Draft

Ecological Risk Assessment Dundalk Marine Terminal Baltimore, Maryland

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Executive Summary

Background

This Ecological Risk Assessment (ERA) has been prepared pursuant to the requirements of Section III.B.7 of the April 5, 2006, Consent Decree entered into by the Maryland Port Administration (MPA), the Maryland Department of the Environment (MDE), and Honeywell International Inc. (Honeywell) for Dundalk Marine Terminal (hereafter referred to as DMT, or Site), located within the City and County of Baltimore, Maryland. The ERA was performed in accordance with the ERA work plan (CH2M HILL, 2006). Although the Consent Decree focuses exclusively on chromium, other constituents related to chromite ore processing residue (COPR) (aluminum, calcium, iron, manganese, and vanadium) in pore water, surface water, and sediment were also assessed. The ERA results establish that chromium and other COPR constituents do not pose unacceptable risk to ecological receptors near DMT. The data and conclusions provided in the ERA meet the requirements stipulated in the Consent Decree. No additional sampling or analysis is required to assess the environmental impacts of COPR constituents from the Site.

Technical Approach

The ERA focuses on releases from the Site to the adjacent waterways which include the Patapsco River and Colgate Creek (hereafter referred to as the study area). The basic approach for the ERA is consistent with U.S. Environmental Protection Agency (USEPA) guidance (1997, 1998, 2000, 2001), which provides an eight-step process with built-in critical management and decision points. Steps 1 and 2 make up the screening level ecological risk assessment (SLERA), while Step 3 is the initial step of the baseline ecological risk assessment (BERA). Step 1 consists of the screening level problem formulation and effects evaluation. The problem formulation includes describing the environmental setting; constituents of interest (COIs) in pore water, surface water, and sediment; fate and transport mechanisms; ecotoxicity mechanisms for the COIs; and potential receptors, exposure pathways, and ecological endpoints. Conservative ecological screening values (ESVs), or concentrations associated with adverse effects, are also defined as part of the ecological effects assessment component of Step 1.

Step 2 comprises a screening level exposure estimate and risk calculation, during which the exposure point concentrations (EPCs) for each identified pathway are compared to the screening level ESVs identified in Step 1. In this ERA, COIs that were measured in pore water, surface water, and surficial sediment samples from DMT at concentrations exceeding the ESVs were identified and were carried forward to Step 3 of the ERA process.

The Step 3a problem formulation evaluation for DMT refines assumptions related to considering regional background (reference) conditions and the spatial extent and magnitude of exposure; reviewing effects levels; and qualitatively reviewing biological data from the study area.

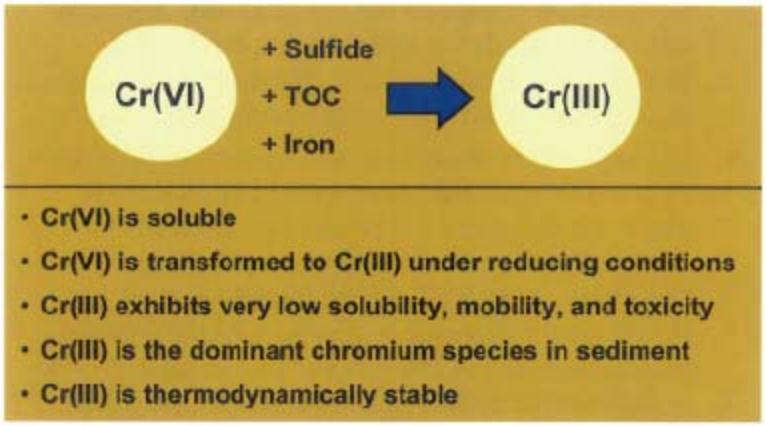
The ERA approach also follows USEPA's *Procedures for the Derivation of Equilibrium Partitioning (EqP) Sediment Benchmarks for the Protection of Benthic Organisms: Metal Mixtures* (USEPA, 2005a) and incorporates concepts identified in the *Issue Paper on the Bioavailability and Bioaccumulation of Metals* submitted to USEPA by the Eastern Research group (McGeer et al., 2004) and in USEPA's *Framework for Metals Risk Assessment* (USEPA, 2007).

According to USEPA, geochemical processes govern the reduction of relatively toxic hexavalent chromium (Cr(VI)) to relatively nontoxic trivalent chromium (Cr(III)) in estuarine environments. Specifically, geochemical parameters such as sulfide and ferrous iron (Fe(II)) are lines of evidence that document the reducing conditions of the sediment wherein chromium exists thermodynamically as Cr(III) rather than Cr(VI). The toxicity of chromium is based on consideration of Cr(VI) and Cr(III) in pore water and surface water relative to USEPA Nationally Recommended Water Quality Criteria (NRWQC). USEPA's EqP approach for chromium is illustrated in Figure ES-1.

The following media were considered in the ERA:

- Pore water
- Surface water
- Surficial sediment

FIGURE ES-1
Summary of USEPA's Equilibrium Partitioning Approach for Chromium



A set of assessment endpoints were identified on the basis of the conceptual site model (CSM) for the study area to guide the development of the measurement endpoints. The following assessment and measurement endpoints were used to assess the potential risks at DMT:

Assessment Endpoints

- Benthic Invertebrate Community Structure and Function
- Aquatic Invertebrate Community Structure and Function
- Fish Population Survival and Reproductive Ability

- **Benthic Invertebrate Community Structure and Function.** (I.e., the sediment-dwelling organism community) (1) Comparison of concentrations of COIs in pore water to USEPA's NRWQC or other ESVs considered protective of survival or reproduction; (2) comparison of concentrations of COIs in bulk surface sediment to conservative ESVs considered protective of survival or reproduction; and (3) consideration of the biological community present in Patapsco River sediments, particularly in areas where COPR constituents were measured.
- **Water Column Invertebrate Community Structure and Function.** Comparison of concentrations of COIs in surface water to USEPA's NRWQC or other ESVs considered protective of survival or reproduction.

- **Fish Survival and Reproductive Ability.** Comparison of concentrations of COIs in surface water adjacent to DMT to USEPA's NRWQC or other ESVs considered protective of survival or reproduction.

The data to support the ERA were collected during the Sediment and Surface Water Study, which comprised four quarterly sampling events in May, August, and December 2007 and February 2008 (CH2M HILL and ENVIRON, 2009) . Forty-one DMT locations and three mid-channel reference locations were sampled as part of the Sediment and Surface Water Study. Maximum chemical concentration data for pore water, surface water, and surficial sediment from the four quarterly sampling events were compared to saltwater NRWQC and ESVs because those are most representative of conditions at DMT. In the absence of saltwater ESVs, freshwater ESVs were used. In addition, this ERA addresses the ancillary sampling of sediment and pore water near the shoreline of the 15th Street outfall conducted in May 2009.[1]

Results and Conclusions

In Step 2 of the ERA, chemical concentration data for pore water, surface water, and sediment for four quarterly sampling events conducted at DMT were compared to conservative ESVs. All measured concentrations of Cr(III) and Cr(VI) in pore water and surface water were below ESVs. Thus, in accordance with the USEPA's approach, chromium was not retained for further evaluation.

Based on the results of Step 2, the following COIs and media were evaluated in Step 3a: iron, magnesium, and manganese in pore water; magnesium and manganese in surface water; and aluminum, manganese, and vanadium in surface sediment. In Step 3a, concentrations of these COIs measured within the study area were compared to those concentrations measured at reference locations. Concentrations of COIs within the study area were similar to those from reference locations for all of the COIs except manganese in surface water and sediment. A refined risk analysis considered the spatial extent and magnitude of exposure, a more detailed review of the ESVs for manganese, and a qualitative review of biological data from the study area with respect to manganese. These lines of evidence illustrate that the manganese concentrations in surface water and bulk sediment do not pose an unacceptable ecological risk to receptors adjacent to DMT. In summary, the Step 3a evaluation did not identify any refined COIs. Thus, ecological risks within the study area are considered acceptable, and no further action to address risk to ecological receptors is indicated.

