1)$$

Where:

$Dose_{total}$	=	Estimated dose from ingestion (mg/kg body weight per day)
IR_{prey}	=	Ingestion rate of prey (kilograms per day [kg/day])
C_{prey}	=	Concentration of chemical in prey (mg/kg)
IR_{soil}	=	Ingestion rate of soil (kg/day)
C_{soil}	=	Concentration of chemical in soil (mg/kg)
SUF	=	Site use factor (unitless), which is a ratio of site-specific area to receptor's foraging range (unitless)
BW	=	Body weight (kg) of receptor

Every effort was made to tailor assumptions to conditions at the TBB Disposal Site to reduce uncertainty. Nevertheless, sources of uncertainty may result from inappropriate assumptions concerning bioavailability, diet proportions of receptors, food-chain transfer, and other biological and physical factors and processes influencing exposure and toxicity at the site. Estimates of dose used reasonably conservative values from appropriate literature based on habitat, taxa, exposure route, and other relevant ecological factors.

The high dose estimate for the salt marsh harvest mouse incorporated these parameters:

- The *lowest* adult body from salt marsh harvest mice trapping data from the Litigation Area at NWSSB Detachment Concord (H.T. Harvey and Associates 1996)
- The *highest* ingestion rate or the *highest* adult body weight (H.T. Harvey and Associates 1996) to calculate the ingestion rate, using the appropriate equation from Nagy (1999)

- A site use factor (SUF) of 1.0

The low dose estimate for the salt marsh harvest mouse incorporated these parameters:

- The *highest* adult body weight from salt marsh harvest mice trapping data from the Litigation Area at NWSSB Detachment Concord (H.T. Harvey and Associates 1996)
- The *lowest* ingestion rate or the *lowest* adult body weight found in the literature to calculate the ingestion rate, using the appropriate equation from Nagy and others (1999)
- A SUF of 1.0

Typical dose estimates for the Black-necked Stilt and Mallard duck incorporated these parameters:

- The *average* adult body weight found in the literature of calculated from the available high and low body weights
- The *average* ingestion rate or the *average* adult body weight found in the literature to calculate the ingestion rate, using the appropriate equation from Nagy (1987)
- An estimate of SUF based on literature evaluation

8.6.2.2 Exposure Parameters in the Dose Model

Exposure models for birds and mammals are based on the assumption that exposure to chemicals is primarily through ingestion of prey and through incidental ingestion of sediment and soil during grooming, feeding, or burrowing activities (Beyer and others 1994). Other possible routes of exposure, such as surface water ingestion, dermal contact, and inhalation, were not evaluated in these models. Exposure models estimate the mass of a chemical ingested daily by a receptor per kilogram of body weight (daily chemical dosage). Estimates of exposure are based generally on knowledge of the spatial and temporal distribution of both chemicals and receptors and on specific natural and life history characteristics that influence exposure to chemicals. Site-specific data on chemical concentrations in soil and prey are used in conjunction with available literature values for other parameters to estimate daily dose. Selection of chemical concentrations in soil and prey used in the models is discussed in the following sections. The values and rationale for the selection of parameters in the dose model are also presented in the following sections for each representative receptor.

Concentrations of Chemicals in Prey and Sediment

To evaluate the risk to aquatic birds, area doses were calculated to include use of both the aquatic and wetland and upland transitional habitats (see Figure 3-1) by receptors. Estimated daily doses were modeled using the UCL_{95} for sediment (n=48) and the maximum tissue concentration for each chemical. The maximum tissue concentration was determined based on three amphipod tissue residue samples (see Table 8-14).

For the salt marsh harvest mouse, point doses were calculated for all COPECs (see Table 8-19) using location-specific sediment and tissue data. Although pickleweed tissue samples were not collected at all sediment locations, the maximum BAF for pickleweed for each chemical was used to estimate location specific tissue concentrations. The maximum pickleweed BAF was calculated using collocated pickleweed and sediment data from the three sampling locations. A daily dose estimate was also calculated on an areawide basis for the wetland and upland transitional habitat (n=30), using the UCL_{95} of the mean concentration of COPECs in sediment and the maximum tissue concentration.

Risk was evaluated for all inorganic COPECs for birds and mammals, even if concentrations in sediment or prey were below detection limits. When concentrations were below the detection limit, a value of one-half the detection limit was used in the model to calculate the daily dose estimate.

Dose Parameters for the Mallard

The Mallard was selected to be representative of waterfowl that inhabit the area. Mallards are present year-round in the Seal Creek Marsh (Downard 1999). Following is a summary of the parameters used in dose calculations for the Mallard.

- **Body Weight:** The body weight selected (1.16 kilograms) represents a mean body weight of male and female mallards in North America (Heitmeyer 1988). Body weight for Mallards of both sexes reported in the literature ranged from 0.98 kg (Heitmeyer 1988) to 1.8 kilograms (Nelson and Martin 1953).

- **Ingestion $Rate_{prey}$:** The ingestion rate for prey was calculated using a body weight from the literature (as described above) in an equation for dry weight daily food intake for all birds (Nagy and others 1999). Using an average Mallard body weight yielded a prey ingestion rate of 0.09 kg/day.

- **Prey Composition:** The Mallard diet is composed of seeds and shoots of sedge, grass, and aquatic vegetation; grain; acorns; insects; and aquatic invertebrates (Ehrlich and others 1988). Animal foods are especially important for females during breeding season and for ducklings. For this assessment, amphipods were assumed to be the only food source to the Mallard, based on occurrence of prey and availability of tissue data from the site. The maximum amphipod concentration for each COPEC was used in the model.

- **Ingestion Rate$_{sediment}$:** The Mallard ingestion rate for sediment was estimated to be 3.3 percent by Beyer and others (1994), based on acid-insoluble ash of scat samples and assumed digestibility of the diet.

- **SUF:** The SUF accounts for the size of the area of concern (contaminated area) in comparison to the home range of the receptor. If the investigation area is greater than the feeding range of the species, it is likely that the animal spends 100 percent of its feeding time in the site and would be assigned a SUF of 1.0. According to Ziener and others (1990) the foraging distance from the nest during the breeding season ranges from 3 to 8 square kilometers (km^2), or 700 to 1,970 acres. The area of the TBB Disposal Site is about 0.004 km^2. A SUF of 0.01 was assumed.

Dose Estimates for the Black-necked Stilt

The Black-necked Stilt is a yearlong resident of the saline emergent wetlands and has been observed year-round in the ponded wetlands of the Seal Creek Marsh. Stilts forage on insects, crustaceans, mollusks, other aquatic invertebrates, and some small fish (Zeiner and others 1990). Exposure to food and incidentally ingested soil are likely to be the major routes of exposure to chemicals for the Black-necked Stilt. The following parameters were used in the model:

- **Body Weight:** Black-necked Stilts are sexually dimorphic; male stilts weigh approximately 1.1 times more than females. Males weigh about 177 grams, and females weigh about 160.31 grams; an average body weight of 166 grams was used in the model (Hamilton 1975).

- **Ingestion Rate$_{prey}$:** The ingestion rate for prey was calculated using a body weight from the literature (as described above) in an equation for dry weight daily food intake for all birds (Nagy and others 1999). Using an average body weight of 166 grams yielded a prey ingestion rate of 0.0257 kg/day.

- **Prey Composition:** Black-necked stilts eat primarily brine shrimp and brine flies (Hamilton 1975). For this assessment, amphipods were assumed to be the only food source to the Black-necked Stilt, based on occurrence of prey and availability of tissue data from the site. The maximum amphipod tissue concentration for each COPEC was used in the model.

- **Ingestion Rate$_{sediment}$:** Black-necked stilts forage by pecking for invertebrates in the sediment or snatching flying insects in mid-flight. Sediment is ingested incidentally as a part of the peck method. A sediment ingestion rate of 7.3 percent of the prey ingestion rate was based on data of the Stilt Sandpiper (*Micropalama himantopus*) from Beyer and others (1994) because they have similar feeding habits and data were not available specifically for the Black-necked stilt. The typical sediment ingestion rate was 0.0019 kg/day.

- **SUF:** Little information is available in the literature regarding the home range of the Black-necked Stilt. Hamilton (1975) estimated a foraging area based on feeding areas located less than 1 km^2 (247 acres) from the nest. Because Black-necked stilts have been observed foraging in Seal Creek Marsh adjacent to the site, a SUF of 0.5 was assumed.

Dose Parameters for the Salt Marsh Harvest Mouse

The salt marsh harvest mouse is an endangered species that has been recorded in both the Tidal and Litigation Areas of NWSSB Detachment Concord (TtEMI 1999a). Although no salt marsh harvest mice were trapped during small-mammal surveys conducted at the TBB Disposal Site in 1998 (TtEMI 1999a), the abundance of pickleweed at the site provides suitable habitat and a food source for the mouse. Exposure to food and incidentally ingested soil are likely to be the major routes of exposure to chemicals for the salt marsh harvest mouse. Because the salt marsh harvest mouse is an endangered species, high and low doses were calculated for specific point locations to bracket the range of exposure. The following parameters were used in estimating site-specific doses for the salt marsh harvest mouse:

- **Body Weight:** Realistic high and low body weights of 0.016 and 0.009 kilogram were obtained from salt marsh harvest mice trapping data from the Litigation Area at NWSSB Detachment Concord (H.T. Harvey and Associates 1996); these values are actual weights of small and large adult salt marsh harvest mice.

- **Ingestion Rate$_{prey}$:** High and low prey ingestion rates of 0.0035 and 0.0026 kg/day were calculated using high and low body weights from salt marsh harvest mice caught at NWSSB Detachment Concord (H.T. Harvey and Associates 1996) in an equation for dry weight food intake for herbivorous mammals (Nagy and others 1999).

- **Prey Composition:** According to Zeiner and others (1990), salt marsh harvest mice eat 100 percent vegetation, including seeds and plants. The diet composition for the salt marsh harvest mouse was assumed to be 100 percent pickleweed, and site-collected pickleweed tissue residue concentrations were used in the model. The maximum concentration of pickleweed concentration for each COPEC was used.

- **Ingestion Rate$_{sediment}$:** The salt marsh harvest mouse ingestion rate for sediment was assumed to be similar to that of a meadow vole. The estimated sediment ingestion rate for meadow voles studied by Beyer and others (1994) was 2.4 percent of the total prey ingestion rate. In the same study, the sediment ingestion rate for white-footed mice was estimated at 2 percent. The higher rate of 2.4 percent of the prey ingestion rate was used to calculate sediment ingestion rates for the salt marsh harvest mouse; the low and high sediment ingestion rates were, therefore, 0.000062 and 0.000084 kg/day, respectively.

- **SUF:** The SUF accounts for the size of the area of concern (contaminated area) in comparison to the home range of the receptor. If the investigation area is greater than the feeding range of the species, it is likely that the animal spends 100 percent of its feeding time in the site and would be assigned a SUF of 1.0. According to Golley and others (1975), the home range of harvest mice ranges from 0.16 to 0.26 hectares. The high and low dose estimates were based on a SUF of 1.0 for the mouse.

8.6.3 Effects: Toxicity Reference Values and Hazard Quotient Interpretation

Site-specific daily dose estimates were compared to high and low TRVs to estimate the potential adverse biological effects on each receptor. Based on this comparison, the risk to representative receptors was characterized; this comparison was performed in a manner consistent with EPA's HQ methodology (EPA 1986), as follows:

$$HQ = \frac{Dose}{TRV} = \frac{(mg/kg-day)}{(mg/kg-day)} \qquad (8\text{-}2)$$

Where:

HQ = Hazard quotient (unitless)

Dose = Chemical-, receptor-, and site-specific daily dose estimate (mg/kg-day)

TRV = Chemical- and receptor-specific toxicity reference value (mg/kg-day)

8.6.3.1 Toxicity Reference Values

With the exception of antimony, barium, chromium, and molybdenum, TRVs used in the baseline ERA were derived from the Navy-BTAG working group (EFA West 1998). Each TRV represents a critical exposure level from a toxicological study and is supported by a data set of toxicological exposures and effects. A low TRV is a conservative value consistent with a chronic no effect level. A high TRV represents a mid-range of LOAEL for a given chemical, where the endpoint of toxicity was

ecologically relevant. TRVs were derived separately for birds and mammals using available toxicological literature.

TRVs for antimony, barium, chromium, and molybdenum were based on toxicological benchmarks for wildlife developed for the ORNL (Sample and others 1996). The no-observed-adverse-effects level (NOAEL) based benchmarks represent values believed to be nonhazardous for wildlife species; LOAEL-based benchmarks represent threshold levels at which adverse effects are likely to become evident. These benchmarks consider chemical exposure through oral ingestion of contaminated media; exposure through inhalation or dermal exposure was not considered. Toxicological benchmarks were derived separately for birds and mammals. A summary of the studies used by the ORNL to develop these toxicological benchmarks is provided in Appendix F. The NOAEL- and LOAEL-based ORNL benchmarks are used as equivalent to high and low Navy/BTAG TRVs.

General TRVs derived for mammals and birds must be converted to each site-specific receptor of concern. This extrapolation of data based on body scaling is called allometric conversion. The underlying assumption of allometric conversions is that physiological functions, such as metabolic rates, are a function of body size (Opresko and others 1993). Allometric conversions assume that smaller animals have higher metabolic rates and are typically able to detoxify or eliminate ingested chemicals more quickly than larger animals (Opresko and others 1993; Sample and others 1996). The allometric conversion equations by Sample and others (1998) were used to extrapolate doses according to methods described by Opresko and others (1993) and Sample and others (1996). The following allometric conversion equations were used for this food-chain analysis:

$$\text{Birds} \quad TRV_{receptor} = TRV_{test\ organism}\,(\text{Body Weight}_{test\ organism} / \text{Body Weight}_{receptor})^{1-1.2}$$

$$\text{Mammals} \quad TRV_{receptor} = TRV_{test\ organism}\,(\text{Body Weight}_{test\ organism} / \text{Body Weight}_{receptor})^{1-0.94}$$

TRVs for each chemical, allometrically converted for each of the representative receptors, are in a TRV technical memorandum (EFA West 1998).

8.6.3.2 Hazard Quotient Approach

Risk to the salt marsh harvest mouse was characterized by calculating a HQ using a high and low point dose for each location in the wetland and upland transitional habitat and a literature-derived TRV (HQ is equal to dose divided by TRV). A low dose estimate was divided by a high TRV, and a high dose

estimate was divided by a low TRV, resulting in two HQs for each chemical-receptor pair that span the range of possible risks identified by this method (EFA West 1998). As explained in EPA regulatory guidance (EPA 1989b), the HQ approach indicates that receptors may be at risk if the HQ exceeds 1.0. Because of differences in the degree of conservatism in selection of TRVs for various chemicals and receptors, resulting HQ values should not be compared between chemicals or receptors; instead they should be considered individually.

Salt Marsh Harvest Mouse

For the salt marsh harvest mouse, the assessment endpoint was protection to the individual level. Therefore, low and high doses were used to calculate HQs to ensure that the assessment of risk accounted for the influence of ecological variability. Age, sex, and seasonal fluctuations in morphology and behavior are sources of variability addressed in food-chain modeling by using a range of exposure factor parameters to estimate doses. This approach yields HQs that bracket a range of risk based on conservative assumptions and acknowledges the ecological variability reported in the literature.

The worst-case scenario is represented by the case in which the $HQ_{(low\ dose/high\ TRV)}$ is greater than 1.0. In the worst-case scenario, the receptor is at significant and immediate risk from that chemical, if all assumptions of the model are correct. The high TRV represents the low to mid-range of doses that caused observable effects in laboratory animals.

The best-case scenario, represented by the situation in which the HQ is calculated using the high dose and the low TRV ($HQ_{(high\ dose/low\ TRV)}$), is less than or equal to 1.0. A $HQ_{(high\ dose/low\ TRV)}$ less than 1.0, indicates no risk from exposure of that receptor to that chemical. High doses were conservatively estimated (assuming small adult size, high ingestion rates, and exposure to maximum contamination levels) and are likely to overestimate the risk, especially for individual animals that range throughout the site. Low TRVs represent a concentration at which no adverse effects were observed in laboratory animals.

A $HQ_{(high\ dose/low\ TRV)}$, greater than 1.0, does not necessarily indicate risk, because the dose is only above a NOAEL. Therefore, the risk analysis was further refined by comparing the high dose to the high TRV, defined as $HQ_{(high\ dose/high\ TRV)}$. An $HQ_{(high\ dose/high\ TRV)}$ greater than 1.0 indicates that the conservative

dose estimate exceeds the low to mid-range of doses that caused observable effects in laboratory animals. This indicates probable risk to the receptor.

Mallard and Black-necked Stilt

Because the assessment endpoint for aquatic birds is for protection of the population and not the individual, typical doses were calculated for receptors using average values for exposure parameters such as body weight and ingestion rate. As such, an $HQ_{(typical\ dose/high\ TRV)}$ and $HQ_{(typical\ dose/low\ TRV)}$ more definitively assess risk to the typical individual within the population. A $HQ_{(typical\ dose/high\ TRV)}$ greater than 1.0 indicates significant risk, while a $HQ_{(typical\ dose/low\ TRV)}$ greater than 1.0 is a more conservative estimate of risk.

The interpretation of each HQ is summarized in the following table below.

SUMMARY OF HQ INTERPRETATION

HQ = Dose/TRV	Low TRV	High TRV
Low Dose	Not applicable	$HQ_{(low\ dose/high\ TRV)} > 1$ indicates significant risk
High Dose	$HQ_{(high\ dose/low\ TRV)} < 1$ indicates little or no risk	$HQ_{(High\ dose/high\ TRV)} > 1$ indicates probable risk
Typical Dose	$HQ_{(typical\ dose/low\ TRV)} < 1$ indicates little or no risk to typical receptor	$HQ_{(Typical\ dose/high\ TRV)} > 1$ indicates significant risk to typical receptor

8.6.3.3 Chemicals Evaluated Qualitatively

HQs could not be calculated if there was no TRV. In cases in which TRVs were unavailable, a dose was calculated for each chemical, and the dose was compared to literature-reported doses associated with effect or no effect levels for any endpoints that were tested. The salt marsh harvest mouse is an endangered species, and most toxicological information was based on rodents. The salt marsh harvest mouse was selected for evaluating those chemicals about which limited information was available. The primary literature source was from ATSDR profiles of each chemical. Best professional judgment was used in interpreting the literature data when information on a chemical was limited. Uncertainty associated with this approach is discussed in Section 8.8. Chemicals evaluated qualitatively included beryllium and silver.

8.6.4 Risk Characterization for Birds and Mammals

Food chain analysis and literature reviews were used to evaluate the potential effects of chemicals on aquatic birds and mammals. Using site-specific prey tissue concentrations (as described in Section 8.6.2.2), this type of food-chain analysis provides a relatively good estimate of dose for those receptors and COPECs for which data are available. Most of the COPECs (with the exception of barium and silver) were evaluated this way. The results of the food-chain modeling and HQ approach to evaluating risk to birds and mammals at the TBB Disposal Site are presented in this section, along with a qualitative interpretation of exposure to the chemicals for which TRVs were not available. The complete dose calculations are provided in Appendices G through I. Summaries of the results are presented as embedded tables throughout this section.

8.6.4.1 Risk to Aquatic Birds

Based on life history and foraging habits, daily dose estimates incorporated use of both the aquatic and wetland and upland transitional habitats by aquatic birds. Area doses were calculated for the Mallard and Black-necked Stilt COPECs using the UCL_{95} of chemicals in sediment and maximum tissue concentrations from prey collected at the site. The UCL_{95} was calculated using sediment data from aquatic and wetland and upland transitional habitats (n=48). Amphipod tissue was assumed as prey for both the Mallard and Black-necked Stilt. Daily dose estimates for the typical receptor for each chemical were then compared to low and high TRVs to calculate an HQ; these calculations are presented in their entirety in Appendices G and H. COPECs for which HQs were calculated included antimony, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, selenium, and zinc. HQs greater than 1.0, for which some degree of risk was indicated, are presented below.

Chemical	Receptor	Typical Dose (mg/kg-day)	Low TRV (mg/kg-day)	High TRV (mg/kg-day)	HQ (Typical Dose/High TRV)	HQ (Typical Dose/Low TRV)
Lead	Mallard	0.34	0.0023	9.0	.0035	**14.1**
Arsenic	Black-necked stilt	11.07	3.72	14.89	**0.74**	**2.98**
Cadmium	Black-necked stilt	0.40	0.06	11.95	0.03	**6.91**
Copper	Black-necked stilt	95.00	1.76	43.64	**2.18**	**54.08**
Lead	Black-necked stilt	36.20	0.016	6.39	**5.67**	**2,256**
Mercury	Black-necked stilt	0.19	0.03	0.13	**1.53**	**7.05**
Selenium	Black-necked stilt	1.68	0.16	0.64	**2.64**	**10.67**
Zinc	Black-necked stilt	228.37	12.12	121.12	**1.88**	**18.84**

For the Mallard, all $HQs_{(typical\ dose/high\ TRV)}$ indicated no immediate or significant risk to the typical receptor from chemical exposure at the site ($HQs_{(typical\ dose/high\ TRV)} < 1.0$). However, the $HQ_{(typical\ dose/low\ TRV)}$ for lead exceeded 1.0, indicating a potential for risk.

For the Black-necked Stilt, $HQs_{(typical\ dose/high\ TRV)}$ for copper, lead, mercury, selenium, and zinc slightly exceeded 1.0, indicating the potential for significant risk to the typical receptor from chemical exposure at the site ($HQs_{(typical\ dose/high\ TRV)} > 1.0$). In addition, $HQs_{(typical\ dose/low\ TRV)}$ also exceeded 1.0 for arsenic and cadmium, indicating a potential for risk from exposure to these chemicals.

Based on either $HQs_{(typical\ dose/high\ TRV)} > 1.0$ or $HQs_{(typical\ dose/low\ TRV)} > 1.0$, arsenic, cadmium, copper, lead, mercury, selenium and zinc were identified as COECs for aquatic birds. A discussion of the risk to the Mallard and Black-necked Stilt from arsenic, cadmium, copper, lead, mercury, selenium, and zinc is provided in the following paragraphs.

Arsenic

A potential risk ($HQ_{(typical\ dose/low\ TRV)} = 3.0$) was indicated for the Black-necked Stilt from arsenic, based on the assumptions of the food-chain model. Arsenic was not a risk to the mallard. Arsenic concentration in soil normally ranges from 1 to 50 mg/kg, though it does not generally exceed 10 mg/kg (Brown and others 1983, as cited in USDOI 1998). Terrestrial flora and fauna, birds, and freshwater biota usually contain less than 1 mg/kg (wet weight) of arsenic (USDOI 1998). At the TBB Disposal Site, UCL_{95} for sediment was 28.7 mg/kg and the maximum concentration of arsenic in invertebrate tissue was 8.3 mg/kg (wet weight).

Adult mallards and ducklings fed diets supplemented with sodium arsenate (at 25, 100, or 400 µg/g) showed that arsenic accumulated in adult liver and eggs, reduced adult weight gain and liver weight, delayed the onset of egg laying, decreased whole egg weight, and caused eggshell thinning (Stanley and others 1994). Arsenic did not affect hatching success and was not teratogenic. In ducklings, arsenic accumulated in the liver and reduced body weight, growth, and liver weight. At those levels of exposure, arsenic did not increase duckling mortality, but it did decrease overall duckling production by adults.

Most of the modeled dose to the Black-necked Stilt was from ingestion of prey, with the conservative assumption of 100 percent bioavailability. Arsenic was detected in amphipod tissue at 141 mg/kg (dry weight) compared to the UCL_{95} of 28.7 mg/kg in sediment. Arsenic concentrations in sediment were

highest in wetland and upland transitional habitat along the shoreline and in the south-central portion of the site. At locations SB003 and SB018, arsenic concentrations exceeded 100 mg/kg.

Arsenic was considered to pose the highest risk to the Black-necked Stilt in the wetland and upland transitional habitat, where sediment concentrations exceeded the UCL_{95} (28.7 mg/kg); locations SB001, SB003, SB004, SB010, SB014, SB015, SB018, SB019, 309SSCS, and 309CSPWSS. Locations for which risk was indicated for aquatic birds (from all chemicals) are shown on Figure 8-6.

Cadmium

A potential risk ($HQ_{(typical\ dose/low\ TRV)} = 6.9$) was indicated for the Black-necked Stilt from cadmium, based on the assumptions of the food-chain model. Cadmium was not a risk to the mallard. Cadmium levels will range from 0.05- to 1.0 mg/kg in uncontaminated soils. In rare instances such as soils derived from the Monterey Shale along the California coast, concentrations will reach levels as high as 30 mg/kg (Page and others 1981. At the TBB Disposal Site, the UCL_{95} for sediment was 1.7 mg/kg.

Birds appear to be relatively resistant to the toxic effects of cadmium. Sublethal effects in birds include growth retardation, nephrotoxicity, anemia, damage to the testicles, absorptive epithelium of the duodenum, reduced egg production, and effects on calcium absorption (Scheuhammer 1987).

Most of the modeled dose to the Black-necked Stilt was from ingestion of prey, with the conservative assumption of 100 percent bioavailability. Cadmium was detected in amphipod tissue at 5.1 mg/kg (dry weight) compared to the UCL_{95} of 1.7 mg/kg in sediment. Cadmium concentrations in sediment were highest in wetland and upland transitional habitat along the shoreline and in the south-central portion of the site. At location SB010 the cadmium concentration exceeds 10 mg/kg.

Cadmium was considered to pose the highest risk to the Black-necked Stilt in both the aquatic and wetland and upland transitional habitat, where sediment concentrations exceeded the UCL_{95} (1.7 mg/kg); locations SB003, SB004, SB009, SB010, SS204, SS205, 309SSCS, and 309CSPWSS. Locations for which risk was indicated for aquatic birds (from all chemicals) are shown on Figure 8-6.

Copper

A significant risk ($HQ_{(typical\ dose\ high\ TRV)} = 2.2$) was indicated for the Black-necked Stilt from copper, based on the assumptions of the food-chain model. The HQ indicating potential risk ($HQ_{(typical\ dose/low\ TRV)}$) was equal to 54.1. Copper was not a risk to the mallard. Diets containing elevated copper levels can slow

the growth rate, diminish egg production, and cause developmental abnormalities in different avian species (Owen 1981). Most of the modeled dose to the Black-necked Stilt was from ingestion of prey, with the conservative assumption of 100 percent bioavailability. Copper was detected in amphipod tissue at 1,100 mg/kg (dry weight) compared to the UCL_{95} of 1,094 mg/kg in sediment. Copper concentrations in sediment were highest in wetland and upland transitional habitat along the shoreline and in the south-central portion of the site. At locations SB003 and SB010, copper concentrations exceeded 6,000 mg/kg.

Copper was considered to pose the highest risk to the Black-necked Stilt in the wetland and upland transitional habitat, where sediment concentrations exceeded the UCL_{95}; locations SB003, SB010, SB018, and SB020. Locations for which risk was indicated for aquatic birds are shown on Figure 8-6.

Lead

A significant risk ($HQ_{(typical\ dose/high\ TRV)} = 5.67$) was indicated for the Black-necked Stilt from lead, based on the assumptions of the food-chain model. Potential risk ($HQ_{(typical\ dose/low\ TRV)}$)was indicated for both the Black-necked Stilt and Mallard ($HQ_{(typical\ dose/low\ TRV)} = 2{,}256$ and 14.1, respectively). Both incidental sediment and prey ingestion were responsible for the elevated dose; lead was detected in amphipod tissue at 385 mg/kg (dry weight), compared to 1,126 mg/kg in the sediment (UCL_{95}).

The TRV for lead was based on a study using lead acetate, a highly bioavailable form of lead. Lead in contaminated soil and dust has been estimated at being 10 to 20 percent as bioavailable as lead acetate (O'Flaherty 1998); therefore, model assumptions are conservative. However, doses calculated using 20 percent of the UCL_{95} for sediment still yielded $HQs_{(typical\ dose/low\ TRV)}$ greater than 1.0

Absorbed lead produces a variety of effects in avian species, including damage to the nervous system, muscular paralysis, inhibition of heme synthesis, damage to kidneys, damage to the liver, and death (Mudge 1983, as cited in Eisler 1988). Sublethal lead exposure may also have adverse effects in reproduction in some avian species by decreasing plasma calcium, inhibition of growth, and reduced hatchability of chicks.

Sampling locations for which the lead concentration was above the UCL_{95} were considered to pose potential risk to the Mallard and Black-necked Stilt, including locations 309SSCS, SB001, SB003, SB004, SB009, and SB010, SB014, and SB017, SB018, SB019, and SB020, all of which are in the

wetland and upland transitional habitat. Locations for which risk was indicated to aquatic birds are shown on Figure 8-6.

Mercury

A significant risk ($HQ_{(typical\ dose\ high\ TRV)} = 1.5$) was indicated for the Black-necked Stilt from mercury, based on the assumptions of the food-chain model. The HQ indicating potential risk ($HQ_{(typical\ dose\ low\ TRV)}$) was equal to 7.5. Mercury was not a risk to the mallard.

Sublethal effects of mercury on birds, administered by a variety of routes, include adverse effects on growth, development, immune system, reproduction, blood and tissue chemistry, metabolism, and behavior (Peterle 1991; Spalding and others 1991; Zillioux and others 1993; Spalding and others 1994). These effects manifest themselves as alopecia (abnormal feather loss), increased instances of disease, reduced food intake leading to weight loss, progressive weakness in wings and legs, difficulty flying, reduction in liver size, inability to coordinate muscle movements, and reduced nesting and hatching success (Peterle 1991; Spalding and others 1991; Becker and others 1994; Bowerman and others 1994; Monteiro and Furness 1995; Monteiro and others 1995). Reproductive effects are noted at low doses of mercury long before overt signs of toxicity are apparent in adults (Scheuhammer 1987; Hoffman and Heinz 1998). Significant reproductive effects of chronic dietary inorganic mercury exposure in birds include delayed testicular development, altered mating behavior, reduced fertility, reduced survivability and growth in young, and gonadal atresia.

Most of the modeled dose to the Black-necked Stilt was from ingestion of prey, with the conservative assumption of 100 percent bioavailability. Mercury was detected in amphipod tissue at 2.4 mg/kg (dry weight) compared to the UCL_{95} of 1.7 mg/kg in sediment. Mercury concentrations in sediment were highest in wetland and upland transitional habitat in the center of the site. At location SB0003 the mercury concentration was measured at 26.4 mg/kg.

Mercury was considered to pose the highest risk to the Black-necked Stilt in the wetland and upland transitional habitat, where sediment concentrations exceeded the UCL_{95} (1.7 mg/kg): locations SB003, SB004, and SB009. Locations for which risk was indicated for aquatic birds (from all chemicals) are shown on Figure 8-6.

Selenium

A significant risk ($HQ_{(typical\ dose/high\ TRV)} = 2.6$) was indicated for the Black-necked Stilt from selenium, based on the assumptions of the food-chain model. The HQ indicating potential risk ($HQ_{(typical\ dose/low\ TRV)}$) was equal to 10.7. Selenium was not a risk to the mallard.

Selenium exposure in the diet or drinking water of avian species is associated with reproductive abnormalities, congenital malformations, selective bioaccumulation, and growth retardation (Eisler 1985). Selenium has been observed to cause reduced hatching of eggs; decreased egg weight; decreased egg production; anemia; alopecia (abnormal loss of feathers); and embryo deformation including deformed eyes, beaks, wings, and feet (Ort and Latshaw 1978, Harr 1979 as cited in Eisler 2000; Heinz 1996; Skorupa 1998). Alopecia is a "classic" symptom of selenium poisoning (Saiki and Ogle 1995). In general, birds have substantially lower thresholds for reproductive toxicity than placental vertebrates such as mammals (USDOI 1998), and eggs are the most reliable tissues for risk/impact interpretive purposes in avian species (Ohlendorf and others 1993; Heinz 1996; Skorupa 1998).

Most of the modeled dose to the Black-necked Stilt was from ingestion of prey, with the conservative assumption of 100 percent bioavailability. Selenium was detected in amphipod tissue at 21.5 mg/kg (dry weight) compared to the UCL_{95} of 3.2 mg/kg in sediment. Selenium concentrations in sediment were high in both the aquatic and wetland and upland transitional habitat. The maximum concentrations of selenium detected at the site were at locations SB017 and SB019 (12 mg/kg).

Selenium was considered to pose the highest risk to the Black-necked Stilt in both the aquatic and wetland and upland transitional habitat, where sediment concentrations exceeded the UCL_{95} (3.2 mg/kg): locations SB103, SB014, SB015, SB018, SB019, SB020, SB004, SB009, SB010, and SB017. Locations for which risk was indicated for aquatic birds (from all chemicals) are shown on Figure 8-6. Although risk from exposure to selenium was indicated at locations SB100 and SB102, they were not included in the risk footprint shown Figure 8-6 for the following reasons: at location SB100, selenium was not detected but was evaluated as such because the detection limit was too high (one-half the detection limit greater than was greater than the UCL_{95}). Location SB102 was not included, because risk was indicated only to the Black-necked stilt only from exposure to selenium. In addition, both locations are outside of the debris area.

Zinc

A significant risk ($HQ_{(typical\ dose\ high\ TRV)} = 1.9$) was indicated for the Black-necked Stilt from zinc, based on the assumptions of the food-chain model. The HQ indicating potential risk ($HQ_{(typical\ dose\ low\ TRV)}$) was equal to 18.8. Zinc was not a risk to the mallard. Most of the modeled dose to the black-necked stilt was from ingestion of prey, with the conservative assumption of 100 percent bioavailability. Zinc was detected in amphipod tissue at 2,855 mg/kg (dry weight), compared to 1,309 mg/kg in sediment (UCL_{95}).

Different species of birds have varying sensitivities to zinc exposure. Acute effects of zinc in ducks caused mortality and pancreatic degradation (Eisler 1993). Reduced growth and death were observed in poultry chicks fed diets containing elevated zinc levels. Younger stages of life appear to be more sensitive to zinc exposure. The pancreas and bone are primary target organs of zinc in birds (Eisler 1993). Decreased weight gain was observed in Japanese quail, chickens, and turkeys fed diets containing zinc (NAS 1980).

Sampling locations for which the zinc concentration was above the UCL_{95} were considered to pose potential risk to the Black-necked Stilt, including locations 309SSCS, SB001, SB003, SB004, SB009, SB010, SB014, SB017, and SS205. With the exception of SS205, all locations are within the wetland and upland transitional habitat. Locations for which risk was indicated to aquatic birds are shown on Figure 8-6.

8.6.4.2 Risk to the Salt Marsh Harvest Mouse

High and low daily dose estimates for the salt marsh harvest mouse were calculated using data collected in the wetland and upland transitional habitat. Point doses were calculated for all mammalian COPECs (see Table 8-14) using location-specific sediment and tissue data. The maximum pickleweed BAF, which was calculated using collocated pickleweed and sediment data from the site, was used to estimate location-specific tissue concentrations. A daily dose estimate was also calculated for the UCL_{95} of the wetland and upland transitional habitat (n=30). High and low daily dose estimates for each chemical were then compared to low and high TRVs to calculate a range of HQs; these calculations are presented in their entirety in Appendix I. COPECs for which HQs were calculated included antimony, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, selenium, and zinc. The summary table below shows ranges of HQs for the salt marsh harvest mouse point doses followed by area dose HQs, which were calculated using the UCL_{95} of the mean for sediment.

Point Dose Hazard Quotients for the Salt Marsh Harvest Mouse				
Chemical	**Location of Maximum $HQ_{(low\ dose/high\ TRV)}$**	**Range of $HQs_{(low\ dose/high\ TRV)}$**	**Range of $HQs_{(high\ dose/low\ TRV)}$**	**Range of $HQs_{(high\ dose/high\ TRV)}$**
Antimony	SB003	0.01 - 5.8	0.26 135	0.02 - 13.5
Arsenic	SB003	0.02 - 20.1	0.66 - 640	0.04 - 46.6
Barium	SB001	0.008 6.8	0.07 - 60.3	0.0018 - 15.7
Cadmium	SB010	0.0009 - 1.4	0.09 - 138	0.001 - 3.138
Chromium	SB015	0.002 - 6.9	0.02 - 63.8	0.004 - 15.9
Copper	SS214	0.0003 - 3.4	0.16 1819	0.00007 - 7.8
Lead	SB003	5E-05 - 0.22	16.1 - 72,563	0.0001 - 0.52
Mercury	SB003	0.001 - 11.5	0.04 - 448	0.003 - 26.7
Molybdenum	SB013	0.06 - 233	1.34 5,396	0.134 - 539
Selenium	SB017	0.01 - 5.8	0.55 - 329	0.02 13.6
Zinc	SB009	0.001 - 2.6	0.17 - 289	0.004 - 6.0

Area Dose Hazard Quotients for the Salt Marsh Harvest Mouse			
Chemical	**$HQs_{(low\ dose/high\ TRV)}$**	**$HQs_{(high\ dose/low\ TRV)}$**	**$HQs_{(high\ dose/high\ TRV)}$**
Antimony	0.11	2.5	0.25
Arsenic	1.1	35.4	2.6
Barium	0.39	3.4	0.9
Cadmium	0.19	19.8	0.45
Chromium	0.15	1.38	0.34
Copper	0.02	11.6	0.05
Lead	0.03	9,522	0.07
Mercury	0.005	0.2	0.01
Molybdenum	0.5	11.9	1.19
Selenium	0.60	33.3	1.4
Zinc	0.18	20.3	0.42

Evaluation of $HQ_{(low\ dose/high\ TRV)}$ indicated that risk to the salt marsh harvest mouse was most significant in discrete areas of the site. Locations for which multiple $HQ_{(low\ dose/high\ TRV)}$ exceeded 1.0 are shown on Figure 8-6. As indicated on Figure 8-6, risk to the salt marsh harvest mouse was greatest in the wetland and upland transitional habitat along the shoreline and the south-central portion of the site. Locations SB003, SB004, SB010, and SB015 have the greatest number of chemical-specific $HQ_{(low\ dose/high\ TRV)}$ greater than 1.0; eight, seven, six, and seven, respectively (see Table 8-20). $HQ_{(low\ dose/high\ TRV)}$ for arsenic, molybdenum, and selenium most frequently exceeded 1.0 (see Table 8-20). Lead was the only COPEC for which the $HQ_{(low\ dose/high\ TRV)}$ did not exceed 1.0 at any location. Locations at which multiple $HQs_{(low\ dose/high\ TRV)}$ were greater than 1.0 included SB001, SB003, SB004, SB009, SB010, SB013, SB014, SB015, SB016, SB017, SB018, SB019, and SB020.

With a few exceptions, high dose/low TRV HQs exceeded 1.0 for most COPECs at most locations (see Table 8-20); however, when the $HQ_{(high\ dose/low\ TRV)}$ was greater than 1.0, risk was not necessarily indicated, because the dose was only above a NOAEL. For $HQs_{(high\ dose/low\ TRV)}$, the greatest magnitude of exceedance was for lead, copper, and molybdenum. Lead $HQs_{(high\ dose/low\ TRV)}$ ranged from 16 to 72,564 at location SB003.

Risk analysis for the salt marsh harvest mouse was further refined by a comparison of the high dose to the high TRV ($HQ_{(high\ dose/high\ TRV)}$). A $HQ_{(high\ dose/high\ TRV)}$ greater than 1.0 indicated that the conservative dose estimate exceeded the low to mid-range of doses that caused observable effects in laboratory animals, indicating a probable risk to the receptor. This evaluation of $HQs_{(high\ dose/high\ TRV)}$ added nine additional locations to the risk footprint, 309CSPWSS, SB005, SB006, SB007, SB008, SB011, SB012, SB016, and SS206 (see Figure 8-6). These are locations where $HQs_{(low\ dose/high\ TRV)}$ did not exceed 1.0 for multiple metals, but where $HQs_{(high\ dose/high\ TRV)}$ did (see Table 8-20). $HQs_{(high\ dose/high\ TRV)}$ for arsenic, molybdenum, and selenium most frequently exceeded 1.0 (see Table 8-20).

The most significant risk drivers to the salt marsh harvest mouse from exposure to chemicals at the TBB Disposal Site are considered to be those inorganic chemicals for which the $HQ_{(low\ dose/high\ TRV)}$ most frequently exceeded 1.0; these are arsenic, molybdenum, and selenium. In addition, copper and lead were also considered to be significant risk drivers because of the magnitude of exceedance of $HQs_{(high\ dose/low\ TRV)}$. For lead, the maximum $HQs_{(high\ dose/low\ TRV)}$ was 72,564; for copper it was 1,819. Therefore, COECs to the salt marsh harvest mouse are arsenic, copper, lead, molybdenum, and selenium. The risk to the salt marsh harvest mouse from exposure to these COECs is discussed in the following paragraphs.

Arsenic

Arsenic posed a significant risk ($HQ_{(low\ dose/high\ TRV)}$ greater than 1.0) to the salt marsh harvest mouse in 20 out of 30 sampling locations at the TBB Disposal Site. The $HQ_{(low\ dose/high\ TRV)}$ for arsenic, based on the maximum sediment concentration (142 mg/kg), was 20; however, the $HQ_{(low\ dose/high\ TRV)}$ for the UCL_{95} was only 1.1. Most of the modeled dose to the salt marsh harvest mouse was from prey ingestion; arsenic was detected in pickleweed and may be readily bioavailable.

Adverse effects produced by arsenic are highly dose-dependent. At low levels, arsenic may be an essential nutrient and substitute for phosphorous in biochemical reactions (ATSDR 1989). However, at

high levels, arsenic is a recognized as an effective poison. Water-soluble arsenic is efficiently absorbed from the gastrointestinal tract and circulated throughout the body. The body burden of arsenic can reach considerable levels, because it can be sequestered in nails, hair, bones, teeth, skin, liver, kidneys, and lungs (ATSDR 1989). In mammalian species, arsenic is a teratogen, which can pass the placental barrier and produce fetal death and malformations consisting of exencephaly, eye defects, and renal and gonadal agenesis (Eisler 1988; ATSDR 1993; Domingo 1994).

The $HQ_{(low\ dose/high\ TRV)}$ for arsenic exceeded 1.0 at the following locations: 309SB106, SB001, SB003, SB004, SB005, SB008, SB009, SB010, SB011, SB013, SB014, SB015, SB018, SB019, SB020, SS206, and SS214 (see Table 8-20). The overall determination of risk was based on multiple $HQs_{(low\ dose/high\ TRV)}$ exceeding 1.0 at a given location. Locations where risk was indicated to the salt marsh harvest mouse are shown on Figure 8-6 (risk at a specific location was determined based on two or more $HQ_{(low\ dose\ high\ TRV)}$ greater than 1.0 or two or more $HQ_{(high\ dose/high\ TRV)}$ greater than 1.0).

Copper

Copper was considered to pose a potential risk ($HQ_{(high\ dose/low\ TRV)} > 1$) to the salt marsh harvest mouse because of the magnitude by which $HQs_{(high\ dose/low\ TRV)}$ exceeded 1.0. At locations SB003, SB010, SB013, SB015, SB018, and SB020, $HQs_{(high\ dose/low\ TRV)}$ were two to three orders of magnitude greater than 1.0. At location SB003 and SB010 the $HQ_{(low\ dose/high\ TRV)}$ also exceeded 1.0. The $HQ_{(high\ dose\ low\ TRV)}$ for the UCL_{95} was 11.6. Most of the modeled dose to the salt marsh harvest mouse was from prey ingestion; however, pickleweed tissue concentration was estimated based on the maximum pickleweed BAF and location-specific sediment concentrations. Sediment concentrations at the locations in question all exceed 1,000 mg/kg (see Figure 3-1).

The toxic effects of copper have been studied on many animals, including: cats, dogs, cattle, sheep, rats, mice, horses, guinea pigs, pigs, and monkeys. Different species of animals display varying levels of sensitivity to copper. However, the principle organ affected by exposure to copper is the liver, where copper primarily accumulates in subcellular organelles, causing liver cirrhosis. In addition to liver cirrhosis, copper exposure can cause necrotic kidney tubules and brain damage (Owen 1981). The acute toxic effects of copper given orally produce gastrointestinal irritation, vomiting (including blood), low blood pressure, jaundice from liver necrosis, and coma. Chronic exposure to copper can cause accumulation of copper in the body, leading to lesions in the liver, brain, and eye, plus hemolytic anemia.

Copper was considered to be a risk to the salt marsh harvest mouse, based on exposure to sediments at locations at SB003, SB010, SB013, SB015, SB018, and SB020. Locations where risk was indicated to the salt marsh harvest mouse are shown Figure 8-6(risk at a specific location was determined based on two or more $HQ_{(low\ dose/high\ TRV)}$ greater than 1.0 or two or more $HQ_{(high\ dose/high\ TRV)}$ greater than 1.0).

Lead

Lead was considered to pose a potential risk ($HQ_{(high\ dose/low\ TRV)} > 1$) to the salt marsh harvest mouse because of the magnitude by which $HQs_{(high\ dose/low\ TRV)}$ exceeded 1.0. At locations 309CSPWSS, SB001, SB003, SB004, SB009, SB010, SB014, SB017, SB018, SB019, and SB020, $HQs_{(high\ dose/low\ TRV)}$ were four orders of magnitude greater than 1.0. Most of the modeled dose to the salt marsh harvest mouse was from incidental ingestion of sediment; lead residue in pickleweed was relatively low (maximum concentration 3.8 mg/kg dry weight). Sediment concentrations at the locations in question all exceeded 1,000 mg/kg.

Lead can have multiple effects in mammalian species. Lead may cause damage to the nervous system, hematological effects, kidney dysfunction, sterility, abortion, neonatal mortality, growth retardation, delays in maturation, and reduced body weight (Amdur and others 1991; Eisler 1988). Younger mammals may have greater sensitivity to lead toxicity because of their developing blood brain barrier. Developing capillaries in the brain allow lead levels in the blood to be transported to newly formed components of the brain (Amdur and others 1991).

Lead was considered to pose a risk to the salt marsh harvest mouse at sampling locations 309CSPWSS, SB001, SB003, SB004, SB0009, SB010, SB014, and SB017, SB018, SB019, SB020. Locations where risk was indicated to the salt marsh harvest mouse are shown on Figure 8-6 (risk at a specific location was determined based on two or more $HQ_{(low\ dose/high\ TRV)}$ greater than 1.0 or two or more $HQ_{(high\ dose/high\ TRV)}$ greater than 1.0).

Molybdenum

$HQs_{(low\ dose/high\ TRV)}$ for molybdenum exceeded 1.0 at 12 locations; however, studies indicate that a 5:1 ratio of copper to molybdenum is sufficient to mitigate the toxic effects of molybdenum (Osweiler and Others 1976). Another study found that 20 to 100 mg/kg in pasture soil can produce a disease called "teart" in cattle and sheep, but this disease was mitigated by the presence of copper or sulfate in the diet (Goyer 1986). The average copper to molybdenum ratio at the TBB Disposal Site is 59:1;

therefore, copper may mitigate the risk to the small mammal population associated with molybdenum at the TBB Disposal Site.

Selenium

Selenium posed a significant risk ($HQs_{(low\ dose/high\ TRV)}$ greater than 1.0) to the salt marsh harvest mouse in 11 of 30 sampling locations at the TBB Disposal Site. The $HQ_{(low\ dose/high\ TRV)}$ for selenium, based on the maximum sediment concentration (12 mg/kg), was 5.9 at location SB017. The $HQ_{(low\ dose/high\ TRV)}$ for the UCL_{95} was less than 1.0.

Chronic effects of selenium on mammals include reproductive abnormalities such as congenital malformations; reduced numbers of young in litters; high mortality of young; infertility among surviving young in rats, mice, swine, and cattle; and intestinal lesions (Harr 1978 and NRC 1983, as cited in Eisler 1985).

Chronic exposure of selenium, known as "alkali disease", has been observed in cattle, hogs, and horses, which graze on feed containing elevated levels of selenium. Adverse effects include: deformed hooves, hair loss, lassitude, articular cartilage erosion, reduced conception, increased reabsorption of fetuses, and heart, kidney, and liver degeneration (Eisler 1985).

The $HQ_{(low\ dose/high\ TRV)}$ for selenium exceeded 1.0 at the following locations: 309CSPWSS, SB004, SB009, SB010, SB014, SB015, SB017, SB018, SB019, and SB020. Locations where risk was indicated to the salt marsh harvest mouse are shown on Figure 8-6 (risk at a specific location was determined based on two or more $HQ_{(low\ dose/high\ TRV)}$ greater than 1.0, or two or more $HQ_{(high\ dose/high\ TRV)}$ greater than 1.0).

Barium and Silver

No TRVs were available for barium and silver; therefore, these chemicals were evaluated qualitatively. The maximum concentration of barium was 4,660 mg/kg at location SB001. Locations for which the concentration of barium exceeded the UCL_{95} (508 mg/kg) were 309CSSS, SB0013, SB0014, SB001, SB003, and SB004.

Published data concerning developmental, reproductive, or carcinogenic effects of barium on mammalian species is very limited (ATSDR 1990a). Rats exposed to barium concentrations in their diet showed toxic responses. In both acute and chronic oral exposure scenarios, increased blood

pressure was observed in exposed rat populations (ATSDR 1990a). In other acute exposure studies, gastrointestinal effects and respiratory weakness were observed in the exposed populations (ATSDR 1990a). Ovary weight and ovary-brain weight ratios both decreased as a result from acute oral exposure to barium in rat populations (Borzelleca and others 1988, as cited in ATSDR 1990a).

The maximum concentration of silver was 6.7 mg/kg at location SS206. Locations for which the concentration of silver exceeded the UCL_{95} (1.3 mg/kg) were SB001, SB003, SB0013, SB0014, SB0015, SB0100, SB0102, and SB0103.

Ingestion studies on silver have shown that silver can be absorbed in the gastrointestinal tract (Amdur and others 1991). Once in the body, silver can accumulate in the liver, while only a small amount is excreted (Amdur and others 1991). A decrease in weight gain was observed in rats exposed to silver in drinking water (Matuk and others 1989, as cited in ATSDR 1990b). Intravenous doses of silver to experimental animals caused pulmonary edema, congestion, and eventually death (Amdur and others 1991).

Potential risk exists to the salt marsh harvest mouse from exposure to barium or silver at locations 309CSSS, SB001, SB003, SB004, SB0013, SB0014, and SB0015; however, at all of these locations, there is overlap with other chemicals that are more likely to drive the risk.

8.6.5 Summary of Chemicals of Ecological Concern and Areas Posing Risk for Birds and Mammals

For the Mallard, all $HQs_{(typical\ dose/high\ TRV)}$ indicated no immediate or significant risk to the typical receptor from chemical exposure at the site ($HQs_{(typical\ dose/high\ TRV)} < 1.0$). However, the $HQ_{(typical\ dose/low\ TRV)}$ for lead exceeded 1.0, indicating a potential for risk.

For the Black-necked Stilt, $HQs_{(typical\ dose/high\ TRV)}$ for copper, lead, mercury, selenium, and zinc slightly exceeded 1.0, indicating the potential for significant risk to the typical receptor from chemical exposure at the site ($HQs_{(typical\ dose/high\ TRV)} > 1.0$). In addition, $HQs_{(typical\ dose/low\ TRV)}$ also exceeded 1.0 for arsenic and cadmium, indicating a potential for risk from exposure to these chemicals.

Based on both $HQs_{(typical\ dose/high\ TRV)} > 1.0$ or $HQs_{(typical\ dose/low\ TRV)} > 1.0$, arsenic, cadmium, copper, lead, mercury, selenium and zinc were identified as COECs for aquatic birds.

To determine areas where the potential for risk was most significant, sampling locations where sediment concentrations exceeded the UCL_{95} for arsenic, cadmium, copper, lead, mercury, selenium, and zinc were identified. Based on an exceedance of the UCL_{95}, potential risk to aquatic birds from one or more of these chemicals was indicated at locations 309SSCS, 309CSPWSS, SB001, SB003, SB004, SB009, SB010, SB014, SB015, SB017, SB018, SB019, SB020, SS205, SB100, SB102, and SB103 (see Figure 8-6).

For the salt marsh harvest mouse, food chain model results indicated significant risk based on the low dose/high TRV exposure scenario; $HQs_{(low\ dose/high\ TRV)} > 1.0$. Significant risk drivers to the salt marsh harvest mouse were identified as inorganic chemicals for which the $HQ_{(low\ dose/high\ TRV)}$ most frequently exceeded 1.0. These drivers were arsenic, molybdenum, and selenium. Molybdenum was excluded based on the results of a qualitative literature evaluation, which indicated that toxic effects are likely mitigated by copper. Copper and lead were also considered to be significant risk drivers because of the magnitude of exceedance of $HQs_{(highdose\ low\ TRV)}$.

Risk to the salt marsh harvest mouse at specific locations was based whether two or more HQs ($HQs_{(low\ dose/high\ TRV)}$ or $HQs_{(high\ dose/high\ TRV)}$) exceeded 1.0. Risk to the salt marsh harvest mouse was indicated at sampling locations 309CSPWSS, SB001, SB003, SB004, SB005, SB006, SB007, SB008, SB009, SB010, SB011, SB012, SB013, SB014, SB015, SB016, SB017, SB018, SB019, SB020, and SS206 (see Figure 8-6).

8.7 RISK CHARACTERIZATION SUMMARY

The risk characterization process integrates information from the exposure and effects assessments to evaluate relationships among chemicals and adverse effects on organisms. This integration relies primarily on strength and weight of evidence arguments developed on the basis of existing information on the site and available scientific literature. Based on the results of the risk characterization, recommendations for future site activities can be developed. This integration involves:

- Evaluation of current and potential adverse biological effects
- Identification of the uncertainties associated with the risk analysis

8.7.1 Weight-of-Evidence Approach

A weight-of-evidence approach was used to identify receptors at risk from site chemicals. Table 8-6 summarizes the lines of evidence supporting the risk assessment conclusions. The main objectives of the risk characterization process were to identify (1) receptors at immediate or potential risk and (2) spatial areas where EPCs may present the greatest risk.

8.7.2 Evaluation of Risk to Assessment Endpoint Receptors

The risk characterization process relies on numerous lines of evidence to identify receptors at risk; different types of evidence were used to evaluate risk to different groups of receptors (see Table 8-6). Risk to plants, invertebrates, birds, and mammals are summarized in the following sections.

8.7.2.1 Risk to Wetland and Upland Transitional Plants

HQs, mean HQs, and BAFs were used as lines of evidence in the assessment of risk to plants. Because no regulatory screening values or criteria existed for plants, ORNL toxicity-based benchmarks were used to evaluate safe levels of chemicals for plants.

Based on HQs, mean HQs, BAFs, and a qualitative literature review, the ERA concluded that arsenic, copper, selenium, and zinc may be available for plant uptake at concentrations greater than required for healthy growth. Risk to plants was indicated at locations SB001, SB003, SB004, SB009, SB010, SB012, SB013, SB014, SB015, SB017, SB018, SB019, SB020, and 309CSSS. Visual observations of the site indicated no apparent visible impact in the form of large areas of dead or dying vegetation, even in areas with the highest inorganic concentrations. Locations where risk to plants was indicated are shown on Figure 8-6.

8.7.2.2 Risk to Populations of Benthic Invertebrates

Amphipod bioassays, HQs, mean HQs, mean ER-Mqs, and BAFs were used as lines of evidence in the assessment of risk to populations of benthic invertebrates. Because no regulatory screening values or criteria exist for benthic invertebrates, ER-Ls and ER-Ms, which are toxicity-based numbers, were used to evaluate safe levels of chemicals for invertebrates.

In general, the number of and the magnitude of exceedances were used as an approximation of risk. Risk drivers or COECs were based on mean ER-Mqs and mean HQs. Mean ER-Mqs were used to

determine locations of most significant risk, and mean HQs were used to identify risk drivers. A mean ER-Mq greater than 1.5 was considered to indicate a location where a high potential existed for adverse effects (Long and MacDonald 1998). Mean ER-Mqs exceeded 1.5 at nine locations, most of which are along the shoreline, where aquatic and wetland and upland transitional habitats overlap. The mean HQ, which is the sum of HQs for one COPEC across sampling locations, exceeded 1.0 for copper, lead, selenium, and zinc.

Inorganic chemicals were measured in amphipod tissue sampled at the site (see Table 8-14). Most of the inorganic chemicals yielded BAFs (tissue concentrations compared to collocated sediment concentrations) greater than 1.0. Therefore, based on the presence of chemicals in tissues of invertebrates, uptake can be assumed likely; however, the effects of these tissue residue levels is not known.

Adverse effects on some aquatic invertebrates are likely to result from maximum contamination levels at the site. Specific areas of the site in which these effects may be greatest, based on HIs, are shown on Figure 8-6. Locations with highest magnitude of exceedance of ER-Ms are along the shoreline in the habitat overlap area. Chemical levels are much lower in the offshore habitat, indicating little risk to invertebrates in the offshore habitat. The relationship between exceedance of screening values and toxicity is not straightforward. ER-Ls and ER-Ms were not developed for risk assessments and should be interpreted with caution (Long 1997). Bulk chemistry results may also overestimate risk, because inorganic chemicals, particularly adsorbed to sediments in reducing environments, are not likely to be completely bioavailable.

Based on the lines of evidence evaluated, potential risk to populations of benthic invertebrates from exposure to copper, lead, selenium, and zinc may exist at locations 309CSPWSS, 309SSCS, SB013, SB014, SB015, SB018, SB019, SB020, and SB0205. Figure 8-6 shows the locations where risk was indicated for all assessment endpoint receptors.

8.7.2.3 Risk to Populations of Aquatic Birds

Food chain analysis, using site-specific prey tissue concentration and a comparison of ingested doses of chemicals with TRVs, was the primary line of evidence for evaluating risk to avian receptors at the site. This evaluation focused on aquatic birds, including the Mallard and Black-necked Stilt,

representing waterfowl and shorebird feeding guilds. The model and assumptions are discussed in Section 8.6.2.

For the Mallard, all $HQs_{(typical\ dose/high\ TRV)}$ indicated no immediate or significant risk to the typical receptor from chemical exposure at the site ($HQs_{(typical\ dose/high\ TRV)} < 1.0$). However, the $HQ_{(typical\ dose/low\ TRV)}$ for lead exceeded 1.0, indicating a potential for risk.

For the Black-necked Stilt, $HQs_{(typical\ dose/high\ TRV)}$ for copper, lead, mercury, selenium, and zinc slightly exceeded 1.0, indicating the potential for significant risk to the typical receptor from chemical exposure at the site ($HQs_{(typical\ dose/high\ TRV)} > 1.0$). In addition, $HQs_{(typical\ dose/low\ TRV)}$ also exceeded 1.0 for arsenic and cadmium, indicating a potential for risk from exposure to these chemicals.

Based on either $HQs_{(typical\ dose\ high\ TRV)} > 1.0$ or $HQs_{(typical\ dose/low\ TRV)} > 1.0$, arsenic, cadmium, copper, lead, mercury, selenium and zinc were identified as COECs for aquatic birds.

To determine areas where the potential for risk was most significant, sampling locations where sediment concentrations exceeded the UCL_{95} for arsenic, cadmium, copper, lead, mercury, and zinc were identified. Based on exceedance of the UCL_{95}, potential risk to aquatic birds from one or more of these chemicals was indicated at locations 309SSCS, 309CSPWSS, SB001, SB003, SB004, SB009, SB010, SB014, SB015, SB017, SB018, SB019, SB020, SS205, SB100, SB102, and SB103 (see Figure 8-6). Although risk from exposure to selenium was indicated at locations SB100 and SB102, they were not included in the risk footprint shown Figure 8-6 for the following reasons: at location SB100, selenium was not detected but was evaluated as such because the detection limit was too high (one-half the detection limit greater than was greater than the UCL_{95}). Location SB102 was not included, because risk was indicated only to the Black-necked stilt only from exposure to selenium. In addition, both locations are outside of the debris area.

8.7.2.4 Risk to Individual Salt Marsh Harvest Mice

Food chain analysis, using site-specific prey tissue concentration and a comparison of ingested doses of chemicals with TRVs, was the primary line of evidence for evaluating risk to the salt marsh harvest mouse at the site. This type of food-chain analysis, using site data, provides a relatively good estimate

of dose for those COPECs for which TRVs are available. The model and assumptions are discussed in Section 8.6.2.

Low dose/high TRV HQs greater than 1.0 indicated significant risk to the salt marsh harvest mouse. Locations for which multiple $HQs_{(low\ dose/high\ TRV)}$ exceeded 1.0 are shown on Figure 8-6. As indicated on Figure 8-6, the highest risk was along the shoreline and the south-central portion of the site.

For the salt marsh harvest mouse, food chain model results indicated significant risk based on the low dose/high TRV exposure scenario; $HQs_{(low\ dose/high\ TRV)} > 1.0$. Significant risk drivers to the salt marsh harvest mouse were identified as inorganic chemicals for which the $HQ_{(low\ dose/high\ TRV)}$ most frequently exceeded 1.0. These drivers were arsenic, molybdenum, and selenium. Molybdenum was excluded based on the results of a qualitative literature evaluation, which indicated that toxic effects are likely mitigated by copper. Copper and lead were also considered to be significant risk drivers because of the magnitude of exceedance of $HQs_{(highdose/low\ TRV)}$.

Risk to the salt marsh harvest mouse at specific locations was determined based on locations for which multiple chemical specific HQs ($HQs_{(low\ dose/high\ TRV)}$ or $HQs_{(high\ dose/high\ TRV)}$) exceeded 1.0. Based on this methodology, risk to the salt marsh harvest mouse was indicated at sampling locations 309CSPWSS, SB001, SB003, SB004, SB005, SB006, SB007, SB008, SB009, SB010, SB011, SB012, SB013, SB014, SB015, SB016, SB017, SB018, SB019, SB020, and SS206 (see Figure 8-6). Locations SB003, SB004, SB010, and SB015 have the greatest number of chemical specific $HQs_{(low\ dose/high\ TRV)}$ greater than 1.0: eight, seven, six, and seven, respectively (see Table 8-20).

8.7.3 Chemicals and Areas of Highest Concern

For risk management purposes, it is important to identify COECs that should be considered risk drivers at the site and areas at which significant adverse effects may warrant action. This information was discussed in detail for each of the assessment endpoint receptors in Sections 8.4, 8.5, and 8.6. This section summarizes chemicals and areas of concern that should be addressed by risk management decisions.

For plants, arsenic, copper, selenium, and zinc may be available for uptake at concentrations greater than required for healthy growth. BAFs measured for pickleweed provided supporting evidence. Risk to plants was indicated at locations SB001, SB003, SB004, SB009, SB010, SB011, SB012, SB013, SB014, SB015, SB017, SB018, SB019, SB020, and 309CSSS.

For benthic invertebrates, potential risk from exposure to copper, lead, selenium, and zinc may exist at locations 309CSPWSS, 309SSCS, SB013, SB014, SB015, SB018, SB019, SB020, and SB020.

Risk to typical aquatic birds from exposure to arsenic, cadmium, copper, lead, mercury, selenium, and zinc exists at sampling locations 309SSCS, 309CSPWSS, SB001, SB003, SB004, SB009, SB010, SB014, SB015, SB017, SB018, SB019, SB020, SS205, and SB103. Although risk from exposure to selenium was indicated at locations SB100 and SB102, they were not included in the risk footprint shown Figure 8-6 for the following reasons: at location SB100, selenium was not detected but was evaluated as such because the detection limit was too high (one-half the detection limit greater than was greater than the UCL_{95}). Location SB102 was not included, because risk was indicated only to the Black-necked stilt only from exposure to selenium. In addition, both locations are outside of the debris area.

Risk to the salt marsh harvest mouse from exposure to arsenic, copper, lead, mercury, selenium, or zinc at sampling locations 309CSPWSS, SB001, SB003, SB004, SB005, SB006, SB007, SB008, SB009, SB010, SB011, SB012, SB013, SB014, SB015, SB016, SB017, SB018, SB019, SB020, and SS206 was indicated (see Figure 8-6).

Figure 8-6 shows the overlap of locations for each assessment endpoint receptor. COECS to one or more receptors included arsenic, copper, lead, mercury, selenium, and zinc. Copper and zinc are COECs to all receptors, while mercury is only a COEC to aquatic birds and the salt marsh harvest mouse. Lead is a COEC to all receptors except plants.

8.8 UNCERTAINTY ANALYSIS

Uncertainty plays an important role in risk-based decision-making and is therefore incorporated explicitly into risk characterization. Identifying known sources of uncertainty is more useful than using conservative default assumptions, because potential error is made more explicit in the risk management process (Suter 1993).

Three sources of uncertainty in ERAs are described in Suter (1993):

1. Mistakes in execution of assessment activities (errors such as incorrect measurements, data recording errors, and computational errors)

2. Imperfect knowledge of factors that could be known (ignorance about some aspect of the ecosystem that may be relevant, such as assumptions used in dose models, practical constraints on the ability to measure everything, and lack of knowledge on toxicological effects of all chemicals on all species)

3. Inherent randomness of the world (stochasticity in physical or biological processes that may affect assumptions or actual risk such as variation in population parameters or rainfall patterns)

The complexity of ecological systems tends to increase the level of uncertainty involved in ERAs as compared to HHRAs. Using realistic assumptions and multiple lines of evidence is the best approach to reducing the uncertainty associated with ERA conclusions. The following sections briefly review some sources of uncertainty identified for the ERA at the TBB Disposal Site.

8.8.1 Sampling and Data Analysis

Sample data collected from the site must be used to evaluate conditions of the whole site; all measured parameters are therefore only estimates with associated error. The sample size was more than adequate for characterization of soil and sediment concentrations. In addition, most priority pollutants were included in the analytical output at many sampling stations. Therefore, the nature and extent of contamination at the TBB Disposal Site is considered to be very well characterized, leaving little uncertainty in this regard.

Data were validated and determined to be of high usability; data computations and summary tables were double-checked. Data quality, as identified and defined in the QAPP, is not considered to be an important source of uncertainty.

8.8.2 Screening Values

Screening values, such as ER-Ls, ER-Ms, and ORNL, used to identify COPECs and determine the level of risk to benthic or plant receptors, include multiple sources of uncertainty. Although these values were based on numerous studies, they include taxa not relevant to site receptors and only represent an estimate of real effects. Effects on receptors at the site may be under- or overestimated based on this approach; however, currently, this is the best method available for preliminary screening of chemical levels. These types of screening values were not available for all chemicals detected at the TBB Disposal Site. Most of the screening values employed are based on single contaminant scenarios;

the effect of multiple chemical stressors operating synergistically or antagonistically is not incorporated into this level of screening.

Screening values are based on total concentrations and do not address uncertainty associated with chemical speciation (some forms are more toxic than others) or level of bioavailability of contaminants.

The lack of screening values for chemicals for wetland plants is a major source of uncertainty in the assessment of risk to plants.

8.8.3 Toxicity Tests

Toxicity tests were conducted on one type of invertebrates in one environmental media for a limited number of samples, and results were extrapolated to evaluate potential risk to all aquatic invertebrates at the site. Toxicity tests are a standard methodology in risk assessment; however, laboratory bioassays do not exactly duplicate exposure and toxicity in the field.

8.8.4 Tissue Residue Data

A limited number of plant and invertebrate tissue samples were collected. These samples were collected in the northern, central, and southern sections of the site and are probably good indicators of the potential for bioaccumulation for each area. Tissue samples were collected in both contaminated and less contaminated areas. Uncertainty associated with tissue analysis includes the assumption that limited samples collected at one time adequately reflect exposure.

8.8.5 Estimated Doses

Assumptions used in estimating ingested doses were identified in Section 8.6.2. These assumptions and model parameters are mostly based on scientific literature and may not accurately represent species or conditions at the site. Sources of uncertainty in dose estimates include inaccuracy in model parameters based on poor literature data, population and individual variation in life history, and variation in dietary patterns of animals at the site. In addition, the use of dose models as estimates of exposure assumes that exposure to the animal through other routes, such as dermal exposure or drinking of surface water, is minimal. In general, it is common practice in ERAs to focus on ingestion of contaminated prey and soil (Pascoe and others 1996), although ignoring other sources may slightly underestimate risk.

8.8.6 Toxicity Reference Values

Uncertainty associated with the derivation and use of TRVs is described in the TRV Technical Memorandum (EFA West 1998). Allometric conversion was incorporated into derivation of TRVs for site-specific receptors; use of this type of body scaling to extrapolate between taxa is a source of uncertainty, because the underlying assumption that a given effect on a small bird is the same as on a larger bird per unit body weight may not be true. This uncertainty was minimized by extrapolating between closely related species, whenever possible.

8.8.7 Hazard Quotients and Hazard Indices

The HQ and HI approach used in comparing site chemicals to screening values and the comparison of ingested doses to TRVs is commonly employed in ERAs (EPA 1992; Tiebout and Brugger 1995). An HQ greater than 1.0 is generally considered to indicate a potential for risk; however, the HQ cannot be used to gauge either the probability or magnitude of effects. The HQ approach has been criticized (Tiebout and Brugger 1995), and caution should be exercised in the interpretation of HQs.

8.8.8 Interspecies Extrapolation

The use of allometric conversions in interspecies extrapolations has already been discussed (see Section 8.8.6). The use of assessment endpoint species as surrogates for other related or ecologically similar taxa is supported by current guidance (EPA 1992a, 1992c); however, differences among taxa are not accounted for in this type of analysis, and uncertainty exists with regard to assessments of risk to whole communities, based on detailed analysis of relatively few taxa.

8.8.9 Individual and Population Variation

Individuals within a population vary in a number of life history and behavioral traits. Dose models incorporated some of this variability by estimating both high and low values for most model parameters. Most of these models, however, are focused on adult individuals and may not accurately represent ingestion of chemicals by small juvenile stages that may feed in a different manner. Even among adults of the same population, considerable individual variation in factors may exist that affect exposure.

9.0 CONCLUSIONS AND RISK MANAGEMENT RECOMMENDATIONS

This RI evaluated whether chemicals left in place at the site present a significant risk to human health or the environment and whether any further action is recommended. Overall benefit to environmental quality must be weighed carefully, and any remedial action would need to be evaluated in the context of the physical disturbance or other impacts associated with cleanup activities. Conclusions of the risk assessment are presented below, followed by a discussion of risk management issues and recommendations.

9.1 HUMAN HEALTH RISK ASSESSMENT CONCLUSIONS

The screening-level HHRA conducted for the TBB Disposal Site indicates that COPCs are currently present at levels that could result in adverse health effects for residents. COPCs are present at higher concentrations at the center of the site, and it is likely that soil and sediment within the 400-mg/kg lead isopleth will be removed to protect ecological receptors. Soil and sediment within the 400-mg/kg lead isopleth also contains elevated levels of COPCs other than lead. Concentrations of COPCs in soil and sediment remaining after remediation of the 400-mg/kg lead isopleth would be within EPA target levels considered to be protective of human health. Potential exposures to remaining COPCs would not be expected to result in adverse health effects. Following remediation of soil and sediment within the 400-mg/kg lead isopleth, the only COPCs remaining at concentrations above EPA Region IX residential PRGs would be arsenic and iron. Remaining levels of both benzo(a)pyrene and iron would be within background ranges, and it is unlikely that further remediation would result in levels below PRGs.

9.2 ECOLOGICAL RISK ASSESSMENT CONCLUSIONS

Despite the sources of uncertainty described in Section 8.8, adequate information was available to evaluate the potential risk to receptors from chemicals at the TBB Disposal Site. One of the primary objectives of the ERA was to establish a risk footprint to help determine the boundary for remedial action.

Contamination at the site exceeds acceptable levels at a number of locations. The current level of inorganic chemical contamination at the site poses probable risk to plant, invertebrate, and bird receptors. The risk to the salt march harvest mouse, a threatened and endangered species, is significant. Areas with the highest levels of inorganic chemicals contamination are located where the

debris is most concentrated, which is along the shoreline and in the center of the site (see Figure 8-6). Removal of the debris would significantly reduce risk to both aquatic and wetland receptors.

9.2.1 Contaminants of Ecological Concern

Concentrations of some inorganic COECs at the site are very high, based on comparison with background and with available screening values. COECs that are a risk to one or more of the assessment endpoint receptors at the TBB Disposal Site include arsenic, copper, lead, mercury, selenium, and zinc.

9.2.2 Risk to Ecological Receptors

Risk to ecological receptors from site contamination was evaluated using a variety of approaches such as comparison of site concentrations with available screening values, bioassays, measures of bioaccumulation, food chain analysis, and literature reviews.

For plants, concentrations of arsenic, copper, selenium, and zinc may be available for uptake at concentrations greater than required for healthy growth. BAFs measured for pickleweed provided supporting evidence. Risk to plants was indicated at locations SB001, SB003, SB004, SB009, SB010, SB012, SB013, SB014, SB015, SB017, SB018, SB019, SB020, and 309CSSS.

For benthic invertebrates, potential risk from exposure to copper, lead, selenium, and zinc may exist at locations 309CSPWSS, 309SSCS, SB013, SB014, SB015, SB018, SB019, SB020, and SB0205.

Risk to typical aquatic birds from exposure to arsenic, cadmium, copper, lead, mercury, selenium, or zinc exists at sampling locations 309SSCS, 309CSPWSS, SB001, SB003, SB004, SB009, SB010, SB014, SB015, SB017, SB018, SB019, SB020, SS205, and SB103.

Risk to the salt marsh harvest mouse from exposure to arsenic, copper, lead, mercury, selenium, or zinc at sampling locations 309CSPWSS, SB001, SB003, SB004, SB005, SB006, SB007, SB008, SB009, SB010, SB011, SB012, SB013, SB014, SB015, SB016, SB017, SB018, SB019, SB020, and SS206 was indicated (see Figure 8-6).

Figure 8-6 shows the overlap of locations for each assessment endpoint receptor. COECS to one or more receptors include arsenic, copper, lead, mercury, selenium, and zinc. Copper and zinc are

COECs to all receptors, while mercury is only a COEC to aquatic birds and the salt marsh harvest mouse. Lead is a COEC to all receptors except plants.

9.3 RISK MANAGEMENT AND RECOMMENDATIONS

Risk management decisions must incorporate more than the technical basis for identifying risk from chemical contamination. Decisions must be based on a careful evaluation of risk assessment conclusions, uncertainty associated with those conclusions, and the ecological costs associated with attempting to remedy the situation.

Removal of the debris from the TBB Disposal Site would result in ecological destruction of all critical habitat; however, no salt marsh harvest mice were reported during surveys conducted at the TBB Disposal Site. Furthermore, compared to other areas in the Tidal Area that provide critical habitat to the salt marsh harvest mouse, the habitat provided at the TBB disposal area is minimal. However, overall habitat quality at the site and the role of the site in the regional ecology of special status species must be considered. Trade-offs in costs and benefits to different taxa must also be evaluated before decisions are made. Decisions regarding remedial actions in critical habitat must also evaluate the loss of habitat and incidental take for the salt marsh harvest mouse during and after the remediation.

Based on CERCLA guidance, risk management decisions are made jointly by all parties involved in the risk assessment process at a site such as the TBB Disposal Site, including the Navy and its contractors, EPA, DTSC, RWQCB, USFWS, National Oceanic and Atmospheric Administration, California Department of Fish and Game, and the public. The Navy anticipates that the decisions made for this site will be based on a technical review of this document by those parties and on a collaborative and interactive process that includes meetings to identify goals and priorities. Specific recommendations made in this document should serve as points of discussion for the risk management team.

Inorganic concentrations in the area of debris at the TBB Disposal Site are sufficiently high that they present a potential risk to plants, benthic invertebrates, and aquatic birds and a significant risk to the salt marsh harvest mouse. These taxa would be temporarily at risk from habitat destruction associated with a removal action.

Given the small size of the site, the Navy recommends that debris be removed from all areas where risk is indicated, based on the results of the human and ecological risk assessments presented in Sections 7.0 and 8.0 of this RI report (Figure 8-6).