[1] Data provided to MDE in a letter from Honeywell to MDE dated September 4, 2009.

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Acronyms and Abbreviations

AET	Apparent Effects Threshold
AVS	acid volatile sulfides
BERA	baseline ecological risk assessment
B-IBI	benthic index of biological integrity
CCC	criterion continuous concentration
cm/s	centimeter per second
COI	constituent of interest
COMAR	Code of Maryland Regulations
COPR	chromite ore processing residue
Cr(III)	trivalent chromium
Cr(VI)	hexavalent chromium
CSM	conceptual site model
CTFR	(Johns Hopkins University) Center for Contaminant Transport, Fate, and Remediation
DMCF	dredged material containment facility
DMT	Dundalk Marine Terminal
DO	dissolved oxygen
DOC	dissolved organic carbon
EA	environmental assessment
EC50	effective concentration 50
EPC	exposure point concentration
EqP	equilibrium partitioning
ERA	ecological risk assessment
ER-M	effects range— median
ESB	equilibrium partitioning sediment benchmark
ESV	ecological screening value
Fe(II)	ferrous (divalent) iron
FONSI	finding of no significant impact
HQ	hazard quotient
IBI	index of biological integrity
LC50	lethal concentration 50
MDE	Maryland Department of the Environment
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MPA	Maryland Port Administration
NOAA	National Oceanic and Atmospheric Administration
NRWQC	Nationally Recommended Water Quality Criteria

ORP	oxidation reduction potential
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyls
ppt	parts per thousand
redox	reduction-oxidation
SEM	simultaneously extracted metals
SLERA	screening level ecological assessment
SMDP	scientific management decision point
SQG	sediment quality guidelines
SQuiRT	screening quick reference tables
TCEQ	Texas Commission on Environmental Quality
TOC	total organic carbon
TOXNET	toxicology data network
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WREC	Wye Research and Education Center

SECTION 1

Introduction

This Ecological Risk Assessment (ERA) has been prepared pursuant to the requirements of Section III.B.7 of the April 5, 2006, Consent Decree entered into by the Maryland Port Administration (MPA), the Maryland Department of the Environment (MDE), and Honeywell International Inc. (Honeywell) for Dundalk Marine Terminal (hereafter referred to as DMT, or Site), located within the City and County of Baltimore, Maryland (Figure 1-1). The ERA was performed in accordance with the ERA work plan (CH2M HILL, 2006). Although the Consent Decree focused exclusively on chromium, other constituents related to chromite ore processing residue (COPR) (aluminum, calcium, iron, manganese, and vanadium) in pore water, surface water, and sediment were also assessed (CH2M HILL, 2007a).

1.1 Purpose and Scope

The purpose of the ERA is to evaluate potential ecological risks associated with exposure to COPR constituents in the sediments and surface water in the Patapsco River and Colgate Creek immediately surrounding DMT. Exposure to hexavalent chromium (Cr(VI)) and trivalent chromium (Cr(III)) is the primary focus of the assessment; exposure to aluminum, calcium, iron, magnesium, manganese, and vanadium, which are also constituents of COPR, is also evaluated. The ERA is based primarily on the data obtained from the sediment and surface water study, which was performed adjacent to DMT from 2006 to 2008 (CH2M HILL and ENVIRON, 2009). The objectives of the study were to characterize the nature and extent of chromium in the Patapsco River within the zone potentially impacted by chromium releases at or from DMT and the geochemical conditions that influence the fate and transport of chromium in the river. The study area for the ERA is the same as the area investigated in the sediment and surface water study. The ERA also uses information from the chromium transport study being conducted pursuant to the requirements of Section III.B.2 of the Consent Decree (CH2M HILL, 2009).

1.2 Technical Approach

This ERA was conducted in accordance with the ERA work plan (CH2M HILL, 2006). As stated in the work plan, the approach follows the guidance in various other documents, including U.S. Environmental Protection Agency's (USEPA) *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997), '*Guidelines for Ecological Risk Assessment* (USEPA, 1998), and '*Procedures for the Derivation of Equilibrium Partitioning (EqP) Sediment Benchmarks for the Protection of Benthic Organisms: Metal Mixtures* (USEPA, 2005a). The technical approach also incorporates concepts discussed in the *Issue Paper on the Bioavailability and Bioaccumulation of Metals* submitted to USEPA by the Eastern Research Group (McGeer et al., 2004) and in USEPA's *Framework for Metals Risk Assessment* (USEPA, 2007), '*Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of*

Stakeholders (USEPA, 2000), and '*The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (USEPA, 2001).

This ERA has been conducted in accordance with recent and widely accepted chromium chemistry and toxicity research and interpretation. This includes recent scientific literature and regulatory guidance (e.g., USEPA, 1985, 2005a; Berry et al., 2002, 2004; MDE, 2004; Besser et al., 2004; Rifkin et al., 2004), and a recent study specific to chromium in Baltimore Harbor (Graham et al., 2009). According to USEPA, geochemical processes govern the reduction of relatively toxic Cr(VI) to relatively nontoxic Cr(III) in estuarine environments. Specifically, geochemical parameters such as sulfide and ferrous iron (Fe(II)) indicate reducing conditions in sediment under which chromium exists thermodynamically as Cr(III) rather than Cr(VI). In line with this research and guidance, in this ERA the toxicity of chromium is based on comparison of Cr(VI) and Cr(III) concentrations in pore water and surface water to USEPA Nationally Recommended Water Quality Criteria (NRWQC).

The basic approach for the ERA is consistent with USEPA guidance (1997, 1998, 2000, 2001), which provides an eight-step process with built-in critical management and decision points to allow stakeholder input on the evaluation of interim findings and refinement of the technical approach (Figure 1-2). Steps 1 and 2 make up the screening level ecological risk assessment (SLERA), while Step 3 is the initial step of the baseline ecological risk assessment (BERA). Step 1 consists of the screening level problem formulation and effects evaluation. The problem formulation for this ERA includes descriptions of the environmental setting; constituents of interest (COIs) in surface water, pore water, and sediment; fate and transport mechanisms; ecotoxicity mechanisms for the COIs; and potential receptors, exposure pathways, and ecological endpoints. Conservative ecological screening values (ESVs), or concentrations associated with adverse effects, were also defined as part of ecological effects assessment component of Step 1.

Step 2 comprises a screening level exposure estimate and risk calculation, during which the exposure point concentrations for each identified pathway are compared to the screening level ESVs identified in Step 1. In this ERA, COIs that were measured in surface water, pore water, and sediment samples from DMT at concentrations exceeding the ESVs were identified as potentially contributing to unacceptable risk and were carried forward to Step 3 of the ERA process. In cases where screening level ESVs for a particular pathway or COI were not exceeded, it was concluded that there was no unacceptable risk and the COI or pathway was not carried forward to Step 3.

Step 3, the initial step of the BERA (i.e., the Problem Formulation), is the critical step in the process of a more detailed evaluation of ecological risks. According to USEPA (2000):

> "The Problem Formulation [i.e., Step 3] is commonly thought of in two parts: Step 3a and Step 3b. Step 3a serves to introduce information to refine the risk estimates from steps one and two. For the majority of Sites, ecological risk assessment activities will cease after completion of Step 3a. At many Sites, a single deliverable document consisting of the reporting of results from Steps 1, 2 and 3a may be submitted. At those Sites with greater ecological concerns, the additional problem formulation is called Step 3b. It is very important at this stage to perform a '"reality check."' Sites that do not warrant further study should not be carried forward."

The Step 3a problem formulation evaluation for DMT provides a refinement of assumptions related to consideration of regional background (reference) conditions, the spatial extent and magnitude of exposure, a review of effects levels, and a qualitative review of biological data from the study area.

1.3 ERA Format

This document includes the primary components identified in the USEPA (1997, 1998, 2000, 2001) guidance (Figure 1-2) within the following five sections:

The **Executive Summary** presents a summary of the ERA including the background and objectives, technical approaches employed to evaluate data from the study area, and the conclusions.

Section 1 (Introduction) provides the administrative background, the purpose and scope of the ERA, and an overview of the technical approach that was used.

Section 2 (Step 1: Screening Level Problem Formulation and Effects Assessment) includes a comprehensive description of the factors that were considered during the problem formulation, including a detailed description of the environmental setting, the identification of COIs to be evaluated, mechanisms of ecotoxicity for each COI, fate and transport pathways, and ecological receptors and exposure pathways. This section also includes a summary of the conceptual site model (CSM) and assessment and measurement endpoints to be used in the ERA and identifies the screening level ESVs to be used for the screening level risk calculation in Step 2.

Section 3 (Step 2: Exposure Estimate and Risk Calculation) details the exposure estimates and initial risk characterization.

Section 4 (Step 3a: BERA Problem Formulation) refines exposure estimates and risk calculations and incorporates relevant site-specific factors into the evaluation of potential ecological risk within the study area.

Section 5 (Summary and Conclusions) summarizes the results of the ERA and discusses the scientific management decision point (SMDP).

Section 6 provides the references cited.

ERA information is presented concisely and in tabular format to the extent possible to expedite review. Supporting information is provided as appendices to the report.

Legend
- Areas
- Railroad Centerline
- Curb
- County/City Boundary

N
W E
S

0 1.5 3 6
Miles

Figure 1-1
Site Map
Dundalk Marine Terminal
Baltimore, Maryland

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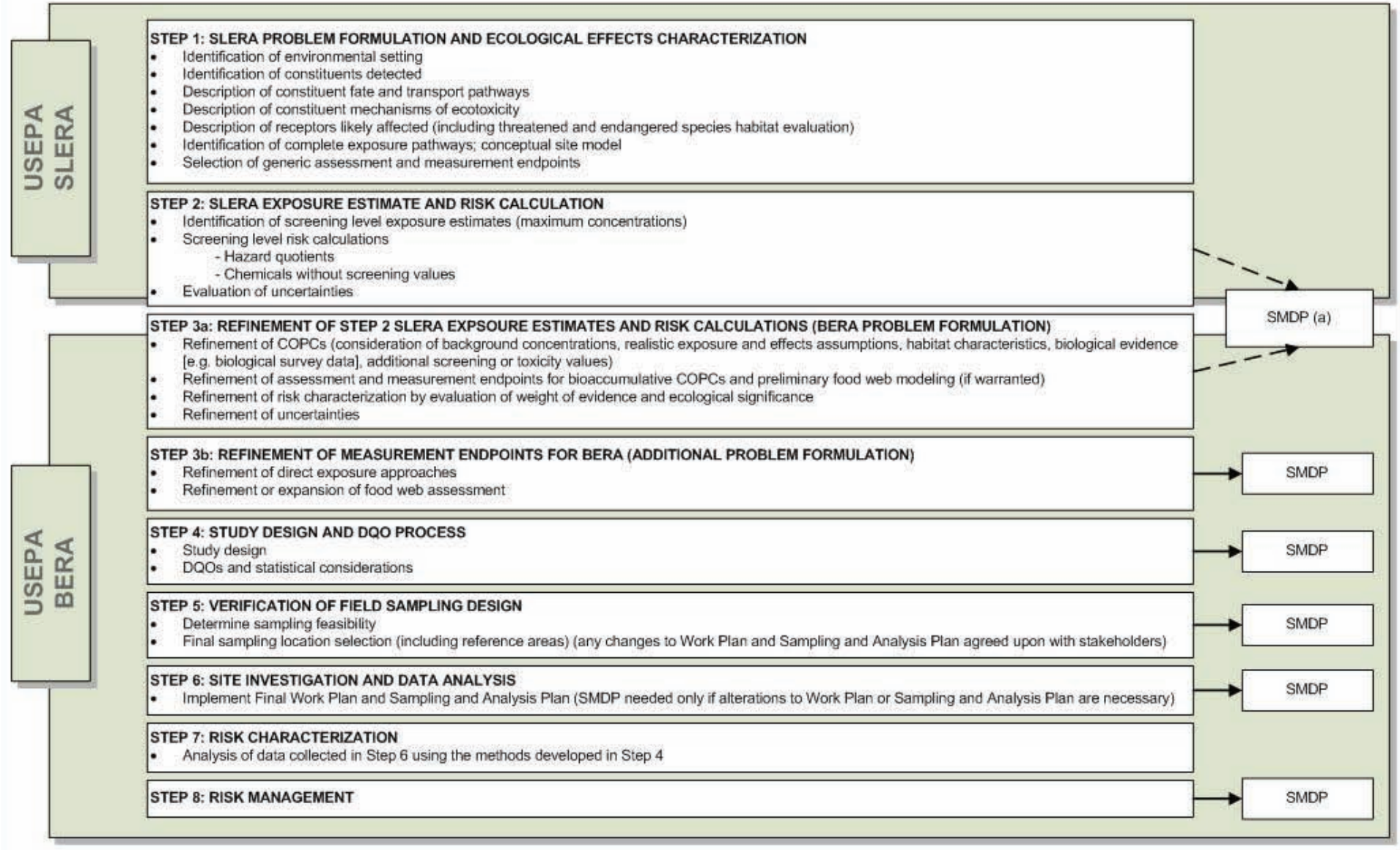

Notes:

(a)	SMDP occurs EITHER after Step 2 or after Step 3a
BERA	baseline ecological risk assessment
COPC	constituent of potential concern
DQO	data quality objectives
SLERA	screening-level ecological risk assessment
SMPD	Scientific Management Decision Point (note that SMDPs do not constitute formal reporting requirements, but identify when stakeholder communication should be considered)
USEPA	United States Environmental Protection Agency

Sources: USEPA Process Adapted from:

USEPA (1997). Ecological Risk Assessment Guidance for Superfund.

USEPA (2000). Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders.

USEPA (2001). ECO-Update: Role of Screening-level Risk Assessments and Refining Contaminants of Concern in Baseline

Figure 1-2
USEPA Expanded Eight-Step
Ecological Risk Assessment Process
Dundalk Marine Terminal
Baltimore, Maryland

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SECTION 2

Step 1: Screening Level Problem Formulation

A screening level problem formulation was developed to identify the COIs, potential pathways, receptors, and exposure scenarios of concern. This information is presented below and provides the basis for the screening level risk characterization presented in Section 3. The problem formulation below focuses on chromium, which is the COPR constituent identified in the Consent Decree. However, other COPR constituents—including aluminum, calcium, iron, magnesium, manganese, and vanadium—are also evaluated in this ERA.

2.1 Environmental Setting

DMT is located in the central part of Baltimore Harbor, on the north side of the Patapsco River (Figure 1-1). DMT is on a peninsula that is bounded on the northwest by Colgate Creek, on the west, south and southeast by the Patapsco River, and on the northeast by the Broening Highway and Norfolk Southern Railroad. DMT is located on land that was created in part by the placement of COPR fill material. The fill material includes mixtures of COPR, man-made fill, and locally available fill materials. COPR is composed primarily of calcium, iron, aluminum, magnesium, and chromium, which comprise greater than 90 percent of its mass (CH2M HILL, 2007b). Trace amounts of manganese and vanadium are also present. Chromium occurs in COPR as both Cr(III) and Cr(VI) forms.