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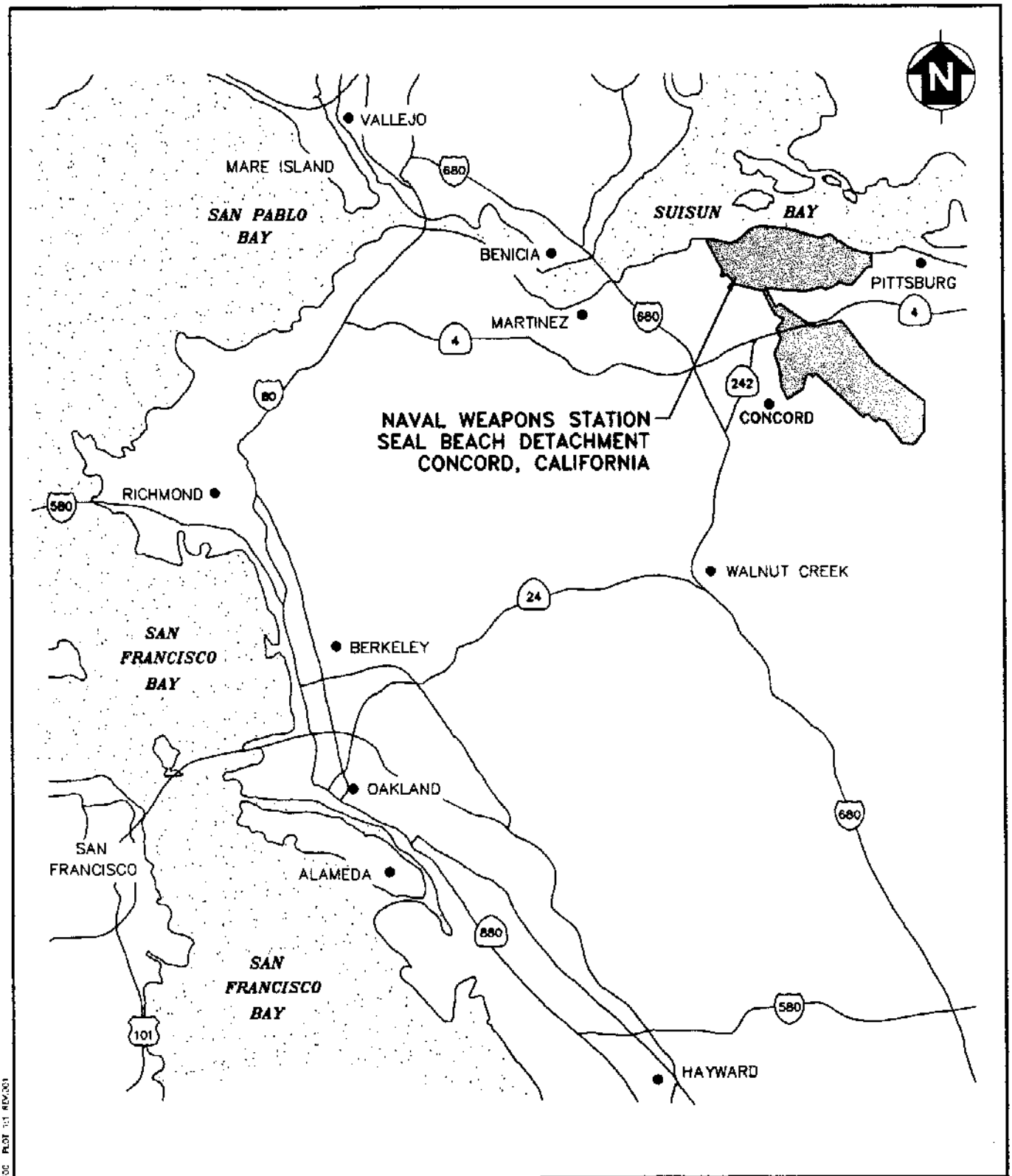

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

ENGINEERING FIELD ACTIVITY WEST

SAN BRUNO, CALIFORNIA

FIGURE 1-1

NAVAL WEAPONS STATION SEAL BEACH,
DETACHMENT CONCORD
SITE VICINITY MAP

DS.0309.15131

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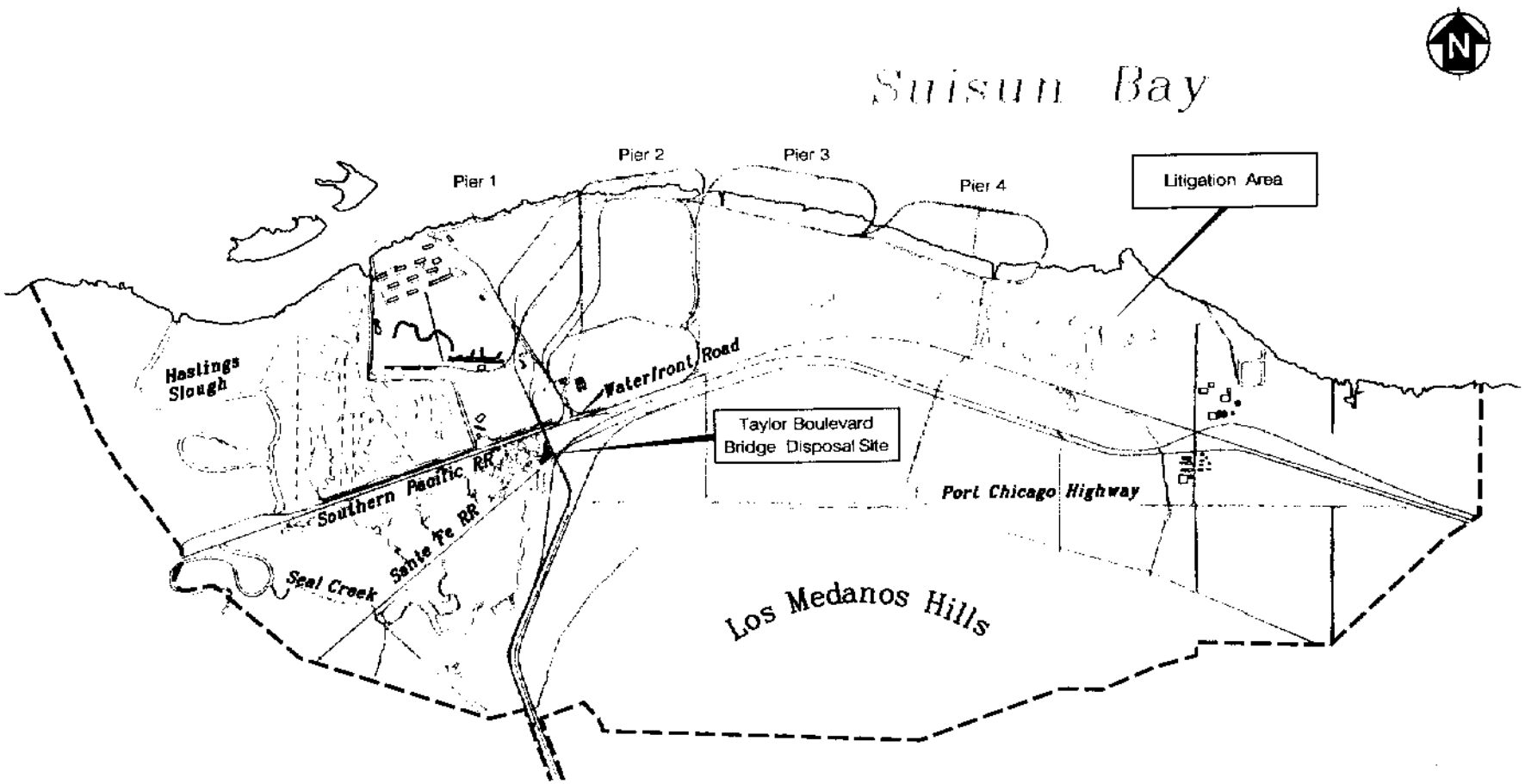


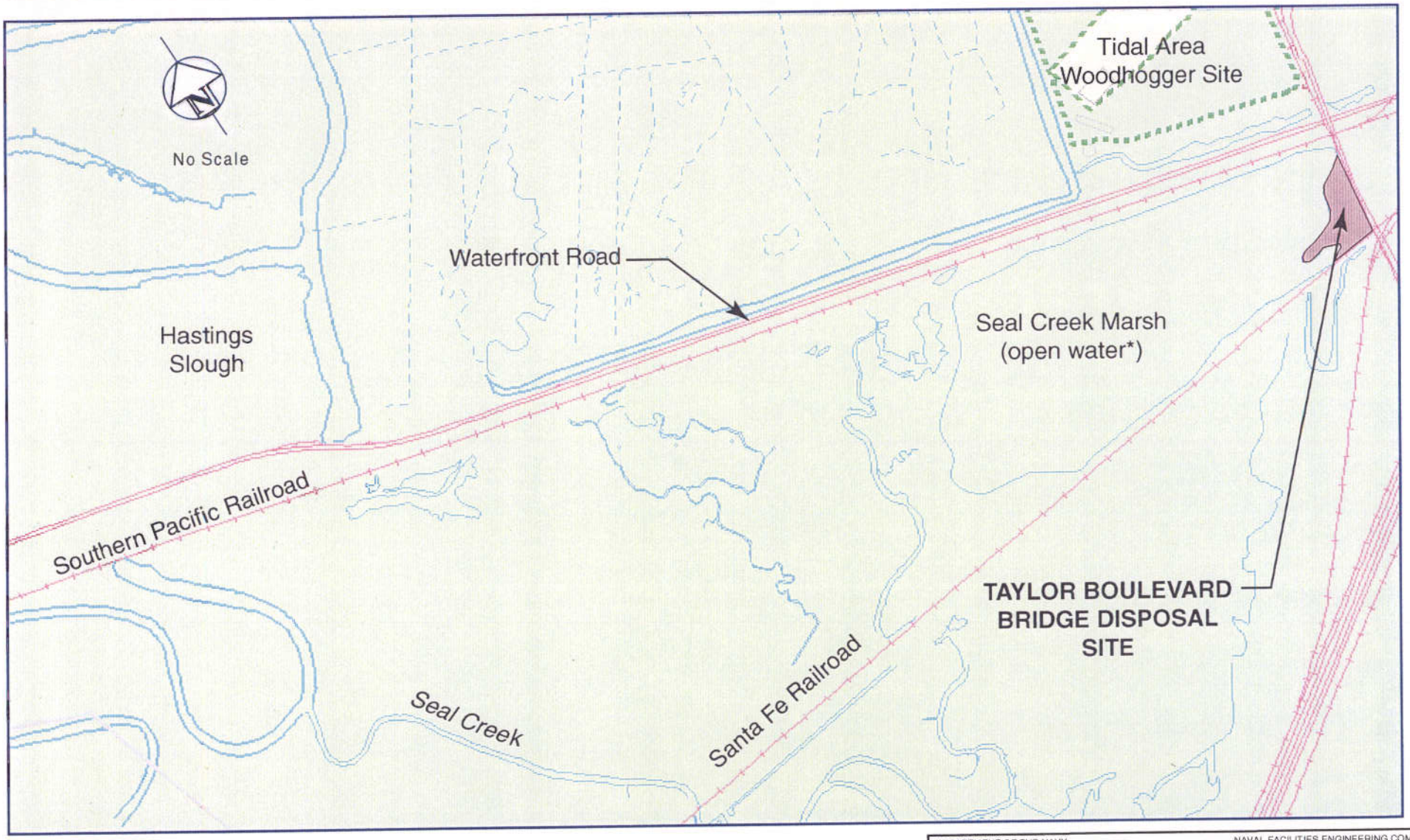
LEGEND:

- Tidal Area Boundary
- Railroad Tracks
- Road
- Building

ENGINEERING FIELD ACTIVITY WEST

FIGURE 1-2
LOCATION OF
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

DS.0309.15131



LEGEND

+++++ Railroad Tracks

═══ Road

NOTE

*Approximate extent of open water in Seal Creek Marsh near the Taylor Boulevard Bridge Disposal Site (May 2000)

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

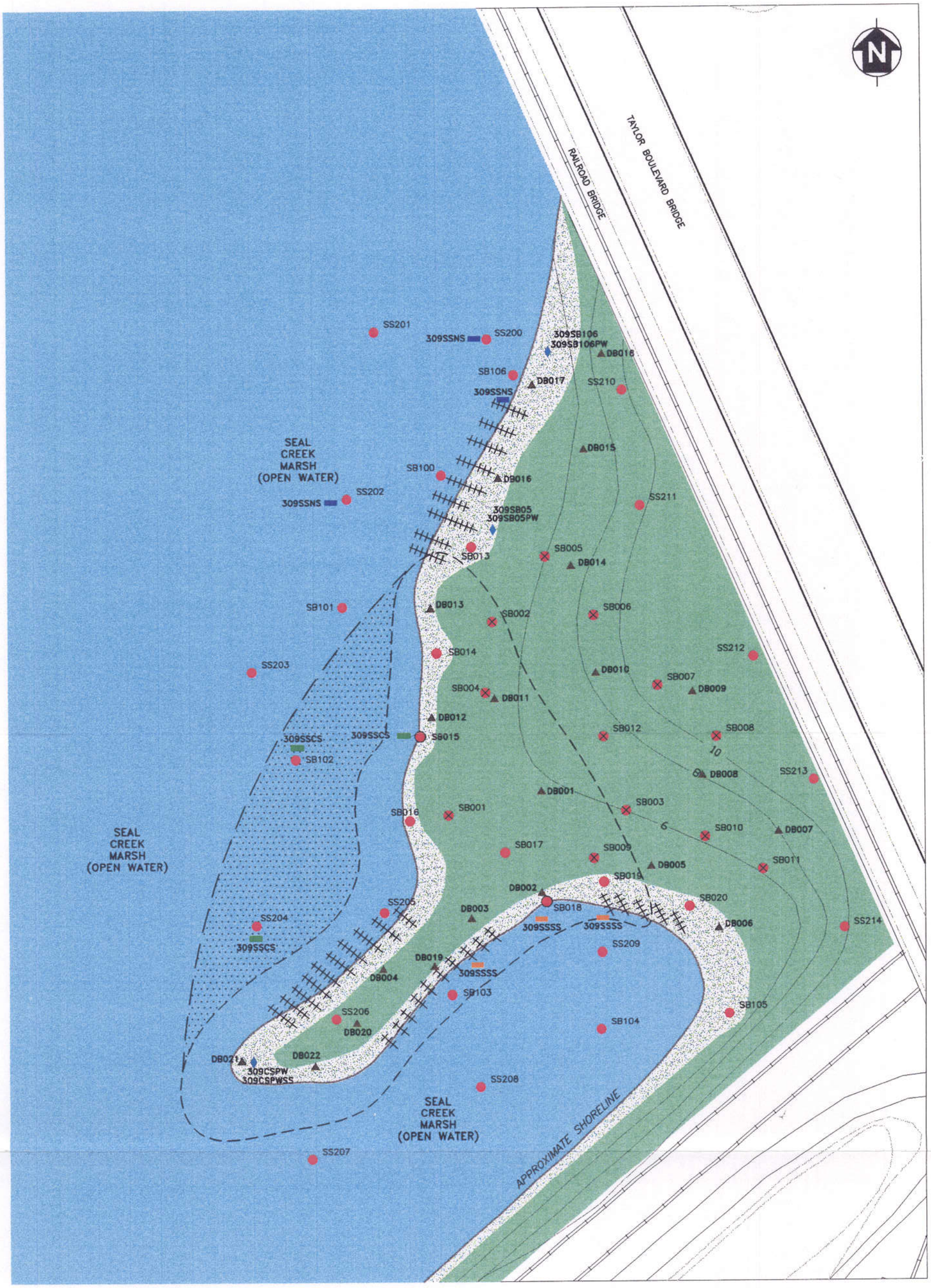
EFA WEST

SAN BRUNO, CALIFORNIA

NAVAL WEAPONS SEAL BEACH DETACHMENT CONCORD — CONCORD, CALIFORNIA

FIGURE 2-1
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE AND VICINITY

DS.0309.15131



LEGEND:

- SS206 — SOIL/SEDIMENT SAMPLE (0–0.5 FEET)
- SOIL/SEDIMENT SAMPLE (0–0.5 FEET AND 1.0–2.5 FEET)
- DEBRIS TEST HOLE
- 3 SAMPLES COMPOSITED FOR METALS ANALYSIS AND BIOASSAY
- PICKLEWEED TISSUE, COLLOCATED SEDIMENT ANALYSIS
- AMPHIPOD TISSUE COLLECTION AREA
- APPROXIMATE SHORELINE
- APPROXIMATE EXTENT OF DEBRIS
- SCATTERED SURFACE DEBRIS
- WETLAND AND UPLAND TRANSITIONAL HABITAT
- AQUATIC HABITAT
- SHORELINE: APPROXIMATE SEASONAL WATER LEVEL VARIATION

20 0 20 40
SCALE IN FEET

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

ENGINEERING FIELD ACTIVITY WEST

SAN BRUNO, CALIFORNIA

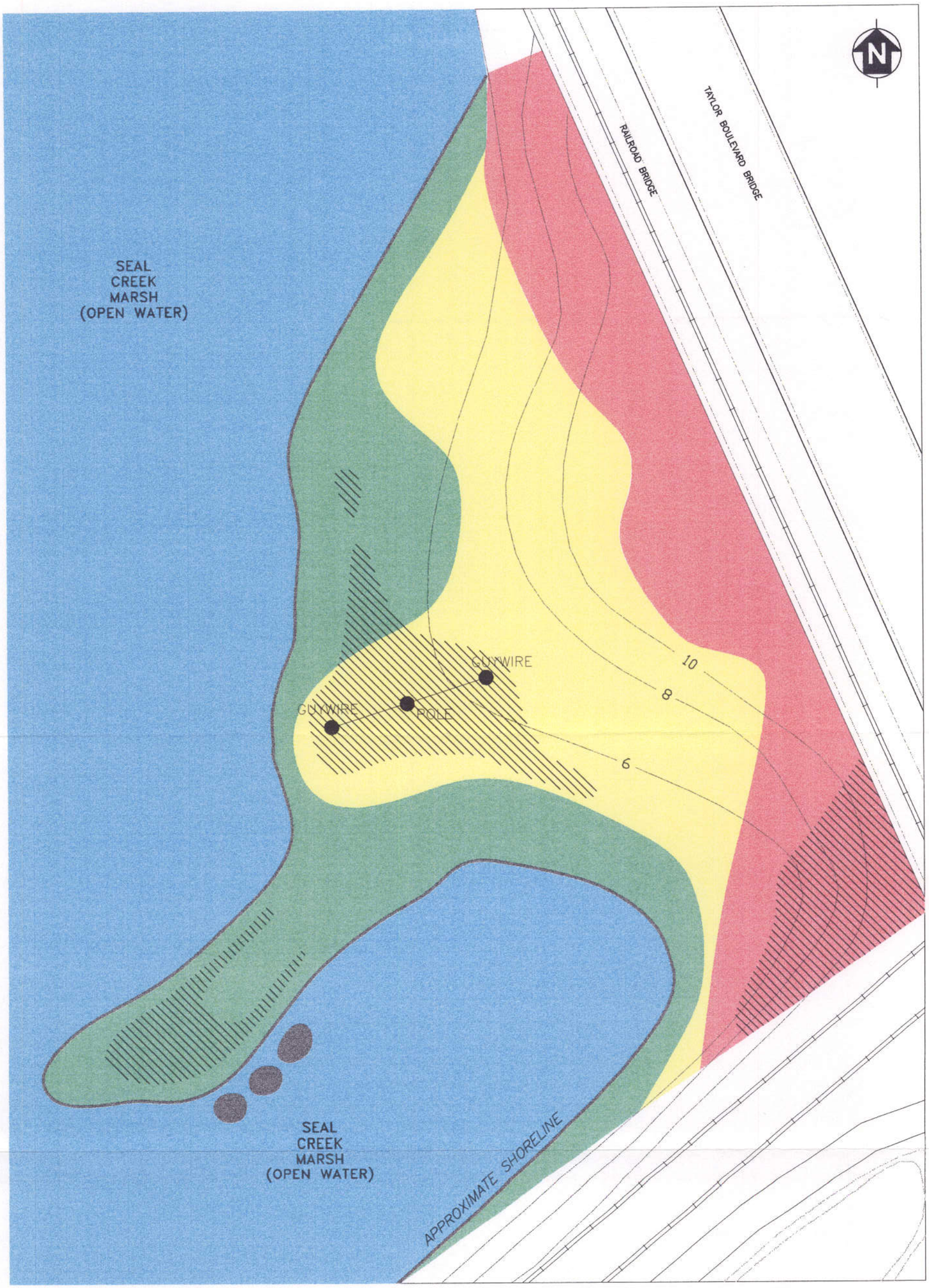
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

FIGURE 3-1

SAMPLE LOCATION MAP
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

KCH (SF) (069-309) EXTENTDEBRIS.DWG 08/25/00 PLOT VIEW:B LTSCALE:PT2 REV:003

DS.0309.15131



LEGEND:

- WETLAND HABITAT (PICKLEWEED, GUMPLANT)
- WETLAND AND UPLAND TRANSITIONAL HABITAT (ALKALI HEATH, SALT GRASS, UPLAND GRASS, GUMPLANT, ATRIPLEX)
- WETLAND AND UPLAND TRANSITIONAL HABITAT (GUMPLANT, YELLOW STAR THISTLE, ATRIPLEX, ARTICHOKE, FENNEL)
- WETLAND AND UPLAND TRANSITIONAL HABITAT (GUMPLANT)
- AQUATIC HABITAT (CATTAIL)
- AQUATIC HABITAT (SUBMERGED)
- APPROXIMATE SHORELINE

15 0 15 30
SCALE IN FEET

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
ENGINEERING FIELD ACTIVITY WEST
SAN BRUNO, CALIFORNIA
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

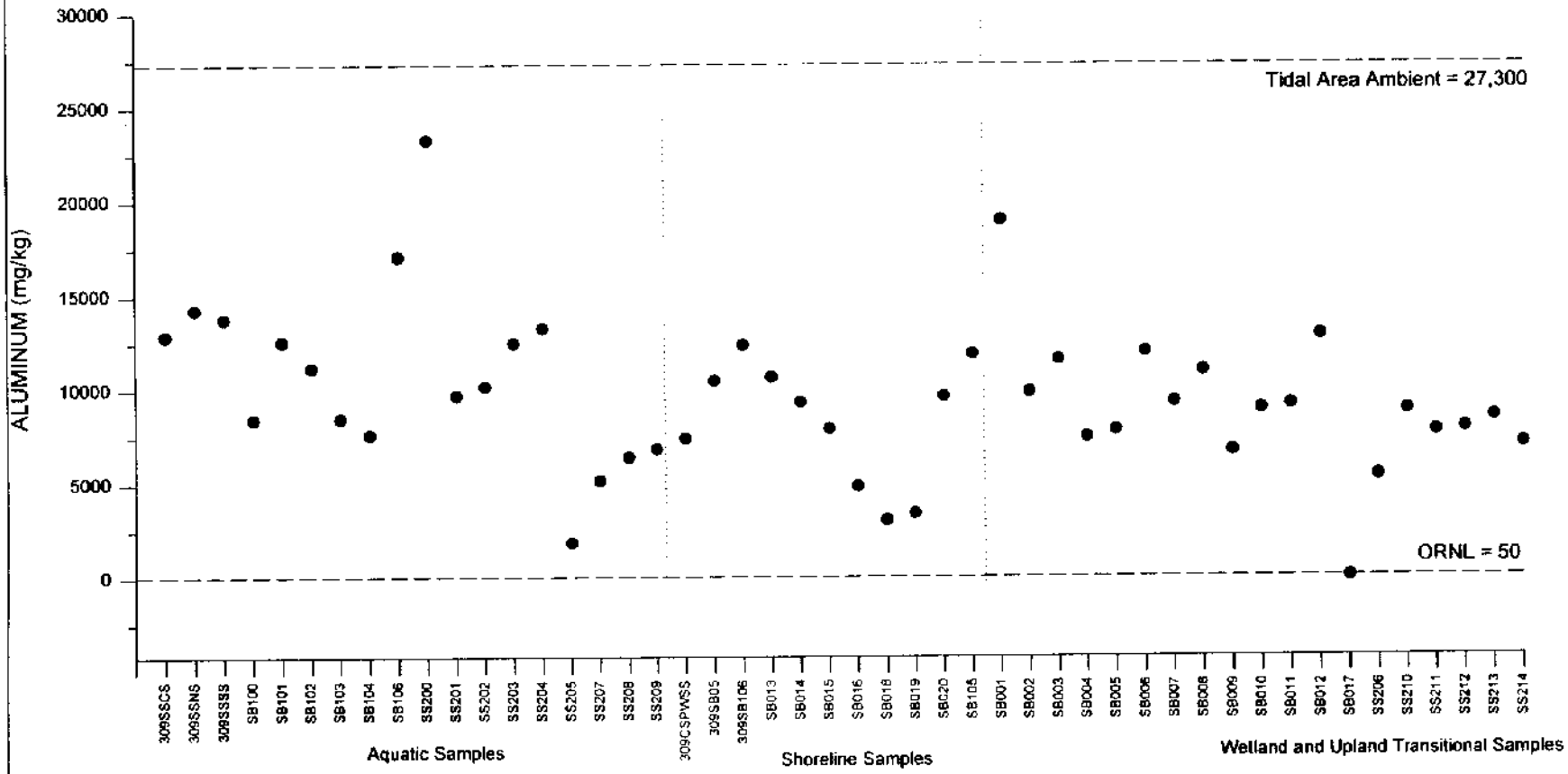
FIGURE 3-2

DOMINANT VEGETATION PRESENT
AT
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

KCM (SF) (069-309) VYPEPRESENT.DWG 08/25/00 PLOT VIEW:8 REV.004

DS.0309.15131

CONCENTRATIONS OF ALUMINUM IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b. "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revsion. Oak Ridge national laboratory, Oak Ridge, TN. 128 pp, ES/ER/TM-85

If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

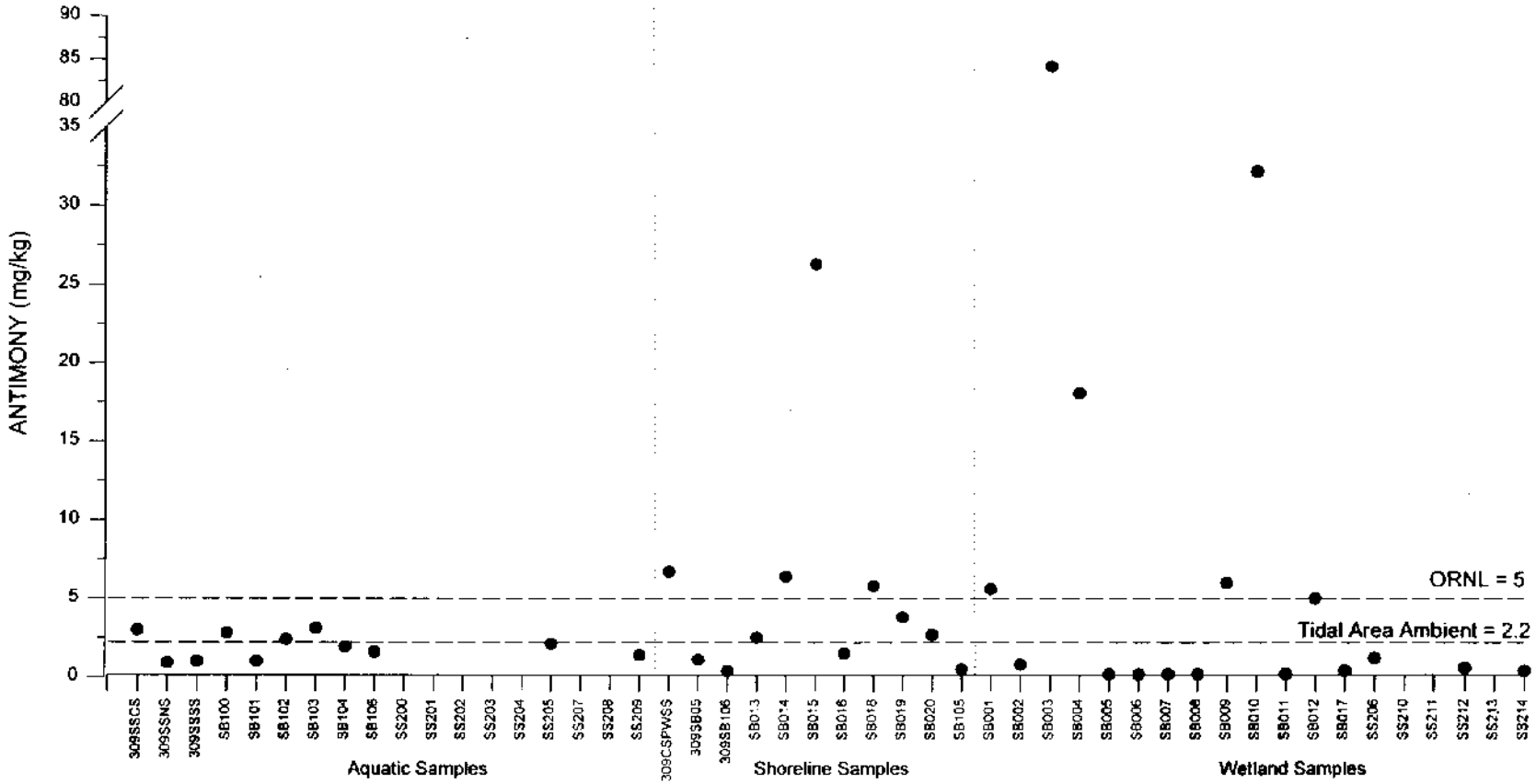
NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-1

Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF ANTIMONY IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b. "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

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If chemical was not detected, the concentration shown is one half of the detection limi

At locations where surface and subsurface samples were collected, maximum concentration is shown

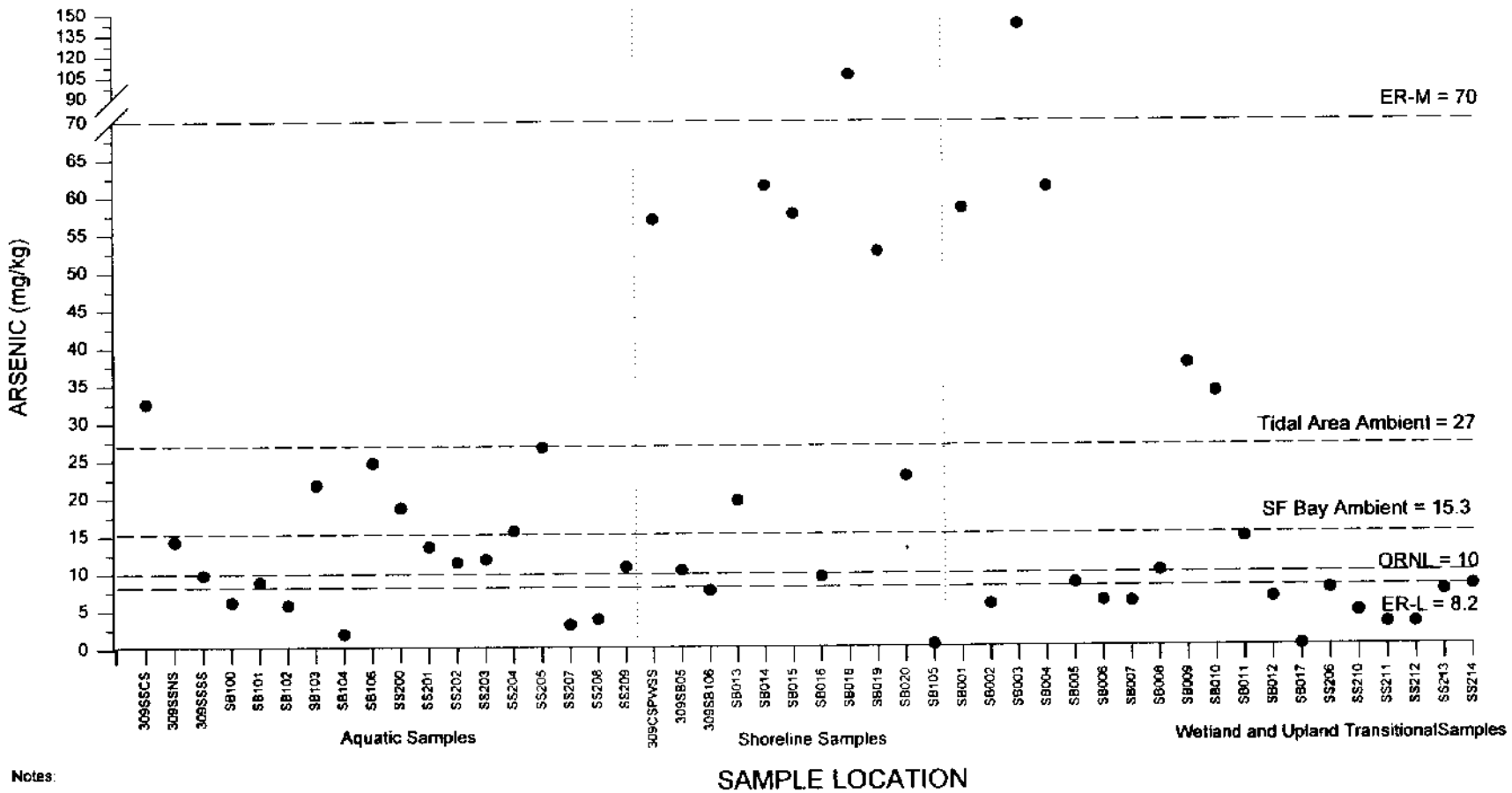
NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-2

Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF ARSENIC IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b. "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

SF Bay Ambient = RWQCB. 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." May

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp. ES/ER/TM-85

ER-M, ER-L = Effects range-median, Effects range-low; Long, E.R., D.D. MacDonald, S.L. Smith, F.D. Calder. 1995 "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." Environmental Management. Volume 19, Number 1. Pages 81-97

If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

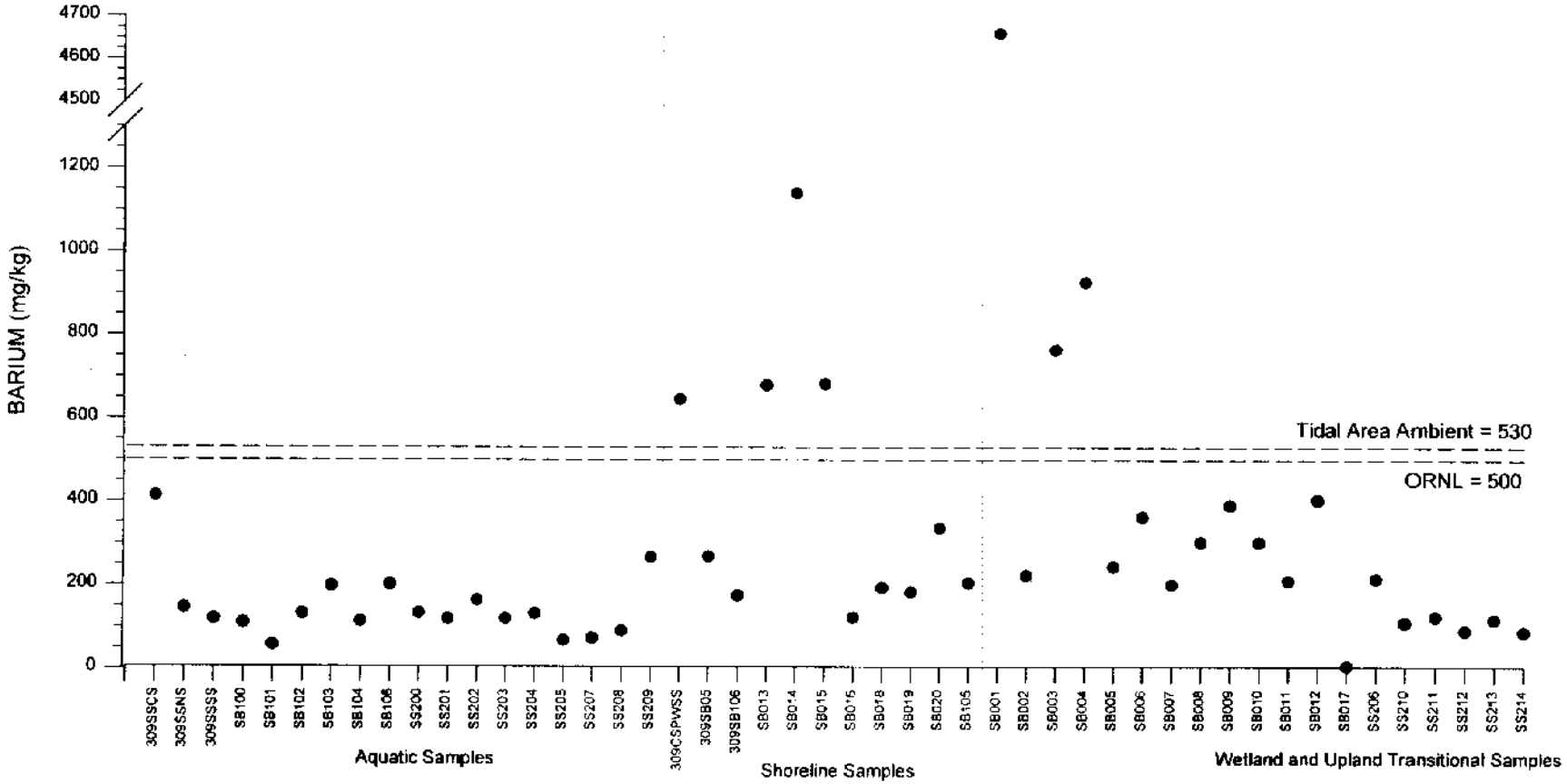
NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-3

Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF BARIUM IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b. "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Woolen. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revsion. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp, ES/ER/TM-85

If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

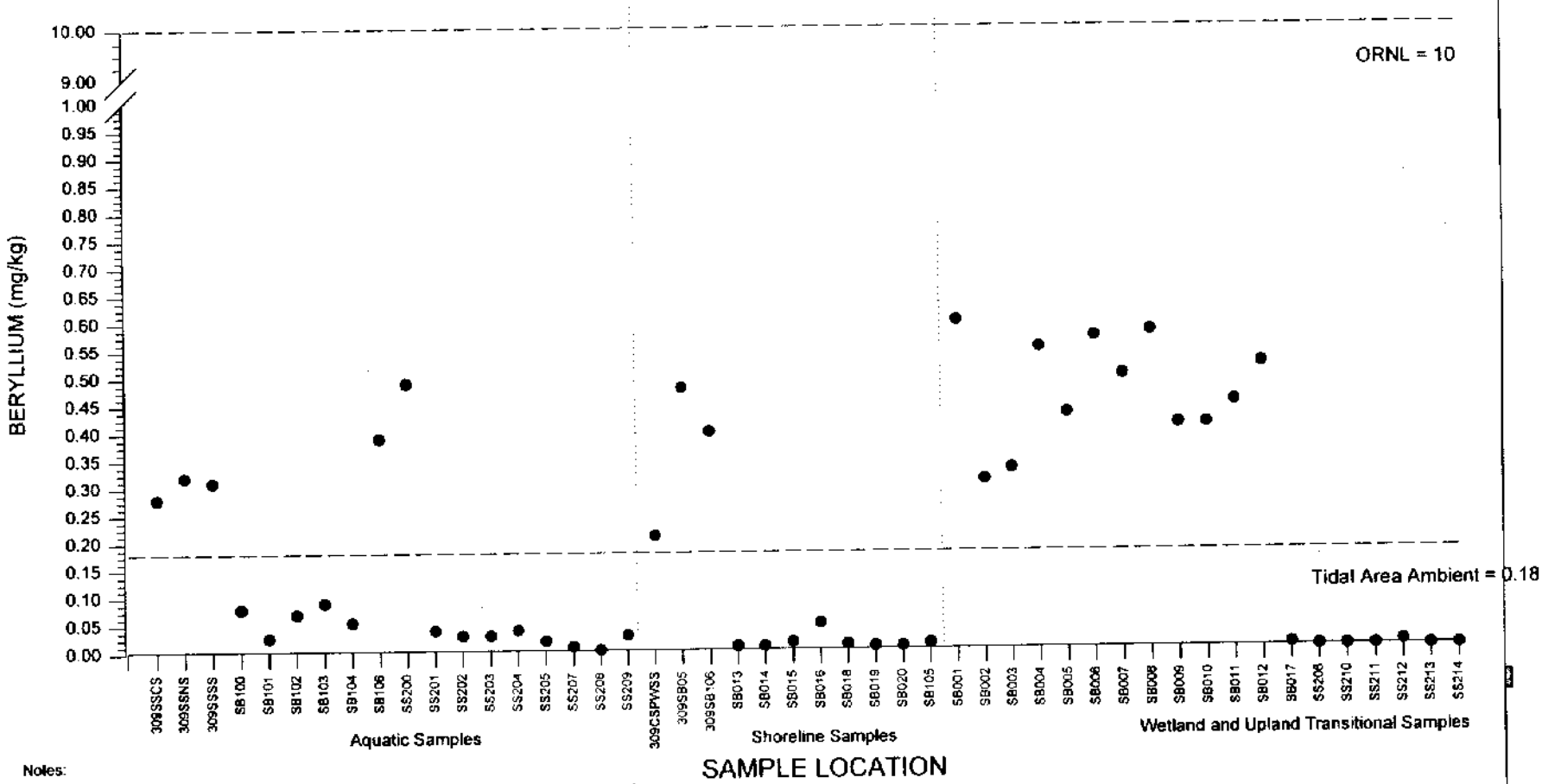
NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-4

Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF BERYLLIUM IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b. "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

SF Bay Ambient = RWQCB. 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." May

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R A., M.E Will, G.W Suter II, and A C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp. ES/ER/TM-85

ER-M, ER-L = Effects range-median, Effects range-low; Long, E R., D.D. MacDonald, S L Smith, F D Calder. 1995 "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." Environmental Management. Volume 19. Number 1. Pages 81-97

If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

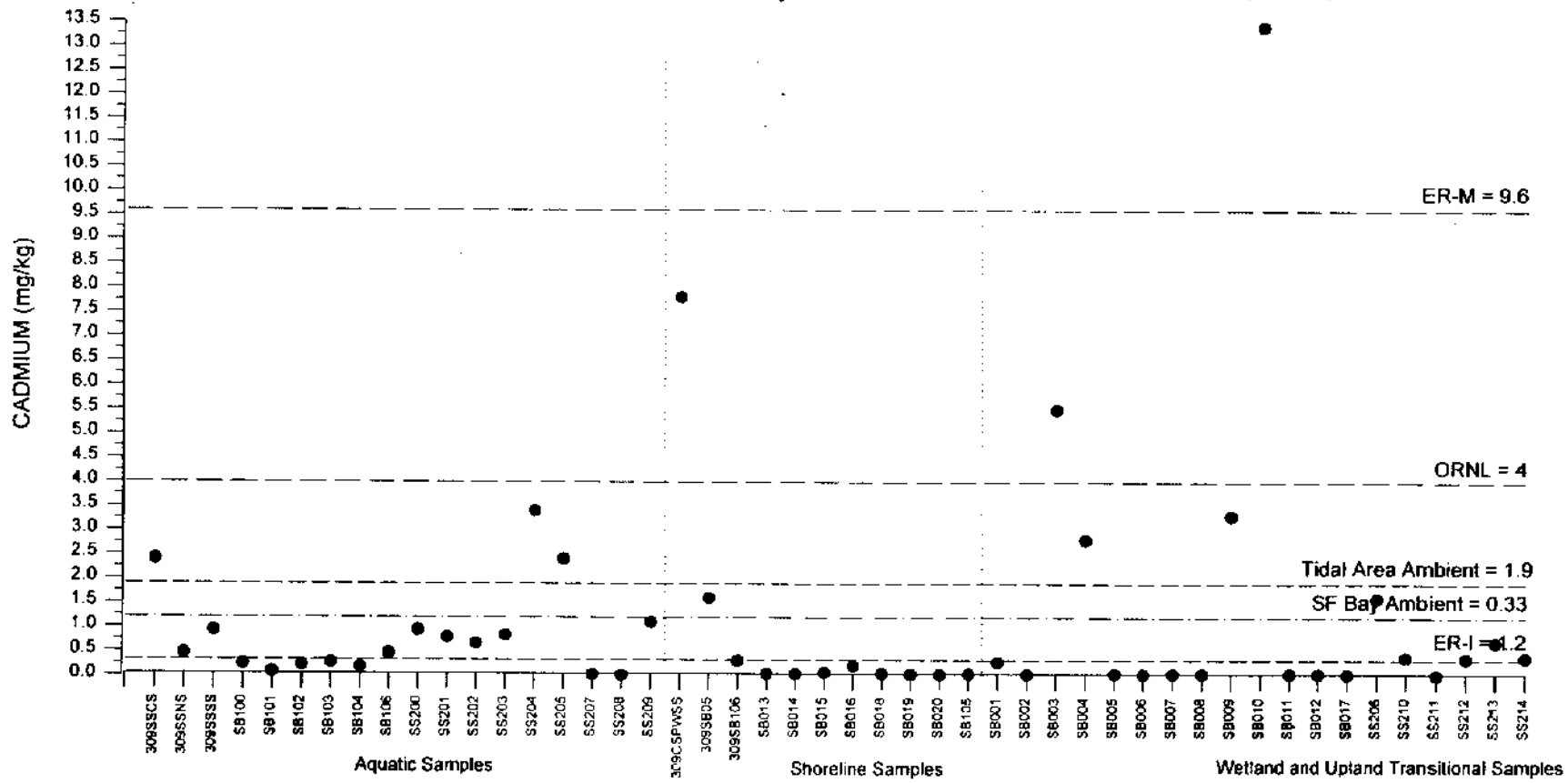
NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-5

Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF CADMIUM IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b "Technical Memorandum. Ambient Metal Concentrations in the Tidal Area Soils

SF Bay Ambient = RWQCB. 1998 "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." May

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp, ES/ER/TM-85

ER-M, ER-L = Effects range-median, Effects range-low; Long, E.R., D.D. MacDonald, S.L. Smith, F.D. Calder 1995. "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." Environmental Management. Volume 19. Number 1. Pages 81-97

If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

SAMPLE LOCATION

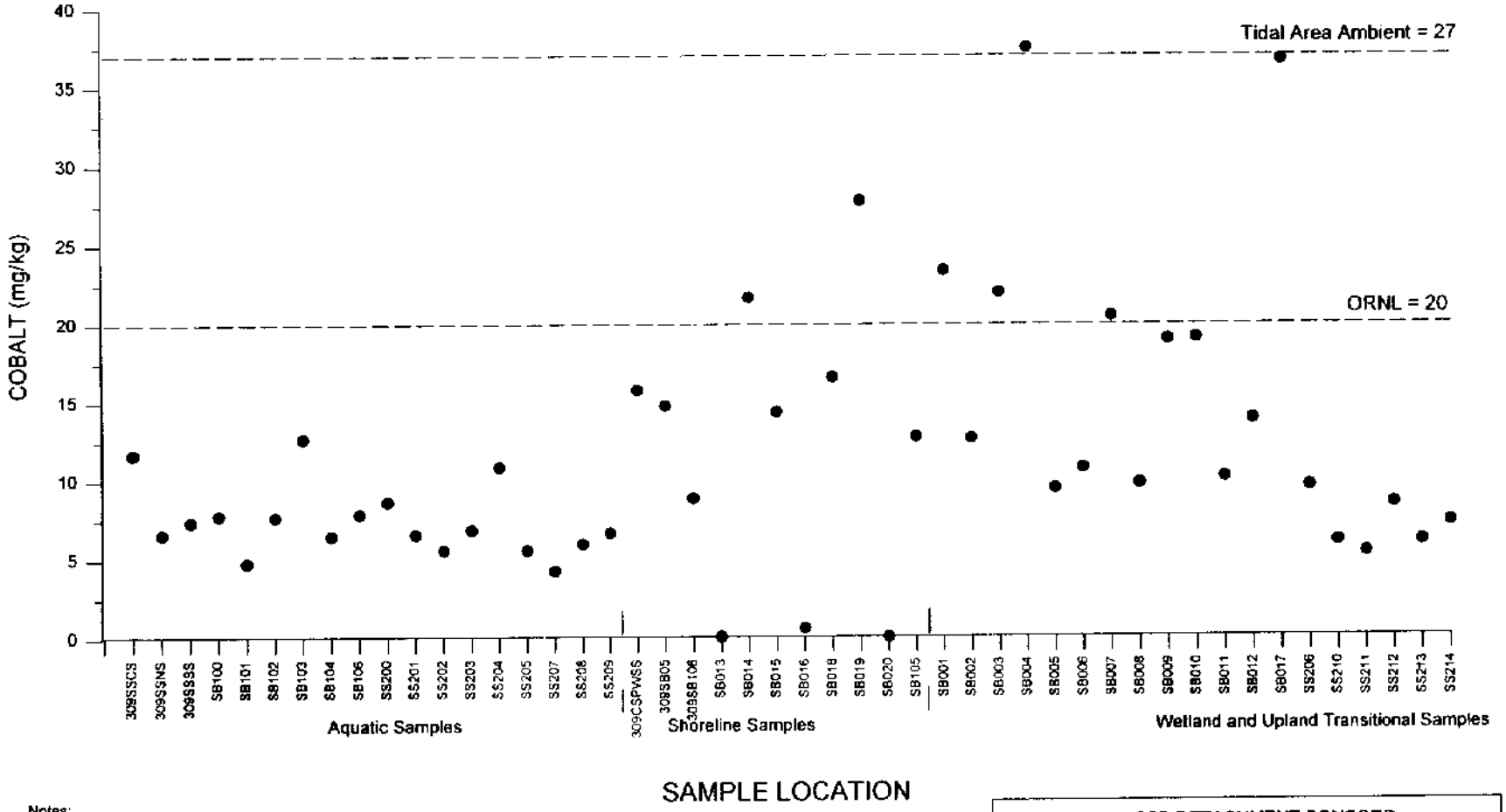
NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-6

Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF COBALT IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b. "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 126 pp. ES/ER/TM-85

If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

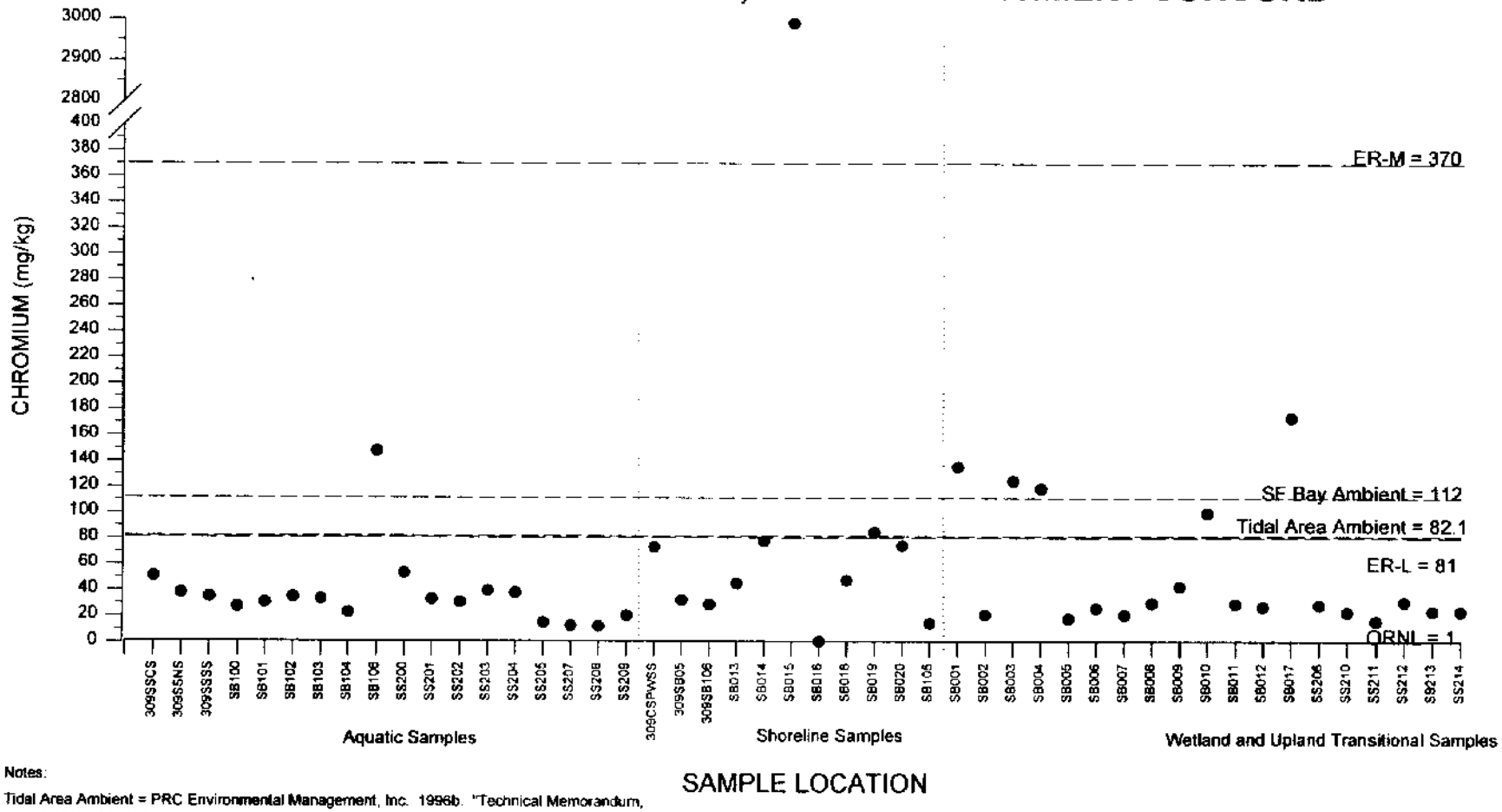
NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-7

Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF CHROMIUM IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b. "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

SF Bay Ambient = RWQCB 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments " May

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory. Oak Ridge. TN. 128 pp. ES/ER/TM-85

ER-M, ER-L = Effects range-median, Effects range-low; Long, E.R., D.D. MacDonald, S.L. Smith, F.D. Calder. 1995. "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments " Environmental Management. Volume 19. Number 1. Pages 81-97

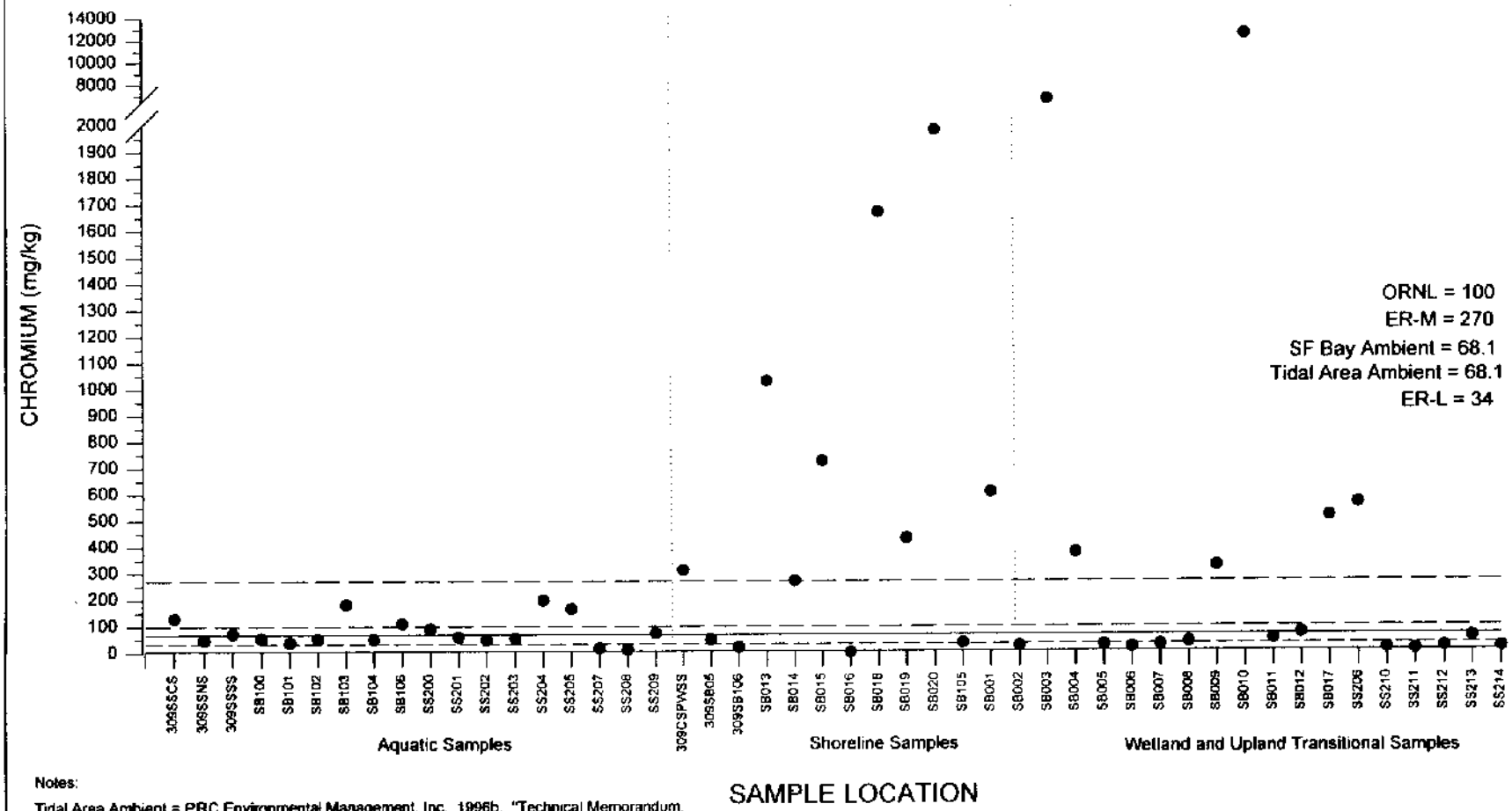
If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

NWSSB DETACHMENT CONCORD CONCORD, CALIFORNIA
FIGURE 5-8
Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF COPPER IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b. "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

SF Bay Ambient = RWQCB. 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments " May

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revsion. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp, ES/ER/TM-85

ER-M, ER-L = Effects range-median, Effects range-low; Long, E.R., D.D. MacDonald, S.L. Smith, F.D. Calder 1995 "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments " Environmental Management. Volume 19. Number 1. Pages 81-97

If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

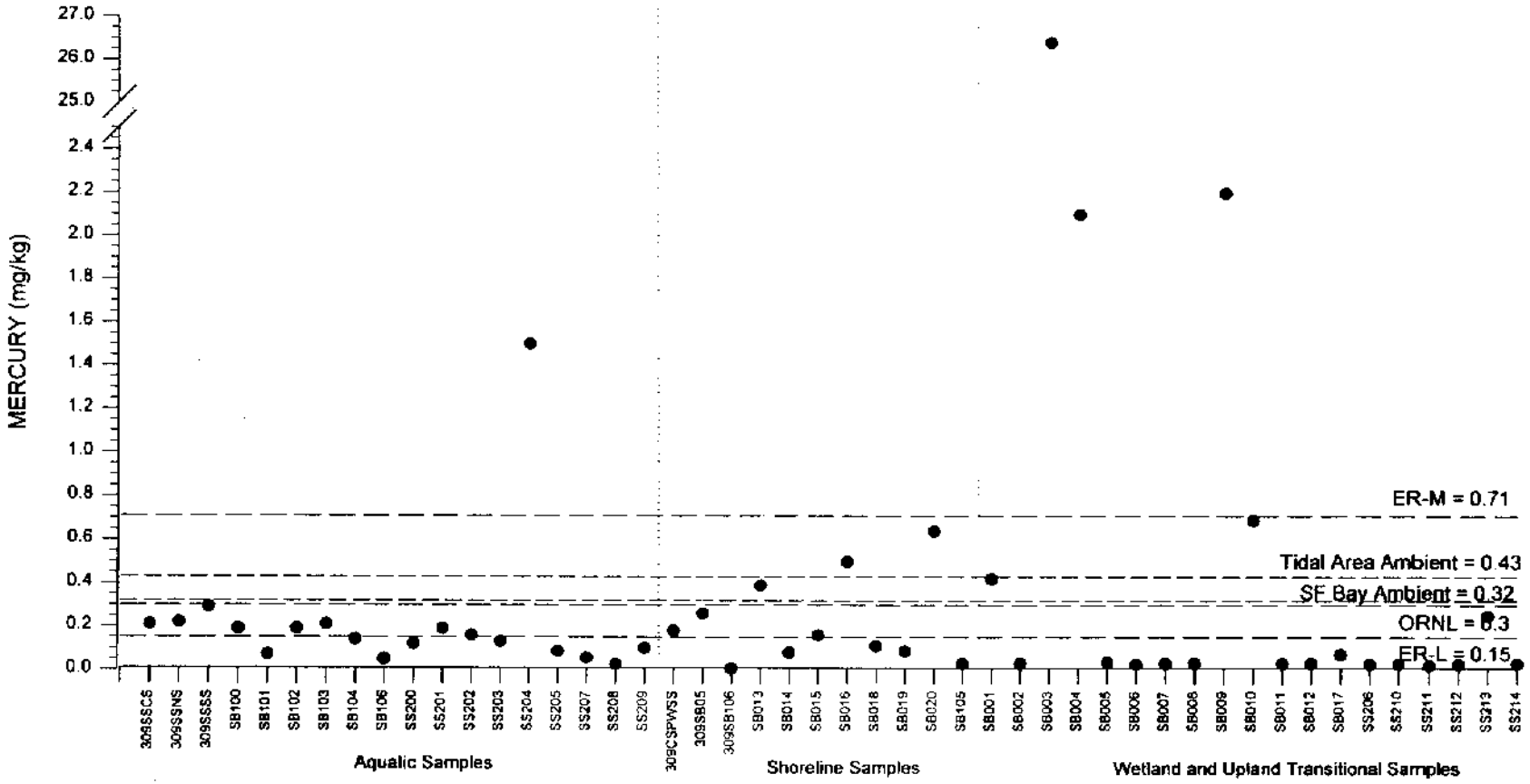
NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-9

Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF MERCURY IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



SAMPLE LOCATION

Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b. "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

SF Bay Ambient = RWQCB. 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." May

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson. R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp, ES/ER/TM-85

ER-M, ER-L = Effects range-median, Effects range-low; Long, E.R., D.D. MacDonald, S.L. Smith, F.D. Calder. 1995 "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments" Environmental Management. Volume 19. Number 1. Pages 81-97

If chemical was not detected, the concentration shown is one half of the detection limit

All locations where surface and subsurface samples were collected, maximum concentration is shown

NWSSB DETACHMENT CONCORD CONCORD, CALIFORNIA
FIGURE 5-10
Tetra Tech EM Inc.

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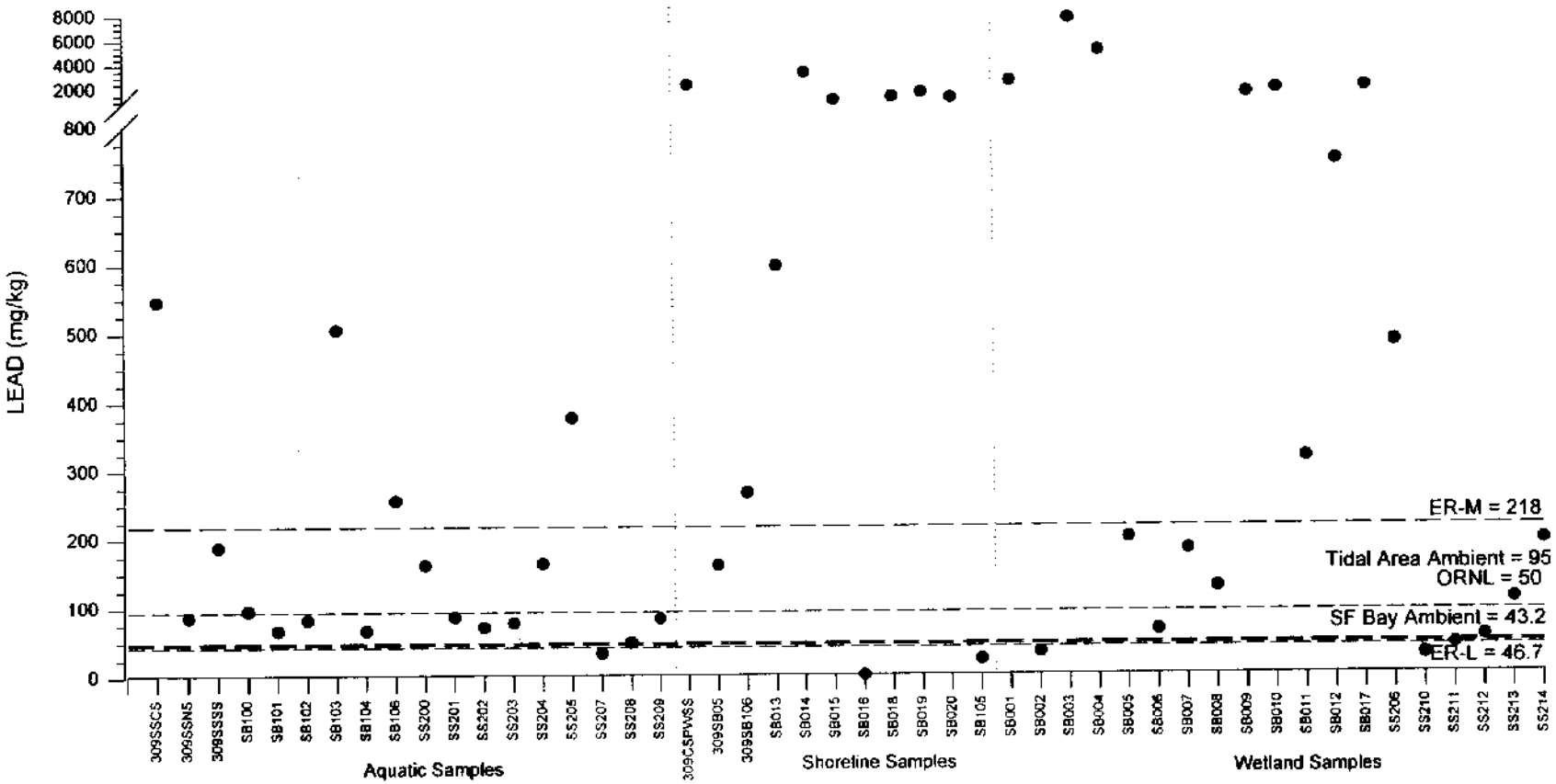
CONCENTRATIONS OF LEAD IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b. "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

SF Bay Ambient = RWQCB. 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." May

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp, ES/ER/TM-85

ER-M, ER-L = Effects range-median, Effects range-low; Long, E.R., D.D. MacDonald, S.L. Smith, F.D. Calder. 1995 "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." Environmental Management. Volume 19. Number 1. Pages 81-97

If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

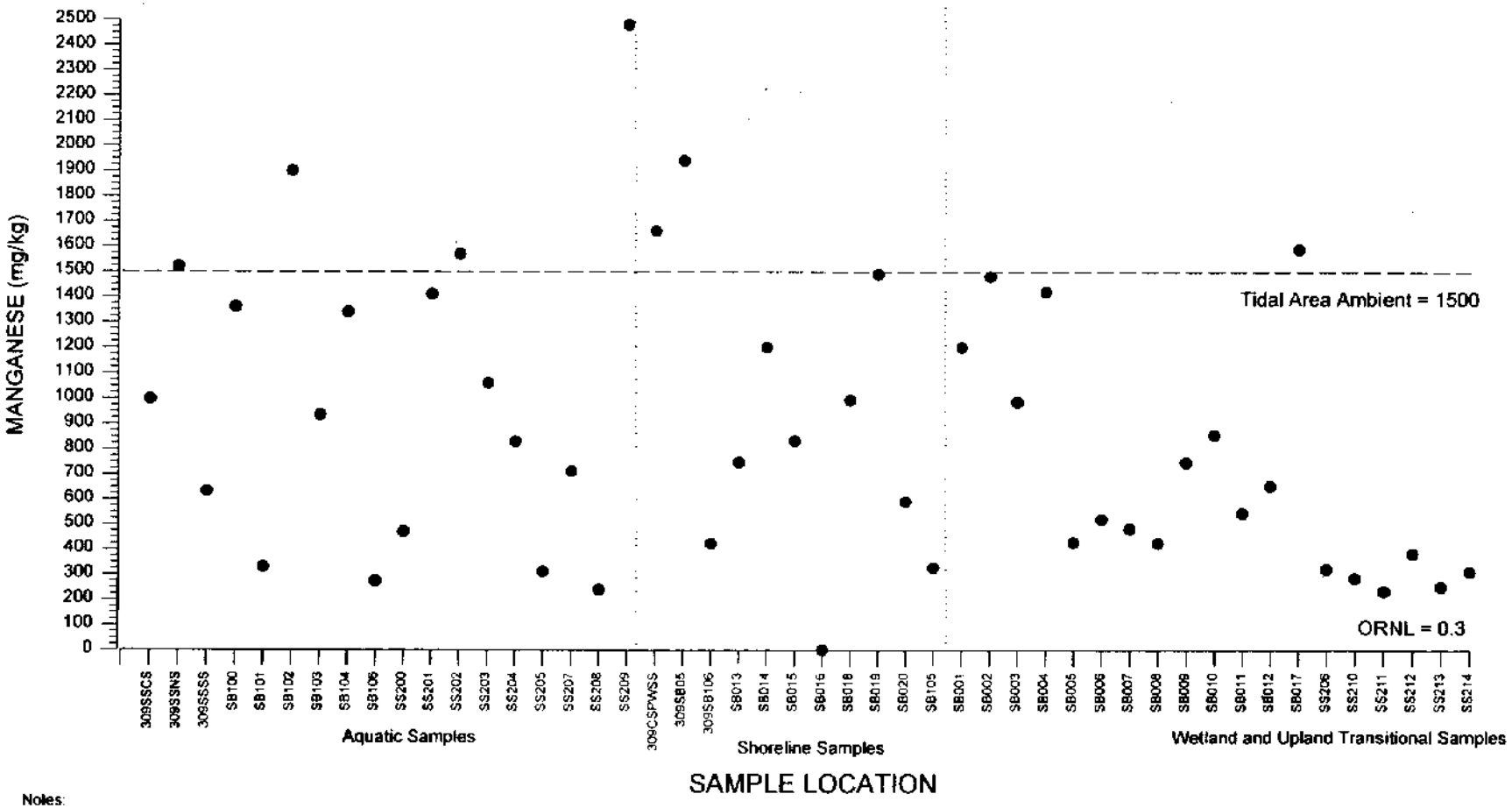
NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-11

Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF MANGANESE IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

SF Bay Ambient = RWQCB. 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." May

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp. ES/ER/TM-85

ER-M, ER-L = Effects range-median, Effects range-low; Long, E.R., D.D. MacDonald, S.L. Smith, F.D. Calder. 1995 "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." Environmental Management. Volume 19. Number 1. Pages 81-97

If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

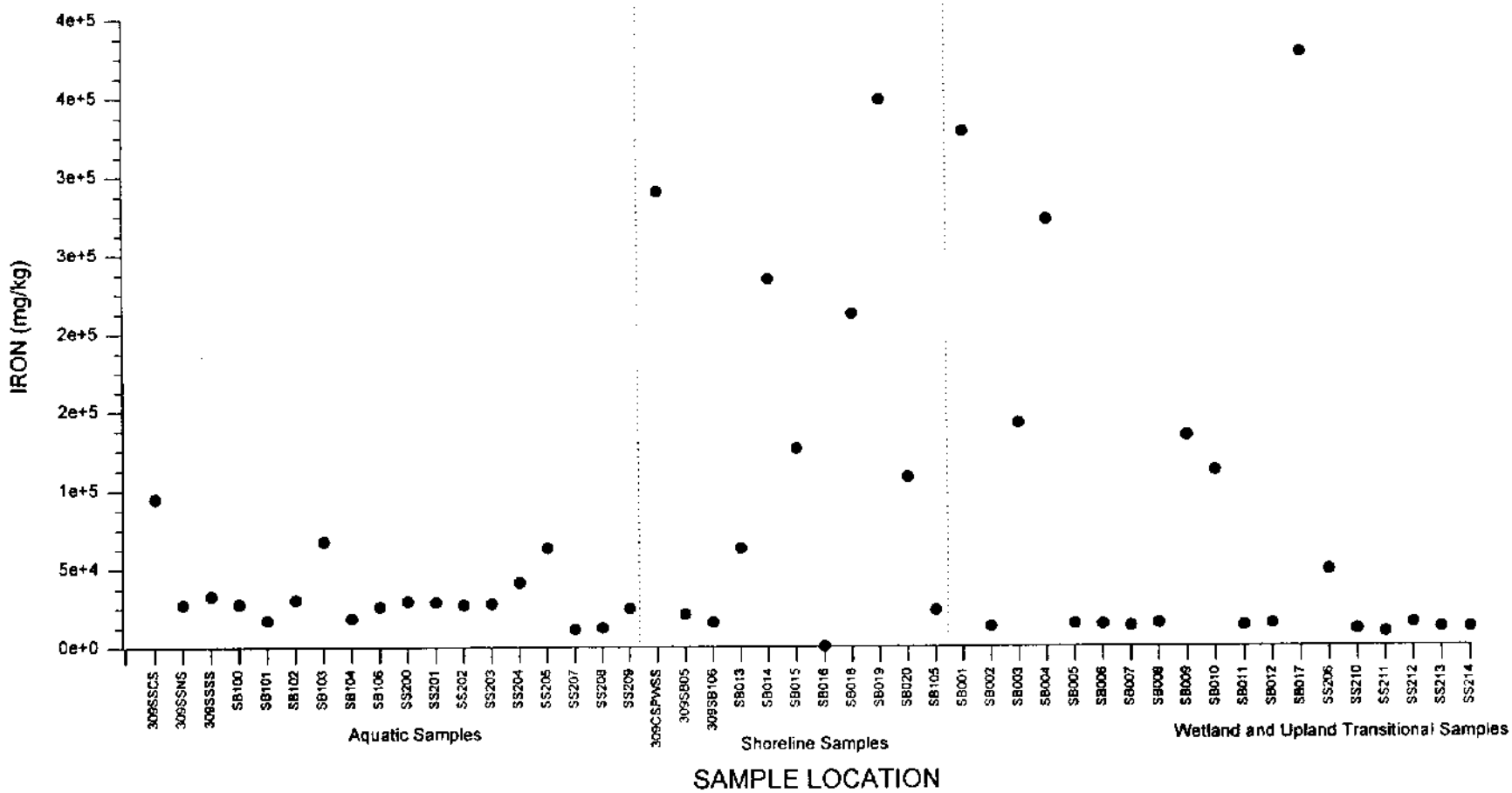
NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-12

Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF IRON IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



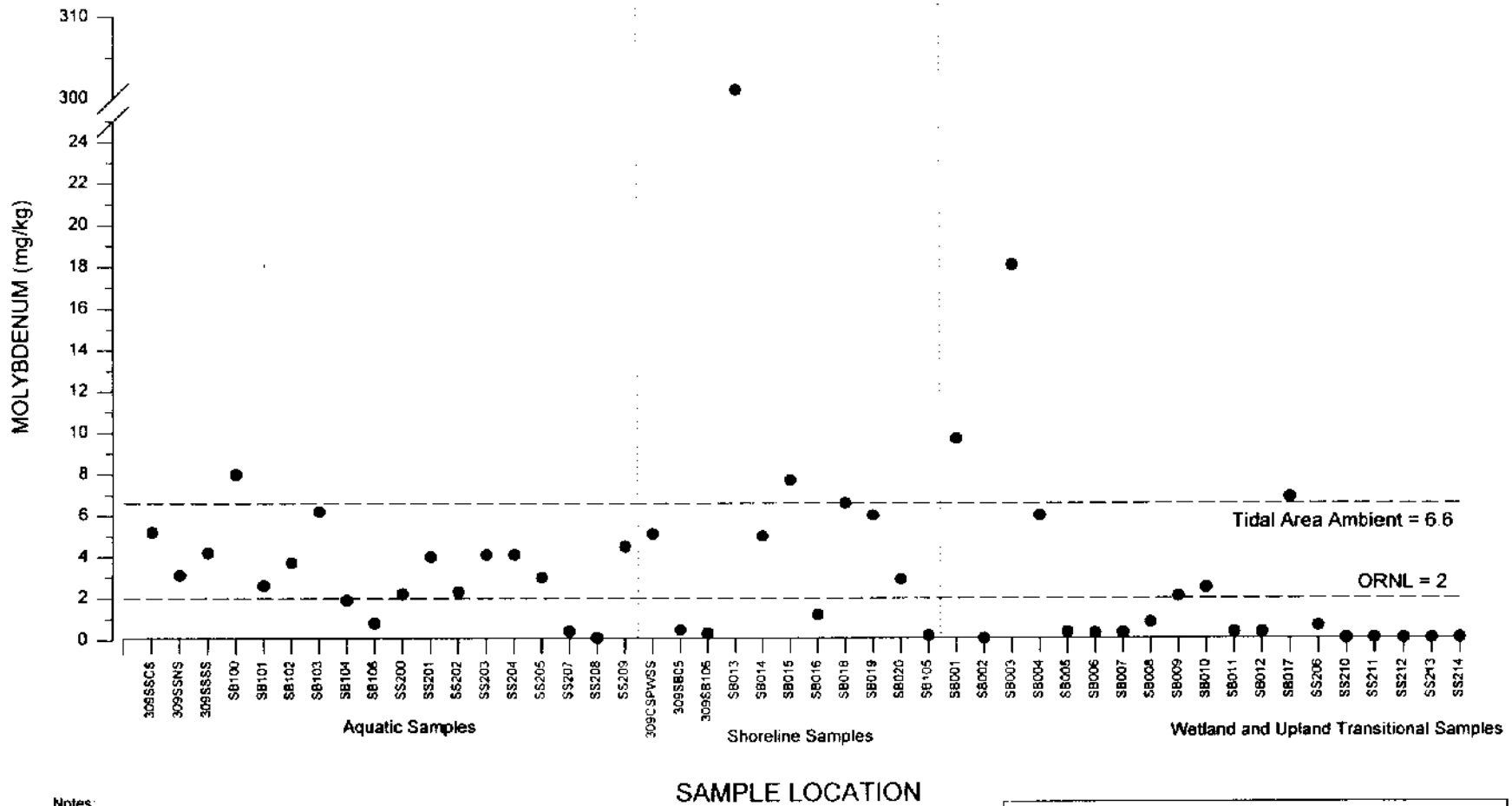
Notes:

If chemical was not detected, the concentration shown is one half of the detection limit
At locations where surface and subsurface samples were collected, maximum concentration is shown

NWSSB DETACHMENT CONCORD CONCORD, CALIFORNIA
FIGURE 5-13
Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF MOLYBDENUM IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp. ES/ER/TM-85

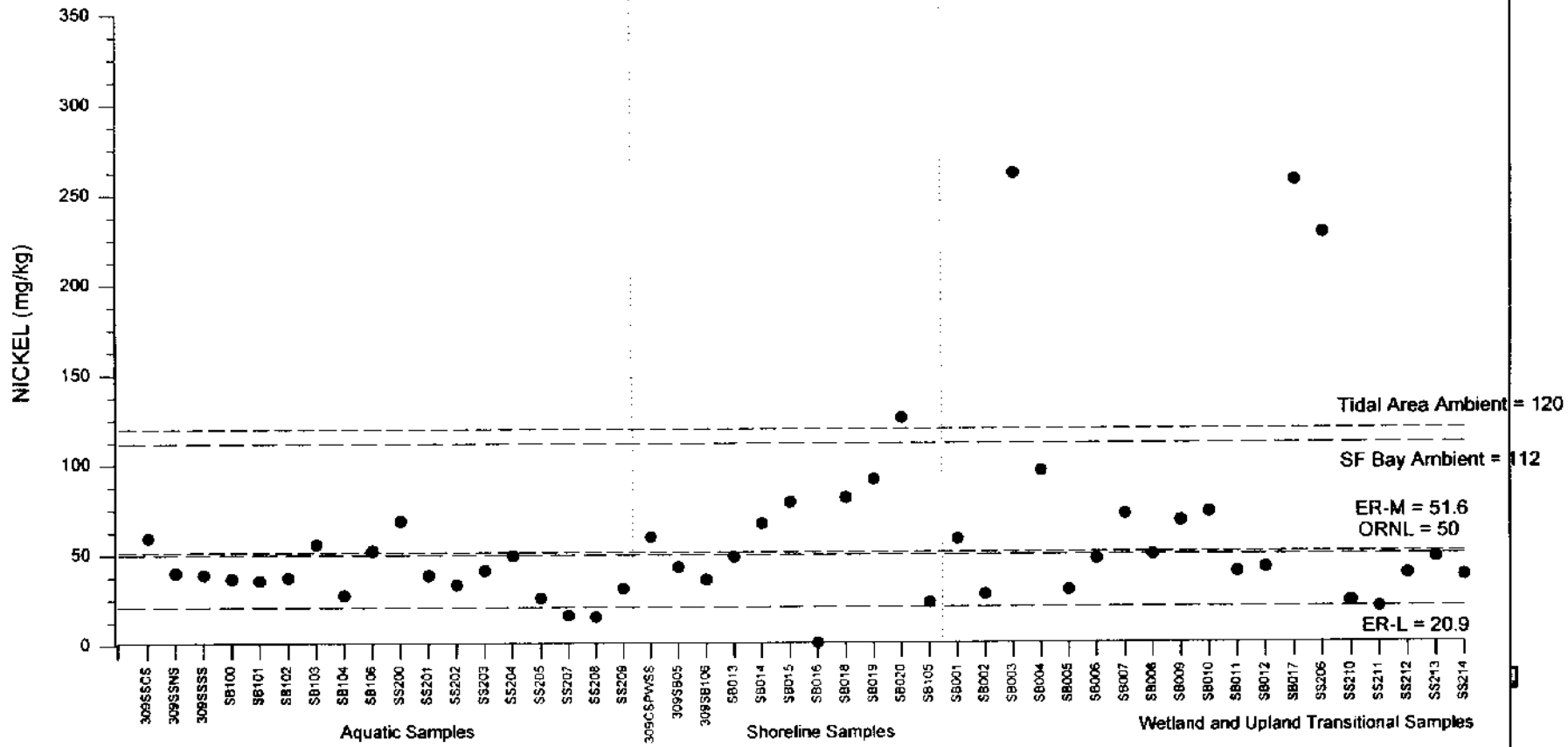
If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

NWSSB DETACHMENT CONCORD CONCORD, CALIFORNIA
FIGURE5-14
Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF NICKEL IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b. "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

SF Bay Ambient = RWQCB. 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." May

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R.A., M.E Will, G W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp. ES/ER/TM-85

ER-M, ER-L = Effects range-median, Effects range-low; Long, E R., D.D. MacDonald, S L. Smith, F D Calder. 1995. "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." Environmental Management. Volume 19. Number 1 Pages 81-97

If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

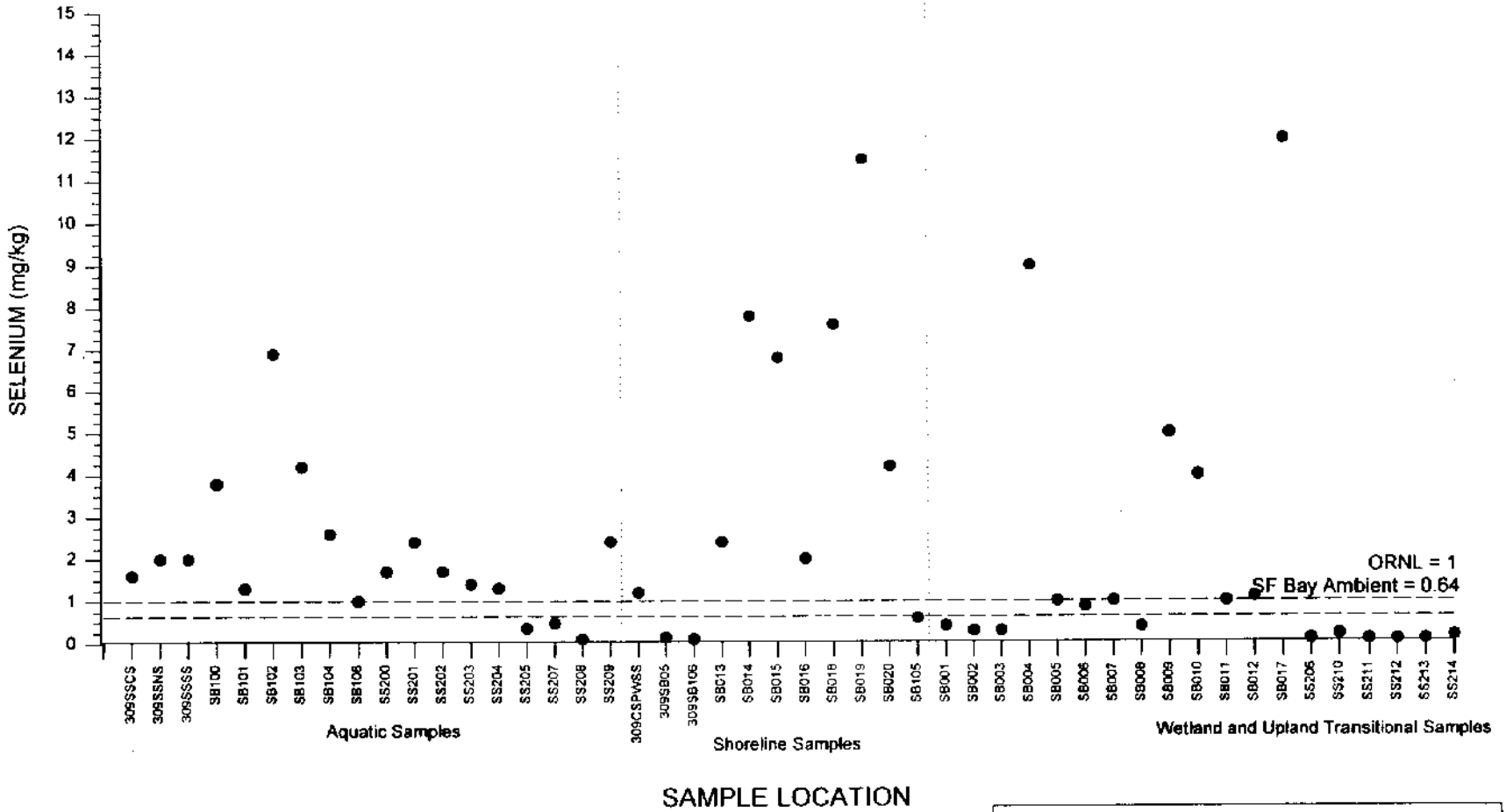
NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-15

Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF SELENIUM IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Woolen. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp. ES/ER/TM-85

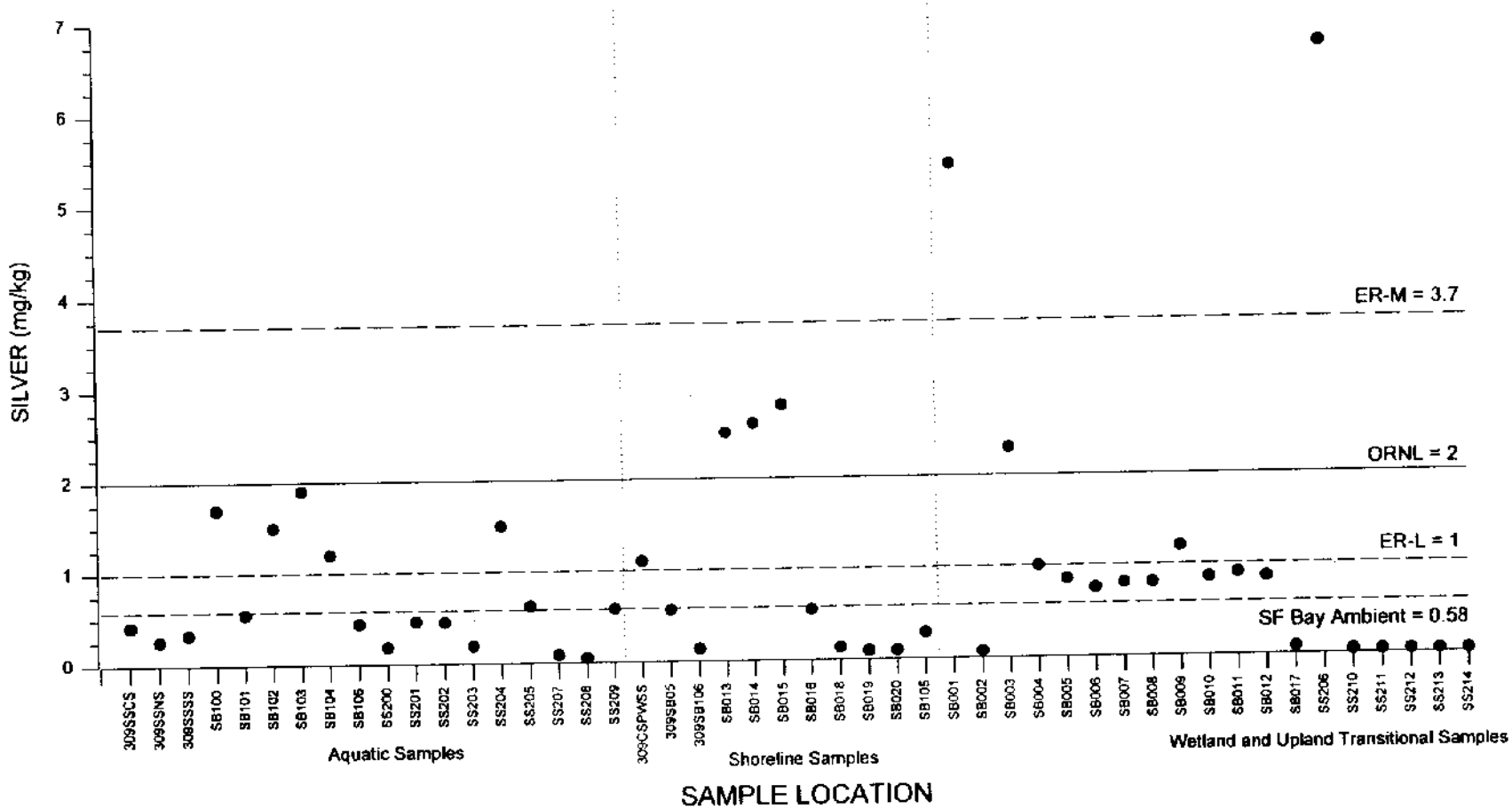
At locations where surface and subsurface samples were collected, maximum concentration is shown

If chemical was not detected, the concentration shown is one half of the detection limit

NWSSB DETACHMENT CONCORD CONCORD, CALIFORNIA
FIGURE 5-16
Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF SILVER IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

SF Bay Ambient = RWQCB 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." May

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp. ES/ER/TM-85

ER-M, ER-L = Effects range-median, Effects range-low; Long, E.R., D.D. MacDonald, S.L. Smith, F.D. Calder 1995 "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." Environmental Management. Volume 19, Number 1 Pages 81-97

If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

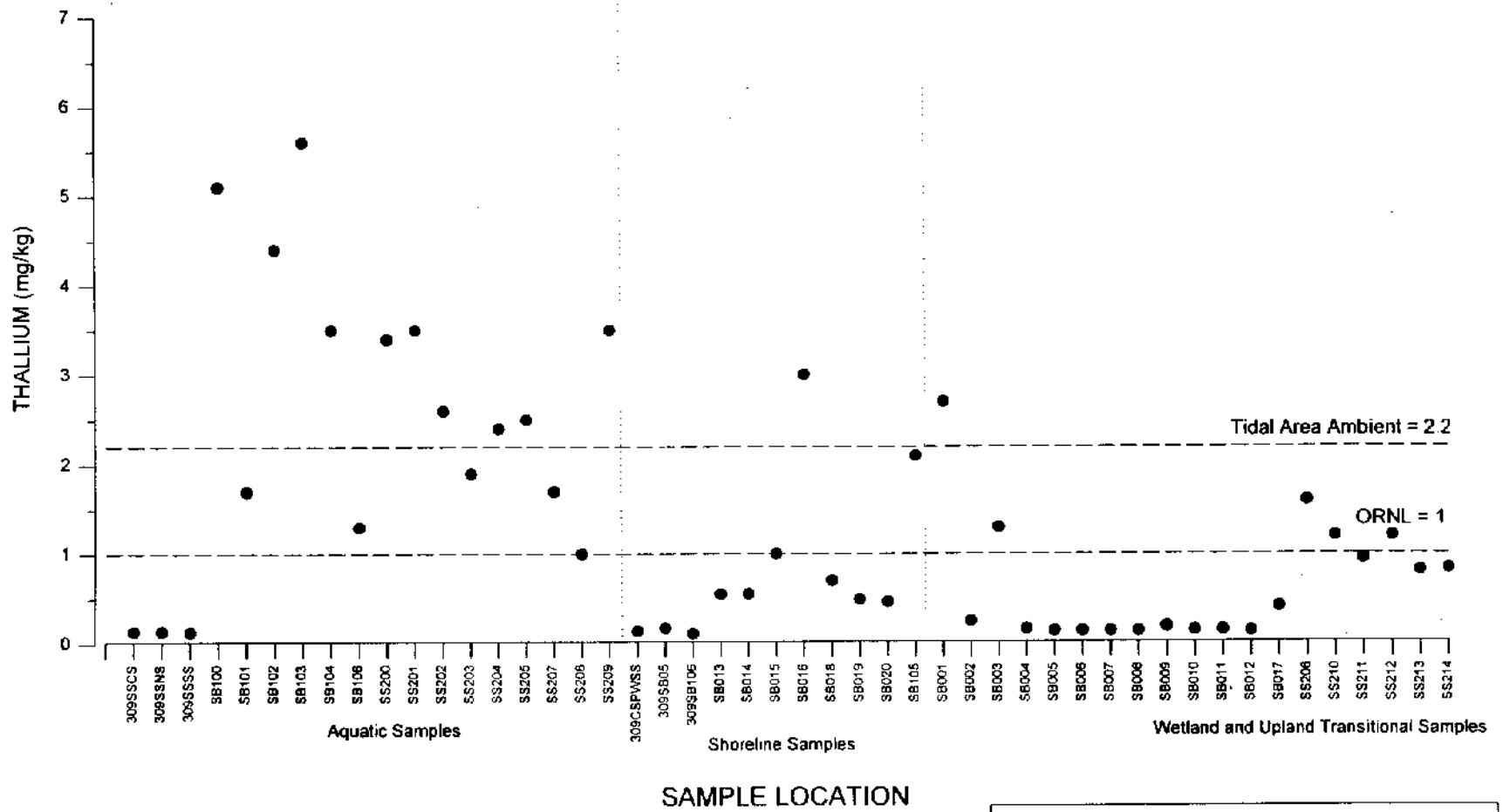
NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-17

Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF THALLIUM IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes.

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp. ES/ER/TM-85

If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

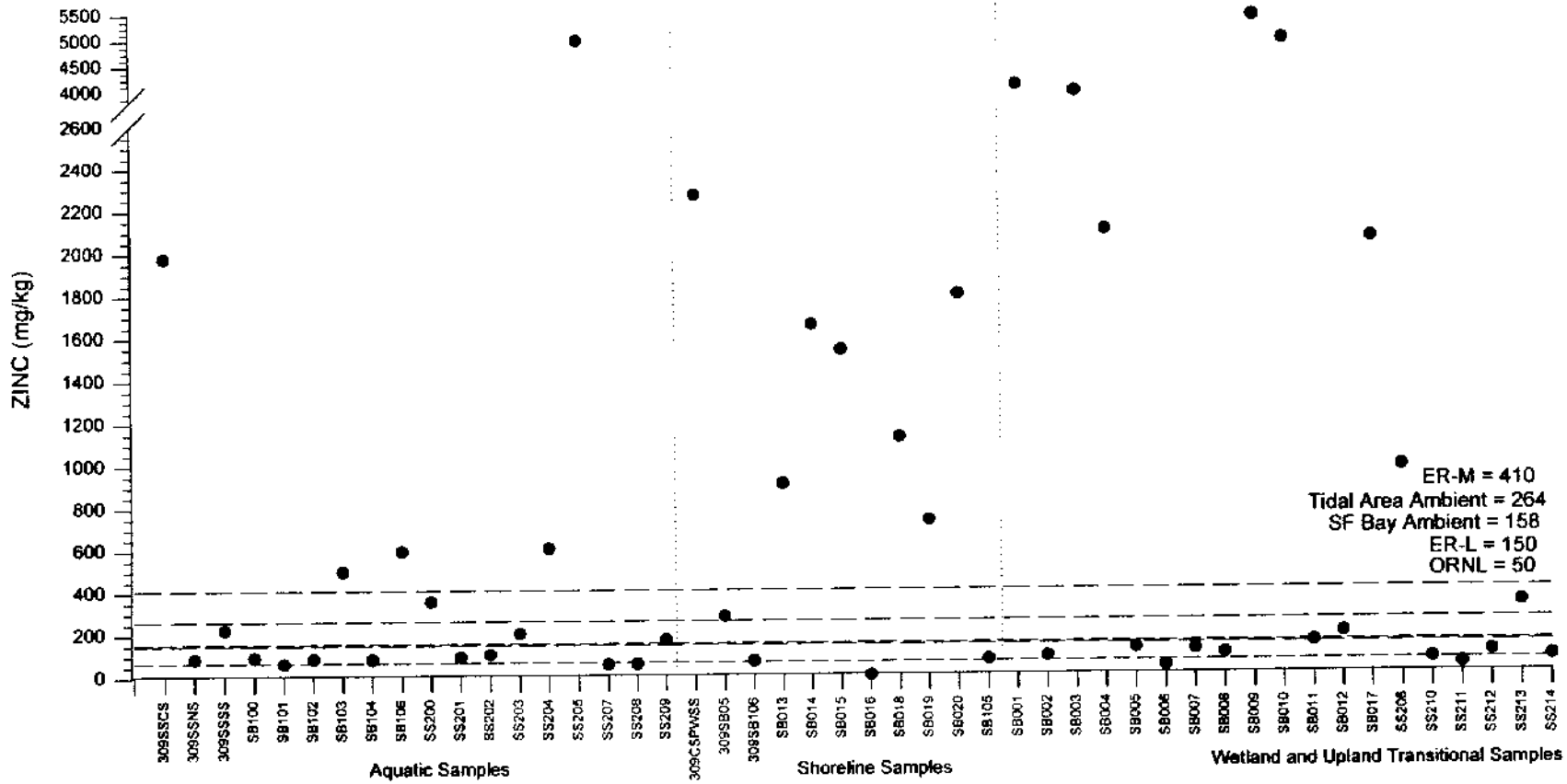
NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-18

Tetra Tech EM Inc.