Baltimore Harbor has a long history of industrial use dating back to the 1800s, including steel production, sugar refinement, garment manufacturing, shipping, and more recently, biotechnology. In addition to chemical inputs, water quality in Baltimore Harbor has been impacted by other stressors such as excess nutrient levels, high suspended solids, and low dissolved oxygen (DO) levels. Baltimore Harbor is listed on Maryland's 303(d) list of impaired water bodies for biological impairment, bacteria, nutrients, suspended sediments, toxics (cyanide, chlordane, and polychlorinated biphenyls (PCBs)), and metals (MDE, 2005). Sediment toxicity has been observed at many locations within the Baltimore Harbor–Patapsco River system, and chemical constituents known to be present in the harbor sediments include polynuclear aromatic hydrocarbons (PAHs), PCBs, chlordane and other pesticides, and heavy metals (McGee et al., 1999; Klosterhaus et al., 2007).

2.1.1 Study Area Description

Information about the surface waters in the vicinity of DMT was collected as part of the Sediment and Surface Water Study (CH2M HILL and ENVIRON, 2009). The information collected included bathymetry, sediment characteristics, and water column characteristics and is summarized below. Study data were collected from 41 DMT locations (Transects A through J) and three midchannel reference locations in the Patapsco River (Figure 2-1). Sediment and water column properties were characterized in May 2007, August 2007, December 2007, and February 2008.

Bathymetry

A bathymetric study of the Patapsco River and Colgate Creek adjacent to DMT completed in December 2006 identified a network of steep-sided dredged navigation channels traversing the study area that allows shipping access to DMT and Seagirt Marine Terminal from the Fort McHenry navigation channel (Figure 2-2). The channels encompass nearly half of the area surveyed and range from 39 to 48 feet deep. The channel bottom topography is variable, a likely artifact of past dredging operations. Water depths measured outside the channels are generally less than 20 feet. Four prominent shallow-water areas were identified. The bottom topography in these shallow areas appears less variable than the channel topography.

Water Column Characteristics

Surface water quality parameters including temperature, salinity, turbidity, pH, and DO were measured in situ during the four quarterly field sampling events (Table 2-1). Surface water temperatures at DMT ranged from 2.5°C to 28.4°C (mean of 15.4°C), and were similar to temperatures at the reference locations (2.8°C to 27.4°C, with a mean of 14.2°C). Temperatures varied significantly with season, but did not appear to vary as a function of sampling location.

Salinities at DMT during all four quarterly sampling events ranged from 3.1 to 16.3 parts per thousand (ppt), with a mean of 10.7 ppt. These values are consistent with those at the reference location (range of 5.2 to 16 ppt; mean of 11 ppt). Salinities appear to be slightly lower in the shallow water transects (Transects A, B, C and J; mean of 8.9 ppt) than in the deeper water transects (D–H; mean of 11 ppt). Salinity profiles show a trend of increasing salinity with depth. The lower salinity measurements in the upper portion of the water column are characteristic of freshwater input (e.g. rainfall and storm drains) and the higher density associated with more saline waters. The salinities were also consistently lower in the spring compared to other seasons. According to MDE regulations, waters in the vicinity of DMT are identified as saline (Code of Maryland Regulations (COMAR) 26.08.02.03-1). The site-specific measures of salinity support this MDE designation.

DO concentrations in the Patapsco River near DMT were substantially higher in the colder months of December and February, with a mean of 10.5 milligrams per liter (mg/L), and lowest in August, with a mean of 3.75 mg/L. Overall, the vast majority of locations throughout the year were well above the MDE standard of 5 mg/L for waters supporting the protection of aquatic life (MDE, 2005). DO concentrations in the shallower transects (Transects A, B, C and J) indicated aerobic conditions throughout the water column except in August, and did not vary with depth. At the deeper sampling locations, DO concentrations declined dramatically with depth. At sampling locations with water depths of greater than 25 feet, the environment at the sediment-water interface was highly reducing, with DO concentrations averaging less than 2.5 mg/L. The pH values throughout the water column ranged from 6.9 to 9.1; overall, pH varied little among transect locations.

Overall, the water column profiles obtained during the quarterly sampling events indicate that in the shallowest areas the water column is typically well mixed. The deeper locations within the berthing areas and at the reference sites are typically stratified with increasing salinity and decreasing DO with depth.

Sediment Characteristics

Surficial sediment samples collected for the *Sediment and Surface Water Study* were generally composed of loosely consolidated sand, silt, and clay mixtures (CH2M HILL and ENVIRON, 2009). Sediments in the shallow area near Area 1501/1602 in the southeastern corner of the terminal (i.e., Transects A and J, and the first two stations on Transect C as shown in Figure 2-1) and to the south of the berthing areas (i.e. the outer extents of Transects D and E) were predominantly sand. Silts and clays were the dominant components of the surficial sediments from the deep berthing areas on the southern side of the terminal and along the northern and western edges of the terminal. The total organic carbon (TOC) content of the sediments ranged from 200 to 48,000 milligrams per kilogram (mg/kg) (0.02 to 4.8 percent), with the sandier areas containing the lowest TOC concentrations.

In situ measurements of pH and oxidation-reduction potential (ORP, or redox) conditions at DMT were collected during the four quarterly field-sampling events that were performed for the sediment and surface water study. The Eh/pH measurements from DMT are presented in Table 2-2. The Eh measurements indicate that reducing to moderately oxidizing conditions occur in surficial sediments within the study area and reference stations in all seasons. The extent of reducing conditions was greatest in August 2007, and least in February 2008. Positive Eh measurements were associated primarily with the shallow area in the southeastern part of the study area (Transects A–C). The pH measurements ranged from 5.5 to 9.8, with a mean pH of 7.4. The sediment pH measurements collected in the field generally ranged from 6.5 to 7.5.

2.1.2 Habitats

There are three primary habitats found in the vicinity of DMT: a shallow subtidal area to the east, deep waters to the south and southeast, and Colgate Creek.

A shallow water subtidal area found on the eastern side of DMT is composed of soft, unconsolidated sandy sediment. The depths of overlying surface water are shown on the bathymetric map (Figure 2-2). This area encompasses sediment and surface water study Transects A, B, C, and J and contained a significant amount of floating and submerged debris. The subtidal area is habitat to a number of benthic and pelagic organisms (see Section 2.5.1). The shallow, soft bottom provides fish and invertebrate habitat. Bottom algae and benthic animals would provide a food supply for both young and adult fish. The soft bottom of the subtidal area may also provide a hiding place for burrowing marine animals, such as clams and worms, as well as flat-bodied predators such as flounders.

Deep water channels surround DMT, specifically along the berthing area and beyond into the shipping area. Depths in the deep water habitat range from 30 to 45 feet (Figure 2-2). Sediment and surface water study Transects D, E, F, G, and H and the reference locations are primarily within deep water habitat, with the outermost station outside the dredged channels. The deep water habitat is in an area that is regularly dredged. Water circulation within this habitat may transport eggs, larvae, food, and oxygen to nursery, spawning, and foraging areas. Concrete marine platforms approximately 60 feet in width extend from DMT toward the deep water channels, creating a covered area between the bulkhead and the ship channel. The habitat beneath the platforms is limited due to the lack of light penetration but the platforms may provide refuge for some species of fish and other aquatic wildlife.

Colgate Creek is west of DMT. Deep water habitat exists immediately adjacent to the terminal, as ocean faring vessels dock regularly on both sides of the creek. Transect H is within the deep water portion of the creek, parallel to the terminal. Where the creek is crossed by the Broening Highway Bridge, the creek becomes shallow with sandy soft bottom sediment similar to that found in the shallow subtidal area. The soft bottom of the subtidal area likely provides habitat for burrowing marine animals, such as clams and worms, as well as flat-bodied predators such as flounders.

Transect I is located perpendicular to DMT on the southwest side of the Broening Highway Bridge.

2.2 Constituents of Interest

The COIs to be considered in this ERA are chromium, aluminum, calcium, iron, magnesium, manganese, and vanadium. With the exception of Cr(VI), these metals are generally not considered toxic in an estuarine environment. There are more than 70 elements dissolved in seawater, but only six make up more than 99 percent of all the dissolved salts. Calcium and magnesium are among the six major elements (others are chloride, sodium, sulfur, and potassium) and comprise approximately 1.2 percent and 3.7 percent of all dissolved salts, respectively. In addition to the six major elements, there are many trace elements in seawater, including manganese, iron, and aluminum (GEOL, 2008). Calcium will not be considered further given its natural occurrence in estuarine waters and the lack of available ESVs for calcium in surface water (see Appendix A).