DS.0309.15131

CONCENTRATIONS OF ZINC IN SEDIMENT
TAYLOR BOULEVARD BRIDGE, NWSSB DETACHMENT CONCORD



Notes:

Tidal Area Ambient = PRC Environmental Management, Inc. 1996b. "Technical Memorandum, Ambient Metal Concentrations in the Tidal Area Soils

SF Bay Ambient = RWQCB. 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." May

ORNL = Oak Ridge National Laboratory Plant Toxicity Benchmark. Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp. ES/ER/TM-85

ER-M, ER-L = Effects range-median, Effects range-low; Long, E.R., D.D. MacDonald, S.L. Smith, F.D. Calder. 1995. "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments" Environmental Management. Volume 19. Number 1. Pages 81-97

If chemical was not detected, the concentration shown is one half of the detection limit

At locations where surface and subsurface samples were collected, maximum concentration is shown

NWSSB DETACHMENT CONCORD
CONCORD, CALIFORNIA

FIGURE 5-19

Tetra Tech EM Inc.

DS.0309.15131

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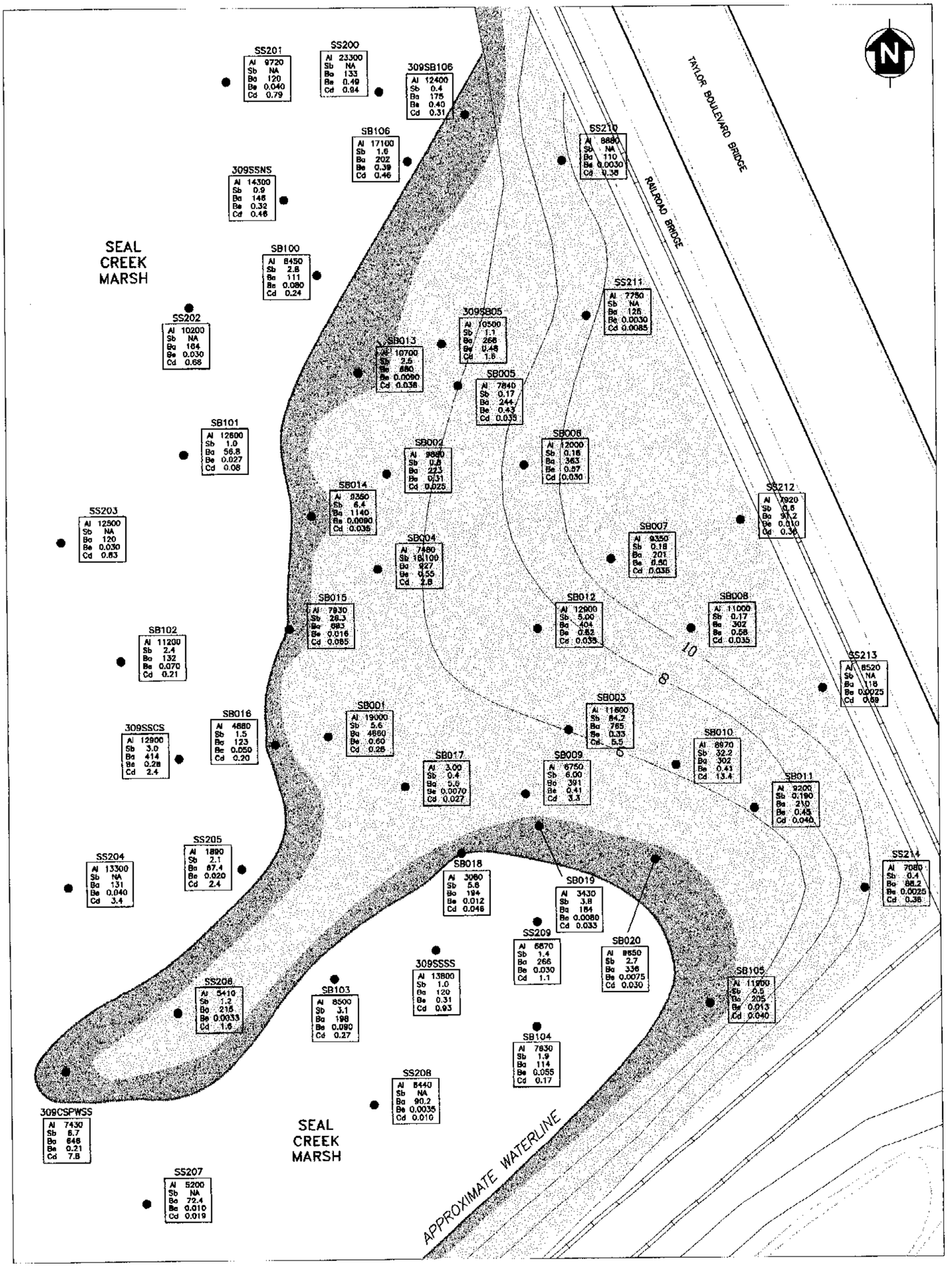


LEGEND:

- ● SAMPLE LOCATION
- WETLAND AND UPLAND TRANSITIONAL HABITAT
- AQUATIC HABITAT
- SHORELINE: APPROXIMATE SEASONAL WATER LEVEL VARIATION
- APPROXIMATE SHORELINE
- NA NOT AVAILABLE
- mg/kg MILLIGRAMS PER KILOGRAM
- UCL UPPER CONFIDENCE LEVEL OF THE MEAN

NOTES:

1. ONE-HALF THE DETECTION LIMIT SUBSTITUTED FOR NONDETECTS
2. FOR LOCATIONS WHERE SURFACE AND SUBSURFACE SAMPLES AVAILABLE, MAXIMUM CONCENTRATION USED IN CALCULATION OF UCL

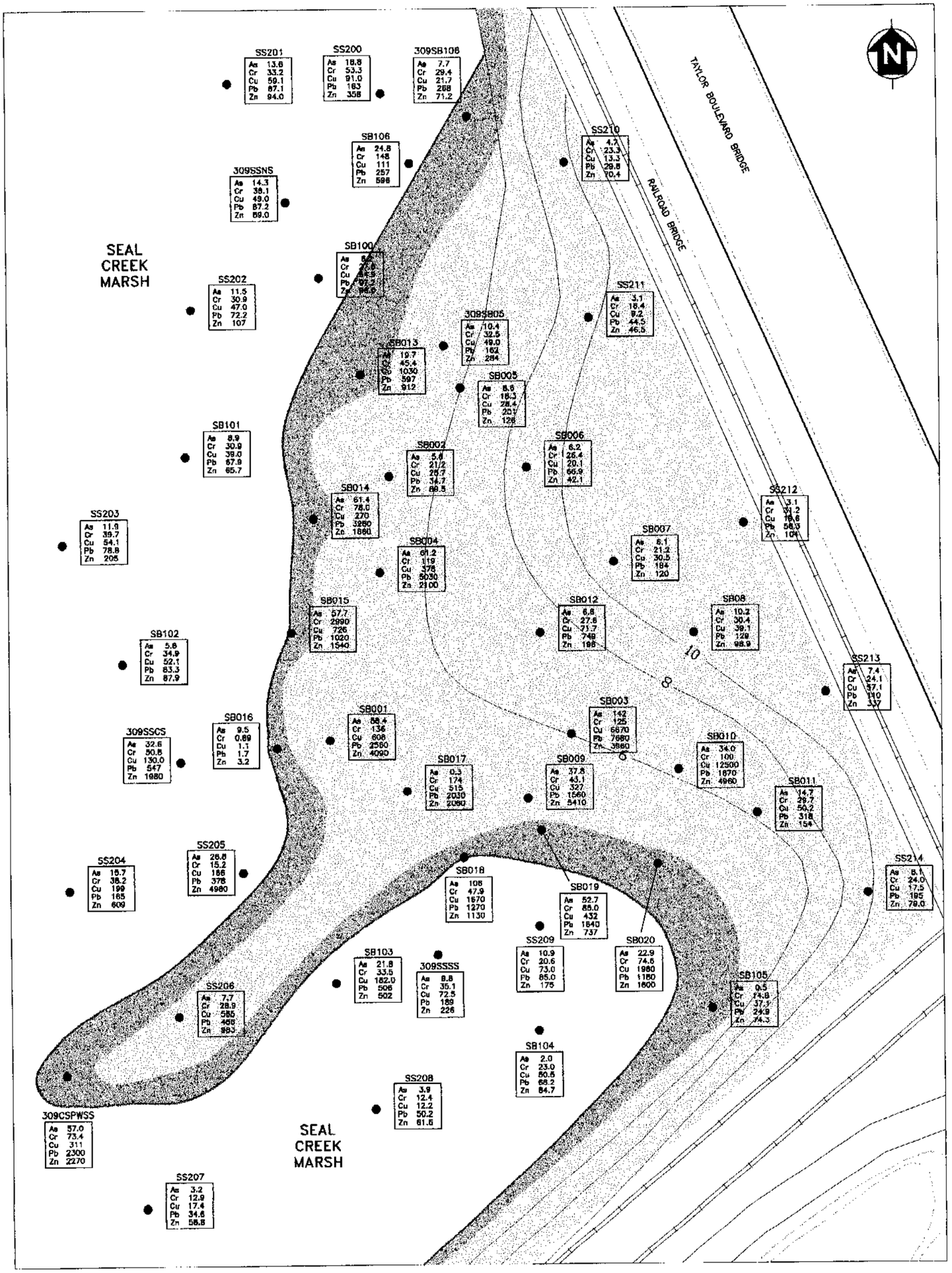
SYMBOL	METAL	CONCORD TIDAL AREA AMBIENT	RWQCB SAN FRANCISCO BAY AMBIENT	WHOLE SITE 95% UCL	AQUATIC HABITAT 95% UCL	WETLAND AND UPLAND TRANSITIONAL 95% UCL
Al	Aluminum	27300	NA	10590	11300	9830
Sb	Antimony	2.2	NA	10.1	5.5	14.7
Ba	Barium	530	NA	508	320	716
Be	Beryllium	0.18	NA	0.24	0.17	0.3
Cd	Cadmium	1.9	0.33	1.7	1.4	2.1

15 0 15 30
SCALE IN FEET

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
ENGINEERING FIELD ACTIVITY WEST
SAN BRUNO, CALIFORNIA
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

FIGURE 5-22
CONCENTRATIONS OF ALUMINUM, ANTIMONY, BARIUM, BERYLLIUM, AND CADMIUM IN SEDIMENT (In mg/kg)
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

DS.0309.15131



LEGEND:

- ● SAMPLE LOCATION
- WETLAND AND UPLAND TRANSITIONAL HABITAT
- AQUATIC HABITAT
- SHORELINE: APPROXIMATE SEASONAL WATER LEVEL VARIATION
- APPROXIMATE SHORELINE
- NA NOT AVAILABLE
- mg/kg MILLIGRAMS PER KILOGRAM
- UCL UPPER CONFIDENCE LEVEL OF THE MEAN

NOTES:

1. ONE-HALF THE DETECTION LIMIT SUBSTITUTED FOR NONDETECTS
2. FOR LOCATIONS WHERE SURFACE AND SUBSURFACE SAMPLES AVAILABLE, MAXIMUM CONCENTRATION USED IN CALCULATION OF UCL

SYMBOL	METAL	CONCORD TIDAL AREA AMBIENT	RWQCB SAN FRANCISCO BAY AMBIENT	WHOLE SITE 95% UCL	AQUATIC HABITAT 95% UCL	WETLAND AND UPLAND TRANSITIONAL 95% UCL
As	Arsenic	27	15.3	26.7	29.2	37.6
Cr	Chromium	82.1	112	204	311	308
Cu	Copper	81	68.1	1094	418	1690
Pb	Lead	95	43.2	1126	747	1690
Zn	Zinc	264	158	1309	1040	1660

15 0 15 30
SCALE IN FEET

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

ENGINEERING FIELD ACTIVITY WEST

SAN BRUNO, CALIFORNIA

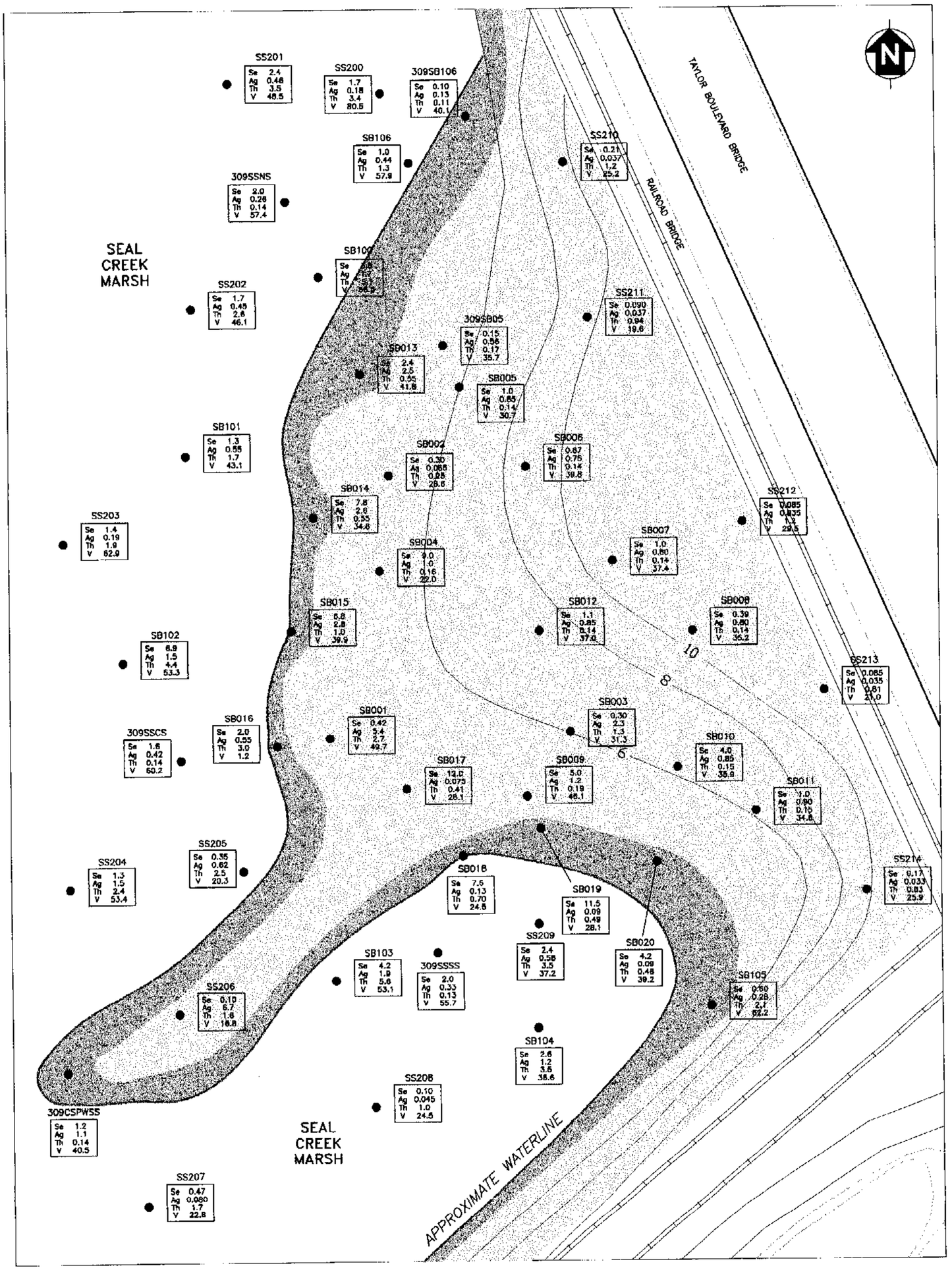
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Figure 5-23

CONCENTRATIONS OF ARSENIC, CHROMIUM, COPPER, LEAD, AND ZINC IN SEDIMENT (in mg/kg)

TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

DS.0309.15131



LEGEND:

- ● SAMPLE LOCATION
- WETLAND AND UPLAND TRANSITIONAL HABITAT
- AQUATIC HABITAT
- SHORELINE: APPROXIMATE SEASONAL WATER LEVEL VARIATION
- APPROXIMATE SHORELINE
- NA NOT ANALYZED
- mg/kg MILLIGRAMS PER KILOGRAM
- UCL UPPER CONFIDENCE LEVEL OF THE MEAN

NOTES:

1. ONE-HALF THE DETECTION LIMIT SUBSTITUTED FOR NONDETECTS
2. FOR LOCATIONS WHERE SURFACE AND SUBSURFACE SAMPLES AVAILABLE, MAXIMUM CONCENTRATION USED IN CALCULATION OF UCL

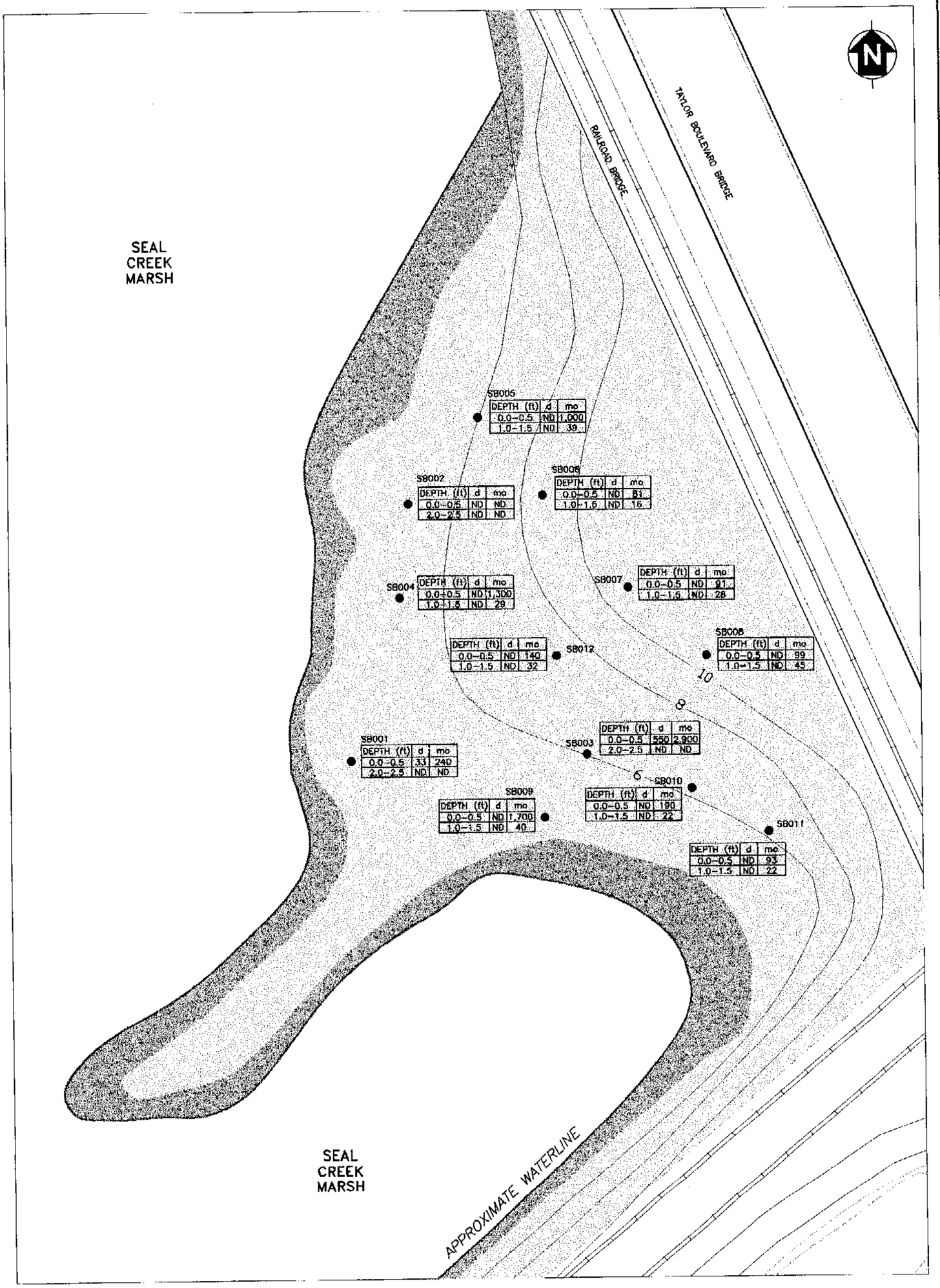
SYMBOL	ANALYTE	CONCORD TIDAL AREA AMBIENT	RWQCB SAN FRANCISCO BAY AMBIENT	WHOLE SITE 95% UCL	AQUATIC HABITAT 95% UCL	WETLAND AND UPLAND TRANSITIONAL 95% UCL
Se	Selenium	NA	0.64	3.2	3.7	3.8
Ag	Silver	NA	0.58	1.3	1.1	1.6
Th	Thallium	2.2	NA	1.7	2.36	0.95
V	Vanadium	96	NA	42	48.3	36

15 0 15 30
SCALE IN FEET

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
ENGINEERING FIELD ACTIVITY WEST
SAN BRUNO, CALIFORNIA
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Figure 5-24
CONCENTRATIONS OF SELENIUM, SILVER, THALLIUM, AND VANADIUM IN SEDIMENT (in mg/kg)
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

DS.0309.15131



LEGEND:

● SAMPLE LOCATION

DEPTH (ft)	d	mo
0.0–0.5	33	240
1.0–1.5	ND	ND

=CONCENTRATION OF MOTOR OIL (mo) IN mg/kg (ND=NOT DETECTED)

=CONCENTRATION OF DIESEL (d) IN mg/kg (ND=NOT DETECTED)

mg/kg MILLIGRAMS PER KILOGRAM

ft FEET

WETLAND AND UPLAND TRANSITIONAL HABITAT

AQUATIC HABITAT

SHORELINE: APPROXIMATE SEASONAL WATER LEVEL VARIATION

APPROXIMATE SHORELINE

15 0 15 30
SCALE IN FEET

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

ENGINEERING FIELD ACTIVITY WEST

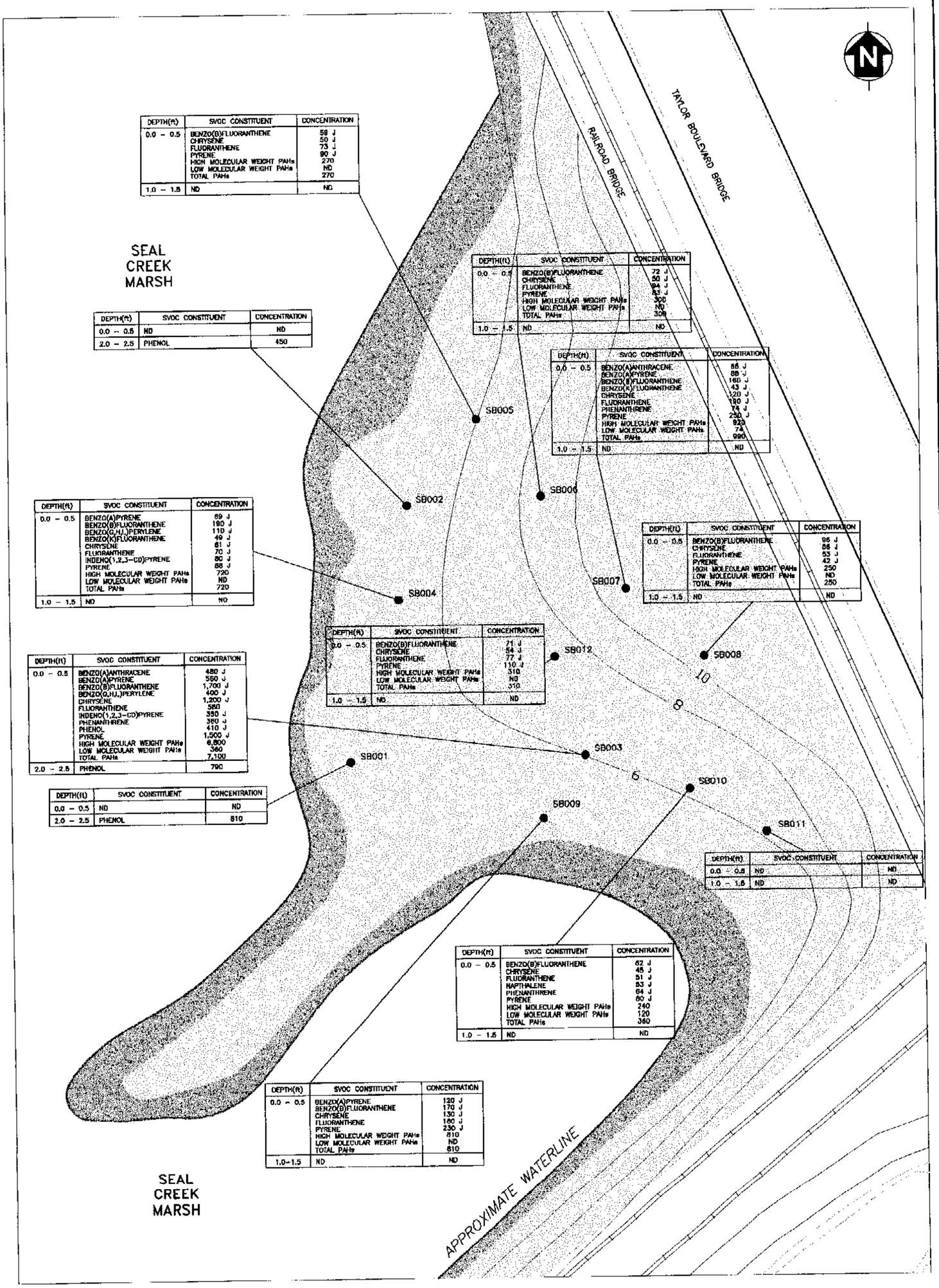
SAN BRUNO, CALIFORNIA

NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Figure 5–25

PETROLEUM HYDROCARBON CONCENTRATIONS IN SEDIMENT TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

DS.0309.15131



DEPTH(ft)	SVOC CONSTITUENT	CONCENTRATION
0.0 – 0.5	BENZO(B)FLUORANTHENE	58 J
	CHRYSENE	50 J
	FLUORANTHENE	73 J
	PYRENE	90 J
	HIGH MOLECULAR WEIGHT PAHs	270
	LOW MOLECULAR WEIGHT PAHs	ND
	TOTAL PAHs	270
1.0 – 1.5	ND	ND

DEPTH(ft)	SVOC CONSTITUENT	CONCENTRATION
0.0 – 0.5	ND	ND
2.0 – 2.5	PHENOL	450

DEPTH(ft)	SVOC CONSTITUENT	CONCENTRATION
0.0 – 0.5	BENZO(B)FLUORANTHENE	72 J
	CHRYSENE	50 J
	FLUORANTHENE	94 J
	PYRENE	83 J
	HIGH MOLECULAR WEIGHT PAHs	300
	LOW MOLECULAR WEIGHT PAHs	ND
	TOTAL PAHs	300
1.0 – 1.5	ND	ND

DEPTH(ft)	SVOC CONSTITUENT	CONCENTRATION
0.0 – 0.5	BENZO(A)ANTHRACENE	86 J
	BENZO(A)PYRENE	88 J
	BENZO(B)FLUORANTHENE	160 J
	BENZO(K)FLUORANTHENE	43 J
	CHRYSENE	120 J
	FLUORANTHENE	190 J
	PHENANTHRENE	74 J
	PYRENE	250 J
	HIGH MOLECULAR WEIGHT PAHs	920
	LOW MOLECULAR WEIGHT PAHs	74
	TOTAL PAHs	990
1.0 – 1.5	ND	ND

DEPTH(ft)	SVOC CONSTITUENT	CONCENTRATION
0.0 – 0.5	BENZO(A)PYRENE	69 J
	BENZO(B)FLUORANTHENE	190 J
	BENZO(G,H,I)PERYLENE	110 J
	BENZO(K)FLUORANTHENE	49 J
	CHRYSENE	61 J
	FLUORANTHENE	70 J
	INDENO(1,2,3-CD)PYRENE	50 J
	PYRENE	85 J
	HIGH MOLECULAR WEIGHT PAHs	720
	LOW MOLECULAR WEIGHT PAHs	ND
	TOTAL PAHs	720
1.0 – 1.5	ND	ND

DEPTH(ft)	SVOC CONSTITUENT	CONCENTRATION
0.0 – 0.5	BENZO(B)FLUORANTHENE	95 J
	CHRYSENE	56 J
	FLUORANTHENE	53 J
	PYRENE	42 J
	HIGH MOLECULAR WEIGHT PAHs	250
	LOW MOLECULAR WEIGHT PAHs	ND
	TOTAL PAHs	250
1.0 – 1.5	ND	ND

DEPTH(ft)	SVOC CONSTITUENT	CONCENTRATION
0.0 – 0.5	BENZO(B)FLUORANTHENE	71 J
	CHRYSENE	54 J
	FLUORANTHENE	77 J
	PYRENE	110 J
	HIGH MOLECULAR WEIGHT PAHs	310
	LOW MOLECULAR WEIGHT PAHs	ND
	TOTAL PAHs	310
1.0 – 1.5	ND	ND

DEPTH(ft)	SVOC CONSTITUENT	CONCENTRATION
0.0 – 0.5	BENZO(A)ANTHRACENE	480 J
	BENZO(A)PYRENE	550 J
	BENZO(B)FLUORANTHENE	1,700 J
	BENZO(G,H,I)PERYLENE	400 J
	CHRYSENE	1,200 J
	FLUORANTHENE	380
	INDENO(1,2,3-CD)PYRENE	350 J
	PHENANTHRENE	380 J
	PHENOL	410 J
	PYRENE	1,500 J
	HIGH MOLECULAR WEIGHT PAHs	6,800
	LOW MOLECULAR WEIGHT PAHs	380
	TOTAL PAHs	7,100
2.0 – 2.5	PHENOL	790

DEPTH(ft)	SVOC CONSTITUENT	CONCENTRATION
0.0 – 0.5	ND	ND
2.0 – 2.5	PHENOL	810

DEPTH(ft)	SVOC CONSTITUENT	CONCENTRATION
0.0 – 0.5	ND	ND
1.0 – 1.5	ND	ND

DEPTH(ft)	SVOC CONSTITUENT	CONCENTRATION
0.0 – 0.5	BENZO(B)FLUORANTHENE	62 J
	CHRYSENE	48 J
	FLUORANTHENE	51 J
	NAPTHALENE	83 J
	PHENANTHRENE	64 J
	PYRENE	80 J
	HIGH MOLECULAR WEIGHT PAHs	240
	LOW MOLECULAR WEIGHT PAHs	120
	TOTAL PAHs	360
1.0 – 1.5	ND	ND

DEPTH(ft)	SVOC CONSTITUENT	CONCENTRATION
0.0 – 0.5	BENZO(A)PYRENE	120 J
	BENZO(B)FLUORANTHENE	170 J
	CHRYSENE	130 J
	FLUORANTHENE	160 J
	PYRENE	230 J
	HIGH MOLECULAR WEIGHT PAHs	810
	LOW MOLECULAR WEIGHT PAHs	ND
	TOTAL PAHs	810
1.0-1.5	ND	ND

LEGEND:

- ● SAMPLE LOCATION
- SVOC SEMIVOLATILE ORGANIC COMPOUNDS
- J ESTIMATED CONCENTRATION
- ND NO SVOCs DETECTED
- PAH POLYCYCLIC AROMATIC HYDROCARBON
- WETLAND AND UPLAND TRANSITIONAL HABITAT
- AQUATIC HABITAT
- SHORELINE: APPROXIMATE SEASONAL WATER LEVEL VARIATION
- APPROXIMATE SHORELINE

NOTES:

1. ALL CONCENTRATIONS ARE MICROGRAMS PER KILOGRAM.
2. TABLES LIST DETECTED SVOCs.

15 0 15 30
SCALE IN FEET

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

ENGINEERING FIELD ACTIVITY WEST

SAN BRUNO, CALIFORNIA

NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Figure 5-26

DETECTED SVOC CONCENTRATIONS IN SEDIMENT SAMPLES TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

RCM (97) (060-230) 5-SVOCSAMPLE.DWG 96/08/00 REV 003 CHANGED LEGEND

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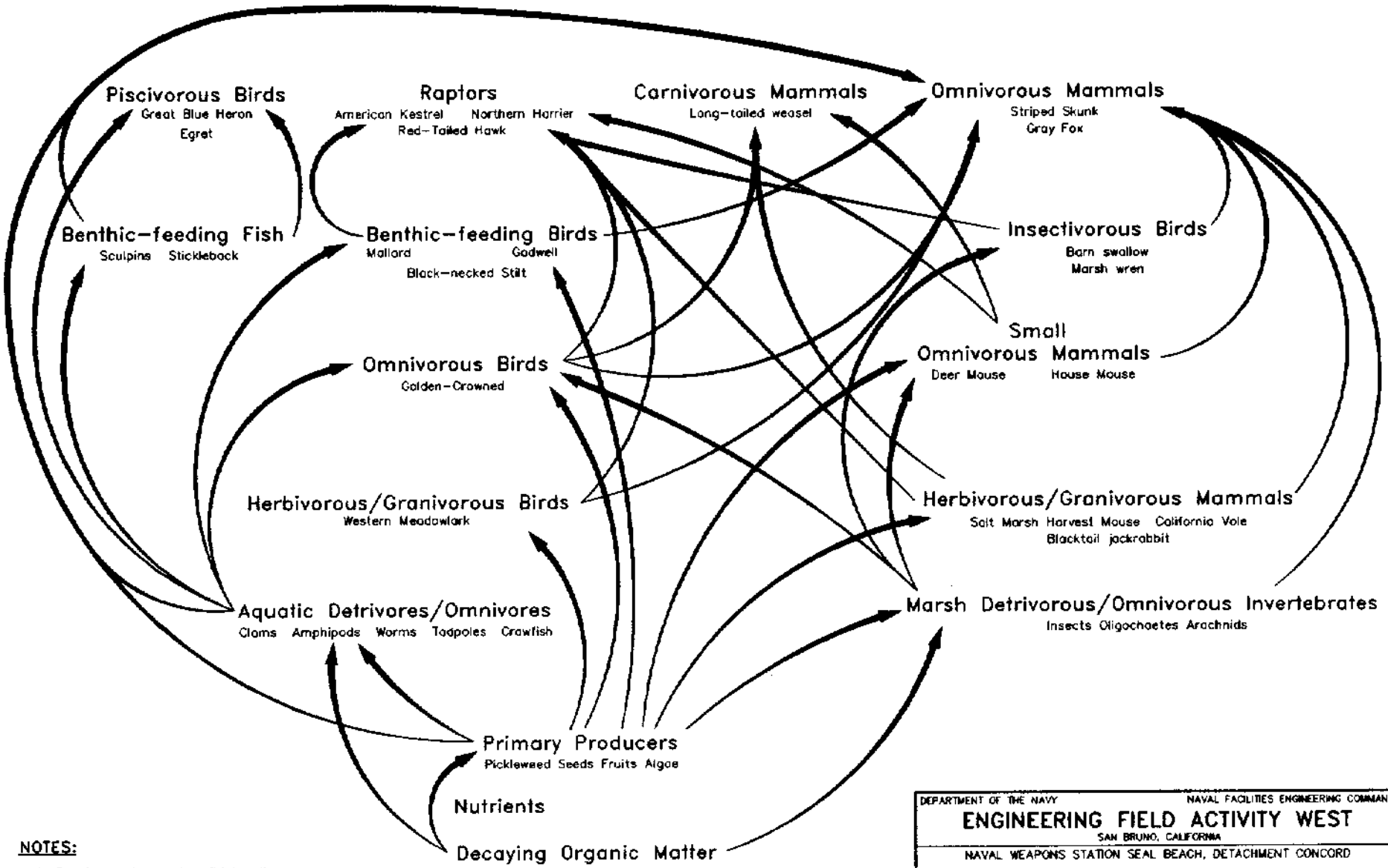

NOTES:

1. Species under each guild heading vary in actual diet composition.
2. The habitat provided at the TBB disposal area is minimal due to its small size, consequently, use of the site by top level receptors is expected to be minimal.

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ENGINEERING FIELD ACTIVITY WEST

SAN BRUNO, CALIFORNIA

NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

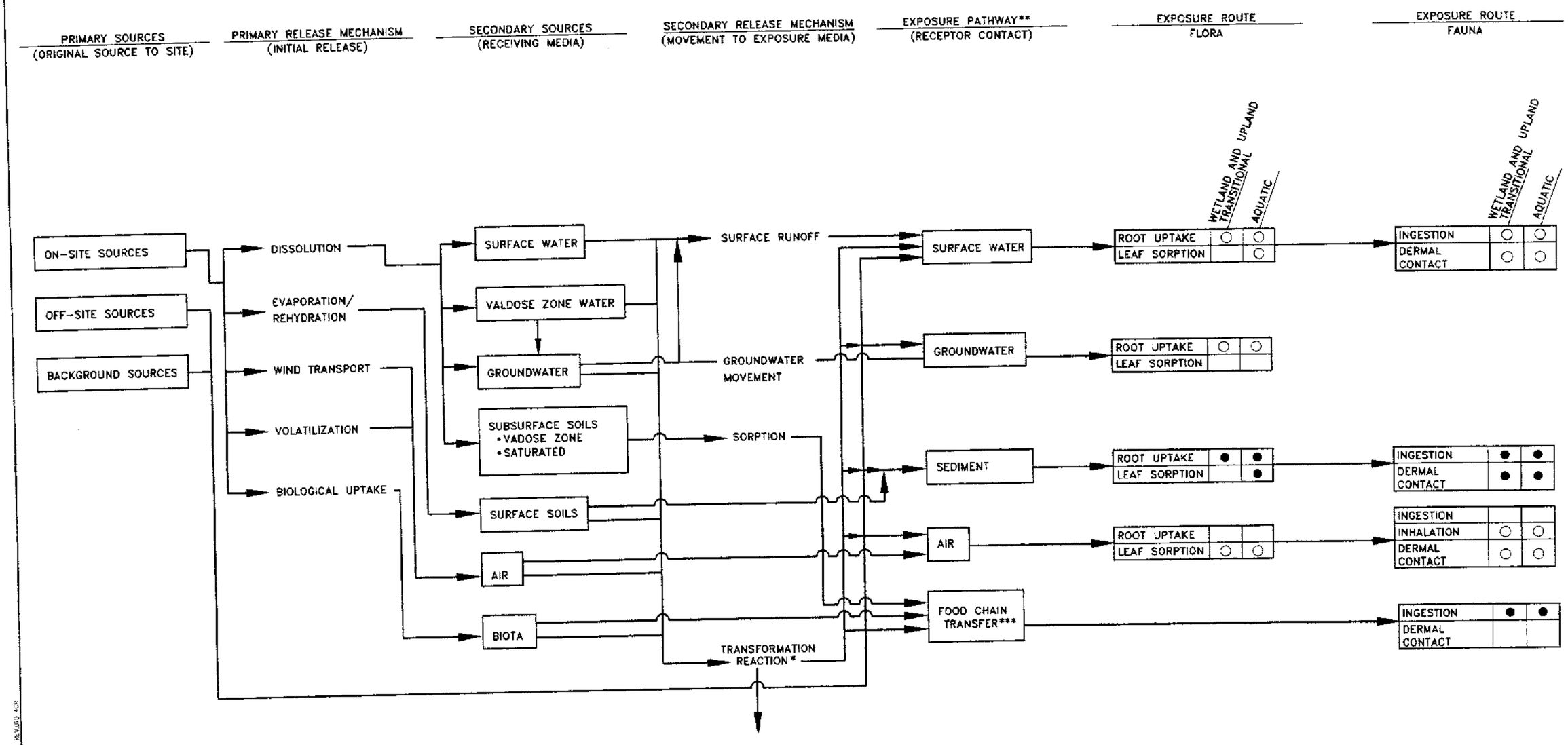
FIGURE B-1

FOOD WEB

AQUATIC AND WETLAND/UPLAND TRANSITIONAL HABITATS

TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

DS.0309.15131



LEGEND

* TRANSFORMATION REACTIONS MAY ALSO OCCUR AS A PRIMARY RELEASE MECHANISM

** ADDITIONAL INTERACTION MAY OCCUR BETWEEN EACH OF THESE PATHWAYS THAT MAY NOT BE SHOWN

*** INCLUDES DETRITIVORES AND CONSUMERS

● MAJOR EXPOSURE ROUTES (EVALUATED IN BASELINE ERA)

○ MINOR EXPOSURE ROUTES (NOT EVALUATED IN BASELINE ERA)

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

ENGINEERING FIELD ACTIVITY WEST

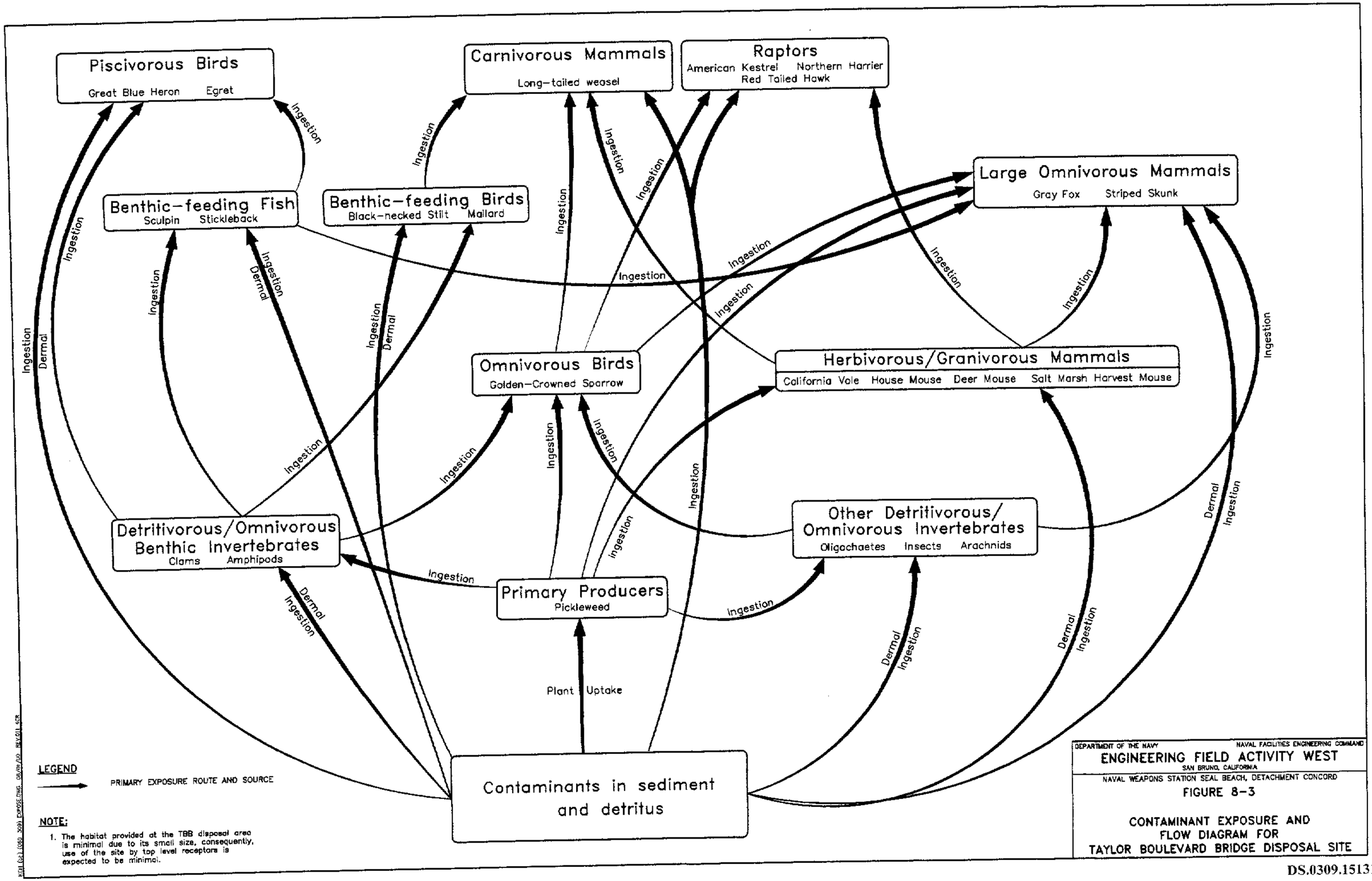
SAN BRUNO, CALIFORNIA

NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

FIGURE 8-2

POTENTIAL EXPOSURE ROUTES
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

DS.0309.15131



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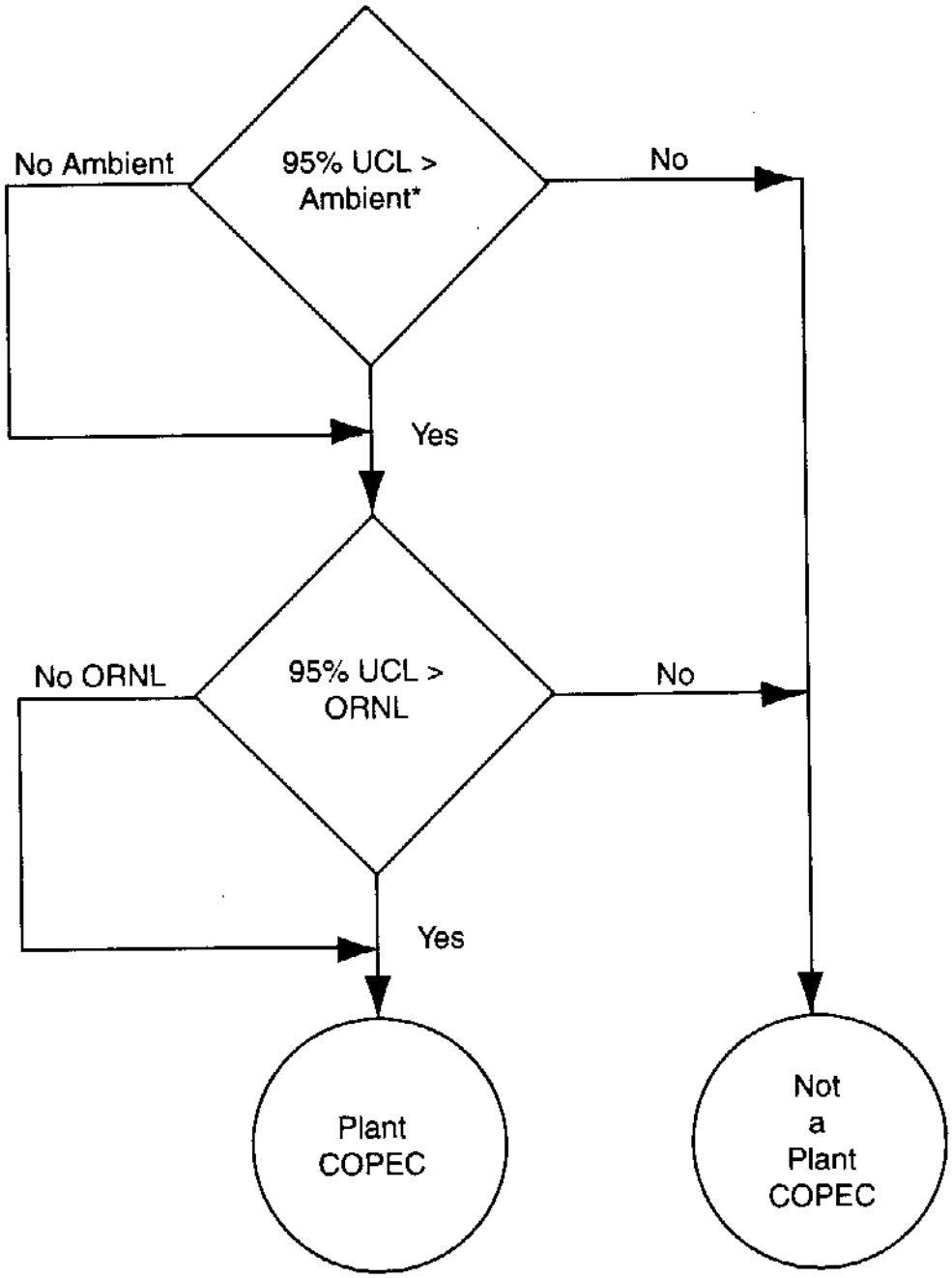


* Ambient = Most conservative of RWQCB San Franicsco Bay or Tidal Area ambient

95% UCL of mean was calculated using 1/2 the detection
limit for nondetects

COPEC = Chemical of potential ecological concern

UCL = Upper confidence limit

ORNL = Oak Ridge National Laboratory

RWQCB = Regional Water Quality Control Board

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

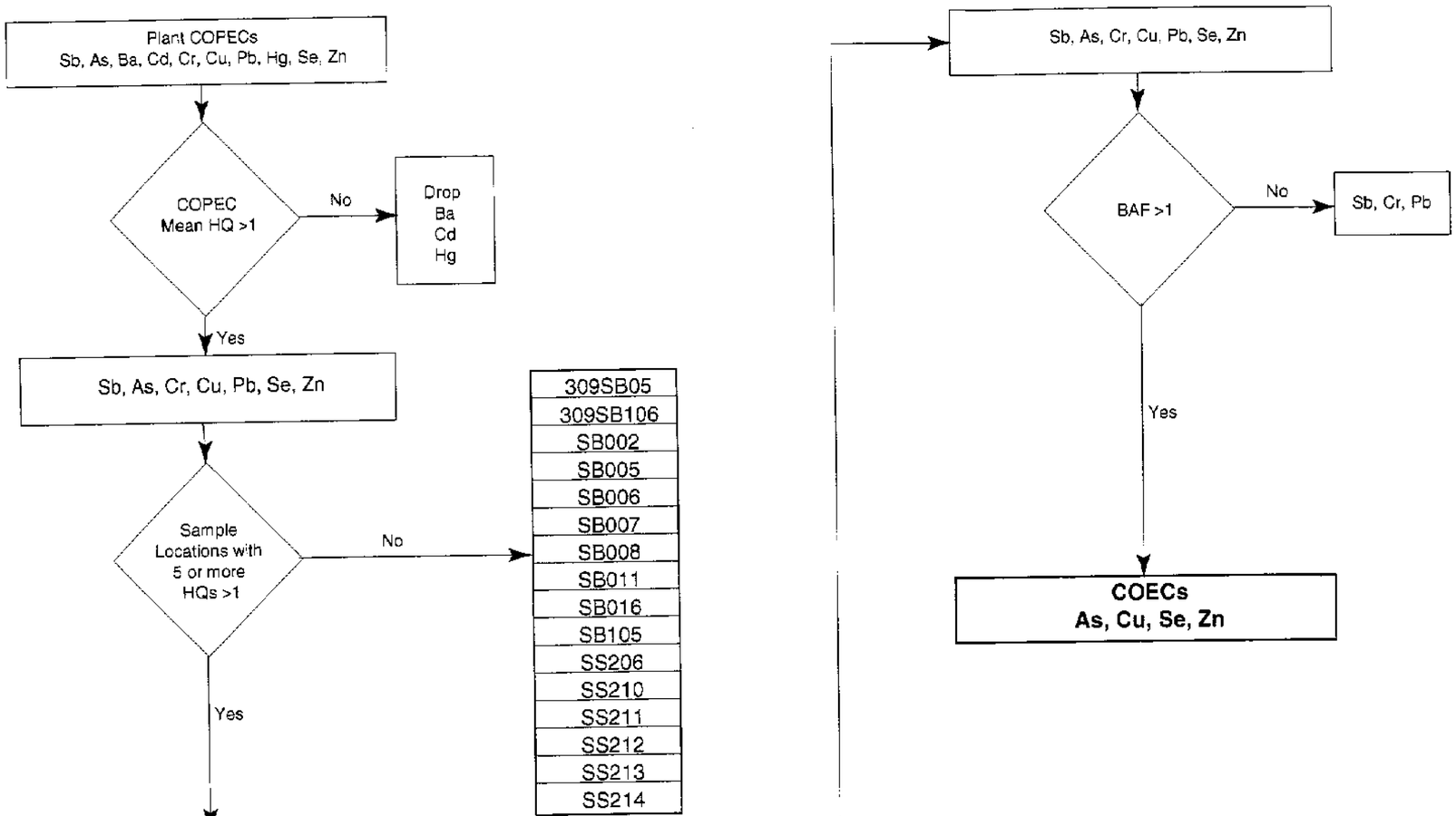
ENGINEERING FIELD ACTIVITY WEST

SAN BRUNO, CALIFORNIA

NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

FIGURE 8-4
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN (COPEC)
PROCESS FLOW CHART FOR WETLAND AND UPLAND TRANSITIONAL PLANTS

DS.0309.15131



Sample Location	Sb	As	Cr	Cu	Pb	Se	Zn
309CSPWSS	1.3	5.7	3.7	6.2	46.0	1.2	45.4
SB001	1.1	5.8	6.8	12.2	51.2	0.42	81.8
SB003	16.8	14.2	6.3	133	154	0.30	79.2
SB004	3.6	6.1	6.0	7.6	101	9.0	42.0
SB009	1.2	3.8	2.2	6.5	31.2	5.0	108
SB010	6.4	3.4	5.0	250	37.4	4.0	99.2
SB012	1.0	0.66	1.4	1.4	15.0	1.1	3.9
SB013	0.50	2.0	2.3	20.6	11.9	2.4	18.2
SB014	1.3	6.1	3.9	5.4	65.6	7.8	33.2
SB015	5.3	5.8	150	14.5	20.4	6.8	30.8
SB017	0.078	0.034	8.7	10.3	40.6	12.0	41.2
SB018	1.2	10.6	2.4	33.4	25.4	7.6	22.6
SB019	0.76	5.3	4.3	8.6	32.8	11.5	14.7
SB020	0.54	2.3	3.7	39.6	23.6	4.2	36.0

EXPLANATION

As, Arsenic.
Ba, Barium.
BAF, Bioaccumulation factor.
Cd, Cadmium.
COECs, Chemicals of ecological concern.
COPECs, Chemicals of potential ecological concern.
Cr, Chromium.
Cu, Copper.
Hg, Mercury.
HQ, Hazard quotient, see note below.
NA, not applicable.
ORNL, Oak Ridge National Laboratory.
Pb, Lead.
Sb, Antimony.
Se, Selenium.
Zn, Zinc.

Hazard quotients (HQ) were calculated by dividing the COPEC concentration at that sample location by the ORNL plant toxicity benchmark for that COPEC.

Mean hazard quotients (mean HQ) were calculated by summing hazard quotients for one COPEC across sample locations and dividing that sum by the number of sample locations at which that COPEC was present.

Bioaccumulation factors were calculated by dividing the plant tissue metal concentration (milligrams/kilogram dry weight) by the sediment metal concentration (milligrams/kilogram dry weight).

Efroynison, R.A., and others. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision." Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER.TM-85.

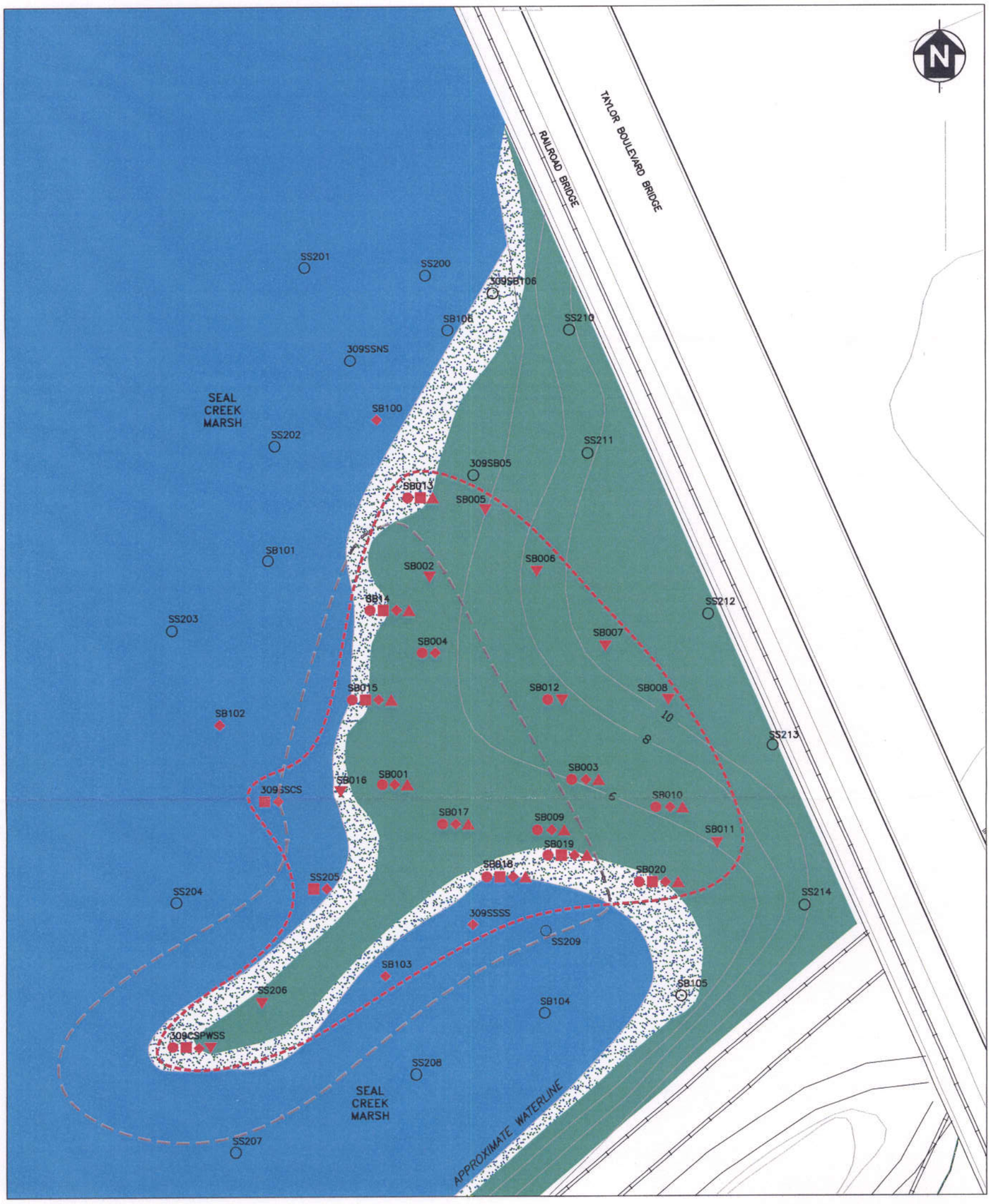
DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

ENGINEERING FIELD ACTIVITY WEST
SAN BRUNO, CALIFORNIA

NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

FIGURE 8-5
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE CHEMICALS OF ECOLOGICAL CONCERN (COEC) PROCESS FLOW CHART FOR WETLAND AND UPLAND TRANSITIONAL PLANTS

DS.0309.15131



LEGEND:

- ○ MINIMAL RISK TO ASSESSMENT ENDPOINT RECEPTORS
- ● RISK TO PLANTS INDICATED; SAMPLE LOCATION HAS FIVE OR MORE HQs GREATER THAN 1.0
- ■ RISK TO BENTHIC INVERTEBRATES INDICATED; ONE OR MORE MEAN ER-Mq GREATER THAN 1.5
- ◆ RISK TO BIRDS INDICATED; SAMPLE LOCATION HAS ONE OR MORE METAL CONCENTRATIONS GREATER THAN 95th PERCENT UCL
- ▲ RISK TO SALT MARSH HARVEST MICE INDICATED; SAMPLE LOCATION HAS TWO OR MORE HQ (Low Dose/High TRV) GREATER THAN 1.0
- ▼ RISK TO SALT MARSH HARVEST MICE INDICATED; SAMPLE LOCATION HAS TWO OR MORE HQ (High Dose/High TRV) GREATER THAN 1.0
- WETLAND AND UPLAND TRANSITIONAL HABITAT
- AQUATIC HABITAT
- SHORELINE: APPROXIMATE SEASONAL WATER LEVEL VARIATION
- SAMPLES 309SSNS, 309SSSS, AND 309SSCS ARE COMPOSITES POOLED FROM THREE SEDIMENT SAMPLES
- APPROXIMATE SHORELINE
- APPROXIMATE EXTENT OF DEBRIS
- APPROXIMATE RISK FOOTPRINT

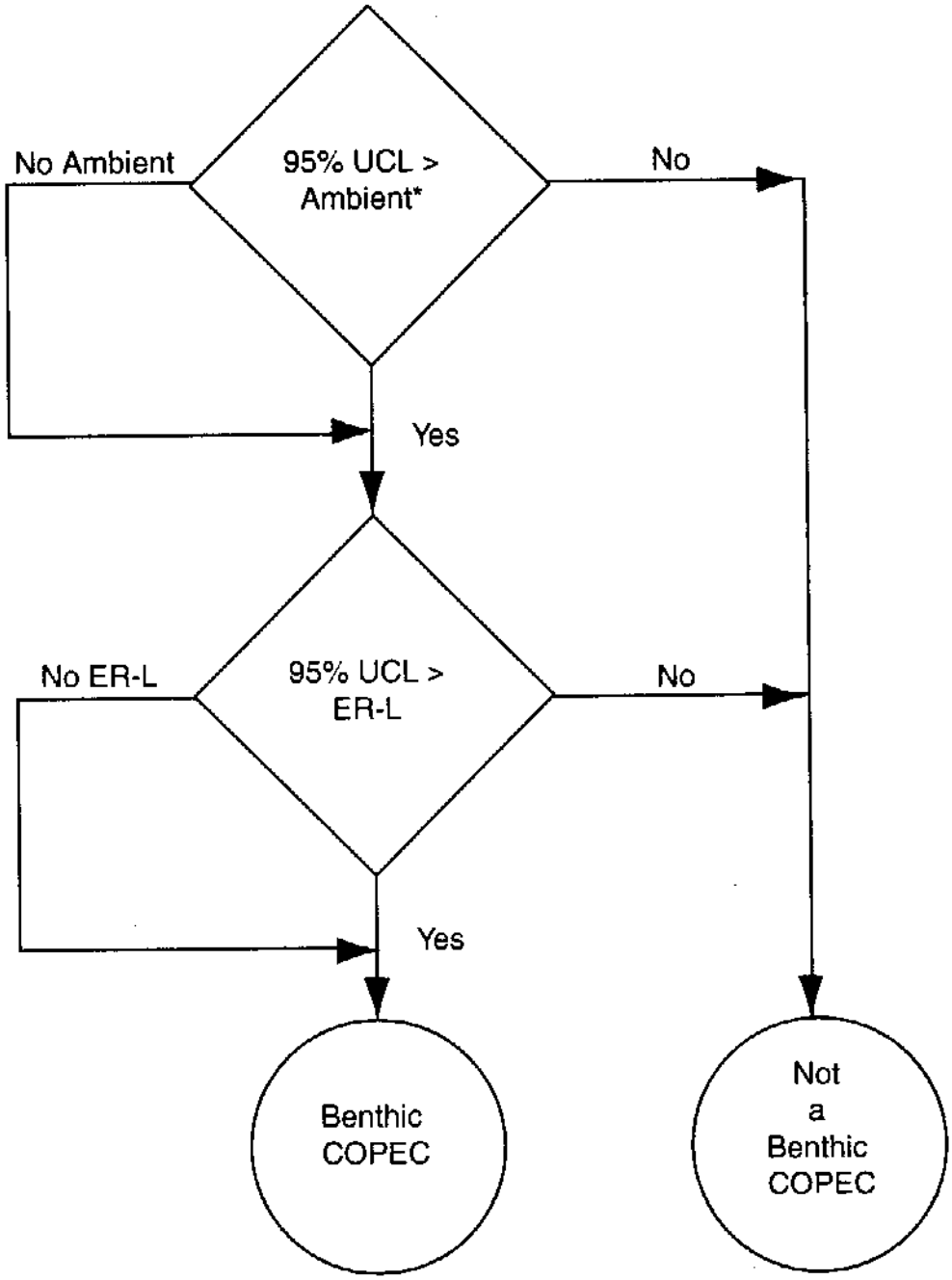
20 0 20 40
SCALE IN FEET

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
ENGINEERING FIELD ACTIVITY WEST
SAN BRUNO, CALIFORNIA
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Figure 8-6
ESTIMATED RISK TO ASSESSMENT ENDPOINT RECEPTORS TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

DS.0309.15131

KCH (SF) (069-309) RISKFT1.DWG 02/27/01 REV.004 by MVT (DN)



* Ambient = Most conservative of RWQCB San Franicsco Bay or Tidal Area ambient

95% UCL was calculated using 1/2 the detection limit for nondetects

COPEC = Chemical of potential ecological concern

UCL = Upper confidence limit

ER-L = Effects range - low

RWQCB = Regional Water Quality Control Board

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

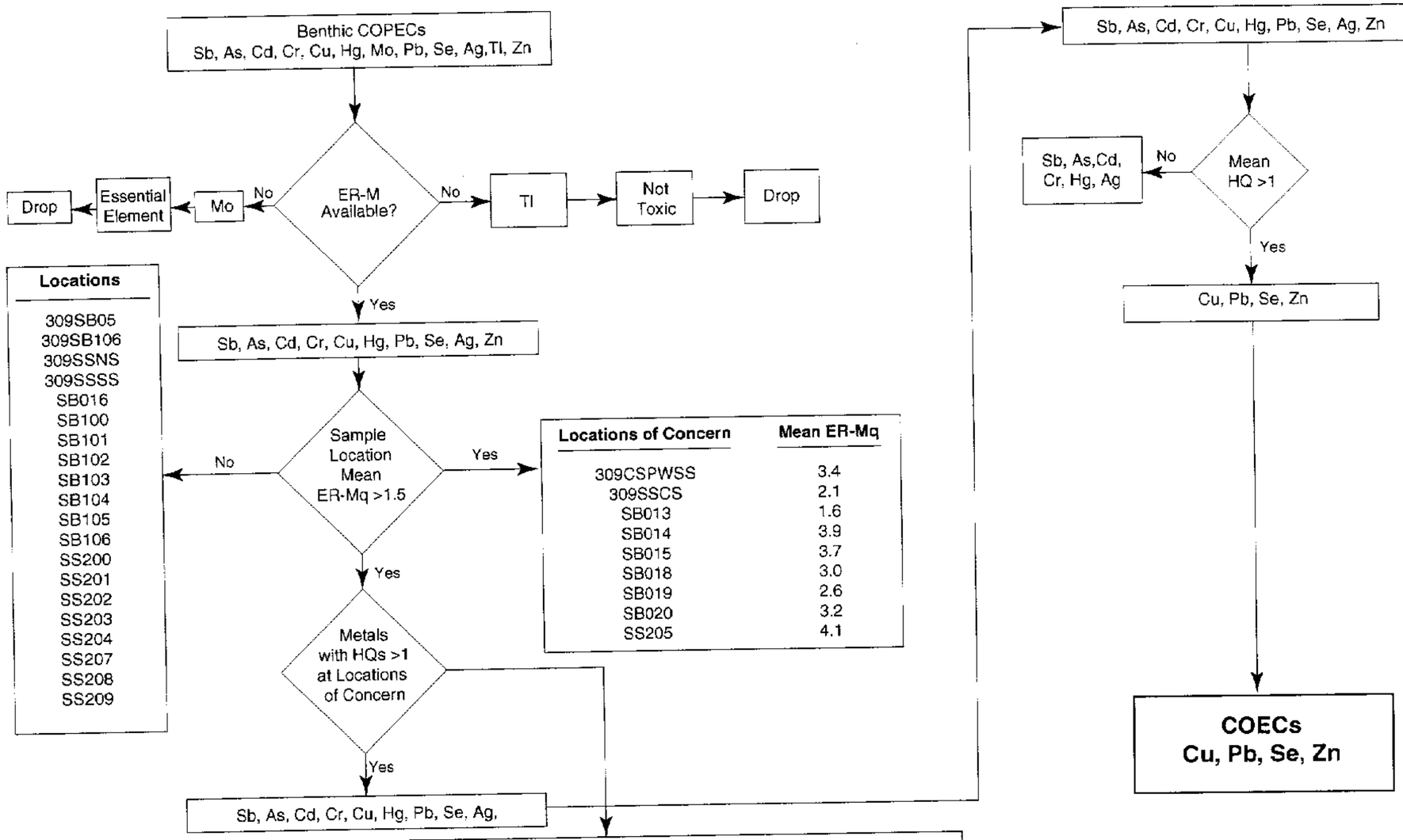
ENGINEERING FIELD ACTIVITY WEST

SAN BRUNO, CALIFORNIA

NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

FIGURE 8-7
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN (COPEC)
PROCESS FLOW CHART FOR BENTHIC INVERTEBRATES

DS.0309.15131



HQs >1 - Bold in Table Below

Sample Location	Sb	As	Cd	Cr	Cu	Pb	Hg	Se	Ag	Zn
309CSPWSS	0.29	0.81	0.81	0.20	**1.2**	**10.6**	0.55	0.86	0.29	**15.1**
309SSCS	0.13	0.47	0.25	0.14	0.48	**2.5**	0.70	**1.1**	0.11	**13.2**
SB013	0.11	0.28	0.0037	0.12	**3.8**	**2.7**	0.90	**1.7**	0.68	**6.1**
SB014	0.28	0.88	0.0036	0.21	1.0	**15.0**	0.27	**5.6**	0.70	**11.1**
SB015	**1.1**	0.82	0.0068	**8.1**	**2.7**	**4.7**	0.10	**4.9**	0.76	**10.3**
SB018	0.25	**1.5**	0.0048	0.13	**6.2**	**5.8**	0.30	**5.4**	0.034	**7.5**
SB019	0.17	0.75	0.0034	0.23	**1.6**	**7.5**	0.20	**8.2**	0.024	**4.9**
SB020	0.12	0.33	0.0031	0.20	**7.3**	**5.4**	0.042	**3.0**	0.023	**12.0**
SS205	0.091	0.38	0.25	0.041	0.61	**1.7**	0.0070	0.25	0.17	**33.2**
Mean HQ	0.29	0.69	0.15	1.0	**2.8**	**6.2**	0.34	**3.5**	0.31	**12.6**

EXPLANATION

As, Arsenic.
COECs, Chemicals of ecological concern.
COPECs, Chemicals of potential ecological concern.
Cd, Cadmium.
Cr, Chromium.
Cu, Copper.
ER-M, Effects range-median. After Long and others (1995).
Hg, Mercury
HQs, Hazard quotients. See note below.
Mean ER-Mq, mean effects range-median quotient. After Long and MacDonald (1998). See note below.
Mean HQ, Mean hazard quotient. See note below.
Mo, Molybdenum.
Pb, Lead.
Sb, Antimony.
Se, Selenium.
Tl, Thallium.
Ag, Silver.
Zn, Zinc.

Hazard quotients (HQ) were calculated by dividing the COPEC concentration at that sample location by the ER-M for that COPEC.

Mean ER-Mq quotients (mean ER-Mq) were calculated by summing hazard quotients for one sample location across COPECs and dividing that sum by the number of COPECs present at that sample location.

Mean hazard quotients (mean HQ) were calculated by summing hazard quotients for one COPEC across sample locations and dividing that sum by the number of sample locations at which the ER-Mq was greater than 1.5.

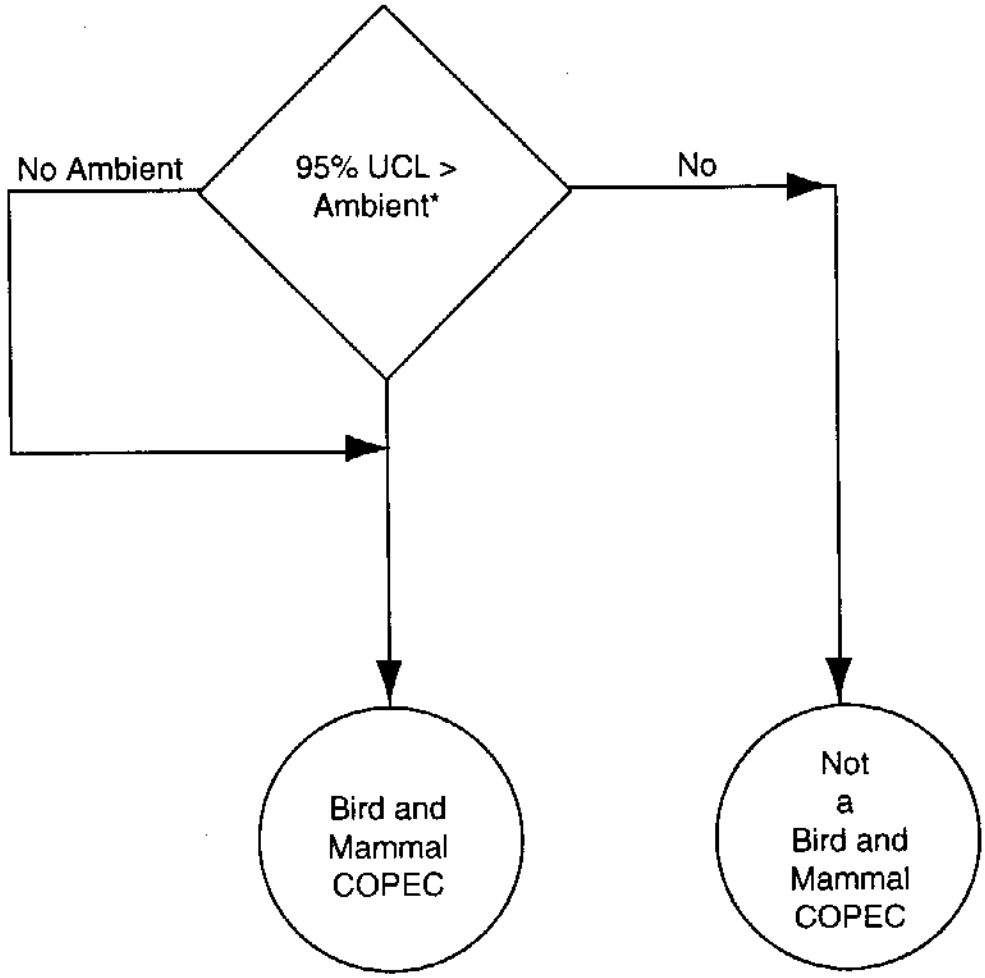
Long, E.R., D.D. MacDonald, S.L. Smith, F.D. Calder, 1995. "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." Environmental Management 19(1):81-97.

Long, E.R. and D.D. MacDonald, 1998. "Recommended Uses of Empirically Derived, Sediment Quality Guidelines for Marine and Estuarine Ecosystems." *Human Ecological Risk Assessment*, Volume 4, Number 5, Pages 1019 through 1039.

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
ENGINEERING FIELD ACTIVITY WEST
SAN BRUNO, CALIFORNIA
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

FIGURE 8-8
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
CHEMICALS OF ECOLOGICAL CONCERN (COEC)
PROCESS FLOW CHART
FOR BENTHIC INVERTEBRATES

DS.0309.15131



* Ambient = Most conservative of RWQCB San Franicsco Bay or Tidal Area ambient

95% UCL was calculated using 1/2 the detection limit for nondetects

COPEC = Chemical of potential ecological concern

RWQCB = Regional Water Quality Control Board

UCL = Upper confidence limit

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

ENGINEERING FIELD ACTIVITY WEST

SAN BRUNO, CALIFORNIA

NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

FIGURE 8-9
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN (COPEC)
PROCESS FLOW CHART FOR BIRDS AND MAMMALS

DS.0309.15131

TABLE 5-1
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
SAMPLE ANALYTE LIST

			Chemistry				Sediment Parameters				Toxicity Test	Bioaccumulation		
Sample Location	Sample Depth(s) (ft. bgs)	Habitat[a]	Metals	SVOCs	TPH-purgeable	TPH-extractable	SEM/AVS	TOC	Grain Size	pH	Amphipod Bioassay	Pickleweed Tissue	Amphipod Tissue	Sample Collection Date
309CSPWSS	0 - 0.5	shoreline	X									X - metals		February-00
309SB05	0 - 0.5	shoreline	X									X - metals		February-00
309SB106	0 - 0.5	shoreline	X									X - metals		February-00
309SSCS	0 - 0.5	aquatic	X				X	X	X	X	X		X - metals	February-00
309SSNS	0 - 0.5	aquatic	X				X	X	X	X	X		X - metals	February-00
309SSSS	0 - 0.5	aquatic	X				X	X	X	X	X		X - metals	February-00
SB001	0-0.5 and 2.0-2.5	wetland / upland	X	X	X	X								February-96
SB002	0-0.5 and 2.0-2.5	wetland / upland	X	X	X	X								February-96
SB003	0-0.5 and 2.0-2.5	wetland / upland	X	X	X	X								February-96
SB004	0-0.5 and 1.0-1.5	wetland / upland	X	X	X	X								March-97
SB005	0-0.5 and 1.0-1.5	wetland / upland	X	X	X	X								March-97
SB006	0-0.5 and 1.0-1.5	wetland / upland	X	X	X	X								March-97
SB007	0-0.5 and 1.0-1.5	wetland / upland	X	X	X	X								March-97
SB008	0-0.5 and 1.0-1.5	wetland / upland	X	X	X	X								March-97
SB009	0-0.5 and 1.0-1.5	wetland / upland	X	X	X	X								March-97
SB010	0-0.5 and 1.0-1.5	wetland / upland	X	X	X	X								March-97
SB011	0-0.5 and 1.0-1.5	wetland / upland	X	X	X	X								March-97
SB012	0-0.5 and 1.0-1.5	wetland / upland	X	X	X	X								March-97
SB013	0 - 0.5	shoreline	X											October-97
SB014	0 - 0.5	shoreline	X											October-97
SB015	0 - 0.5	shoreline	X											October-97
SB016	0 - 0.5	shoreline	X											October-97
SB017	0 - 0.5	wetland / upland	X											October-97
SB018	0 - 0.5	shoreline	X											October-97
SB019	0 - 0.5	shoreline	X											October-97
SB020	0 - 0.5	shoreline	X											October-97
SB100	0 - 0.5	aquatic	X											March-98
SB101	0 - 0.5	aquatic	X											March-98
SB102	0 - 0.5	aquatic	X											March-98
SB103	0 - 0.5	aquatic	X											March-98
SB104	0 - 0.5	aquatic	X											March-98
SB105	0 - 0.5	shoreline	X											March-98
SB106	0 - 0.5	aquatic	X											March-98
SS200	0 - 0.5	aquatic	X											June-98
SS201	0 - 0.5	aquatic	X											June-98
SS202	0 - 0.5	aquatic	X											June-98
SS203	0 - 0.5	aquatic	X											June-98
SS204	0 - 0.5	aquatic	X											June-98
SS205	0 - 0.5	aquatic	X											June-98
SS206	0 - 0.5	wetland / upland	X											June-98
SS207	0 - 0.5	aquatic	X											June-98
SS208	0 - 0.5	aquatic	X											June-98
SS209	0 - 0.5	aquatic	X											June-98
SS210	0 - 0.5	wetland / upland	X											June-98

TABLE 5-1
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
SAMPLE ANALYTE LIST

			Chemistry				Sediment Parameters				Toxicity Test	Bioaccumulation		
Sample Location	Sample Depth(s) (ft. bgs)	Habitat[a]	Metals	SVOCs	TPH-purgeable	TPH-extractable	SEM/AVS	TOC	Grain Size	pH	Amphipod Bioassay	Pickleweed Tissue	Amphipod Tissue	Sample Collection Date
SS211	0 - 0.5	wetland / upland	X											June-98
SS212	0 - 0.5	wetland / upland	X											June-98
SS213	0 - 0 5	wetland / upland	X											June-98
SS214	0 - 0.5	wetland / upland	X											June-98

Notes:

AVS - acid volatile sulfides
bgs - below ground surface
ft - feet
SVOCs - semivolatile organic compounds
SEM - simultaneously extractable metals
TOC - total organic carbon
TPH - total petroleum hydrocarbons
a - Shoreline locations are part of the wetland and upland transitional habitat and aquatic habitat

TABLE 5-2
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
DESCRIPTIVE SAMPLING DATA

Analyte	Total Number of Samples	Number of Surface Samples	Number of Subsurface Samples	Frequency of Detection	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Location of Maximum Detect	Depth of Maximum Detect (bgs)
Whole Site								
Aluminum	60	48	12	60/60	3	23300	033TBB200	0 - 0.5
Antimony*	45	38	7	26/45	0.37	84.2	TBBSB003	0 - 0.5
Arsenic	60	48	12	58/60	0.34	142	TBBSB003	0 - 0.5
Barium	60	48	12	60/60	5.6	4660	TBBSB001	0 - 0.5
Beryllium	60	48	12	37/60	0.01	0.6	TBBSB001	2 - 2.5
Cadmium	60	48	12	23/60	0.31	13.4	TBBSB010	0 - 0.5
Chromium	60	48	12	60/60	0.89	2990	TBBSB015	0 - 0.5
Cobalt	60	48	12	57/60	4.3	37.5	TBBSB004	0 - 0.5
Copper	60	48	12	55/60	1.1	12500	TBBSB010	0 - 0.5
Iron	60	48	12	60/60	63.2	378000	TBBSB017	0 - 0.5
Lead	60	48	12	60/60	1.7	7680	TBBSB003	0 - 0.5
Magnesium	60	48	12	60/60	88.2	15600	309SSSS	0 - 0.5
Manganese	60	48	12	60/60	0.69	2480	033TBB209	0 - 0.5
Mercury	60	48	12	14/60	0.18	26.4	TBBSB003	0 - 0.5
Molybdenum	60	48	12	41/60	0.08	301	TBBSB013	0 - 0.5
Nickel	60	48	12	60/60	0.89	262	TBBSB003	0 - 0.5
Selenium	60	48	12	31/60	0.17	12	TBBSB017	0 - 0.5
Silver	60	48	12	17/60	0.13	6.7	033TBB206	0 - 0.5
Thallium	60	48	12	22/60	0.11	3.5	033TBB201	0 - 0.5
Vanadium	60	48	12	60/60	1.2	80.5	033TBB200	0 - 0.5
Zinc	60	48	12	60/60	3.2	5410	TBBSB009	0 - 0.5

TABLE 5-2
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
DESCRIPTIVE SAMPLING DATA (CONTINUED)

Analyte	Total Sampled	No. Surface Samples	No. Subsurface Samples	Frequency of Detection	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Location of Maximum Detect	Depth of Maximum Detect (bgs)
Aquatic Habitat								
Aluminum	29	29	0	29/29	1890.00	23300.00	033TBB200	0 - 0.5
Antimony**	22	22	0	15/22	0.37	26.30	TBBSB015	0 - 0.5
Arsenic	29	29	0	27/29	3.20	106.00	TBBSB018	0 - 0.5
Barium	29	29	0	29/29	56.80	1140.00	TBBSB014	0 - 0.5
Beryllium	29	29	0	15/29	0.01	0.49	033TBB200	0 - 0.5
Cadmium	29	29	0	14/29	0.31	7.80	309CSPWSS	0 - 0.5
Chromium	29	29	0	29/29	0.89	2990.00	TBBSB015	0 - 0.5
Cobalt	29	29	0	26/29	4.30	27.80	TBBSB019	0 - 0.5
Copper	29	29	0	29/29	1.10	1980.00	TBBSB020	0 - 0.5
Iron	29	29	0	29/29	63.20	348000.00	TBBSB019	0 - 0.5
Lead	29	29	0	29/29	1.70	3280.00	TBBSB014	0 - 0.5
Magnesium	29	29	0	29/29	88.20	15600.00	309SSSS	0 - 0.5
Manganese	29	29	0	29/29	0.69	2480.00	033TBB209	0 - 0.5
Mercury	29	29	0	8/29	0.18	1.50	033TBB204	0 - 0.5
Molybdenum	29	29	0	28/29	0.10	301.00	TBBSB013	0 - 0.5
Nickel	29	29	0	29/29	0.89	126.00	TBBSB020	0 - 0.5
Selenium	29	29	0	18/29	0.47	11.50	TBBSB019	0 - 0.5
Silver	29	29	0	14/29	0.13	2.80	TBBSB015	0 - 0.5
Thallium	29	29	0	16/29	0.11	3.50	033TBB201	0 - 0.5
Vanadium	29	29	0	29/29	1.20	80.50	033TBB200	0 - 0.5
Zinc	29	29	0	29/29	3.20	4980.00	033TBB205	0 - 0.5

DESCRIPTIVE SAMPLING DATA (CONTINUED)

TABLE 5-2
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

Analyte	Total Sampled[a]	No. Surface Samples	No. Subsurface Samples	Frequency of Detection	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Location of Maximum Detect	Depth of Maximum Detect (bgs)
Wetland and Upland Transitional Plant Habitat								
Aluminum	42	30	12	42/42	3.00	19000.00	TBBSB001	2 - 2.5
Antimony***	34	27	7	20/42	0.37	84.20	TBBSB003	0 - 0.5
Arsenic	42	30	12	41/42	0.34	142.00	TBBSB003	0 - 0.5
Barium	42	30	12	42/42	5.60	4660.00	TBBSB001	0 - 0.5
Beryllium	42	30	12	25/42	0.01	0.60	TBBSB001	2 - 2.5
Cadmium	42	30	12	12/42	0.31	13.40	TBBSB010	0 - 0.5
Chromium	42	30	12	42/42	0.89	2990.00	TBBSB015	0 - 0.5
Cobalt	42	30	12	39/42	5.40	37.50	TBBSB004	0 - 0.5
Copper	42	30	12	37/42	1.10	12500.00	TBBSB010	0 - 0.5
Iron	42	30	12	42/42	63.20	378000.00	TBBSB017	0 - 0.5
Lead	42	30	12	42/42	1.70	7680.00	TBBSB003	0 - 0.5
Magnesium	42	30	12	42/42	88.20	9980.00	TBBSB105	0 - 0.5
Manganese	42	30	12	42/42	0.69	1940.00	309SB05	0 - 0.5
Mercury	42	30	12	10/42	0.18	26.40	TBBSB003	0 - 0.5
Molybdenum	42	30	12	23/42	0.08	301.00	TBBSB013	0 - 0.5
Nickel	42	30	12	42/42	0.89	262.00	TBBSB003	0 - 0.5
Selenium	42	30	12	20/42	0.17	12.00	TBBSB017	0 - 0.5
Silver	42	30	12	9/42	0.13	6.70	033TBB206	0 - 0.5
Thallium	42	30	12	10/42	0.11	2.10	TBBSB105	0 - 0.5
Vanadium	42	30	12	42/42	1.20	62.20	TBBSB105	0 - 0.5
Zinc	42	30	12	42/42	3.20	5410.00	TBBSB009	0 - 0.5

Notes:
* - Whole Site - 15 samples were rejected or antimony not analyzed
** - Aquatic habitat - 8 samples were rejected or antimony not analyzed
*** - Wetland and Upland Transitional Habitat - 8 samples were rejected or antimony not analyzed
a - When samples were collected in both surface and subsurface at the same location, subsequent calculations used the maximum concentration
bgs - below ground surface
mg/kg - milligrams per kilogram

TABLE 7-1

NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD TIDAL AREA AMBIENT

Analyte	Concord Tidal Area Ambient 99th % UCL[a] (mg/kg)
Aluminum	27,300
Antimony	2.2
Arsenic	27
Barium	530
Beryllium	0.18
Cadmium	1.90
Chromium	82.1
Cobalt	36
Copper	81
Lead	95
Manganese	1,500
Mercury	0.32
Molybdenum	6.6
Nickel	120
Selenium	NA
Silver	NA
Thallium	2.2
Vanadium	96
Zinc	264

Notes:

mg/kg milligram per kilogram

UCL Upper confidence limit of the mean

a PRC Environmental Management, Inc. 1996. "Technical Memorandum. Ambient Metal Concentrations in the Tidal Area Soils."

TABLE 7-2

EXPOSURE POINT CONCENTRATIONS FOR SOIL AND SEDIMENT COPCs
AREA WITHIN THE 400 MG/KG LEAD ISOPLETH (AREA A)
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE, NAVAL WEAPONS SEAL BEACH DETACHMENT CONCORD

Chemical of Potential Concern	Detection Frequency	Type of Distribution	Concentration (mg/kg)							
			Miminum SQL	Maximum SQL	Minimum Detected	Maximum Detected	Mean[a]	UCL_{95}[b]	CTE[c]	RME[d]
Metal										
Antimony	15/16	Lognormal	6.2	6.2	0.39	84.2	13.3	40.5	13.3	40.5
Arsenic	16/16	Lognormal	NL	NL	0.34	142	46.7	282	46.7	142
Barium	16/16	Lognormal	NL	NL	5.6	4,660	716	3,370	716	3,370
Beryllium	4/16	Lognormal	0.01	0.18	0.020	0.31	0.076	0.30	0.076	0.30
Cadmium	6/16	Lognormal	0.05	0.68	1.6	13.4	2.23	67.5	2.23	13.4
Chromium	16/16	Lognormal	NL	NL	17.7	2,990	261	379	261	379
Cobalt	14/16	Lognormal	11	12	9.6	37.5	18.9	26.0	18.9	26.0
Copper	16/16	Lognormal	NL	NL	71.7	12,500	1,770	4,610	1,770	4,610
Iron	16/16	Normal	NL	NL	8,500	378,000	179,000	230,000	179,000	230,000
Lead	16/16	Lognormal	NL	NL	486	7,680	2,110	3,470	2,110	3,470
Manganese	16/16	Lognormal	NL	NL	321	1,660	1,010	1,280	1,010	1,280
Mercury	8/16	Lognormal	0.05	0.84	0.18	26.4	2.1	10.1	2.1	10.1
Molybdenum	15/16	Lognormal	0.58	0.58	0.67	301	24.2	60.4	24.2	60.4
Nickel	16/16	Lognormal	NL	NL	21.9	262	105	153	105	153
Selenium	12/16	Normal	0.2	8.4	1.1	12.0	4.8	6.6	4.8	6.6
Silver	7/16	Lognormal	0.9	11.4	1.1	6.7	2.3	4.2	2.3	4.2
Thallium	2/16	Not Tested	0.24	11.2	0.14	1.6	1.0	2.4	1.0	2.4
Tin	1/1	Not Tested	NL	NL	1,700	1,700	1,700	1,700	1,700	1,700
Zinc	16/16	Lognormal	NL	NL	196	5,410	2,140	4,160	2,140	4,160
Semivolatile Organic Compound										
Benzo(a)anthracene	1/6	Not Tested	0.35	0.58	0.5	0.5	0.3	0.4	0.3	0.4

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TABLE 7-2 (Continued)

EXPOSURE POINT CONCENTRATIONS FOR SOIL AND SEDIMENT COPCs
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE, NAVAL WEAPONS SEAL BEACH DETACHMENT CONCORD
400 MG/KG LEAD ISOPLETH (AREA A)

Chemical of Potential Concern	Detection Frequency	Type of Distribution	Concentration (mg/kg)							
			Miminum SQL	Maximum SQL	Minimum Detected	Maximum Detected	Mean[a]	UCL_{95}[b]	CTE[c]	RME[d]
Benzo(a)pyrene	3/6	Not Tested	0.35	0.46	0.07	0.6	0.2	0.6	0.2	0.6
Benzo(b)fluoranthene	5/6	Lognormal	0.46	0.46	0.06	2	0.4	5	0.4	2
Benzo(g,h,i)perylene	2/6	Not Tested	0.35	0.58	0.1	0.4	0.2	0.4	0.2	0.4
Benzo(k)fluoranthene	1/6	Not Tested	0.35	2.2	0.05	0.05	0.3	2	0.05	0.05
Chrysene	5/6	Lognormal	0.46	0.46	0.05	1	0.3	5	0.3	1
Fluoranthene	5/6	Lognormal	0.46	0.46	0.05	0.6	0.2	1	0.2	0.6
Indeno(1,2,3-cd)pyrene	2/6	Not Tested	0.35	0.58	0.08	0.4	0.2	0.4	0.2	0.4
Naphthalene	1/6	Not Tested	0.35	0.58	0.05	0.05	0.2	0.5	0.05	0.05
Phenanthrene	2/6	Not Tested	0.35	0.58	0.06	0.4	0.2	0.5	0.2	0.4
Phenol	1/6	Not Tested	0.35	0.58	0.4	0.4	0.3	0.4	0.3	0.4
Pyrene	5/6	Lognormal	0.46	0.46	0.08	2	0.4	3	0.4	2

Notes

a The value presented is the arithmetic mean, calculated using distribution-dependent formulas. Substitute values of one-half the SQL are used for all analytical results reported as not detected.

b The value presented is the UCL_{95}, calculated using distribution-dependent formulas. Substitute values of one-half the SQL are used for all analytical results reported as not detected.

c The value presented is the lesser of the maximum detected concentration and the arithmetic mean.

d The value presented is the lesser of the maximum detected concentration and the UCL_{95}.

COPC Chemical of potential concern
CTE Central tendency exposure
mg/kg Milligrams per kilogram
NL Not listed (the analyte was detected in all samples)
RME Reasonable maximum exposure
SQL Sample quantitation limit
UCL_{95} 95 percent upper confidence limit on the arithmetic mean

TABLE 7-3

EXPOSURE POINT CONCENTRATIONS FOR SOIL AND SEDIMENT COPCs
AREA OUTSIDE THE 400 MG/KG LEAD ISOPLETH (AREA B)
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE, NAVAL WEAPONS SEAL BEACH DETACHMENT CONCORD

Chemical of Potential Concern	Detection Frequency	Type of Distribution	Concentration (mg/kg)							
			Miminum SQL	Maximum SQL	Minimum Detected	Maximum Detected	Mean[a]	UCL_{95}[b]	CTE[c]	RME[d]
Metal										
Antimony	18/41	Lognormal	0.32	5.6	0.28	2.1	0.80	1.1	0.80	1.1
Arsenic	39/41	Lognormal	3.9	5.0	2.0	26.8	7.7	9.7	7.7	9.7
Barium	41/41	Lognormal	NL	NL	56.8	404	171	198	171	198
Beryllium	30/41	Lognormal	0.01	0.17	0.01	0.60	0.25	0.62	0.25	0.60
Cadmium	14/41	Lognormal	0.05	0.48	0.31	3.4	0.40	0.81	0.40	0.81
Chromium	41/41	Lognormal	NL	NL	0.89	148	27.4	35.9	27.4	35.9
Copper	36/41	Lognormal	11.8	12.9	1.1	199	39.0	61.8	39.0	61.8
Iron	41/41	Lognormal	NL	NL	63.2	88,800	19,500	36,300	19,500	36,300
Lead	41/41	Lognormal	NL	NL	1.7	378	88.3	210	88.3	210
Manganese	41/41	Lognormal	NL	NL	0.69	2,480	647	1,570	647	1,570
Mercury	3/41	Not Tested	0.04	0.75	0.25	1.5	0.13	0.16	0.13	0.16
Molybdenum	23/41	Lognormal	0.15	0.74	0.08	8.0	1.2	2.3	1.2	2.3
Selenium	16/41	Lognormal	0.17	7.6	0.17	6.9	1.1	1.5	1.1	1.5
Silver	7/41	Normal	0.08	3.4	0.13	1.5	0.56	0.68	0.56	0.68
Thallium	17/36	Lognormal	0.24	10.2	0.11	3.5	1.3	2.7	1.3	2.7
Zinc	41/41	Lognormal	NL	NL	3.2	4,980	235	275	235	275
Semivolatile Organic Compound										
Benzo(a)anthracene	1/18	Not Tested	0.37	0.61	0.07	0.07	0.2	0.2	0.07	0.07
Benzo(a)pyrene	1/18	Not Tested	0.37	0.61	0.09	0.09	0.2	0.2	0.09	0.09

TABLE 7-3

EXPOSURE POINT CONCENTRATIONS FOR SOIL AND SEDIMENT COPCs
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE, NAVAL WEAPONS SEAL BEACH DETACHMENT CONCORD
AREA OUTSIDE 400 MG/KG LEAD ISOPLETH (AREA B)

Chemical of Potential Concern	Detection Frequency	Type of Distribution	Concentration (mg/kg)							
			Miminum SQL	Maximum SQL	Minimum Detected	Maximum Detected	Mean[a]	UCL_{95}[b]	CTE[c]	RME[d]
Benzo(b)fluoranthene	4/18	Lognormal	0.39	0.61	0.06	0.2	0.2	0.2	0.2	0.2
Benzo(k)fluoranthene	1/18	Not Tested	0.37	0.61	0.04	0.04	0.2	0.3	0.04	0.04
Chrysene	4/18	Lognormal	0.39	0.61	0.05	0.1	0.2	0.3	0.1	0.1
Fluoranthene	4/18	Lognormal	0.39	0.61	0.05	0.2	0.2	0.2	0.2	0.2
Phenanthrene	1/18	Not Tested	0.37	0.61	0.07	0.07	0.2	0.2	0.07	0.07
Phenol	3/18	Not Tested	0.36	0.43	0.5	0.8	0.3	0.3	0.3	0.3
Pyrene	4/18	Lognormal	0.39	0.61	0.04	0.3	0.2	0.3	0.2	0.3

Notes

[a] The value presented is the arithmetic mean, calculated using distribution-dependent formulas. Substitute values of one-half the SQL are used for all analytical results reported as not detected.

[b] The value presented is the UCL_{95}, calculated using distribution-dependent formulas. Substitute values of one-half the SQL are used for all analytical results reported as not detected.

[c] The value presented is the lesser of the maximum detected concentration and the arithmetic mean.

[d] The value presented is the lesser of the maximum detected concentration and the UCL_{95}.

COPC Chemical of potential concern
CTE Central tendency exposure
mg/kg Milligrams per kilogram
NL Not listed (the analyte was detected in all samples)
RME Reasonable maximum exposure
SQL Sample quantitation limit
UCL_{95} 95 percent upper confidence limit on the arithmetic mean

TABLE 7-4
CANCER RISK AND HAZARD INDEX FROM POTENTIAL RESIDENTIAL EXPOSURE TO COPCS IN SOIL
AREA WITHIN THE 400 MG/KG LEAD ISOPLETH (AREA A)
TAYLOR BOULEVARD BRIDGE DEBRIS AREA, NAVAL WEAPONS SEAL BEACH DETACHMENTCONCORD

Chemical of Potential Concern	RME Exposure Point Concentration (mg/kg)	EPA Region 9 Residential PRG (mg/kg)		RME Cancer Risk	RME Hazard Quotient
		Cancer	Noncancer		
Metal					
Antimony	40.5	--	31	--	1.3
Arsenic	142	0.39	22	3.6E-04	6.5
Barium	3,370	--	5,400	--	0.62
Beryllium	0.30	1,100	150	2.7E-10	< 0.01
Cadmium[a]	13.4	9	37	1.5E-06	0.36
Chromium[b]	379	210	100,000	1.8E-06	< 0.01
Cobalt	26.0	--	4,700	--	< 0.01
Copper	4,610	--	2,900	--	1.6
Iron	230,000	--	23,000	--	10
Manganese	1,280	--	1,800	--	0.71
Mercury	10.1	--	23	--	0.44
Molybdenum	60.4	--	390	--	0.15
Nickel[a]	153	150	1,600	1.0E-06	0.10
Selenium	6.6	--	390	--	0.02
Silver	4.2	--	390	--	0.01
Thallium	2.4	--	5.5	--	0.44
Tin	1,700	--	--	--	--
Zinc	4,160	--	23,000	--	0.18
Semivolatile Organic Compound					
Benzo(a)anthracene	0.4	0.62	--	6.5E-07	--
Benzo(a)pyrene	0.6	0.062	--	9.7E-06	--
Benzo(b)fluoranthene	2	0.62	--	3.2E-06	--
Benzo(g,h,i)perylene[c]	0.4	--	22,000	--	< 0.01
Benzo(k)fluoranthene[a]	0.05	0.61	--	8.2E-08	--
Chrysene[a]	1	6.1	--	1.6E-07	--
Fluoranthene	0.6	--	2,300	--	< 0.01
Indeno(1,2,3-cd)pyrene	0.4	0.62	--	6.5E-07	--
Naphthalene	0.05	--	56	--	< 0.01

TABLE 7-4
CANCER RISK AND HAZARD INDEX FROM POTENTIAL RESIDENTIAL EXPOSURE TO COPCS IN SOIL
AREA WITHIN THE 400 MG/KG LEAD ISOPLETH (AREA A)
TAYLOR BOULEVARD BRIDGE DEBRIS AREA, NAVAL WEAPONS SEAL BEACH DETACHMENTCONCORD

Chemical of Potential Concern	RME Exposure Point Concentration (mg/kg)	EPA Region 9 Residential PRG (mg/kg)		RME Cancer Risk	RME Hazard Quotient
		Cancer	Noncancer		
Phenanthrene[d]	0.4	--	2,300	--	< 0.01
Phenol	0.4	--	37,000	--	< 0.01
Pyrene	2	--	2,300	--	< 0.01
			TOTAL:	4E-04	22

Notes:

a Cal-modified PRG (EPA 1999)
The cancer PRG for chromium assumes a 1 to 6 ratio of hexavalent chromium to trivalent chromium. The noncancer PRG is not a risk-based number, but rather the
b 'max' concentration listed in the PRG document. This PRG value is assigned to all chemicals for which the risk-based PRG is greater than 100,000.
c A PRG is not available for benzo(g,h,i)perylene; the PRG for anthracene was used as a surrogate value.
d A PRG is not available for phenanthrene; the PRG for pyrene was used as a surrogate value.

-- Not available or applicable
mg/kg Milligrams per kilogram
PRG U.S. Environmental Protection Agency Region 9 preliminary remediation goal (EPA 1999)
RME Reasonable maximum exposure

TABLE 7-5
CANCER RISK AND HAZARD INDEX FROM POTENTIAL RESIDENTIAL EXPOSURE TO COPCS IN SOIL
AREA OUTSIDE THE 400 MG/KG LEAD ISOPLETH (AREA B)
TAYLOR BOULEVARD BRIDGE DEBRIS AREA, NAVAL WEAPONS SEAL BEACH DETACHMENT CONCORD

Chemical of Potential Concern	RME Exposure Point Concentration (mg/kg)	EPA Region 9 Residential PRG (mg/kg)		RME Cancer Risk	RME Hazard Quotient
		Cancer	Noncancer		
Metal					
Antimony	1.1	--	31	--	0.035
Arsenic	9.7	0.39	22	2.5E-05	0.44
Barium	198	--	5,400	--	0.037
Beryllium	0.60	1,100	150	5.5E-10	< 0.01
Cadmium[a]	0.81	9	37	9.0E-08	0.022
Chromium[b]	35.9	210	100,000	1.7E-07	< 0.01
Copper	61.8	--	2,900	--	0.021
Iron	36,300	--	23,000	--	1.6
Manganese	1,570	--	1,800	--	0.87
Mercury	0.16	--	23	--	< 0.01
Molybdenum	2.3	--	390	--	< 0.01
Selenium	1.5	--	390	--	< 0.01
Silver	0.68	--	390	--	< 0.01
Thallium	2.7	--	5.5	--	0.49
Zinc	275	--	23,000	--	0.012
Semivolatile Organic Compound					
Benzo(a)anthracene	0.07	0.62	--	1.1E-07	--
Benzo(a)pyrene	0.09	0.062	--	1.5E-06	--
Benzo(b)fluoranthene	0.2	0.62	--	3.2E-07	--
Benzo(k)fluoranthene[a]	0.04	0.61	--	6.6E-08	--
Chrysene[a]	0.1	6.1	--	1.6E-08	--
Fluoranthene	0.2	--	2,300	--	< 0.01
Phenanthrene[c]	0.07	--	2,300	--	< 0.01
Phenol	0.3	--	37,000	--	< 0.01
Pyrene	0.3	--	2,300	--	< 0.01
			TOTAL:	**3E-05**	**4**

Notes:

TABLE 7-5
CANCER RISK AND HAZARD INDEX FROM POTENTIAL RESIDENTIAL EXPOSURE TO COPCS IN SOIL
AREA OUTSIDE THE 400 MG/KG LEAD ISOPLETH (AREA B)
TAYLOR BOULEVARD BRIDGE DEBRIS AREA, NAVAL WEAPONS SEAL BEACH DETACHMENT CONCORD

a	Cal-modified PRG (EPA 1999)
b	The cancer PRG for chromium assumes a 1 to 6 ratio of hexavalent chromium to trivalent chromium. The noncancer PRG is not a risk-based number, but rather the 'max' concentration listed in the PRG document. This PRG value is assigned to all chemicals for which the risk-based PRG is greater than 100,000 mg/kg.
c	A PRG is not available for phenanthrene; the PRG for pyrene was used as a surrogate value.
--	Not available or applicable
mg/kg	Milligrams per kilogram
PRG	U.S. Environmental Protection Agency Region 9 preliminary remediation goal (EPA 1999)
RME	Reasonable maximum exposure

TABLE 8-1
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
PROBLEM FORMULATION TABLE

Receptor Class and Specific Receptors	Assessment Endpoint	Risk Questions	Surrogate Species or Community	Measurement Endpoints	Uncertainties	Weight of evidence approach (Decision criteria)
1° PRODUCERS Wetland and upland transitional plants	Protection and maintenance of populations of wetland and upland transitional plants. Sufficient rates of survival, growth, and germination to sustain populations of wetland and upland plants	Are concentrations of chemicals in sediment present at levels above the Oak Ridge National Laboratory (ORNL) plant benchmarks?	Various plant species used in studies upon which ORNL benchmarks were based	(1) Chemical characterization of sediment and comparison to ORNL toxicity benchmarks for plants	(1) Difference between site-specific bioavailability and form of chemical, and that used to derive benchmark (2) Difference in species composition of site-specific plants and those used in development of benchmarks	Chemical concentrations that significantly exceed available literature-derived effects levels will indicate risk to wetland and upland transitional plants at the site. Potential adverse effects from several chemicals or at numerous locations will indicate risk to wetland and upland transitional plant populations
1° CONSUMERS Benthic macroinvertebrates such as amphipods, isopods, polychaetes, oligochaetes, bivalves, gastropods, and decapods	Protection of populations of benthic invertebrates Sufficient rates of survival and growth to sustain populations of benthic invertebrates	Is reburial and survival of amphipods used in bulk sediment toxicity tests lower than the Regional Water Quality Control Board reference envelope?	Amphipods (*Eohaustorius estuarinus*) Invertebrate species used in the development of the ER-Ls and ER-Ms.	(1) Chemical characterization of sediment and comparison to ER-Ls and ER-Ms at which effects on populations are expected (2) Biological testing - whole sediment bioassay using the amphipod *Eohaustorius estuarius* (statistically significant reduction in survival and reburial)	(1) Limited sample locations tested using bioassays (2) Chemicals may be introduced into site from tidal sources (3) Species vary significantly in their sensitivities to contaminants (4) Limitations in data in the literature to assess potential effects from some chemicals present (5) Actual conditions of exposure at these sites may not be represented during toxicity testing. (6) Ambient levels of chemicals often exceed ER-Ls and ER-Ms (e.g. nickel)	Chemical concentrations that significantly exceed ER-Ms will indicate risk to aquatic invertebrates at the site Biologically and statistically significant reduction in survival or reburial in amphipod bioassay will indicate risk to invertebrate receptors
1° CONSUMERS Salt marsh harvest mouse (endangered species; federally protected) *	Protection of individual salt marsh harvest mice Sufficient rates of survival, growth, and reproduction to sustain individual herbivorous mammals	Do site-specific modeled doses to representative species, such as the salt marsh harvest mouse exceed the Navy high and low TRVs for specific endpoints identified?	Laboratory rodents used in toxicological studies upon which TRVs are based.	Food-chain modeling for the salt marsh harvest mouse, using measured concentrations of chemicals in pickleweed tissues and incidentally ingested soil; comparisons with TRVs at which effects on individuals expected	(1) Bioavailability and form of site contaminants compared with studies used as the basis for TRVs. (2) TRVs not available for all chemicals; a qualitative review will be conducted for chemicals for which TRVs are unavailable (3) Species sensitivities differ; laboratory test animal in TRV study may not be suitable surrogate for wildlife receptor of concern	A hazard quotient approach will be used to evaluate risk (HQ=dose/TRV). Chemicals for which site-specific doses exceed the high TRV that represents the mid-range of effects level will carry the strongest weight and are the best evidence of risk to higher level receptors.
2° CONSUMERS Shorebirds (Black-necked Stilt and others)	Protection of populations of shorebirds Sufficient rates of survival, growth, and reproduction to sustain individual shorebirds/wading birds	Do site-specific modeled doses to representative species, such as the Black necked Stilt, exceed the Navy high and low TRVs for specific endpoints identified?	Laboratory animals, such as chickens, used in toxicological studies upon which the TRVs were based	Food-chain modeling to Black necked stilt, using measured concentrations of chemicals in prey and sediment; comparison of site-specific dose to literature-derived TRVs	1. Doses calculated based on concentrations in amphipod tissue; actual diets may differ 2. Bioavailability of site contaminants compared to those in studies upon which TRVs were based 3. Species sensitivity varies; laboratory test animal may not be suitable surrogate for wildlife species	A hazard quotient approach will be used to evaluate risk (HQ=dose/TRV). Chemicals for which site-specific doses exceed the high TRV that represents the mid-range of effects level will carry the strongest weight and are the best evidence of risk to higher level receptors.

TABLE 8-1
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
PROBLEM FORMULATION TABLE (CONTINUED)

Receptor Class and Specific Receptors	Assessment Endpoint	Risk Questions	Surrogate Species or Community	Measurement Endpoints	Uncertainties	Weight of evidence approach (Decision criteria)
2° CONSUMERS Waterfowl (Mallard)	Protection of populations of waterfowl Sufficient rates of survival, growth, and reproduction to sustain populations of avian aquatic omnivores	Do site-specific modeled doses to representative species, such as the Mallard, exceed the Navy high and low TRVs for specific endpoints identified ?	Laboratory animals, such as chickens, used in toxicological studies upon which the TRVs were based	Food-chain modeling to the Mallard using measured concentrations of chemicals in prey and sediment; comparison of site-specific dose to literature-derived TRVs	1. Doses calculated based on concentrations in field collected fish, invertebrate, tadpole and plant tissues; actual diet may differ from assumed diet 2. Bioavailability of site contaminants compared to those in studies upon which TRVs were based 3. Species sensitivity varies; laboratory test animal may not be suitable surrogate for wildlife species	A hazard quotient approach was used to evaluate risk (HQ=dose/TRV). Chemicals for which site-specific doses exceed the high TRV that represents the mid-range of effects level will carry the strongest weight and are the best evidence of risk to higher level receptors.

Table Notes:
* Although no salt marsh harvest mice have been trapped at the site, this species is presumed to reside at the site due to the presence of pickleweed.

ER-L = Effects range-low
ER-M = Effects range-median
HQ = Hazard quotient
ORNL = Oak Ridge National Laboratory
RMP = Regional Monitoring Program
TRV = Toxicity Reference Value

1° Primary
2° Secondary

TABLE 8-2
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
RATIONALE FOR SELECTION OF ASSESSMENT ENDPOINTS

Assessment Endpoints	Rationale
Protection and maintenance of populations of wetland and upland transitional plants Sufficient rates of survival, growth, and germination to sustain populations of wetland and upland plants	- Provides habitat structure and cover - Food and habitat for salt marsh harvest mouse - Exposure via sediment and surface water
Protection of populations of benthic invertebrates Sufficient rates of survival and growth to sustain populations of benthic invertebrates	- Prey of shorebirds - Sensitive to contaminated sediments - Exposure via sediment and surface water
Protection of populations of waterfowl (Mallard) Sufficient rates of survival, growth, and reproduction to sustain populations of avian aquatic omnivores	- Protected under Migratory Bird Treaty Act (MBTA) - Exposure via prey, surface water, and sediment
Protection of populations of shorebirds (Black-necked stilt) Sufficient rates of survival, growth, and reproduction to sustain individual shorebirds (black necked stilt)	- Prey of raptors - Exposure via prey, sediment, and surface water
Protection of individual salt marsh harvest mice Sufficient rates of survival, growth, and reproduction to sustain individual herbivorous mammals	- Special-status species - Prey of top predators - Exposure via prey, soil, and surface water

TABLE 8-3
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
NATURAL HISTORY OF ASSESSMENT ENDPOINT SPECIES

Species	Status	CA Native	Suisun Bay Residency	Home Range	Exposure Route	Feeding Guild
Wetland and Upland Transitional Plants	None	Yes	All year	N/A	Soil, Sediment, Surface water	Primary Producer
Benthic Invertebrate Community	None	Yes	All year	Soft bottom estuarine and marine habitats	Sediment, Surface water, Prey	Detritivores, omnivores, carnivores
Mallard Duck *Anas platyrhynchos*	Harvested	Yes	All year	Breeding range: avg. 225-468 hectare (ha)	Sediment, Surface water, Prey	Omnivore 90% plant material, animal foods important during breeding
Black-necked stilt *Himantopus mexicanus*	None	Yes	All year	Foraging area: generally located less than 1 kilometer from nest	Sediment, Surface water, Prey	Carnivore insects, crustaceans, mollusks and other aquatic invertebrates, and some small fish
Salt Marsh Harvest Mouse *Reithrodontomys raviventris halicoetes*	FE, CE	Yes	All year	Avgerage 2,133 meter^2	Sediment, Soil, Surface water, Prey	Herbivore Leaves, stems, seeds

TABLE 8-3 (CONTINUED)

NATURAL HISTORIES FOR REPRESENTATIVE SPECIES AT THE TBB DISPOSAL SITE

Table Notes:

Status

Species of special conservation status, as registered in the California Department of Fish and Game's Natural Diversity Data Base, are indicated by the following codes.

CE	California Endangered
SSC	California Department of Fish and Game (CDFG) Species of Special Concern
SE	State Endangered Species
ST	State Threatened Species
SC	Candidate for listing as Endangered Species by state
FE	Federal Endangered Species
AB	Species listed on the Audubon Blue List of birds designated by the National Audubon Society as experiencing a population decline
None	Species has no special status

Native

Yes	Species is native to California.	No	Species is not native to California.

Exposure Route

The exposure route column reflects the primary routes of exposure to contaminants for the species.

Feeding Guild

Carnivore	Eats primarily animals.	Omnivore	Eats a combination of animals and plants.
Herbivore	Eats primarily plants.	Detritivore	Eats primarily detritus.
Primary Producer	Photosynthesizes.		

TABLE 8-4
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
RELATIONSHIP BETWEEN THE ASSESSMENT ENDPOINTS AND MEASUREMENT ENDPOINTS

ASSSESSMENT ENDPOINTS	MEASUREMENT ENDPOINTS
Protection and maintenance of populations of wetland and upland transitional plants Sufficient rates of survival, growth, and germination to sustain populations of wetland and upland plants	Bulk sediment chemical characterization and comparison to toxicological benchmarks
Protection of populations of benthic invertebrates Sufficient rates of survival and growth to sustain populations of benthic invertebrates	Bulk sediment chemical characterization and comparison to guidance values and amphipod toxicity test (10-day whole sediment bioassay using the estuarine amphipods *Eohaustorius estuarius*).
Protection of populations of waterfowl (Mallard) Sufficient rates of survival, growth, and reproduction to sustain populations of avian aquatic omnivores	Food chain modeling using measured tissue concentrations in invertebrate tissue.
Protection of populations of shorebirds (Black-necked stilt) Sufficient rates of survival, growth, and reproduction to sustain individual shorebirds (black necked stilt)	Food chain modeling using measured tissue concentrations in invertebrate tissue.
Protection of individual salt marsh harvest mice Sufficient rates of survival, growth, and reproduction to sustain individual herbivorous mammals	Food chain modeling using measured tissue concentrations in pickleweed.

TABLE 8-5
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
LINES OF EVIDENCE

Assessment Endpoint	Line of Evidence	Data set	Steps	Decision Point
Protection and maintenance of populations of wetland and upland transitional plants (Sufficient rates of survival, growth, and germination to sustain populations of wetland and upland plants)	Toxicity - compare to ORNL benchmarks for plants (growth and yield)	Wetland & upland transitional sediment chemistry (n = 30, includes shoreline data). For locations where surface and subsurface data are available, use the maximum concentration	1. Calculate 95th percent UCL 2. Compare 95th percent UCL to Tidal ambient, RWQCB ambient, and ORNL benchmark 3. If 95th UCL exceeds most conservative ambient and ORNL benchmark, then chemical is a plant COPEC. If less than conservative ambient or ORNL, not a COPEC 4. To evaluate spatial extent, calculate HQ for each point (HQ = metal conc / ORNL (use ½ detection limit for nondetects))	Screening process will determine plant COPECs HQs to evaluate spatial distribution of contaminants
	Bioaccumulation (calculate BAF)	Collocated sediment and pickleweed samples (n = 3)	1. For each COPEC, convert pickleweed residue to dry weight (wet wt. concentration / % solid) 2. Calculate BAF (tissue /sediment) (use ½ the detection limit for nondetects)	This is a qualitative evaluation; no benchmarks available.
	Toxicity - literature review of toxicity to plants	Review of the primary literature for COPECs with high BAFs and high magnitude and spatial extent. Focus on wetland plants.		Qualitative evaluation of potential toxicity

TABLE 8-5
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
LINES OF EVIDENCE

Assessment Endpoint	Line of Evidence	Data set	Steps	Decision Point
Protection of populations of benthic invertebrates (sufficient rates of survival and growth to sustain populations of benthic invertebrates)	Toxicity - comparison to a ER-L and ER-M screening values for benthic invertebrates	1. Aquatic sediment samples (n = 29, includes shoreline data).	1. Calculate 95th percent 2. Compare 95th percent UCL to Tidal ambient, RWQCB ambient, and ER-L 3. If 95th UCL exceeds most conservative ambient and ER-L, it is an invertebrate COPEC. If less than conservative ambient or ER-L, it is not an invertebrate COPEC 4. To evaluate spatial extent of contamination, calculate mean ER-M quotients for each COPEC and sampling location a. HQ = metal conc / ER-M (use ½ detection limit for nondetects) b. Mean ER-M HQ (per location) = Sum HQ / Number of HQs	Screening process will determine invertebrate COPEC. HQs to evaluate spatial distribution
	Bioaccumulation (calculate BAF)	Collocated sediment and amphipod data (n = 3)	1. For each sample, convert amphipod residue to dry weight (wet wt. concentration / % solid) 2. Calculate BAF (tissue /soil).	Qualitative evaluation; no benchmarks available.
	Toxicity – survival and reburial of *Eohaustorius estuarius*	*Eohaustorius* bioassays (n = 3)	Compare site survival to RWQCB reference site survival and site reburial to laboratory control	H_o: Survival > reference envelope (68%) H_o: Reburial > 90% laboratory control
	Factors affecting bioavailability	Sediment samples (n = 3). Evaluate SEM/AVS, grain size, pH, and TOC	1. Calculate SEM/AVS ratio a. Convert SEM metals to umoles b. Convert AVS to umoles c. SEM/AVS 2. For each location, determine %fine grain sediment (<62 µm) 3. TOC	SEM/AVS < 1.0 suggests metal is not bioavailable. Metals may become more bioavailable at lower pH Grain size important variable, as smaller particles carry greater contaminant loads TOC increases with grain size.

TABLE 8-5
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
LINES OF EVIDENCE

Assessment Endpoint	Line of Evidence	Data set	Steps	Decision Point
Birds: Protection of populations of waterfowl and shorebirds [(Mallard and Black-necked stilt). Sufficient rates of survival, growth, and reproduction to sustain populations of avian aquatic receptors] **Mammals:** Protection of individual salt marsh harvest mice (sufficient rates of survival, growth, and reproduction to sustain individual herbivorous mammals)	Food-chain modeling	Sediment data. For birds data set includes aquatic and 'wetland and upland transitional' habitats (n = 48; includes shoreline). For the salt marsh harvest mouse, data set includes only samples collected from the 'wetland and upland transitional' habitat (n=30; includes shoreline data).	**Birds** 1. Calculate 95th UCL for birds (n = 48) 2. Compare 95th UCL for birds to ambient. If exceeds most conservative of Tidal Area ambient or RWQCB ambient, then bird COPEC. 3. Calculate a typical dose for avian receptors (Mallard and Black-necked stilt). In dose equation, use maximum prey concentration for each COPEC and 95 percent UCL sediment concentration. 4. Calculate HQs). HQ = dose / TRV. **Salt Marsh Harvest Mouse** 1. Calculate 95th UCL for salt march harvest mouse (n = 30) 2. Compare 95th UCL for salt march harvest mouse to ambient. If 95th UCL exceeds most conservative of tidal or RWQCB ambient, then salt march harvest mouse COPEC. 3. Using the maximum pickleweed BAF, calculate location specific tissue concentrations (BAF * sediment concentration) 4. Calculate high and low point doses using site sediment and estimated tissue 5. Calculate HQs ($HQ_{(High\ dose/low\ TRV)}$, $HQ_{(Low\ dose/high\ TRV)}$, and $HQ_{(High\ dose/high\ TRV)}$. HQ = dose / TRV.	$HQ_{(High\ dose/low\ TRV)} > 1$ indicates significant risk $HQ_{(Low\ dose/high\ TRV)} < 1$ indicates little or no risk $HQ_{(High\ dose/high\ TRV)} > 1$ indicates probable risk (salt marsh harvest mouse only)

TABLE 8-5
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
LINES OF EVIDENCE

Table Notes:

* - times
um - micrometers
BAF – Bioaccumulation factor
COEC – Chemical of Ecological Concern
COPEC – Chemical of potential ecological concern
ER- L – Effects range-low
ER-M – Effects range-median
H_o – Null hypothesis
HQ – Hazard quotient
ORNL – Oak Ridge National Laboratory
RWQCB – Regional Water Quality Control Board
SEM/AVS – Simultaneously extractable metals/acid volatile sulfide
TOC – Total organic chemistry
Toxicity reference value
umoles - micromoles
95 percent UCL – 95th percent upper confidence limit of the mean (one-tailed)

TABLE 8-6
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
INORGANIC CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN FOR PLANTS

Analyte	Concord Tidal Area Ambient 99th % UCL[a] (mg/kg)	RWQCB San Francisco Bay Sediment Ambient[b] (mg/kg)	ORNL Plant Toxicity Benchmark[c] (mg/kg)	TBB Sediment 95% UCL[d] (mg/kg)	Plant COPEC
Aluminum	27,300	NA	50.0	9830	N
Antimony	2.2	NA	5.0	13.2	Y
Arsenic	27	15.3	10.0	37.6	Y
Barium	530	NA	500	716	Y
Beryllium	0.18	NA	10.0	0.30	N
Cadmium	1.90	0.33	4.0	2.1	Y[e]
Chromium	82.1	112	20.0	308	Y
Cobalt	36	NA	100	16.6	N
Copper	81	68.1	50.0	1690	Y
Lead	95	43.2	50.0	1690	Y
Manganese	1,500	NA	0.30	925	N
Mercury	0.32	0.43	2.0	2.7	Y
Molybdenum	6.6	NA	30.0	28.4	N
Nickel	120	112	50.0	92.2	N
Selenium	NA	0.64	1.0	3.8	Y
Silver	NA	0.58	2.0	1.6	N
Thallium	2.2	NA	1.0	0.95	N
Vanadium	96	NA	2.0	36.0	N
Zinc	264	158	50.0	1660	Y

Notes:

mg/kg milligram per kilogram
COPEC Chemical of potential ecological concern
ORNL Oak Ridge National Laboratory
TBB Taylor Boulevard Bridge
UCL Upper confidence limit of the mean
N No
n = 30 Number of samples evaluated in the dataset
Y Yes

a PRC Environmental Management, Inc. 1996. "Technical Memorandum. Ambient Metal Concentrations in the Tidal Area Soils."

b RWQCB. 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." May.

c Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revsion. Oak Ridge national laboratory, Oak Ridge, TN. 128 pp, ES/ER/TM-85.

d Nondetects were included in the calculation of the 95 percent UCL of the mean as one-half the detection limit. For locations where surface and subsurface data were available, the maximum concentration was used in the calculation of the 95 percent UCL of the mean. Plant dataset includes samples collected in the wetland and upland transitional habitat (n = 30; includes shoreline samples).

e Cadmium was not a COPEC based on the ambient and ORNL benchmark screening process, but was reclassified as a COPEC following a review of the metals that dropped out of the screening process.

TABLE 8-7
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
BENCHMARK METRICS FOR PLANT COPECS IN THE WETLAND AND UPLAND TRANSITIONAL PLANT HABITAT

COPEC	95th % UCL mg/kg	Wetland and Upland Transitional Habitat Range[d] mg/kg	Screening Values			Number Locations > Tidal Area Ambient (Percent)	Number Locations > SF Bay Ambient (Percent)	Number Locations > ORNL Plant Toxicity Benchmark (Percent)
			Tidal Area Ambient[a] mg/kg	SF Bay Ambient[b] mg/kg	ORNL Toxicity Benchmark[c] mg/kg			
Antimony	13.2	0.16-84.2	2.2	NA	5.0	13/27 (48)	NA	9/27 (33)
Arsenic	37.6	0.34-142	27.0	15.3	10.0	10/30 (33)	12/30 (40)	15/30 (50)
Barium	716	5.6-4,660	530	NA	500	7/30 (23)	NA	7/30 (23)
Chromium	308	0.89-2,990	82.1	112	20.0	7/30 (23)	5/30 (17)	26/30 (87)
Cadmium	2.1	0.025-13.4	1.9	0.33	4.0	5/30 (17)	11/30 (37)	3/30 (10)
Copper	1690	1.1-12,500	81.0	68.1	50.0	14/30 (47)	15/30 (50)	16/30 (53)
Lead	1690	1.7-7,680	95.0	43.2	50.0	23/30 (77)	25/30 (83)	25/30 (83)
Mercury	2.7	0.0050-26.4	0.32	0.43	2.0	8/30 (27)	6/30 (20)	3/30 (10)
Selenium	3.8	0.085-12.0	NA	0.64	1.0	NA	17/30 (57)	13/30 (43)
Zinc	1660	3.2-5,410	264	158.0	50.0	16/30 (53)	17/30 (57)	27/30 (90)

Notes:
mg/kg - milligrams per kilogram.
NA - Not applicable.
ORNL - Oak Ridge National Laboratory.
SF - San Francisco.
Numbers less than 10 are reported with two significant digits; numbers 10 and greater are reported with three significant digits.
[a]PRC. 1996. "Technical Memorandum, Estimation of Ambient Metal Concentrtions in the Tidal Area Soils." Naval Weapons Station, Concord, California. 12 April.
[b]RWQCB. 1998. "Ambient Concentrations of Toxic chemicals in San Francisco Bay Sediments." Regional Water Quality Board, April.
[c]Efroymson, R.A., and others. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision." Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-85.
[d]Concentrations used to compile the range included a substitution of one half of the detection limit for those chemicals that were not detected.

TABLE 8-8
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
HAZARD QUOTIENTS FOR COPECS FOR THE WETLAND AND UPLAND TRANSITIONAL PLANT HABITAT

Sample Location	Hazard Quotients (Sediment Concentration / ORNL Plant Toxicity Benchmark)									
	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	COPPER	LEAD	MERCURY	SELENIUM	ZINC
309CSPWSS	1.3	5.7	1.3	2.0	3.7	6.2	46.0	0.090	1.2	45.4
309SB05	0.22	1.0	0.54	0.40	1.6	0.98	3.2	0.13	0.15	5.7
309SB106	0.074	0.77	0.35	0.078	1.5	0.43	5.4	0.0025	0.10	1.4
SB001	1.1	5.8	9.3	0.070	6.8	12.2	51.2	0.21	0.42	81.8
SB002	0.16	0.58	0.45	0.0063	1.1	0.51	0.69	0.015	0.30	1.8
SB003	16.8	14.2	1.5	1.4	6.3	133	154	13.2	0.30	79.2
SB004	3.6	6.1	1.9	0.70	6.0	7.6	101	1.1	9.0	42.0
SB005	0.034	0.86	0.49	0.0088	0.92	0.57	4.0	0.018	0.95	2.5
SB006	0.032	0.62	0.73	0.0075	1.3	0.40	1.3	0.013	0.87	0.84
SB007	0.035	0.61	0.40	0.0088	1.1	0.61	3.7	0.015	0.96	2.4
SB008	0.034	1.0	0.60	0.0088	1.5	0.78	2.6	0.015	0.39	2.0
SB009	1.2	3.8	0.78	0.83	2.2	6.5	31.2	1.1	5.0	108
SB010	6.4	3.4	0.60	3.35	5.0	250	37.4	0.35	4.0	99.2
SB011	0.038	1.5	0.42	0.010	1.5	1.0	6.4	0.015	1.0	3.1
SB012	1.0	0.66	0.81	0.0088	1.4	1.4	15.0	0.015	1.1	3.9
SB013	0.50	2.0	1.4	0.0090	2.3	20.6	11.9	0.20	2.4	18.2
SB014	1.3	6.1	2.3	0.0088	3.9	5.4	65.6	0.040	7.8	33.2
SB015	5.3	5.8	1.4	0.016	150	14.5	20.4	0.078	6.8	30.8
SB016	0.29	0.95	0.25	0.050	0.045	0.022	0.034	0.25	2.0	0.064
SB017	0.078	0.034	0.011	0.0068	8.7	10.3	40.6	0.035	12.0	41.2
SB018	1.2	10.6	0.39	0.012	2.4	33.4	25.4	0.055	7.6	22.6
SB019	0.76	5.3	0.37	0.0083	4.3	8.6	32.8	0.043	11.5	14.7
SB020	0.54	2.3	0.67	0.0075	3.7	39.6	23.6	0.32	4.2	36.0
SB105	0.092	0.048	0.41	0.010	0.74	0.74	0.50	0.015	0.60	1.5
SS206	0.24	0.77	0.43	0.40	1.4	11.3	9.7	0.013	0.10	19.7
SS210	NA	0.47	0.22	0.10	1.2	0.27	0.60	0.013	0.21	1.4
SS211	NA	0.31	0.25	0.0021	0.82	0.18	0.89	0.010	0.090	0.93
SS212	0.12	0.31	0.18	0.090	1.6	0.39	1.1	0.013	0.085	2.1
SS213	NA	0.74	0.24	0.17	1.2	1.1	2.2	0.13	0.085	6.7
SS214	0.088	0.81	0.18	0.095	1.2	0.35	3.9	0.014	0.17	1.6
Mean Hazard Quotient	1.6	2.8	0.96	0.33	7.5	19.0	23.4	0.58	2.7	23.7

Notes:
BOLD = HQ > 1
COPEC - Chemical of potential ecological concern
NA - Not analyzed.
HQ, Hazard quotient = Sample location COPEC concentration divided by ORNL plant toxicity benchmark for that COPEC.
HQs were calculated for plant COPECs: antimony, arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, and zinc.
Mean hazard quotient = Sum of hazard quotients across sample locations for one COPEC divided by the number of sample locations at which that COPEC was present.
Numbers less than 10 are reported with two significant digits; numbers 10 or greater are reported with three significant digits.

TABLE 8-9
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE, NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD, BIOACCUMULATION FACTORS FOR PICKLEWEED IN THE WETLAND AND UPLAND TRANSITIONAL PLANT HABITAT

	309CSPW		309CSPWSS		309SB05PW		309SB05		309SB106PW		309SB106		
Sample ID	Tissue (mg/kg wet wt)	Tissue (mg/kg dry wt)	Sediment (mg/kg dry wt)	BAF	Tissue (mg/kg wet wt)	Tissue (mg/kg dry wt)	Sediment (mg/kg dry wt)	BAF	Tissue (mg/kg wet wt)	Tissue (mg/kg dry wt)	Sediment (mg/kg dry wt)	BAF	Max BAF (mg/kg dry wt)
% Solid	11.1	NA	NA	NA	69.8	NA	NA	NA	15.1	NA	NA	NA	NA
Antimony	0.060	0.54	6.7	0.080	0.10	0.14	1.1	0.13	0.030	0.20	0.37	0.53	0.53
Arsenic	3.5	31.5	57.0	0.55	0.30	0.43	10.4	0.041	5.4	35.8	7.7	**4.6**	**4.6**
Barium	4.4	39.6	646	0.061	9.4	13.5	268	0.050	5.1	33.8	175	0.19	0.19
Cadmium	0.36	3.2	7.8	0.42	0.060	0.090	1.6	0.050	0.080	0.52	0.31	**1.7**	**1.7**
Chromium	0.79	7.1	73.4	0.10	1.9	2.7	32.5	0.084	0.90	5.9	29.4	0.20	0.20
Copper	5.0	45.0	311	0.14	9.1	13.0	49.0	0.27	3.5	23.2	21.7	**1.1**	**1.1**
Lead	0.42	3.8	2300	0.0016	1.9	2.7	162	0.017	0.29	1.9	268	0.0071	0.017
Mercury	0.010	0.090	0.18	0.50	0.020	0.029	0.26	0.11	0.010	0.066	0.0050	**13.2**	**13.1**
Selenium	0.50	4.5	1.2	**3.7**	0.050	0.072	0.30	0.24	0.049	0.32	0.10	**3.2**	**3.7**
Zinc	54.8	494	2270	0.22	28.4	40.7	284	0.14	15.0	99.3	71.2	**1.4**	**1.4**

Notes:
mg/kg wet wt - Milligrams per kilogram in wet weight.
mg/kg dry wt - Milligrams per kilogram in dry weight.
BAF - Bioaccumulation factor
NA - Not applicable
Bold = BAF > 1
BAF = tissue concentration (mg/kg dry wt) / sediment concentration (mg/kg dry weight).
BAFs calculated for plant chemicals of potential ecological concern (COPECs).
Chemicals not detected are reported as one half of the detection limit.
Numbers less than 10 are reported with two significant digits; numbers 10 or greater are reported with three significant digits.
Tissue concentration (mg/kg dry wt) = tissue concentration (mg/kg wet weight) / % solid/100).

TABLE 8-10
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE, NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD, OVERVIEW OF RISK ASSESSMENT PROCESS FOR PLANTS

ASSESSMENT ENDPOINT: Protection and maintenance of populations of wetland and upland transitional plants (sufficient rates of survival, growth, and germination to sustain populations of wetland and upland plants)

SCREENING PROCESS	COPECS	HAZARD QUOTIENT (HQ) AND MEAN HQs	HQ RESULTS	COPEC PLANT LITERATURE REVIEW	COECs
• Calculate 95th percent UCL of the mean in wetland and upland transitional plant habitat. • Compare each metal 95th percent UCL to lower of ambient 99th percent UCL for Concord Tidal Area or ambient 95th percent UCL for San Francisco Bay metal concentrations. • Compare to ORNL plant toxicity benchmark (Efroynison, and others 1997). The metal was a COPEC if it exceeded the lower of the San Francisco Bay *or* Concord Tidal Area ambient concentrations *and* exceeded the ORNL plant toxicity benchmark. Cadmium was reclassified as a COPEC after reviewing metals that dropped out of the screening process.	Antimony Arsenic Barium Cadmium Chromium Copper Lead Mercury Selenium Zinc	• HQs (sample location metal concentration divided by ORNL plant toxicity benchmark) were calculated for COPECs at each sample location. • Mean HQs were calculated across sample locations for each COPEC at the habitat. See notes. **BIOACCUMULATION** • Collected three pickleweed tissue samples and three colocated sediment samples. • Calculated bioaccumulation factors (pickleweed tissue concentration divided by colocated sediment metal concentration) for COPECS. **BIOAVAILABILITY** • Three sediment samples used to calculate bioaccumulation factors were analyzed for pH and total organic carbon.	**Mean hazard quotients:** • Antimony, 1.6. • Arsenic, 2.8. • Barium, 0.96. • Cadmium, 0.33. • Chromium, 7.5. • Copper, 19.0. • Lead, 23.4. • Mercury, 0.58. • Selenium, 2.7. • Zinc, 23.7. **BIOACCUMULATION RESULTS** • Bioaccumulation factors > 1 suggest uptake and are listed below for COPECs: 309CSPWSS: Selenium, 3.7. 309SB05: None. 309SB106: Arsenic, 4.6. Cadmium, 1.7. Copper, 1.1. Mercury, 13.1. Selenium, 3.7. Zinc, 1.4. **BIOAVAILABILITY RESULTS** • pHs ranged from 7.56 to 8.22, and total organic carbon ranged from 43,600 to 102,000 mg/kg	**Antimony** (Sb). Probably immobile in soil and not available for uptake. Uptake occurs via airborne particulates deposited on foliage. **Arsenic** (As). Plant toxicity well characterized. Uptake and accumulation can occur. Toxicity occurs above threshold concentration. **Barium** (Ba). Very little relevant literature; available literature indicated minimal toxicity for BAFs < 100. **Cadmium** (Cd). Little terrestrial plant literature; accumulated but not biomagnified. **Chromium** (Cr). Little terrestrial plant literature; can be toxic. **Copper** (Cu). Plant toxicity well described. Can cause significant toxicity if available for uptake. **Lead** (Pb). Plant toxicity well described. Can cause significant toxicity if available for uptake **Mercury** (Hg). Plant toxicity poorly described. Uptake and availability in plants poorly understood. **Selenium** (Se). Plant toxicity well described. Uptake and accumulation occur. Toxic above threshold concentration. **Zinc** (Zn). Plant toxicity well described. Causes significant toxicity if available for uptake.	Arsenic Copper Selenium Zinc See text and Figure 8-5 for explanation of how COECs were identified.

TABLE 8-10
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE, NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD, OVERVIEW OF RISK ASSESSMENT PROCESS FOR PLANTS

Table Notes
BAFs - Bioaccumulation factors
COPEC - Chemical of potential ecological concern
COEC - Chemical of ecological concern
ORNL - Oak Ridge National Laboratory
UCL - Upper confidence limit of the mean

Hazard quotients were calculated by dividing the COPEC concentration at that sample location by the ORNL plant toxicity benchmark for that COPEC.

Mean hazard quotients (mean HQ) were calculated by summing hazard quotients for one COPEC across sample locations and dividing that sum by the number of sample locations at which that COPEC was present.

Efroymson, R.A., and others. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision." Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER.TM-85.

PRC. 1996. "Technical Memorandum, Estimation of Ambient Metal Concentrations in the Tidal Area Soils." Naval Weapons Station, Concord, California. 12 April.

RWQCB. 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." April.

TABLE 8-11
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
INORGANIC CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN
FOR BENTHIC INVERTEBRATES

Analyte	Concord Tidal Area Ambient 99th % UCL[a] (mg/kg)	RWQCB San Francisco Bay Sediment Ambient[b] (mg/kg)	ER-L[cd] (mg/kg)	ER-M[cd] (mg/kg)	TBB Sediment 95th % UCL[d] (mg/kg)[e]	Benthic Invertebrate COPEC
Aluminum	27,300	NA	NA	NA	11300	N
Antimony	2.2	NA	2.0[e]	25.0[e]	5.5	Y
Arsenic	27.0	15.3	8.2	70.0	29.2	Y
Barium	530	NA	NA	NA	320	N
Beryllium	0.18	NA	NA	NA	0.17	N
Cadmium	1.9	0.33	1.2	9.6	1.4	Y
Chromium	82.1	112	81.0	370	311	Y
Cobalt	36.0	NA	NA	NA	11.0	N
Copper	81.0	68.1	34.0	270	418	Y
Lead	95.0	43.2	46.7	218	747	Y
Manganese	1,500	NA	NA	NA	1170	N
Mercury	0.32	0.43	0.15	0.71	0.30	Y[f]
Molybdenum	6.6	NA	NA	NA	29.1	Y
Nickel	120	112	20.9	51.6	54.8	N
Selenium	NA	0.64	0.70[e]	1.4[e]	3.7	Y
Silver	NA	0.58	1.0	3.7	1.1	Y
Thallium	2.2	NA	NA	NA	2.36	Y
Vanadium	96.0	NA	NA	NA	48.3	N
Zinc	264	158	150	410	1040	Y

Notes:

NA	Not available	RWQCB	Regional Water Quality Control Board
mg/kg	Milligrams per kilogram	UCL	Upper confidence limit of the mean
ER-L	Effects-range low	ER-M	Effects range median
COPEC	Chemical of potential ecological concern	TBB	Taylor Boulevard Bridge

a PRC Environmental Management, Inc. 1996b. "Technical Memorandum. Ambient Metal Concentrations in the Tidal Area Soils."

b RWQCB. 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." May.

c Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." Environmental Management. Vol. 19. No. 1. Pages 81-97.

d National Oceanic and Atmospheric Administration (NOAA). 1991. "The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program." NOAA. Office of Oceanography and Marine Assessment. Seattle. Washington. Technical Memorandum NOS OMA 52. (Also cited as Long and Morgan 1990.)

e Nondetects were included in the calculation of the 95 percent UCL as one-half of the detection limit.

The aquatic dataset includes samples collected in the aquatic habitat and shoreline area.

f Mercury was not a COPEC based on the ambient and ER-L benchmark screening process, but was reclassified as a COPEC following a review of the metals that dropped out of the screening process.

TABLE 8-12
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
BENCHMARK METRICS FOR BENTHIC INVERTEBRATE COPECS

COPEC	95th % UCL mg/kg	Aquatic Habitat Range[d] mg/kg	Screening Values: Tidal Area Ambient[a] mg/kg	Screening Values: SF Bay Ambient[b] mg/kg	Screening Values: ER-L[c] mg/kg	Screening Values: ER-M[c] mg/kg	Number Locations > Tidal Area Ambient: (Percent)	Number Locations > SF Bay Ambient: (Percent)	Number Locations > ER-L (Percent)	Number Locations > ER-M (Percent)
Antimony	5.5	0.50-26.3	2.2	NA	2.0	25.0	11/22 (50)	NA	12/22 (55)	1/22 (5)
Arsenic	29.2	0.50-106	27.0	15.3	8.2	70.0	6/29 (21)	13/29 (45)	22/29 (76)	1/29 (3)
Cadmium	1.4	0.010-7.8	1.9	0.33	1.2	9.6	4/29 (14)	13/29 (45)	5/29 (17)	0/29 (0)
Chromium	311	0.89-2,990	82.1	112	81.0	370	3/29 (10)	2/29 (7)	2/29 (7)	1/29 (3)
Copper	418	1.1-1,670	81.0	68.1	34.0	270	13/29 (45)	15/29 (45)	25/29 (86)	6/29 (21)
Lead	747	1.7-3,280	95.0	43.2	46.7	218	17/29 (59)	26/29 (90)	25/29 (86)	12/29 (41)
Molybdenum	29.1	0.10-301	6.6	NA	NA	NA	3/29 (10)	NA	NA	NA
Selenium	3.7	0.10-11.5	NA	0.64	0.70	1.4	NA	23/29 (79)	23/29 (79)	18/29 (62)
Silver	1.1	0.045-2.8	NA	0.58	1.0	3.7	NA	10/29 (34)	9/29 (31)	0/29 (0)
Zinc	1040	3.2-4,980	264	158	150	410	14/29 (48)	17/29 (59)	17/29 (59)	12/29 (41)

Notes:
ER-L - Effects range-low (Long and others 1995).
ER-M - Effects range-median (Long and others 1995).
mg/kg - Milligrams per kilogram.
SF- San Francisco.
UCL - Upper confidence limit of the mean

Numbers less than 10 are reported with two significant digits; numbers 10 and greater are reported with three significant digits.

[a]PRC. 1996. "Technical Memorandum, Estimation of Ambient Metal Concentrations in the Tidal Area Soils." Naval Weapons Station, Concord, California 12 April.

[b]RWQCB. 1998. "Ambient Concentrations of Toxic chemicals in San Francisco Bay Sediments." Regional Water Quality Control Board. April.

[c]Long, E.R., and others. 1995. "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." *Environmental Management*. Volume 19, Number 1. Pages 81 through 97.

[d]Concentrations used to compile the range included concentrations of one half the detection limit for those metals that were not detected in the aquatic habitat.

TABLE 8-13
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
HAZARD QUOTIENTS FOR COPECS IN THE AQUATIC HABITAT

Sample Location	Mean ER-M Quotient	Hazard Quotients (Sediment Concentration/ER-M Concentration)									
		Antimony	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Selenium	Silver	Zinc
309CSPWSS	**3.4**	0.29	0.81	0.81	0.20	**1.2**	**10.6**	0.55	0.86	0.29	**15.1**
309SB05	0.40	0.049	0.15	0.16	0.088	0.18	0.74	0.11	0.11	0.15	**1.9**
309SB106	0.26	0.016	0.11	0.032	0.079	0.080	**1.2**	0.23	0.071	0.035	0.47
309SSCS	**2.1**	0.13	0.47	0.25	0.14	0.48	**2.5**	0.70	**1.1**	0.11	**13.2**
309SSNS	0.36	0.040	0.20	0.048	0.10	0.18	0.40	0.15	**1.4**	0.070	0.59
309SSSS	0.52	0.043	0.14	0.10	0.095	0.27	0.87	0.12	**1.4**	0.090	**1.5**
SB013	**1.6**	0.11	0.28	0.0037	0.12	**3.8**	**2.7**	0.90	**1.7**	0.68	**6.1**
SB014	**3.5**	0.28	0.88	0.0036	0.21	**1.0**	**15.0**	0.27	**5.6**	0.70	**11.1**
SB015	**3.3**	**1.1**	0.82	0.0068	**8.1**	**2.7**	**4.7**	0.10	**4.9**	0.76	**10.3**
SB016	0.23	0.063	0.14	0.0208	0.0024	0.0041	0.0078	0.27	**1.4**	0.15	0.021
SB018	**2.7**	0.25	**1.5**	0.0048	0.13	**6.2**	**5.8**	0.30	**5.4**	0.034	**7.5**
SB019	**2.4**	0.17	0.75	0.0034	0.23	**1.6**	**7.5**	0.20	**8.2**	0.024	**4.9**
SB020	**2.8**	0.12	0.33	0.0031	0.20	**7.3**	**5.4**	0.042	**3.0**	0.023	**12.0**
SB100	0.54	0.12	0.089	0.025	0.075	0.20	0.45	0.070	**2.7**	0.46	0.64
SB101	0.26	0.041	0.13	0.0083	0.084	0.14	0.31	0.17	0.89	0.15	0.44
SB102	0.78	0.10	0.083	0.021	0.094	0.19	0.38	0.27	**4.9**	0.39	0.59
SB103	**1.2**	0.13	0.31	0.028	0.091	0.67	**2.3**	0.23	**3.0**	0.50	**3.3**
SB104	0.40	0.083	0.028	0.017	0.062	0.19	0.31	0.18	**1.9**	0.31	0.56
SB105	0.38	0.020	0.0068	0.0041	0.040	0.14	0.11	**2.1**	0.43	0.074	0.50
SB106	0.82	0.070	0.35	0.048	0.40	0.41	**1.2**	0.12	0.68	0.12	**4.0**
SS200	0.67	NA	0.27	0.10	0.14	0.34	0.75	0.077	**1.2**	0.047	**2.4**
SS201	0.44	NA	0.19	0.082	0.090	0.22	0.40	0.035	**1.7**	0.12	0.63
SS202	0.38	NA	0.16	0.069	0.084	0.17	0.33	0.14	**1.2**	0.12	0.71
SS203	0.45	NA	0.17	0.086	0.11	0.20	0.36	0.25	1.0	0.050	**1.4**
SS204	0.99	NA	0.22	0.35	0.10	0.74	0.76	0.37	0.93	0.41	**4.1**
SS205	**3.7**	0.091	0.38	0.25	0.041	0.61	**1.7**	0.0070	0.25	0.17	**33.2**
SS207	0.17	NA	0.046	0.0020	0.035	0.064	0.16	0.30	0.34	0.022	0.39
SS208	0.15	NA	0.056	0.0010	0.034	0.045	0.23	0.31	0.071	0.012	0.41
SS209	0.50	0.061	0.16	0.11	0.056	0.27	0.39	0.41	**1.7**	0.16	**1.2**
Mean Hazard Quotient		0.12	0.32	0.090	0.39	1.0	**2.3**	0.31	**2.0**	0.21	**4.8**

TABLE 8-13
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
HAZARD QUOTIENTS FOR COPECS IN THE AQUATIC HABITAT

Notes:

ER-M - Effects-range median (Long and others 1995).
HQ - Hazard quotient.
NA - Not analyzed.
Bold = HQ > 1
Hazard quotient = Sampling location metal concentration/ER-M metal concentration.
Hazard quotients were calculated for all benthic invertebrate COPECs except molybdenum and thallium. No ER-Ms were available for molybdenum and thallium.
Mean ER-M quotient = Sum of COPEC HQs for one sample location/Number of COPECs present at sample location.
Mean HQ = Sum of HQs for one COPEC/Number of locations
Numbers less than 10 are reported with two significant digits; numbers 10 or greater are reported with three significant digits.

Long, E.R., and others. 1995. "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." *Environmental Management*. Volume 19, Number 1. Pages 81 through 97.

TABLE 8-14
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE, NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD, BIOACCUMULATION FACTORS FOR AMPHIPODS IN THE AQUATIC HABITAT

	309CSIT		309SSCS		309NSIT		309SSNS		309SSIT		309SSSS		
Sample ID	Tissue (mg/kg wet wt)	Tissue (mg/kg dry wt)	Sediment (mg/kg dry wt)	BAF	Tissue (mg/kg wet wt)	Tissue (mg/kg dry wt)	Sediment (mg/kg dry wt)	BAF	Tissue (mg/kg wet wt)	Tissue (mg/kg dry wt)	Sediment (mg/kg dry wt)	BAF	Max BAF (mg/kg dry wt)
% Solid	5.1	NA	NA	NA	5.5	NA	NA	NA	5.9	NA	NA	NA	NA
Antimony	0.16	3.1	3.0	1.0	0.24	4.4	0.91	**4.8**	0.46	7.8	0.98	**8.0**	**8.0**
Arsenic	4.5	88.2	32.6	**2.7**	4.9	89.1	14.3	**6.2**	8.3	141	9.8	**14.4**	**14.4**
Cadmium	0.10	2.0	2.4	0.82	0.070	1.3	0.46	**2.8**	0.30	5.1	0.93	**5.5**	**5.5**
Chromium	2.1	41.3	50.8	0.81	1.8	32.8	38.1	0.86	3.7	63.3	35.1	**1.8**	**1.8**
Copper	58.4	1150	130	**8.8**	27.0	491	49.0	**10.0**	42.7	725	72.5	**10.0**	**10.0**
Lead	7.2	141	547	0.26	4.1	74.5	87.2	0.85	22.7	385	189	**2.0**	**2.0**
Mercury	0.12	2.4	0.21	**11.2**	0.11	2.0	0.22	**9.1**	0.080	1.4	0.29	**4.7**	**11.2**
Molybdenum	0.56	11.0	5.2	**2.1**	0.50	9.1	3.1	**2.9**	0.83	14.1	4.2	**3.4**	**3.4**
Selenium	0.98	19.3	1.6	**12.0**	1.2	21.8	2.0	**10.9**	0.50	8.5	2.0	**4.2**	**12.0**
Silver	1.0	19.6	0.42	**46.6**	0.54	9.8	0.26	**37.8**	0.34	5.8	0.33	**17.5**	**46.6**
Thallium	0.0050	0.10	0.14	0.70	0.0050	0.090	0.14	0.65	0.020	0.34	0.13	**2.6**	**2.6**
Zinc	112	2200	1980	**1.1**	157	2860	89.0	**32.1**	89.2	1510	226	**6.7**	**32.1**

Notes:
mg/kg dry wt = milligrams per kilogram in dry weight.
mg/kg wet wt = milligrams per kilogram in wet weight.
BAF- Bioccumulation factor.
COPEC - Chemical of potential ecological concern.
Max - Maximum.
NA - Not applicable.
Bold = BAF > 1
BAF = Tissue concentration (mg/kg dry weight)/Sediment concentration (mg/kg dry weight).
BAFs calculated for chemicals of potential ecological concern.
Chemicals that were not detectied are reported as one half the detection limit.
Tissue (mg/kg dry wt) = Tissue concentration in milligrams per kilogram wet weight/percent solid.

TABLE 8-15
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
SURVIVAL AND REBUIRIAL OF *EOHAUSTARIUS ESTUARIUS* AMPHIPODS IN BULK SEDIMENT BIOASSAY

Effects of Exposure to TBB Sediments on *Eohaustorius* Survival						
	% Survival					
Sediment Sample ID	Rep A	Rep B	Rep C	Rep D	Rep E	Mean[a]
Control	95	100	100	100	95	98
309SSNS	90	75	95	65	60	77
309SSCS	80	90	100	65	95	86
309SSSS	85	90	85	95	85	88

a – Mean is greater than RWQCB 68% reference envelope and 75% lab benchmark

Effects of Exposure to TBB Sediments on *Eohaustorius* Reburial						
	% Successful Reburial					
Sediment Sample ID	Rep A	Rep B	Rep C	Rep D	Rep E	Mean
Control	95	95	100	100	95	97
309SSNS	94	100	95	100	83	95
309SSCS	100	100	100	100	100	100
309SSSS	100	100	100	100	100	100

Summary of Overlying Water Quality Conditions						
Sediment Sample ID	pH Range	DO Range (mg/L)	Salinity Range (ppt)	Total Ammonia (mg/L - N)		Temperature Range (°C)
				Day 2	Day 8	
Control	7.80-8.06	8.0-8.6	18.0-18.8	0.06	0.05	15.5-17.4
309SSNS	8.02-9.40	8.2-9.5	19.3-20.7	4.14	1.15	15.5-17.5
309SSCS	8.02-9.13	7.8-9.2	19.4-21.0	3.70	1.42	15.5-17.2
309SSSS	8.02-9.29	7.7-9.6	19.9-21.9	2.96	0.16	15.5-17.3

Reference Toxicant Testing: Effects of Cadmium on *Eohaustorius* Survival			
	% Survival		
Nominal Cadmium Concentration (mg/L)	Replicate A	Replicate B	Mean
Control	100	100	100
0.75	100	100	100
1.5	90	90	90
3	30	40	35*
6	0	0	0*
9	0	0	0*

*Significantly less than the control at $p < 0.05$.

Notes:

°C – Degrees Celsius
% - percent
DO – Dissolved oxygen
mg/L – Milligrams per liter
ppt – parts per thousand
REP – Replicate
RWQCB – Regional Water Quality Control Board
TBB – Taylor Boulevard Bridge

TABLE 8-16
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
PHYSICAL AND CHEMICAL PARAMETERS AFFECTING BIOAVAILABILITY IN SEDIMENTS

Parameters Affecting Availability of Chemicals in Sediment

Analyte	Unit	Location		
		309SSCS	309SSNS	309SSS
SEM - AVS	NA	-1445	-273	-411
Sediment Fines	%	48.7	64.1	63
pH	pH	7.89	7.56	7.8
Total Organic Carbon	mg/kg	111,000	123,000	104,000

SEM and AVS Data for Composite Sediment Samples from the Aquatic Habitat

Location	SEM - AVS Difference	AVS (µmoles)	Sum Metals (µmoles)	Cadmium (µmoles)	Copper (µmoles)	Lead (µmoles)	Nickel (µmoles)	Zinc (µmoles)
309SSCS	-1445	1483	38.0	0.00067	1.1	4.5	1.0	31.4
309SSNS	-273	276	3.1	0.0088	0.69	0.47	0.42	1.5
309SSSS	-411	423	11.9	0.023	1.1	0.92	6.6	3.3

mg/kg - Milligrams per kilogram
% - percent
µmoles - micro mole
AVS - Acid volatile sulfide
NA - Not applicatble
SEM - Simultaneously extractable metals

TABLE 8-17
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
OVERVIEW OF RISK ASSESSMENT PROCESS FOR BENTHIC INVERTEBRATES

ASSESSMENT ENDPOINT: Protection of populations of benthic invertebrates (sufficient rates of survival and growth to sustain populations of benthic invertebrates)

SCREENING PROCESS

- Calculate 95th percent UCL for each metal at aquatic habitat.
- Compare each metal 95th percent UCL to lower of ambient 99th percent UCL for Concord Tidal Area or ambient 95th percent UCL for San Francisco Bay metal concentrations.
- Compare to ER-L benthic invertebrate toxicity benchmark (Long, and others 1995).

The metal was a COPEC if it exceeded the lower of the San Francisco Bay *or* Tidal Area ambient concentrations *and* exceeded the ER-L benthic invertebrate toxicity benchmark.

Mercury was reclassified as a COPEC after reviewing metals that dropped out of the screening process.

COPECS

Antimony
Arsenic
Cadmium
Chromium
Copper
Lead
Mercury
Molybdenum
Selenium
Silver
Thallium
Zinc

HAZARD AND MEAN QUOTIENTS

- Hazard quotients (sample location metal concentration divided by ER-M benthic invertebrate toxicity benchmark) were calculated for each COPEC except Mo and Tl at each sample location.
- Mean ER-M quotients (mean ER-Mq) were calculated across COPECs for each sample location at the habitat. See notes.
- Mean hazard quotients were calculated across sample locations for each COPEC at the habitat. See notes.

BIOACCUMULATION

- Used three composite sediment samples.
- Calculated bioaccumulation factors (amphipod tissue concentration divided by composite sediment metal concentration).

AMPHIPOD BIOASSAYS

- Used three composite sediment samples in bioassays.
- Conducted 10-day, solid-phase sediment toxicity test with amphipod, *Eohaustorius estuarius*.

BIOAVAILABILITY

- Used three composite sediment samples and analyzed for SEM and AVS.

QUOTIENT RESULTS

- Using Long and MacDonald (1998) 1.5 benchmark, 7 sample locations and 2 composite samples were potentially at risk.
  SB013, SB014, SB015, SB018, SB019, SB020, SS205, 309CSPWSS, 309SSCS

BIOACCUMULATION RESULTS

BAFs > 1 (below) suggest uptake.

309SSCS	309SSNS	309SSSS
As, 2.7	Sb, 4.8	Sb, 8.0
Cu, 8.8	As, 6.2	As, 14.4
Hg, 11.2	Cd, 2.8	Cd, 5.5
Mo, 2.1	Cu, 10.0	Cr, 1.8
Se, 12.0	Hg, 9.1	Cu, 10.0
Ag, 46.6	Mo, 2.9	Pb, 2.0
Zn, 1.1	Se, 10.7	Hg, 4.7
	Ag, 37.6	Mo, 3.4
	Zn, 32.1	Se, 4.2
		Ag, 17.3
		Zn, 6.7

AMPHIPOD BIOASSAY RESULTS

- control, 98% mean survival; 309SSNS, 77%; 309SSCS, 86%; 309SSSS, 88%.
- control, 98% mean reburial; 309SSNS, 95%; 309SSCS, 100%; 309SSSS, 100%.

BIOAVAILABILITY RESULTS

- SEM-AVS differences were 309SSCS, -1445; 309SSNS, -273; 309SSSS, -411.
- Suggests divalent metals not available for uptake.

COPEC LITERATURE REVIEW FOR BENTHIC INVERTEBRATES

Antimony (Sb). Little literature. Toxicity poorly defined.

Arsenic (As). Well studied; toxic; can be accumulated.

Cadmium (Cd). Well studied; toxic; more toxic in freshwater.

Chromium (Cr). Moderately well studied; toxic; can be accumulated.

Copper (Cu). Well studied; toxic; generally not accumulated; ultimate sink is bone.

Lead (Pb). Well studied; toxic; accumulated, but not at high concentrations.

Mercury (Hg). Well studied; toxic; accumulated and biomagnified in methyl form.

Molybdenum (Mo). Essential element. Few data for benthic animals; toxicity uncertain.

Selenium (Se). Well studied; toxic; can be significantly accumulated.

Silver (Ag). Well studied; very toxic; can be accumulated primarily in seawater.

Thallium (Tl). Little literature. Toxicity poorly defined.

Zinc (Zn). Well studied; toxic; generally not accumulated; ultimate sink is bone.

COECs

Copper
Lead
Selenium
Zinc

See text and Figure 8-8 for explanation of how COECs were chosen.

TABLE 8-17
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
OVERVIEW OF RISK ASSESSMENT PROCESS FOR BENTHIC INVERTEBRATES

Table Notes

AVS - Acid volatile sulfide
BAF - Bioaccumulation factors
COEC - Chemicals of ecological concern
COPECs, chemicals of potential ecological concern
ER-L - Effects range, low
ER-M - Effects range, median
HQ - Hazard quotient
RWQCB - Regional Water Quality Control Board
SEM - Simultaneously extracted metals
UCL - Upper confidence limit of the mean

HQ = Sediment concentration / ER-M
Mean HQ = Sum HQ across sampling locations / number sampling locations
Mean ER-M quotient (mean ER-Mq) = sum of HQs at one sampling location / number of HQs at location

Long, E.R., and others. 1995. "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations In Marine and Estuarine Sediments." *Environmental Management*. Volume 19, Number 1. Pages 81 through 97.

Long, E.R. and D.D. MacDonald. 1998. "Recommended Uses of Empirically Derived, Sediment Quality Guidelines for Marine and Estuarine Ecosystems." *Hum. Ecol. Risk Assess*. Volume 4, Number 5. Pages 1019-1039.

RWQCB, 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." April.

PRC. 1999. "Technical Memorandum, Estimation of Ambient Metal Concentrations in the Tidal Area Soils." Naval Weapons Station, Concord, California. 12 April.

TABLE 8-18
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
INORGANIC CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN
FOR AQUATIC BIRDS

Analyte	Concord Tidal Area Ambient 99th % UCL[a] (mg/kg)	RWQCB San Francisco Bay Sediment Ambient[b] (mg/kg)	TBB Sediment 95% UCL[c] (mg/kg)	Aquatic Birds COPEC
Aluminum	27,300	NA	10590	N
Antimony	2.2	NA	10.1	Y
Arsenic	27.0	15.3	28.7	Y
Barium	530	NA	508	N
Beryllium	0.18	NA	0.24	Y
Cadmium	1.9	0.33	1.7	Y
Chromium	82.1	112	204	Y
Cobalt	36.0	NA	13.5	N
Copper	81.0	68.1	1094	Y
Lead	95.0	43.2	1126	Y
Manganese	1,500	NA	1008	N
Mercury	0.32	0.43	1.7	Y
Molybdenum	6.6	NA	19.4	Y
Nickel	120	112	73.3	N
Selenium	NA	0.64	3.2	Y
Silver	NA	0.58	1.3	Y
Thallium	2.2	NA	1.7	N
Vanadium	96.0	NA	42.0	N
Zinc	264	158	1309	Y

Notes:
mg/kg milligram per kilogram
COPEC Chemical of potential ecological concern
TBB Taylor Boulevard Bridge
UCL Upper confidence limit of the mean
n = 48
a PRC Environmental Management, Inc. 1996b. "Technical Memorandum. Ambient Metal Concentrations in the Tidal Area Soils."
b RWQCB. 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." May.
c Nondetects were included in the calculation of the 95 percent UCL as one-half the detection limit.

For locations where surface and subsurface data were available, the maximum concentration was used in the calculation of the 95 percent UCL.

Aquatic bird dataset includes samples collected in the wetland and upland transitional and aquatic habitat.

TABLE 8-19
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE,
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD,
INORGANIC CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN
FOR THE SALT MARSH HARVEST MOUSE

Analyte	Concord Tidal Area Ambient 99th % UCL[a] (mg/kg)	RWQCB San Francisco Bay Sediment Ambient[b] (mg/kg)	TBB Sediment 95% UCL[c] (mg/kg)	SMHM COPEC
Aluminum	27,300	NA	9830	N
Antimony	2.2	NA	14.7	Y
Arsenic	27.0	15.3	37.6	Y
Barium	530	NA	716	Y
Beryllium	0.18	NA	0.30	Y
Cadmium	1.9	0.33	2.1	Y
Chromium	82.1	112	308	Y
Cobalt	36.0	NA	16.6	N
Copper	81.0	68.1	1690	Y
Lead	95.0	43.2	1690	Y
Manganese	1,500	NA	925	N
Mercury	0.32	0.43	2.7	Y
Molybdenum	6.6	NA	28.4	Y
Nickel	120	112	92.2	N
Selenium	NA	0.64	3.8	Y
Silver	NA	0.58	1.6	Y
Thallium	2.2	NA	0.95	N
Vanadium	96.0	NA	36.0	N
Zinc	264	158	1660	Y

Notes:
mg/kg milligram per kilogram
COPEC Chemical of potential ecological concern
TBB Taylor Boulevard Bridge
UCL Upper confidence limit of the mean
n = 30

a PRC Environmental Management, Inc. 1996b. "Technical Memorandum. Ambient Metal Concentrations in the Tidal Area Soils."

b RWQCB. 1998. "Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments." May.

c Nondetects were included in the calculation of the 95 percent UCL as one-half the detection limit.

For locations where surface and subsurface data were available, the maximum concentration was used in the calculation of the 95 percent UCL.

SMHM dataset includes samples collected in the wetland and upland transitional habitat (includes shoreline samples).

TABLE 8-20
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE, NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD, SUMMARY OF HQs FOR THE SALT MARSH HARVEST MOUSE

$HQ_{(low\ dose/high\ TRV)}$	309CSPWSS	309SB05	309SB106	SB01	SB02	SB03	SB04	SB05	SB06	SB07	SB08	SB09	SB10	SB105	SB11	SB12	SB13	SB14	SB15	SB16	SB17	SB18	SB19	SB20	SS206	SS210	SS211	SS212	SS213	SS214	Number of $HQ_{(low\ dose/high\ TRV)}$ greater than 1.0 by chemical
Antimony						5.8	1.3						2.2						1.8												4
Arsenic	1.0		1.1	8.3		20.1	8.7	1.2			1.4	5.4	4.8		2.1		2.8	8.7	8.2	1.3		15.0	7.5	3.2	1.1				1.0	1.1	20
Barium				6.6		1.1	1.4										1.0	1.7	1.0												6
Cadmium				6.8		1.1	1.4										1.0	1.7	1.0												6
Chromium																			6.9												1
Copper						1.8							3.4																		2
Lead																															0
Mercury						11.5						1.3																			2
Molybdenum				7.5		14.0	4.7					1.6	1.9				233.4	3.9	5.0		5.4	5.1	4.7	2.2							12
Selenium							4.4					2.4	2.0				1.2	3.8	3.3	1.0	5.9	3.7	5.6	2.1							11
Zinc				2.0		1.9	1.0					2.6	2.4								1.0										6
Number of $HQ_{(low\ dose/high\ TRV)}$ greater than 1.0 by location	1	0	1	5	0	8	7	1	0	0	1	5	3	0	1	0	5	5	7	2	3	3	3	3	1	0	0	0	1	1	

$HQ_{(high\ dose/high\ TRV)}$	309CSPWSS	309SB05	309SB106	SB01	SB02	SB03	SB04	SB05	SB06	SB07	SB08	SB09	SB10	SB105	SB11	SB12	SB13	SB14	SB15	SB16	SB17	SB18	SB19	SB20	SS206	SS210	SS211	SS212	SS213	SS214	Number of $HQ_{(high\ dose/high\ TRV)}$ greater than 1.0 by chemical
Antimony						13.5	2.9					1.0	5.2					1.0	4.2												6
Arsenic	2.3		2.5	19.1	1.9	46.8	20.1	2.8	2.0	2.0	3.3	12.4	11.1		4.8	2.2	6.5	20.1	18.9	3.1		34.7	17.3	7.5	2.5	1.5	1.0	1.0	2.4	2.7	27
Barium				15.7		2.6	3.1		1.2		1.0	1.3	1.0			1.4	2.3	3.8	2.3					1.1							12
Cadmium						1.3							3.1																		2
Chromium																			15.9												1
Copper						4.2							7.8									1.0		1.2							4
Lead																															0
Mercury						27	2.1					2.2																			3
Molybdenum	1.1			17.4		32.4	10.8				1.5	3.8	4.5				540	9.0	13.8	2.2	12.4	11.8	10.8	5.2	1.2						16
Selenium	1.4						10.2	1.1	1.0	1.1		5.7	4.5		1.1	1.2	2.7	8.8	7.7	2.3	13.6	8.6	13.0	4.8							17
Zinc				4.5		4.4	2.3					6.0	5.5				1.0	1.8	1.7		2.3	1.3		2.0	1.1						12
Number of $HQ_{(high\ dose/high\ TRV)}$ greater than 1.0 by location	3	0	1	4	1	8	7	2	3	2	3	7	8	0	2	3	5	8	7	3	3	5	3	6	3	1	1	1	1	1	

$HQ_{(high\ dose/low\ TRV)}$	309CSPWSS	309SB05	309SB106	SB01	SB02	SB03	SB04	SB05	SB06	SB07	SB08	SB09	SB10	SB105	SB11	SB12	SB13	SB14	SB15	SB16	SB17	SB18	SB19	SB20	SS206	SS210	SS211	SS212	SS213	SS214	Number of $HQ_{(high\ dose/low\ TRV)}$ greater than 1.0 by chemical
Antimony	2.0			9.0	1.3	135	29.0					9.6	51.6			8.0	4.0	10.3	42.2	2.3		9.3	6.1	4.3	1.9			1.0			17
Arsenic	32.2		34.7	263	26.1	640	276	38.8	27.9	27.5	46.0	170	153.2	2.1	66.2	29.7	88.8	277	260	42.8	1.5	478	237	103	34.7	21.2	14.0	14.0	33.3	36.5	29
Barium	3.3	1.2	2.3	60.3	2.9	9.9	12.0	3.2	4.7	2.6	3.9	5.1	3.9	2.7	2.7	5.2	8.8	14.7	8.8	1.6		2.5	2.4	4.3	2.8	1.4	1.6	1.2	1.5	1.1	29
Cadmium	20.6		3.2	2.9		58.6	28.8					34.0	138							2.1					16.5	3.9		3.7	7.1	3.9	13
Chromium				2.9		2.7	2.5						2.1				1.0	1.7	63.8		3.7	1.0	1.8	1.6							11
Copper	7.1	1.9	3.2	88.5	3.7	971	55.0	4.1	2.9	4.4	5.7	47.6	1819	5.4	7.3	10.4	150	39.3	106		74.9	243	62.9	288	82.2	1.9	1.3	2.9	8.3	2.5	29
Lead	12665	14[illegible]9	1788	24188	328	72564	47525	1899	332	1739	1219	14739	17668	235	3005	7077	564[illegible]	30991	9637	16.1	19180	11999	15495	11149	4592	282	420	532	1039	1842	30
Mercury				7.1		448	36					37	11.7				8.6	1.4	2.6	8.4	1.2	1.9	1.4	10.9					4.2		14
Molybdenum	11.1	3.0	5.6	174	1.3	324	107.6	5.5	5.7	5.3	15.[illegible]	37.6	44.8	3.6	6.7	6.5	5396.3	89.6	138	21.5	124	118	108	52.0	12.0	1.6	1.6	1.4	1.4	1.8	30
Selenium	32.9		2.4	11.5	8.1	8.2	247	26.0	23.9	25.3	10.5	137	110	16.4	27.4	30.2	65.8	214	168	54.8	329	208	315	115	2.7	5.8	2.5	2.3	2.3	4.7	30
Zinc	20.8	1.8	3.8	218	4.8	211	112	6.7	2.2	6.4	5.3	289	265	4.0	8.2	[illegible]0.5	48.7	88.6	82.2		110.0	60.3	39.3	96.1	52.5	3.8	2.5	5.6	18.0	4.2	29
Number of $HQ_{(high\ dose/low\ TRV)}$ greater than 1.0 by location	9	5	8	11	8	[illegible]1	11	7	7	7	7	10	11	7	7	8	10	10	10	8	8	10	10	10	9	8	7	9	9	8	

Note: Blank cells indicate a HQ less than 1.0 . HQ = Hazard quotient TRV = Toxicity reference value

APPENDIX A

DATA QUALITY OBJECTIVE STEPS FOR SAMPLING AT THE TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

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APPENDIX A

DATA QUALITY OBJECTIVE STEPS FOR SAMPLING AT THE TAYLOR BOULEVARD BRIDGE DISPOSAL SITE NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7
State the Problem	**Identify the Decisions**	**Identify the Inputs to the Decisions**	**Define Study Boundaries**	**Develop Decision Rules**	**Specify Tolerable Limits on Errors**	**Optimize Sampling Design**
*Lead concentrations at some locations are high enough (>250ppm) that remediation is expected. An ERA is required to make decisions about areas outside the 250ppm lead isopleth. *Confirmation of the extent of the glass debris is also necessary.	*Does the nature and extent of chemicals outside the 250 mg/kg isopleth present an unacceptable level of risk to ecological receptors? *Are sediments from the area outside the 250 mg/kg isopleth associated with adverse effects in the bioassays? *Is the ecological risk posed by chemicals in the area outside the 250 mg/kg isopleth sufficient to warrant a risk management decision?	*Validated defensible chemical data for soil, sediment, and prey tissues *inorganic chemicals concentrations in pickleweed tissue, to model the doses to the salt marsh harvest mouse *inorganic chemicals concentrations in benthic invertebrate tissue from the shoreline area to model doses to resident shorebirds *a measure of direct toxicity (toxicity test) to representative benthic invertebrate species, and *A summary of toxicological effects of exposure to representative receptors from the literature.	* For this study the spatial boundary will be limited to the geographical area that has been previously sampled outside the 250 mg/kg lead concentration isopleth from which soil and sediment samples have already been collected.	*If the site chemistry is elevated above screening values and if bioassays show adverse effects, risk will be indicated. *If food-chain modeling shows doses to higher level receptors using invertebrates and pickleweed tissue samples as prey that are above TRVs, then risk to these receptors would be indicated. *If significant risk is indicated at the site, then risk management recommendations will be made.	*The limits on error for the chemical data and tissue analyses are defined in the individual analytical methods. *The limits on error for the bioassay results are defined in the Final Summary Report and Field Work Plan for Supplemental Sampling at TBB (TtEMI 1999). *The limits on error for the weight-of-evidence approach are based on professional judgement.	* The design of the sampling program for this investigation, including the sampling methods, numbers of samples collected, and locations of samples, was based on a review of site-specific historical information, the results of previous investigation activities conducted at the site, and various regulatory guidance documents.

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7
State the Problem	**Identify the Decisions**	**Identify the Inputs to the Decisions**	**Define Study Boundaries**	**Develop Decision Rules**	**Specify Tolerable Limits on Errors**	**Optimize Sampling Design**
	*Is there risk to receptors based on food-chain modeling with aquatic invertebrate tissue samples as the prey component?					