COI concentrations in pore water, surface water, and sediment were measured in the Sediment and Surface Water Study (CH2M HILL and ENVIRON, 2009). The field program was comprised of four quarterly sampling events in May, August, and December 2007 and February 2008 to ensure characterization of seasonal differences in geochemical conditions that govern chromium speciation. The evaluation of the nature and extent of chromium in the surface waters surrounding DMT was based on the comparison of Cr(VI) and dissolved total chromium concentrations in pore water and surface water to USEPA's NRWQC.[2] The study also included the comparison of DMT pore water, surface water, and sediment sample results for chromium and the other COPR constituents to midchannel reference area results, and characterization of geochemical conditions in the Patapsco River. Sampling results are reported in detail in the Sediment and Surface Water Study Report (CH2M HILL and ENVIRON, 2009) and are summarized below. Chemical concentration data are discussed further in Section 3.1. Ancillary sampling of sediment and pore water that was conducted in May 2009 near the shoreline by the 15th Street outfall is addressed briefly below and in greater detail in Section 4.3.2.

2.2.1 Chromium

Cr(VI) and total and dissolved total chromium were analyzed in all pore water and surface water samples. Sediment samples were analyzed for total chromium only because according

[2] USEPA (1986) adopted saltwater criteria to protect aquatic life only for Cr(VI) but not for Cr(III) due to its low toxicity in saltwater. Therefore, while saltwater and freshwater criteria are available for Cr(VI), only freshwater criteria are available for Cr(III). Nevertheless, freshwater criteria based on site-specific hardness values were determined for DMT as part of a conservative assessment of nature and extent.

to USEPA and other published studies, Cr(VI) partitions to pore water if present and biologically available in sediment, and therefore the pore water measurements for Cr(VI) are the accurate and accepted method of quantifying Cr(VI) associated with sediments (USEPA, 2005a; Berry et al., 2004; Besser et al., 2004). The major findings in the Sediment and Surface Water Study regarding the nature and extent of chromium in pore water, surface water, and sediment adjacent to DMT were as follows (CH2M HILL and ENVIRON, 2009):

- Cr(VI) was not detected in pore water in any of the samples taken from DMT in any of the four quarterly sampling events. The detection limit of 5 µg/L was well below the USEPA's saltwater acute and chronic NRWQC for Cr(VI) of 1,100 and 50 µg/L, respectively.
- Cr(VI) was not detected in 97 percent of the surface water samples analyzed,[3] and in those limited locations where it was detected, concentrations were well below the USEPA's chronic NRWQC. Detected concentrations were consistently identified in areas adjacent to stormwater discharge outfalls, and with limited exception the detections followed wet weather events.
- Dissolved total chromium was detected at very low concentrations in pore water and surface water during the four quarterly sampling events. Detected concentrations were similar to those seen at the reference locations and were well below the USEPA's chronic NRWQC for Cr(III) in freshwater (note that there are no Cr(III) criteria for salt water).
- Total chromium concentrations in sediment were consistent with those found at the reference locations except near Area 1501/1602 at the southeast part of the study area, and in Colgate Creek in the northwest part of the study area. In Area 1501/1602, concentrations were highest in the surficial (0 to 6 inches in depth) and mid-depth samples (approximately 12 to 18 inches in depth), and decreased with increasing distance from the shoreline and with increasing depth in the sediment column. In Colgate Creek, the highest chromium concentrations in sediment were found at depth at the location farthest from DMT.

Ancillary sediment and pore water samples were collected along the shoreline of the 15th Street outfall after submittal of the Sediment and Surface Water Study Report to MDE. Sample results were provided to MDE in a letter from Honeywell to MDE dated September 4, 2009. Sample results from this targeted evaluation of the 15th Street outfall following a wet weather event were generally consistent with those from the Sediment and Surface Water Study and are addressed in Section 4.3.2. In the ancillary data collection effort, Cr(VI) was only detected at one location at a concentration of 108 µg/L. While this detection is slightly above the chronic NRWQC of 50 µg/L, it is well below the acute criterion of 1,100 µg/L, and Cr(VI) was not detected at the surrounding locations.

2.2.2 Other COPR Constituents

Concentrations of other COPR constituents (aluminum, iron, magnesium, manganese, and vanadium) have been delineated relative to reference concentrations in pore water, surface water, and sediment. The Sediment and Surface Water Study presents data indicating that the measured concentrations of these constituents are generally within the range of

[3] Sample count excludes duplicate samples.

concentrations observed at reference locations, except as discussed further in this ERA report.

2.3 Chemical and Physical Fate and Transport Mechanisms

The following section provides a summary of the transport pathways from DMT to the surrounding surface waters, and the fate and transport characteristics of the COPR constituents that are evaluated in this ERA. A detailed discussion of chromium geochemistry is presented, as chromium is the main focus of the Consent Order. Detailed discussions of the fate and transport properties of the other COPR constituents are included in Appendix A.

2.3.1 Transport Pathways from DMT to the Adjacent Waterways

The COPR fill used to create DMT is the site-related potential source of COIs to the Patapsco River adjacent to DMT. A detailed evaluation of the fate and transport of chromium at DMT is presented in the Chromium Transport Study Report (CH2M HILL, 2009). The CSM for the transport of chromium from DMT to the Patapsco River and the fate of chromium in the river based on the results of the Sediment and Surface Water Study is summarized below and illustrated in Figure 2-3:

- Areas of groundwater upwelling were identified in the near shore environment near Area 1501/1602 in the Trident probe groundwater upwelling survey; however, analytical results for groundwater samples from riverfront perimeter monitoring wells in Area 1501/1602 indicate that Cr(VI) is not detected at concentrations above the NRWQC. Therefore, groundwater does not appear to be a significant pathway for the transport of Cr(VI) from DMT to the river.
- The absence of Cr(VI) in pore water also indicates that Cr(VI) is not being transported from DMT to the river via groundwater upwelling. The data from the pore water samples also demonstrate that historical releases from DMT via surface water discharge and storm drain outfalls have not resulted in the accumulation of Cr(VI) in sediment.
- These results are consistent with the CSM, which shows that during wet weather, the influence of Cr(VI) from stormwater discharges on the adjacent water body is minimal, even in the area where the least mixing/dilution occurs. Furthermore, there is considerable evidence that the Cr(VI) released to the Patapsco is rapidly reduced to Cr(III).
- The presence of total chromium in sediment adjacent to the shoreline of Area 1501/1602 is likely related to historical surface water runoff from uncovered COPR stockpiles and other filling operations that occurred during past land reclamation activities. Total chromium in sediment in the vicinity of the 14th and 15th Street outfalls may also be related to historical releases of Cr(VI) via the storm drain outfalls that was reduced to Cr(III), which precipitated out of the water column and accumulated in sediment.
- The findings of the DMT sediment and surface water investigation are consistent with those seen by the USEPA and others in other estuarine environments and those seen by Johns Hopkins University (JHU) researchers at other locations in Baltimore Harbor (e.g.,

Berry et al., 2004; USEPA, 2005a; Sorensen et al., 2007; Graham et al., 2009; ENVIRON, 2008).

2.3.2 Chemical Fate and Transport Processes

Chromium geochemistry is summarized below. Information about the fate and transport of chromium in the Patapsco River based on the results of the Surface Water and Sediment Study is also presented.

Chromium Geochemistry

Chromium concentrations in excess of naturally occurring background levels are widespread in sediments in urbanized and industrialized estuaries, due to runoff from road surfaces, combined sewer overflows, and municipal and industrial discharges (Meador et al., 1994; Paul et al., 2002; USEPA, 2004). Although early efforts to evaluate sediment quality and the significance of chromium in sediment focused on analyses of total chromium (Long et al., 1995), recent studies suggest that chromium speciation in sediment must be understood to support more accurate evaluations of potential ecological impacts (USEPA, 2005a; Berry et al., 2004; Besser et al., 2004; Martello et al., 2007; and Sorensen et al., 2007).