Notes:

DQO	Data Quality Objectives
EE/CA	Engineering evaluation and cost analysis
EPA	Environmental Protection Agency
FSP	Field sampling plan
IRP	Installation Restoration Program
MDRD	Minimum detectable relative difference
PRGs	Preliminary Remediation Goals
WP	Work plan

APPENDIX B

DEBRIS TEST HOLE BORE LOGS

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LITHOLOGIC BORING LOG

Date: 1/31/2000 | Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB001
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1000 FINISH BORING: 1015
TOTAL DEPTH (ft bgs): 2.0	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): NA DATE/TIME: NA	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ∇ Static water level; * Staining/ Odor; CONTACTS: Distinct, Inferred, Gradational
							1		ML / debris / CL	SURFACE-DEBRIS (minor) GLASS FRAGMENTS w/ SOME PIECES OF CHARRED WOOD + VEGETATION 0-0.5' SANDY SILT (ML), DARK BROWN, MOIST, LOW PLASTICITY, 10-15% VERY FINE GRAINED SAND, SOME ROOT MATERIAL AND GLASS FRAGMENTS 0.5-1.5' DEBRIS LAYER OF GLASS FRAGMENTS AND RUSTED METAL 1.5-2.0' SILTY CLAY (CL), OLIVE GRAY, MOIST, MODERATELY PLASTIC
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vernimen

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Date: 1/31/2000

LITHOLOGIC BORING LOG

Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB002
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil and debris
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1020 FINISH BORING: 1040
TOTAL DEPTH (ft bgs): 3.5	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): 1.0 DATE/TIME: 1/31 1040	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	Description
										SYMBOLS: ∇ Static water level; • Staining/Odor; CONTACTS: Distinct, Inferred, Gradational
									ML w/much glass debris	SURFACE - PICKLEWEED
										SANDY SILT (ML) W/SOME CLAY AND MOSTLY GLASS FRAGMENT DEBRIS, DARK BROWN, MOIST TO WET W/DEPTH, LOW PLASTICITY, VERY FINE GRAINED SAND
							1			
										SATURATED, GLASS FRAGMENT/RUST/SOIL MATRIX
							2			
							3		ML	GLASS FRAGMENT DEBRIS TAPERS OFF FROM 3.0 - 3.5 FT.
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vernimen

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LITHOLOGIC BORING LOG

Date: 1/31/2000 | Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB003
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1044 FINISH BORING: 1055
TOTAL DEPTH (ft bgs): 3.0	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): 0.5 DATE/TIME: 1/31 1055	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	Description
									ML	SURFACE: PICKLEWEED AND GLASS DEBRIS
										SANDY SILT (ML), MODERATE DARK BROWN, WET TO SATURATED W/DEPTH, LOW PLASTICITY, 15-20% VERY FINE GRAINED SAND W/ MANY GLASS FRAGMENTS
							1			
										RUSTED METAL AND GLASS DEBRIS
							2		ML w/ glass & metal debris	
							3			SHOVEL REFUSAL AT 3.0 FT. bgs
							4			
							5			
							6			
							7			
							8			
							9			
							10			

SYMBOLS:
∇ Static water level
* Staining/ Odor

CONTACTS:
— Distinct
-- Inferred
\ Gradational

Richard Vernimen

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Date: 1/31/2000

LITHOLOGIC BORING LOG

Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB004
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1100 FINISH BORING: 1115
TOTAL DEPTH (ft bgs): 3.0	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): 0.5 DATE/TIME: 1115	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ∇ Static water level; • Staining/Odor; CONTACTS: Distinct, Inferred, Gradational
							1		ML w/ glass and rusted metal debris	SURFACE: VEGETATION AND SOME GLASS FRAGMENTS
										0-0.5' SANDY SILT (ML) W/ LITTLE CLAY AND MUCH GLASS AND RUSTED METAL DEBRIS, DARK BROWN, WET TO SATURATED W/DEPTH, LOW PLASTICITY, 20-30% VERY FINE-GRAINED SAND, SOME ROOT MATERIAL SATURATED AT 0.5 FT BGS
							2			0.5-3.0' MOSTLY (~35%) GLASS FRAGMENTS AND RUSTY METAL DEBRIS W/ SANDY SILT (ML) AS ABOVE
							3			SHOVEL REFUSAL AT 3.0 FT. BGS + DIFFICULTY REMOVING MATERIAL FROM THE WATER-FILLED HOLE
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vernimen

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LITHOLOGIC BORING LOG

Date: 1/31/2000 | Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB005
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1120 FINISH BORING: 1130
TOTAL DEPTH (ft bgs): 2.0	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): NA DATE/TIME:	

SYMBOLS:
∇ Static water level
• Staining/ Odor

CONTACTS:
— Distinct
— Inferred
\ Gradational

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	
										SURFACE: PICKLEWEED + MINOR GLASS AND WOOD DEBRIS
										0-2.0' SILTY CLAY (CH), OLIVE GRAY, WET,
										MEDIUM TO HIGH PLASTICITY
							1		CH	
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vernimen

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Date: 1/31/2000

LITHOLOGIC BORING LOG

Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB006
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1115 FINISH BORING: 1125
TOTAL DEPTH (ft bgs): 1.5	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): NA DATE/TIME:	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ▽ Static water level * Staining/ Odor CONTACTS: __ Distinct — Inferred \ Gradational	
									ML		SURFACE: PICKLEWEED AND FEW SCATTERED GLASS FRAGMENTS
											0-1.0' SANDY SILT (ML), OLIVE GRAY/BROWN, WET, LOW PLASTICITY, 10-15% VERY FINE-GRAINED SAND, GRADING TO
							1		CH		1.0-1.5' SILTY CLAY (CH), OLIVE GRAY, WET, MEDIUM TO HIGH PLASTICITY
							2				
							3				
							4				
							5				
							6				
							7				
							8				
							9				
							10				

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LITHOLOGIC BORING LOG

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PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB007
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1130 FINISH BORING: 1140
TOTAL DEPTH (ft bgs): 1.5	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): NA DATE/TIME:	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ∇ Static water level; * Staining/ Odor; CONTACTS: Distinct, Inferred, Gradational
									ML	SURFACE: VEGETATION, MINOR BRICK FRAGMENTS; CLAYEY SILT (ML) w/ TRACE VERY FINE-GRAINED SAND, BROWNISH GRAY, MOIST, LOW PLASTICITY
							1			
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

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LITHOLOGIC BORING LOG

Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB003
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1120 FINISH BORING: 1130
TOTAL DEPTH (ft bgs): 1.5	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): NA DATE/TIME:	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	Description
										SURFACE: GRASS w/ MINOR GLASS FRAGMENT DEBRIS
									CH	0-1.5' SILTY CLAY (CH), GRAYISH BLACK, WET, MEDIUM TO HIGH PLASTICITY
							1			↓
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

SYMBOLS:
∇ Static water level
• Staining/ Odor

CONTACTS:
__ Distinct
-- Inferred
\ Gradational

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LITHOLOGIC BORING LOG

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PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB009
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1435 FINISH BORING: 1445
TOTAL DEPTH (ft bgs): 1.5	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): NA DATE/TIME: —	

SYMBOLS:
∇ Static water level
• Staining/ Odor

CONTACTS:
__ Distinct
— Inferred
\ Gradational

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	
										SURFACE: GRASS w/MINOR CONCRETE AND GLASS FRAGMENTS
									ML	CLAYEY SILT (ML) w/TRACE VERY FINE-GRAINED SAND, OLIVE GRAY/BROWN, DAMP, LOW PLASTICITY NO DEBRIS
							1			
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

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LITHOLOGIC BORING LOG

Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB010
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1425 FINISH BORING: 1435
TOTAL DEPTH (ft bgs): 1.5	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): NA DATE/TIME:	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ▽ Static water level • Staining/ Odor CONTACTS: __ Distinct -- Inferred / Gradational
										SURFACE: GRASS w/MINOR BRICK AND GLASS FRAGMENTS
							1		ML	CLAYEY SILT (ML) w/ TRACE VERY FINE-GRAINED SAND, OLIVE GRAY/BROWN, DAMP, LOW PLASTICITY NO DEBRIS ↓
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

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Date: 1/31/2000

LITHOLOGIC BORING LOG

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PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB011
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1130 FINISH BORING: 1140
TOTAL DEPTH (ft bgs): 2.0	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): NA DATE/TIME:	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ∇ Static water level • Staining/ Odor CONTACTS: __ Distinct — Inferred \ Gradational
									ML w/ glass debris	SURFACE: GRASS, BRICK & GLASS FRAGMENTS
										CLAYEY SILT (ML) w/TRACE FINE-GRAINED SAND,
										OLIVE GRAY/BROWN, DAMP, LOW PLASTICITY, w/SOME
							1			GLASS DEBRIS FROM 0.5 – 1.0 BGS
									ML no glass	NO GLASS DEBRIS
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vernimen

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LITHOLOGIC BORING LOG

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PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB012
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1140 FINISH BORING: 1150
TOTAL DEPTH (ft bgs): 2.5	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): Ø DATE/TIME:	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ∇ Static water level * Staining/ Odor CONTACTS: __ Distinct --- Inferred / Gradational
									CL w/glass debris	SURFACE: VEGETATION W/ MUCH GLASS DEBRIS
										Ø-1.5' SILTY CLAY (CL) W/ TRACE VERY FINE-GRAINED
										SAND AND LOTS OF GLASS DEBRIS, OLIVE BROWN/GRAY,
							1			WET, LOW PLASTICITY
									CH	SILTY CLAY (CH) DARK OLIVE GRAY, WET, MEDIUM
										TO HIGH PLASTICITY, NO DEBRIS
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vernimen

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Date: 1/31/2000

LITHOLOGIC BORING LOG

Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB013
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vermimen
BACKFILL DATE: 1/31/2000 BY: Richard Vermimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1145 FINISH BORING: 1155
TOTAL DEPTH (ft bgs): 2.0	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): 0.5 DATE/TIME: 1155	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ∇ Static water level • Staining/ Odor CONTACTS: __ Distinct --- Inferred \ Gradational
									CH w/ glass deb.	SURFACE: PICKLEWEED w/ SOME GLASS FRAGMENTS
										SILTY CLAY (CH), OLIVE GRAY, WET, MEDIUM
										TO HIGH PLASTICITY, w/ SOME GLASS DEBRIS
							1			FROM 0 - 1.0'
										↓
										LESS GLASS DEBRIS
									CH	
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Refusal

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LITHOLOGIC BORING LOG

Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB014
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1430 FINISH BORING: 1440
TOTAL DEPTH (ft bgs): 1.5	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): NA DATE/TIME:	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ▽ Static water level * Staining/ Odor CONTACTS: __ Distinct — Inferred \ Gradational
										SURFACE: GRASS (no visible glass debris)
										CLAYEY SILT (ML) w/TRACE VERY FINE-GRAINED
									ML	SAND, OLIVE GRAY/BROWN, DAMP, LOW PLASTICITY
							1			↓
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vernimen

TETRA TECH EM INC.

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DS.0309.15131

LITHOLOGIC BORING LOG

Date: 1/31/2000 | Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB015
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1430 FINISH BORING: 1440
TOTAL DEPTH (ft bgs): 1.5	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): NA DATE/TIME:	

SYMBOLS:
∇ Static water level
• Staining/ Odor

CONTACTS:
— Distinct
--- Inferred
\ Gradational

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	
										SURFACE: GRASS w/MINOR CONCRETE AND CHARRED WOOD DEBRIS
							1		ML	CLAYEY SILT (ML) w/TRACE VERY FINE-GRAINED SAND, OLIVE GRAY/BROWN, DAMP, LOW PLASTICITY ↓
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vernimen

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Date: 1/31/2000

LITHOLOGIC BORING LOG

Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB016
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1155 FINISH BORING: 1205
TOTAL DEPTH (ft bgs): 1.5	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): NA DATE/TIME:	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ∇ Static water level * Staining/ Odor CONTACTS: __ Distinct — Inferred \ Gradational
										SURFACE: PICKLEWEED - no debris
										SILTY CLAY (CL), OLIVE GRAY, MOIST, LOW TO
										MEDIUM PLASTICITY
							1		CL	NO DEBRIS NOTED TO DEPTH
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vernimen

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LITHOLOGIC BORING LOG

Date: 1/31/2000 | Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB017
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1200 FINISH BORING: 1210
TOTAL DEPTH (ft bgs): 2.0	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): NA DATE/TIME:	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ∇ Static water level; * Staining/ Odor; CONTACTS: Distinct, Inferred, Gradational
										SURFACE: PICKLEWEED (no debris)
									CL	SILTY CLAY (CL), OLIVE GRAY W/ SOME BLACK MOTTLING, MOIST, LOW TO MEDIUM PLASTICITY,
							1		CL	no debris throughout the interval
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vernimen

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Date: 1/31/2000

LITHOLOGIC BORING LOG

Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB018
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1205 FINISH BORING: 1215
TOTAL DEPTH (ft bgs): 2.0	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): NA DATE/TIME:	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ∇ Static water level * Staining/ Odor CONTACTS: Distinct / Inferred / Gradational
										SURFACE VEGETATION (no debris)
										CLAYEY SILT (ML) DARK BROWN, MOIST, LOW TO
									ML	MEDIUM PLASTICITY
							1			
									ML	no debris throughout the interval
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vernimen

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LITHOLOGIC BORING LOG

Date: 1/31/2000 | Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB019
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1440 FINISH BORING: 1500
TOTAL DEPTH (ft bgs): 2.0	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): 0.0 DATE/TIME: 1/31 1500	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ∇ Static water level; • Staining/Odor; CONTACTS: Distinct, Inferred, Gradational
							1		mostly debris w/ML	SURFACE: PICKLEWEED (dead) + GLASS DEBRIS SANDY SILT (ML) w/ TRACE CLAY AND MOSTLY DEBRIS (glass and rusted metal), OLIVE GRAY/BROWN, WET, LOW PLASTICITY SATURATED, DEBRIS CONTINUES (glass fragments, glass bottles, rust) ← shovel refusal at 2.0 ft. bgs
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vernimen

TETRA TECH EM INC.

DS.0309.15131

Date: 1/31/2000

LITHOLOGIC BORING LOG

Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB020
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1340 FINISH BORING: 1410
TOTAL DEPTH (ft bgs): 3.5	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): 1.0 DATE/TIME: 1-31/1410	

SYMBOLS:
∇ Static water level
* Staining/ Odor

CONTACTS:
— Distinct
— Inferred
\ Gradational

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	
										SURFACE: PICKLEWEED (dead) + OTHER VEGETATION AND GLASS FRAGMENTS
										SANDY SILT (ML) w/ TRACE CLAY AND MOSTLY DEBRIS (glass and rusted metal), OLIVE GRAY/ BROWN, WET, LOW PLASTICITY
							1		mostly debris w/ ML	
										SATURATED
							2			debris continues, ~~gl~~ GLASS, RUST, BOTTLES
							3			slightly less debris
										shovel refusal at 3.5 ft bgs
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vernimen

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Date: 1/31/2000

LITHOLOGIC BORING LOG

Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB021
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vermimen
BACKFILL DATE: 1/31/2000 BY: Richard Vermimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1415 FINISH BORING: 1425
TOTAL DEPTH (ft bgs): 3.0	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): 0.5 DATE/TIME: 1425	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	SYMBOLS: ∇ Static water level; ▪ Staining/Odor; CONTACTS: __ Distinct, — Inferred, \ Gradational
										SURFACE: PICKLEWEED (dead) + OTHER VEGETATION AND GLASS FRAGMENTS
									mostly debris w/ML	SANDY SILT (ML) w/ TRACE CLAY AND MOSTLY DEBRIS (glass and rusted metal), OLIVE GRAY/BROWN, WET, LOW PLASTICITY
							1			SATURATED
							2			DEBRIS CONTINUES (glass w/ rusted metal and ~20% SANDY SILT as above
										somewhat less debris 2.75-3.0 ft. bgs
							3			shovel refusal at 3.0 ft. bgs
							4			
							5			
							6			
							7			
							8			
							9			
							10			

Richard Vermimen

TETRA TECH EM INC.

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DS.0309.15137

Date: 1/31/2000

LITHOLOGIC BORING LOG

Sheet 1 of 1

PROJECT: CTO 309 NWSDB CONCORD CLEAN II	SITE ID: Concord - TBB BORING ID: DB022
PROJECT MANAGER: Cindi Rose	CHARGE NO.: G0069-309B0101
PROJECT TASK: Taylor Blvd. Bridge Site Debris Borings	LOGGED BY: Richard Vernimen
BACKFILL DATE: 1/31/2000 BY: Richard Vernimen	MATERIAL: native soil
WEATHER: partly cloudy, cool, ~60°F	BEGIN BORING: 1410 FINISH BORING: 1420
TOTAL DEPTH (ft bgs): 3.5	LOCATION OF BOREHOLE:
WATER DEPTH (ft bgs): 0.5 DATE/TIME: 1420/1-31	

Sample ID	Sample Time	OVM (ppm)	Drive Interval	Recovered Interval	Lab Sample	Blows per ft	Depth (ft bgs)	Graphic	USCS Soil Type	Description
										SURFACE: PICKLEWEED (dead) + OTHER VEGETATION AND GLASS FRAGMENTS
										SANDY SILT (ML) W/ TRACE CLAY AND MOSTLY DEBRIS (glass and rusted metal), OLIVE GRAY/ BROWN, WET, LOW PLASTICITY
							1		mostly debris w/ML	
										SATURATED
							2			DEBRIS CONTINUES (glass, rust, some brick fragments)
										SOMEWHAT LESS DEBRIS FROM 2.5 FT. bgs TO DEPTH
							3			
										shovel refusal at 3.5 ft. bgs
							4			
							5			
							6			
							7			
							8			
							9			
							10			

SYMBOLS:
∇ Static water level
* Staining/ Odor

CONTACTS:
— Distinct
--- Inferred
\ Gradational

Richard Vernimen

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DS.0309.15131

APPENDIX C

TOXICOLOGICAL PROFILES FOR CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN

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C.1 ARSENIC

Arsenic is a naturally occurring element that is widely distributed in the environment and is used in metallurgy to harden copper, lead, and alloys and in the manufacture of certain types of glass. Historically, some forms of arsenic have been used as pesticides.

Arsenic is present in the environment in both inorganic and organic forms. The bioavailability and toxicity of arsenic are dependent upon the chemical and physical forms of arsenic, the exposure route, and the species of concern. Inorganic arsenic is present in the environment in two major forms, arsenate (As5+) and arsenite (As3+). In the environment, arsenate is more abundant and bioaccumulates more rapidly than arsenite; however, arsenite is the more toxic form (Sadiq 1992). Any environmental conditions that promote an increase in arsenite concentrations will increase the toxicity of arsenic in the environment. The oxidation-reduction environment is the most important environmental parameter that affects the bioavailability of arsenic. Reduced conditions in the environment cause the ratio of arsenite to arsenate to increase, thus increasing the toxicity of arsenic in the environment. In addition to oxidation-reduction, the pH of the aquatic environment influences the toxicity of arsenic. As the pH of the water increases, the toxicity of arsenic decreases as more arsenate is produced (Sadiq 1992).

Marine organisms accumulate more arsenic than freshwater organisms. Arsenate is more readily bioaccumulated than arsenite (Sadiq 1992). Bioconcentration factors (BCF) experimentally determined for arsenic appear to be relatively low. The methylated species of arsenic are efficiently transferred in the food chain (Eisler 1988a); however, it does not appear to be biomagnified through the food chain (Eisler, 1988a; Callahan and others 1979; EPA 1982a and 1983e, as cited in ATSDR 1993b).

PLANTS

Terrestrial plants may accumulate arsenic by root uptake from the soil or by absorption of airborne arsenic deposited on the leaves. Certain species of plants may accumulate substantial levels of arsenic (Shaw 1990). Soil concentrations of arsenic have been known to reduce crop plant yields (NRCC 1978, as cited in Eisler 1988a). If the roots of the plant absorb excess arsenic, the plant will stop growing and developing (NRCC 1978, as cited in Eisler 1988a). The chemical form of arsenic absorbed by plants will determine the type of toxic effect plants will have when exposed. Effects can range from inhibition of light activation, wilting, chlorosis, browning, dehydration, and death (National Academy of Science [NAS] 1977, as cited in Eisler 1988a).

Marine phytoplankton have the ability to bioconcentrate inorganic arsenic to high levels, then transform them to methylated arsenic. The methylated species are efficiently transferred in the food chain (Eisler 1988a); however, it does not appear to be biomagnified through the food chain (Eisler 1988a; Callahan and others 1979; EPA 1982a and 1983e, as cited in ATSDR 1993b).

INVERTEBRATES

Arsenic has been used as a pesticide in the past. Arsenic may reduce growth and metabolism of soil microbiota, reduce numbers of bacteria and protozoans, and may adversely affect earthworms to reduce their numbers in the soil (NRCC 1978, as cited in Eisler 1988a).

AMPHIBIANS AND REPTILES

Very little information was available on the effects of arsenic on amphibians and reptiles. One report states, however, that developing toad embryos exposed to arsenic concentrations observed that 50 percent of developing embryos died or were malformed (Eisler 1988a).

FISH AND AQUATIC ORGANISMS

Arsenic can produce both carcinogenic and mutagenic effects in aquatic organisms (Eisler 1988a). Toxic effects of arsenic in fish include impaired behavior, reduced growth, lack of appetite, and failure to metabolize food (Eisler 1988a). The chemical form of arsenic, the type of organism, and the organism's life stage all influence the organism's susceptibility to arsenic compounds. In general, the earlier life stages and smaller organisms are more sensitive to arsenic concentrations (Sadiq 1992).

In addition to the stage of development of an organism, the toxic effect of arsenic is influenced by the type organism. Marine organisms accumulate more arsenic than freshwater organisms. Bioaccumulation of arsenic in marine organisms is influenced by the amount of arsenic in sea water and is further influenced by the marine organism's feeding habits. Bottom feeders appear to be more sensitive to arsenic concentrations than other types of fish (Sadiq 1992). This is because bottom feeders filter the water column and the fine particulate matter in the water for food. Arsenic in the fine particular matter is incidentally ingested during this search for food. As a result, bottom feeders, such as molluscs, accumulate more arsenic in their soft tissue than fish (Sadiq 1992). Fish on the other hand do not have to filter the water column for food, and as a result, the main route of uptake occurs when they filter the water column for oxygen with their gills. This filtering process occurring in the fish gill tissue is the main route of uptake of arsenic for these types of aquatic organisms (Sadiq 1992).

BIRDS

Some species of birds are more sensitive to arsenic exposure, while others appear to be more tolerant of arsenic exposure (Eisler 1988a). The acute oral exposure of inorganic arsenic destroys the blood vessel lining in the gut, which can result in lower blood pressure (Nystrom 1984, as cited in Eisler 1988a). The acute oral exposure of arsenite in birds was observed to cause hepatocyte damage by arsenic inhibition of the sodium pump in cells (Nystrom 1984, as cited in Eisler 1988a). Acute effects of arsenite in birds include, muscular incoordination,

debility, slowness, jerkiness, falling, hyperactivity, fluffed feathers, drooped eyelids, huddled position, unkempt appearance, loss of righting reflex, immobility, and seizures (Eisler 1988a). Chronic effects include systemic, growth, behavioral, and reproductive problems (Stanley and others 1994; Whitworth and others 1991; Camardese and others 1990).

MAMMALS

Arsenic is a carcinogen, teratogen, and a possible mutagen. Adverse effects produced by arsenic are highly dose-dependent. At low levels, arsenic may be an essential nutrient and substitute for phosphorous in biochemical reactions (ATSDR 1993b). At high levels, however, arsenic is recognized as an effective poison. Chronic exposure to low levels of arsenic can produce malaise and fatigue, gastrointestinal distress, anemia and basophilic stippling, neuropathy, and skin lesions, which can develop into skin cancer. Water-soluble arsenic is efficiently absorbed from the gastrointestinal tract and circulated throughout the body. Trivalent arsenic is detoxified in the liver by conversion to methylarsenic acid and dimethylarsenic acid, which are the principal forms excreted in the urine. The body burden of arsenic can reach considerable levels because it can be sequestered in nails, hair, bones, teeth, skin, liver, kidneys, and lungs (ATSDR 1993b). In mammalian species, arsenic is a teratogen that can pass the placental barrier and produce fetal death and malformations consisting of exencephaly, eye defects, and renal and gonadal agenesis (Eisler 1988a; ATSDR 1993b; Domingo 1994).

C.2 BARIUM

Barium is an alkaline earth metal that is widely distributed in the environment and is used to produce alloys, paints, soap, paper, rubber, ceramics, and glass. Barium is naturally present in plant and animal tissue and may be an essential element in trace amounts.

The solubility of barium compounds influences the adsorption and toxicity of these compounds. The more soluble barium compounds are more easily adsorbed by organisms and may be accumulated in the skeleton (Amdur and others 1991).

Barium is found mainly in inorganic complexes and is stable in the +2 valence state. Environmental conditions such as pH, Eh, cation exchange capacity, and calcium carbonate levels in soil will affect the movement of barium in the environment (ATSDR 1990a). In an aquatic environment, barium will most likely precipitate out of solution as a $BaSO_4$ or $BaCO_3$ insoluble salt, or the barium ion will absorb to particulate matter (ATSDR 1990a).

Barium can bioaccumulate in terrestrial and aquatic organisms (ATSDR 1990a). Marine plants can bioconcentrate barium by a factor of 1,000 times the concentration found in the water. Marine animals, plankton, and brown algae have reported BCFs of 100, 120, and 260, respectively (Bowen 1966; Schroeder 1970, as cited in ATSDR 1990a). Terrestrial plants bioconcentrate low levels of barium from the soil (Schroeder 1970, as cited in ATSDR 1990a).

PLANTS

Some plants may accumulate barium from soil. Brazil nuts can accumulate high levels of barium (Amdur 1991; ATSDR 1990a).

INVERTEBRATES

No information was available on the effects of barium on invertebrates.

AMPHIBIANS AND REPTILES

No information was available on the effects of barium on amphibians and reptiles.

FISH AND AQUATIC ORGANISMS

In the aquatic environment, the most likely route of particulate metals into fish is through the gill, gut, or skin (Pulsford and others 1992). Very little information was available on the effects of barium on fish and aquatic organisms. In one study, however, barium was observed to inhibit chlorine absorption in the intestine of winter flounder (Charney and Taglietta 1992).

MAMMALS

In addition to skeletal deposition, ingestion of barium salts can result in gastrointestinal distress, muscular paralysis, lowered pulse rate, muscle stimulation, and irregular cardiac contractions (Amdur and others 1991). Rats exposed to barium concentrations in their diet showed toxic responses. In both acute and chronic oral exposure scenarios increased blood pressure was observed in exposed rat populations (ATSDR 1990a). In other acute exposure studies gastrointestinal effects and respiratory weakness were observed in the exposed populations (ATSDR 1990a). Ovary weight and ovary to brain weight ratios both decreased as a result of acute oral exposure to barium in rat populations (Borzelleca and others 1988, as cited in ATSDR 1990a). Published data concerning developmental, reproductive, or carcinogenic effects of barium on mammalian species are very limited (ATSDR 1990a).

C.3 BERYLLIUM

In most types of soil, beryllium is expected to be tightly sorbed onto clay particles (Fishbein 1981, as cited in ATSDR 1993c). Beryllium is expected to have limited mobility in soil, although its mobility may increase as a result of formation of soluble hydroxide complexes in soils of higher pH (Callahan and others 1979, as cited in ATSDR 1993c).

In aquatic environments, most beryllium is usually present sorbed to suspended matter or to sediment, rather than in a dissolved form in the water column. Beryllium may precipitate into sediment as a result of a formation of insoluble complexes and is usually sorbed onto clay particles in sediment. A high percentage of beryllium is expected to be immobile in water as a result of this association with sediment particles, although at a high pH, the formation of water-soluble complexes with hydroxide ions may increase the solubility and mobility of beryllium (Callahan and others 1979, as cited in ATSDR 1993c).

Bioconcentration of beryllium in fish is not likely because of the low absorption of beryllium from the water column by aquatic animals. Significant biomagnification of beryllium within the food chain has not been observed (Fishbein 1981, as cited in ATSDR 1993c).

PLANTS AND INVERTEBRATES

Very little information was available on the effects of beryllium on plants or invertebrates.

AMPHIBIANS AND REPTILES

Very little information was available on the effects of beryllium on amphibians and reptiles. However, in a journal article, Jagoe and others (1993) suggest that the toxic effects of beryllium are similar to those by aluminum. In general, metals induce their toxic effects in the gill surface (skin) of amphibians. Reduced survival of adult populations of frogs and salamanders has been observed when the study organisms were chronically exposed to aluminum in the test water (Horne and Dunson 1995). In addition, aluminum exposure was shown to cause a significant increase in embryonic mortality (Horne and Dunson 1995).

FISH AND AQUATIC ORGANISMS

Very little information was available on the effects of beryllium on fish and aquatic organisms. However, in a journal article, Jagoe and others (1993) suggest that the toxic effects of beryllium are similar to those produced by aluminum. In general, metals induce their toxic effects in the gill surface of aquatic organisms. Like other metals, beryllium affects the physiological processes occurring at the gill surface, including ion regulation and gas exchange (Jagoe and others 1993). At low concentrations, beryllium causes gill damage. At higher concentrations effects include development of chloride cell apical crypts, increased mucus production, microridge loss, epithelial hyperplasia, and fusions of primary lamellae (Jagoe and others 1993). Beryllium water concentrations were found to cause gill abnormalities and damage to the fish species studied (Jagoe and others 1993).

BIRDS

Very little information was available on the effects of beryllium on birds.

MAMMALS

The major toxicological effects of beryllium occur when the compound is inhaled from the air, and beryllium is then deposited in the lungs of mammals. The mammals that were studied include mice, rats, rabbits, and monkeys. The toxicological effects of beryllium in the lung include pneumonitis, hypersensitivity, and chronic granulomatous pulmonary disease (Amdur 1991).

C.4 CADMIUM

Cadmium is a naturally occurring element. It is used in the production of nickel-cadmium batteries, metal plating, pigments, plastics, synthetics, and alloys. Cadmium in soils may leach into water, especially under acidic conditions (Callahan and others 1979; Elinder 1985, as cited in ATSDR 1993d), and cadmium-containing soil particles may be distributed into the air or eroded into water (EPA 1985, as cited in ATSDR 1993d). In the aquatic environment, the bioavailability of cadmium is dependent on such factors as pH, redox potential, water hardness, and the presence of other complexing agents. The most bioavailable form of cadmium is the Cd^{2+} ion. An increase in temperature or salinity will increase the bioavailable form of cadmium and as a result increase the bioaccumulation and toxicity of cadmium to aquatic organisms. A decrease in pH will increase the amount of cadmium ions in water and increase bioaccumulation in aquatic organisms (Sadiq 1992).

Cadmium has no essential biological function and is highly toxic to plants and animals. It is a carcinogen and teratogen, and a suspected mutagen. Cadmium is associated with severe sublethal effects on reproduction at relatively low environmental concentrations (Eisler 1985a). Aquatic and terrestrial organisms at all trophic levels bioconcentrate and bioaccumulate cadmium

(Eisler 1985a). Bioconcentration in fish depends on the pH and the organic content of the water (John and others 1987, as cited in ATSDR 1993d). Although some data suggest that lower trophic levels display biomagnification of cadmium, the data available on biomagnification, especially for animals at the top of the food chain, are inconclusive (Beyer 1986; Gochfeld and Burger 1982, as cited in ATSDR 1993d).

PLANTS

Cadmium is known to be toxic to plants at much lower soil concentrations than other heavy metals. Cadmium is more readily taken up by plants than other metals (EPA 1981), and as a result, some plants can accumulate high levels of cadmium in their developing leaflets (Morishita and Boratynski 1992).

INVERTEBRATES

Some insects can accumulate large quantities of cadmium without observable adverse effects (Jamil and Hussain 1992). Certain insects, such as caddis flies, can accumulate high levels of cadmium in their gill tissue (Sadiq 1992). However, very little information was available concerning the effects of cadmium on invertebrates.

AMPHIBIANS AND REPTILES

Very little information was available concerning the effects of cadmium on amphibians and reptiles.

FISH AND AQUATIC ORGANISMS

Marine organisms appear more resistant to cadmium than freshwater organisms. Cadmium accumulates in the gill tissue of mussels, the digestive glands of scallops, and the liver and kidney of bony fish and sharks (Loring and Prosi 1986; Bryan and Gibbs 1973; Grimanis and others 1978, as cited in Sadiq 1992). In general, however, cadmium accumulates in the liver and

kidney of fish (Sindayigaya and others 1994; Sadiq 1992). Cadmium has been shown to be highly toxic in aquatic environments and has been implicated as the cause of deleterious effects on fish and aquatic organisms, including increased mortality, respiratory disruptions, altered enzyme levels, abnormal muscular contractions, reduced growth, and reduced reproduction (Eisler 1985a). Cadmium concentrations in water caused damage to the reproductive organs of fish, a decrease in the survival rate of fish embryos, and a reduction of growth rates of fry (EPA 1976). Crustaceans appear to be more sensitive to cadmium concentrations, as compared to fish and molluscs (Phillips 1980, as cited in Sadiq 1992), and younger stages of aquatic life appear to be more sensitive to cadmium than adults (Sadiq 1992).

BIRDS

Sublethal effects in birds include growth retardation, nephrotoxicity, anemia, damage to the testicles and absorptive epithelium of the duodenum, reduced egg production, and effects on calcium absorption (Scheuhammer 1987).

MAMMALS

In mammalian species, cadmium concentrates in the liver and kidneys and is excreted in the urine at a very slow rate. The acute toxic effects of cadmium given orally produce nausea, vomiting, salivation, diarrhea, and abdominal cramps. Immediate death may be caused by shock and dehydration; renal and cardiopulmonary failure may cause death a week or so after ingestion. Chronic toxicity effects of cadmium given orally to rats are decreased motor skills, peripheral neuropathy, weakness, and muscle atrophy. When inhaled cadmium is a carcinogen that can produce tumors in the lung, trachea, and bronchus.

Cadmium is a known developmental toxin causing teratogenic and mutagenic effects. Parental doses of cadmium have been shown to decrease testosterone and produce adverse effects on the testes and prostate of test animals. Prenatal exposure to cadmium has fetotoxic effects, such as reduced fetal weights (ATSDR 1993d), and can cause adverse effects during the development of

the lung, brain, testes, eye, and palate (Domingo 1994). It is believed that small amounts of cadmium could affect embryonic DNA and protein synthesis (Holt and Webb 1987, as cited in Domingo 1994).

C.5 COBALT

Sources of cobalt in the environment are both natural and anthropogenic. Cobalt is naturally present in soil, freshwater, and seawater. Anthropogenic sources of cobalt include fossil fuel burning, vehicular and aircraft exhaust, processing of cobalt-containing alloys and chemicals, sewage sludge, fertilizers derived from phosphate rocks, and copper and nickel smelting and refining (ATSDR 1992a).

Most of the cobalt emitted into the environment settles into the soil or sediment. Cobalt mobility is dependent on the amount of chelating agents in the soil, the pH, and the redox potential of the soil. Lower pH levels increase the mobility of cobalt in the soil. Metal oxides, crystalline minerals, and natural organic matter in the soil decrease the mobility of cobalt. Cobalt is slightly mobilized by normal weathering (pH 5 to 8), moderately mobile in the presence of oxidizing sulfide ore, and immobile in organic-rich environments (Perelman 1967).

In most fresh waters, less than 2 percent of cobalt species are present in the dissolved form in the water column, while the rest is precipitated or adsorbed on suspended solids and sediments. Under acidic conditions and in the presence of excess chloride ions or organic and inorganic chelating agents, some mobilization of cobalt from the sediments may occur (ATSDR 1992a). In these conditions, the formation of cobalt complexes may increase the amount of cobalt in the water column.

Traces of cobalt are accumulated by microorganisms, higher plants, and animals. Although essential, excessive intake results in accumulation and toxicity (Considine 1976). Mollusks, crustaceans, and other bottom feeders have been reported to accumulate large quantities of cobalt (Jenkins 1980). However, a study of organisms in Ottawa River sediments, showed no

detectable bioaccumulation of cobalt-60 (Evans and others 1988). Bioaccumulation factors for cobalt on a dry-weight basis were 100 to 4,000 for marine fish and 40 to 1,000 for freshwater fish (Smith and Carson 1981). The concentration of cobalt in normal rat tissues has been shown to range from 0.001 to 0.006 parts per million (ppm) of dry matter (Considine 1976). Cobalt appears not to bioaccumulate significantly in benthic bottom feeders in comparison to its concentration is sediment (ATSDR 1992a).

Plant uptake of cobalt from soil is not appreciable. In highly acidic soils and in some higher plants. however. significant uptake has been observed (ATSDR 1992a). The translocation of cobalt from roots to above-ground parts of plants is not significant in most soils. The soil to plant BCF for cobalt ranges from 0.01 to 0.3 (ATSDR 1992a). Plant uptake of cobalt is enhanced by low soil pH (HSDB 1994) but inhibited by complexes formed by organic complexing agents such as (EDTA) in soil (Killey and others 1984; McLaren and others 1986). There is little biomagnification of cobalt in animals at higher trophic levels (Jenkins 1980).

PLANTS

At elevated levels cobalt is a phytotoxin. However. certain plants are known to develop a mechanism of cobalt tolerance and can grow on serpentinite or ore bodies (Kabata-Pendias and Pendias 1992).

INVERTEBRATES

Very little information was available on the effects of cobalt on invertebrates.

AMPHIBIANS AND REPTILES

Very little information was available on the effects of cobalt on amphibians and reptiles.

FISH AND AQUATIC ORGANISMS

Very little information was available on the effects of cobalt on fish and aquatic organisms. Due to a lack of toxicological data, the EPA has not determined an ambient water quality criterion for cobalt (Diamond and others 1992).

BIRDS

Very little information was available on the effects of cobalt on birds.

MAMMALS

Cardiomyopathy is the primary adverse effect of cobalt in acutely or chronically exposed animals (ATSDR 1992a). Additional studies on animals suggest that exposure to high amounts of cobalt during pregnancy affect fetal health.

Inhalation of cobalt by animals results in respiratory, cardiovascular, hematological, hepatic, renal, ocular, and body weight effects. Short-term exposure of rats to high levels of cobalt in air results in lung damage and death. Short-term exposure of rats, guinea pigs, hamsters, and pigs to lower levels of cobalt in air results in lung damage and increased red blood cells.

Testicular atrophy was reported in rats and mice exposed to cobalt concentrations in air (ATSDR 1992a). Similarly testicular degeneration and atrophy have been reported in rats exposed to cobalt concentrations in water (ATSDR 1992a).

Stunted growth and decreased survival of offspring is noted in study rats exposed to cobalt in their diet from the third trimester of gestation through lactation (Domingo and others 1985). Rodent fetal growth and development, however, were not adversely affected by gestation-only exposure to high cobalt levels (Paternian and others 1988; Seidenberg 1986), so the stunted growth and decreased survival of offspring may be attributable to cobalt transfer through milk.

The rate of absorption of ingested cobalt is variable, depending on such factors as chemical form, nutritional state of body, and preexisting foods in stomach (ATSDR 1992a). Study rats absorbed 30 to 40 percent of the administered dose (Hollins and McCullogh 1971; Taylor 1962).

C.6 COPPER

Copper is a naturally occurring element that is widely distributed in the environment. Copper is the main component of alloys, which include brass, bronze, and gun metal. Copper is an essential trace mineral nutrient and a toxicant (ATSDR 1996).

Copper is very mobile under oxidizing and acidic conditions and immobile in organic-rich and reducing environments. Adsorption increases with pH and with higher organic matter content. In aquatic systems, copper binds primarily to organic matter and forms complexes with both organic and inorganic ligands (mainly with calcium carbonate) that settle out in sediments (Kirk-Othmer 1965). Under normal pH and redox conditions, copper tends to be present in sediments in the form of organic complexes and coprecipitates with iron oxides, manganese oxides, and cupric carbonate complexes.

Copper is an essential nutrient, and under homeostatic control, biomagnification is not a significant fate process for copper. Bioaccumulated copper is stored in the liver, kidney, bone marrow, and hair (Hammond and Beliles 1980, as cited in Talmage and Walton 1991). Fish can bioconcentrate copper with BCFs ranging from the tens to the hundreds. Mollusks have BCFs for copper that range up to 30,000 (Perwack and others 1980; Chapman and others 1968; Raymont 1972).

PLANTS

Based on yield reductions of 14 to 28 percent in agronomic and grassland plants, 100 milligrams per kilogram (mg/kg) of total copper in the soil is considered to be a threshold concentration for

toxicity to plants (EPA 1987 and Bengtsson and Tranvik 1989, as cited in International Copper Association [ICA] 1992).

INVERTEBRATES

Based on yield reductions of 14 to 28 percent in agronomic and grassland plants, 100 mg/kg of total copper in the soil is considered to be a threshold concentration for toxicity to soil invertebrates (EPA 1987 and Bengtsson and Tranvik 1989, as cited in ICA 1992). Copper is used as an ingredient in many fungicides and insecticides applied on agricultural crops (Meister 1995).

AMPHIBIANS AND REPTILES

Copper is highly toxic to amphibians. Environmental conditions, including pH and water hardness, and the life stage of the amphibian exposed both affect the organism's sensitivity and adverse response to exposure to metal concentrations in water. Although the information concerning amphibians and metal toxicity is limited, it is believed that the primary mechanism of action of metal-induced toxicity and low pH environments is body loss of sodium across the gill surface (MacDonald and Wood 1993, as cited in Horne and Dunson 1995). Tadpoles were adversely affected when exposed to aqueous copper concentrations (Bayliss 1924, as cited in Owen 1981). Copper is toxic to certain types of frogs and salamanders during both acute and chronic exposure studies, causing embryonic curling, body loss of sodium, and mortality (Horne and Dunson 1995). Copper induced mortality more quickly in high pH and low water hardness environments (Horne and Dunson 1995). The earlier life stages of amphibians appear to be more sensitive to copper toxicity (Horne and Dunson 1995).

No data were found on the effects of copper on reptiles.

FISH AND AQUATIC ORGANISMS

Copper is highly toxic in aquatic environments and is a priority pollutant (EPA 1992). Copper is toxic to many fish and aquatic organisms, including mussels, stripped bass, bluegill, and carp. The gill is the primary organ for concentrating copper in aquatic organisms. Copper is mainly accumulated in the gill, liver, filaments, stomach, and intestine (Harvey 1978, as cited in Owen 1981). Copper concentrations can significantly affect the hatchability of fish eggs and reduce the growth of fry (EPA 1976). The species of the organism and the organism's age influence the toxicity characteristics of copper. In general, younger organisms are affected at lower concentration levels.

BIRDS

Copper can have toxic effects on birds. Diets containing elevated copper levels can slow the growth rate, diminish egg production, and cause developmental abnormalities in different avian species (Owen 1981).

MAMMALS

The toxic effects of copper have been studied on many animals, including cats, dogs, cattle, sheep, rats, mice, horses, guinea pigs, pigs, and monkeys. Different species of animals display varying levels of sensitivity to copper. However, the main organ affected by exposure to copper is the liver where copper primarily accumulates in the subcellular organelles causing liver cirrhosis. In addition to liver cirrhosis, copper exposure can cause necrotic kidney tubules and brain damage (Owen 1981). The acute toxic effects of copper given orally include gastrointestinal irritation, vomiting (including blood), low blood pressure, jaundice due to liver necrosis, and coma. Chronic exposure to copper can cause accumulation of copper in the body leading to lesions in the liver, brain, and eye and hemolytic anemia.

C.7 LEAD

Lead has been characterized as a poison for centuries, and environmental pollution from lead is well documented (Eisler 1988b). Lead has been used in the production of solder, pipes, paint, ceramics, roofing materials, caulking, and ammunition and a gasoline additive. From a geochemical perspective, lead is ubiquitous and occurs in rocks, soils, water, plants, animals, and air. Lead is neither essential nor beneficial to living organisms, and all data show that its metabolic effects are adverse. Lead is a mutagen and a teratogen. When it is absorbed in excessive amounts, lead also is carcinogenic or cocarcinogenic, impairs reproduction, adversely impairs liver and thyroid functions, and interferes with resistance to infectious disease (EPA 1979, as cited in Eisler 1988b). In general, lead is toxic in most of its chemical forms and can be incorporated into the body via inhalation, ingestion, dermal absorption, and placental transfer. Lead is a poison that accumulates in the body, and once the amount in the body reaches a certain level, it starts to affect behavior as well as the hematopoietic, vascular, nervous, renal, and reproductive systems (Eisler 1988b).

The biological availability and fate of lead in soil is affected by such factors as soil pH, organic content, ion-exchange characteristics, and the amount of lead in the soil (NSF 1977, as cited in ATSDR 1993f). Plants and animals may bioconcentrate and bioaccumulate lead; however, biomagnification has not been well documented. Several studies have shown that invertebrates can accumulate lead in their tissues; however, the variability in the extent of lead bioaccumulation suggests much interspecies variation in the mechanisms of lead uptake. Organolead compounds, such as trialkyl and tetraalkyl lead compounds, are more toxic than inorganic forms and have been shown to bioconcentrate in aquatic organisms, as do inorganic lead compounds. High accumulations of lead from ambient sea water by marine plants are well documented. Although lead is bioconcentrated from water, little evidence suggests that it is transferred through the food chain (Wong and others 1978, Branica and Konrad 1980; Settle and Patterson 1980, as cited in Eisler 1988b). Lead concentrations tend to decrease with increasing trophic level in both detrital and grazing food chains in freshwater and marine habitats (Wong and others 1978; Stewart and Schulz-Baldes 1976, as cited in Eisler 1988b).

PLANTS

Lead is not essential for plants, and excessive amounts can cause growth inhibition as well as reduced photosynthesis, mitosis, and water absorption (Demayo and others 1982, as cited in Eisler 1988b).

INVERTEBRATES

A concentration of 12,800 mg/kg of lead in soil is associated with reductions in natural populations of decomposers, such as fungi, earthworms, and arthropods (Beyer and Anderson 1985, as cited in Eisler 1988b).

AMPHIBIANS AND REPTILES

Environmental conditions, including pH and water hardness, and the life stage of the amphibian exposed, affect the organism's sensitivity and adverse response to exposure to metal concentrations in water. Although the information concerning amphibians and metal toxicity is limited, the primary mechanism of action of metal-induced toxicity and low pH environments is believed to be body loss of sodium across the gill surface (MacDonald and Wood 1993, as cited in Horne and Dunson 1995). Reduced rates of learning acquisition and retention were observed in tadpoles exposed to lead water concentrations (Strickler-Shaw and Taylor 1989, as cited in Freda 1991). Very little evidence has been published on the effects of lead and amphibians; however, lead may be important as a toxicant to developing embryos (Horne and Dunson 1995).

FISH AND AQUATIC ORGANISMS

Lead is toxic to most aquatic organisms; however, the adverse effects are modified by environmental conditions. Fish continuously exposed to toxic concentrations of waterborne lead show various signs of lead poisoning, including spinal curvature, anemia, degeneration of the caudal fin, destruction of spinal neurons, reduced ability to swim against a current, destruction of the respiratory epithelium, muscular atrophy, paralysis, renal pathology, growth inhibition,

retardation of sexual maturity, testicular and ovarian histopathology, decreased survival rate of fry, and death (Eisler 1988b; EPA 1976).

BIRDS

Absorbed lead produces a variety of effects in avian species, including damage to the nervous system, muscular paralysis, inhibition of heme synthesis, damage to kidneys, damage to the liver, and death (Mudge 1983, as cited in Eisler 1988b). Sublethal lead exposure may also have adverse effects of reproduction in some avian species by decreasing plasma calcium, inhibition of growth, and reduced hatchability of chicks.

MAMMALS

Lead can have multiple effects in mammalian species. Lead may cause damage to the nervous system, hematological effects, kidney disfunction, sterility, abortion, neonatal mortality, growth retardation, delays in maturation, and reduced body weight (Amdur and others 1991; Eisler 1988b). Younger mammals may have greater sensitivity to lead toxicity due to their developing blood brain barrier. Developing capillaries in the brain allow lead levels in the blood to be transported to newly formed components of the brain (Amdur and others 1991).

C.8 MANGANESE

Manganese is a naturally occurring substance found in many types of soil. Manganese is an essential trace mineral with many oxidation states. Although its primary use is in iron and copper alloys, it is also used in dry cells, matches and pyrotechnics, fossil fuels, and a variety of chemical processes.

Manganese metal has four different oxidation states (2+, 3+, 4+, and 7+). The specific chemical form is determined by environmental factors such as pH, Eh, microbial activity, and available anions (ATSDR 1991). The most common form of manganese is present in the divalent form

(Mn^{2+}) (EPA 1984a, as cited in ATSDR 1991). The ability of manganese to adsorb to soil and sediment depends on the organic content present in the soil or sediment and the ion exchange capacity of that medium (Curtin and others 1980, Hemstock and Low 1953, Kabata-Pendias and Pendias 1984, McBride 1979, and Schnitzer 1969, as cited in ATSDR 1991). As a result soil adsorption values range from 0.2 to 10,000 milliliters per gram (mL/g).

Manganese that is present in water may be bioconcentrated by lower trophic levels (ATSDR 1991). Manganese BCFs have been reported as 2,500 to 6,300 for phytoplankton, 300 to 5,500 for marine algae, 800 to 830 for intertidal mussels, and 35 to 930 for coastal fish (Folsom and others 1963, as cited in ATSDR 1991). In another study, BCFs were similarly reported as 10,000 to 20,000 for marine and freshwater plants, 10,000 to 40,000 for invertebrates, and 100 to 600 for fish (Thompson and others 1972, as cited in ATSDR 1991). Although bioconcentration occurs in lower trophic levels, in higher trophic level receptors, homeostasis is reached, and as a result, biomagnification of manganese in the food chain is believed to be insignificant (EPA 1984a, as cited in ATSDR 1991).

PLANTS

Manganese concentrations were found to be higher in the sprout stage than in the adult stage of *Spartina alterniflora* (Williams and Murdoch 1969). However, manganese concentrations increased to the highest levels after death. These concentrations and related concentration factors were similar to those found in terrestrial monocots, marine algae, and submerged grasses (Williams and Murdoch 1969).

INVERTEBRATES

No data were found on the effects of manganese on terrestrial invertebrates.

AMPHIBIANS AND REPTILES

Very little information was available on the effects of manganese on amphibians and reptiles. In one study, however, manganese has been observed to alter membrane sodium permeability in amphibians (Arhem 1980, as cited in Power and others 1989). In adult frogs, the highest concentration of manganese was found to be in the skin (Baudo 1976, as cited in Power and others 1989).

FISH AND AQUATIC ORGANISMS

Reproductive effects, such as a decrease in spermatogenic activity and injury to testis, have been recorded in fish treated with $MnSO_4$ (Srivastava and Agrawal 1983, as cited in Joardan and Sharma 1990).

BIRDS

Manganese levels in birds were higher in bones, livers, and kidneys than in the brain, heart, or muscle (Mahoney 1978). High levels of manganese caused decreased hemoglobin and liver iron levels, mild anemia, and depressed growth in chicks (Southern and Baker 1983). Reproductive effects were minimal in birds fed 90 times the normal dietary level of manganese (Laskey and Edens 1985).

MAMMALS

Symptoms that were observed in rats that ingested elevated levels of manganese included a decrease in weight gain, increase in physical activity, alterations of brain chemicals, slight irritation of the stomach, and delayed testicular development (ATSDR 1991). In addition, pregnant rats that drank water containing levels of manganese were observed to have litters that weighed less than normal (ATSDR 1991). Monkeys that drank water containing elevated levels of manganese became weak, and their muscles became rigid (ATSDR 1991).

Rats and monkeys that inhaled elevated concentrations of manganese dust developed irritation and swelling in the lungs (ATSDR 1991). Monkeys also developed chemical alterations in the brain as a result of manganese inhalation (ATSDR 1991). Mice that were exposed to elevated concentrations of manganese in the air were more likely to catch pneumonia and develop behavioral changes (ATSDR 1991). The parents who inhaled air concentrations of manganese had increased behavioral malformations and smaller offspring than those of the control group (ATSDR 1991).

C.9 MERCURY

Inorganic and organic forms of mercury are relatively well characterized within an ecotoxicological context. Methyl-mercury and other organomercurical compounds (including ethyl- and phenyl-mercuricals) are among the most toxic organometals in the environment and bioaccumulate through the food chain (Fimreite 1979). The chemical form of mercury influences its distribution in the body, and the comparative toxicity data suggest that the organic species (ethyl- , methyl-, and phenyl-mercury) of the metal are far more toxic than inorganic mercury (Peterle 1991). In general, methyl-mercury as well as its metallic (Hg^0), mercurous (Hg^+), and mercuric (Hg^{++}) form are nonessential and exert their toxicity at the biochemical level as inhibitors of enzyme-catalyzed reactions and protein synthesis.

Mercury is a known mutagen, teratogen, and carcinogen. Its toxicity and environmental effects vary with its form, dose, and route of ingestion and with the species, sex, age, and general condition of the organism (Eisler 1987a, Fimreite 1979). Depending on the pH, salt content, and composition of the soil, mercury usually forms various complexes with chloride and hydroxide ions in the soil (Alloway 1990). Biotransformation is an important fate process in the environmental partitioning of mercury. Under favorable conditions, microorganisms in soil and sediment can convert various forms of mercury to methyl-mercury, which is more available for uptake by various organisms and for transport in the food chain and more mobile than inorganic forms (Peterle 1991).

Mercury has a high potential for bioaccumulation and biomagnification (Eisler 1987a). Methylated mercury is the form most readily bioconcentrated and bioaccumulated (Kramer and Neidhart 1975). Biomagnification of methyl-mercury has been documented for both aquatic and terrestrial food chains (Eisler 1987a). Concentrations of methyl-mercury in higher trophic-level fish have been biomagnified reportedly on the order of 10,000 to 100,000 times those concentrations found in ambient waters (Callahan and others 1979). The accumulation of mercury by aquatic organisms is enhanced at elevated water temperatures, reduced water salinity or hardness, reduced water pH, increased age of the organism, and reduced organic matter in the medium. Mercury transfer and biomagnification through mammalian food chains is well documented.

PLANTS

Plants take up mercury from the soil in relatively insignificant amounts because roots appear to act as a barrier. However, mercury compounds applied to other parts of plants appear to be readily absorbed and translocated (Adriano 1986).

INVERTEBRATES

Some types of invertebrates can accumulate mercury through the food chain with little or no observable effects (Jamil and Hussain 1992). In certain types of flies, however, methyl-mercury can alter chromosomes, causing abnormalities in offspring (NAS 1978 and Khera 1979, as cited in Eisler 1987a). Mercury concentrations in soil have been observed to cause reduced segment regeneration in worms, and at elevated levels, cause mortality (Abbasi and Soni 1983, as cited in Eisler 1987a). For marine invertebrates, mercury was observed to inhibit reproduction (Eisler 1987a).

AMPHIBIANS AND REPTILES

Very little information was available on the effects of mercury on amphibians and reptiles. In one study, however, frogs did not metamorphose when exposed to mercury concentrations (EPA 1980, as cited in Eisler 1987a).

FISH AND AQUATIC ORGANISMS

Methyl-mercury appears to be the most toxic form of mercury (MacDonald 1993). Earlier developmental stages of fish and aquatic organisms are more sensitive to mercury toxicity than the more mature individuals. The effects of chronically exposed fish and aquatic organisms include loss of appetite, brain lesions, cataracts, abnormal motor coordination, and behavioral changes. In addition to the chronic symptoms of mercury toxicity, mercury at comparatively low concentrations adversely affects the reproduction, growth, behavior, metabolism, blood chemistry, osmoregulation, and oxygen exchange of marine and freshwater organisms (Eisler 1987a). Mercury is very toxic to aquatic organisms because of its ability to bind to sulphydryl groups (Sindayigaya 1994). The degree of toxicity is increased in elevated water temperatures and in reduced salinity environments (Eisler 1987a).

BIRDS

Sublethal effects of mercury on birds, administered by a variety of routes, include adverse effects on growth, development, reproduction, blood and tissue chemistry, metabolism, and behavior (Eisler 1987a). Reproductive effects are noted at low doses long before the acute effects are noticeable in the exposed adult populations (Scheuhammer 1987). Significant reproductive effects of chronic dietary inorganic mercury exposure in birds include delayed testicular development, altered mating behavior, reduced fertility, reduced survivability and growth in

young, and gonadal atresia. Mercury is also transferred to the egg in avian species, where it has adverse effects on the developing embryo (Peterle 1991).

MAMMALS

Methyl-mercury is the more acutely toxic form of mercury. Mercury can cause adverse neurological, renal, behavioral, and reproductive effects in mammals. Nephrotoxicity is the most common effect mercury has on mammals. Acute toxicity responses to the organic form of the metal include ataxia, aphagia, tremors, and diminished capacities for coordinated movements. In chronic exposures, methyl-mercury intoxication is characterized by central nervous system and peripheral nervous system neuropathies (Lindström and others 1991, as cited in ATSDR 1994b). Methyl-mercury also exhibits reproductive effects in both sexes as well as in the developing embryo and fetus (Cagiano and others 1990). Methyl-mercury can cause other reproductive effects, which include diminished neurological function and behavioral deficits in newborns (Khera and others 1973).

C.10 MOLYBDENUM

Molybdenum is found in all living organisms and is considered to be an essential or beneficial nutrient. This element is primarily used in the production of steel alloys, which are used in building aircraft and weapons. Fossil fuel combustion, smelting, mining, and milling operations have all contributed to molybdenum contamination in the environment. Molybdenum chemistry is complex and not adequately understood. In water at a pH of more than seven, molybdenum exists primarily as the molybdate ion; at a pH of less than seven, various polymeric compounds are formed, including the paramolybdate ion (Busev 1969, as cited in Eisler 1989a). In soils molybdate is sorbed most readily to alkaline, high calcium, and high chloride soils. Retention is lowest in low pH, low sulfate soils (Smith and others 1987, as cited in Eisler 1989a).

Molybdenum interacts toxicologically with other trace elements, especially copper and inorganic sulfates. In mammals, molybdenum can protect against poisoning by copper, mercury, and

probably other metals and may have anti-carcinogenic properties. However, ruminants are sensitive to molybdenum poisoning, especially when accompanied by a deficiency in copper or inorganic sulfates (Eisler 1989a).

Very little information on the bioaccumulative potential of molybdenum was found.

PLANTS

Plants readily accumulate molybdate, except in soils with low pH, high sulfate, low phosphate, and high organic matter content (Gupta and Lipsett 1981, as cited in Eisler 1989a). No toxicity of molybdenum to field-grown crops has been observed (Soon and Bates 1985, as cited in Eisler 1989a).

INVERTEBRATES

Molybdenum compounds have been used in baits to control termites. These molybdenum baits were fatal to the termite population; however, the other species of insects including fire ants, beetles, and cockroaches were unaffected by the bait (Brill and others 1987, as cited in Eisler 1989a).

AMPHIBIANS AND REPTILES

Very little information was available on the effects of molybdenum on amphibians and reptiles.

FISH AND AQUATIC ORGANISMS

Freshwater and marine fish appear to be relatively resistant to molybdenum exposure (Eisler 1989a). However, rainbow trout eggs exposure to molybdenum for 28 days through day 4 post-

hatch caused mortality at elevated levels. Very little information was available on the effects of molybdenum on aquatic invertebrates and fish.

BIRDS

Data are scarce on the effects of molybdenum on avian wildlife under controlled conditions. All studies on birds have been restricted to domestic poultry, which appear to be relatively resistant to molybdenum exposure. At elevated levels, however, molybdenum has been observed to decrease the growth rate of chicks and turkey poults, reduce egg production, and decrease hatchability (Friberg and others 1975, as cited in Eisler 1989a).

MAMMALS

Molybdenum is essential in mammalian diets, can protect against poisoning by copper or mercury, and may be useful in controlling cancer. Almost all studies conducted to date on the effects of molybdenum under controlled conditions have been on livestock, especially cattle and sheep. Molybdenum poisoning in ruminants has been observed in livestock (Eisler 1989a). In certain areas of England, cattle and sheep that grazed in fields that had high levels of molybdenum and low levels of copper and inorganic sulfate developed molybdenosis (Underwood 1979, as cited in Eisler 1989a). Symptoms of molybdenosis include: weight loss, diarrhea, and death in extreme cases. Data on the effects of molybdenum on mammalian wildlife are scarce. All evidence indicates that other mammals besides cattle and sheep are comparatively tolerant of high dietary intakes of molybdenum (Underwood 1971, Buck 1978, Chappell and others 1979, and Friberg and Lener 1986; as cited in Eisler 1989a).

C.11 NICKEL

Nickel is a naturally occurring metal. Nickel is mined for use in electroplating, iron and steel processing, nickel-cadmium batteries, fuel combustion, and a variety of other applications.

Nickel has many oxidation states: -1, 0, +1, +2, +3, and +4. Ni^{2+}, however, is the most common form present in the environment (Environment Canada 1994a). Nickel is strongly adsorbed by soil, although to a lesser degree than lead, copper, and zinc (Rai and Zachara 1984; Alloway 1990). Many forms of nickel are found in soil, and many factors affect the extent to which these different forms of nickel are adsorbed, making nickel adsorption highly site-specific. Amorphous oxides of iron, manganese, and clay minerals are the most important adsorbents of nickel in soil. In alkaline soils, adsorption may be irreversible, thus limiting nickel's availability and mobility in these soils. Cations, such as calcium and magnesium, reportedly reduce adsorption as a result of competition for binding sites, whereas anions, like sulfate, reduce adsorption because of complexation. Nickel adsorption depends strongly on pH (Rai and Zachara 1984; Alloway 1990). In an aquatic environment, environmental factors, such as pH, redox potential, and organic matter content, can affect the fate, transport, and biological availability of nickel (Environment Canada 1994a).

BCFs for nickel have been reported between 120 and 550 for submerged lichens; 770 and 1,500 for submerged mosses; 2,000 and 4,500 for *Daphnia;* 200 to 1,000 for clams, zooplankton, and benthos; and 230 and 330 for fish (Dietz 1973, Cowgill 1976, Mathis and Cummings 1973, and Hutchinson and others 1976, as cited in Environment Canada 1994a). Recent studies of nickel levels in voles and rabbits living on sludge-amended land did not indicate any accumulation of nickel in these herbivores or in the plants on which they fed (Alberici and others 1989, and Dressler and others 1986, as cited in ATSDR 1993g). Animals appear to be able to regulate the amount of nickel that is accumulated in the body, and as a result, biomagnification in upper trophic levels is believed to be insignificant (Environment Canada 1994a).

PLANTS

Nickel tends to be less available in soils than zinc or cadmium but is generally more available to plants than copper (Alloway 1990). The soil chemistry of nickel is relatively simple and is largely based on its occurrence as the divalent Ni^{2+}. Nickel becomes more soluble with decreasing pH, allowing more nickel to be bioavailable to plants. The clay content and texture of

the soil will also influence the bioavailabiltiy of nickel to plants. Depending upon these edaphic factors and on nickel's biological role as a ultra-trace element, nickel is bioconcentrated by plants; the greatest bioconcentration occurs in soils that have naturally high levels of nickel where some plants are classified as "hyperaccumulators" (Alloway 1990). Similar patterns of nickel bioconcentration also occur in highly contaminated soils (for example, near nickel and copper smelters).

The effects of nickel toxicity on plants include reduced growth of roots and shoots, poor branching, deformation of plant parts, decreased dry matter production, leaf spotting, abnormal flower shape, mitotic root tip disturbance, germination inhibition, and chlorosis (Mishra and Kar 1974, Rauser 1978, McIlveen and Negusanti in press, as cited in Environment Canada 1994a).

INVERTEBRATES

Very little information was available on the effects of nickel on invertebrates. However, microorganism growth and survival were reduced as a result of elevated nickel exposure (Babich and Stotzky 1982, as cited in Environment Canada 1994a).

AMPHIBIANS AND REPTILES

Nickel exposure in amphibians has been observed to slow down the response time of the potassium system in myelinated nerve fibers (Arhem 1980, as cited in Power and others 1989). In addition, nickel has also been observed to alter sodium permeability across cell membranes in amphibians (Arhem 1980, as cited in Power and others 1989).

FISH AND AQUATIC ORGANISMS

Nickel is both a carcinogen and a mutagen in the aquatic environment (EPA 1992). The observed effects of nickel exposure in an aquatic environment to fish and invertebrates include tissue damage, genotoxicity, and decreased growth (EIFAC 1984, and IPCS 1991, as cited in

Environment Canada 1994a). Molluscs and crustaceans appear to be more sensitive to nickel exposure than other aquatic organisms (Hall 1978, as cited in Environment Canada 1994a).

BIRDS

Elevated dietary concentrations of nickel caused growth inhibition in poultry. The expression of nickel toxicity is influenced by the age, reproductive status, nutritional content of the diet, and exposure duration in test organisms. This information should be considered in the interpretation of the risk posed by nickel to terrestrial wildlife (NAS 1980).

No effects were observed on adult mallards exposed to nickel in their diet. No effects to adult mallards were observed regarding body weight, histological changes in liver and kidneys, tissue damage, blood chemistry, egg-laying ability, hatchability percentages, and hatchling survival to 14 days of age (Eastin and O'Shea 1981, as cited in Environment Canada 1994a). However, mallard ducklings fed diets containing elevated nickel concentrations up to 90 days were observed to develop tremors and ataxia (Cain and Pafford 1981, as cited in Environment Canada 1994a). Newly hatched chickens were also observed to have slower growth rates as a result of diets containing elevated nickel concentrations (Ling and Leach 1979, as cited in Environment Canada 1994a).

MAMMALS

Growth inhibition was the primary effect to domestic livestock fed elevated levels of nickel in their diet. The expression of nickel toxicity was observed to be influenced by the age, reproductive status, nutritional content of the diet, and exposure duration in test organisms. This information should be considered in the interpretation of the risk posed by nickel to terrestrial wildlife (NAS 1980).

Rats in a subchronic gavage study of nickel chloride in water experienced lethargy, ataxia, irregular breathing, reduced body temperature, and discolored extremities (EPA 1994).

Inhalation of nickel subsulfide in rats increased the incidence of lung tumors (ATSDR 1993g). The central nervous system appears to be the target organ for nickel oral toxicity, while the lung is the target organ for inhalation exposure.

C.12 SELENIUM

Selenium is an essential trace element but is harmful at concentrations only slightly higher than the nutritional requirement (Eisler 1985b). Results of laboratory studies and field investigations with fish, mammals, and birds have led to general agreement that elevated concentrations of selenium in diet or water are associated with reproductive abnormalities and growth retardation. Not as extensively documented are reports of selenium-induced chromosomal aberrations, intestinal lesions, shifts in species composition of freshwater algal communities, swimming impairment of protozoans, and behavioral modifications (Eisler 1985b).

In aerobic waters, selenium is present in the selenite (H_2SeO_3, $HSeO_3^-$, SeO_3^{-2}) or selenate (H_2SeO_4, $HSeO_4^-$, SeO_4^{-2}) quadravalent or hexavalent oxidation states. These chemical species are very soluble, and most of the selenium discharged into the aquatic environment is transported in these forms to the ocean. Selenium has a sorptive affinity for hydrous metals oxides, clays, and organic materials. Sorption by sediments or suspended solids can result in enrichment of selenium concentrations in sediment beds. Sorption or precipitation with hydrous iron oxides is probably the major control on mobility of selenium in aerobic waters. Selenium can be methylated by a variety of organisms, including benthic microflora. In a reducing environment, hydrogen selenide may be formed. Both the methylated forms and hydrogen selenide are volatile and may escape to the atmosphere. Formation of volatile selenium compounds in the sediments can remobilize sorbed selenium (Eisler 1985b).

The current understanding of selenium toxicology indicates that ecological effects are primarily caused by selenium in the food chain, rather than selenium dissolved in the water column (Philips 1988, and Luoma and others 1992, as cited in Taylor and others 1992). Once in the water column, selenium enters the food chain through bioconcentration by phytoplankton, which

are then consumed in large quantities by crustaceans and bivalves. Crustaceans and bivalves are, in turn, eaten by fish and waterfowl. Bioconcentration, bioaccumulation, and biomagnification of selenium can increase selenium levels more than 1,000 fold from water to fish and animals (Saiki and Lowe 1987, as cited in Taylor and others 1992). The greatest step increase occurs between water and phytoplankton and other aquatic plants; subsequent steps in the food chain typically increase selenium concentrations by a factor of 2 to 6 (Lemly and Smith 1987, as cited in Taylor and other 1992). BCFs for various species of marine algae range from 16,000 to 337,000, depending on the species and the water column levels (Zhang and others 1990, as cited in Taylor 1992).

PLANTS

Selenium has been observed to cause growth retardation in freshwater green algae (Hutchinson and Stokes 1975, Klaverkamp and others 1983, as cited Eisler 1985b).

INVERTEBRATES

Very little information was available on the adverse effects of selenium on invertebrates.

AMPHIBIANS AND REPTILES

Very little information was available on the effects of selenium on amphibians and reptiles. One report, however, states that during frog development, cranial and vertebral deformities and lower survival were documented when exposed to selenium concentrations (Browne and Dumont 1979, as cited in Eisler 1995).

FISH AND AQUATIC ORGANISMS

In general, selenite is more toxic to earlier life stages, and the degree of the effect is increased with increasing temperatures (Klaverkamp and others 1983, as cited in Eisler 1985b). Selenium is teratogenic, and its toxicity depends greatly on its chemical form (Eisler 1985b). It has been suggested that selenite is more toxic than selenate and is preferentially concentrated over selenate by mussels (EPA 1990, as cited in Eisler 1985b). Signs of selenium poisoning include loss of equilibrium, lethargy, loss of coordination, muscle spasms, protruding eyes, swollen abdomen, liver degeneration and swelling, reduced blood hemoglobin levels, increased white blood cell numbers, swollen gill lamella with extensive cellular vacuolization, and necrotic and degenerating ovarian follicles (Ellis and others 1937, Sorensen 1984, as cited in Eisler 1985b). Elevated concentrations of selenium were observed to cause reproductive failure, anemia, reduced hatch, reduced growth, reduced swimming rate, and chromosomal aberrations in aquatic organisms (Hodson and others 1980, Adams 1976, Bovee and O'Brien 1982, Krishnaja and Rege 1982, as cited in Eisler 1985b).

BIRDS

Selenium exposure in the diet or drinking water of avian species is associated with reproductive abnormalities, congenital malformations, selective bioaccumulation, and growth retardation (Eisler 1985b). Selenium has been observed to cause reduced hatching of eggs, decreased egg weight, decreased egg production, anemia, and embryo deformation, including deformed eyes, beaks, wings, and feet (Ort and Latshaw 1978, and Harr 1979, as cited in Eisler 1985b).

MAMMALS

Chronic effects of selenium on mammals include reproductive abnormalities such as congenital malformations; reduced numbers of young in litters; high mortality of young; infertility among surviving young in rats, mice, swine, and cattle; and intestinal lesions (Harr 1978, and NRC 1983, as cited in Eisler 1985b).

Chronic exposure of selenium, known as alkali disease, has been observed in cattle, hogs, and horses that graze on feed containing elevated levels of selenium. Adverse effects include deformed hooves, hair loss, lassitude, articular cartilage erosion, reduced conception, increased reabsorption of fetuses, and heart, kidney, and liver degeneration (Eisler 1985b).

C.13 SILVER

Silver occurs naturally in the environment in the form of silver nitrate, silver chloride, silver sulfide, or silver oxide (USPHS 1990). Some industrial discharges can introduce silver compounds into the environment. It tends to form complexes with inorganic chemicals and humic substances in soils. Consequently, the mobility of silver in soils is affected by drainage and erosion potential, the presence of soil organic matter, oxidation-reduction potential, and pH conditions. Silver tends to be mobile in well-drained soils. Organic matter complexes with silver and causes it to become immobile. Because silver is toxic to soil microorganisms and inhibits bacterial enzymes, biotransformation is not expected to be a significant process (Domsch 1984, as cited in ATSDR 1990c).

The transport and partitioning of silver in surface waters and soils are influenced by the particular form of the compound. The major forms of silver in water include the monovalent ion as sulfate, bicarbonate, or sulfate salts; more complex ions with chlorides and sulfates; and as an integral part of, or adsorbed onto, particulate matter and aquatic biota (Boyle 1968, as cited in ATSDR 1990c). Sorption is the dominant process leading to the partitioning of silver in sediments (Callahan and others 1979, as cited in ATSDR 1990c), and pH and oxidation-reduction conditions affect sorption (Anderson and others 1973, as cited in ATSDR 1990c). When decaying animal and plant material is abundant, silver strongly precipitates as the sulfide form or combines with humic materials (Smith and Carson 1977, as cited in ATSDR 1990c).

Silver is bioaccumulated by marine organisms (Nelson and others 1983). There is no evidence that silver is biomagnified in terrestrial animals, although this may occur in some aquatic invertebrates (Adriano 1986).

PLANTS

Silver is not considered to be highly phytotoxic; even high concentrations in soil appear to have little or no effect on plant growth.

INVERTEBRATES

Very little information was available on the effects of silver on invertebrates.

AMPHIBIANS AND REPTILES

Very little information was available on the effects of silver on amphibians and reptiles.

FISH AND AQUATIC ORGANISMS

Silver is one of the most hazardous trace elements to aquatic species (EPA 1992). The younger life stages of development appear to be the most sensitive to silver concentrations (Klein-MacPhee and others 1984). Silver concentrations have been observed to cause increased larvae mortality, physical abnormalities in developing larvae, reduced hatch, and reduced growth in winter flounder larvae (Klein-MacPhee and others 1984). Juvenile mussels exposed to silver concentrations exhibited growth inhibition (Calabrese and others 1984). Silver also has been observed to effect reproductive behavior and reduce larvae releases from gastropods (Nelson and others 1983).

BIRDS

Very little information was available on the effects of silver on birds.

MAMMALS

Inhalation studies have shown that silver can be absorbed in the lungs, while ingestion studies have shown that silver can be absorbed in the gastrointestinal tract (Amdur and others 1991). Once in the body, silver can accumulate in the liver, while only a small amount is excreted (Amdur and others 1991). A decrease in weight gain was observed in rats exposed to silver in drinking water (Matuk and others 1989, as cited in ATSDR 1990c). Intravenous doses of silver to experimental animals caused pulmonary edema, congestion, and eventual death (Amdur and others 1991).

C.14 THALLIUM

Thallium naturally occurs in the environment. As a trace metal, thallium co-occurs with other metals and coal; its release to the environment is frequently coincidental with industrial activities using these raw materials. Compounds that contain thallium are generally highly soluble in water; hence, thallium may be biologically active in aqueous solution. When in solution, thallium generally occurs as a monovalent cation. In soil and sediments thallium is generally adsorbed to particulates within the physical matrix. The biotic and abiotic processes that influence the cycling of thallium in the environment are poorly understood; however, the biological fate and effects of thallium have been described sufficiently to evaluate its potential risks in aquatic and terrestrial habitats.

Low levels of thallium may be bioconcentrated in an aquatic environment. Experimental thallium BCFs have been determined for aquatic vertebrates and invertebrates, and values range between 10 and 1,500. The majority of these BCFs are reported at less than 100 (Zitko and Carson 1975, Zitko 1975, Barrows and others 1978, as reported in ATSDR 1992c). The relatively large range probably represents species and body size differences in experimental conditions. In terrestrial habitats, plants take up thallium from the rhizosphere; hence, the potential for its entry into terrestrial food chains exists (Ewer 1988, Sharma and others 1986, Cataldo and Wildung 1983, as cited in ATSDR 1992c).

PLANTS

When present in the soil in sufficient quantities, terrestrial vascular plants may bioaccumulate thallium (Ewers 1988; Sharma and Singh 1986). Published information on the effects of thallium on terrestrial microorganisms, plants, and animals is limited (ATSDR 1992c).

INVERTEBRATES

Various forms of thallium have been used as insecticides. Thallium acetate and thallium sulfate were used as ant poisons (Travis 1943).

AMPHIBIANS AND REPTILES

Very little information was available concerning the effects of thallium on amphibians and reptiles; however, in the aquatic environment, study results indicate that thallium is as acutely toxic as copper on a weight basis (Zitko and others 1975).

FISH AND AQUATIC ORGANISMS

Very little information was available concerning the effects of thallium on fish and aquatic organisms; however, in the aquatic environment, study results indicate that thallium is as acutely toxic as copper on a weight basis (Zitko and others 1975). In one study, thallium concentrations reduced the percent embryo hatchability, reduced the growth of fish larvae, and caused mortality in the fish species studied (LeBlanc and Dean 1984).

BIRDS

Very little information was available concerning the effects of thallium on birds. Thallium has been used as a poison to control predators and rodents. Birds, such as eagles, hawks, magpies, and turkey vultures, were accidentally poisoned by these baits (Robinson 1948). In one acute toxicity test, eagles were given a single LD_{50} dose. Effects included loss of muscular coordination, loss of balance, reluctance to move, loss of appetite, belligerence, fear-threat

displays, falling, debilitation, loss of righting reflex, distress, breathing complications, and immobility (Bean and Hudson 1976).

MAMMALS

Thallium is very toxic to mammals, and various forms of thallium were once used to control pest populations in the United States. Species that were poisoned by the pesticide include coyotes, dogs, bobcats, rodents, and other animals (Robinson 1948).

In mammals thallium can affect the heart, lung, liver, kidney, nervous system, and reproductive organs (ATSDR 1992c). In rats, exposure to large amounts of thallium for a short period of time can cause heart malfunctions and death. In smaller amounts, rats that drank water containing chronic levels of thallium were observed to have damage to their testes and nervous system (ATSDR 1992c).

C.15 ZINC

Zinc is an essential trace element for all living organisms, and zinc deficiency can be a problem for both plants and animals. Zinc is primarily used as a protective coating for metals and used in the production of alloys such as bronze and brass. The adverse effects of zinc exposure to animals include growth retardation, testicular atrophy, skin changes, and poor appetite (Prasad 1979, as cited in Eisler 1993).

Most of the zinc introduced into aquatic environments is eventually partitioned into sediment. Zinc released from sediment is enhanced under conditions of high dissolved oxygen, low salinity, and low pH. Dissolved zinc usually consists of the hydrated zinc ion and various organic and inorganic complexes. In reducing conditions, organically bound zinc typically forms insoluble sulfides (MacDonald 1993).

BCFs vary widely between and within species of aquatic organisms (Eisler 1993). In marine environments, the most effective zinc accumulators included red and brown algae, ostreid and crassotreid oysters, and scallops. Invertebrates can bioaccumulate large quantities of zinc (Jamil 1992), which could potentially be passed on to higher trophic level consumers. Studies show that bony structures can act as long-term repositories for zinc (Macapinlac and others 1966). Zinc concentrations have been shown to increase with increasing trophic levels from phytoplankton to zooplankton, but not to fish (Balasubramian 1994).

PLANTS

Zinc is an essential nutrient for plant growth in small amounts but is toxic to plants at elevated levels. Zinc can cause significant adverse effects on growth, survival, and reproduction in representative sensitive species of aquatic plants (Eisler 1993). Elevated levels of zinc in soil can cause mortality in some terrestrial plants and inhibit photosynthesis in others (Eisler 1993).

INVERTEBRATES

Certain terrestrial and aquatic invertebrates are sensitive to zinc. Reduced growth, inhibited reproduction, and reduced survival are effects that zinc can have on both terrestrial and aquatic invertebrates (Eisler 1993).

AMPHIBIANS AND REPTILES

Environmental conditions, including pH and water hardness, and the life stage of the amphibian exposed both affect the organism's sensitivity and adverse response to exposure to metal concentrations in water. Although the information concerning amphibians and metal toxicity is limited, the primary mechanism of action of metal induced toxicity and low pH environments is believed to be body loss of sodium across the gill surface (MacDonald and Wood 1993, as cited in Horne and Dunson 1995). In one study there were no significant effects of acute and chronic

exposures of frogs and salamanders and their larvae to zinc (Horne and Dunson 1995). In addition, the pH of the aquatic environment had no effect on the toxicity of zinc unlike the other metals that were studied (Horne and Dunson 1995).

However, another study observed that zinc caused significant adverse effects on growth, survival, and reproduction in representative sensitive species of amphibians (Eisler 1993). In this study, zinc was shown to cause teratogenic effects to frog embryos (Eisler 1993).

FISH AND AQUATIC ORGANISMS

The gill epithelium is the primary route of zinc entry into the body of fish (Eisler 1993). Zinc can cause significant adverse effects on growth, survival, and reproduction in representative sensitive species of protozoans, sponges, molluscs, crustaceans, echinoderms, and fish (Eisler 1993). Zinc has been shown to cause teratogenic effects to fish embryos (Eisler 1993).

BIRDS

Different species of birds have varying sensitivities to zinc exposure. Acute effects of zinc in ducks caused mortality and pancreatic degradation (Eisler 1993). Reduced growth and death were observed in poultry chicks fed diets containing elevated zinc levels. Younger stages of life appear to be more sensitive to zinc exposure. The pancreas and bone are primary target organs of zinc in birds (Eisler 1993). Decreased weight gain was observed in Japanese quail, chickens, and turkeys fed diets containing zinc (NAS 1980).

MAMMALS

Zinc is relatively nontoxic in mammals; however, excessive zinc intake adversely affects survival of all tested mammals and produces a wide variety of neurological, hematological, immunological, hepatic, renal, cardiovascular, developmental, and genotoxic effects (PHS 1989,

as cited in Eisler 1993). The pancreas and bone are primary target organs of zinc exposure in mammals (Eisler 1993). Toxic effects of zinc can be observed in many domestic animals, including dogs, cats, ferrets, cattle, sheep, and horses, as a result of ingesting zinc-containing objects (Eisler 1993). Zinc concentrations in the diet of pregnant rats and sheep caused increased incidence of hypocuprosis, still births, and fetal resorptions (Ketchenson and others 1969, and Campbell and Mill 1979, as cited in Domingo 1994).

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APPENDIX D

SEDIMENT SAMPLING ANALYTICAL RESULTS

Reviewed By:

Date:

***Eohaustorius estuarius* Data Validation**

Criteria	Sample IDs		
	309SSNS	**309SSCS**	**309SSSS**
Amphipod size range 3 to 5 mm	Yes	Yes	Yes
<5% amphipod mortality during transport	Not noted	Not noted	Not noted
Mean (of 5) control survival ≥ 90% at end	Yes	Yes	Yes
Reference toxicant for each batch of organisms	Yes	Yes	Yes
EC_{50} ± 2 SD of expected mean for reference toxicant	Yes	Yes	Yes
• Swimming behavior observed	Not noted	Not noted	Not noted
• Full digestive tracts observed	Not noted	Not noted	Not noted
• Gray or yellow/white color on receipt	Not noted	Not noted	Not noted
Amphipods collected at the same location	Yes	Yes	Yes
Salinity acclimation ≤ 5ppt/day	Yes	Yes	Yes
Temperature acclimation ≤ 3°C/day	Not noted	Not noted	Not noted
Test begun w/in 10 days of amphipod receipt	Yes	Yes	Yes
Test begun w/in 14 days of sediment receipt	Yes	Yes	Yes
Samples examined for indigenous organisms	Not noted	Not noted	Not noted
Overlying Water			
• Temperature 15±2°C (daily)	15.5 – 17.5	15.5 – 17.2	15.5 – 17.3
• Salinity = 20 ± 2ppt (daily)	19.3 – 20.7	19.4 – 21.0	19.9 – 21.9
• pH (daily)	8.02 – 9.40	8.02 – 9.13	8.02 – 9.29
Total NH_3 ≤ 60 mg/L (day 2/8)[1]	4.14 / 1.15	3.70 / 1.42	2.96 / 0.16
Un-ionized NH_3 ≤ 0.8 mg/L (day 2/8)[1]	Not noted	Not noted	Not noted
• DO ≥ 7.7 mg/L (> 90% saturation @ start & end)	8.2 – 9.5	7.8 – 9.2	7.7 – 9.6
Total sulfide < 1.22 mg/L @ pH=8.0[2]	Not noted	Not noted	Not noted
Pore Water ^ Initial			
Salinity (ppt)	30.0	22.3	22.4
pH	7.66	7.98	7.83
Total NH_3 (mg/L)	26.4	19.5	17.7
Un-ionized NH_3 (mg/L)	Not noted	Not noted	Not noted
Sulfide (mg/L)	31.0	11.1	1.08
Comments			
Qualifier			

Notes:

[1] (U.S. EPA, 1994). Ammonia limits at pH = 7.7.

[2] (Knezovich and others 1996). No effect concentration

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APPENDIX D-1

INORGANIC CHEMICALS
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Sample Location	309SSCS			309SSNS			309SSSS			309SB05			309SB106			309CSPWSS			SB001			SB001		
Sample Date	2/1/2000			2/1/2000			2/1/2000			2/2/2000			2/2/2000			2/2/2000			2/6/1996			2/6/1996		
Sample Depth (ft.)	0.00 - 0.50[a]			0.00 - 0.50[a]			0.00 - 0.50[a]			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			2.00 - 2.50		
Analyte	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.
ALUMINUM	12900	3.98		14300	3.99		13800	3.79		10500	4.64		12400	3.86		7430	4.19		6970	5		19000	6.6	
ANTIMONY	3.02	0.01	J	0.91	0.01	J	0.98	0.01	J	1.12	0.01	J	0.37	0.01	J	6.72	0.01	J	5.6	0.45	J	0.59	0.59	UJ
ARSENIC	32.6	0.1		14.3	0.1		9.8	0.09		10.4	0.1		7.7	0.1		57	0.1		58.4	0.39		7.6	0.51	
BARIUM	414	0.4		146	0.4		120	0.38		268	0.46		175	0.39		646	0.42		4660	0.08		87.3	0.11	
BERYLLIUM	0.28	0.01		0.32	0.01		0.31	0.01		0.48	0.01		0.4	0.01		0.21	0.01		0.03	0.03	U	0.6	0.04	
CADMIUM	2.38	0.02	J	0.46	0.02	J	0.93	0.02	J	1.55	0.02	J	0.31	0.02	J	7.8	0.02	J	0.56	0.56	U	0.07	0.07	U
CALCIUM	33800	1.99		51300	1.99		31600	1.89		2850	2.32		2780	1.93		10200	2.09		27900	4	J	4000	5.2	J
CHROMIUM	50.8	0.03	J	38.1	0.03	J	35.1	0.03	J	32.5	0.04	J	29.4	0.03	J	73.4	0.04	J	136	0.11		46.3	0.15	
COBALT	11.7	0.004		6.59	0.004		7.35	0.004		14.8	0.005		8.88	0.004		15.8	0.005		23.4	0.11		9.1	0.15	
COPPER	130	0.02	J	49	0.02	J	72.5	0.02	J	49	0.03	J	21.7	0.02	J	311	0.03	J	608	0.14	J	33.6	0.18	J
IRON	94700	1.99		27300	1.99		32900	1.89		20900	2.32		15600	1.93		290000	10.5		328000	31		14800	4	
LEAD	547	7.96		87.2	7.97		189	7.57		162	9.28		268	7.73		2300	41.9		2560	0.22		22.6	0.29	
MAGNESIUM	12500	0.8		15300	0.8		15600	0.76		5970	0.93		5500	0.77		4850	0.84		2490	4.6		8060	6	
MANGANESE	998	0.4		1520	0.4		632	0.38		1940	0.46		422	0.39		1660	2.09		1200	0.03		328	0.04	
MERCURY	0.21	0.01		0.22	0.01		0.29	0.01		0.26	0.01		0.05	0.01	UJ	0.18	0.01		0.42	0.07		0.09	0.09	U
MOLYBDENUM	5.22	0.01	J	3.09	0.01	J	4.15	0.01	J	0.47	0.01	J	0.31	0.01	J	5.13	0.01	J	9.7	0.17		0.24	0.22	U
NICKEL	59.5	0.02	J	40	0.02	J	39	0.02	J	43.2	0.03	J	36.2	0.02	J	59.7	0.03	J	58.6	0.2		41.3	0.26	
POTASSIUM	3960	199		4020	199		4460	189		3830	232		2680	193		1360	209		2600	6.1	J	6480	8	J
SELENIUM	1.6	0.2		2	0.2		2	0.2		0.6	0.3	UJ	0.3	0.2	UJ	1.2	0.3		0.65	0.65	U	0.84	0.84	U
SILVER	0.422	0.01		0.26	0.01		0.333	0.009		0.563	0.01		0.131	0.01		1.08	0.01		5.4	0.14		0.36	0.18	U
SODIUM	46500	11.9		51000	12		63700	11.4		4170	13.9		10500	11.6		2520	12.6		1030	23.6	J	11500	30.8	J
THALLIUM	0.14	0.01	J	0.14	0.01	J	0.13	0.01	J	0.17	0.01	J	0.11	0.01	J	0.14	0.01	J	5.3	5.3	U	0.7	0.7	U
VANADIUM	60.2	0.4		57.4	0.4		55.7	0.38		35.7	0.46		40.1	0.39		40.5	2.09	J	14.2	0.11		49.7	0.15	
ZINC	1980	0.4	J	89	0.4	J	226	0.38	J	284	0.46	J	71.2	0.39	J	2270	2.09	J	4090	2.8		85.3	0.37	

Notes:
U = not detected at detection limit indicated
J = estimated value

APPENDIX D-1

INORGANIC CHEMICALS
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Sample Location	SB002			SB002			SB003			SB003			SB004			SB004			SB005			SB005		
Sample Date	2/6/1996			2/6/1996			2/6/1996			2/6/1996			3/18/1997			3/18/1997			3/18/1997			3/18/1997		
Sample Depth (ft.)	0.00 - 0.50			2.00 - 2.50			0.00 - 0.50			2.00 - 2.50			0.00 - 0.50			1.00 - 1.50			0.00 - 0.50			1.00 - 1.50		
Analyte	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.
ALUMINUM	6300	4.6		9880	4.6		4570	4.7		11600	4.5		4750	4.3		7480	4.1		4200	3.7		7840	4.1	
ANTIMONY	0.8	0.41	J	0.41	0.41	UJ	84.2	0.42	J	0.4	0.4	UJ	18.1	0.4	J	0.37	0.37	UR	0.81	0.34	UJ	0.37	0.37	UR
ARSENIC	5.8	0.36		4.6	0.36		142	0.37		3.1	0.35		61.2	0.5	J	2	0.45	J	8.6	0.41	J	2.9	0.44	J
BARIUM	223	0.08		117	0.08		765	0.08		278	0.07		927	1.96		387	1.9		123	1.7		244	1.9	
BERYLLIUM	0.16	0.03		0.31	0.03		0.03	0.03	UJ	0.33	0.02		0.16	0.16	U	0.55	0.15	J	0.25	0.14	J	0.43	0.15	J
CADMIUM	0.05	0.05	U	0.05	0.05	U	5.5	0.05		0.05	0.05	U	2.8	0.078	J	0.07	0.07	UJ	0.07	0.07	UJ	0.07	0.07	UJ
CALCIUM	2430	3.6	J	977	3.6	J	3160	3.7	J	669	3.5	J	17800	7.15		1090	6.8	J	2530	6.2		1030	6.7	J
CHROMIUM	16.5	0.1		21.2	0.1		125	0.1		23	0.1		119	0.86		17.4	0.82		13.6	0.74		18.3	0.81	
COBALT	12.7	0.1		6.6	0.1		22	0.1		9.5	0.1		37.5	1.9		5.8	1.8	J	9.5	1.7	J	8.5	1.8	J
COPPER	25.7	0.13	J	13.7	0.13	J	6670	0.13	J	12.7	0.12	J	378	0.4	J	12.3	0.38	UJ	28.4	0.34	J	12.1	0.37	UJ
IRON	11700	2.8		12600	2.8		142000	14.4		12500	2.7		272000	237	J	88800	225.4	J	14400	20.3	J	9850	22.2	J
LEAD	34.7	0.21		8	0.2		7680	1.1		6.5	0.2		5030	22.2	J	6.4	0.42	J	201	0.38	J	9.7	0.42	J
MAGNESIUM	3070	4.2		5140	4.1		1680	4.3		5370	4.1		2700	6.1		4020	5.8		1640	5.2		3480	5.8	
MANGANESE	1480	0.03		156	0.03		987	0.03		414	0.02		1420	1.15		312	0.55		428	0.5		368	0.54	
MERCURY	0.06	0.06	U	0.06	0.06	U	26.4	0.7		0.06	0.06	U	2.1	0.065		0.08	0.08	U	0.06	0.05	U	0.07	0.07	U
MOLYBDENUM	0.54	0.15	U	0.15	0.15	U	18.1	0.16	J	0.15	0.15	U	6	0.8		0.74	0.74	U	0.67	0.67	U	0.73	0.73	U
NICKEL	27.8	0.18		24.8	0.18		262	0.18		32.9	0.17		96.3	2.1		27.3	1.9		20.8	1.8		30.2	1.9	
POTASSIUM	3290	5.6	J	3340	5.5	J	1130	5.7	J	3280	5.4	J	869	25.4	J	2950	24.1		1180	21.8		2080	23.8	
SELENIUM	0.59	0.59	U	0.59	0.59	U	0.6	0.6	UJ	0.57	0.57	U	9	0.9	J	0.84	0.84	UJ	0.95	0.76	J	0.83	0.83	UJ
SILVER	0.13	0.13	U	0.13	0.13	U	2.3	0.13		0.12	0.12	U	1.9	1.9	U	1.8	1.8	U	1.6	1.6	U	1.7	1.7	U
SODIUM	2240	21.5	J	5470	21.4	J	630	22	J	7140	20.9	J	1720	6.4		5370	6.1		1660	5.5		5220	6	
THALLIUM	1.4	0.49	U	0.48	0.48	U	2.5	2.5	UJ	0.47	0.47	U	0.32	0.32	U	0.28	0.28	U	0.28	0.28	U	0.28	0.28	U
VANADIUM	26.3	0.1		28.6	0.1		31.3	0.1		30.1	0.1		16.9	0.6		22	0.55		27.3	0.5		30.7	0.54	
ZINC	89.5	0.26		34.3	0.25		3960	1.3		32	0.25		2100	4.4	J	18.8	2.1	J	126	1.9	J	23.5	2.1	J

Notes:
U = not detected at c
J = estimated value

APPENDIX D-1

INORGANIC CHEMICALS
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Sample Location	SB006			SB006			SB007			SB007			SB008			SB008			SB009			SB009		
Sample Date	3/18/1997			3/18/1997			3/18/1997			3/18/1997			3/18/1997			3/18/1997			3/18/1997			3/18/1997		
Sample Depth (ft.)	0.00 - 0.50			1.00 - 1.50			0.00 - 0.50			1.00 - 1.50			0.00 - 0.50			1.00 - 1.50			0.00 - 0.50			1.00 - 1.50		
Analyte	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.
ALUMINUM	5400	3.5		12000	3.5		4040	3.5		9350	3.8		7860	3.7		11000	3.7		6360	5.5		6750	3.5	
ANTIMONY	0.71	0.32	UJ	0.35	0.32	UJ	0.95	0.32	UJ	0.39	0.35	UJ	1	0.34	UJ	0.49	0.34	UJ	6	0.5	J	0.32	0.32	UR
ARSENIC	6.2	0.38	J	3.5	0.4	J	6.1	0.4	J	3	0.42	J	10.2	0.4	J	2.6	0.41	J	37.8	0.6	J	4.9	0.38	J
BARIUM	115	1.6		363	1.6		124	1.6		201	1.7		236	1.7		302	1.7		391	2.5		149	1.6	
BERYLLIUM	0.35	0.13	J	0.57	0.13	J	0.3	0.13	J	0.5	0.14	J	0.47	0.13	J	0.58	0.14	J	0.22	0.2	J	0.41	0.13	J
CADMIUM	0.06	0.06	UJ	0.06	0.06	UJ	0.06	0.06	UJ	0.07	0.07	UJ	0.07	0.07	UJ	0.07	0.07	UJ	3.3	0.1	J	0.06	0.06	UJ
CALCIUM	2550	5.8		2200	5.9		2450	5.9		2380	6.4		4710	6.1		1930	6.2		8490	9.2		1540	5.8	
CHROMIUM	15.6	0.7		26.4	0.71		20.5	0.71		21.2	0.77		30.4	0.74		22.8	0.75		43.1	1.1		16.6	0.7	
COBALT	8.3	1.6	J	10.8	1.6		20.5	1.6		10.9	1.7	J	9.8	1.7	J	8.3	1.7	J	19	2.5		10.1	1.6	J
COPPER	20.1	0.32	J	12.9	0.32	UJ	30.5	0.32	J	11.8	0.35	UJ	39.1	0.34	J	14.4	0.34	J	327	0.5	J	13.9	0.32	J
IRON	7870	19.3	J	14000	19.5	J	12800	19.6	J	10600	21.1	J	14700	20.3	J	12100	20.7	J	134000	305	J	10600	19.3	J
LEAD	66.9	0.4	J	8.6	0.36	J	184	0.37	J	7.4	0.4	J	129	0.4	J	8.2	0.4	J	1560	2.9	J	7.8	0.36	J
MAGNESIUM	1840	5		3880	5		1640	5		3620	5.4		4000	5.2		3810	5.3		5030	7.9		2970	5	
MANGANESE	415	0.5		519	0.5		367	0.47		482	0.51		425	0.49		388	0.5		747	0.74		156	0.47	
MERCURY	0.09	0.05	U	0.05	0.05	U	0.19	0.05	U	0.1	0.06	U	0.09	0.05	U	0.07	0.06	U	2.2	0.1		0.08	0.06	U
MOLYBDENUM	0.64	0.64	U	0.64	0.64	U	0.65	0.65	U	0.7	0.7	U	0.84	0.67	J	0.68	0.68	U	2.1	1		0.64	0.64	U
NICKEL	23.2	1.6		47.5	1.7		72.2	1.7		36.6	1.8		49.8	1.7		37.9	1.8		68.6	2.6		24.7	1.6	
POTASSIUM	581	20.7	J	649	20.8	J	605	21	J	510	22.6	J	918	21.7	J	494	22.2	J	1650	33	J	2450	20.6	
SELENIUM	0.74	0.72	J	0.87	0.73	J	0.96	0.73	J	0.79	0.79	UJ	0.76	0.76	UJ	0.77	0.77	UJ	5	1.1	J	0.72	0.72	UJ
SILVER	1.5	1.5	U	1.5	1.5	U	1.5	1.5	U	1.6	1.6	U	1.6	1.6	U	1.6	1.6	U	2.4	2.4	U	1.5	1.5	U
SODIUM	578	5.2	J	3730	5.2		402	5.3	J	3040	5.7		274	5.5	J	2770	5.6		10700	8.2		5730	5.2	
THALLIUM	0.26	0.26	U	0.28	0.28	U	0.24	0.24	U	0.28	0.28	U	0.26	0.26	U	0.28	0.28	U	0.37	0.37	U	0.3	0.3	U
VANADIUM	30.2	0.5		39.8	0.5		27.8	0.47		37.4	0.51		35.2	0.49		30.9	0.5		45.1	0.74		39.6	0.47	
ZINC	42.1	1.8	J	27.6	1.8	J	120	1.8	J	23	2	J	98.9	1.9	J	26	1.9	J	5410	14.1	J	21.5	1.8	J

Notes:
U = not detected at c
J = estimated value

APPENDIX D-1

INORGANIC CHEMICALS
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Sample Location	SB010			SB010			SB011			SB011			SB012			SB012			SB013			SB014		
Sample Date	3/18/1997			3/18/1997			3/18/1997			3/18/1997			3/7/1997			3/18/1997			10/13/1997			10/13/1997		
Sample Depth (ft.)	0.00 - 0.50			1.00 - 1.50			0.00 - 0.50			1.00 - 1.50			0.00 - 0.50			1.00 - 1.50			0.00 - 0.50			0.00 - 0.50		
Analyte	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.
ALUMINUM	4920	3.6		8970	4		8090	4.1		9200	3.7		5750	3.2		12900	4		10700	3.9	J	9350	3.9	J
ANTIMONY	32.2	0.33	J	0.47	0.36	UJ	0.66	0.38	UJ	0.34	0.34	UR	5	0.29	J	0.37	0.37	UR	2.5	0.51	J	6.4	0.51	J
ARSENIC	34	0.4	J	2.6	0.43	J	14.7	0.45	J	2.4	0.41	J	6.6	0.35	J	3.4	0.44	J	19.7	0.44		61.4	0.44	
BARIUM	302	1.6		257	1.8		210	1.9		90.2	1.7		127	1.5		404	1.8		680	0.73	J	1140	0.72	J
BERYLLIUM	0.2	0.13	J	0.41	0.15	J	0.33	0.15	J	0.45	0.14	J	0.31	0.12	J	0.52	0.15	J	0.02	0.018	U	0.02	0.018	U
CADMIUM	13.4	0.07	J	0.07	0.07	UJ	0.08	0.08	UJ	0.07	0.07	UJ	0.16	0.06	UJ	0.07	0.07	UJ	0.1	0.071	UJ	0.68	0.07	UJ
CALCIUM	3910	5.9		944	6.6	J	3850	6.9		1690	6.2		1750	5.3		1660	6.7		7370	15.8	J	12500	15.7	J
CHROMIUM	100	0.72		19.9	0.8		29.7	0.83		20.3	0.75		17.7	0.64		27.6	0.8		45.4	0.16	J	78	0.16	J
COBALT	19.1	1.6		10.5	1.8	J	10.2	1.9	J	7.5	1.7	J	13.9	1.4		10.7	1.8	J	11.1	0.23	UJ	21.7	0.23	
COPPER	12500	32.5	J	19	0.36	J	50.2	0.38	J	12.4	0.34	U	71.7	0.29	J	14.3	0.37	J	1030	0.19	J	270	0.19	J
IRON	112000	197	J	10600	21.9	J	13200	22.9	J	10000	20.7	J	8500	17.6	J	14400	22.2	J	62800	11.3	J	234000	112	J
LEAD	1870	3.7	J	7.6	0.41	J	318	0.85	J	6.1	0.4	J	749	1.7	J	9.7	0.41	J	597	0.3	J	3280	0.3	J
MAGNESIUM	1990	5.1		3320	5.6		3730	5.9		3730	5.3		1650	4.5		4300	5.7		8880	15.7		6430	15.6	
MANGANESE	857	0.48		501	0.53		544	0.56		364	0.5		654	0.43		444	0.54		748	0.12	J	1200	1.2	J
MERCURY	0.69	0.06		0.05	0.05	U	0.11	0.06	U	0.08	0.06	U	0.12	0.06	U	0.06	0.06	U	0.39	0.18		0.17	0.16	UJ
MOLYBDENUM	2.5	0.65		0.72	0.72	U	0.75	0.75	U	0.68	0.68	U	0.58	0.58	U	0.73	0.73	U	301	0.21		5	0.21	
NICKEL	73.5	1.7		28.8	1.9		40.3	1.9		28.3	1.8		21.9	1.5		42.6	1.9		48.7	0.16	J	67.2	0.16	J
POTASSIUM	1140	21.1		2100	23.5		1770	24.5		2750	22.1		833	18.8	J	946	23.7	J	3650	34.2		3220	34	
SELENIUM	4	0.74	J	0.82	0.82	UJ	1	0.85	J	0.77	0.77	UJ	1.1	0.66	J	0.98	0.83	J	2.4	0.71		7.8	0.7	
SILVER	1.5	1.5	U	1.7	1.7	U	1.8	1.8	U	1.6	1.6	U	1.4	1.4	U	1.7	1.7	U	2.5	0.19		2.6	0.19	
SODIUM	550	5.3	J	4510	5.9		3490	6.2		6140	5.6		651	4.7	J	5520	6		20600	851		16300	84.5	
THALLIUM	0.27	0.27	U	0.29	0.29	U	0.29	0.29	U	0.29	0.29	U	0.24	0.24	U	0.28	0.28	U	1.1	1.1	U	1.1	1.1	U
VANADIUM	31.2	0.48		35.9	0.53		34.6	0.55		25.4	0.5		31.1	0.43		37	0.54		41.8	0.21		34.8	0.21	
ZINC	4960	36.4	J	24	2.1	J	154	2.1	J	19.5	1.9	J	196	1.6	J	28.1	2.1	J	912	5.7	J	1660	5.6	J

Notes:
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APPENDIX D-1

INORGANIC CHEMICALS
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Sample Location	SB015			SB016			SB017			SB018			SB019			SB020			SB100			SB101		
Sample Date	10/13/1997			10/16/1997			10/13/1997			10/13/1997			10/13/1997			10/13/1997			2/11/1998			2/11/1998		
Sample Depth (ft.)	0.00 - 0.50			0.00 - 0.25			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50		
Analyte	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.
ALUMINUM	7930	6.9	J	4880	21.7	J	3	3	J	3080	5	J	3430	3.6	J	9650	3.3	J	8450	19.8		12600	6.6	
ANTIMONY	26.3	0.92	J	2.9	2.9	UJ	0.39	0.39	J	5.8	0.67	J	3.8	0.47	J	2.7	0.44	J	5.6	5.6	UJ	1.9	1.9	UJ
ARSENIC	57.7	0.79		9.5	2.5	J	0.34	0.34		106	0.57		52.7	0.41		22.9	0.38		6.2	5.8	J	8.9	1.9	
BARIUM	683	1.3	J	123	4.1	J	5.6	5.6	J	194	0.94	J	184	0.67	J	336	0.62	J	111	6.8	J	56.8	2.2	J
BERYLLIUM	0.03	0.032	U	0.1	0.099	U	0.01	0.014	U	0.02	0.023	U	0.02	0.016	U	0.02	0.015	U	0.16	0.16	U	0.17	0.053	UJ
CADMIUM	0.13	0.13	UJ	0.4	0.4	UJ	0.05	0.054	UJ	0.09	0.092	UJ	0.07	0.065	UJ	0.06	0.06	UJ	0.48	0.48	U	0.16	0.16	U
CALCIUM	16300	28.2	J	67100	88.4	J	10900	12.1	J	7460	20.5	J	3670	14.5	J	4120	13.5	J	40100	170		10800	56.1	
CHROMIUM	2990	0.29	J	0.89	0.89	J	174	0.12	J	47.9	0.21	J	85	0.15	J	74.6	0.14	J	27.6	1.8		30.9	0.59	
COBALT	14.4	0.41	J	1.3	1.3	UJ	36.7	0.18		16.6	0.3		27.8	0.21		12.2	0.2	UJ	7.8	2.7	J	4.8	0.91	J
COPPER	726	0.35	J	1.1	1.1	J	515	0.15	J	1670	0.25	J	432	0.18	J	1980	0.17	J	54.9	3.7		39	1.2	
IRON	126000	20.2	J	63.2	63.2	J	378000	86.7	J	212000	14.6	J	348000	104	J	108000	9.6	J	27700	41.3		17300	13.7	
LEAD	1020	0.54	J	1.7	1.7	J	2030	0.23	J	1270	0.39	J	1640	0.28	J	1180	0.26	J	97.2	2.9	J	67.9	0.96	J
MAGNESIUM	7770	28.2		88.2	88.2		3730	12.1		5980	20.4		5320	14.5		6170	13.4		12500	204		6470	67.6	
MANGANESE	833	0.22	J	0.69	0.69	J	1590	0.95	J	994	0.16	J	1490	1.1	J	591	0.11	J	1360	0.48		330	0.16	
MERCURY	0.16	0.31	U	0.5	0.99	U	0.15	0.14	UJ	0.16	0.22	UJ	0.08	0.17	U	0.64	0.15		0.74	0.37	U	0.28	0.14	U
MOLYBDENUM	7.7	0.38		1.2	1.2	J	6.9	0.16		6.6	0.28		6	0.2		2.9	0.18		8	2.4	J	2.6	0.8	J
NICKEL	79.1	0.29	J	0.89	0.89	J	258	0.12	J	81.5	0.21	J	91.7	0.15	J	126	0.14	J	36.9	3.4	J	35.8	1.1	
POTASSIUM	3410	61.2		192	192		1510	26.3		1710	44.4		1840	31.5		2370	29.2		3570	354	J	3390	117	
SELENIUM	6.8	1.3		4	4	U	12	0.54		7.6	0.92		11.5	0.65		4.2	0.6		7.6	7.6	U	2.5	2.5	U
SILVER	2.8	0.35	J	1.1	1.1	U	11.4	0.15	UJ	1.2	0.25	UJ	0.91	0.18	UJ	0.9	0.17	UJ	3.4	3.4	U	1.1	1.1	U
SODIUM	29500	152		477	477		16600	654		22000	110		20100	784		22000	726		49500	978		14800	323	
THALLIUM	1.9	1.9	U	6	6	U	0.82	0.82	U	1.4	1.4	U	1.7	0.98	UJ	0.91	0.91	U	10.2	10.2	UJ	3.4	3.4	UJ
VANADIUM	39.9	0.38		1.2	1.2	J	28.1	0.16		24.5	0.28		28.1	0.2		39.2	0.18		56.5	2.6	J	43.1	0.85	
ZINC	1540	10.1	J	3.2	3.2	J	2060	4.4	J	1130	7.4	J	737	5.2	J	1800	4.8	J	96	5		65.7	1.7	

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APPENDIX D-1

INORGANIC CHEMICALS
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Sample Location	SB102			SB103			SB104			SB105			SB106			SS200			SS201			SS202		
Sample Date	2/11/1998			2/11/1998			2/11/1998			2/11/1998			2/11/1998			6/8/1998			6/8/1998			6/8/1998		
Sample Depth (ft.)	0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50		
Analyte	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.
ALUMINUM	11200	16.9		8500	21.9		7630	13.5		11900	3.2		17100	5.1		23300	2.2	J	9720	2.8	J	10200	2.7	J
ANTIMONY	4.8	4.8	UJ	6.2	6.2	UJ	3.8	3.8	UJ	0.92	0.92	UJ	1.6	1.4	J	1.4	1.4	R	1.8	1.8	R	1.7	1.7	R
ARSENIC	5.8	5	J	21.8	6.4		3.9	3.9	U	5	0.95	UJ	24.8	1.5		18.8	0.99	J	13.6	1.3	J	11.5	1.2	J
BARIUM	132	5.8	J	198	7.5	J	114	4.6	J	205	1.1		202	1.7		133	0.51	J	120	0.67	J	164	0.62	J
BERYLLIUM	0.14	0.14	U	0.18	0.18	U	0.11	0.11	U	0.026	0.026	U	0.39	0.041	J	0.49	0.027	J	0.04	0.04	J	0.03	0.03	J
CADMIUM	0.41	0.41	U	0.53	0.53	UJ	0.33	0.33	U	0.079	0.079	U	0.46	0.12	J	0.94	0.08	J	0.79	0.11	J	0.66	0.098	J
CALCIUM	53300	145		26800	187		37800	115		8470	27.7		3750	43.5		15300	16.1	J	40500	21.2	J	51600	19.8	J
CHROMIUM	34.9	1.5		33.5	2		23	1.2		14.8	0.29		148	0.46		53.3	0.24	J	33.2	0.32	J	30.9	0.29	J
COBALT	7.7	2.3	J	12.7	3	J	6.5	1.9	J	12.8	0.45	J	7.9	0.7	J	8.7	0.37	J	6.6	0.49	J	5.6	0.46	J
COPPER	52.1	3.2		182	4.1		50.5	2.5		37.1	0.61		111	0.95		91	0.32	J	59.1	0.42	J	47	0.39	J
IRON	30300	35.3		67400	45.6		18500	28.1		23300	6.8		26000	10.6		29500	4.9	J	28800	6.4	J	27200	6	J
LEAD	83.3	2.5	J	506	3.2	J	68.2	2	J	24.9	0.47	J	257	0.75	J	163	0.48	J	87.1	0.63	J	72.2	0.59	J
MAGNESIUM	12800	175		13300	226		9580	139		9980	33.4		7090	52.5		12300	15.5	J	12300	20.4	J	12200	19	J
MANGANESE	1900	0.41		936	0.53		1340	0.33		327	0.079		274	0.12		471	0.053	J	1410	0.07	J	1570	0.066	J
MERCURY	0.75	0.38	U	0.84	0.42	U	0.54	0.27	U	0.12	0.06	U	0.19	0.1	UJ	0.24	0.24	U	0.37	0.37	U	0.31	0.31	U
MOLYBDENUM	3.7	2.1	J	6.2	2.7	J	1.9	1.6	J	0.4	0.4	U	0.8	0.62	J	2.2	0.4	J	4	0.53	J	2.3	0.49	J
NICKEL	37.4	2.9	J	55.8	3.7	J	27.5	2.3	J	23.2	0.55		52.4	0.87		68.8	0.35	J	38.6	0.46	J	33.4	0.43	J
POTASSIUM	3820	302	J	4420	391	J	3230	240	J	5020	57.9		5390	90.9		7080	38.7	J	3750	51	J	3570	47.5	J
SELENIUM	6.9	6.5	J	8.4	8.4	UJ	5.2	5.2	U	1.2	1.2	U	1.9	1.9	U	1.7	1.2		2.4	1.6		1.7	1.5	
SILVER	2.9	2.9	U	3.7	3.7	U	2.3	2.3	U	0.55	0.55	U	1.4	0.87	UJ	0.35	0.35	U	0.46	0.46	J	0.45	0.43	J
SODIUM	34200	835		46600	1080		22400	664		1940	160		7260	251		30900	1390		38000	1830		34900	1710	
THALLIUM	8.7	8.7	UJ	11.2	11.2	UJ	6.9	6.9	UJ	2.1	1.7	J	2.6	2.6	UJ	3.4	1.8	J	3.5	2.4	J	2.6	2.2	J
VANADIUM	53.3	2.2	J	53.1	2.8	J	36.6	1.8	J	62.2	0.42		57.9	0.66		80.5	0.4	J	48.5	0.53	J	46.1	0.49	J
ZINC	87.9	4.3		502	5.5		84.7	3.4		74.3	0.82		596	1.3		358	0.58	J	94	0.82	J	107	0.74	J

Notes:
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APPENDIX D-1

INORGANIC CHEMICALS
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Sample Location	SS203			SS204			SS205			SS206			SS207			SS208			SS209			SS210		
Sample Date	6/8/1998			6/8/1998			6/8/1998			6/8/1998			6/8/1998			6/8/1998			6/8/1998			6/8/1998		
Sample Depth (ft.)	0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50		
Analyte	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.
ALUMINUM	12500	2.3	J	13300	2.8	J	1890	1.8	J	5410	0.53	J	5200	1	J	6440	0.53	J	6870	2	J	8880	0.46	J
ANTIMONY	1.5	1.5	R	1.8	1.8	R	2.1	1.1	J	1.2	0.33	J	0.64	0.64	R	0.34	0.34	R	1.4	1.3	J	0.29	0.29	R
ARSENIC	11.9	1.1	J	15.7	1.3	J	26.8	0.82	J	7.7	0.24	J	3.2	0.46	J	3.9	0.24	J	10.9	0.93	J	4.7	0.21	J
BARIUM	120	0.54	J	131	0.67	J	67.4	0.42	J	215	0.12	J	72.4	0.24	J	90.2	0.13	J	266	0.48	J	110	0.11	J
BERYLLIUM	0.03	0.03	J	0.04	0.04	J	0.02	0.02	J	0.02	0.0066	UJ	0.01	0.01	J	0.16	0.0066	UJ	0.03	0.03	J	0.11	0.0057	UJ
CADMIUM	0.83	0.086	J	3.4	0.11	J	2.4	0.067	J	1.6	0.02	J	0.26	0.038	UJ	0.27	0.02	UJ	1.1	0.075	J	0.38	0.017	J
CALCIUM	44500	17.3	J	21900	21.2	J	10800	13.4	J	4270	4	J	19800	7.6	J	2540	4	J	99500	15.2	J	7250	3.4	J
CHROMIUM	39.7	0.26	J	38.2	0.32	J	15.2	0.2	J	28.9	0.059	J	12.9	0.11	J	12.4	0.059	J	20.6	0.23	J	23.3	0.051	J
COBALT	6.9	0.4	J	10.9	0.49	J	5.6	0.31	J	9.6	0.092	J	4.3	0.18	J	6	0.092	J	6.7	0.35	J	6.1	0.08	J
COPPER	54.1	0.34	J	199	0.42	J	166	0.27	J	565	0.079	J	17.4	0.15	J	12.2	0.079	J	73	0.3	J	13.3	0.068	J
IRON	27900	5.2	J	41200	6.4	J	63200	4.1	J	48600	1.2	J	11300	2.3	J	12300	1.2	J	24700	4.6	J	10700	1	J
LEAD	78.8	0.51	J	165	0.63	J	378	0.4	J	486	0.12	J	34.6	0.23	J	50.2	0.12	J	85	0.45	J	29.8	0.1	J
MAGNESIUM	10500	16.6	J	13000	20.3	J	3810	12.9	J	2360	3.8	J	5090	7.3	J	3440	3.8	J	14300	14.5	J	2670	3.3	J
MANGANESE	1060	0.057	J	830	0.07	J	311	0.044	J	321	0.013	J	712	0.025	J	240	0.013	J	2480	0.05	J	285	0.011	J
MERCURY	0.26	0.26	U	1.5	0.32		0.17	0.17	U	0.05	0.05	U	0.11	0.11	U	0.05	0.05	U	0.2	0.2	U	0.05	0.05	U
MOLYBDENUM	4.1	0.43	J	4.1	0.53	J	3	0.33	J	0.67	0.098	J	0.42	0.19	J	0.1	0.1	J	4.5	0.38	J	0.09	0.09	J
NICKEL	41.4	0.37	J	49.5	0.46	J	25.9	0.29	J	229	0.085	J	16.2	0.16	J	15.5	0.086	J	31.2	0.33	J	23.9	0.074	J
POTASSIUM	3590	41.5	J	4990	50.9	J	997	32.3	J	1190	9.5	J	1580	18.2	J	1670	9.6	J	3260	36.4	J	1160	8.3	J
SELENIUM	1.4	1.3	J	1.3	1.6	J	0.69	0.69	UJ	0.2	0.2	U	0.47	0.56	J	0.2	0.2	U	2.4	1.1		0.21	0.26	J
SILVER	0.37	0.37	U	1.5	0.46	J	0.62	0.29	J	6.7	0.085		0.17	0.16	UJ	0.09	0.09	U	0.58	0.33	J	0.09	0.074	UJ
SODIUM	18400	149		52800	1830		11400	116		1640	34.1		4640	65.4		1380	34.4		39500	1310		133	29.7	J
THALLIUM	1.9	1.9	J	2.4	2.4	J	2.5	1.5	J	1.6	0.44	J	1.7	0.84	J	0.96	0.44	J	3.5	1.7	J	1.2	0.38	J
VANADIUM	62.9	0.43	J	53.4	0.53	J	20.3	0.33	J	16.8	0.098	J	22.8	0.19	J	24.5	0.099	J	37.2	0.38	J	25.2	0.085	J
ZINC	205	0.66	J	609	0.79	J	4980	5.3	J	983	1.5	J	58.8	0.28	J	61.6	0.15	J	175	0.61	J	70.4	0.13	J

Notes:
U = not detected at c
J = estimated value

INORGANIC CHEMICALS
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Sample Location	SS211			SS212			SS213			SS214		
Sample Date	6/8/1998			6/8/1998			6/8/1998			6/8/1998		
Sample Depth (ft.)	0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50		
Analyte	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.
ALUMINUM	7750	0.46	J	7920	0.43	J	8520	0.44	J	7080	0.41	J
ANTIMONY	0.29	0.29	R	0.6	0.27	J	0.28	0.28	R	0.44	0.26	J
ARSENIC	3.1	0.21	J	3.1	0.2	J	7.4	0.2	J	8.1	0.19	J
BARIUM	125	0.11	J	91.2	0.1	J	118	0.1	J	88.2	0.096	J
BERYLLIUM	0.17	0.0057	UJ	0.01	0.01	J	0.14	0.0054	UJ	0.01	0.0051	UJ
CADMIUM	0.25	0.017	UJ	0.36	0.016	J	0.69	0.016	J	0.38	0.015	J
CALCIUM	2690	3.4	J	3140	3.2	J	3100	3.3	J	2990	3.1	J
CHROMIUM	16.4	0.051	J	31.2	0.048	J	24.1	0.049	J	24	0.046	J
COBALT	5.4	0.08	J	8.5	0.075	J	6.1	0.076	J	7.3	0.071	J
COPPER	9.2	0.068	J	19.6	0.064	J	57.1	0.065	J	17.5	0.061	J
IRON	8580	1	J	14600	0.98	J	11900	0.98	J	11600	0.92	J
LEAD	44.5	0.1	J	56.3	0.096	J	110	0.097	J	195	0.091	J
MAGNESIUM	2650	3.3	J	4890	3.1	J	2510	3.1	J	4360	2.9	J
MANGANESE	233	0.011	J	383	0.011	J	251	0.011	J	311	0.01	J
MERCURY	0.04	0.04	U	0.05	0.05	U	0.25	0.045		0.08	0.055	UJ
MOLYBDENUM	0.09	0.09	J	0.08	0.08	J	0.08	0.08	J	0.1	0.076	J
NICKEL	20.4	0.074	J	39	0.07	J	48	0.07	J	37.9	0.066	J
POTASSIUM	537	8.2	J	608	7.8	J	1180	7.8	J	993	7.4	J
SELENIUM	0.18	0.18	U	0.17	0.17	U	0.17	0.17	U	0.17	0.23	J
SILVER	0.1	0.074	UJ	0.09	0.07	UJ	0.15	0.07	UJ	0.08	0.066	UJ
SODIUM	159	29.6	J	64	27.9	UJ	187	28.1	J	80.2	26.4	UJ
THALLIUM	0.94	0.38	J	1.2	0.36	J	0.81	0.36	J	0.83	0.34	J
VANADIUM	19.6	0.085	J	29.5	0.08	J	21	0.081	J	25.9	0.076	J
ZINC	46.5	0.12	J	104	0.12	J	337	1.2	J	79	0.11	J

Notes:
U = not detected at c
J = estimated value

APPENDIX D-2

SEMIVOLATILE ORGANIC COMPOUNDS AND TOTAL PETROLEUM HYDROCARBONS
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Sample Location	SB001			SB003			SB004			SB009			SB010			SB011			SB012		
Sample Date	2/6/1996			2/6/1996			3/18/1997			3/18/1997			3/18/1997			3/18/1997			3/7/1997		
Sample Depth (ft.)	0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50		
Analyte	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.
LOW MOLECULAR WEIGHT POLYCYCLIC AROMATIC HYDROCARBONS ([LMW PAH] UG/KG)																					
2-METHYLNAPHTHALENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
ACENAPHTHENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
ACENAPHTHYLENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
ANTHRACENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	UJ	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
FLUORENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
NAPHTHALENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	53.00	370.00	J	430.00	430.00	U	350.00	350.00	U
PHENANTHRENE	460.00	460.00	U	360.00	430.00	J	450.00	450.00	UJ	580.00	580.00	U	64.00	370.00	J	430.00	430.00	U	350.00	350.00	U
SUM LMW PAH	1840.00	5.00		2585.00	4.70		1800.00	4.30		2320.00	5.50		1461.00	3.60		1720.00	4.10		1400.00	3.20	
HIGH MOLECULAR WEIGHT POLYCYCLIC AROMATIC HYDROCARBONS ([HMW PAH] UG/KG)																					
BENZO(A)ANTHRACENE	460.00	460.00	U	480.00	430.00	J	450.00	450.00	UJ	580.00	580.00	UJ	370.00	370.00	U	430.00	430.00	UJ	350.00	350.00	UJ
BENZO(A)PYRENE	460.00	460.00	UJ	560.00	430.00	J	69.00	450.00	J	120.00	580.00	J	370.00	370.00	UJ	430.00	430.00	UJ	350.00	350.00	UJ
BENZO(B)FLUORANTHENE	460.00	460.00	UJ	1700.00	430.00	J	190.00	450.00	J	170.00	580.00	J	62.00	370.00	J	430.00	430.00	U	71.00	350.00	J
BENZO(G,H,I)PERYLENE	460.00	460.00	UJ	400.00	430.00	J	110.00	450.00	J	580.00	580.00	U	370.00	370.00	UJ	430.00	430.00	UJ	350.00	350.00	UJ
BENZO(K)FLUORANTHENE	460.00	460.00	UJ	2200.00	2200.00	UJ	49.00	450.00	J	580.00	580.00	U	370.00	370.00	UJ	430.00	4.10		350.00	350.00	UJ
CHRYSENE	460.00	460.00	U	1200.00	430.00	J	61.00	450.00	J	130.00	580.00	J	45.00	370.00	J	2150.00	4.10		54.00	350.00	J
DIBENZ(A,H)ANTHRACENE	460.00	460.00	UJ	2200.00	2200.00	UJ	450.00	450.00	UJ	580.00	580.00	U	370.00	370.00	UJ	430.00	430.00	U	350.00	350.00	UJ
FLUORANTHENE	460.00	460.00	U	580.00	430.00		70.00	450.00	J	160.00	580.00	J	51.00	370.00	J	210.00	210.00	U	77.00	350.00	J
INDENO(1,2,3-CD)PYRENE	460.00	460.00	UJ	350.00	430.00	J	80.00	450.00	J	580.00	580.00	U	370.00	370.00	UJ	210.00	210.00	U	350.00	350.00	UJ
PYRENE	460.00	460.00	U	1500.00	430.00	J	88.00	450.00	J	230.00	580.00	J	80.00	370.00	J	210.00	210.00	U	110.00	350.00	J
SUM HMW PAH	1840.00	5.00		22510.00	4.70		2601.00	4.30		3880.00	5.50		1639.00	3.60		430.00	430.00	U	1811.00	3.20	
TOTAL PAHS	3680.00	5.00		25095.00	4.70		4401.00	4.30		6200.00	5.50		3100.00	3.60		1100.00	1100.00	U	3211.00	3.20	
OTHER SEMIVOLATILE ORGANIC COMPOUNDS (UG/KG)																					
2-CHLORONAPHTHALENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
1,2,4-TRICHLOROBENZENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
1,2-DICHLOROBENZENE	460.00	460.00	U	430.00	430.00	U	220.00	220.00	U	280.00	280.00	U	180.00	180.00	U	430.00	430.00	U	170.00	170.00	U
1,3-DICHLOROBENZENE	460.00	460.00	U	430.00	430.00	U	220.00	220.00	U	280.00	280.00	U	180.00	180.00	U	430.00	430.00	U	170.00	170.00	U
1,4-DICHLOROBENZENE	460.00	460.00	U	430.00	430.00	U	220.00	220.00	U	280.00	280.00	U	180.00	180.00	U	1100.00	1100.00	U	170.00	170.00	U
2,2'-OXYBIS(1-CHLOROPROPANE)	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
2,4,5-TRICHLOROPHENOL	1100.00	1100.00	U	1000.00	1000.00	U	1100.00	1100.00	U	1500.00	1500.00	U	930.00	930.00	U	430.00	430.00	U	890.00	890.00	U
2,4,6-TRICHLOROPHENOL	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
2,4-DICHLOROPHENOL	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
2,4-DIMETHYLPHENOL	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	1100.00	1100.00	U	350.00	350.00	U
2,4-DINITROPHENOL	1100.00	1100.00	U	1000.00	1000.00	U	1100.00	1100.00	U	1500.00	1500.00	U	930.00	930.00	U	430.00	430.00	U	890.00	890.00	U
2,4-DINITROTOLUENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	UJ	350.00	350.00	U
2,6-DINITROTOLUENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	1100.00	1100.00	U	350.00	350.00	U
2-CHLOROPHENOL	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	1100.00	1100.00	U	350.00	350.00	U
2-METHYLPHENOL	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
2-NITROANILINE	1100.00	1100.00	U	1000.00	1000.00	U	1100.00	1100.00	U	1500.00	1500.00	U	930.00	930.00	U	430.00	430.00	U	890.00	890.00	U
2-NITROPHENOL	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
3,3'-DICHLOROBENZIDINE	460.00	460.00	UJ	2200.00	2200.00	UJ	450.00	450.00	UJ	580.00	580.00	UJ	370.00	370.00	U	430.00	430.00	U	350.00	350.00	UJ
3-NITROANILINE	1100.00	1100.00	U	1000.00	1000.00	U	1100.00	1100.00	U	1500.00	1500.00	U	930.00	930.00	U	430.00	430.00	U	890.00	890.00	U
4,6-DINITRO-2-METHYLPHENOL	1100.00	1100.00	U	1000.00	1000.00	U	1100.00	1100.00	UJ	1500.00	1500.00	U	930.00	930.00	U	1100.00	1100.00	U	890.00	890.00	U
4-BROMOPHENYL-PHENYLETHER	460.00	460.00	U	430.00	430.00	U	450.00	450.00	UJ	580.00	580.00	U	370.00	370.00	U	1100.00	1100.00	U	350.00	350.00	U
4-CHLORO-3-METHYLPHENOL	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
4-CHLOROANILINE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
4-CHLOROPHENYL-PHENYLETHER	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	170.00	170.00	UJ	350.00	350.00	U
4-METHYLPHENOL	460.00	460.00	U	430.00	430.00	J	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	UJ	350.00	350.00	U
4-NITROANILINE	1100.00	1100.00	U	1000.00	1000.00	U	1100.00	1100.00	U	1500.00	1500.00	U	930.00	930.00	U	430.00	430.00	U	890.00	890.00	U

APPENDIX D-2

SEMIVOLATILE ORGANIC COMPOUNDS AND TOTAL PETROLEUM HYDROCARBONS
TAYLOR BOULEVARD BRIDGE DISPOSAL SITE
NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD

Sample Location	SB001			SB003			SB004			SB009			SB010			SB011			SB012		
Sample Date	2/6/1996			2/6/1996			3/18/1997			3/18/1997			3/18/1997			3/18/1997			3/7/1997		
Sample Depth (ft.)	0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50			0.00 - 0.50		
Analyte	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.	Result	Det. Lim.	Qual.
4-NITROPHENOL	1100.00	1100.00	U	1000.00	1000.00	U	1100.00	1100.00	U	1500.00	1500.00	U	930.00	930.00	U	430.00	430.00	U	890.00	890.00	U
BIS(2-CHLOROETHOXY)METHANE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
BIS(2-CHLOROETHYL)ETHER	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
BIS(2-ETHYLHEXYL)PHTHALATE	460.00	460.00	U	2200.00	2200.00	U	620.00	450.00	UJ	230.00	230.00	UJ	150.00	150.00	U	430.00	430.00	U	140.00	140.00	UJ
BUTYLBENZYLPHTHALATE	460.00	460.00	U	2200.00	2200.00	U	450.00	450.00	UJ	580.00	580.00	UJ	370.00	370.00	U	430.00	430.00	U	350.00	350.00	UJ
CARBAZOLE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	UJ	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
DI-N-BUTYLPHTHALATE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
DI-N-OCTYLPHTHALATE	460.00	460.00	UJ	2200.00	2200.00	UJ	450.00	450.00	UJ	580.00	580.00	U	370.00	370.00	UJ	430.00	430.00	U	350.00	350.00	UJ
DIBENZOFURAN	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
DIETHYLPHTHALATE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
DIMETHYLPHTHALATE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
HEXACHLOROBENZENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	UJ	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
HEXACHLOROBUTADIENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	1100.00	1100.00	U	350.00	350.00	U
HEXACHLOROCYCLOPENTADIENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	430.00	430.00	U	350.00	350.00	U
HEXACHLOROETHANE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	NA	NA	NA	350.00	350.00	U
ISOPHORONE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	NA	NA	NA	350.00	350.00	U
N-NITROSO-DI-N-PROPYLAMINE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	NA	NA	NA	350.00	350.00	U
N-NITROSODIPHENYLAMINE (1)	460.00	460.00	U	430.00	430.00	U	450.00	450.00	UJ	580.00	580.00	U	370.00	370.00	U	NA	NA	NA	350.00	350.00	U
NITROBENZENE	460.00	460.00	U	430.00	430.00	U	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	NA	NA	NA	350.00	350.00	U
PENTACHLOROPHENOL	1100.00	1100.00	U	1000.00	1000.00	U	1100.00	1100.00	UJ	1500.00	1500.00	U	930.00	930.00	U	NA	NA	NA	890.00	890.00	U
PHENOL	460.00	460.00	U	410.00	430.00	J	450.00	450.00	U	580.00	580.00	U	370.00	370.00	U	NA	NA	NA	350.00	350.00	U
TOTAL PETROLEUM HYDROCARBONS (MG/KG)																					
DIESEL (EXTRACTABLE)	33.00	35.00	J	550.00	260.00		140.00	140.00	U	180.00	180.00	U	56.00	56.00	U	13.00	13.00	U	11.00	11.00	U
MOTOR OIL (EXTRACTABLE)	240.00	35.00		2900.00	260.00		1300.00	135.00		1700.00	180.00		190.00	56.00		93.00	13.00		140.00	11.00	
GASOLINE (PURGEABLE)	0.70	0.70	UJ	0.65	0.65	UJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

U = Not detected with detection limit indicated

J = Estimated value

Blank = Value above detection limit

NA = not analyzed

Notes:

[a] = Detected concentration greater than Concord Tidal Ambient

[b] = Detected concentration greater than SF Bay Ambient

[c] = Detected concentration greater than effects range low (ERL)

[d] = Detected concentration greater than wetlands cover

[e] = Detected concentration greater than effects range median (ERM)

[f] = Detected concentration greater than wetlands noncover

- = Less than respective screening value

_ = Respective screening value not available, na = screening value not available

U = Not detected with detection limit indicated, J = Estimated value, Blank = Value above detection limit, NA = not analyzed

APPENDIX E

DISCUSSION OF BIOACCUMULATION AND FACTORS THAT INFLUENCE THE BIOACCUMULATION PROCESS

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APPENDIX E

BIOACCUMULATION

1.0 Introduction

Bioaccumulation is the concentration of a chemical in plant or animal tissues taken up from (e.g., originating) from water, sediment or diet (= body burden). The total quantity of chemicals in a sediment (= bulk sediment analysis) or water sample is usually measured. Total metal does not imply that all of the metal is available to plants or aquatic animals for uptake and accumulation. Only that portion of the total sediment concentration which is in the appropriate chemical form (e.g., available) can be taken up by plants and animals. Although chemical techniques exist to assess the available form (e.g., ionic state) of a chemical, they are rarely performed because of their high cost and time-consuming nature. Availability, uptake, and accumulation are discussed in the following sections.

1.1 Definitions

Bioaccumulation describes the process through which chemicals enter plants or animals from water, soil, sediment, or air (called uptake) followed by storage in either plant or animal tissues (called accumulation). A **bioaccumulation factor** is the ratio of the animal or plant tissue chemical concentration divided by the water or sediment chemical concentration. The BAF is usually calculated using dry tissue and sediment chemical concentrations. **Bioavailability** describes whether or not a chemical is in the correct chemical form to enter the plant or animal, i.e., be taken up into plant roots or cross fish gills and enter the bloodstream.
Biomagnification describes the differing chemical body burdens present in animals at different food chain levels. Biomagnification results in animals at the higher trophic levels having chemical body burdens that are significantly greater than the chemical body burdens in animals at lower trophic levels.

1.2 Principles

A chemical must be available to enter a plant or benthic invertebrate and cause toxic effects. Availability is a function of the form in which a chemical exists; for metals form refers to ionic state and whether the metal is bound or unbound. Divalent metals such as copper and zinc dissolve in water as +2 ions. In this form they are available in the interstitial water of soils, pore water of sediments, or in lakes, streams and the ocean for uptake by plants and animals. Bound metals may or may not be available. If the uptake route is from water, metal associated with or bound to a particle is not available. If the uptake is ingestion, metal associated with or bound to a particle is available.

To move a dissolved chemical from soil or water into an organism usually requires transfer mechanisms. Such mechanisms can be passive (diffusion) or active (ATP coupled transport). The chemical enters the organism through plant roots, the cuticle on the surface of plant leaves, across the skin (dermally) of fish, across the gills of aquatic animals, or through the mouth (ingestion). In each case the chemical crosses a biological membrane covering the epidermis. When a metal-associated particle is ingested by an animals, the process is slightly different. When the metal-associated particle enters the gut, the acid present in the gut frees the metal from the particle. The metal is now a +2 ion, crosses the membrane lining the gut, and enters the bloodstream of the animal.

The magnitude of accumulation in animals depends upon the excretion rate, the tissue in which the metal is stored, and whether the animal has a biochemical mechanism (such as the protein metallothionein) to store or sequester the metal in a non-toxic mode. Since plants typically lack excretion mechanisms, accumulation magnitude in plants is determined by the tissue in which the metal is stored and whether the plant has a mechanism to store or sequester the metal in a non-toxic mode. Sometimes metal concentrations in an animal never reach steady state (when excretion and uptake are equal). In these cases if all factors remain constant, the chemical body burden increases throughout the animal's life span. However, if the animal grows (i.e., get larger and gains weight), the concentration (chemical per unit tissue) decreases. Conversely, if uptake is passive and/or excretion equals uptake, the chemical concentration in the tissues declines as the animal grows.

Rate independent accumulation occurs when metal uptake stimulates synthesis of metal-specific binding proteins such as metallothionein (Luoma 1983). Metallothionein (and other similar proteins with high cysteine content) plays a role in metal homeostasis (e.g., zinc) and in detoxifying toxic metals (e.g., cadmium) and is present in both plants and animals. These unique proteins give plants and animals the ability to render very high concentrations of normally-toxic metals harmless by sequestering the metal in a cellular matrix that makes the metal unavailable. For example, pine needles contain extremely high aluminum concentrations that are non-toxic to the tree because of the mode in which the aluminum is bound in the pine needle. Many clams can sequester metals in a non-toxic mode in a crystalline style

1.3 Assessing Bioavailability and Bioaccumulation

Measuring bioavailability in sediment or soils is difficult. The direct method would be to determine the actual chemical form; for example, is the metal a +2 ion (the available form to plants and animals) or is the metal complexed (not available to plants and animals)? Polarography and chromatography are chemical methods that can be used to determine the form in which a chemical exists in the field. However, because these direct methods are both costly and time-consuming, indirect methods to measure chemical availability in soils and sediments have been developed.

Indirect techniques include (1) correlating bulk chemistry with pore water chemistry, (2) analyzing chemicals in water or acid extracts from sediment or soil (such as WET-di and WET-acid extractions), and (3) analyzing other parameters such as total organic carbon, pH, redox potential, salinity, hardness, and particle grain size that influence availability.

The correlation between bulk chemistry and pore water concentration for the same chemical is generally weak so this technique is seldom used. Chemical concentrations measured in deionized water or acid soil extracts also correlate poorly with bulk chemistry measurements of the same metal in sediment or soil. This weak correlation stems from the inability in the laboratory to duplicate the time element present in the field in natural soil or sediment elution by water. Secondly, the column through which the water or acid elutes cannot be packed with soil or sediment in a manner that gives consistent reproducible results. The best indirect indicators of bioavailability are the characteristics of the soil or sediment such as grain size and

total organic carbon content. As understanding of sediment chemistry grows, the ability to predict chemical availability and thus bioaccumulation increases.

Understanding of how metals dissolved in the pore water (= interstitial water) of sediments cause toxicity to benthic organisms is explained by equilibrium partitioning (DiToro, and others 1991). Metals associated with particles exist in equilibrium with metals dissolved in the sediment pore water, i.e., the metal sorbs or desorbs from/to the particle in an equilibrium process. Particle size, composition, and especially the amount and type of organic carbon in the particle play important roles in regulating this equilibrium.

Toxicity to benthic organisms does not correlate with the total metal concentration of a sediment (either on a wet or dry weight basis) (Science Advisory Board 1995; Carlson, and others 1991). Equilibrium partitioning demonstrated that availability, accumulation, and toxicity to benthic organisms correlated with the metal concentration present in the sediment pore water (Giesy and Hoke 1989). Sediment metal availability can be predicted via the sulfide concentration present in the sediment (Carlson, and others 1991; Hare, Carignan, and Herta-Diaz 1994). In anoxic sediments one mole of sulfide binds one mole of metal making the metal unavailable for uptake or accumulation. Only divalent metals such zinc, copper, cadmium, and lead, bind to sulfides. The concept does not apply to metals such as selenium and arsenic that exist in multiple valence states; while sulfide may bind some proportion of these metals in anoxic sediments, it does not necessarily bind all of the available metal. Unbound divalent metal ions dissolve in the sediment pore water, i.e., they are available. These metal ions can be taken up and/or accumulated by benthic organisms. If present in the pore water or in the organism's tissues at sufficiently high concentrations, the metals are toxic.

1.4 Factors That Affect Bioaccumulation and Uptake

The following sections briefly describe factors that affect uptke and accumulation of chemicals in plants and animals.

1.4.1 Total Organic Carbon and Grain Size

Typically chemicals such as metals adsorb to particles. As a result, factors that enhance metal adsorption to particles increase potential metal availability.

Since the number of charged binding sites increases as particle size decreases (allowing more chemical to bind to the particle), particle size plays an important role in determining availability. When a filter-feeding, benthic invertebrates eats smaller particles carrying higher quantities of chemical, the animal eats more particles to become satiated. The animal therefore accumulates more chemical. In soils or sediment, smaller particles carrying higher quantities of chemicals result in more metal per unit area of soil or sediment being potentially available to plants. If this metal dissolves in the pore water of the sediment or soil, plant uptake through the roots increases. Hence, grain size is an important variable as smaller particles carry greater contaminant loads.

Often the primary site of adsorption of chemicals to particles is the total organic carbon present in the particle. Since the concentration of total organic carbon in a particle increases as particle size decreases, smaller particles are again associated with higher chemical concentrations. As above; smaller particles therefore cause higher chemical accumulation in plants and animals.

1.4.2 pH

The hydrogen ion concentration (pH) affects metal accumulation and uptake. Metal solubility increases as pH decreases (Meyer, and others 1994). Hence, in soils or sediments with low pHs, the ratio of bound to unbound metal decreases resulting in more metal being in solution in the pore water of the sediment or soil. This increase in pore water metal concentrations means that more metal is available to the plant for uptake through its roots. Although the total metal concentration in a soil or sediment has not changed, because of greater availability at lower pHs metal uptake from the soil or sediment increases.

In lakes or streams, metals typically dissolve as +2 ions (or the equivalent hydrated form). As the pH decreases, the percentage of metals in the free ionic state increases. Thus, more metal is available for uptake across fish or invertebrate gills. As explained above, the total metal

concentration is unchanged; however, the decreased pH has resulted in more metal ions being available for uptake. Since the metal ion is the toxic form, metals are generally more toxic to aquatic life in acid waters.

1.4.3 Oxidation-Reduction Potential

Oxidation-reduction potential (Eh or redox potential) measures the tendency of a system to act as an oxidizing (electron acceptor) or a reducing (electron donor) agent.

In sediments, the chemical forms of sulfur, iron, manganese, and nitrogen are determined by the redox status of the environment in which each chemical occurs. In reduced sediments iron and manganese are in the divalent, soluble state. In oxic sediments iron oxides are in a solid form called a precipitate. Metals adsorb to negatively charged sites on the surfaces of these precipitates. When reduced sediments are oxidized, hydrous iron and manganese oxides form rapidly. These soluble oxides scavenge dissolved metals (arsenic, copper, and zinc) from the water column and then precipitate, a process called coprecipitation (COE 1989). If these coprecipitates are oxidized, soluble metals are released back into the water column increasing the dissolved metal concentration (Meyer, and others 1994).

Redox processes therefore (1) determine whether a divalent metal is sorbed, precipitated,or unavailable, and (2) influence the chemical form of chemicals such as arsenic and selenium. Unlike zinc and copper that exist in water or sediment in a single ionic form (+2 ion), arsenic and selenium occur in water, sediments, and soil in multiple valence states. Somearsenic and selenium valence states are available for uptake to animals and plants; others are not

1.4.4 Hardness

Hardness describes the concentration of multivalent cations, particularly calcium and magnesium in freshwater. There is no equivalent concept for seawater or for soils or sediments. Divalent cations (Ca^{2+} and Mg^{2+}) cause particulate, colloidal, or soluble organic matter in the water column to flocculate and settle; trace metals may coprecipitate with this flocculated material (COE 1989). Calcium and magnesium cations generally do not affect

speciation of cationic toxicants, but may compete for binding sites on the same ligands. Hardness does not affect speciation of anionic toxicants (Erickson, and others 1994).

Most metals are less toxic to aquatic organisms in hard water (Meyer, and others 1994). The specific chemical mechanism that causes this reduction in toxicity is not well understood although it is generally attributed to the competition between calcium, magnesium, and metal ions to cross the gill membranes on the gill lamallae.

1.4.5 Salinity

Salinity is a measure of the percent salt dissolved in seawater and usually is reported in parts per thousand units. Salinity modifies chemical availability by through its influence of metal particle binding. Availability of metals that do not bind strongly to particles in seawater (such as zinc and copper) is not strongly influenced by salinity. However, metals that bind strongly to particles in seawater (such as cadmium) are strongly influenced by salinity. Cadmium is more toxic to freshwater organisms because in freshwater it is unbound, occurring primarily as a +2 ion . In seawater cadmium binds strongly to particulates, reducing the availability of cadmium to non-filter feeding aquatic organisms. As a result, bivalves accumulate more cadmium as salinity decreases (Hawker 1990). Bioavailability of metals in estuarine habitats varies widely caused by rapid freshwater/seawater transitions.

1.4.6 Biologically-Mediated Transformation

Many organometallic compounds form through biologically-mediated processes. For example, microorganisms alkylate lead and mercury, and phytoplankton synthesize organic forms of arsenic which are biomagnified (Hawker 1990). Biomethylation increases the availability and toxicity of arsenic, selenium, and mercury by making the metal more lipid-soluble which makes passage across biological membranes easier (Meyer, and others 1994). Increasing the number of organic substitutions on a metallic compound makes the compound more hydrophobic and therefore more likely to bioaccumulate (Hawker 1990).

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APPENDIX F

OAK RIDGE NATIONAL LABORATORY
LOWEST OBSERVED ADVERSE EFFECT LEVEL
AND NO OBSERVED ADVERSE EFFECT LEVEL STUDIES
USED AS TOXICITY REFERENCE VALUES

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Compound: Antimony

Form: Antimony Potassium Tartrate

Reference: Schroeder et al. 1968b

Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Water Consumption: 0.0075 L/d (calculated using allometric equation from EPA 1988a)

Study Duration: lifetime (>1 yr = chronic)

Endpoint: lifespan, longevity

Exposure Route: oral in water

Dosage: one dose level:
5 ppm Sb = LOAEL

Calculations:

$$LOAEL: \left(\frac{5\,mg\ Sb}{L\ water} \times \frac{7.5\,mL\ water}{day} \times \frac{1\,L}{1000\,mL} \right) / 0.03\ kg\ BW = 1.25\ mg/kg/d$$

Comments: Because median lifespan was reduced among female mice exposed to the 5 ppm dose level and the study considered exposure throughout the entire lifespan, this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.125 mg/kg/d

Final LOAEL: 1.25 mg/kg/d

Compound:	Barium
Form:	Barium Chloride
Reference:	Perry et al. 1983
Test Species:	Rat
	Body weight: 0.435 kg (from study)
	Water Consumption: 0.022 L/d (from study)
Study Duration:	16 months (> 1yr = chronic)
Endpoint:	growth, hypertension
Exposure Route:	oral in water
Dosage:	three dose level:
	1, 10, and 100, ppm Ba (as Barium Chloride);
	NOAEL = 100 ppm

Calculations:

$$NOAEL: \left(\frac{100\,mg\ Ba}{L\ water} \times \frac{22\,mL\ water}{day} \times \frac{1\,L}{1000\,mL} \right) / 0.435\ kg\ BW = 5.06\ mg/kg/d$$

Comments: While none of the three dose levels had any affect on food or water consumption or on growth, cardiovascular hypertension was observed among rats exposed to 10 or 100 ppm Ba. Because the significance of hypertension in wild populations is unclear, the maximum dose that did not affect growth, food or water consumption (100 ppm) was considered to be a chronic NOAEL.

Final NOAEL: 5.1 mg/kg/d

Compound:	Barium
Form:	Barium Chloride (66% Ba)
Reference:	Borzelleca et al. 1988
Test Species:	Rat
	Body weight: 0.35 kg (EPA 1988a)
Study Duration:	10 days (< 1yr = subchronic)
Endpoint:	mortality
Exposure Route:	oral gavage in water
Dosage:	four dose levels:
	100, 145, 209, and 300 mg Barium Chloride /kg/d
	LOAEL = (300x0.66)=198 mg Ba /kg/d
Calculations:	not applicable

Comments: Exposure of rats to 300 mg/kg/d $BaCl_2$ for 10 days resulted in 30% mortality to female rats. No adverse effects were observed at any other dose levels. The 300 mg/kg/d dose was considered to be a subchronic LOAEL. A chronic LOAEL was estimated by multiplying the subchronic LOAEL by a subchronic to chronic uncertainty factor of 0.1.

Final LOAEL: 19.8 mg/kg/d

Compound: Barium

Form: Barium Hydroxide

Reference: Johnson et al. 1960

Test Species: 1-day old chicks
Body weight: 0.121 kg ($mean_{♂+♀}$ at 14 d; EPA 1988a)
Food Consumption: 0.0126 kg/d (calculated using allometric equation from EPA 1988a)

Study Duration: 4 wk (< 10 wk = subchronic)

Endpoint: mortality

Exposure Route: oral in diet

Dosage: eight dose level:
250, 500, 1000, 2000, 4000, 8000, 16,000, and 32,000 ppm
Ba (as Barium Hydroxide)
NOAEL = 2000 ppm

Calculations:

$$NOAEL: \left(\frac{2000\,mg\ Ba}{kg\ food} \times \frac{12.6\,g\ food}{day} \times \frac{1\,kg}{1000\,g} \right) / \ 0.121\ kg\ BW = 208.26\ mg/kg/d$$

$$LOAEL: \left(\frac{4000\,mg\ Ba}{kg\ food} \times \frac{12.6\,g\ food}{day} \times \frac{1\,kg}{1000\,g} \right) / \ 0.121\ kg\ BW = 416.53\ mg/kg/d$$

Comments: To estimate daily Ba intake throughout the 4 week study period, food consumption of 2-week-old chicks was calculated. While this value will over- and underestimate food consumption by younger and older chicks, it was assumed to approximate food consumption throughout the entire 4 week study. While Barium exposures up to 2000 ppm produced no mortality, chicks in the 4000 to 32000 ppm groups experienced 5% to 100% mortality. Because 2000 ppm was the highest nonlethal dose, this dose was considered to be a subchronic NOAEL. The 4000 ppm dose was considered to be a subchronic LOAEL. Chronic NOAELs and LOAELs were estimated by multiplying the subchronic NOAELs and LOAELs by a subchronic to chronic uncertainty factor of 0.1.

Final NOAEL: 20.8 mg/kg/d
Final LOAEL: 41.7 mg/kg/d

Compound: Chromium
Form: Cr^{+6} as $K_2Cr_2O_4$
Reference: MacKenzie et al. 1958
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Water Consumption: 0.046 L/d (calculated using allometric equation from EPA 1988a)
Study Duration: 1 yr
Endpoint: body weight and food consumption
Exposure Route: oral in water
Dosage: six dose levels:
0.45, 2.2, 4.5, 7.7, 11.2, and 25 ppm Cr^{+6} in water
No effects observed at any dose level
Calculations:

$$NOAEL: \left(\frac{25\,mg\ Cr^{+6}}{L\ water} \times \frac{0.046\,L\ water}{day} \right) / 0.35\ kg\ BW = 3.28\ mg/kg/d$$

Comments: Because no significant differences were observed at any dose level studied and the study considered exposure over 1 year, the maximum dose was considered to be a chronic NOAEL.
Final NOAEL: 3.28 mg/kg/d

Compound: Chromium
Form: Cr^{+6}
Reference: Steven et al. 1976 (cited in Eisler 1986)
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Water Consumption: 0.046 L/d (calculated using allometric equation from EPA 1988a)
Study Duration: 3 months (<1 yr = subchronic)
Endpoint: mortality
Exposure Route: oral in water
Dosage: two dose levels:
134 and 1000 ppm Cr^{+6} in water; 1000 ppm = LOAEL
Calculations:

$$LOAEL: \left(\frac{1000\,mg\ Cr^{+6}}{L\ water} \times \frac{0.046\,L\ water}{day} \right) / 0.35\ kg\ BW = 131.4\ mg/kg/d$$

Comments: Because the 1000 ppm dose was identified as the toxicity threshold, this dose was considered to be a subchronic LOAEL. A chronic LOAEL was estimated by multiplying the subchronic LOAEL by a subchronic-chronic uncertainty factor of 0.1.
Final LOAEL: 13.14 mg/kg/d

Compound: Molybdenum

Form: Molybdate (MoO_4)

Reference: Schroeder and Mitchner 1971

Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Food Consumption: 0.0055 kg/d
Water Consumption: 0.0075 L/d
(calculated using allometric equation from EPA 1988a)

Study Duration: 3 generations (> 1 yr and during critical lifestage=chronic)

Endpoint: reproduction

Exposure Route: oral in water

Dosage: one dose level:
10 mg Mo/L + 0.45 mg/kg in diet = LOAEL

Calculations:

$$NOAEL: \left(\frac{10\,mg\ Mo}{L\ water} \times \frac{7.5mL\ water}{day} \times \frac{1\,L}{1000\,mL} \right) / 0.03\ kg\ BW = 2.5mg/kg/d$$

$$LOAEL: \left(\frac{0.45\,mg\ Mo}{kg\ food} \times \frac{5.5g\ food}{day} \times \frac{1\,kg}{1000\,g} \right) / 0.03\ kg\ BW = 0.0825mg/kg/d$$

Total Exposure = 2.5 mg/kg/d + 0.0825 mg/kg/d =2.5825 mg/kg/d

Comments: Because mice exposed to Mo displayed reduced reproductive success with a high incidence of runts, this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.26 mg/kg/d

Final LOAEL: 2.6 mg/kg/d

Compound: Molybdenum
Form: Sodium Molybdate
Reference: Lepore and Miller 1965
Test Species: Chicken
Body weight: 1.5 kg (EPA 1988a)
Food Consumption: 0.106 kg/d
(calculated using allometric equation from EPA 1988a)
Study Duration: 21 d through reproduction (during a critical lifestage=chronic)
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
500, 1000, and 2000 ppm Mo; 500 ppm = LOAEL

Calculations:

$$LOAEL: \left(\frac{500\,mg\ Mo}{L\ water} \times \frac{106mg\ food}{day} \times \frac{1\,kg}{1000\,mg} \right) / 1.5\ kg\ BW = 35.33\,mg/kg/d$$

Comments: Embryonic viability was reduced to zero in the 500 ppm Mo treatment, therefore this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 3.5/kg/d
Final LOAEL: 35.3 mg/kg/d

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APPENDIX G

DOSE CALCULATIONS FOR THE MALLARD DUCK

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APPENDIX G1

MALLARD DOSE CALCULATIONS TBB DISPOSAL SITE NWS SBD CONCORD

Chemical[a]	Sample Location	Dose Type	IR_{prey} (kg/day)	[amphipod] (mg/kg dry wt.)	$IR_{amphipod}$ (kg/day) (100% IR_{prey})	Ingestion from Aquatic Prey (mg/day)	[sediment 95%UCL] (mg/kg dry wt.)	$IR_{sediment}$ (kg/day) 3.3%	Ingestion from Sediment	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Antimony	95 UCL	Typical	0.0917	7.8	0.0917	0.72	10.10	0.003	0.03	0.01	1.16	6.43E-03					
Arsenic	95 UCL	Typical	0.0917	141	0.0917	12.9	28.70	0.003	0.09	0.01	1.16	1.12E-01	5.49E+00	2.20E+01	X		
Beryllium	95 UCL	Typical	0.0917	1.38	0.0917	0.13	0.24	0.003	0.00	0.01	1.16	1.09E-03					
Cadmium	95 UCL	Typical	0.0917	5.1	0.0917	0.47	1.70	0.003	0.01	0.01	1.16	4.07E-03	8.62E-02	1.76E+01	X		
Chromium	95 UCL	Typical	0.0917	63.3	0.0917	5.8	204.00	0.003	0.62	0.01	1.16	5.53E-02					
Copper	95 UCL	Typical	0.0917	1147	0.0917	105	1094.00	0.003	3.31	0.01	1.16	9.35E-01	2.59E+00	6.44E+01	X		
Lead	95 UCL	Typical	0.0917	385	0.0917	35.3	1126.00	0.003	3.41	0.01	1.16	3.34E-01	2.37E-02	9.43E+00		X	
Mercury	95 UCL	Typical	0.0917	2.4	0.0917	0.22	1.70	0.003	0.01	0.01	1.16	1.91E-03	4.02E-02	1.85E-01	X		
Molybdenum	95 UCL	Typical	0.0917	14.1	0.0917	1.3	19.40	0.003	0.06	0.01	1.16	1.16E-02					
Selenium	95 UCL	Typical	0.0917	21.5	0.0917	2.0	3.20	0.003	0.01	0.01	1.16	1.70E-02	2.32E-01	9.39E-01	X		
Silver	95 UCL	Typical	0.0917	19.6	0.0917	1.8	1.30	0.003	0.00	0.01	1.16	1.56E-02					
Zinc	95 UCL	Typical	0.0917	2855	0.0917	262	1309.00	0.003	3.96	0.01	1.16	2.29E+00	1.79E+01	1.79E+02	X		

Notes:

[amphipod] Concentration of chemical in amphipod
BW Body weight
IR_{prey} Ingestion rate of prey
$IR_{sediment}$ Ingestion rate of sediment
kg/day Kilograms per day
mg/kg Milligrams per kilogram
mg/kg/day Milligrams per kilogram per day
NA Not available
[sediment] Concentration of chemical in sediment
SUF Site use factor
TRV Toxicity reference value
UCL Upper confidence limit

a Chemicals were selected based on available TRV information
b The dose for the 95 percent upper cofidence limit was only calculated for chemicals with an HQ greater than 1
-- Not applicable to the analysis

APPENDIX G2

MALLARD HAZARD QUOTIENT CALCULATIONS
TBB DISPOSAL SITE NWS SBD CONCORD

Chemical	Sample Location	Typical Dose (mg/kg/day)	Low TRV (mg/kg/day)	High TRV (mg/kg/day)	HQ_1 (Typical Dose/ High TRV)	HQ_2 (Typical Dose/ Low TRV)
Antimony	95 UCL[a]	6.43E-03			--	--
Arsenic	95 UCL[a]	1.12E-01	5.49E+00	2.20E+01	5.10E-03	2.04E-02
Beryllium	95 UCL[a]	1.09E-03			--	--
Cadmium	95 UCL[a]	4.07E-03	8.62E-02	1.76E+01	2.31E-04	4.72E-02
Chromium	95 UCL[a]	5.53E-02			--	
Copper	95 UCL[a]	9.35E-01	2.59E+00	6.44E+01	1.45E-02	3.61E-01
Lead	95 UCL[a]	3.34E-01	2.37E-02	9.43E+00	**3.54E-02**	**1.41E+01**
Mercury	95 UCL[a]	1.91E-03	4.02E-02	1.85E-01	1.03E-02	4.75E-02
Molybdenum	95 UCL[a]	1.16E-02				--
Selenium	95 UCL[a]	1.70E-02	2.32E-01	9.39E-01	1.81E-02	7.34E-02
Silver	95 UCL[a]	1.56E-02			--	--
Zinc	95 UCL[a]	2.29E+00	1.79E+01	1.79E+02	1.28E-02	1.28E-01

Notes: **Bold font indicates an HQ greater than 1**

HQ Hazard quotient
mg/kg/day Milligrams per kilogram per day
TRV Toxicity reference value
UCL Upper confidence limit of the mean

a The dose for the mallard was calculated using the 95 UCL of aquatic and wetland sediment data (n=48) and the maximum tissue concentration

APPENDIX II

DOSE CALCULATIONS FOR THE BLACK-NECKED STILT

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APPENDIX H1

BLACK-NECKED STILT DOSE CALCULATIONS IN THE FROID AND TAYLOR AQUATIC UNIT TIDAL AREA QEA, NWS SBD CONCORD

Chemical[a]	Sample Location	Dose Type	IR_{prey} (kg/day)	[amphipod] (mg/kg)	$IR_{amphipod}$ (kg/day) (100% IR_{prey})	Ingestion from Aquatic Prey (mg/day)	[sediment] (mg/kg)	$IR_{sediment}$ (kg/day) 7.3%	Ingestion from Sediment	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Antimony	95 UCL	Typical	0.026	7.81	0.026	0.20	10.10	1.876E-03	0.02	0.50	0.166	0.66					
Arsenic	95 UCL	Typical	0.026	140.92	0.026	3.62	28.70	1.876E-03	0.05	0.50	0.166	11.07	3.72	14.89		X	
Beryllium	95 UCL	Typical	0.026	1.38	0.026	0.04	0.24	1.876E-03	0.00	0.50	0.166	0.11					
Cadmium	95 UCL	Typical	0.026	5.09	0.026	0.13	1.70	1.876E-03	0.00	0.50	0.166	0.40	0.06	11.95		X	
Chromium	95 UCL	Typical	0.026	63.33	0.026	1.63	204.00	1.876E-03	0.38	0.50	0.166	6.05					
Copper	95 UCL	Typical	0.026	1147.35	0.026	29.49	1094.00	1.876E-03	2.05	0.50	0.166	95.00	1.76	43.64			X
Lead	95 UCL	Typical	0.026	385.40	0.026	9.90	1126.00	1.876E-03	2.11	0.50	0.166	36.20	0.02	6.39			X
Mercury	95 UCL	Typical	0.026	2.36	0.026	0.06	1.70	1.876E-03	0.00	0.50	0.166	0.19	0.027	0.13			X
Molybdenum	95 UCL	Typical	0.026	14.09	0.026	0.36	19.40	1.876E-03	0.04	0.50	0.166	1.20					
Selenium	95 UCL	Typical	0.026	21.45	0.026	0.55	3.20	1.876E-03	0.01	0.50	0.166	1.68	0.16	0.64			X
Silver	95 UCL	Typical	0.026	19.65	0.026	0.50	1.30	1.876E-03	0.00	0.50	0.166	1.53					
Zinc	95 UCL	Typical	0.026	2854.55	0.026	73.36	1309.00	1.876E-03	2.46	0.50	0.166	228.37	12.12	121.21			X

Notes:

[amphipod] Concentration of chemical in amphipod
BW Body weight
IR_{prey} Ingestion rate of prey
$IR_{sediment}$ Ingestion rate of sediment
kg/day Kilograms per day
mg/kg Milligrams per kilogram
mg/kg/day Milligrams per kilogram per day
NA Not available
[sediment] Concentration of chemical in sediment
SUF Site use factor
TRV Toxicity reference value
UCL Upper confidence limit

a Chemicals were selected based on available TRV information
b The dose for the 95 percent upper confidence limit was only calculated for chemicals with an HQ greater than 1
-- Not applicable to the analysis

APPENDIX H2

BLACK-NECKED STILT HAZARD QUOTIENT CALCULATIONS IN THE TBB DISPOSAL SITE, NWS SBD CONCORD

Chemical	Sample Location	Typical Dose (mg/kg/day)	Low TRV (mg/kg/day)	High TRV (mg/kg/day)	HQ_1 (Typical Dose/ High TRV)	HQ_2 (Typical Dose/ Low TRV)
Antimony	95 UCL[a]	0.66			--	--
Arsenic	95 UCL[a]	11.07	3.72	14.89	0.74	**2.98**
Beryllium	95 UCL[a]	0.11			--	--
Cadmium	95 UCL[a]	0.40	0.06	11.95	0.03	**6.91**
Chromium	95 UCL[a]	6.05				
Copper	95 UCL[a]	95.00	1.76	43.64	**2.18**	**54.08**
Lead	95 UCL[a]	36.20	0.0160	6.39	**5.67**	**2256**
Mercury	95 UCL[a]	0.19	0.03	0.13	1.53	**7.05**
Molybdenum	95 UCL[a]	1.20				
Selenium	95 UCL[a]	1.68	0.16	0.64	**2.64**	**10.67**
Silver	95 UCL[a]	1.53			--	--
Zinc	95 UCL[a]	228.37	12.12	121.21	**1.88**	**18.84**

Notes: **Bold font indicates an HQ greater than 1**

na Not available

HQ Hazard quotient

mg/kg/day Milligrams per kilogram per day

TRV Toxicity reference value

UCL Upper confidence limit

a The dose was only calculated for COPECs. 95 percent UCLs include both aquatic and wetland data. The maximum amphipod tissue concentration was used in dose calculat

APPENDIX I

DOSE CALCULATIONS FOR THE SALT MARSH HARVEST MOUSE

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APPENDIX I1

SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	High Dose (mg/kg/day)	Low Dose (mg/kg/day)	High Dose Low TRV (mg/kg/day)	High Dose High TRV (mg/kg/day)	Low Dose Low TRV (mg/kg/day)	Low Dose High TRV (mg/kg/day)	HQ_1 (Low Dose/ High TRV)	HQ_2 (High Dose/ Low TRV)	HQ_3 (High Dose/ High TRV)
Antimony	309CSPWSS	0.27	0.11	0.13	1.34	0.13	1.30	8.79E-02	2.03E+00	2.03E-01
Arsenic	309CSPWSS	12.79	5.35	0.40	5.46	0.38	5.28	1.01E+00	3.22E+01	2.34E+00
Barium	309CSPWSS	21.44	8.96	6.44	24.66	6.22	23.83	3.76E-01	3.33E+00	8.69E-01
Beryllium	309CSPWSS	1.95E-02	8.14E-03	0.00	0.00	0.00	0.00			
Cadmium	309CSPWSS	1.33	0.56	0.06	2.85	0.06	2.75	2.03E-01	2.06E+01	4.69E-01
Chromium	309CSPWSS	3.45	1.44	4.09	16.37	3.95	15.81	9.12E-02	8.45E-01	2.11E-01
Copper	309CSPWSS	20.42	8.53	2.87	671.02	2.77	648.25	1.32E-02	7.12E+00	3.04E-02
Lead	309CSPWSS	22.94	9.58	0.00	251.44	0.00	242.91	3.95E-02	1.27E+04	9.12E-02
Mercury	309CSPWSS	0.04	0.02	0.30	5.04	0.29	4.87	3.15E-03	1.22E-01	7.28E-03
Molybdenum	309CSPWSS	3.10	1.29	0.28	2.79	0.27	2.70	4.79E-01	1.11E+01	1.11E+00
Selenium	309CSPWSS	1.75	0.73	0.05	1.29	0.05	1.24	5.87E-01	3.29E+01	1.36E+00
Silver	309CSPWSS	0.14	0.06	0.00	0.00	0.00	0.00			
Zinc	309CSPWSS	213.18	89.08	10.23	491.61	9.88	474.93	1.88E-01	2.08E+01	4.34E-01
Antimony	309SB05	0.07	0.03	0.13	1.34	0.13	1.30	2.13E-02	4.92E-01	4.92E-02
Arsenic	309SB05	0.26	0.11	0.40	5.46	0.38	5.28	2.09E-02	6.65E-01	4.84E-02
Barium	309SB05	7.74	3.23	6.44	24.66	6.22	23.83	1.36E-01	1.20E+00	3.14E-01
Beryllium	309SB05	1.01E-02	4.20E-03	0.00	0.00	0.00	0.00			
Cadmium	309SB05	0.05	0.02	0.06	2.85	0.06	2.75	7.28E-03	7.39E-01	1.68E-02
Chromium	309SB05	1.36	0.57	4.09	16.37	3.95	15.81	3.60E-02	3.33E-01	8.32E-02
Copper	309SB05	5.53	2.31	2.87	671.02	2.77	648.25	3.56E-03	1.93E+00	8.24E-03
Lead	309SB05	2.57	1.07	0.00	251.44	0.00	242.91	4.42E-03	1.42E+03	1.02E-02
Mercury	309SB05	0.01	0.01	0.30	5.04	0.29	4.87	1.16E-03	4.52E-02	2.69E-03
Molybdenum	309SB05	0.84	0.35	0.28	2.79	0.27	2.70	1.30E-01	3.01E+00	3.01E-01
Selenium	309SB05	0.03	0.01	0.05	1.29	0.05	1.24	9.85E-03	5.51E-01	2.28E-02
Silver	309SB05	0.04	0.02	0.00	0.00	0.00	0.00			
Zinc	309SB05	18.47	7.72	10.23	491.61	9.88	474.93	1.63E-02	1.81E+00	3.76E-02
Antimony	309SB106	0.08	0.03	0.13	1.34	0.13	1.30	2.57E-02	5.93E-01	5.93E-02
Arsenic	309SB106	13.80	5.77	0.40	5.46	0.38	5.28	1.09E+00	3.47E+01	2.53E+00
Barium	309SB106	14.60	6.10	6.44	24.66	6.22	23.83	2.56E-01	2.27E+00	5.92E-01
Beryllium	309SB106	1.64E-02	6.87E-03	0.00	0.00	0.00	0.00			
Cadmium	309SB106	0.21	0.09	0.06	2.85	0.06	2.75	3.13E-02	3.18E+00	7.25E-02
Chromium	309SB106	2.56	1.07	4.09	16.37	3.95	15.81	6.77E-02	6.27E-01	1.57E-01
Copper	309SB106	9.10	3.80	2.87	671.02	2.77	648.25	5.86E-03	3.17E+00	1.36E-02
Lead	309SB106	3.24	1.35	0.00	251.44	0.00	242.91	5.57E-03	1.79E+03	1.29E-02
Mercury	309SB106	0.03	0.01	0.30	5.04	0.29	4.87	2.18E-03	8.49E-02	5.05E-03
Molybdenum	309SB106	1.55	0.65	0.28	2.79	0.27	2.70	2.40E-01	5.56E+00	5.56E-01
Selenium	309SB106	0.13	0.05	0.05	1.29	0.05	1.24	4.22E-02	2.36E+00	9.76E-02
Silver	309SB106	0.05	0.02	0.00	0.00	0.00	0.00			
Zinc	309SB106	38.79	16.21	10.23	491.61	9.88	474.93	3.41E-02	3.79E+00	7.89E-02
Antimony	SB01	1.21	0.50	0.13	1.34	0.13	1.30	3.88E-01	8.98E+00	8.98E-01
Arsenic	SB01	104.56	43.69	0.40	5.46	0.38	5.28	8.28E+00	2.63E+02	1.91E+01
Barium	SB01	387.82	162.05	6.44	24.66	6.22	23.83	6.80E+00	6.03E+01	1.57E+01
Beryllium	SB01	5.46E-02	2.28E-02	0.00	0.00	0.00	0.00			
Cadmium	SB01	0.19	0.08	0.06	2.85	0.06	2.75	2.84E-02	2.88E+00	6.56E-02
Chromium	SB01	11.85	4.95	4.09	16.37	3.95	15.81	3.13E-01	2.90E+00	7.24E-01
Copper	SB01	253.94	106.11	2.87	671.02	2.77	648.25	1.64E-01	8.85E+01	3.78E-01
Lead	SB01	43.80	18.30	0.00	251.44	0.00	242.91	7.54E-02	2.42E+04	1.74E-01
Mercury	SB01	2.14	0.89	0.30	5.04	0.29	4.87	1.83E-01	7.13E+00	4.24E-01
Molybdenum	SB01	48.60	20.31	0.28	2.79	0.27	2.70	7.52E+00	1.74E+02	1.74E+01
Selenium	SB01	0.61	0.26	0.05	1.29	0.05	1.24	2.06E-01	1.15E+01	4.76E-01
Silver	SB01	2.26	0.94	0.00	0.00	0.00	0.00			
Zinc	SB01	2233.14	933.13	10.23	491.61	9.88	474.93	1.96E+00	2.18E+02	4.54E+00
Antimony	SB02	0.17	0.07	0.13	1.34	0.13	1.30	5.55E-02	1.28E+00	1.28E-01

APPENDIX I1
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	High Dose (mg/kg/day)	Low Dose (mg/kg/day)	High Dose Low TRV (mg/kg/day)	High Dose High TRV (mg/kg/day)	Low Dose Low TRV (mg/kg/day)	Low Dose High TRV (mg/kg/day)	HQ_1 (Low Dose/ High TRV)	HQ_2 (High Dose/ Low TRV)	HQ_3 (High Dose/ High TRV)
Arsenic	SB02	10.38	4.34	0.40	5.46	0.38	5.28	8.22E-01	2.61E+01	1.90E+00
Barium	SB02	18.56	7.75	6.44	24.66	6.22	23.83	3.25E-01	2.88E+00	7.52E-01
Beryllium	SB02	2.82E-02	1.18E-02	0.00	0.00	0.00	0.00			
Cadmium	SB02	0.02	0.01	0.06	2.85	0.06	2.75	2.53E-03	2.57E-01	5.86E-03
Chromium	SB02	1.85	0.77	4.09	16.37	3.95	15.81	4.88E-02	4.52E-01	1.13E-01
Copper	SB02	10.73	4.49	2.87	671.02	2.77	648.25	6.92E-03	3.74E+00	1.60E-02
Lead	SB02	0.59	0.25	0.00	251.44	0.00	242.91	1.02E-03	3.28E+02	2.36E-03
Mercury	SB02	0.15	0.06	0.30	5.04	0.29	4.87	1.31E-02	5.09E-01	3.03E-02
Molybdenum	SB02	0.38	0.16	0.28	2.79	0.27	2.70	5.82E-02	1.34E+00	1.34E-01
Selenium	SB02	0.43	0.18	0.05	1.29	0.05	1.24	1.45E-01	8.09E+00	3.34E-01
Silver	SB02	0.03	0.01	0.00	0.00	0.00	0.00			
Zinc	SB02	48.87	20.42	10.23	491.61	9.88	474.93	4.30E-02	4.78E+00	9.94E-02
Antimony	SB03	18.14	7.58	0.13	1.34	0.13	1.30	5.84E+00	1.35E+02	1.35E+01
Arsenic	SB03	254.24	106.24	0.40	5.46	0.38	5.28	2.01E+01	6.40E+02	4.66E+01
Barium	SB03	63.67	26.60	6.44	24.66	6.22	23.83	1.12E+00	9.89E+00	2.58E+00
Beryllium	SB03	3.00E-02	1.25E-02	0.00	0.00	0.00	0.00			
Cadmium	SB03	3.67	1.53	0.06	2.85	0.06	2.75	5.57E-01	5.66E+01	1.29E+00
Chromium	SB03	10.89	4.55	4.09	16.37	3.95	15.81	2.88E-01	2.67E+00	6.65E-01
Copper	SB03	2785.84	1164.08	2.87	671.02	2.77	648.25	1.80E+00	9.71E+02	4.15E+00
Lead	SB03	131.41	54.91	0.00	251.44	0.00	242.91	2.26E-01	7.26E+04	5.23E-01
Mercury	SB03	134.43	56.17	0.30	5.04	0.29	4.87	1.15E+01	4.48E+02	2.67E+01
Molybdenum	SB03	90.69	37.90	0.28	2.79	0.27	2.70	1.40E+01	3.24E+02	3.24E+01
Selenium	SB03	0.44	0.18	0.05	1.29	0.05	1.24	1.47E-01	8.22E+00	3.40E-01
Silver	SB03	0.96	0.40	0.00	0.00	0.00	0.00			
Zinc	SB03	2162.16	903.47	10.23	491.61	9.88	474.93	1.90E+00	2.11E+02	4.40E+00
Antimony	SB04	3.90	1.63	0.13	1.34	0.13	1.30	1.26E+00	2.90E+01	2.90E+00
Arsenic	SB04	109.58	45.79	0.40	5.46	0.38	5.28	8.68E+00	2.76E+02	2.01E+01
Barium	SB04	77.15	32.24	6.44	24.66	6.22	23.83	1.35E+00	1.20E+01	3.13E+00
Beryllium	SB04	5.01E-02	2.09E-02	0.00	0.00	0.00	0.00			
Cadmium	SB04	1.87	0.78	0.06	2.85	0.06	2.75	2.84E-01	2.88E+01	6.56E-01
Chromium	SB04	10.37	4.33	4.09	16.37	3.95	15.81	2.74E-01	2.54E+00	6.33E-01
Copper	SB04	157.88	65.97	2.87	671.02	2.77	648.25	1.02E-01	5.50E+01	2.35E-01
Lead	SB04	86.07	35.96	0.00	251.44	0.00	242.91	1.48E-01	4.75E+04	3.42E-01
Mercury	SB04	10.69	4.47	0.30	5.04	0.29	4.87	9.17E-01	3.56E+01	2.12E+00
Molybdenum	SB04	30.06	12.56	0.28	2.79	0.27	2.70	4.65E+00	1.08E+02	1.08E+01
Selenium	SB04	13.10	5.48	0.05	1.29	0.05	1.24	4.41E+00	2.47E+02	1.02E+01
Silver	SB04	0.40	0.17	0.00	0.00	0.00	0.00			
Zinc	SB04	1146.60	479.12	10.23	491.61	9.88	474.93	1.01E+00	1.12E+02	2.33E+00
Antimony	SB05	0.04	0.02	0.13	1.34	0.13	1.30	1.18E-02	2.73E-01	2.73E-02
Arsenic	SB05	15.40	6.43	0.40	5.46	0.38	5.28	1.22E+00	3.88E+01	2.82E+00
Barium	SB05	20.31	8.49	6.44	24.66	6.22	23.83	3.56E-01	3.16E+00	8.23E-01
Beryllium	SB05	3.91E-02	1.64E-02	0.00	0.00	0.00	0.00			
Cadmium	SB05	0.02	0.01	0.06	2.85	0.06	2.75	3.55E-03	3.60E-01	8.20E-03
Chromium	SB05	1.59	0.67	4.09	16.37	3.95	15.81	4.21E-02	3.90E-01	9.74E-02
Copper	SB05	11.86	4.96	2.87	671.02	2.77	648.25	7.65E-03	4.13E+00	1.77E-02
Lead	SB05	3.44	1.44	0.00	251.44	0.00	242.91	5.92E-03	1.90E+03	1.37E-02
Mercury	SB05	0.18	0.07	0.30	5.04	0.29	4.87	1.53E-02	5.94E-01	3.53E-02
Molybdenum	SB05	1.83	0.76	0.28	2.79	0.27	2.70	2.83E-01	6.54E+00	6.54E-01
Selenium	SB05	1.38	0.58	0.05	1.29	0.05	1.24	4.65E-01	2.60E+01	1.08E+00
Silver	SB05	0.36	0.15	0.00	0.00	0.00	0.00			
Zinc	SB05	68.80	28.75	10.23	491.61	9.88	474.93	6.05E-02	6.73E+00	1.40E-01
Antimony	SB06	0.03	0.01	0.13	1.34	0.13	1.30	1.11E-02	2.57E 01	2.57E-02
Arsenic	SB06	11.10	4.64	0.40	5.46	0.38	5.28	8.79E-01	2.79E+01	2.03E+00