USEPA (2005a) states that geochemical processes govern the reduction of Cr(VI) to Cr(III) in aquatic environments, and geochemical processes are critical to the attenuation of chromium in sediments. The presence of Cr(III) is strongly favored in natural waters and sediments because the concentrations of sediment constituents known to reduce Cr(VI) to Cr(III) generally far outweigh the concentrations of the few constituents known to oxidize Cr(III) to Cr(VI). Furthermore, once reduced, Cr(III) is very stable in aquatic environments and highly unlikely to oxidize to Cr(VI). Thus, chromium in sediments is more likely to be in its Cr(III) form than its Cr(VI) form (James and Bartlett, 1983; Fendorf and Zasoski, 1992; Milacic and Stupar, 1995; Weaver and Hochella, 2003).

The USEPA (2005a) approach can be summarized as follows with regard to acid volatile sulfides (AVS), one of the key geochemical indicators of chromium speciation:

- USEPA recognizes the geochemical relationship between chromium and reducing agents, including AVS.
- AVS is formed only in reducing environments.
- Cr(VI) is thermodynamically unstable in reducing environments (i.e., anaerobic sediments).
- Therefore, in the presence of AVS, Cr(VI) is readily transformed to Cr(III), making Cr(III) the dominant species in sediments where total chromium has been measured.
- Cr(VI) reduction is not necessarily limited to areas with high AVS and can be catalyzed by other reductants. The advantage of AVS is that it can be easily, reliably, and inexpensively measured.
- Aquatic toxicity data show that Cr(VI) is much more toxic than Cr(III), which is very poorly soluble in water and exhibits very low aquatic toxicity.

- Therefore, when AVS is present in sediment, chromium-related toxicity is unlikely, especially in estuarine environments.

Understanding chromium speciation and incorporating it in the ERA is important because Cr(III) and Cr(VI) exhibit widely differing chemical properties and ecotoxicological effects. Cr(VI) exhibits much greater solubility, mobility, bioavailability, and toxicity than Cr(III) in sediments and surface waters (Richard and Bourg, 1991; James, 2002; USEPA, 1985 and 2005a). Cr(III) is relatively insoluble at environmentally relevant pH levels, even in geochemically simple aqueous solutions, due to the formation of insoluble hydroxide and oxide compounds. In sediment, Cr(III) solubility is further limited by strong complexation with sediment minerals and organic ligands (Sass and Rai, 1987; Fendorf and Zasoski, 1992; James, 2002). For example, binding of iron and Cr(III)-containing compounds lowers solubility considerably, similar to the inert, highly crystalline chromite ore ($FeO \bullet Cr_2O_3$) (James, 2002). The insolubility of Cr(III) generally limits its bioavailability and mobility in saline environments (Eisler, 1986). Indeed, due to a lack of Cr(III) toxicity in saltwater exposures, the USEPA has adopted saltwater criteria to protect aquatic life only for Cr(VI) (USEPA, 1986).

Several organic and inorganic constituents in anaerobic sediments facilitate rapid reduction of Cr(VI) to Cr(III), including sulfides, Fe(II), and organic matter (Hansel et al., 2003); bacterially mediated reduction of Cr(VI) is also known (Schmieman et al., 1998). Reduction of Cr(VI) to Cr(III) is rapid under reducing or even mildly oxidizing conditions, occurring within minutes to days depending on the reducing agent (Berry et al., 2004; Lin, 2002; Richard and Bourg, 1991; Schroeder and Lee, 1975; Stollenwerk and Grove, 1985).

Fate and Transport of Chromium at DMT

The approach for evaluating the fate and transport of chromium in the Sediment and Surface Water Study was based on characterizing the geochemical conditions that influence chromium speciation and stability during each of the four sampling events. Seasonal variations in geochemical parameters were evaluated as they may affect the reducing conditions that govern chromium speciation. These parameters included divalent iron and divalent manganese, TOC and dissolved organic carbon (DOC), sulfide, ORP, and AVS/simultaneously extracted metals (SEM) (sediment only). The major findings based on the Sediment and Surface Water Study were as follows:

- Measurements of geochemical parameters in surface water, pore water and sediment (e.g. AVS and Fe(II)) demonstrate that conditions are favorable to the presence of chromium as Cr(III) rather than Cr(VI). Sediments at DMT consistently contained measurable concentrations of these geochemical constituents despite fluctuations that naturally occur with the change of season.

- A statistically significant relationship was observed between dissolved total chromium and Cr(VI) concentrations in surface water samples where Cr(VI) was detected ($p < 0.05$). This relationship demonstrates that Cr(VI) is rapidly reduced to Cr(III) in the water column, where it most likely precipitates to the sediment.

- Based on the results of the Sediment and Surface Water Study and other related studies with respect to chromium geochemistry, total chromium in sediment is unlikely to

oxidize to Cr(VI) in the future because the geochemical conditions necessary for this process do not naturally occur in the estuarine environment.

The extent to which Cr(III) oxidizes to Cr(VI) in a laboratory environment depends on the presence and mineralogy of manganese (hydroxides, pH, and the form and solubility of Cr(III); however, once reduced in a natural aquatic environment, Cr(III) is very stable and highly unlikely to oxidize to Cr(VI) (Magar et al., 2008; James and Bartlett, 1983; Fendorf and Zasoski, 1992; Milacic and Stupar, 1995; Weaver and Hochella, 2003). Cr(III) oxidation is less likely to occur in the environment than under laboratory conditions, because aged waste materials containing Cr(III) are typically less soluble and more inert to oxidation and $Cr(OH)_3$ precipitates may form on manganese (hydr)oxide surfaces (James and Bartlett, 1983; Fendorf and Zasoski, 1992; Fendorf, 1995; Martello et al., 2007).

Johns Hopkins University Contaminant Transport, Fate and Remediation (CTFR) evaluated whether Cr(III) would oxidize to Cr(VI) from Baltimore Harbor sediments, including a location from DMT. Sediments were aerated continuously for 10 days and time series analyses of Cr(VI) in water were conducted. Results showed that Cr(VI) was not detected in any of the Baltimore Harbor aerated sediment controls (Graham and Wadhawan, 2007 and 2009; ENVIRON, 2008). Only highly artificial laboratory conditions induced the oxidation of any Cr(III) to Cr(VI) and even then, the Cr(VI) rapidly reduced back to Cr(III) in very short timeframes.

2.3.3 Physical Fate and Transport

Once released into the aquatic environment, chromium and other COPR constituents can be transported in dissolved phase in the water column, or adsorbed to sediment particles and transported in the solid phase. The hydrodynamic and sediment transport processes that may influence the transport of COIs are described below.

Multiple dye studies were conducted in April 1987 on the 15th Street (96-inch) drain at DMT (EA, 1987). Dye concentrations were measured with fluorometers at the bulkhead and onboard a vessel in the mixing zone. The results of the dye study suggested that a "conservative" parameter would undergo a dilution between 1:200 and 1:400 within 2,000 feet of the outfall. Dilutions of 1:1,000 to 1:3,000 would apply within 5,000 feet of the discharge point. These results can be used to estimate the attenuation of dissolved-phase COIs in the water column near DMT.