Chemical[a]	Sample Location	High Dose (mg/kg/day)	Low Dose (mg/kg/day)	High Dose Low TRV (mg/kg/day)	High Dose High TRV (mg/kg/day)	Low Dose Low TRV (mg/kg/day)	Low Dose High TRV (mg/kg/day)	HQ_1 (Low Dose/ High TRV)	HQ_2 (High Dose/ Low TRV)	HQ_3 (High Dose/ High TRV)
Barium	SB06	30.21	12.62	6.44	24.66	6.22	23.83	5.30E-01	4.69E+00	1.22E+00
Beryllium	SB06	5.19E-02	2.17E-02	0.00	0.00	0.00	0.00			
Cadmium	SB06	0.02	0.01	0.06	2.85	0.06	2.75	3.04E-03	3.09E-01	7.03E-03
Chromium	SB06	2.30	0.96	4.09	16.37	3.95	15.81	6.08E-02	5.63E-01	1.41E-01
Copper	SB06	8.40	3.51	2.87	671.02	2.77	648.25	5.41E-03	2.93E+00	1.25E-02
Lead	SB06	1.14	0.48	0.00	251.44	0.00	242.91	1.97E-03	6.32E+02	4.55E-03
Mercury	SB06	0.13	0.05	0.30	5.04	0.29	4.87	1.09E-02	4.24E-01	2.52E-02
Molybdenum	SB06	1.60	0.67	0.28	2.79	0.27	2.70	2.48E-01	5.74E+00	5.74E-01
Selenium	SB06	1.27	0.53	0.05	1.29	0.05	1.24	4.26E-01	2.39E+01	9.86E-01
Silver	SB06	0.31	0.13	0.00	0.00	0.00	0.00			
Zinc	SB06	22.99	9.61	10.23	491.61	9.88	474.93	2.02E-02	2.25E+00	4.68E-02
Antimony	SB07	0.04	0.02	0.13	1.34	0.13	1.30	1.21E-02	2.81E-01	2.81E-02
Arsenic	SB07	10.92	4.56	0.40	5.46	0.38	5.28	8.65E-01	2.75E+01	2.00E+00
Barium	SB07	16.73	6.99	6.44	24.66	6.22	23.83	2.93E-01	2.60E+00	6.78E-01
Beryllium	SB07	4.55E-02	1.90E-02	0.00	0.00	0.00	0.00			
Cadmium	SB07	0.02	0.01	0.06	2.85	0.06	2.75	3.55E-03	3.60E-01	8.20E-03
Chromium	SB07	1.85	0.77	4.09	16.37	3.95	15.81	4.88E-02	4.52E-01	1.13E-01
Copper	SB07	12.74	5.32	2.87	671.02	2.77	648.25	8.21E-03	4.44E+00	1.90E-02
Lead	SB07	3.15	1.32	0.00	251.44	0.00	242.91	5.42E-03	1.74E+03	1.25E-02
Mercury	SB07	0.15	0.06	0.30	5.04	0.29	4.87	1.31E-02	5.09E-01	3.03E-02
Molybdenum	SB07	1.75	0.73	0.28	2.79	0.27	2.70	2.71E-01	6.27E+00	6.27E-01
Selenium	SB07	1.40	0.58	0.05	1.29	0.05	1.24		2.63E+01	1.09E+00
Silver	SB07	0.33	0.14	0.00	0.00	0.00	0.00			
Zinc	SB07	65.52	27.38	10.23	491.61	9.88	474.93	5.76E-02	6.40E+00	1.33E-01
Antimony	SB08	0.04	0.02	0.13	1.34	0.13	1.30	1.18E-02	2.73E-01	2.73E-02
Arsenic	SB08	18.26	7.63	0.40	5.46	0.38	5.28	1.45E+00	4.60E+01	3.34E+00
Barium	SB08	25.13	10.50	6.44	24.66	6.22	23.83	4.41E-01	3.91E+00	1.02E+00
Beryllium	SB08	5.28E-02	2.21E-02	0.00	0.00	0.00	0.00			
Cadmium	SB08	0.02	0.01	0.06	2.85	0.06	2.75	3.55E-03	3.60E-01	8.20E-03
Chromium	SB08	2.65	1.11	4.09	16.37	3.95	15.81	7.00E-02	6.48E-01	1.62E-01
Copper	SB08	16.33	6.82	2.87	671.02	2.77	648.25	1.05E-02	5.69E+00	2.43E-02
Lead	SB08	2.21	0.92	0.00	251.44	0.00	242.91	3.80E-03	1.22E+03	8.78E-03
Mercury	SB08	0.15	0.06	0.30	5.04	0.29	4.87	1.31E-02	5.09E-01	3.03E-02
Molybdenum	SB08	4.21	1.76	0.28	2.79	0.27	2.70	6.51E-01	1.51E+01	1.51E+00
Selenium	SB08	0.56	0.23	0.05	1.29	0.05	1.24	1.89E-01	1.06E+01	4.36E-01
Silver	SB08	0.33	0.14	0.00	0.00	0.00	0.00			
Zinc	SB08	54.00	22.56	10.23	491.61	9.88	474.93	4.75E-02	5.28E+00	1.10E-01
Antimony	SB09	1.29	0.54	0.13	1.34	0.13	1.30	4.16E-01	9.62E+00	9.62E-01
Arsenic	SB09	67.68	28.28	0.40	5.46	0.38	5.28	5.36E+00	1.70E+02	1.24E+01
Barium	SB09	32.54	13.60	6.44	24.66	6.22	23.83	5.71E-01	5.06E+00	1.32E+00
Beryllium	SB09	3.73E-02	1.56E-02	0.00	0.00	0.00	0.00			
Cadmium	SB09	2.20	0.92	0.06	2.85	0.06	2.75	3.34E-01	3.40E+01	7.73E-01
Chromium	SB09	3.75	1.57	4.09	16.37	3.95	15.81	9.92E-02	9.19E-01	2.29E-01
Copper	SB09	136.58	57.07	2.87	671.02	2.77	648.25	8.80E-02	4.76E+01	2.04E-01
Lead	SB09	26.69	11.15	0.00	251.44	0.00	242.91	4.59E-02	1.47E+04	1.06E-01
Mercury	SB09	11.20	4.68	0.30	5.04	0.29	4.87	9.61E-01	3.73E+01	2.22E+00
Molybdenum	SB09	10.52	4.40	0.28	2.79	0.27	2.70	1.63E+00	3.76E+01	3.76E+00
Selenium	SB09	7.28	3.04	0.05	1.29	0.05	1.24	2.45E+00	1.37E+02	5.66E+00
Silver	SB09	0.50	0.21	0.00	0.00	0.00	0.00			
Zinc	SB09	2953.86	1234.29	10.23	491.61	9.88	474.93	2.60E+00	2.89E+02	6.01E+00
Antimony	SB10	6.94	2.90	0.13	1.34	0.13	1.30	2.23E+00	5.16E+01	5.16E+00
Arsenic	SB10	60.88	25.44	0.40	5.46	0.38	5.28	4.82E+00	1.53E+02	1.11E+01
Barium	SB10	25.13	10.50	6.44	24.66	6.22	23.83	4.41E-01	3.91E+00	1.02E+00

APPENDIX I1
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	High Dose (mg/kg/day)	Low Dose (mg/kg/day)	High Dose Low TRV (mg/kg/day)	High Dose High TRV (mg/kg/day)	Low Dose Low TRV (mg/kg/day)	Low Dose High TRV (mg/kg/day)	HQ_1 (Low Dose/ High TRV)	HQ_2 (High Dose/ Low TRV)	HQ_3 (High Dose/ High TRV)
Beryllium	SB10	3.73E-02	1.56E-02	0.00	0.00	0.00	0.00			
Cadmium	SB10	8.93	3.73	0.06	2.85	0.06	2.75	1.36E+00	1.38E+02	3.14E+00
Chromium	SB10	8.71	3.64	4.09	16.37	3.95	15.81	2.30E-01	2.13E+00	5.32E-01
Copper	SB10	5220.83	2181.56	2.87	671.02	2.77	648.25	3.37E+00	1.82E+03	7.78E+00
Lead	SB10	32.00	13.37	0.00	251.44	0.00	242.91	5.50E-02	1.77E+04	1.27E-01
Mercury	SB10	3.51	1.47	0.30	5.04	0.29	4.87	3.01E-01	1.17E+01	6.97E-01
Molybdenum	SB10	12.53	5.23	0.28	2.79	0.27	2.70	1.94E+00	4.48E+01	4.48E+00
Selenium	SB10	5.82	2.43	0.05	1.29	0.05	1.24	1.96E+00	1.10E+02	4.53E+00
Silver	SB10	0.36	0.15	0.00	0.00	0.00	0.00			
Zinc	SB10	2708.16	1131.62	10.23	491.61	9.88	474.93	2.38E+00	2.65E+02	5.51E+00
Antimony	SB105	0.10	0.04	0.13	1.34	0.13	1.30	3.19E-02	7.38E-01	7.38E-02
Arsenic	SB105	0.85	0.36	0.40	5.46	0.38	5.28	6.74E-02	2.14E+00	1.56E-01
Barium	SB105	17.06	7.13	6.44	24.66	6.22	23.83	2.99E-01	2.65E+00	6.92E-01
Beryllium	SB105	1.18E-03	4.94E-04	0.00	0.00	0.00	0.00			
Cadmium	SB105	0.03	0.01	0.06	2.85	0.06	2.75	4.00E-03	4.07E-01	9.25E-03
Chromium	SB105	1.29	0.54	4.09	16.37	3.95	15.81	3.41E-02	3.16E-01	7.88E-02
Copper	SB105	15.50	6.47	2.87	671.02	2.77	648.25	9.99E-03	5.40E+00	2.31E-02
Lead	SB105	0.43	0.18	0.00	251.44	0.00	242.91	7.33E-04	2.35E+02	1.69E-03
Mercury	SB105	0.15	0.06	0.30	5.04	0.29	4.87	1.31E-02	5.09E-01	3.03E-02
Molybdenum	SB105	1.00	0.42	0.28	2.79	0.27	2.70	1.55E-01	3.59E+00	3.59E-01
Selenium	SB105	0.87	0.37	0.05	1.29	0.05	1.24	2.94E-01	1.64E+01	6.80E-01
Silver	SB105	0.11	0.05	0.00	0.00	0.00	0.00			
Zinc	SB105	40.57	16.95	10.23	491.61	9.88	474.93	3.57E-02	3.97E+00	8.25E-02
Antimony	SB11	0.04	0.02	0.13	1.34	0.13	1.30	1.32E-02	3.05E-01	3.05E-02
Arsenic	SB11	26.32	11.00	0.40	5.46	0.38	5.28	2.08E+00	6.62E+01	4.82E+00
Barium	SB11	17.48	7.30	6.44	24.66	6.22	23.83	3.06E-01	2.72E+00	7.09E-01
Beryllium	SB11	4.10E-02	1.71E-02	0.00	0.00	0.00	0.00			
Cadmium	SB11	0.03	0.01	0.06	2.85	0.06	2.75	4.05E-03	4.12E-01	9.37E-03
Chromium	SB11	2.59	1.08	4.09	16.37	3.95	15.81	6.84E-02	6.33E-01	1.58E-01
Copper	SB11	20.97	8.76	2.87	671.02	2.77	648.25	1.35E-02	7.31E+00	3.12E-02
Lead	SB11	5.44	2.27	0.00	251.44	0.00	242.91	9.36E-03	3.00E+03	2.16E-02
Mercury	SB11	0.15	0.06	0.30	5.04	0.29	4.87	1.31E-02	5.09E-01	3.03E-02
Molybdenum	SB11	1.88	0.79	0.28	2.79	0.27	2.70	2.91E-01	6.72E+00	6.72E-01
Selenium	SB11	1.46	0.61	0.05	1.29	0.05	1.24	4.90E-01	2.74E+01	1.13E+00
Silver	SB11	0.38	0.16	0.00	0.00	0.00	0.00			
Zinc	SB11	84.08	35.14	10.23	491.61	9.88	474.93	7.40E-02	8.22E+00	1.71E-01
Antimony	SB12	1.08	0.45	0.13	1.34	0.13	1.30	3.47E-01	8.02E+00	8.02E-01
Arsenic	SB12	11.82	4.94	0.40	5.46	0.38	5.28	9.36E-01	2.97E+01	2.16E+00
Barium	SB12	33.62	14.05	6.44	24.66	6.22	23.83	5.90E-01	5.22E+00	1.36E+00
Beryllium	SB12	4.73E-02	1.98E-02	0.00	0.00	0.00	0.00			
Cadmium	SB12	0.02	0.01	0.06	2.85	0.06	2.75	3.55E-03	3.60E-01	8.20E-03
Chromium	SB12	2.40	1.00	4.09	16.37	3.95	15.81	6.35E-02	5.88E-01	1.47E-01
Copper	SB12	29.95	12.51	2.87	671.02	2.77	648.25	1.93E-02	1.04E+01	4.46E-02
Lead	SB12	12.82	5.36	0.00	251.44	0.00	242.91	2.20E-02	7.08E+03	5.10E-02
Mercury	SB12	0.15	0.06	0.30	5.04	0.29	4.87	1.31E-02	5.09E-01	3.03E-02
Molybdenum	SB12	1.83	0.76	0.28	2.79	0.27	2.70	2.83E-01	6.54E+00	6.54E-01
Selenium	SB12	1.60	0.67	0.05	1.29	0.05	1.24	5.39E-01	3.02E+01	1.25E+00
Silver	SB12	0.36	0.15	0.00	0.00	0.00	0.00			
Zinc	SB12	107.02	44.72	10.23	491.61	9.88	474.93	9.42E-02	1.05E+01	2.18E-01
Antimony	SB13	0.54	0.23	0.13	1.34	0.13	1.30	1.73E-01	4.01E+00	4.01E-01
Arsenic	SB13	35.27	14.74	0.40	5.46	0.38	5.28	2.79E+00	8.88E+01	6.46E+00
Barium	SB13	56.59	23.65	6.44	24.66	6.22	23.83	9.92E-01	8.79E+00	2.29E+00
Beryllium	SB13	8.19E-04	3.42E-04	0.00	0.00	0.00	0.00			

Chemical[a]	Sample Location	High Dose (mg/kg/day)	Low Dose (mg/kg/day)	High Dose Low TRV (mg/kg/day)	High Dose High TRV (mg/kg/day)	Low Dose Low TRV (mg/kg/day)	Low Dose High TRV (mg/kg/day)	HQ_1 (Low Dose/ High TRV)	HQ_2 (High Dose/ Low TRV)	HQ_3 (High Dose/ High TRV)
Cadmium	SB13	0.02	0.01	0.06	2.85	0.06	2.75	3.60E-03	3.65E-01	8.32E-03
Chromium	SB13	3.95	1.65	4.09	16.37	3.95	15.81	1.05E-01	9.68E-01	2.42E-01
Copper	SB13	430.20	179.76	2.87	671.02	2.77	648.25	2.77E-01	1.50E+02	6.41E-01
Lead	SB13	10.22	4.27	0.00	251.44	0.00	242.91	1.76E-02	5.64E+03	4.06E-02
Mercury	SB13	1.99	0.83	0.30	5.04	0.29	4.87	1.70E-01	6.62E+00	3.94E-01
Molybdenum	SB13	1508.14	630.19	0.28	2.79	0.27	2.70	2.33E+02	5.40E+03	5.40E+02
Selenium	SB13	3.49	1.46	0.05	1.29	0.05	1.24	1.18E+00	6.58E+01	2.72E+00
Silver	SB13	1.04	0.44	0.00	0.00	0.00	0.00			
Zinc	SB13	497.95	208.07	10.23	491.61	9.88	474.93	4.38E-01	4.87E+01	1.01E+00
Antimony	SB14	1.38	0.58	0.13	1.34	0.13	1.30	4.44E-01	1.03E+01	1.03E+00
Arsenic	SB14	109.93	45.94	0.40	5.46	0.38	5.28	8.71E+00	2.77E+02	2.01E+01
Barium	SB14	94.87	39.64	6.44	24.66	6.22	23.83	1.66E+00	1.47E+01	3.85E+00
Beryllium	SB14	8.19E-04	3.42E-04	0.00	0.00	0.00	0.00			
Cadmium	SB14	0.02	0.01	0.06	2.85	0.06	2.75	3.55E-03	3.60E-01	8.20E-03
Chromium	SB14	6.79	2.84	4.09	16.37	3.95	15.81	1.80E-01	1.66E+00	4.15E-01
Copper	SB14	112.77	47.12	2.87	671.02	2.77	648.25	7.27E-02	3.93E+01	1.68E-01
Lead	SB14	56.12	23.45	0.00	251.44	0.00	242.91	9.65E-02	3.10E+04	2.23E-01
Mercury	SB14	0.41	0.17	0.30	5.04	0.29	4.87	3.49E-02	1.36E+00	8.08E-02
Molybdenum	SB14	25.05	10.47	0.28	2.79	0.27	2.70	3.88E+00	8.96E+01	8.96E+00
Selenium	SB14	11.36	4.75	0.05	1.29	0.05	1.24	3.82E+00	2.14E+02	8.84E+00
Silver	SB14	1.09	0.45	0.00	0.00	0.00	0.00			
Zinc	SB14	906.36	378.73	10.23	491.61	9.88	474.93	7.97E-01	8.86E+01	1.84E+00
Antimony	SB15	5.67	2.37	0.13	1.34	0.13	1.30	1.82E+00	4.22E+01	4.22E+00
Arsenic	SB15	103.31	43.17	0.40	5.46	0.38	5.28	8.18E+00	2.60E+02	1.89E+01
Barium	SB15	56.84	23.75	6.44	24.66	6.22	23.83	9.97E-01	8.83E+00	2.30E+00
Beryllium	SB15	1.46E-03	6.08E-04	0.00	0.00	0.00	0.00			
Cadmium	SB15	0.04	0.02	0.06	2.85	0.06	2.75	6.59E-03	6.69E-01	1.52E-02
Chromium	SB15	260.46	108.84	4.09	16.37	3.95	15.81	6.88E+00	6.38E+01	1.59E+01
Copper	SB15	303.23	126.71	2.87	671.02	2.77	648.25	1.95E-01	1.06E+02	4.52E-01
Lead	SB15	17.45	7.29	0.00	251.44	0.00	242.91	3.00E-02	9.64E+03	6.94E-02
Mercury	SB15	0.79	0.33	0.30	5.04	0.29	4.87	6.77E-02	2.63E+00	1.57E-01
Molybdenum	SB15	38.58	16.12	0.28	2.79	0.27	2.70	5.97E+00	1.38E+02	1.38E+01
Selenium	SB15	9.90	4.14	0.05	1.29	0.05	1.24	3.33E+00	1.86E+02	7.70E+00
Silver	SB15	1.17	0.49	0.00	0.00	0.00	0.00			
Zinc	SB15	840.84	351.35	10.23	491.61	9.88	474.93	7.40E-01	8.22E+01	1.71E+00
Antimony	SB16	0.31	0.13	0.13	1.34	0.13	1.30	1.01E-01	2.32E+00	2.32E-01
Arsenic	SB16	17.01	7.11	0.40	5.46	0.38	5.28	1.35E+00	4.28E+01	3.11E+00
Barium	SB16	10.24	4.28	6.44	24.66	6.22	23.83	1.80E-01	1.59E+00	4.15E-01
Beryllium	SB16	4.50E-03	1.88E-03	0.00	0.00	0.00	0.00			
Cadmium	SB16	0.13	0.06	0.06	2.85	0.06	2.75	2.03E-02	2.06E+00	4.68E-02
Chromium	SB16	0.08	0.03	4.09	16.37	3.95	15.81	2.05E-03	1.90E-02	4.74E-03
Copper	SB16	0.46	0.19	2.87	671.02	2.77	648.25	2.96E-04	1.60E-01	6.85E-04
Lead	SB16	0.03	0.01	0.00	251.44	0.00	242.91	5.00E-05	1.61E+01	1.16E-04
Mercury	SB16	2.52	1.05	0.30	5.04	0.29	4.87	2.16E-01	8.40E+00	5.00E-01
Molybdenum	SB16	6.01	2.51	0.28	2.79	0.27	2.70	9.31E-01	2.15E+01	2.15E+00
Selenium	SB16	2.91	1.22	0.05	1.29	0.05	1.24	9.80E-01	5.48E+01	2.27E+00
Silver	SB16	0.23	0.10	0.00	0.00	0.00	0.00			
Zinc	SB16	1.75	0.73	10.23	491.61	9.88	474.93	1.54E-03	1.71E-01	3.55E-03
Antimony	SB17	0.08	0.04	0.13	1.34	0.13	1.30	2.70E-02	6.25E-01	6.25E 02
Arsenic	SB17	0.61	0.25	0.40	5.46	0.38	5.28	4.82E-02	1.53E+00	1.11E-01
Barium	SB17	0.47	0.19	6.44	24.66	6.22	23.83	8.17E-03	7.24E-02	1.89E-02
Beryllium	SB17	6.37E-04	2.66E-04	0.00	0.00	0.00	0.00			
Cadmium	SB17	0.02	0.01	0.06	2.85	0.06	2.75	2.74E-03	2.78E 01	6.32E-03

APPENDIX I1
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	High Dose (mg/kg/day)	Low Dose (mg/kg/day)	High Dose Low TRV (mg/kg/day)	High Dose High TRV (mg/kg/day)	Low Dose Low TRV (mg/kg/day)	Low Dose High TRV (mg/kg/day)	HQ_1 (Low Dose/ High TRV)	HQ_2 (High Dose/ Low TRV)	HQ_3 (High Dose/ High TRV)
Chromium	SB17	15.16	6.33	4.09	16.37	3.95	15.81	4.01E-01	3.71E+00	9.26E-01
Copper	SB17	215.10	89.88	2.87	671.02	2.77	648.25	1.39E-01	7.49E+01	3.21E-01
Lead	SB17	34.74	14.51	0.00	251.44	0.00	242.91	5.98E-02	1.92E+04	1.38E-01
Mercury	SB17	0.36	0.15	0.30	5.04	0.29	4.87	3.06E-02	1.19E+00	7.07E-02
Molybdenum	SB17	34.57	14.45	0.28	2.79	0.27	2.70	5.35E+00	1.24E+02	1.24E+01
Selenium	SB17	17.47	7.30	0.05	1.29	0.05	1.24	5.88E+00	3.29E+02	1.36E+01
Silver	SB17	0.03	0.01	0.00	0.00	0.00	0.00			
Zinc	SB17	1124.76	469.99	10.23	491.61	9.88	474.93	9.90E-01	1.10E+02	2.29E+00
Antimony	SB18	1.25	0.52	0.13	1.34	0.13	1.30	4.02E-01	9.30E+00	9.30E-01
Arsenic	SB18	189.79	79.30	0.40	5.46	0.38	5.28	1.50E+01	4.78E+02	3.47E+01
Barium	SB18	16.15	6.75	6.44	24.66	6.22	23.83	2.83E-01	2.51E+00	6.55E-01
Beryllium	SB18	1.05E-03	4.37E-04	0.00	0.00	0.00	0.00			
Cadmium	SB18	0.03	0.01	0.06	2.85	0.06	2.75	4.66E-03	4.73E 01	1.08E-02
Chromium	SB18	4.17	1.74	4.09	16.37	3.95	15.81	1.10E-01	1.02E+00	2.55E-01
Copper	SB18	697.50	291.46	2.87	671.02	2.77	648.25	4.50E-01	2.43E+02	1.04E+00
Lead	SB18	21.73	9.08	0.00	251.44	0.00	242.91	3.74E-02	1.20E+04	8.64E 02
Mercury	SB18	0.56	0.23	0.30	5.04	0.29	4.87	4.80E-02	1.87E+00	1.11E-01
Molybdenum	SB18	33.07	13.82	0.28	2.79	0.27	2.70	5.12E+00	1.18E+02	1.18E+01
Selenium	SB18	11.07	4.62	0.05	1.29	0.05	1.24	3.72E+00	2.08E+02	8.61E+00
Silver	SB18	0.05	0.02	0.00	0.00	0.00	0.00			
Zinc	SB18	616.98	257.81	10.23	491.61	9.88	474.93	5.43E-01	6.03E+01	1.26E+00
Antimony	SB19	0.82	0.34	0.13	1.34	0.13	1.30	2.64E-01	6.09E+00	6.09E 01
Arsenic	SB19	94.36	39.43	0.40	5.46	0.38	5.28	7.47E+00	2.37E+02	1.73E+01
Barium	SB19	15.31	6.40	6.44	24.66	6 22	23.83	2.69E-01	2.38E+00	6.21E-01
Beryllium	SB19	7.28E-04	3.04E-04	0.00	0.00	0.00	0.00			
Cadmium	SB19	0.02	0.01	0.06	2.85	0.06	2.75	3.29E-03	3.34E-01	7.61E-03
Chromium	SB19	7.40	3.09	4.09	16.37	3.95	15.81	1.96E-01	1.81E+00	4.52E-01
Copper	SB19	180.43	75.39	2.87	671.02	2.77	648.25	1.16E-01	6.29E+01	2.69E-01
Lead	SB19	28.06	11.73	0.00	251.44	0.00	242.91	4.83E-02	1.55E+04	1.12E-01
Mercury	SB19	0.43	0.18	0.30	5.04	0.29	4.87	3.71E-02	1.44E+00	8.58E-02
Molybdenum	SB19	30.06	12.56	0.28	2.79	0.27	2.70	4.65E+00	1.08E+02	1.08E+01
Selenium	SB19	16.74	7.00	0.05	1.29	0.05	1.24	5.63E+00	3.15E+02	1.30E+01
Silver	SB19	0.04	0.02	0.00	0.00	0.00	0.00			
Zinc	SB19	402.40	168.15	10.23	491.61	9.88	474.93	3.54E-01	3.93E+01	8.19E-01
Antimony	SB20	0.58	0.24	0.13	1.34	0.13	1.30	1.87E-01	4.33E+00	4.33E-01
Arsenic	SB20	41.00	17.13	0.40	5.46	0.38	5.28	3.25E+00	1.03E+02	7.51E+00
Barium	SB20	27.96	11.68	6.44	24.66	6.22	23.83	4.90E-01	4.34E+00	1.13E+00
Beryllium	SB20	6.83E-04	2.85E-04	0.00	0.00	0.00	0.00			
Cadmium	SB20	0.02	0.01	0.06	2.85	0.06	2.75	3.04E-03	3.09E-01	7.03E-03
Chromium	SB20	6.50	2.72	4.09	16.37	3.95	15.81	1.72E-01	1.59E+00	3.97E-01
Copper	SB20	826.98	345.56	2.87	671.02	2.77	648.25	5.33E-01	2.88E+02	1.23E+00
Lead	SB20	20.19	8.44	0.00	251.44	0.00	242.91	3.47E-02	1.11E+04	8.03E-02
Mercury	SB20	3.26	1.36	0.30	5.04	0.29	4.87	2.80E-01	1.09E+01	6.46E-01
Molybdenum	SB20	14.53	6.07	0.28	2.79	0.27	2.70	2.25E+00	5.20E+01	5.20E+00
Selenium	SB20	6.12	2.56	0.05	1.29	0.05	1.24	2.06E+00	1.15E+02	4.76E+00
Silver	SB20	0.04	0.01	0.00	0.00	0.00	0.00			
Zinc	SB20	982.80	410.67	10.23	491.61	9.88	474.93	8.65E-01	9.61E+01	2.00E+00
Antimony	SS206	0.26	0.11	0.13	1.34	0.13	1.30	8.32E-02	1.92E+00	1.92E-01
Arsenic	SS206	13.79	5.76	0.40	5.46	0.38	5.28	1.09E+00	3.47E+01	2.52E+00
Barium	SS206	17.89	7.48	6.44	24.66	6.22	23.83	3.14E-01	2.78E+00	7.25E-01
Beryllium	SS206	3.00E-04	1.25E-04	0.00	0.00	0.00	0.00			
Cadmium	SS206	1.07	0.45	0.06	2.85	0.06	2.75	1.62E-01	1.65E+01	3.75E-01
Chromium	SS206	2.52	1.05	4.09	16.37	3.95	15.81	6.65E-02	6.16E-01	1.54E-01

APPENDIX I1
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	High Dose (mg/kg/day)	Low Dose (mg/kg/day)	High Dose Low TRV (mg/kg/day)	High Dose High TRV (mg/kg/day)	Low Dose Low TRV (mg/kg/day)	Low Dose High TRV (mg/kg/day)	HQ_1 (Low Dose/ High TRV)	HQ_2 (High Dose/ Low TRV)	HQ_3 (High Dose/ High TRV)
Copper	SS206	235.98	98.61	2.87	671.02	2.77	648.25	1.52E-01	8.22E+01	3.52E-01
Lead	SS206	8.32	3.47	0.00	251.44	0.00	242.91	1.43E-02	4.59E+03	3.31E-02
Mercury	SS206	0.13	0.05	0.30	5.04	0.29	4.87	1.09E-02	4.24E-01	2.52E-02
Molybdenum	SS206	3.36	1.40	0.28	2.79	0.27	2.70	5.20E-01	1.20E+01	1.20E+00
Selenium	SS206	0.15	0.06	0.05	1.29	0.05	1.24	4.90E-02	2.74E+00	1.13E-01
Silver	SS206	2.80	1.17	0.00	0.00	0.00	0.00			
Zinc	SS206	536.72	224.27	10.23	491.61	9.88	474.93	4.72E-01	5.25E+01	1.09E+00
Antimony	SS210			0.13	1.34	0.13	1.30			
Arsenic	SS210	8.42	3.52	0.40	5.46	0.38	5.28	6.66E-01	2.12E+01	1.54E+00
Barium	SS210	9.15	3.83	6.44	24.66	6.22	23.83	1.61E-01	1.42E+00	3.71E-01
Beryllium	SS210	2.73E-04	1.14E-04	0.00	0.00	0.00	0.00			
Cadmium	SS210	0.25	0.11	0.06	2.85	0.06	2.75	3.85E-02	3.91E+00	8.90E-02
Chromium	SS210	2.03	0.85	4.09	16.37	3.95	15.81	5.36E-02	4.97E-01	1.24E-01
Copper	SS210	5.55	2.32	2.87	671.02	2.77	648.25	3.58E-03	1.94E+00	8.28E-03
Lead	SS210	0.51	0.21	0.00	251.44	0.00	242.91	8.77E-04	2.82E+02	2.03E-03
Mercury	SS210	0.13	0.05	0.30	5.04	0.29	4.87	1.09E-02	4.24E-01	2.52E-02
Molybdenum	SS210	0.45	0.19	0.28	2.79	0.27	2.70	6.98E-02	1.61E+00	1.61E-01
Selenium	SS210	0.31	0.13	0.05	1.29	0.05	1.24	1.03E-01	5.76E+00	2.38E-01
Silver	SS210	0.02	0.01	0.00	0.00	0.00	0.00			
Zinc	SS210	38.44	16.06	10.23	491.61	9.88	474.93	3.38E-02	3.76E+00	7.82E-02
Antimony	SS211			0.13	1.34	0.13	1.30			
Arsenic	SS211	5.55	2.32	0.40	5.46	0.38	5.28	4.40E-01	1.40E+01	1.02E+00
Barium	SS211	10.40	4.35	6.44	24.66	6.22	23.83	1.82E-01	1.62E+00	4.22E-01
Beryllium	SS211	2.73E-04	1.14E-04	0.00	0.00	0.00	0.00			
Cadmium	SS211	0.01	0.00	0.06	2.85	0.06	2.75	8.61E-04	8.75E-02	1.99E-03
Chromium	SS211	1.43	0.60	4.09	16.37	3.95	15.81	3.78E-02	3.50E-01	8.73E-02
Copper	SS211	3.84	1.61	2.87	671.02	2.77	648.25	2.48E-03	1.34E+00	5.73E-03
Lead	SS211	0.76	0.32	0.00	251.44	0.00	242.91	1.31E-03	4.20E+02	3.03E-03
Mercury	SS211	0.10	0.04	0.30	5.04	0.29	4.87	8.73E-03	3.40E-01	2.02E-02
Molybdenum	SS211	0.45	0.19	0.28	2.79	0.27	2.70	6.98E-02	1.61E+00	1.61E-01
Selenium	SS211	0.13	0.05	0.05	1.29	0.05	1.24	4.41E-02	2.47E+00	1.02E-01
Silver	SS211	0.02	0.01	0.00	0.00	0.00	0.00			
Zinc	SS211	25.39	10.61	10.23	491.61	9.88	474.93	2.23E-02	2.48E+00	5.16E-02
Antimony	SS212	0.13	0.05	0.13	1.34	0.13	1.30	4.16E-02	9.62E-01	9.62E-02
Arsenic	SS212	5.55	2.32	0.40	5.46	0.38	5.28	4.40E-01	1.40E+01	1.02E+00
Barium	SS212	7.59	3.17	6.44	24.66	6.22	23.83	1.33E-01	1.18E+00	3.08E-01
Beryllium	SS212	9.10E-04	3.80E-04	0.00	0.00	0.00	0.00			
Cadmium	SS212	0.24	0.10	0.06	2.85	0.06	2.75	3.65E-02	3.70E+00	8.43E-02
Chromium	SS212	2.72	1.14	4.09	16.37	3.95	15.81	7.18E-02	6.65E-01	1.66E-01
Copper	SS212	8.19	3.42	2.87	671.02	2.77	648.25	5.28E-03	2.85E+00	1.22E-02
Lead	SS212	0.96	0.40	0.00	251.44	0.00	242.91	1.66E-03	5.32E+02	3.83E-03
Mercury	SS212	0.13	0.05	0.30	5.04	0.29	4.87	1.09E-02	4.24E-01	2.52E-02
Molybdenum	SS212	0.40	0.17	0.28	2.79	0.27	2.70	6.20E-02	1.43E+00	1.43E-01
Selenium	SS212	0.12	0.05	0.05	1.29	0.05	1.24	4.16E-02	2.33E+00	9.63E-02
Silver	SS212	0.01	0.01	0.00	0.00	0.00	0.00			
Zinc	SS212	56.78	23.73	10.23	491.61	9.88	474.93	5.00E-02	5.55E+00	1.16E-01
Antimony	SS213			0.13	1.34	0.13	1.30			
Arsenic	SS213	13.25	5.54	0.40	5.46	0.38	5.28	1.05E+00	3.33E+01	2.43E+00
Barium	SS213	9.82	4.10	6.44	24.66	6.22	23.83	1.72E-01	1.53E+00	3.98E-01
Beryllium	SS213	2.28E-04	9.51E-05	0.00	0.00	0.00	0.00			
Cadmium	SS213	0.46	0.19	0.06	2.85	0.06	2.75	6.99E-02	7.10E+00	1.62E-01
Chromium	SS213	2.10	0.88	4.09	16.37	3.95	15.81	5.55E-02	5.14E-01	1.28E-01
Copper	SS213	23.85	9.97	2.87	671.02	2.77	648.25	1.54E-02	8.31E+00	3.55E-02

APPENDIX I1

SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	High Dose (mg/kg/day)	Low Dose (mg/kg/day)	High Dose Low TRV (mg/kg/day)	High Dose High TRV (mg/kg/day)	Low Dose Low TRV (mg/kg/day)	Low Dose High TRV (mg/kg/day)	HQ_1 (Low Dose/ High TRV)	HQ_2 (High Dose/ Low TRV)	HQ_3 (High Dose/ High TRV)
Lead	SS213	1.88	0.79	0.00	251.44	0.00	242.91	3.24E-03	1.04E+03	7.49E-03
Mercury	SS213	1.27	0.53	0.30	5.04	0.29	4.87	1.09E-01	4.24E+00	2.52E-01
Molybdenum	SS213	0.40	0.17	0.28	2.79	0.27	2.70	6.20E-02	1.43E+00	1.43E-01
Selenium	SS213	0.12	0.05	0.05	1.29	0.05	1.24	4.16E-02	2.33E+00	9.63E-02
Silver	SS213	0.01	0.01	0.00	0.00	0.00	0.00			
Zinc	SS213	184.00	76.89	10.23	491.61	9.88	474.93	1.62E-01	1.80E+01	3.74E-01
Antimony	SS214	0.09	0.04	0.13	1.34	0.13	1.30	3.05E-02	7.06E-01	7.06E-02
Arsenic	SS214	14.50	6.06	0.40	5.46	0.38	5.28	1.15E+00	3.65E+01	2.66E+00
Barium	SS214	7.34	3.07	6.44	24.66	6.22	23.83	1.29E-01	1.14E+00	2.98E-01
Beryllium	SS214	2.28E-04	9.51E-05	0.00	0.00	0.00	0.00			
Cadmium	SS214	0.25	0.11	0.06	2.85	0.06	2.75	3.85E-02	3.91E+00	8.90E-02
Chromium	SS214	2.09	0.87	4.09	16.37	3.95	15.81	5.52E-02	5.12E-01	1.28E-01
Copper	SS214	7.31	3.05	2.87	671.02	2.77	648.25		2.55E+00	1.09E-02
Lead	SS214	3.34	1.39	0.00	251.44	0.00	242.91	5.74E-03	1.84E+03	1.33E-02
Mercury	SS214	0.14	0.06	0.30	5.04	0.29	4.87	1.20E-02	4.67E-01	2.78E-02
Molybdenum	SS214	0.50	0.21	0.28	2.79	0.27	2.70	7.75E-02	1.79E+00	1.79E-01
Selenium	SS214	0.25	0.10	0.05	1.29	0.05	1.24	8.33E-02	4.66E+00	1.93E-01
Silver	SS214	0.01	0.01	0.00	0.00	0.00	0.00			
Zinc	SS214	43.13	18.02	10.23	491.61	9.88	474.93	3.80E-02	4.22E+00	8.77E-02
Antimony	UCL 95	0.33	0.14	0.13	1.34	0.13	1.30	1.07E-01	2.46E+00	2.46E-01
Arsenic	UCL 95	14.08	5.88	0.40	5.46	0.38	5.28	1.11E+00	3.54E+01	2.58E+00
Barium	UCL 95	22.10	9.23	6.44	24.66	6.22	23.83	3.88E-01	3.43E+00	8.96E-01
Beryllium	UCL 95	2.03E-02	8.49E-03	0.00	0.00	0.00	0.00			
Cadmium	UCL 95	1.28	0.54	0.06	2.85	0.06	2.75	1.95E-01	1.98E+01	4.50E-01
Chromium	UCL 95	5.64	2.36	4.09	16.37	3.95	15.81	1.49E-01	1.38E+00	3.45E-01
Copper	UCL 95	33.29	13.91	2.87	671.02	2.77	648.25	2.15E-02	1.16E+01	4.96E-02
Lead	UCL 95	17.24	7.21	0.00	251.44	0.00	242.91	2.97E-02	9.52E+03	6.86E-02
Mercury	UCL 95	0.06	0.03	0.30	5.04	0.29	4.87	5.17E-03	2.01E-01	1.19E-02
Molybdenum	UCL 95	3.31	1.38	0.28	2.79	0.27	2.70	5.13E-01	1.19E+01	1.19E+00
Selenium	UCL 95	1.77	0.74	0.05	1.29	0.05	1.24	5.96E-01	3.33E+01	1.38E+00
Silver	UCL 95	0.14	0.06	0.00	0.00	0.00	0.00			
Zinc	UCL 95	207.49	86.70	10.23	491.61	9.88	474.93	1.83E-01	2.03E+01	4.22E-01

na Not available
HQ Hazard quotient
mg/kg/day Milligrams per kilogram per day
TRV Toxicity reference value
UCL Upper confidence limit

APPENDIX I2

SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical*	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Antimony	309CSPWSS	High	0.54	0.004	0.00	0.0001	6.72	0.00	1.00	0.009	0.27	0.17	1.69		X	
Arsenic	309CSPWSS	High	31.53	0.004	0.1104	0.0001	57	0.005	1.00	0.009	12.79	0.79	8.79			X
Barium	309CSPWSS	High	39.64	0.004	0.1387	0.0001	646	0.054	1.00	0.009	21.44	13.45	49.44		X	
Beryllium	309CSPWSS	High	0.05	0.004	0.0002	0.0001	0.21	0.000	1.00	0.009	0.02	0.00	0.00			
Cadmium	309CSPWSS	High	3.24	0.004	0.0114	0.0001	7.8	0.001	1.00	0.009	1.35	0.08	3.51		X	
Chromium	309CSPWSS	High	7.12	0.004	0.0249	0.0001	73.4	0.006	1.00	0.009	3.45	8.19	32.81	X		
Copper	309CSPWSS	High	45.05	0.004	0.158	0.0001	311	0.03	1.00	0.009	20.42	3.61	812.91		X	
Lead	309CSPWSS	High	3.78	0.004	0.0132	0.0001	2300	0.19	1.00	0.009	22.94	0.003	288.93		X	
Mercury	309CSPWSS	High	0.09	0.004	0.00032	0.0001	0.18	0.00002	1.00	0.009	0.04	0.30	5.04	X		
Molybdenum	309CSPWSS	High	7.84	0.004	0.0274	0.0001	5.13	0.000	1.00	0.009	3.10	0.35	3.51		X	
Selenium	309CSPWSS	High	4.46	0.004	0.016	0.0001	1.2	0.0001	1.00	0.009	1.75	0.06	1.56			X
Silver	309CSPWSS	High	0.33	0.004	0.0012	0.0001	1.08	0.000	1.00	0.009	0.14	0.00	0.00			
Zinc	309CSPWSS	High	493.69	0.004	1.73	0.0001	2270	0.19	1.00	0.009	243.18	12.47	863.96		X	
Antimony	309CSPWSS	Low	0.54	0.003	0.00	0.0003	6.72	0.00	1.00	0.016	0.11	0.15	1.46	X		
Arsenic	309CSPWSS	Low	31.53	0.003	0.0820	0.0001	57	0.004	1.00	0.016	5.35	0.68	7.61		X	
Barium	309CSPWSS	Low	39.64	0.003	0.1031	0.0001	646	0.040	1.00	0.016	8.96	11.65	42.82	X		
Beryllium	309CSPWSS	Low	0.05	0.003	0.0001	0.0003	0.21	0.000	1.00	0.016	0.01	0.00	0.00			
Cadmium	309CSPWSS	Low	3.24	0.003	0.0084	0.0001	7.8	0.000	1.00	0.016	0.56	0.07	3.12		X	
Chromium	309CSPWSS	Low	7.12	0.003	0.0185	0.0001	73.4	0.005	1.00	0.016	1.44	7.09	28.42	X		
Copper	309CSPWSS	Low	45.05	0.003	0.117	0.0001	311	0.02	1.00	0.016	8.53	3.12	704.00		X	
Lead	309CSPWSS	Low	3.78	0.003	0.0098	0.0001	2300	0.14	1.00	0.016	9.58	0.003	250.22		X	
Mercury	309CSPWSS	Low	0.09	0.003	0.00023	0.0001	0.18	0.00001	1.00	0.016	0.02	0.29	4.87	X		
Molybdenum	309CSPWSS	Low	7.84	0.003	0.0204	0.0001	5.13	0.000	1.00	0.016	1.29	0.30	3.04		X	
Selenium	309CSPWSS	Low	4.46	0.003	0.012	0.0001	1.2	0.0001	1.00	0.016	0.73	0.06	1.35		X	
Silver	309CSPWSS	Low	0.33	0.003	0.0009	0.0001	1.08	0.000	1.00	0.016	0.06	0.00	0.00			
Zinc	309CSPWSS	Low	493.69	0.003	1.28	0.0001	2270	0.14	1.00	0.016	89.08	10.80	748.21		X	
Antimony	309SB05	High	0.14	0.004	0.00	0.0001	1.12	0.00	1.00	0.009	0.07	0.17	1.69	X		
Arsenic	309SB05	High	0.43	0.004	0.0015	0.0001	10.4	0.001	1.00	0.009	0.26	0.79	8.79	X		
Barium	309SB05	High	13.47	0.004	0.0471	0.0001	268	0.023	1.00	0.009	7.74	13.45	49.44	X		
Beryllium	309SB05	High	0.01	0.004	0.0001	0.0001	0.48	0.000	1.00	0.009	0.01	0.00	0.00			
Cadmium	309SB05	High	0.09	0.004	0.0003	0.0001	1.55	0.000	1.00	0.009	0.05	0.08	3.61	X		
Chromium	309SB05	High	2.72	0.004	0.0095	0.0001	32.5	0.002	1.00	0.009	1.36	8.19	32.81	X		
Copper	309SB05	High	13.04	0.004	0.046	0.0001	49	0.00	1.00	0.009	5.53	3.61	812.91		X	
Lead	309SB05	High	2.72	0.004	0.0095	0.0001	162	0.01	1.00	0.009	2.57	0.003	288.93		X	
Mercury	309SB05	High	0.03	0.004	0.00010	0.0001	0.26	0.00002	1.00	0.009	0.01	0.30	5.04	X		
Molybdenum	309SB05	High	2.15	0.004	0.0075	0.0001	0.47	0.000	1.00	0.009	0.84	0.35	3.51		X	
Selenium	309SB05	High	0.07	0.004	0.000	0.0001	0.15	0.0000	1.00	0.009	0.03	0.06	1.56	X		
Silver	309SB05	High	0.08	0.004	0.0003	0.0001	0.563	0.000	1.00	0.009	0.04	0.00	0.00			
Zinc	309SB05	High	40.69	0.004	0.14	0.0001	284	0.02	1.00	0.009	18.47	12.47	863.96		X	
Antimony	309SB05	Low	0.14	0.003	0.00	0.0001	1.12	0.00	1.00	0.016	0.03	0.15	1.46	X		
Arsenic	309SB05	Low	0.43	0.003	0.0011	0.0001	10.4	0.001	1.00	0.016	0.11	0.68	7.61	X		
Barium	309SB05	Low	13.47	0.003	0.0250	0.0001	268	0.017	1.00	0.016	3.23	11.65	42.82	X		
Beryllium	309SB05	Low	0.01	0.003	0.0000	0.0001	0.48	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	309SB05	Low	0.09	0.003	0.0002	0.0001	1.55	0.000	1.00	0.016	0.02	0.07	3.12	X		
Chromium	309SB05	Low	2.72	0.003	0.0071	0.0001	32.5	0.002	1.00	0.016	0.57	7.09	28.42	X		
Copper	309SB05	Low	13.04	0.003	0.034	0.0001	49	0.00	1.00	0.016	2.31	3.12	704.00	X		
Lead	309SB05	Low	2.72	0.003	0.0071	0.0001	162	0.01	1.00	0.016	1.07	0.003	250.22		X	
Mercury	309SB05	Low	0.03	0.003	0.00007	0.0001	0.26	0.00002	1.00	0.016	0.01	0.29	4.87	X		
Molybdenum	309SB05	Low	2.15	0.003	0.0056	0.0001	0.47	0.000	1.00	0.016	0.35	0.30	3.04		X	
Selenium	309SB05	Low	0.07	0.003	0.000	0.0001	0.15	0.0000	1.00	0.016	0.01	0.06	1.35	X		

DS.0309.15131

APPENDIX I2
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Silver	309SB05	Low	0.08	0.003	0.0002	0.0001	0.563	0.000	1.00	0.016	0.02	0.00	0.00			
Zinc	309SB05	Low	40.69	0.003	0.12	0.0001	284	0.02	1.00	0.016	7.72	10.80	748.21	X		
Antimony	309SB106	High	0.20	0.004	0.00	0.0001	0.37	0.00	1.00	0.009	0.08	0.17	1.69	X		
Arsenic	309SB106	High	35.29	0.004	0.1235	0.0001	7.7	0.001	1.00	0.009	13.80	0.79	8.79			X
Barium	309SB106	High	33.33	0.004	0.1167	0.0001	175	0.015	1.00	0.009	14.60	13.45	49.44		X	
Beryllium	309SB106	High	0.03	0.004	0.0001	0.0001	0.4	0.000	1.00	0.009	0.02	0.00	0.00			
Cadmium	309SB106	High	0.52	0.004	0.0018	0.0001	0.31	0.000	1.00	0.009	0.21	0.08	3.61		X	
Chromium	309SB106	High	5.88	0.004	0.0206	0.0001	29.4	0.002	1.00	0.009	2.56	8.19	32.81	X		
Copper	309SB106	High	22.88	0.004	0.080	0.0001	21.7	0.00	1.00	0.009	9.10	3.61	812.91		X	
Lead	309SB106	High	1.90	0.004	0.0066	0.0001	268	0.02	1.00	0.009	3.24	0.003	288.93		X	
Mercury	309SB106	High	0.07	0.004	0.00023	0.0001	0.005	0.00000	1.00	0.009	0.03	0.30	5.04	X		
Molybdenum	309SB106	High	3.99	0.004	0.0140	0.0001	0.31	0.000	1.00	0.009	1.55	0.35	3.51		X	
Selenium	309SB106	High	0.32	0.004	0.001	0.0001	0.1	0.0000	1.00	0.009	0.13	0.06	1.56		X	
Silver	309SB106	High	0.14	0.004	0.0005	0.0001	0.131	0.000	1.00	0.009	0.05	0.00	0.00			
Zinc	309SB106	High	98.04	0.004	0.34	0.0001	71.2	0.01	1.00	0.009	38.79	12.47	863.96		X	
Antimony	309SB106	Low	0.20	0.003	0.00	0.0001	0.37	0.00	1.00	0.016	0.03	0.15	1.46	X		
Arsenic	309SB106	Low	35.29	0.003	0.0918	0.0001	7.7	0.000	1.00	0.016	5.77	0.68	7.61		X	
Barium	309SB106	Low	33.33	0.003	0.0867	0.0001	175	0.011	1.00	0.016	6.10	0.00	0.00			X
Beryllium	309SB106	Low	0.03	0.003	0.0001	0.0001	0.4	0.000	1.00	0.016	0.01	7.09	28.42			
Cadmium	309SB106	Low	0.52	0.003	0.0014	0.0001	0.31	0.000	1.00	0.016	0.09	0.00	250.22		X	
Chromium	309SB106	Low	5.88	0.003	0.0153	0.0001	29.4	0.002	1.00	0.016	1.07	0.30	3.94		X	
Copper	309SB106	Low	22.88	0.003	0.059	0.0001	21.7	0.00	1.00	0.016	3.80	0.00	0.00			X
Lead	309SB106	Low	1.90	0.003	0.0049	0.0001	268	0.02	1.00	0.016	1.35	0.003	273.42		X	
Mercury	309SB106	Low	0.07	0.003	0.00017	0.0001	0.005	0.00000	1.00	0.016	0.01	0.29	4.87	X		
Molybdenum	309SB106	Low	3.99	0.003	0.0104	0.0001	0.31	0.000	1.00	0.016	0.65	0.35	3.51		X	
Selenium	309SB106	Low	0.32	0.003	0.001	0.0001	0.1	0.0000	1.00	0.016	0.05	0.10	1.47	X		
Silver	309SB106	Low	0.14	0.003	0.0004	0.0001	0.131	0.000	1.00	0.016	0.02	NA	NA			
Zinc	309SB106	Low	98.04	0.003	0.25	0.0001	71.2	0.00	1.00	0.016	16.21	11.79	817.63		X	
Antimony	SB01	High	2.97	0.004	0.01	0.0001	5.6	0.00	1.00	0.009	1.21	0.17	1.69		X	
Arsenic	SB01	High	267.47	0.004	0.9362	0.0001	58.4	0.005	1.00	0.009	104.56	0.79	8.79			X
Barium	SB01	High	885.40	0.004	3.0989	0.0001	4660	0.391	1.00	0.009	387.82	13.45	49.44			X
Beryllium	SB01	High	0.13	0.004	0.0004	0.0001	0.6	0.000	1.00	0.009	0.05	0.00	0.00			
Cadmium	SB01	High	0.47	0.004	0.0017	0.0001	0.28	0.000	1.00	0.009	0.19	0.08	3.61		X	
Chromium	SB01	High	27.20	0.004	0.0952	0.0001	136	0.011	1.00	0.009	11.85	8.19	32.81		X	
Copper	SB01	High	638.40	0.004	2.234	0.0001	608	0.05	1.00	0.009	253.94	3.61	812.91		X	
Lead	SB01	High	51.20	0.004	0.1792	0.0001	2560	0.22	1.00	0.009	43.80	0.003	288.93		X	
Mercury	SB01	High	5.49	0.004	0.01921	0.0001	0.42	0.00004	1.00	0.009	2.14	0.30	5.04		X	
Molybdenum	SB01	High	124.74	0.004	0.4366	0.0001	9.7	0.001	1.00	0.009	48.60	0.35	3.51			X
Selenium	SB01	High	1.56	0.004	0.005	0.0001	0.42	0.0000	1.00	0.009	0.61	0.06	1.56		X	
Silver	SB01	High	5.67	0.004	0.0198	0.0001	5.4	0.000	1.00	0.009	2.26	0.00	0.00			
Zinc	SB01	High	5644.20	0.004	19.75	0.0001	4090	0.34	1.00	0.009	2233.14	12.47	863.96			X
Antimony	SB01	Low	2.97	0.003	0.01	0.0001	5.6	0.00	1.00	0.016	0.50	0.15	1.46		X	
Arsenic	SB01	Low	267.47	0.003	0.6954	0.0001	58.4	0.004	1.00	0.016	43.69	0.68	7.61			X
Barium	SB01	Low	885.40	0.003	2.3020	0.0001	4660	0.291	1.00	0.016	162.05	11.65	42.82			X
Beryllium	SB01	Low	0.13	0.003	0.0003	0.0001	0.6	0.000	1.00	0.016	0.02	0.00	0.00			
Cadmium	SB01	Low	0.47	0.003	0.0012	0.0001	0.28	0.000	1.00	0.016	0.08	0.07	3.12		X	
Chromium	SB01	Low	27.20	0.003	0.0707	0.0001	136	0.008	1.00	0.016	4.95	7.09	28.42	X		
Copper	SB01	Low	638.40	0.003	1.660	0.0001	608	0.04	1.00	0.016	106.11	3.12	704.00		X	
Lead	SB01	Low	51.20	0.003	0.1331	0.0001	2560	0.16	1.00	0.016	18.30	0.003	250.22		X	
Mercury	SB01	Low	5.49	0.003	0.01427	0.0001	0.42	0.00003	1.00	0.016	0.89	0.29	4.87		X	

APPENDIX I2
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Molybdenum	SB01	Low	124.74	0.003	0.3243	0.0001	9.7	0.001	1.00	0.016	20.31	0.30	3.04			X
Selenium	SB01	Low	1.56	0.003	0.004	0.0001	0.42	0.0000	1.00	0.016	0.26	0.06	1.35		X	
Silver	SB01	Low	5.67	0.003	0.0147	0.0001	5.4	0.000	1.00	0.016	0.94	0.00	0.00			
Zinc	SB01	Low	5644.20	0.003	14.67	0.0001	4090	0.26	1.00	0.016	933.13	10.80	748.21			X
Antimony	SB02	High	0.42	0.004	0.00	0.0001	0.8	0.00	1.00	0.009	0.17	0.17	1.69		X	
Arsenic	SB02	High	26.56	0.004	0.0930	0.0001	5.8	0.000	1.00	0.009	10.38	0.79	8.79			X
Barium	SB02	High	42.37	0.004	0.1483	0.0001	223	0.019	1.00	0.009	18.56	13.45	49.44		X	
Beryllium	SB02	High	0.07	0.004	0.0002	0.0001	0.31	0.000	1.00	0.009	0.03	0.00	0.00			
Cadmium	SB02	High	0.04	0.004	0.0001	0.0001	0.025	0.000	1.00	0.009	0.02	0.08	3.61	X		
Chromium	SB02	High	4.24	0.004	0.0148	0.0001	21.2	0.002	1.00	0.009	1.85	8.19	32.81	X		
Copper	SB02	High	26.99	0.004	0.094	0.0001	25.7	0.00	1.00	0.009	10.73	3.61	812.91		X	
Lead	SB02	High	0.69	0.004	0.0024	0.0001	34.7	0.00	1.00	0.009	0.59	0.003	288.93		X	
Mercury	SB02	High	0.39	0.004	0.00137	0.0001	0.03	0.00000	1.00	0.009	0.15	0.30	5.04	X		
Molybdenum	SB02	High	0.96	0.004	0.0034	0.0001	0.075	0.000	1.00	0.009	0.38	0.35	3.51		X	
Selenium	SB02	High	1.10	0.004	0.004	0.0001	0.295	0.0000	1.00	0.009	0.45	0.06	1.56		X	
Silver	SB02	High	0.07	0.004	0.0002	0.0001	0.065	0.000	1.00	0.009	0.03	0.00	0.00			
Zinc	SB02	High	123.51	0.004	0.43	0.0001	59.5	0.01	1.00	0.009	48.87	12.47	863.96		X	
Antimony	SB02	Low	0.42	0.003	0.00	0.0001	0.8	0.00	1.00	0.016	0.07	0.15	1.46	X		
Arsenic	SB02	Low	26.56	0.003	0.0691	0.0001	5.8	0.000	1.00	0.016	4.34	0.68	7.61		X	
Barium	SB02	Low	42.37	0.003	0.1102	0.0001	223	0.014	1.00	0.016	7.75	11.65	42.82	X		
Beryllium	SB02	Low	0.07	0.003	0.0002	0.0001	0.31	0.000	1.00	0.016	0.01	0.00	0.00			
Cadmium	SB02	Low	0.04	0.003	0.0001	0.0001	0.025	0.000	1.00	0.016	0.01	0.07	3.12	X		
Chromium	SB02	Low	4.24	0.003	0.0110	0.0001	21.2	0.001	1.00	0.016	0.77	7.09	28.42	X		
Copper	SB02	Low	26.99	0.003	0.070	0.0001	25.7	0.00	1.00	0.016	4.49	3.12	704.00		X	
Lead	SB02	Low	0.69	0.003	0.0018	0.0001	34.7	0.00	1.00	0.016	0.25	0.003	250.22		X	
Mercury	SB02	Low	0.39	0.003	0.00102	0.0001	0.03	0.00000	1.00	0.016	0.06	0.29	4.87	X		
Molybdenum	SB02	Low	0.96	0.003	0.0025	0.0001	0.075	0.000	1.00	0.016	0.16	0.30	3.04	X		
Selenium	SB02	Low	1.10	0.003	0.003	0.0001	0.295	0.0000	1.00	0.016	0.18	0.06	1.35		X	
Silver	SB02	Low	0.07	0.003	0.0002	0.0001	0.065	0.000	1.00	0.016	0.01	0.00	0.00			
Zinc	SB02	Low	123.51	0.003	0.32	0.0001	89.5	0.01	1.00	0.016	20.42	10.80	748.21		X	
Antimony	SB03	High	44.63	0.004	0.16	0.0001	84.2	0.01	1.00	0.009	18.14	0.17	1.69			X
Arsenic	SB03	High	650.36	0.004	2.2763	0.0001	142	0.012	1.00	0.009	254.24	0.79	8.79			X
Barium	SB03	High	145.35	0.004	0.5087	0.0001	765	0.064	1.00	0.009	63.67	13.45	49.44			X
Beryllium	SB03	High	0.07	0.004	0.0002	0.0001	0.33	0.000	1.00	0.009	0.03	0.00	0.00			
Cadmium	SB03	High	9.30	0.004	0.0325	0.0001	5.5	0.000	1.00	0.009	3.67	0.08	3.61			X
Chromium	SB03	High	25.00	0.004	0.0875	0.0001	125	0.011	1.00	0.009	10.89	8.19	32.81		X	
Copper	SB03	High	7003.50	0.004	24.512	0.0001	6670	0.56	1.00	0.009	2785.84	3.61	812.91			X
Lead	SB03	High	153.60	0.004	0.5376	0.0001	7680	0.65	1.00	0.009	131.41	0.003	288.93		X	
Mercury	SB03	High	345.05	0.004	1.20767	0.0001	26.4	0.00222	1.00	0.009	134.43	0.30	5.04			X
Molybdenum	SB03	High	232.77	0.004	0.8147	0.0001	18.1	0.002	1.00	0.009	90.69	0.35	3.51			X
Selenium	SB03	High	1.12	0.004	0.004	0.0001	0.3	0.0000	1.00	0.009	0.44	0.06	1.56		X	
Silver	SB03	High	2.42	0.004	0.0085	0.0001	2.3	0.000	1.00	0.009	0.96	0.00	0.00			
Zinc	SB03	High	5464.80	0.004	19.13	0.0001	3960	0.33	1.00	0.009	2162.16	12.47	863.96			X
Antimony	SB03	Low	44.63	0.003	0.12	0.0001	84.2	0.01	1.00	0.016	7.58	0.15	1.46			X
Arsenic	SB03	Low	650.36	0.003	1.6909	0.0001	142	0.009	1.00	0.016	105.24	0.68	7.61			X
Barium	SB03	Low	145.35	0.003	0.3779	0.0001	765	0.048	1.00	0.016	26.60	11.65	42.82		X	
Beryllium	SB03	Low	0.07	0.003	0.0002	0.0001	0.33	0.000	1.00	0.016	0.01	0.00	0.00			
Cadmium	SB03	Low	9.30	0.003	0.0242	0.0001	5.5	0.000	1.00	0.016	1.52	0.07	3.12		X	
Chromium	SB03	Low	25.00	0.003	0.0650	0.0001	125	0.008	1.00	0.016	4.55	7.09	28.42	X		
Copper	SB03	Low	7003.50	0.003	18.209	0.0001	6670	0.42	1.00	0.016	1164.08	3.12	704.00			X

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APPENDIX I2
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical*	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Lead	SB03	Low	153.60	0.003	0.3994	0.0001	7680	0.48	1.00	0.016	54.91	0.003	250.22		X	
Mercury	SB03	Low	345.05	0.003	0.89712	0.0001	26.4	0.00165	1.00	0.016	55.17	0.29	4.87			X
Molybdenum	SB03	Low	232.77	0.003	0.6052	0.0001	18.1	0.001	1.00	0.016	37.90	0.30	3.04			X
Selenium	SB03	Low	1.12	0.003	0.003	0.0001	0.3	0.0000	1.00	0.016	0.18	0.06	1.35		X	
Silver	SB03	Low	2.42	0.003	0.0063	0.0001	2.3	0.000	1.00	0.016	0.40	0.00	0.00			
Zinc	SB03	Low	5464.80	0.003	14.21	0.0001	3960	0.25	1.00	0.016	903.47	10.80	748.21			X
Antimony	SB04	High	9.59	0.004	0.03	0.0001	18.1	0.00	1.00	0.009	3.90	0.17	1.69			X
Arsenic	SB04	High	280.30	0.004	0.9810	0.0001	61.2	0.005	1.00	0.009	109.58	0.79	8.79			X
Barium	SB04	High	176.13	0.004	0.6165	0.0001	927	0.078	1.00	0.009	77.15	13.45	49.44			X
Beryllium	SB04	High	0.12	0.004	0.0004	0.0001	0.55	0.000	1.00	0.009	0.05	0.00	0.00			
Cadmium	SB04	High	4.73	0.004	0.0166	0.0001	2.8	0.000	1.00	0.009	1.87	0.08	3.61		X	
Chromium	SB04	High	23.80	0.004	0.0833	0.0001	119	0.010	1.00	0.009	10.37	8.19	32.81		X	
Copper	SB04	High	396.90	0.004	1.389	0.0001	378	0.03	1.00	0.009	157.88	3.61	812.91		X	
Lead	SB04	High	100.60	0.004	0.3521	0.0001	5030	0.42	1.00	0.009	86.07	0.003	288.93		X	
Mercury	SB04	High	27.45	0.004	0.09606	0.0001	2.1	0.00018	1.00	0.009	10.69	0.30	5.04			X
Molybdenum	SB04	High	77.16	0.004	0.2701	0.0001	6	0.001	1.00	0.009	30.36	0.35	3.51			X
Selenium	SB04	High	33.48	0.004	0.117	0.0001	9	0.0008	1.00	0.009	13.10	0.06	1.56			X
Silver	SB04	High	1.00	0.004	0.0035	0.0001	0.95	0.000	1.00	0.009	0.40	0.00	0.00			
Zinc	SB04	High	2898.00	0.004	10.14	0.0001	2100	0.18	1.00	0.009	1146.60	12.47	863.96			X
Antimony	SB04	Low	9.59	0.003	0.02	0.0001	18.1	0.00	1.00	0.016	1.63	0.15	1.46			X
Arsenic	SB04	Low	280.30	0.003	0.7288	0.0001	61.2	0.004	1.00	0.016	45.79	0.68	7.61			X
Barium	SB04	Low	176.13	0.003	0.4579	0.0001	927	0.058	1.00	0.016	32.24	11.65	42.82		X	
Beryllium	SB04	Low	0.12	0.003	0.0003	0.0001	0.55	0.000	1.00	0.016	0.02	0.00	0.00			
Cadmium	SB04	Low	4.73	0.003	0.0123	0.0001	2.8	0.000	1.00	0.016	0.78	0.07	3.12		X	
Chromium	SB04	Low	23.80	0.003	0.0619	0.0001	119	0.007	1.00	0.016	4.33	7.09	28.42	X		
Copper	SB04	Low	396.90	0.003	1.032	0.0001	378	0.02	1.00	0.016	65.97	3.12	704.00		X	
Lead	SB04	Low	100.60	0.003	0.2616	0.0001	5030	0.31	1.00	0.016	35.96	0.003	250.22		X	
Mercury	SB04	Low	27.45	0.003	0.07136	0.0001	2.1	0.00013	1.00	0.016	4.47	0.29	4.87		X	
Molybdenum	SB04	Low	77.16	0.003	0.2006	0.0001	6	0.000	1.00	0.016	12.56	0.30	3.04			X
Selenium	SB04	Low	33.48	0.003	0.087	0.0001	9	0.0006	1.00	0.016	5.48	0.06	1.35			X
Silver	SB04	Low	1.00	0.003	0.0026	0.0001	0.95	0.000	1.00	0.016	0.17	0.00	0.00			
Zinc	SB04	Low	2898.00	0.003	7.53	0.0001	2100	0.13	1.00	0.016	479.12	10.80	748.21		X	
Antimony	SB05	High	0.09	0.004	0.00	0.0001	0.17	0.00	1.00	0.009	0.04	0.17	1.69	X		
Arsenic	SB05	High	39.39	0.004	0.1379	0.0001	8.6	0.001	1.00	0.009	15.40	0.79	8.79			X
Barium	SB05	High	46.36	0.004	0.1623	0.0001	244	0.020	1.00	0.009	20.31	13.45	49.44		X	
Beryllium	SB05	High	0.09	0.004	0.0003	0.0001	0.43	0.000	1.00	0.009	0.04	0.00	0.00			
Cadmium	SB05	High	0.06	0.004	0.0002	0.0001	0.035	0.000	1.00	0.009	0.02	0.08	3.61	X		
Chromium	SB05	High	3.66	0.004	0.0128	0.0001	18.3	0.002	1.00	0.009	1.59	8.19	32.81	X		
Copper	SB05	High	29.82	0.004	0.104	0.0001	28.4	0.00	1.00	0.009	11.86	3.61	812.91		X	
Lead	SB05	High	4.02	0.004	0.0141	0.0001	201	0.02	1.00	0.009	3.44	0.003	288.93		X	
Mercury	SB05	High	0.46	0.004	0.00160	0.0001	0.035	0.00000	1.00	0.009	0.18	0.30	5.04	X		
Molybdenum	SB05	High	4.69	0.004	0.0164	0.0001	0.365	0.000	1.00	0.009	1.83	0.35	3.51		X	
Selenium	SB05	High	3.53	0.004	0.012	0.0001	0.95	0.0001	1.00	0.009	1.38	0.06	1.56		X	
Silver	SB05	High	0.89	0.004	0.0031	0.0001	0.85	0.000	1.00	0.009	0.36	0.00	0.00			
Zinc	SB05	High	173.88	0.004	0.61	0.0001	126	0.01	1.00	0.009	68.80	12.47	863.96		X	
Antimony	SB05	Low	0.09	0.003	0.00	0.0001	0.17	0.00	1.00	0.016	0.02	0.15	1.46	X		
Arsenic	SB05	Low	39.39	0.003	0.1024	0.0001	8.6	0.001	1.00	0.016	6.43	0.68	7.61		X	
Barium	SB05	Low	46.36	0.003	0.1205	0.0001	244	0.015	1.00	0.016	8.49	11.65	42.82	X		
Beryllium	SB05	Low	0.09	0.003	0.0002	0.0001	0.43	0.000	1.00	0.016	0.02	0.00	0.00			
Cadmium	SB05	Low	0.06	0.003	0.0002	0.0001	0.035	0.000	1.00	0.016	0.01	0.07	3.12	X		

APPENDIX 12
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Chromium	SB05	Low	3.66	0.003	0.0095	0.0002	18.3	0.001	1.00	0.016	0.67	7.09	28.42	X		
Copper	SB05	Low	29.82	0.003	0.078	0.0001	28.4	0.00	1.00	0.016	4.96	3.12	704.00		X	
Lead	SB05	Low	4.02	0.003	0.0105	0.0001	201	0.01	1.00	0.016	1.44	0.003	250.22		X	
Mercury	SB05	Low	0.46	0.003	0.00119	0.0001	0.035	0.00000	1.00	0.016	0.07	0.29	4.87	X		
Molybdenum	SB05	Low	4.69	0.003	0.0122	0.0001	0.365	0.000	1.00	0.016	0.76	0.30	3.04		X	
Selenium	SB05	Low	3.53	0.003	0.009	0.0001	0.95	0.0001	1.00	0.016	0.58	0.06	1.35		X	
Silver	SB05	Low	0.89	0.003	0.0023	0.0001	0.85	0.000	1.00	0.016	0.15	0.00	0.00			
Zinc	SB05	Low	173.88	0.003	0.45	0.0001	126	0.01	1.00	0.016	28.75	10.80	748.21		X	
Antimony	SB06	High	0.08	0.004	0.00	0.0001	0.16	0.00	1.00	0.009	0.03	0.17	1.69	X		
Arsenic	SB06	High	28.40	0.004	0.0994	0.0001	6.2	0.00	1.00	0.009	11.10	0.79	8.79			X
Barium	SB06	High	68.97	0.004	0.2414	0.0001	363	0.030	1.00	0.009	30.21	13.45	49.44		X	
Beryllium	SB06	High	0.12	0.004	0.0004	0.0001	0.57	0.000	1.00	0.009	0.05	0.00	0.00			
Cadmium	SB06	High	0.05	0.004	0.0002	0.0001	0.03	0.000	1.00	0.009	0.02	0.08	3.61	X		
Chromium	SB06	High	5.28	0.004	0.0185	0.0001	26.4	0.002	1.00	0.009	2.30	8.19	32.81	X		
Copper	SB06	High	21.11	0.004	0.074	0.0001	20.1	0.00	1.00	0.009	8.40	3.61	812.91		X	
Lead	SB06	High	1.34	0.004	0.0047	0.0001	66.9	0.01	1.00	0.009	1.14	0.003	288.93		X	
Mercury	SB06	High	0.33	0.004	0.00114	0.0001	0.025	0.00000	1.00	0.009	0.13	0.30	5.04	X		
Molybdenum	SB06	High	4.12	0.004	0.0144	0.0001	0.32	0.000	1.00	0.009	1.60	0.35	3.51		X	
Selenium	SB06	High	3.24	0.004	0.011	0.0001	0.87	0.0001	1.00	0.009	1.27	0.06	1.56		X	
Silver	SB06	High	0.79	0.004	0.0028	0.0001	0.75	0.000	1.00	0.009	0.31	0.00	0.00			
Zinc	SB06	High	58.10	0.004	0.20	0.0001	42.1	0.00	1.00	0.009	22.99	12.47	863.96		X	
Antimony	SB06	Low	0.08	0.003	0.00	0.0001	0.16	0.00	1.00	0.016	0.01	0.15	1.46	X		
Arsenic	SB06	Low	28.40	0.003	0.0758	0.0001	6.2	0.000	1.00	0.016	4.64	0.68	7.61		X	
Barium	SB06	Low	68.97	0.003	0.1793	0.0001	363	0.023	1.00	0.016	12.62	11.65	42.82		X	
Beryllium	SB06	Low	0.12	0.003	0.0003	0.0001	0.57	0.000	1.00	0.016	0.02	0.00	0.00			
Cadmium	SB06	Low	0.05	0.003	0.0001	0.0001	0.03	0.000	1.00	0.016	0.01	0.07	3.12	X		
Chromium	SB06	Low	5.28	0.003	0.0137	0.0001	26.4	0.002	1.00	0.016	0.96	7.09	28.42	X		
Copper	SB06	Low	21.11	0.003	0.055	0.0001	20.1	0.00	1.00	0.016	3.51	3.12	704.00		X	
Lead	SB06	Low	1.34	0.003	0.0035	0.0001	66.9	0.00	1.00	0.016	0.48	0.003	250.22		X	
Mercury	SB06	Low	0.33	0.003	0.00085	0.0001	0.025	0.00000	1.00	0.016	0.05	0.29	4.87	X		
Molybdenum	SB06	Low	4.12	0.003	0.0107	0.0001	0.32	0.000	1.00	0.016	0.67	0.30	3.04		X	
Selenium	SB06	Low	3.24	0.003	0.008	0.0001	0.87	0.0001	1.00	0.016	0.53	0.06	1.35		X	
Silver	SB06	Low	0.79	0.003	0.0020	0.0001	0.75	0.000	1.00	0.016	0.13	0.00	0.00			
Zinc	SB06	Low	58.10	0.003	0.15	0.0001	42.1	0.00	1.00	0.016	9.61	10.80	748.21	X		
Antimony	SB07	High	0.09	0.004	0.00	0.0001	0.175	0.00	1.00	0.009	0.04	0.17	1.69	X		
Arsenic	SB07	High	27.94	0.004	0.0978	0.0001	6.1	0.001	1.00	0.009	10.92	0.79	8.79			X
Barium	SB07	High	38.19	0.004	0.1337	0.0001	201	0.017	1.00	0.009	16.73	13.45	49.44		X	
Beryllium	SB07	High	0.11	0.004	0.0004	0.0001	0.5	0.000	1.00	0.009	0.05	0.00	0.00			
Cadmium	SB07	High	0.06	0.004	0.0002	0.0001	0.035	0.000	1.00	0.009	0.02	0.08	3.61	X		
Chromium	SB07	High	4.24	0.004	0.0148	0.0001	21.2	0.002	1.00	0.009	1.85	8.19	32.81	X		
Copper	SB07	High	32.03	0.004	0.112	0.0001	30.5	0.00	1.00	0.009	12.74	3.61	812.91		X	
Lead	SB07	High	3.68	0.004	0.0129	0.0001	184	0.02	1.00	0.009	3.15	0.003	288.93		X	
Mercury	SB07	High	0.39	0.004	0.00137	0.0001	0.03	0.00000	1.00	0.009	0.15	0.30	5.04	X		
Molybdenum	SB07	High	4.50	0.004	0.0158	0.0001	0.35	0.000	1.00	0.009	1.75	0.35	3.51		X	
Selenium	SB07	High	3.57	0.004	0.012	0.0001	0.96	0.0001	1.00	0.009	1.40	0.06	1.56		X	
Silver	SB07	High	0.84	0.004	0.0029	0.0001	0.8	0.000	1.00	0.009	0.33	0.00	0.00			
Zinc	SB07	High	165.60	0.004	0.58	0.0001	120	0.01	1.00	0.009	65.52	12.47	863.96		X	
Antimony	SB07	Low	0.09	0.003	0.00	0.0001	0.175	0.00	1.00	0.016	0.02	0.15	1.46	X		
Arsenic	SB07	Low	27.94	0.003	0.0726	0.0001	6.1	0.000	1.00	0.016	4.56	0.68	7.61		X	
Barium	SB07	Low	38.19	0.003	0.0993	0.0001	201	0.013	1.00	0.016	6.99	11.65	42.82	X		

APPENDIX I2

SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Beryllium	SB07	Low	0.11	0.003	0.0003	0.0001	0.5	0.000	1.00	0.016	0.02	0.00	0.00			
Cadmium	SB07	Low	0.06	0.003	0.0002	0.0001	0.035	0.000	1.00	0.016	0.01	0.07	3.12	X		
Chromium	SB07	Low	4.24	0.003	0.0118	0.0001	21.2	0.002	1.00	0.016	0.77	7.09	28.42	X		
Copper	SB07	Low	32.03	0.003	0.083	0.0001	30.5	0.00	1.00	0.016	5.32	3.12	704.00		X	
Lead	SB07	Low	3.68	0.003	0.0096	0.0001	184	0.01	1.00	0.016	1.32	0.003	250.22		X	
Mercury	SB07	Low	0.39	0.003	0.00102	0.0001	0.03	0.00000	1.00	0.016	0.06	0.29	4.87	X		
Molybdenum	SB07	Low	4.50	0.003	0.0117	0.0001	0.35	0.000	1.00	0.016	0.73	0.30	3.04		X	
Selenium	SB07	Low	3.57	0.003	0.009	0.0001	0.96	0.0001	1.00	0.016	0.58	0.06	1.35		X	
Silver	SB07	Low	0.84	0.003	0.0022	0.0001	0.8	0.000	1.00	0.016	0.14	0.00	0.00			
Zinc	SB07	Low	165.60	0.003	0.43	0.0001	120	0.01	1.00	0.016	27.38	10.80	748.21		X	
Antimony	SB08	High	0.09	0.004	0.00	0.0001	0.17	0.00	1.00	0.009	0.04	0.17	1.69	X		
Arsenic	SB08	High	46.72	0.004	0.1635	0.0001	10.2	0.001	1.00	0.009	18.26	0.79	8.79			X
Barium	SB08	High	57.38	0.004	0.2008	0.0001	302	0.025	1.00	0.009	25.13	13.45	49.44		X	
Beryllium	SB08	High	0.12	0.004	0.0004	0.0001	0.58	0.000	1.00	0.009	0.05	0.00	0.00			
Cadmium	SB08	High	0.06	0.004	0.0002	0.0001	0.035	0.000	1.00	0.009	0.02	0.08	3.61	X		
Chromium	SB08	High	6.08	0.004	0.0213	0.0001	30.4	0.003	1.00	0.009	2.65	8.19	32.81	X		
Copper	SB08	High	41.06	0.004	0.144	0.0001	39.1	0.00	1.00	0.009	16.33	3.61	812.91		X	
Lead	SB08	High	2.58	0.004	0.0090	0.0001	129	0.01	1.00	0.009	2.21	0.003	288.93		X	
Mercury	SB08	High	0.39	0.004	0.00137	0.0001	0.03	0.00000	1.00	0.009	0.15	0.30	5.04	X		
Molybdenum	SB08	High	10.80	0.004	0.0378	0.0001	0.84	0.000	1.00	0.009	4.21	0.35	3.51			X
Selenium	SB08	High	1.43	0.004	0.005	0.0001	0.385	0.0000	1.00	0.009	0.56	0.06	1.56		X	
Silver	SB08	High	0.84	0.004	0.0029	0.0001	0.8	0.000	1.00	0.009	0.33	0.00	0.00			
Zinc	SB08	High	136.48	0.004	0.48	0.0001	98.9	0.01	1.00	0.009	54.00	12.47	865.96		X	
Antimony	SB08	Low	0.09	0.003	0.00	0.0001	0.17	0.00	1.00	0.016	0.02	0.15	1.46	X		
Arsenic	SB08	Low	46.72	0.003	0.1215	0.0001	10.2	0.001	1.00	0.016	7.63	0.68	7.61			X
Barium	SB08	Low	57.38	0.003	0.1492	0.0001	302	0.019	1.00	0.016	10.50	11.65	42.82	X		
Beryllium	SB08	Low	0.12	0.003	0.0003	0.0001	0.58	0.000	1.00	0.016	0.02	0.00	0.00			
Cadmium	SB08	Low	0.06	0.003	0.0002	0.0001	0.035	0.000	1.00	0.016	0.01	0.07	3.12	X		
Chromium	SB08	Low	6.08	0.003	0.0158	0.0001	30.4	0.002	1.00	0.016	1.11	7.09	28.42	X		
Copper	SB08	Low	41.06	0.003	0.107	0.0001	39.1	0.00	1.00	0.016	6.82	3.12	704.00		X	
Lead	SB08	Low	2.58	0.003	0.0067	0.0001	129	0.01	1.00	0.016	0.92	0.003	250.22		X	
Mercury	SB08	Low	0.39	0.003	0.00102	0.0001	0.03	0.00000	1.00	0.016	0.06	0.29	4.87	X		
Molybdenum	SB08	Low	10.80	0.003	0.0281	0.0001	0.84	0.000	1.00	0.016	1.76	0.30	3.04		X	
Selenium	SB08	Low	1.43	0.003	0.004	0.0001	0.385	0.0000	1.00	0.016	0.23	0.06	1.35		X	
Silver	SB08	Low	0.84	0.003	0.0022	0.0001	0.8	0.000	1.00	0.016	0.14	0.00	0.00			
Zinc	SB08	Low	136.48	0.003	0.35	0.0001	98.9	0.01	1.00	0.016	22.56	10.80	748.21		X	
Antimony	SB09	High	3.18	0.004	0.01	0.0001	6	0.00	1.00	0.009	1.29	0.17	1.69		X	
Arsenic	SB09	High	173.12	0.004	0.6059	0.0001	37.8	0.003	1.00	0.009	67.68	0.79	8.79			X
Barium	SB09	High	74.29	0.004	0.2600	0.0001	391	0.033	1.00	0.009	32.54	13.45	49.44		X	
Beryllium	SB09	High	0.09	0.004	0.0003	0.0001	0.41	0.000	1.00	0.009	0.04	0.00	0.00			
Cadmium	SB09	High	5.58	0.004	0.0195	0.0001	5.3	0.000	1.00	0.009	2.20	0.08	3.61		X	
Chromium	SB09	High	8.62	0.004	0.0302	0.0001	43.1	0.004	1.00	0.009	3.75	8.19	32.81	X		
Copper	SB09	High	343.35	0.004	1.202	0.0001	327	0.03	1.00	0.009	136.58	3.61	812.91		X	
Lead	SB09	High	31.20	0.004	0.1092	0.0001	1566	0.15	1.00	0.009	26.69	0.003	288.93		X	
Mercury	SB09	High	28.75	0.004	0.10064	0.0001	2.2	0.00018	1.00	0.009	11.20	0.30	5.04			X
Molybdenum	SB09	High	27.01	0.004	0.0945	0.0001	2.1	0.000	1.00	0.009	10.52	0.35	3.51			X
Selenium	SB09	High	18.60	0.004	0.065	0.0001	5	0.0004	1.00	0.009	7.28	0.06	1.56			X
Silver	SB09	High	1.26	0.004	0.0044	0.0001	1.2	0.000	1.00	0.009	0.50	0.00	0.00			
Zinc	SB09	High	7465.80	0.004	26.13	0.0001	5416	0.45	1.00	0.009	2953.86	12.47	865.96			X
Antimony	SB09	Low	3.18	0.003	0.01	0.0001	6	0.00	1.00	0.016	0.54	0.15	1.46		X	