No flow or current measurements are available in the immediate vicinity of the DMT. Current velocities in the Patapsco River tend to be weak and variable, with maximum velocities of less than 30 centimeters per second (cm/s) (USACE, 2006). Baltimore Harbor is a net depositional environment for sediment. Shoaling rates in channels and anchorages adjacent to DMT are about 3 inches per year (USACE and MPA, 1997). Once deposited, sediments could potentially be resuspended by currents, tides, waves, dredging, ship traffic, or other human activities. A study of sediment resuspension in Baltimore Harbor indicated that a loosely consolidated surface "fluff" layer is commonly present on top of a well-consolidated sediment bed (Maa et al., 1998). Under normal flow conditions, bottom shear stresses due to wave and current activity are insufficient to erode the consolidated sediment bed, but can readily resuspend and transport fluff. Based on existing information regarding flow velocities and sediment transport in Baltimore Harbor, COIs that are adsorbed to

consolidated sediments in the vicinity of DMT are not likely to erode under typical hydrodynamic conditions.

2.4 Ecotoxicity Mechanisms for COIs

The constituent-specific mechanisms of ecotoxicity for each of the COIs evaluated in the ERA are described in detail in Appendix A. A discussion of toxicological screening values based upon these mechanisms of toxicity and the selection of these values for use in this ERA is provided in Section 3.2.

2.5 Ecological Receptors and Exposure Pathways

An essential component of the ERA is an understanding of the specific ecological receptors potentially present within the communities found within the study area or within the influence of the study area. Also of importance is an understanding of the complete pathways from the potential sources of contamination to these ecological receptors. The discussion below provides a summary of readily available information from the literature, Site-specific observations, and Site-specific knowledge regarding the ecological receptors and complete exposure pathways to those receptors.

2.5.1 Ecological Receptors

Benthic Community

Several studies conducted between 1975 and 2006 examined benthic community conditions within Baltimore Harbor and the Patapsco River watershed. A 1975 study in Baltimore Harbor found that the tubifex worm, a pollution-tolerant species, was fairly common, but that crustaceans and mollusks (species relatively intolerant to pollution) were scarce (USACE, 2001). In 1983, in response to deteriorating benthic community conditions within Chesapeake Bay and its tributaries, the USEPA along with several states in the Bay's watershed implemented biological monitoring under the Chesapeake Bay Agreement (MDNR, 2005a). Sediment toxicity was observed at many locations within the Harbor and tolerant communities were observed in the mid 1990s (McGee et al., 1999).

Benthic monitoring programs use a benthic index of biotic integrity (B-IBI) or index of biological integrity (IBI) to assess benthic community conditions. The IBI uses characteristics of the benthic macroinvertebrate assemblage structure and function to assess the overall water resource condition (MDNR, 2005a; Dauer et al., 2000). The Wye Research and Education Center (WREC) calculated IBI scores for sites in Baltimore Harbor beginning in 1996 in conjunction with toxicity tests using the estuarine amphipod *Leptocheirus plumulosus* (Klosterhaus et al., 2007). One station was established in Colgate Creek which showed degraded conditions based on low IBI scores as well as a low Shannon Weiner Diversity Index score. Amphipod survival and density studies were also performed in 1996 at a station in the open shallow water area across from DMT (i.e. just beyond Transects C, B, and A). Amphipod survival was nearly 100% and density was one of the highest in the study at over 30,000 organisms per square meter. Results for Colgate Creek, however, indicated low survival and limited organism abundance, and researchers noted elevated ammonia levels (i.e., approximately three to five times higher than anywhere else sampled) (Klosterhaus et

al., 2007). Ammonia is common in industrial and sewage effluents and the concentrations of ammonia seen by Klosterhaus et al. at the Colgate Creek location were above USEPA NRWQC for ammonia (USEPA, 1989). Ammonia is not a constituent of COPR.

During the first quarterly sampling event of the Sediment and Surface Water Study (May 2007), a qualitative benthos analysis was conducted at DMT to provide descriptions of biological assemblages (Appendix B). Observed organisms were typical of estuarine assemblages of two distinct benthic communities. The two most likely community types were predicted based on species identified, bottom sediment type, and water velocity. These communities are described below. There are no natural oyster bars in the area, although the Patapsco River Oyster Reef Restoration Project is located near Fort Carroll, approximately 5 miles from DMT (NOAA, 2008).

Sediments at the northwest side of DMT consisted of soft clay and silt, with traces of sand, shell marl, and gravel indicative of a low-energy depositional environment. The dominant organisms found in the sediment were polychaetes with a few observations of small amphipods (Table 2-3). Based on environment and biological observations, this area most likely supports a community of soft-bodied polychaetes that are probably a mix of deposit feeders, suspension feeders, detritivores, and large carnivores. While not observed, various smaller crustaceans, amphipods, and other worms are probably present in this community (Appendix B).

Sediments at the southeast side of DMT consisted of medium sand and some shell marl, which are indicative of a higher-energy environment. Small clams, polychaetes, amphipods, and a few arthropods were observed in the sediment. The sediment and biota found in this area most likely supports a community of armored organisms that specialize in burrowing in sandy sediment, and may include clams and other suspension feeders, amphipods, isopods, copepods, and armored arthropods (Appendix B). A second qualitative analysis was performed in June 2008 in the area adjacent to sampling location J4 (Table 2-3). Amphipods and crabs were dominant in this survey, confirming the predictions of the 2007 report; however, sampling also identified isopods, barnacles, mussels, pipefish, mysid shrimp, and worms (polychaetes and oligochaetes).

Pelagic Community

Long-term monitoring of phytoplankton densities shows higher surface phytoplankton concentrations in the Patapsco River relative to the mainstem Chesapeake Bay in most seasons, particularly in spring and summer (MDNR, 2005b). In general, estimations of phytoplankton biomass in surface water were typical for Baltimore Harbor, which commonly has eutrophic conditions.

Fisheries and plankton studies were conducted within and adjacent to the proposed Masonville Dredged Material Containment Facility (DMCF) (Figure 1-1), approximately 3 miles west of DMT, in July 2003, May 2004, October 2004, May 2005 and August 2005 (USEPA, 2006a). Due to the close proximity and similar environment (e.g., current velocity and sediment type), pelagic species observed at the Masonville DMCF site represent assemblages that can be expected at DMT. Zooplankton samples were dominated by mud and fiddler crab zoea, with moderate densities of copepods, shrimp larvae, and amphipods. The plankton communities near Masonville were similar to the control sites near Key Bridge

(USEPA, 2006a). In another study, low abundance and diversity of plankton were observed and may be attributed to predation by the high density of comb jellyfish (*Ctenophora*) that were also observed inhabiting the waters during the July 2004 sampling efforts (EA, 2005).

Ichthyoplankton samples indicated low diversity and low abundance of fish species, primarily consisting of northern pipefish and goby, during summer 2004 surveys at Masonville. These results may be attributed to the high abundances of comb jellies inhabiting these waters during the sampling events and preying on the ichthyoplankton. In addition, young anadromous fish collected in seine surveys in May in all years sampled indicates that anadromous fish tend to develop beyond their planktonic stages before reaching the Masonville area (USEPA, 2006a).

In general, the estuarine portion of the Patapsco River salinity regime, ranging from 2 to 10 ppt, supports a slightly different finfish community than the mainstem Chesapeake Bay. Fish collected at Masonville DMCF were typical species of the mesohaline reaches of the Chesapeake Bay. Commercially and/or recreationally important species collected during trawl and gillnet efforts at Masonville included striped bass (*Morone saxatilis*), white perch (*Morone americana*), Atlantic menhaden (*Brevoortia tyrannus*), bluefish (*Pomatomus saltatrix*), largemouth bass (*Micropterus salmoides*), American eel (*Anguilla rostrata*), and blue crab (*Callinectes sapidus*). White perch dominated the collection for both trawl and gillnet efforts in all three seasons. However, samples collected at deeper areas supported only a limited numbers of pelagic species (USEPA, 2006a).

Wildlife

No avian studies have been conducted immediately adjacent to DMT. Thus, as with the pelagic community, studies from the nearby areas provide an understanding of wildlife found within the study area. A description of ecological communities is provided in the Final Supplemental Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) for the dredging of sites in Baltimore Harbor including the Seagirt terminal and the west side of DMT (i.e., Colgate Creek). A study at the Masonville DMCF also provides a description of what can be expected at DMT.