APPENDIX I2
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[1]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Arsenic	SB09	Low	173.12	0.003	0.4501	0.0001	37.8	0.002	1.00	0.016	28.28	0.68	7.61			X
Barium	SB09	Low	74.29	0.003	0.1932	0.0001	291	0.024	1.00	0.016	13.60	11.65	42.82		X	
Beryllium	SB09	Low	0.09	0.003	0.0002	0.0001	0.41	0.000	1.00	0.016	0.02	0.00	0.00			
Cadmium	SB09	Low	5.58	0.003	0.0145	0.0001	3.3	0.000	1.00	0.016	0.92	0.07	3.12		X	
Chromium	SB09	Low	8.62	0.003	0.0224	0.0001	43.1	0.003	1.00	0.016	1.57	7.09	28.42	X		
Copper	SB09	Low	343.35	0.003	0.893	0.0001	527	0.02	1.00	0.016	57.07	3.12	704.00		X	
Lead	SB09	Low	31.20	0.003	0.0811	0.0001	1560	0.20	1.00	0.016	11.15	0.003	250.22		X	
Mercury	SB09	Low	28.75	0.003	0.07476	0.0001	2.2	0.00014	1.00	0.016	4.68	0.29	4.87		X	
Molybdenum	SB09	Low	27.01	0.003	0.0702	0.0001	2.1	0.000	1.00	0.016	4.40	0.30	3.04			X
Selenium	SB09	Low	18.60	0.003	0.048	0.0001	5	0.0003	1.00	0.016	3.04	0.06	1.35			X
Silver	SB09	Low	1.26	0.003	0.0033	0.0001	1.2	0.000	1.00	0.016	0.21	0.00	0.00			
Zinc	SB09	Low	7465.80	0.003	19.41	0.0001	5410	0.34	1.00	0.016	1234.29	10.80	748.21			X
Antimony	SB10	High	17.07	0.004	0.06	0.0001	32.2	0.00	1.00	0.009	6.94	0.17	1.69			X
Arsenic	SB10	High	155.72	0.004	0.5450	0.0001	34	0.003	1.00	0.009	60.88	0.79	8.79			X
Barium	SB10	High	57.38	0.004	0.2008	0.0001	302	0.025	1.00	0.009	25.13	12.45	49.44		X	
Beryllium	SB10	High	0.09	0.004	0.0003	0.0001	0.41	0.000	1.00	0.009	0.04	0.00	0.00			
Cadmium	SB10	High	22.65	0.004	0.0793	0.0001	13.4	0.001	1.00	0.009	8.93	0.08	3.61			X
Chromium	SB10	High	20.00	0.004	0.0700	0.0001	100	0.008	1.00	0.009	8.71	8.19	32.81		X	
Copper	SB10	High	13125.00	0.004	45.938	0.0001	12500	1.05	1.00	0.009	5220.83	3.61	812.91			X
Lead	SB10	High	37.40	0.004	0.1309	0.0001	1870	0.16	1.00	0.009	32.00	0.003	288.93		X	
Mercury	SB10	High	9.02	0.004	0.03156	0.0001	0.69	0.00006	1.00	0.009	3.51	0.30	5.04		X	
Molybdenum	SB10	High	32.15	0.004	0.1125	0.0001	2.5	0.000	1.00	0.009	12.53	0.35	3.51			X
Selenium	SB10	High	14.88	0.004	0.052	0.0001	4	0.0003	1.00	0.009	5.82	0.06	1.56			X
Silver	SB10	High	0.89	0.004	0.0031	0.0001	0.85	0.000	1.00	0.009	0.36	0.00	0.00			
Zinc	SB10	High	6844.80	0.004	23.96	0.0001	4960	0.42	1.00	0.009	2708.16	12.47	863.96			X
Antimony	SB10	Low	17.07	0.003	0.04	0.0001	32.2	0.00	1.00	0.016	2.90	0.15	1.46			X
Arsenic	SB10	Low	155.72	0.003	0.4049	0.0001	34	0.002	1.00	0.016	25.44	0.68	7.61			X
Barium	SB10	Low	57.38	0.003	0.1492	0.0001	302	0.019	1.00	0.016	10.50	11.55	42.82	X		
Beryllium	SB10	Low	0.09	0.003	0.0002	0.0001	0.41	0.000	1.00	0.016	0.02	0.00	0.00			
Cadmium	SB10	Low	22.65	0.003	0.0589	0.0001	13.4	0.001	1.00	0.016	3.73	0.07	3.12			X
Chromium	SB10	Low	20.00	0.003	0.0520	0.0001	100	0.006	1.00	0.016	3.64	7.09	28.42	X		
Copper	SB10	Low	13125.00	0.003	34.125	0.0001	12500	0.78	1.00	0.016	2181.56	3.12	704.00			X
Lead	SB10	Low	37.40	0.003	0.0972	0.0001	1870	0.12	1.00	0.016	13.37	0.003	250.22		X	
Mercury	SB10	Low	9.02	0.003	0.02345	0.0001	0.69	0.00004	1.00	0.016	1.47	0.29	4.87		X	
Molybdenum	SB10	Low	32.15	0.003	0.0836	0.0001	2.5	0.000	1.00	0.016	5.23	0.30	3.04			X
Selenium	SB10	Low	14.88	0.003	0.039	0.0001	4	0.0002	1.00	0.016	2.43	0.06	1.35			X
Silver	SB10	Low	0.89	0.003	0.0023	0.0001	0.85	0.000	1.00	0.016	0.15	0.00	0.00			
Zinc	SB10	Low	6844.80	0.003	17.80	0.0001	4960	0.31	1.00	0.016	1131.62	10.80	748.21			X
Antimony	SB105	High	0.24	0.004	0.00	0.0001	0.46	0.00	1.00	0.009	0.10	0.17	1.69	X		
Arsenic	SB105	High	2.18	0.004	0.0076	0.0001	0.475	0.000	1.00	0.009	0.85	0.79	8.79		X	
Barium	SB105	High	38.95	0.004	0.1363	0.0001	205	0.017	1.00	0.009	17.06	12.45	49.44		X	
Beryllium	SB105	High	0.00	0.004	0.0000	0.0001	0.013	0.000	1.00	0.009	0.00	0.00	0.00			
Cadmium	SB105	High	0.07	0.004	0.0002	0.0001	0.0395	0.000	1.00	0.009	0.03	0.08	3.61	X		
Chromium	SB105	High	2.96	0.004	0.0104	0.0001	14.8	0.001	1.00	0.009	1.29	8.19	32.81	X		
Copper	SB105	High	38.96	0.004	0.136	0.0001	37.1	0.00	1.00	0.009	15.50	3.61	812.91		X	
Lead	SB105	High	0.50	0.004	0.0017	0.0001	24.9	0.00	1.00	0.009	0.43	0.003	288.93		X	
Mercury	SB105	High	0.39	0.004	0.00137	0.0001	0.03	0.00000	1.00	0.009	0.15	0.30	5.04	X		
Molybdenum	SB105	High	2.57	0.004	0.0090	0.0001	0.2	0.000	1.00	0.009	1.00	0.35	3.51		X	
Selenium	SB105	High	2.23	0.004	0.008	0.0001	0.6	0.0001	1.00	0.009	0.87	0.06	1.56		X	
Silver	SB105	High	0.29	0.004	0.0010	0.0001	0.275	0.000	1.00	0.009	0.11	0.00	0.00			

APPENDIX I2
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical*	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Zinc	SB105	High	102.53	0.004	0.36	0.0001	74.3	0.01	1.00	0.009	40.57	12.47	863.96		X	
Antimony	SB105	Low	0.24	0.003	0.00	0.0001	0.46	0.00	1.00	0.016	0.04	0.15	1.46	X		
Arsenic	SB105	Low	2.18	0.003	0.0057	0.0001	0.475	0.000	1.00	0.016	0.36	0.68	7.61	X		
Barium	SB105	Low	38.95	0.003	0.1013	0.0001	205	0.013	1.00	0.016	7.13	11.65	42.82	X		
Beryllium	SB105	Low	0.00	0.003	0.0000	0.0001	0.013	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SB105	Low	0.07	0.003	0.0002	0.0001	0.0395	0.000	1.00	0.016	0.01	0.07	3.12	X		
Chromium	SB105	Low	2.96	0.003	0.0077	0.0001	14.8	0.001	1.00	0.016	0.54	7.09	28.42	X		
Copper	SB105	Low	38.96	0.003	0.101	0.0001	37.1	0.00	1.00	0.016	6.47	3.12	704.00		X	
Lead	SB105	Low	0.50	0.003	0.0013	0.0001	24.9	0.00	1.00	0.016	0.18	0.003	250.22		X	
Mercury	SB105	Low	0.39	0.003	0.00102	0.0001	0.03	0.00000	1.00	0.016	0.06	0.29	4.87	X		
Molybdenum	SB105	Low	2.57	0.003	0.0067	0.0001	0.2	0.000	1.00	0.016	0.42	0.30	3.04		X	
Selenium	SB105	Low	2.23	0.003	0.006	0.0001	0.6	0.0000	1.00	0.016	0.37	0.06	1.35		X	
Silver	SB105	Low	0.29	0.003	0.0008	0.0001	0.275	0.000	1.00	0.016	0.05	0.00	0.00			
Zinc	SB105	Low	102.53	0.003	0.27	0.0001	74.3	0.00	1.00	0.016	16.95	10.80	748.21		X	
Antimony	SB11	High	0.10	0.004	0.00	0.0001	0.19	0.00	1.00	0.009	0.04	0.17	1.69	X		
Arsenic	SB11	High	67.33	0.004	0.2356	0.0001	14.7	0.001	1.00	0.009	26.32	0.79	8.79			X
Barium	SB11	High	39.90	0.004	0.1397	0.0001	210	0.018	1.00	0.009	17.48	13.45	49.44		X	
Beryllium	SB11	High	0.09	0.004	0.0003	0.0001	0.45	0.000	1.00	0.009	0.04	0.00	0.00			
Cadmium	SB11	High	0.07	0.004	0.0002	0.0001	0.04	0.000	1.00	0.009	0.03	0.08	3.61	X		
Chromium	SB11	High	5.94	0.004	0.0208	0.0001	29.7	0.002	1.00	0.009	2.59	8.19	32.81	X		
Copper	SB11	High	52.71	0.004	0.184	0.0001	50.2	0.00	1.00	0.009	20.97	3.61	812.91		X	
Lead	SB11	High	6.36	0.004	0.0223	0.0001	318	0.03	1.00	0.009	5.44	0.003	288.93		X	
Mercury	SB11	High	0.39	0.004	0.00137	0.0001	0.03	0.00000	1.00	0.009	0.15	0.30	5.04	X		
Molybdenum	SB11	High	4.82	0.004	0.0169	0.0001	0.375	0.000	1.00	0.009	1.88	0.35	3.51		X	
Selenium	SB11	High	3.72	0.004	0.013	0.0001	1	0.0001	1.00	0.009	1.46	0.06	1.56		X	
Silver	SB11	High	0.95	0.004	0.0033	0.0001	0.9	0.000	1.00	0.009	0.38	0.00	0.00			
Zinc	SB11	High	212.52	0.004	0.74	0.0001	154	0.01	1.00	0.009	84.08	12.47	863.96		X	
Antimony	SB11	Low	0.10	0.003	0.00	0.0001	0.19	0.00	1.00	0.016	0.02	0.15	1.46	X		
Arsenic	SB11	Low	67.33	0.003	0.1750	0.0001	14.7	0.001	1.00	0.016	11.00	0.68	7.61			X
Barium	SB11	Low	39.90	0.003	0.1037	0.0001	210	0.013	1.00	0.016	7.30	11.65	42.82	X		
Beryllium	SB11	Low	0.09	0.003	0.0002	0.0001	0.45	0.000	1.00	0.016	0.02	0.00	0.00			
Cadmium	SB11	Low	0.07	0.003	0.0002	0.0001	0.04	0.000	1.00	0.016	0.01	0.07	3.12	X		
Chromium	SB11	Low	5.94	0.003	0.0154	0.0001	29.7	0.002	1.00	0.016	1.08	7.09	28.42	X		
Copper	SB11	Low	52.71	0.003	0.137	0.0001	50.2	0.00	1.00	0.016	8.76	3.12	704.00		X	
Lead	SB11	Low	6.36	0.003	0.0165	0.0001	318	0.02	1.00	0.016	2.27	0.003	250.22		X	
Mercury	SB11	Low	0.39	0.003	0.00102	0.0001	0.03	0.00000	1.00	0.016	0.06	0.29	4.87	X		
Molybdenum	SB11	Low	4.82	0.003	0.0125	0.0001	0.375	0.000	1.00	0.016	0.79	0.30	3.04		X	
Selenium	SB11	Low	3.72	0.003	0.010	0.0001	1	0.0001	1.00	0.016	0.61	0.06	1.35		X	
Silver	SB11	Low	0.95	0.003	0.0025	0.0001	0.9	0.000	1.00	0.016	0.16	0.00	0.00			
Zinc	SB11	Low	212.52	0.003	0.55	0.0001	154	0.01	1.00	0.016	35.14	10.80	748.21		X	
Antimony	SB12	High	2.65	0.004	0.01	0.0001	5	0.00	1.00	0.009	1.09	0.17	1.69		X	
Arsenic	SB12	High	30.23	0.004	0.1058	0.0001	6.6	0.001	1.00	0.009	11.82	0.79	8.79			X
Barium	SB12	High	76.76	0.004	0.2687	0.0001	404	0.034	1.00	0.009	33.62	13.45	49.44		X	
Beryllium	SB12	High	0.11	0.004	0.0004	0.0001	0.52	0.000	1.00	0.009	0.05	0.00	0.00			
Cadmium	SB12	High	0.06	0.004	0.0002	0.0001	0.035	0.000	1.00	0.009	0.02	0.08	3.61	X		
Chromium	SB12	High	5.52	0.004	0.0193	0.0001	27.6	0.002	1.00	0.009	2.40	8.19	32.81	X		
Copper	SB12	High	75.29	0.004	0.263	0.0001	71.7	0.01	1.00	0.009	29.95	3.61	812.91		X	
Lead	SB12	High	14.98	0.004	0.0524	0.0001	749	0.06	1.00	0.009	12.82	0.003	288.93		X	
Mercury	SB12	High	0.39	0.004	0.00137	0.0001	0.03	0.00000	1.00	0.009	0.15	0.30	5.04	X		
Molybdenum	SB12	High	4.69	0.004	0.0164	0.0001	0.365	0.000	1.00	0.009	1.83	0.35	3.51		X	

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APPENDIX I2
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Selenium	SB12	High	4.09	0.004	0.014	0.0001	1.1	0.0001	1.00	0.009	1.60	0.36	1.56			X
Silver	SB12	High	0.89	0.004	0.0031	0.0001	0.85	0.000	1.00	0.009	0.36	0.00	0.00			
Zinc	SB12	High	270.48	0.004	0.95	0.0001	196	0.02	1.00	0.009	107.02	12.47	863.96		X	
Antimony	SB12	Low	2.65	0.003	0.01	0.0001	5	0.00	1.00	0.016	0.45	0.15	1.46		X	
Arsenic	SB12	Low	30.23	0.003	0.0786	0.0001	6.6	0.000	1.00	0.016	4.94	0.68	7.61		X	
Barium	SB12	Low	76.75	0.003	0.1996	0.0001	404	0.025	1.00	0.016	14.05	11.65	42.82		X	
Beryllium	SB12	Low	0.11	0.003	0.0003	0.0001	0.52	0.000	1.00	0.016	0.02	0.00	0.00			
Cadmium	SB12	Low	0.06	0.003	0.0002	0.0001	0.035	0.000	1.00	0.016	0.01	0.07	3.12	X		
Chromium	SB12	Low	5.52	0.003	0.0144	0.0001	27.6	0.002	1.00	0.016	1.00	7.09	28.42	X		
Copper	SB12	Low	75.29	0.003	0.196	0.0001	71.7	0.00	1.00	0.016	12.53	3.12	704.00		X	
Lead	SB12	Low	14.98	0.003	0.0389	0.0001	749	0.05	1.00	0.016	5.36	0.003	250.22		X	
Mercury	SB12	Low	0.39	0.003	0.00102	0.0001	0.03	0.00000	1.00	0.016	0.06	0.29	4.87	X		
Molybdenum	SB12	Low	4.69	0.003	0.0122	0.0001	0.365	0.000	1.00	0.016	0.76	0.30	3.04		X	
Selenium	SB12	Low	4.09	0.003	0.011	0.0001	1.1	0.0001	1.00	0.016	0.67	0.06	1.35		X	
Silver	SB12	Low	0.89	0.003	0.0023	0.0001	0.85	0.000	1.00	0.016	0.15	0.00	0.00			
Zinc	SB12	Low	270.48	0.003	0.70	0.0001	196	0.01	1.00	0.016	44.72	10.80	748.21		X	
Antimony	SB13	High	1.33	0.004	0.00	0.0001	2.5	0.00	1.00	0.009	0.54	0.17	1.69		X	
Arsenic	SB13	High	90.23	0.004	0.3158	0.0001	19.7	0.002	1.00	0.009	35.27	0.79	8.79			X
Barium	SB13	High	129.20	0.004	0.4522	0.0001	680	0.057	1.00	0.009	56.59	13.45	49.44			X
Beryllium	SB13	High	0.00	0.004	0.0000	0.0001	0.009	0.000	1.00	0.009	0.00	0.00	0.00			
Cadmium	SB13	High	0.06	0.004	0.0002	0.0001	0.0355	0.000	1.00	0.009	0.02	0.08	3.61	X		
Chromium	SB13	High	9.08	0.004	0.0318	0.0001	45.4	0.004	1.00	0.009	3.95	8.19	32.81	X		
Copper	SB13	High	1081.50	0.004	3.785	0.0001	1030	0.09	1.00	0.009	430.20	3.61	812.91		X	
Lead	SB13	High	11.94	0.004	0.0418	0.0001	597	0.05	1.00	0.009	10.22	0.003	288.93		X	
Mercury	SB13	High	5.10	0.004	0.01784	0.0001	0.39	0.00003	1.00	0.009	1.99	0.30	5.04		X	
Molybdenum	SB13	High	3870.86	0.004	13.5480	0.0001	301	0.025	1.00	0.009	1508.14	0.35	3.51			X
Selenium	SB13	High	8.93	0.004	0.031	0.0001	2.4	0.0002	1.00	0.009	3.49	0.06	1.56			X
Silver	SB13	High	2.63	0.004	0.0092	0.0001	2.5	0.000	1.00	0.009	1.04	0.00	0.00			
Zinc	SB13	High	1258.56	0.004	4.40	0.0001	912	0.08	1.00	0.009	497.95	12.47	863.96		X	
Antimony	SB13	Low	1.33	0.003	0.00	0.0001	2.5	0.00	1.00	0.016	0.23	0.15	1.46		X	
Arsenic	SB13	Low	90.23	0.003	0.2346	0.0001	19.7	0.001	1.00	0.016	14.74	0.68	7.61			X
Barium	SB13	Low	129.20	0.003	0.3359	0.0001	680	0.042	1.00	0.016	23.65	11.65	42.82		X	
Beryllium	SB13	Low	0.00	0.003	0.0000	0.0001	0.009	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SB13	Low	0.06	0.003	0.0002	0.0001	0.0355	0.000	1.00	0.016	0.01	0.07	3.12	X		
Chromium	SB13	Low	9.08	0.003	0.0236	0.0001	45.4	0.003	1.00	0.016	1.65	7.09	28.42	X		
Copper	SB13	Low	1081.50	0.003	2.812	0.0001	1030	0.06	1.00	0.016	179.76	3.12	704.00		X	
Lead	SB13	Low	11.94	0.003	0.0310	0.0001	597	0.04	1.00	0.016	4.27	0.003	250.22		X	
Mercury	SB13	Low	5.10	0.003	0.01325	0.0001	0.39	0.00002	1.00	0.016	0.83	0.29	4.87		X	
Molybdenum	SB13	Low	3870.86	0.003	10.0642	0.0001	301	0.019	1.00	0.016	630.19	0.30	3.04			X
Selenium	SB13	Low	8.93	0.003	0.023	0.0001	2.4	0.0001	1.00	0.016	1.46	0.06	1.35			X
Silver	SB13	Low	2.63	0.003	0.0068	0.0001	2.5	0.000	1.00	0.016	0.44	0.00	0.00			
Zinc	SB13	Low	1258.56	0.003	3.27	0.0001	912	0.06	1.00	0.016	208.07	10.80	748.21		X	
Antimony	SB14	High	3.39	0.004	0.01	0.0001	6.4	0.00	1.00	0.009	1.38	0.17	1.69		X	
Arsenic	SB14	High	281.21	0.004	0.9842	0.0001	51.4	0.005	1.00	0.009	109.93	0.79	8.79			X
Barium	SB14	High	216.60	0.004	0.7581	0.0001	2140	0.196	1.00	0.009	94.87	13.45	49.44			X
Beryllium	SB14	High	0.00	0.004	0.0000	0.0001	0.009	0.000	1.00	0.009	0.00	0.00	0.00			
Cadmium	SB14	High	0.06	0.004	0.0002	0.0001	0.035	0.000	1.00	0.009	0.02	0.08	3.61	X		
Chromium	SB14	High	15.60	0.004	0.0546	0.0001	78	0.007	1.00	0.009	6.79	8.19	32.81	X		
Copper	SB14	High	283.50	0.004	0.992	0.0001	270	0.02	1.00	0.009	112.77	3.61	812.91		X	
Lead	SB14	High	65.60	0.004	0.2296	0.0001	3280	0.28	1.00	0.009	55.12	0.003	288.93		X	

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APPENDIX I2
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Mercury	SB14	High	1.05	0.004	0.00366	0.0003	0.08	0.00001	1.00	0.009	0.41	0.30	5.04		X	
Molybdenum	SB14	High	64.30	0.004	0.2251	0.0003	5	0.000	1.00	0.009	25.05	0.35	3.51			X
Selenium	SB14	High	29.02	0.004	0.102	0.0003	7.8	0.0007	1.00	0.009	11.36	0.06	1.56			X
Silver	SB14	High	2.73	0.004	0.0096	0.0003	2.6	0.000	1.00	0.009	1.09	0.00	0.00			
Zinc	SB14	High	2290.80	0.004	8.02	0.0003	1660	0.14	1.00	0.009	906.36	12.47	863.96			X
Antimony	SB14	Low	3.39	0.003	0.01	0.0001	6.4	0.00	1.00	0.016	0.58	0.15	1.46		X	
Arsenic	SB14	Low	281.21	0.003	0.7312	0.0001	61.4	0.004	1.00	0.016	45.94	0.68	7.61			X
Barium	SB14	Low	216.63	0.003	0.5632	0.0001	1140	0.071	1.00	0.016	39.64	11.65	42.82		X	
Beryllium	SB14	Low	0.00	0.003	0.0000	0.0001	0.009	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SB14	Low	0.06	0.003	0.0002	0.0001	0.035	0.000	1.00	0.016	0.04	0.07	3.12	X		
Chromium	SB14	Low	15.60	0.003	0.0406	0.0001	78	0.005	1.00	0.016	2.84	7.09	28.42	X		
Copper	SB14	Low	283.50	0.003	0.737	0.0001	270	0.02	1.00	0.016	47.12	3.12	704.00		X	
Lead	SB14	Low	65.60	0.003	0.1706	0.0001	3280	0.20	1.00	0.016	23.45	0.003	250.22		X	
Mercury	SB14	Low	1.05	0.003	0.00272	0.0001	0.08	0.00000	1.00	0.016	0.17	0.29	4.87	X		
Molybdenum	SB14	Low	64.30	0.003	0.1672	0.0001	5	0.000	1.00	0.016	10.47	0.30	3.04			X
Selenium	SB14	Low	29.02	0.003	0.075	0.0001	7.8	0.0005	1.00	0.016	4.75	0.06	1.35			X
Silver	SB14	Low	2.73	0.003	0.0071	0.0001	2.6	0.000	1.00	0.016	0.45	0.00	0.00			
Zinc	SB14	Low	2290.80	0.003	5.96	0.0001	1660	0.10	1.00	0.016	378.73	10.80	748.21		X	
Antimony	SB15	High	13.94	0.004	0.05	0.0001	26.3	0.00	1.00	0.009	5.67	0.17	1.69			X
Arsenic	SB15	High	264.27	0.004	0.9249	0.0001	57.7	0.005	1.00	0.009	103.31	0.79	8.79			X
Barium	SB15	High	129.77	0.004	0.4542	0.0001	683	0.057	1.00	0.009	56.84	13.45	49.44			X
Beryllium	SB15	High	0.00	0.004	0.0000	0.0001	0.016	0.000	1.00	0.009	0.00	0.00	0.00			
Cadmium	SB15	High	0.11	0.004	0.0004	0.0001	0.065	0.000	1.00	0.009	0.04	0.08	3.61	X		
Chromium	SB15	High	598.00	0.004	2.0930	0.0001	2990	0.251	1.00	0.009	260.46	8.19	32.81			X
Copper	SB15	High	762.30	0.004	2.668	0.0001	726	0.06	1.00	0.009	303.23	3.61	812.93		X	
Lead	SB15	High	20.40	0.004	0.0714	0.0001	1020	0.09	1.00	0.009	17.45	0.003	288.93		X	
Mercury	SB15	High	2.03	0.004	0.00709	0.0001	0.155	0.00001	1.00	0.009	0.79	0.30	5.04		X	
Molybdenum	SB15	High	99.02	0.004	0.3466	0.0001	7.7	0.001	1.00	0.009	38.58	0.35	3.51			X
Selenium	SB15	High	25.30	0.004	0.089	0.0001	6.8	0.0006	1.00	0.009	9.90	0.06	1.56			X
Silver	SB15	High	2.94	0.004	0.0103	0.0001	2.8	0.000	1.00	0.009	1.17	0.00	0.00			
Zinc	SB15	High	2125.20	0.004	7.44	0.0001	1540	0.13	1.00	0.009	840.84	12.47	863.96		X	
Antimony	SB15	Low	13.94	0.003	0.04	0.0001	26.3	0.00	1.00	0.016	2.37	0.15	1.46			X
Arsenic	SB15	Low	264.27	0.003	0.6871	0.0001	57.7	0.004	1.00	0.016	43.17	0.68	7.61			X
Barium	SB15	Low	129.77	0.003	0.3374	0.0001	683	0.043	1.00	0.016	23.75	11.65	42.82		X	
Beryllium	SB15	Low	0.00	0.003	0.0000	0.0001	0.016	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SB15	Low	0.11	0.003	0.0003	0.0001	0.065	0.000	1.00	0.016	0.02	0.07	3.12	X		
Chromium	SB15	Low	598.00	0.003	1.5548	0.0001	2990	0.187	1.00	0.016	108.84	7.09	28.42			X
Copper	SB15	Low	762.30	0.003	1.982	0.0001	726	0.05	1.00	0.016	126.71	3.12	704.00		X	
Lead	SB15	Low	20.40	0.003	0.0530	0.0001	1020	0.06	1.00	0.016	7.29	0.003	250.22		X	
Mercury	SB15	Low	2.03	0.003	0.00527	0.0001	0.155	0.00001	1.00	0.016	0.33	0.29	4.87		X	
Molybdenum	SB15	Low	99.02	0.003	0.2575	0.0001	7.7	0.000	1.00	0.016	16.12	0.30	3.04			X
Selenium	SB15	Low	25.30	0.003	0.066	0.0001	6.8	0.0004	1.00	0.016	4.14	0.06	1.35			X
Silver	SB15	Low	2.94	0.003	0.0076	0.0001	2.8	0.000	1.00	0.016	0.49	0.00	0.00			
Zinc	SB15	Low	2125.20	0.003	5.53	0.0001	1540	0.10	1.00	0.016	353.35	10.80	748.21		X	
Antimony	SB16	High	0.77	0.004	0.00	0.0001	1.45	0.00	1.00	0.009	0.31	0.17	1.69		X	
Arsenic	SB16	High	43.51	0.004	0.1523	0.0001	9.5	0.001	1.00	0.009	17.01	0.79	8.79			X
Barium	SB16	High	23.37	0.004	0.0818	0.0001	123	0.010	1.00	0.009	10.24	13.45	49.44	X		
Beryllium	SB16	High	0.01	0.004	0.0000	0.0001	0.0495	0.000	1.00	0.009	0.00	0.00	0.30			
Cadmium	SB16	High	0.34	0.004	0.0012	0.0001	0.2	0.000	1.00	0.009	0.13	0.08	3.61		X	
Chromium	SB16	High	0.18	0.004	0.0006	0.0001	0.89	0.000	1.00	0.009	0.08	8.19	32.81	X		

DS.0309.15131

APPENDIX I2
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Copper	SB16	High	1.16	0.004	0.004	0.0001	1.1	0.00	1.00	0.009	0.46	3.61	812.91	X		
Lead	SB16	High	0.03	0.004	0.0001	0.0001	1.7	0.00	1.00	0.009	0.03	0.003	288.93		X	
Mercury	SB16	High	6.47	0.004	0.02264	0.0001	0.495	0.00004	1.00	0.009	2.52	0.30	5.04		X	
Molybdenum	SB16	High	15.43	0.004	0.0540	0.0001	1.2	0.000	1.00	0.009	6.01	0.35	3.51			X
Selenium	SB16	High	7.44	0.004	0.026	0.0001	2	0.0002	1.00	0.009	2.91	0.06	1.56			X
Silver	SB16	High	0.58	0.004	0.0020	0.0001	0.55	0.000	1.00	0.009	0.23	0.00	0.00			
Zinc	SB16	High	4.42	0.004	0.02	0.0001	3.2	0.00	1.00	0.009	1.75	12.47	863.96	X		
Antimony	SB16	Low	0.77	0.003	0.00	0.0001	1.45	0.00	1.00	0.016	0.13	0.15	1.46	X		
Arsenic	SB16	Low	43.51	0.003	0.1131	0.0001	9.5	0.001	1.00	0.016	7.11	0.68	7.61		X	
Barium	SB16	Low	23.37	0.003	0.0606	0.0001	123	0.008	1.00	0.016	4.28	11.65	42.82	X		
Beryllium	SB16	Low	0.01	0.003	0.0000	0.0001	0.0495	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SB16	Low	0.34	0.003	0.0009	0.0001	0.2	0.000	1.00	0.016	0.06	0.07	3.12	X		
Chromium	SB16	Low	0.18	0.003	0.0005	0.0001	0.89	0.000	1.00	0.016	0.03	7.09	28.42	X		
Copper	SB16	Low	1.16	0.003	0.003	0.0001	1.1	0.00	1.00	0.016	0.19	3.12	704.00	X		
Lead	SB16	Low	0.03	0.003	0.0001	0.0001	1.7	0.00	1.00	0.016	0.01	0.003	250.22		X	
Mercury	SB16	Low	6.47	0.003	0.01682	0.0001	0.495	0.000003	1.00	0.016	1.05	0.29	4.87		X	
Molybdenum	SB16	Low	15.43	0.003	0.0401	0.0001	1.2	0.000	1.00	0.016	2.51	0.30	3.04		X	
Selenium	SB16	Low	7.44	0.003	0.019	0.0001	2	0.0001	1.00	0.016	1.22	0.06	1.35		X	
Silver	SB16	Low	0.58	0.003	0.0015	0.0001	0.55	0.000	1.00	0.016	0.10	0.00	0.00			
Zinc	SB16	Low	4.42	0.003	0.01	0.0001	3.2	0.00	1.00	0.016	0.73	10.80	748.21	X		
Antimony	SB17	High	0.21	0.004	0.00	0.0001	0.39	0.00	1.00	0.009	0.04	0.17	1.69	X		
Arsenic	SB17	High	1.56	0.004	0.0055	0.0001	0.34	0.000	1.00	0.009	0.61	0.79	8.79	X		
Barium	SB17	High	1.06	0.004	0.0037	0.0001	5.6	0.000	1.00	0.009	0.47	13.45	49.44	X		
Beryllium	SB17	High	0.00	0.004	0.0000	0.0001	0.007	0.000	1.00	0.009	0.00	0.00	0.00			
Cadmium	SB17	High	0.05	0.004	0.0002	0.0001	0.027	0.000	1.00	0.009	0.02	0.08	3.61	X		
Chromium	SB17	High	34.80	0.004	0.1218	0.0001	174	0.015	1.00	0.009	15.16	8.29	32.81		X	
Copper	SB17	High	540.75	0.004	1.893	0.0001	515	0.04	1.00	0.009	215.10	3.61	812.91		X	
Lead	SB17	High	40.60	0.004	0.1421	0.0001	2030	0.17	1.00	0.009	34.74	0.003	288.93		X	
Mercury	SB17	High	0.91	0.004	0.00320	0.0001	0.07	0.00001	1.00	0.009	0.36	0.30	5.04		X	
Molybdenum	SB17	High	88.73	0.004	0.3106	0.0001	6.9	0.001	1.00	0.009	34.57	0.35	3.51			X
Selenium	SB17	High	44.64	0.004	0.156	0.0001	12	0.0010	1.00	0.009	17.47	0.06	1.56			X
Silver	SB17	High	0.08	0.004	0.0003	0.0001	0.075	0.000	1.00	0.009	0.03	0.00	0.00			
Zinc	SB17	High	2842.80	0.004	9.95	0.0001	2060	0.17	1.00	0.009	1124.76	12.47	863.96			X
Antimony	SB17	Low	0.21	0.003	0.00	0.0001	0.39	0.00	1.00	0.016	0.04	0.15	1.46	X		
Arsenic	SB17	Low	1.56	0.003	0.0040	0.0001	0.34	0.000	1.00	0.016	0.25	0.68	7.61	X		
Barium	SB17	Low	1.06	0.003	0.0028	0.0001	5.6	0.000	1.00	0.016	0.19	11.65	42.82	X		
Beryllium	SB17	Low	0.00	0.003	0.0000	0.0001	0.007	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SB17	Low	0.05	0.003	0.0001	0.0001	0.027	0.000	1.00	0.016	0.01	0.07	3.12	X		
Chromium	SB17	Low	34.80	0.003	0.0905	0.0001	174	0.014	1.00	0.016	6.33	7.09	28.42	X		
Copper	SB17	Low	540.75	0.003	1.406	0.0001	515	0.03	1.00	0.016	89.88	3.12	704.00		X	
Lead	SB17	Low	40.60	0.003	0.1056	0.0001	2030	0.13	1.00	0.016	14.51	0.003	250.22		X	
Mercury	SB17	Low	0.91	0.003	0.00238	0.0001	0.07	0.00000	1.00	0.016	0.15	0.29	4.87	X		
Molybdenum	SB17	Low	88.73	0.003	0.2307	0.0001	6.9	0.000	1.00	0.016	14.45	0.30	3.04			X
Selenium	SB17	Low	44.64	0.003	0.116	0.0001	12	0.0007	1.00	0.016	7.30	0.06	1.35			X
Silver	SB17	Low	0.08	0.003	0.0002	0.0001	0.075	0.000	1.00	0.016	0.01	0.00	0.00			
Zinc	SB17	Low	2842.80	0.003	7.39	0.0001	2060	0.13	1.00	0.016	469.99	10.80	748.21		X	
Antimony	SB18	High	3.07	0.004	0.01	0.0001	5.8	0.00	1.00	0.009	1.25	0.17	1.69		X	
Arsenic	SB18	High	485.48	0.004	1.6992	0.0001	106	0.009	1.00	0.009	189.79	0.79	8.79			X
Barium	SB18	High	36.86	0.004	0.1290	0.0001	194	0.016	1.00	0.009	16.15	12.45	49.44		X	
Beryllium	SB18	High	0.00	0.004	0.0000	0.0001	0.0115	0.000	1.00	0.009	0.00	0.00	0.00			

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APPENDIX I2
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Cadmium	SB18	High	0.08	0.004	0.0003	0.0001	0.046	0.000	1.00	0.009	0.03	0.08	3.61	X		
Chromium	SB18	High	9.58	0.004	0.0335	0.0001	47.9	0.004	1.00	0.009	4.17	8.19	32.81	X		
Copper	SB18	High	1753.50	0.004	6.137	0.0001	1670	0.14	1.00	0.009	697.50	3.61	812.91		X	
Lead	SB18	High	25.40	0.004	0.0889	0.0001	1270	0.11	1.00	0.009	21.73	0.003	288.93		X	
Mercury	SB18	High	1.44	0.004	0.00503	0.0001	0.11	0.00001	1.00	0.009	0.56	0.30	5.04		X	
Molybdenum	SB18	High	84.88	0.004	0.2971	0.0001	6.6	0.001	1.00	0.009	33.07	0.35	3.51			X
Selenium	SB18	High	28.27	0.004	0.099	0.0001	7.6	0.0006	1.00	0.009	11.07	0.06	1.56			X
Silver	SB18	High	0.13	0.004	0.0005	0.0001	0.125	0.000	1.00	0.009	0.05	0.00	0.00			
Zinc	SB18	High	1559.40	0.004	5.46	0.0001	1130	0.09	1.00	0.009	516.98	12.47	853.96		X	
Antimony	SB18	Low	3.07	0.003	0.01	0.0001	5.8	0.00	1.00	0.016	0.52	0.15	1.46		X	
Arsenic	SB18	Low	485.48	0.003	1.2622	0.0001	106	0.007	1.00	0.016	79.30	0.68	7.61			X
Barium	SB18	Low	36.86	0.003	0.0958	0.0001	194	0.012	1.00	0.016	6.75	11.65	42.82	X		
Beryllium	SB18	Low	0.00	0.003	0.0000	0.0001	0.0115	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SB18	Low	0.08	0.003	0.0002	0.0001	0.046	0.000	1.00	0.016	0.01	0.07	3.12	X		
Chromium	SB18	Low	9.58	0.003	0.0249	0.0001	47.9	0.003	1.00	0.016	1.74	7.09	28.42	X		
Copper	SB18	Low	1753.50	0.003	4.559	0.0001	1670	0.10	1.00	0.016	291.46	3.12	704.00		X	
Lead	SB18	Low	25.40	0.003	0.0660	0.0001	1270	0.08	1.00	0.016	9.08	0.003	250.22		X	
Mercury	SB18	Low	1.44	0.003	0.00374	0.0001	0.11	0.00001	1.00	0.016	0.23	0.29	4.87	X		
Molybdenum	SB18	Low	84.88	0.003	0.2207	0.0001	6.6	0.000	1.00	0.016	13.82	0.30	3.04			X
Selenium	SB18	Low	28.27	0.003	0.074	0.0001	7.6	0.0005	1.00	0.016	4.62	0.06	1.35			X
Silver	SB18	Low	0.13	0.003	0.0003	0.0001	0.125	0.000	1.00	0.016	0.02	0.00	0.00			
Zinc	SB18	Low	1559.40	0.003	4.05	0.0001	1130	0.07	1.00	0.016	257.81	10.80	748.21		X	
Antimony	SB19	High	2.01	0.004	0.01	0.0001	3.8	0.00	1.00	0.009	0.82	0.17	1.69		X	
Arsenic	SB19	High	241.37	0.004	0.8448	0.0001	52.7	0.004	1.00	0.009	94.36	0.79	8.79			X
Barium	SB19	High	34.96	0.004	0.1224	0.0001	184	0.015	1.00	0.009	15.31	13.45	49.44		X	
Beryllium	SB19	High	0.00	0.004	0.0000	0.0001	0.008	0.000	1.00	0.009	0.00	0.00	0.00			
Cadmium	SB19	High	0.05	0.004	0.0002	0.0001	0.0325	0.000	1.00	0.009	0.02	0.08	3.61	X		
Chromium	SB19	High	17.00	0.004	0.0595	0.0001	85	0.007	1.00	0.009	7.40	8.19	32.81	X		
Copper	SB19	High	453.60	0.004	1.588	0.0001	432	0.04	1.00	0.009	180.43	3.61	812.91		X	
Lead	SB19	High	32.80	0.004	0.1148	0.0001	1640	0.14	1.00	0.009	28.06	0.003	288.93		X	
Mercury	SB19	High	1.11	0.004	0.00389	0.0001	0.085	0.00001	1.00	0.009	0.43	0.30	5.04		X	
Molybdenum	SB19	High	77.16	0.004	0.2701	0.0001	6	0.001	1.00	0.009	30.06	0.35	3.51			X
Selenium	SB19	High	42.78	0.004	0.150	0.0001	11.5	0.0010	1.00	0.009	16.74	0.06	1.56			X
Silver	SB19	High	0.09	0.004	0.0003	0.0001	0.09	0.000	1.00	0.009	0.04	0.00	0.00			
Zinc	SB19	High	1017.06	0.004	3.56	0.0001	737	0.06	1.00	0.009	402.40	12.47	863.96		X	
Antimony	SB19	Low	2.01	0.003	0.01	0.0001	3.8	0.00	1.00	0.016	0.34	0.15	1.46		X	
Arsenic	SB19	Low	241.37	0.003	0.6276	0.0001	52.7	0.003	1.00	0.016	39.43	0.68	7.61			X
Barium	SB19	Low	34.96	0.003	0.0909	0.0001	184	0.011	1.00	0.016	6.40	11.65	42.82	X		
Beryllium	SB19	Low	0.00	0.003	0.0000	0.0001	0.008	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SB19	Low	0.05	0.003	0.0001	0.0001	0.0325	0.000	1.00	0.016	0.01	0.07	3.12	X		
Chromium	SB19	Low	17.00	0.003	0.0442	0.0001	85	0.005	1.00	0.016	3.09	7.09	28.42	X		
Copper	SB19	Low	453.60	0.003	1.179	0.0001	432	0.03	1.00	0.016	75.39	3.12	704.00		X	
Lead	SB19	Low	32.80	0.003	0.0853	0.0001	1640	0.10	1.00	0.016	11.73	0.003	250.22		X	
Mercury	SB19	Low	1.11	0.003	0.00289	0.0001	0.085	0.00001	1.00	0.016	0.18	0.29	4.87	X		
Molybdenum	SB19	Low	77.16	0.003	0.2006	0.0001	6	0.000	1.00	0.016	12.56	0.30	3.04			X
Selenium	SB19	Low	42.78	0.003	0.111	0.0001	11.5	0.0007	1.00	0.016	7.00	0.06	1.35			X
Silver	SB19	Low	0.09	0.003	0.0002	0.0001	0.09	0.000	1.00	0.016	0.02	0.00	0.00			
Zinc	SB19	Low	1017.06	0.003	2.64	0.0001	737	0.05	1.00	0.016	168.15	10.80	748.21		X	
Antimony	SB20	High	3.43	0.004	0.01	0.0001	2.7	0.00	1.00	0.009	0.58	0.17	1.69		X	
Arsenic	SB20	High	104.88	0.004	0.3671	0.0001	22.9	0.002	1.00	0.009	41.00	0.79	8.79			X

APPENDIX I2
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Barium	SB20	High	63.84	0.004	0.2234	0.0001	336	0.028	1.00	0.009	27.96	13.45	49.44		X	
Beryllium	SB20	High	0.00	0.004	0.0000	0.0001	0.0375	0.000	1.00	0.009	0.00	0.00	0.00			
Cadmium	SB20	High	0.05	0.004	0.0002	0.0001	0.03	0.000	1.00	0.009	0.02	0.08	3.61	X		
Chromium	SB20	High	14.92	0.004	0.0522	0.0001	74.6	0.006	1.00	0.009	6.50	8.19	32.81	X		
Copper	SB20	High	2079.00	0.004	7.277	0.0001	1980	0.17	1.00	0.009	826.98	3.61	812.91			X
Lead	SB20	High	23.60	0.004	0.0826	0.0001	1180	0.10	1.00	0.009	20.19	0.003	288.93		X	
Mercury	SB20	High	8.36	0.004	0.02928	0.0001	0.64	0.00005	1.00	0.009	3.26	0.30	5.04		X	
Molybdenum	SB20	High	37.29	0.004	0.1305	0.0001	2.9	0.000	1.00	0.009	14.53	0.35	3.51			X
Selenium	SB20	High	15.62	0.004	0.055	0.0001	4.2	0.0004	1.00	0.009	6.12	0.06	1.56			X
Silver	SB20	High	0.09	0.004	0.0003	0.0001	0.085	0.000	1.00	0.009	0.04	0.00	0.00			
Zinc	SB20	High	2484.00	0.004	8.69	0.0001	1800	0.15	1.00	0.009	982.80	12.47	863.96			X
Antimony	SB20	Low	1.43	0.003	0.00	0.0001	2.7	0.00	1.00	0.016	0.24	0.15	1.46		X	
Arsenic	SB20	Low	104.88	0.003	0.2727	0.0001	22.9	0.001	1.00	0.016	17.13	0.68	7.61			X
Barium	SB20	Low	63.84	0.003	0.1660	0.0001	336	0.021	1.00	0.016	11.68	11.65	42.82		X	
Beryllium	SB20	Low	0.00	0.003	0.0000	0.0001	0.0375	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SB20	Low	0.05	0.003	0.0002	0.0001	0.03	0.000	1.00	0.016	0.01	0.07	3.12	X		
Chromium	SB20	Low	14.92	0.003	0.0388	0.0001	74.6	0.005	1.00	0.016	2.72	7.09	28.42	X		
Copper	SB20	Low	2079.00	0.003	5.405	0.0001	1980	0.12	1.00	0.016	345.56	3.12	704.00		X	
Lead	SB20	Low	23.60	0.003	0.0614	0.0001	1180	0.07	1.00	0.016	8.44	0.003	250.22		X	
Mercury	SB20	Low	8.36	0.003	0.02175	0.0001	0.64	0.00004	1.00	0.016	1.36	0.29	4.87		X	
Molybdenum	SB20	Low	37.29	0.003	0.0970	0.0001	2.9	0.000	1.00	0.016	6.07	0.30	3.04			X
Selenium	SB20	Low	15.62	0.003	0.041	0.0001	4.2	0.0003	1.00	0.016	2.56	0.06	1.35			X
Silver	SB20	Low	0.09	0.003	0.0002	0.0001	0.085	0.000	1.00	0.016	0.01	0.00	0.00			
Zinc	SB20	Low	2484.00	0.003	6.46	0.0001	1800	0.11	1.00	0.016	410.67	10.80	748.21		X	
Antimony	SS206	High	0.64	0.004	0.00	0.0001	1.2	0.00	1.00	0.009	0.26	0.17	1.69		X	
Arsenic	SS206	High	35.27	0.004	0.1234	0.0001	7.7	0.001	1.00	0.009	13.79	0.79	8.79			X
Barium	SS206	High	40.85	0.004	0.1430	0.0001	215	0.018	1.00	0.009	17.89	13.45	49.44		X	
Beryllium	SS206	High	0.00	0.004	0.0000	0.0001	0.0033	0.000	1.00	0.009	0.00	0.00	0.00			
Cadmium	SS206	High	2.70	0.004	0.0095	0.0001	1.6	0.000	1.00	0.009	1.07	0.08	3.61		X	
Chromium	SS206	High	5.78	0.004	0.0202	0.0001	28.9	0.002	1.00	0.009	2.52	8.19	32.81	X		
Copper	SS206	High	593.25	0.004	2.076	0.0001	565	0.05	1.00	0.009	235.98	3.61	812.91		X	
Lead	SS206	High	9.72	0.004	0.0340	0.0001	486	0.04	1.00	0.009	8.32	0.003	288.93		X	
Mercury	SS206	High	0.33	0.004	0.00114	0.0001	0.025	0.00000	1.00	0.009	0.13	0.30	5.04	X		
Molybdenum	SS206	High	8.62	0.004	0.0302	0.0001	0.67	0.000	1.00	0.009	3.36	0.35	3.51		X	
Selenium	SS206	High	0.37	0.004	0.001	0.0001	0.1	0.0000	1.00	0.009	0.15	0.06	1.56		X	
Silver	SS206	High	7.04	0.004	0.0246	0.0001	6.7	0.001	1.00	0.009	2.80	0.00	0.00			
Zinc	SS206	High	1356.54	0.004	4.75	0.0001	983	0.08	1.00	0.009	536.72	12.47	863.96		X	
Antimony	SS206	Low	0.64	0.003	0.00	0.0001	1.2	0.00	1.00	0.016	0.11	0.15	1.46	X		
Arsenic	SS206	Low	35.27	0.003	0.0917	0.0001	7.7	0.000	1.00	0.016	5.76	0.68	7.61		X	
Barium	SS206	Low	40.85	0.003	0.1062	0.0001	215	0.013	1.00	0.016	7.48	11.65	42.82	X		
Beryllium	SS206	Low	0.00	0.003	0.0000	0.0001	0.0033	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SS206	Low	2.70	0.003	0.0070	0.0001	1.6	0.000	1.00	0.016	0.45	0.07	3.12		X	
Chromium	SS206	Low	5.78	0.003	0.0150	0.0001	28.9	0.002	1.00	0.016	1.05	7.09	28.42	X		
Copper	SS206	Low	593.25	0.003	1.542	0.0001	565	0.04	1.00	0.016	98.61	3.12	704.00		X	
Lead	SS206	Low	9.72	0.003	0.0253	0.0001	486	0.03	1.00	0.016	3.47	0.003	250.22		X	
Mercury	SS206	Low	0.33	0.003	0.00085	0.0001	0.025	0.00000	1.00	0.016	0.05	0.29	4.87	X		
Molybdenum	SS206	Low	8.62	0.003	0.0224	0.0001	0.67	0.000	1.00	0.016	1.40	0.30	3.04		X	
Selenium	SS206	Low	0.37	0.003	0.001	0.0001	0.1	0.0000	1.00	0.016	0.06	0.06	1.35		X	
Silver	SS206	Low	7.04	0.003	0.0183	0.0001	6.7	0.001	1.00	0.016	1.17	0.00	0.00			
Zinc	SS206	Low	1356.54	0.003	3.53	0.0001	983	0.06	1.00	0.016	224.27	10.80	748.21		X	

APPENDIX 12
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Antimony	SS210	High	NA	0.004	#VALUE!	0.0001	NA	#VALUE!	1.00	0.009	#VALUE!	0.17	1.69	#VALUE!	#VALUE!	#VALUE!
Arsenic	SS210	High	21.53	0.004	0.0753	0.0001	4.7	0.000	1.00	0.009	8.42	0.79	8.79		X	
Barium	SS210	High	20.90	0.004	0.0732	0.0001	110	0.009	1.00	0.009	9.15	13.45	49.44	X		
Beryllium	SS210	High	0.00	0.004	0.0000	0.0001	0.003	0.000	1.00	0.009	0.00	0.00	0.00			
Cadmium	SS210	High	0.64	0.004	0.0022	0.0001	0.38	0.000	1.00	0.009	0.25	0.08	3.61		X	
Chromium	SS210	High	4.66	0.004	0.0163	0.0001	23.3	0.002	1.00	0.009	2.03	8.19	32.81	X		
Copper	SS210	High	13.97	0.004	0.049	0.0001	13.3	0.001	1.00	0.009	5.55	3.61	812.91		X	
Lead	SS210	High	0.60	0.004	0.0021	0.0001	29.8	0.001	1.00	0.009	0.51	0.003	288.93		X	
Mercury	SS210	High	0.33	0.004	0.00114	0.0001	0.025	0.00000	1.00	0.009	0.13	0.30	5.04	X		
Molybdenum	SS210	High	1.16	0.004	0.0041	0.0001	0.09	0.000	1.00	0.009	0.45	0.35	3.51		X	
Selenium	SS210	High	0.78	0.004	0.003	0.0001	0.21	0.0000	1.00	0.009	0.31	0.06	1.56		X	
Silver	SS210	High	0.04	0.004	0.0001	0.0001	0.037	0.000	1.00	0.009	0.02	0.00	0.00			
Zinc	SS210	High	97.15	0.004	0.34	0.0001	70.4	0.01	1.00	0.009	38.44	12.47	863.96		X	
Antimony	SS210	Low	NA	0.003	#VALUE!	0.0001	NA	#VALUE!	1.00	0.016	#VALUE!	0.15	1.46	#VALUE!	#VALUE!	#VALUE!
Arsenic	SS210	Low	21.53	0.003	0.0560	0.0001	4.7	0.000	1.00	0.016	3.52	0.68	7.61		X	
Barium	SS210	Low	20.90	0.003	0.0543	0.0001	110	0.007	1.00	0.016	3.83	11.65	42.82	X		
Beryllium	SS210	Low	0.00	0.003	0.0000	0.0001	0.003	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SS210	Low	0.64	0.003	0.0017	0.0001	0.38	0.000	1.00	0.016	0.11	0.07	3.12		X	
Chromium	SS210	Low	4.66	0.003	0.0121	0.0001	23.3	0.001	1.00	0.016	0.85	7.09	28.42	X		
Copper	SS210	Low	13.97	0.003	0.036	0.0001	13.3	0.00	1.00	0.016	2.32	3.12	704.00	X		
Lead	SS210	Low	0.60	0.003	0.0015	0.0001	29.8	0.00	1.00	0.016	0.21	0.003	250.22		X	
Mercury	SS210	Low	0.33	0.003	0.00085	0.0001	0.025	0.00000	1.00	0.016	0.05	0.29	4.87	X		
Molybdenum	SS210	Low	1.16	0.003	0.0030	0.0001	0.09	0.000	1.00	0.016	0.19	0.30	3.04	X		
Selenium	SS210	Low	0.78	0.003	0.002	0.0001	0.21	0.0000	1.00	0.016	0.13	0.06	1.35		X	
Silver	SS210	Low	0.04	0.003	0.0001	0.0001	0.037	0.000	1.00	0.016	0.01	0.00	0.00			
Zinc	SS210	Low	97.15	0.003	0.25	0.0001	70.4	0.00	1.00	0.016	16.06	10.80	748.21		X	
Antimony	SS211	High	NA	0.004	#VALUE!	0.0001	NA	#VALUE!	1.00	0.009	#VALUE!	0.17	1.69	#VALUE!	#VALUE!	#VALUE!
Arsenic	SS211	High	14.20	0.004	0.0497	0.0001	3.1	0.000	1.00	0.009	5.55	0.79	8.79		X	
Barium	SS211	High	23.75	0.004	0.0831	0.0001	125	0.011	1.00	0.009	10.40	13.45	49.44	X		
Beryllium	SS211	High	0.00	0.004	0.0000	0.0001	0.003	0.000	1.00	0.009	0.00	0.00	0.00			
Cadmium	SS211	High	0.01	0.004	0.0001	0.0001	0.0085	0.000	1.00	0.009	0.01	0.08	3.61	X		
Chromium	SS211	High	3.28	0.004	0.0115	0.0001	16.4	0.001	1.00	0.009	1.43	8.19	32.81	X		
Copper	SS211	High	9.66	0.004	0.034	0.0001	9.2	0.00	1.00	0.009	3.84	3.61	812.91		X	
Lead	SS211	High	0.89	0.004	0.0031	0.0001	44.5	0.00	1.00	0.009	0.76	0.003	288.93		X	
Mercury	SS211	High	0.26	0.004	0.00091	0.0001	0.02	0.00000	1.00	0.009	0.10	0.30	5.04	X		
Molybdenum	SS211	High	1.16	0.004	0.0041	0.0001	0.09	0.000	1.00	0.009	0.45	0.35	3.51		X	
Selenium	SS211	High	0.33	0.004	0.001	0.0001	0.09	0.0000	1.00	0.009	0.13	0.06	1.56		X	
Silver	SS211	High	0.04	0.004	0.0001	0.0001	0.037	0.000	1.00	0.009	0.02	0.00	0.00			
Zinc	SS211	High	64.17	0.004	0.22	0.0001	46.5	0.00	1.00	0.009	25.39	12.47	863.96		X	
Antimony	SS211	Low	NA	0.003	#VALUE!	0.0001	NA	#VALUE!	1.00	0.016	#VALUE!	0.15	1.46	#VALUE!	#VALUE!	#VALUE!
Arsenic	SS211	Low	14.20	0.003	0.0369	0.0001	3.1	0.000	1.00	0.016	2.32	0.68	7.61		X	
Barium	SS211	Low	23.75	0.003	0.0618	0.0001	125	0.008	1.00	0.016	4.55	11.65	42.82	X		
Beryllium	SS211	Low	0.00	0.003	0.0000	0.0001	0.003	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SS211	Low	0.01	0.003	0.0000	0.0001	0.0085	0.000	1.00	0.016	0.00	0.07	3.12	X		
Chromium	SS211	Low	3.28	0.003	0.0085	0.0001	16.4	0.001	1.00	0.016	0.60	7.09	28.42	X		
Copper	SS211	Low	9.66	0.003	0.025	0.0001	9.2	0.00	1.00	0.016	1.61	3.12	704.00	X		
Lead	SS211	Low	0.89	0.003	0.0023	0.0001	44.5	0.00	1.00	0.016	0.32	0.003	250.22		X	
Mercury	SS211	Low	0.26	0.003	0.00068	0.0001	0.02	0.00000	1.00	0.016	0.04	0.29	4.87	X		
Molybdenum	SS211	Low	1.16	0.003	0.0030	0.0001	0.09	0.000	1.00	0.016	0.19	0.30	3.04	X		
Selenium	SS211	Low	0.33	0.003	0.001	0.0001	0.09	0.0000	1.00	0.016	0.05	0.06	1.35	X		

DS.0309.15131

APPENDIX I2
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Silver	SS211	Low	0.04	0.003	0.0001	0.0001	0.037	0.000	1.00	0.016	0.02	0.00	0.00			
Zinc	SS211	Low	64.17	0.003	0.17	0.0001	46.5	0.00	1.00	0.016	10.61	10.80	748.21	X		
Antimony	SS212	High	0.32	0.004	0.00	0.0001	0.6	0.00	1.00	0.009	0.13	0.17	1.69	X		
Arsenic	SS212	High	14.20	0.004	0.0497	0.0001	3.1	0.000	1.00	0.009	5.55	0.79	8.79		X	
Barium	SS212	High	17.33	0.004	0.0695	0.0001	91.2	0.008	1.00	0.009	7.59	13.45	49.44	X		
Beryllium	SS212	High	0.00	0.004	0.0000	0.0001	0.01	0.000	1.00	0.009	0.00	0.00	0.00			
Cadmium	SS212	High	0.61	0.004	0.0021	0.0001	0.36	0.000	1.00	0.009	0.24	0.08	3.61		X	
Chromium	SS212	High	6.24	0.004	0.0218	0.0001	31.2	0.003	1.00	0.009	2.72	8.19	32.81	X		
Copper	SS212	High	20.58	0.004	0.072	0.0001	19.6	0.00	1.00	0.009	8.19	3.61	812.91		X	
Lead	SS212	High	1.13	0.004	0.0039	0.0001	56.3	0.00	1.00	0.009	0.96	0.003	288.93		X	
Mercury	SS212	High	0.33	0.004	0.00114	0.0001	0.025	0.00000	1.00	0.009	0.13	0.30	5.04	X		
Molybdenum	SS212	High	1.03	0.004	0.0036	0.0001	0.08	0.000	1.00	0.009	0.40	0.35	3.51		X	
Selenium	SS212	High	0.32	0.004	0.001	0.0001	0.085	0.0000	1.00	0.009	0.12	0.06	1.56		X	
Silver	SS212	High	0.04	0.004	0.0001	0.0001	0.035	0.000	1.00	0.009	0.01	0.00	0.00			
Zinc	SS212	High	143.52	0.004	0.50	0.0001	104	0.01	1.00	0.009	56.78	12.47	863.96		X	
Antimony	SS212	Low	0.32	0.003	0.00	0.0001	0.6	0.00	1.00	0.016	0.05	0.15	1.46	X		
Arsenic	SS212	Low	14.20	0.003	0.0369	0.0001	3.1	0.000	1.00	0.016	2.32	0.68	7.61		X	
Barium	SS212	Low	17.33	0.003	0.0451	0.0001	91.2	0.006	1.00	0.016	3.17	11.65	42.82	X		
Beryllium	SS212	Low	0.00	0.003	0.0000	0.0001	0.01	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SS212	Low	0.61	0.003	0.0016	0.0001	0.36	0.000	1.00	0.016	0.10	0.07	3.12		X	
Chromium	SS212	Low	6.24	0.003	0.0162	0.0001	31.2	0.002	1.00	0.016	1.14	7.09	28.42	X		
Copper	SS212	Low	20.58	0.003	0.054	0.0001	19.6	0.00	1.00	0.016	3.42	3.12	704.00		X	
Lead	SS212	Low	1.13	0.003	0.0029	0.0001	56.3	0.00	1.00	0.016	0.40	0.003	250.22		X	
Mercury	SS212	Low	0.33	0.003	0.00085	0.0001	0.025	0.00000	1.00	0.016	0.05	0.29	4.87	X		
Molybdenum	SS212	Low	1.03	0.003	0.0027	0.0001	0.08	0.000	1.00	0.016	0.17	0.30	3.04	X		
Selenium	SS212	Low	0.32	0.003	0.001	0.0001	0.085	0.0000	1.00	0.016	0.05	0.06	1.35	X		
Silver	SS212	Low	0.04	0.003	0.0001	0.0001	0.035	0.000	1.00	0.016	0.02	0.00	0.00			
Zinc	SS212	Low	143.52	0.003	0.37	0.0001	104	0.01	1.00	0.016	23.73	10.80	748.21		X	
Antimony	SS213	High	NA	0.004	#VALUE!	0.0001	NA	#VALUE!	1.00	0.009	#VALUE!	0.17	1.69	#VALUE!	#VALUE!	#VALUE!
Arsenic	SS213	High	33.89	0.004	0.1186	0.0001	7.4	0.001	1.00	0.009	13.25	0.79	8.79			X
Barium	SS213	High	22.42	0.004	0.0785	0.0001	118	0.010	1.00	0.009	9.82	13.45	49.44	X		
Beryllium	SS213	High	0.00	0.004	0.0000	0.0001	0.0025	0.000	1.00	0.009	0.00	0.00	0.00			
Cadmium	SS213	High	1.17	0.004	0.0041	0.0001	0.69	0.000	1.00	0.009	0.46	0.08	3.61		X	
Chromium	SS213	High	4.82	0.004	0.0169	0.0001	24.1	0.002	1.00	0.009	2.10	8.19	32.81	X		
Copper	SS213	High	59.96	0.004	0.210	0.0001	57.1	0.00	1.00	0.009	23.85	3.61	812.91		X	
Lead	SS213	High	2.20	0.004	0.0077	0.0001	110	0.01	1.00	0.009	1.88	0.003	288.93		X	
Mercury	SS213	High	3.27	0.004	0.01144	0.0001	0.25	0.00002	1.00	0.009	1.27	0.30	5.04		X	
Molybdenum	SS213	High	1.03	0.004	0.0036	0.0001	0.08	0.000	1.00	0.009	0.40	0.35	3.51		X	
Selenium	SS213	High	0.32	0.004	0.001	0.0001	0.085	0.0000	1.00	0.009	0.12	0.06	1.56		X	
Silver	SS213	High	0.04	0.004	0.0001	0.0001	0.035	0.000	1.00	0.009	0.01	0.00	0.00			
Zinc	SS213	High	465.06	0.004	1.63	0.0001	337	0.03	1.00	0.009	184.00	12.47	863.96		X	
Antimony	SS213	Low	NA	0.003	#VALUE!	0.0001	NA	#VALUE!	1.00	0.016	#VALUE!	0.15	1.46	#VALUE!	#VALUE!	#VALUE!
Arsenic	SS213	Low	33.89	0.003	0.0881	0.0001	7.4	0.000	1.00	0.016	5.54	0.68	7.61		X	
Barium	SS213	Low	22.42	0.003	0.0583	0.0001	118	0.007	1.00	0.016	4.10	11.65	42.82	X		
Beryllium	SS213	Low	0.00	0.003	0.0000	0.0001	0.0025	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SS213	Low	1.17	0.003	0.0030	0.0001	0.69	0.000	1.00	0.016	0.19	0.07	3.12		X	
Chromium	SS213	Low	4.82	0.003	0.0125	0.0001	24.1	0.002	1.00	0.016	0.88	7.09	28.42	X		
Copper	SS213	Low	59.96	0.003	0.156	0.0001	57.1	0.00	1.00	0.016	9.97	3.12	704.00		X	
Lead	SS213	Low	2.20	0.003	0.0057	0.0001	110	0.01	1.00	0.016	0.79	0.003	250.22		X	
Mercury	SS213	Low	3.27	0.003	0.00850	0.0001	0.25	0.00002	1.00	0.016	0.53	0.29	4.87		X	

DS.0309.15131

APPENDIX I2
SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SCF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Molybdenum	SS213	Low	1.03	0.003	0.0027	0.0001	0.08	0.000	1.00	0.016	0.17	0.30	3.04	X		
Selenium	SS213	Low	0.32	0.003	0.001	0.0001	0.085	0.0000	1.00	0.016	0.05	0.06	1.35	X		
Silver	SS213	Low	0.04	0.003	0.0001	0.0001	0.035	0.000	1.00	0.016	0.01	0.00	0.00			
Zinc	SS213	Low	465.06	0.003	1.21	0.0001	337	0.02	1.00	0.016	76.89	10.80	748.21		X	
Antimony	SS214	High	0.23	0.004	0.00	0.0001	0.44	0.00	1.00	0.009	0.09	0.17	1.69	X		
Arsenic	SS214	High	37.10	0.004	0.1298	0.0001	8.1	0.001	1.00	0.009	14.50	0.79	8.79			X
Barium	SS214	High	16.76	0.004	0.0587	0.0001	88.2	0.007	1.00	0.009	7.34	13.45	49.44	X		
Beryllium	SS214	High	0.00	0.004	0.0000	0.0001	0.0025	0.000	1.00	0.009	0.00	0.00	0.00			
Cadmium	SS214	High	0.64	0.004	0.0022	0.0001	0.38	0.000	1.00	0.009	0.25	0.08	3.61		X	
Chromium	SS214	High	4.80	0.004	0.0168	0.0001	24	0.002	1.00	0.009	2.09	8.19	32.81	X		
Copper	SS214	High	18.38	0.004	0.064	0.0001	17.5	0.00	1.00	0.009	7.31	3.61	812.91		X	
Lead	SS214	High	3.90	0.004	0.0137	0.0001	195	0.02	1.00	0.009	3.34	0.003	288.93		X	
Mercury	SS214	High	0.36	0.004	0.00126	0.0001	0.0275	0.00000	1.00	0.009	0.14	0.30	5.04	X		
Molybdenum	SS214	High	1.29	0.004	0.0045	0.0001	0.1	0.000	1.00	0.009	0.50	0.35	3.51		X	
Selenium	SS214	High	0.63	0.004	0.002	0.0001	0.17	0.0000	1.00	0.009	0.25	0.06	1.56		X	
Silver	SS214	High	0.03	0.004	0.0001	0.0001	0.033	0.000	1.00	0.009	0.01	0.00	0.00			
Zinc	SS214	High	109.02	0.004	0.38	0.0001	79	0.01	1.00	0.009	43.13	12.47	863.96		X	
Antimony	SS214	Low	0.23	0.003	0.00	0.0001	0.44	0.00	1.00	0.016	0.04	0.15	1.46	X		
Arsenic	SS214	Low	37.10	0.003	0.0965	0.0001	8.1	0.001	1.00	0.016	6.06	0.68	7.61		X	
Barium	SS214	Low	16.76	0.003	0.0436	0.0001	88.2	0.006	1.00	0.016	3.07	11.65	42.82	X		
Beryllium	SS214	Low	0.00	0.003	0.0000	0.0001	0.0025	0.000	1.00	0.016	0.00	0.00	0.00			
Cadmium	SS214	Low	0.64	0.003	0.0017	0.0001	0.38	0.000	1.00	0.016	0.11	0.07	3.12		X	
Chromium	SS214	Low	4.80	0.003	0.0125	0.0001	24	0.001	1.00	0.016	0.87	7.09	28.42	X		
Copper	SS214	Low	18.38	0.003	0.048	0.0001	17.5	0.00	1.00	0.016	3.05	3.12	704.00	X		
Lead	SS214	Low	3.90	0.003	0.0101	0.0001	195	0.01	1.00	0.016	1.39	0.003	250.22		X	
Mercury	SS214	Low	0.36	0.003	0.00093	0.0001	0.0275	0.00000	1.00	0.016	0.06	0.29	4.87	X		
Molybdenum	SS214	Low	1.29	0.003	0.0033	0.0001	0.1	0.000	1.00	0.016	0.21	0.30	3.04	X		
Selenium	SS214	Low	0.63	0.003	0.002	0.0001	0.17	0.0000	1.00	0.016	0.10	0.06	1.35		X	
Silver	SS214	Low	0.03	0.003	0.0001	0.0001	0.033	0.000	1.00	0.016	0.01	0.00	0.00			
Zinc	SS214	Low	109.02	0.003	0.28	0.0001	79	0.00	1.00	0.016	18.02	10.80	748.21		X	
Antimony	UCL 95	High	0.54	0.004	0.00	0.0001	13.2	0.00	1.00	0.009	0.33	0.17	1.69		X	
Arsenic	UCL 95	High	35.29	0.004	0.1235	0.0001	37.6	0.003	1.00	0.009	14.08	0.79	8.79			X
Barium	UCL 95	High	39.64	0.004	0.1387	0.0001	716	0.060	1.00	0.009	22.10	13.45	49.44		X	
Beryllium	UCL 95	High	0.05	0.004	0.0002	0.0001	0.3	0.000	1.00	0.009	0.02	0.00	0.00			
Cadmium	UCL 95	High	3.24	0.004	0.0114	0.0001	2.1	0.000	1.00	0.009	1.28	0.08	3.61		X	
Chromium	UCL 95	High	7.12	0.004	0.0249	0.0001	308	0.026	1.00	0.009	5.54	8.19	32.81	X		
Copper	UCL 95	High	45.05	0.004	0.158	0.0001	1690	0.14	1.00	0.009	33.29	3.61	812.91		X	
Lead	UCL 95	High	3.78	0.004	0.0132	0.0001	1690	0.14	1.00	0.009	17.24	0.003	288.93		X	
Mercury	UCL 95	High	0.09	0.004	0.00032	0.0001	2.7	0.00023	1.00	0.009	0.06	0.30	5.04	X		
Molybdenum	UCL 95	High	7.84	0.004	0.0274	0.0001	28.4	0.002	1.00	0.009	3.31	0.35	3.51		X	
Selenium	UCL 95	High	4.46	0.004	0.016	0.0001	3.8	0.0003	1.00	0.009	1.77	0.06	1.56			X
Silver	UCL 95	High	0.33	0.004	0.0012	0.0001	1.6	0.000	1.00	0.009	0.14	0.00	0.00			
Zinc	UCL 95	High	493.69	0.004	1.73	0.0001	1660	0.14	1.00	0.009	207.49	12.47	863.96		X	
Antimony	UCL 95	Low	0.54	0.003	0.00	0.0001	13.2	0.00	1.00	0.016	0.14	0.15	1.46	X		
Arsenic	UCL 95	Low	35.29	0.003	0.0918	0.0001	37.6	0.002	1.00	0.016	5.88	0.68	7.61		X	
Barium	UCL 95	Low	39.64	0.003	0.1031	0.0001	716	0.045	1.00	0.016	9.23	11.65	42.82	X		
Beryllium	UCL 95	Low	0.05	0.003	0.0001	0.0001	0.3	0.000	1.00	0.016	0.01	0.00	0.00			
Cadmium	UCL 95	Low	3.24	0.003	0.0084	0.0001	2.1	0.000	1.00	0.016	0.54	0.07	3.12		X	
Chromium	UCL 95	Low	7.12	0.003	0.0185	0.0001	308	0.019	1.00	0.016	2.36	7.09	28.42	X		
Copper	UCL 95	Low	45.05	0.003	0.117	0.0001	1690	0.11	1.00	0.016	13.91	3.12	704.00		X	

APPENDIX I2

SALT MARSH HARVEST MOUSE DOSE CALCULATIONS TBB DISPOSAL SITE NWSSBD CONCORD

Chemical[a]	Sample Location	Dose Type	[Pickleweed] (mg/kg)	IR_{prey} (kg/d)	Ingestion from Prey (mg/d)	IR_{soil} (kg/d)	[Soil] (mg/kg)	Ingestion from Soil (mg/d)	SUF	BW (kg)	Dose (mg/kg/day)	Low TRV	High TRV	Below Low TRV	Between Low and High TRVs	Above High TRV
Lead	UCL 95	Low	3.78	0.003	0.0098	0.0001	1690	0.11	1.00	0.016	7.21	0.003	250.22		X	
Mercury	UCL 95	Low	0.09	0.003	0.00023	0.0001	2.7	0.00017	1.00	0.016	0.03	0.29	4.87	X		
Molybdenum	UCL 95	Low	7.84	0.003	0.0202	0.0001	28.4	0.002	1.00	0.016	1.38	0.30	3.04		X	
Selenium	UCL 95	Low	4.46	0.003	0.012	0.0001	3.8	0.0002	1.00	0.016	0.74	0.06	1.35		X	
Silver	UCL 95	Low	0.33	0.003	0.0009	0.0001	1.6	0.000	1.00	0.016	0.06	0.00	0.00			
Zinc	UCL 95	Low	493.69	0.003	1.28	0.0001	1660	0.10	1.00	0.016	86.70	10.80	748.21		X	

Notes:

Ambient Hi — The high dose calculation using the Tidal Area 99th percent ambient value
Ambient Lo — The low dose calculation using the Tidal Area 99th percent ambient value
Amb Typical — The typical dose calculation using the Tidal Area 99th percent ambient value
BW — Body weight
DDT — Dichlorodiphenyltrichloroethane
IR_{prey} — Ingestion rate of prey
IR_{soil} — Ingestion rate of soil
kg/day — Kilograms per day
mg/d — Milligrams per day
mg/kg — Milligrams per kilogram
mg/kg/day — Milligrams per kilogram per day
NA — Not available
PAH — Polynuclear aromatic hydrocarbon
PCB — Polychlorinated biphenyl
[Pickleweed] — Concentration of chemical in pickleweed
[Soil] — Concentration of chemical in soil
SUF — Site use factor
TRV — Toxicity reference value
UCL — Upper confidence limit

a — Chemicals were selected based on available TRV information
b — The dose for the 95UCL was only calculated for chemicals with an HQ greater than 1
c — Total DDTs are the sum of dichlorodiphenyldichloroethane, dichlorodiphenyldichloroethene, and DDT
... — Not applicable to the analysis

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APPENDIX J

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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J.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The following sections identify the preliminary applicable or relevant and appropriate requirements (ARAR) for the NWSBD Concord Tidal Area. ARARs are substantive federal and state environmental laws and regulations that provide cleanup levels or performance standards for the remedial alternatives to be developed for the TBB disposal site. The ARAR identification process begins during the planning stages of the RI and continues as alternatives are developed and evaluated in the FS. ARARs are finalized in the remedial action decision document. ARAR definitions are discussed in Section J.1. Section J.2 evaluates environmental requirements and identifies preliminary ARARs for the TBB disposal site.

J.1 ARAR DEFINITIONS

Section 121(d) of CERCLA, as amended by Superfund Amendments and Reauthorization Act (SARA), states that on-site remedial actions must attain ARARs. ARARs may include regulations, standards, criteria, or limitations promulgated under federal or state laws. An ARAR may be either "applicable," or "relevant and appropriate," but not both. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR Part 300) defines "applicable," "relevant and appropriate," and "to be considered" as follows:

- "Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable."
- "Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria or limitations promulgated under federal or state environmental or facility siting law that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be relevant and appropriate."
- "Advisories, criteria, guidance, or proposed standards to be considered (TBC) consist of advisories, criteria, or guidance that are developed by EPA, other federal agencies,

or states that may be useful in developing CERCLA remedies. The TBC values and guidelines may be used as EPA deems appropriate."

The identification of ARARs involves considering a number of site-specific factors including potential remedial actions, chemicals of concern at the site, physical characteristics of the site, and site location. A requirement is applicable if it directly and fully addresses or regulates the hazardous substance, pollutant, contaminant, action being taken, or other circumstances at the site. To determine whether a particular requirement would be legally applicable, it is necessary to evaluate specific jurisdictional prerequisites of the statute or regulation. All pertinent jurisdictional prerequisites must be met for the requirement to be applicable. Jurisdictional prerequisites include:

- Who, as specified by the regulation, is subject to its authority
- The types of substances and activities listed as falling under the authority of the regulation
- The time period for which the regulation is in effect
- The types of activities the regulation requires, limits, or prohibits

If jurisdictional requirements are met, the requirement is applicable. If not, the next step is to consider whether the requirement is relevant and appropriate (EPA 1988c).

The basic considerations in determining whether a requirement is relevant and appropriate include evaluating whether the requirement (1) regulates or addresses problems sufficiently similar to those encountered at the CERCLA site (that is, relevance), and (2) is well suited for use at the particular site (that is, appropriateness). Determining whether a requirement is relevant and appropriate is site specific and must be based on best professional judgment (EPA 1988c). A requirement may be relevant but not appropriate for the specific site; cleanup must comply with only those requirements that are determined to be both relevant and appropriate. Portions of a requirement may be relevant and appropriate even if a requirement in its entirety is not (EPA 1988c).

Waivers from attaining specific ARARs may be obtained under certain conditions, as presented in Section 121(d)(4) of CERCLA as amended by SARA. The conditions are as follows:

- The remedial action selected is only part of a total remedial action that will attain the ARAR when completed.
- Compliance with the ARAR will result in greater risk to human health and the environment.
- Compliance with the ARAR is technically impractical from an engineering perspective.

- The remedial action selected will attain a standard of performance equivalent to the ARAR through use of another method or approach.
- With respect to a state ARAR, the state has not consistently applied or demonstrated the intention to consistently apply the standard, requirement, criteria, or limitation in similar circumstances for other remedial actions within the state.

Several of these waivers may be relevant to the TBB disposal site as a whole or to specific remedial alternatives and will require further technical evaluation. As the RI/FS and design phases progress, the applicability of the waivers will be assessed. The Navy may invoke a waiver if applicable, provided that the remedial actions are protective of human health and the environment.

The Navy has formally requested ARARs from the state for all NWSBD Concord Tidal Area sites (WESTDIV 1993). Responses were received from the following state agencies:

- San Francisco Bay Regional Water Quality Control Board
- Department of Toxic Substances Control
- Department of Fish and Game
- San Francisco Bay Conservation and Development Commission

In a letter dated February, 1999, EFA WEST requested ARARs from the state for the TBB disposal site. The information received from state agencies for the original four Tidal Area sites was not specific to the TBB disposal site and contained only generic references to state requirements. The Navy previously met with state regulators informally to discuss ARARs specific to the original four Tidal Area sites. Based on the meetings and the RI prepared for the Tidal Area sites, the Navy will describe below how state requirements apply to the TBB disposal site.

Three categories of ARARs exist: chemical-, location-, and action-specific requirements. Chemical-specific ARARs are health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical cleanup values. These values specify the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. If more than one ARAR applies to a chemical, the most stringent will be identified as an ARAR for any remedial action. Four media are potentially associated with the TBB disposal site that may have been assigned chemical-specific ARARs: soil, sediment, groundwater, and surface water.

Location-specific ARARs are restrictions on the concentration of hazardous substances or the conduct of activities due to the characteristics of the site or its immediate environment. For example, location of the site or proposed remedial action in a flood plain, wetland, historic place, or sensitive ecosystem may trigger location-specific ARARs.

Action-specific ARARs are technology- or activity-based requirements or limitations on actions that may be taken. These requirements are triggered by the particular remedial activities selected. Action-specific ARARs do not in themselves determine the remedial alternative; rather, they indicate how an alternative must be conducted. Action-specific ARARs will be identified for the TBB disposal site in the FS phase, based on the assumption that contaminated surface materials will be removed.

TBCs may be used when ARARs do not exist for a certain contaminant or medium. TBCs may include remediation goals calculated using EPA's "Risk Assessment Guidance for Superfund" Part B (EPA 1989) or other guidance and criteria available from other federal agencies and from state agencies. Cleanup levels for soil and sediment must be established using TBCs because no ARARs exist for contaminants in soil. Section 3.0 discusses the screening criteria that will be used to evaluate data collected during the RI. These screening criteria are TBCs and may or may not become cleanup levels for soil or sediment.

Section J.2 below describes the environmental requirements that may be pertinent to the TBB disposal site and the preliminary ARARs identified. The ARARs preliminarily identified in this report may change as the RI/FS and remedy selection processes proceed. Such changes may include (1) screening out requirements identified as preliminary ARARs, or (2) identifying additional requirements as ARARs.

J.2 PRELIMINARY ARARS FOR TBB DISPOSAL SITE

The subsections below (1) evaluate chemical- and location-specific environmental requirements that may be pertinent to the TBB disposal site, and (2) identify preliminary ARARs for the TBB disposal site. Action-specific ARARs will be evaluated in the FS.

J.2.1 Chemical-Specific ARARs for Site 30, TBB Disposal Site

Chemical-specific ARARs provide specific numeric contaminant levels for various environmental media. The media that may be affected at the TBB disposal site include soil, groundwater, and surface water. Table 3 lists the preliminary chemical-specific ARARs for the TBB disposal site.

J.2.1.1 Soil and Sediment

No federal or state action levels have been promulgated for chemical concentrations of TPH, PAH, and inorganic constituents in soils or sediments. Therefore, there are no chemical-specific ARARs for soil at the TBB disposal site.

J.2.1.2 Surface Water

Surface water quality requirements are found in Section 3 of the Water Quality Control Plans developed for the San Francisco Bay Region, Regional Water Quality Control Board (RWQCB). Applicable water quality standards for the State of California, promulgated by EPA to fulfill the requirements of Section 303(c) of the Clean Water Act, 33 USCS 1313(c), are also identified as applicable requirements for any toxic priority pollutants that could be reasonably expected to interfere with the beneficial uses of surface waters found at the Seal Creek Marsh.

J.2.1.3 Groundwater

There are no chemical-specific ARARs for groundwater at the TBB disposal site.

J.2.2 Location-Specific ARARs for Site 30, TBB Disposal Site

The location-specific ARARs for the TBB disposal site are associated with the potential presence of endangered or threatened species and with the location of the site near the Seal Creek Marsh, a wetland. Remedial actions taken at the site must be designed to avoid jeopardizing any endangered species. Table 3 lists the location-specific ARARs for the TBB disposal site.

The TBB disposal site provides potential habitat for the endangered salt marsh harvest mouse. Although no salt marsh harvest mice have been trapped at the site, this species is presumed to reside at the site due to the presence of pickleweed. As a result, the substantive portions of the Endangered Species Act, Title 16 United States Code (USC) Section 1531 and its associated regulations at 50 CFR Part 17, Parts 222 and 402, are applicable to the TBB disposal site. In addition, the substantive portions of the California Endangered Species Act and the Fish and Game Code Sections 1900, 2050 to 2068, 2070, 2080, and 2090 to 2096 that are more stringent than the Endangered Species Act are applicable to the TBB disposal site. The FS will further evaluate compliance with these ARARs.

Section 307(c)(1) of the Coastal Zone Management Act, 16 United States Codes (U.S.C.) ' 1451(c)(1), requires that a federal agency conduct an activity that is outside the coastal zone, but that affects any land or water use or natural resource of the coastal zone, in a manner consistent to the maximum extent

practicable with the enforceable policies of state coastal management programs. As federally owned land, NWSBD Concord is outside the coastal zone pursuant to 16 U.S.C. ' 1453(1). Nevertheless, if any remedial activities affect any land or water use or natural resource of the coastal zone, the Navy will consult with the state coastal management agency in an effort to determine whether substantive requirements of the state coastal plan will be met.

TABLE J1

PRELIMINARY ARARs FOR THE TAYLOR BOULEVARD BRIDGE DISPOSAL SITE

Statutory Citation	Regulatory Citation	Medium	Description	Preliminary ARARs Determination	Comments
Chemical-Specific Requirements					
Porter-Cologne Water Quality Control Act (California Water Code § 13304)	State Water Resources Control Board Amended Resolution No. 92-49: "Policies and Procedures for Investigation and Cleanup and Abatement under Section 13304 of the Water Code"	Water	Section III.G of Resolution No. 92-49 requires dischargers to abate the effect of discharge in a manner that promotes attainment of either background water quality or the best water quality that is reasonable.	TBC	Relevant and appropriate for Site 30
Porter-Cologne Water Quality Act (California Water Code § 13240 and 13241)	Water Quality Control Plans for the San Francisco Bay Region Basin, 1995, Section 3	Water	Establishes water quality objectives.	Relevant and appropriate	Relevant and appropriate at Site 30
Clean Water Act (42USC § 1313 (c))	40 CFR Part 131	Water	Numeric water quality criteria for priority toxic pollutants	Applicable	Applicable to discharger of toxic pollutants that could be reasonably expected to interfere with beneficial use of surface water

TABLE J1 (CONTINUED)

PRELIMINARY ARARs FOR THE TBB DISPOSAL SITE

Statutory Citation	Regulatory Citation	Medium	Description	Preliminary ARARs Determination	Comments
Location-Specific Requirements					
Endangered Species Act (16 USC § 1531)	50 CFR Part 17	Soil and water	This statute establishes requirements for remedial actions to conserve endangered species and to avoid harming or taking endangered species.	Relevant and appropriate	Relevant and appropriate for Site 30 due to potential habitat for the endangered salt marsh harvest mouse. Action taken at the site must provide for the protection of this endangered species. Compliance with the location-specific ARAR will be evaluated in the FS.
Fish and Game Code Sections 2080, 3005(a), 3511, and 5650		Soil and water	These regulations provide for the conservation of endangered species, as well as fish, plants and bird life.	Relevant and appropriate	Relevant and appropriate for Site 30 due to potential habitat for endangered species and other protected animals and plants

TABLE J1 (CONTINUED)

PRELIMINARY ARARs FOR THE TBB DISPOSAL SITE

Statutory Citation	Regulatory Citation	Medium	Description	Preliminary ARARs Determination	Comments
Coastal Zone Management Act 16 USC § 1456(c)(1)(A); McAteer-Petris Act (California Government Code 66600 *et seq.*)	15 CFR Part 930	Soil and water	Under this authority, the actions of the Navy at NWSBD Concord must be consistent with the policies of approved state management programs (San Francisco Bay Conservation and Development Commission Bay Plan).	Relevant and appropriate	Relevant and appropriate because remedial activities may affect land or water use, or natural resources of the coastal zone
Executive Order 11990	40 CFR Section 6.302(a)	Soil and water	Executive Order 11990, Protection of Wetlands, requires federal agencies conducting certain activities to avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists.	TBC	To be considered for Site 30 due to presence of the wetlands
Executive Order 11988		Soil and water	Executive Order 11988, Floodplain Management, requires federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain.	TBC	To be considered for Site 30 due to its location in a floodplain

TABLE J1 (CONTINUED)

PRELIMINARY ARARs FOR THE TBB DISPOSAL SITE

Statutory Citation	Regulatory Citation	Medium	Description	Preliminary ARARs Determination	Comments
Action-Specific Requirements					
California Health and Safety Code (HSC) §§ 25100 *et seq.*	22 CCR § 66261.21 through 66261.24	Soil	Criteria for determining whether excavated media exhibits hazardous waste characteristics	Applicable	Applicable to Site 30
California Water Code § 13172; Public Resources Code § 43103	27 CCR § 20210 and 20220	Soil	Requires designated waste and nonhazardous solid waste to be discharged at classified units	Applicable	Applicable to materials excavated at Site 30 and disposed of on site
Bay Area Air Quality Management District Regulations	Regulations 6-301, 6-302 and 6-305	Air	Requirements for controlling particulate and visible emissions during excavation and transport of soil	Relevant and appropriate	Relevant and appropriate to Site 30
Land Disposal Requirements (22 CCR)	22 CCR § 66268.7(a)	Soil	Criteria for determining whether waste is subject to land disposal restrictions	Applicable	Applicable to soils at Site 30 that qualify as hazardous waste
Waste Generator Requirements (22 CCR)	22 CCR § 66261.11, 66261.20, 66262.30, 66262.31, 66262.32, 66262.33, and 66262.34	Soil	Establishes requirements for generators of hazardous waste	Applicable	Applicable to soils at Site 30 that qualify as hazardous waste if disposed on site

Notes:

ARAR Applicable or relevant and appropriate requirement

CCR California Code of Regulations

CFR Code of Federal Regulations

TBC To be considered

USC United States Code

The TBB disposal site includes a wetland; as a result, the Protection of Wetlands Executive Order No. 11990 and its implementing regulation at 40 CFR Section 6.302(a) and Appendix A are TBCs for the TBB disposal site. The provisions of this Executive Order require federal agencies to avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid construction in wetlands. The FS will further describe how each remedial alternative analyzed in detail will comply with Executive Order 11990.

The TBB disposal site is in the 100-year floodplain. Under Executive Order 11988, Floodplain Management, the Navy must evaluate the effects of actions they may take in a floodplain and must avoid adverse impacts, if practicable. The FS will further describe how each remedial alternative analyzed in detail will comply with Executive Order 11988.

The National Wildlife Refuge System Act is not an ARAR because no part of the TBB disposal site is associated with a national wildlife refuge. The Wild and Scenic Rivers Act is not an ARAR because there are no wild or scenic rivers (as designated by the act) associated with the TBB disposal site. The Wilderness Act is not an ARAR for the TBB disposal site because there are no wilderness areas associated with the site. The National Historic Preservation Act, Archeological and Historical Preservation Act, and Historic Sites. Buildings, and Antiquities Act are not ARARs for the TBB disposal site because there are no properties, historic or archeological data, or landmarks at the TBB disposal site that fall under the purview of those laws.

Other location-specific requirements are not ARARs for the TBB disposal site because the circumstances that would make them ARARs do not exist at the site.

J.2.3 Action-Specific ARARs for Site 30, TBB Disposal Site

Due to the limited horizontal and vertical extent of contamination at Site 30 and the high concentrations of inorganic chemicals detected, it is most likely that excavation and off-site disposal will be the favored alternative in the FS when it is conducted. On-site treatment or encapsulation of contaminants are unlikely to be chosen for the site, for a variety of reasons. As a result, ARARs associated with excavation of the contaminated debris and soil are evaluated on a preliminary basis in Table 3. Full evaluation of action-specific ARARs for all considered alternatives will be presented in the FS.