As reported in the Final Supplemental EA and FONSI for the Baltimore Harbor Dredging, the U.S. Fish and Wildlife Service (USFWS) reports the existence of two waterbird nesting colonies near Baltimore Harbor. An established colony of black-crowned night herons, consisting of approximately 350 breeding pairs, nest at Sollers Point near the northern end of the Francis Scott Key Bridge. Approximately 500 pairs of herring gulls nest at a site on Sparrows Point. Many resident species such as great blue herons (*Ardea herodias*), double-crested cormorants (*Phalocrocorax auritus*), and osprey are also located in the study area. Additionally, a variety of waterfowl species winter in the Baltimore Harbor area including mallards (*Anas brachyrhynchos*), scaup (*Aythya affinis)*, bufflehead (*Bucephala albeola*), goldeneye (*Bucephala clangula*), ruddy duck (*Oxyura jamaicensis*), canvasbacks (*Aythya valisineria*), Canada geese (*Branta canadensis*), and black duck (*Anas rubripes*).

Bird census monitoring surveys were conducted in February, March, April, June, August, and September of 2005 at the Masonville DMCF (USEPA, 2006a). Birds observed associated with the shoreline and open water included resident species of waterfowl and herons such as Canada goose, mallard, and great blue heron. Year round resident species are

supplemented with a variety of wintering and migrant species of waterfowl including bufflehead, green-winged teal (*Anas crecca*), lesser scaup, ring-necked duck (*Aythya collaris*), canvasback, gadwall (*Anas strepera*), and ruddy duck (*Oxyura jamaicensis*). Summer resident species include great egret (*Ardea alba*), green heron (*Butorides virescens*), black-crowned night-heron (*Nycticorax nycticorax*) and double-crested cormorant.

The open water and near shore line near DMT indicate that some of these aquatic-oriented species seen at Masonville will likely have at least some lofting and foraging areas at DMT. Wintering sea ducks like scoters, long-tailed ducks, and mergansers, may use the open water for the shellfish, invertebrates and fish they eat during the winter months. Hooded mergansers (*Lophodytes cucullatus*) are known to occur within Baltimore City limits. The species is currently ranked as S1B (rare and a migrant with breeding status) and is actively tracked by the Wildlife and Heritage Service (MDNR, 2007). Hooded mergansers were not observed at the Masonville site; however, transient winter foraging may occur at DMT. In addition, a pair of bald eagles (*Haliaeetus leucocephalus*) was utilizing a nest tree at Masonville cove and was observed during spring, summer and fall 2004 surveys. The nest tree fell in March 2005, an adult bald eagle was sighted during the September 2005 survey, and another bald eagle nest site is located near Black Marsh, approximately 8 miles from the project area (USACE, 2005). Therefore, bald eagles may use the waters surrounding DMT for foraging throughout the year.

Special Status Species

There are 31 federally listed endangered or threatened species in Maryland; however, only a few occur in the general area of the DMT. Federally listed endangered sea turtle species found in the Chesapeake Bay include hawksbill (*Eretmochelys imbricate*), Kemp's ridley (*Lepidochelys kempii*), and leatherback (*Dermochelys coriacea*) (USFWS, 2008). Federally listed threatened sea turtle species found in the Bay include green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) (USFWS, 2008). Due to the industrial character of the area, lacking natural shore line and vegetation, it would be unlikely to find a sea turtle from the Bay in the Harbor or Patapsco River. The shortnose sturgeon (*Acipenser brevirostrum*) is the only endangered species that could potentially occur in the DMT area (USFWS, 2008). Data from the reward program for incidental catches of shortnose and Atlantic sturgeon (*Acipenser oxyrhynchus*) showed no shortnose sturgeon captured upstream of the Key Bridge (Figure 1-1), approximately 4 miles from DMT, suggest that sturgeon are probably transient to the Harbor and likely to only use the channels (USFWS, 2005). The closest Atlantic sturgeon taken was in the mouth of the Patapsco River, approximately 7 miles from DMT (USFWS, 2005). Due to their preference for higher salinities and known distributions within the Bay, Atlantic sturgeons are expected to be transients within the Patapsco estuary and rare to the study area.

Representative Receptors of Potential Concern for the Study Area

Based on observations while collecting the abiotic media within the study area (i.e., pore water, surface water, and sediment samples), the qualitative benthic study conducted in the study area, and other studies of fish, wildlife, and benthic communities conducted in the vicinity of the study area, the following specific receptors of potential concern were identified for the SLERA:

- Benthic invertebrates – amphipods, polychaetes, marine clams, and mysid shrimp
- Pelagic fish - northern pipefish, white perch
- Omnivorous Birds – mallard, hooded merganser
- Piscivorous Birds - osprey

2.5.2 Exposure Pathways

Ecological receptors can potentially be exposed to chromium and other COPR constituents in surface water or sediments. In both of these media, exposure is primarily via direct contact. Presence of the COIs at detectable levels creates a direct ingestion exposure pathway. However, as summarized below, chromium and other COPR constituents do not enter the food web so ingestion of food is not a complete exposure pathway.

Surface Water

Organisms spending at least a portion of their life cycle in the water column (i.e., pelagic-dwelling organisms) can be exposed to dissolved- or suspended-phase contaminants in the water. The exposure can be through dermal contact, ingestion, or exposure to gill surfaces as part of the gas exchange process. The organisms can be at risk from the combination of these exposure pathways and the ESVs developed for surface water account for the combination. As noted previously, Cr(VI) is very soluble in water, but Cr(III) is not. Other COPR constituents are also soluble in water including calcium, magnesium, and vanadium.

Sediment and Pore Water

For sediment dwelling organisms the exchange of nutrients, gases, and potential contaminants is most frequently through the pore water (water in the interstitial spaces in the sediment). Consistent with this exchange mechanism, the recent state of the science suggests that pore water is the more relevant inorganic constituent exposure pathway for benthic organisms. USEPA's *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Metal Mixtures (Cadmium, Copper, Lead, Nickel, Silver, and Zinc)* (USEPA, 2005a) and the *Framework for Metals Risk Assessment* (USEPA, 2007) advocate evaluating metals in sediment in the aqueous phase (i.e., pore water) and incorporating additional information such as AVS in relation to SEM concentrations. In addition to this exposure mechanism, the sediment-dwelling community is in direct contact with the sediment and can incidentally ingest sediment during feeding.

Food Chain Exposure

Cr(III) is an essential nutrient for biological organisms; however, chromium does not biomagnify in the food web (Eisler, 1986; Newman, 1998; NPS, 1997). Flora and fauna have natural mechanisms to regulate uptake and elimination of Cr(III). Specifically, Cr(III) plays a role in sugar and protein metabolism. As a result of bioregulation, the extent to which Cr(III) is accumulated is expected to be concentration-dependent. That is, the ratio of chromium in tissue to bioavailable chromium in environmental media will be highest when bioavailable chromium is scarce and lowest when bioavailable chromium is relatively abundant (NPS, 1997). Cr(VI) does not persist in biological tissues. Cr(VI) is rapidly taken up by cells through the sulfate transport system and is quickly reduced to Cr(III) in all tissues (IRIS, 2003; NPS, 1997). There is no evidence that Cr(III) is converted to Cr(VI) in biological systems (IRIS, 2003). Thus, Cr(VI) exerts toxicity through direct contact

mechanisms rather than bioaccumulation to a critical concentration in tissue. As with chromium, the other COPR constituents are not considered to bioaccumulate within the food web, particularly given that some of the COPR constituents are natural components of seawater (ATSDR, 2006; CBP, 2008; NOAA, 2007). A review the bioaccumulation potential of the other COPR constituents is provided in Appendix A.

Studies have shown that chromium associated with COPR does not accumulate in the food chain. Conder et al. (2008) demonstrated that avian receptors in Upper Newark Bay/ Hackensack River complex that forage adjacent to a COPR fill area with total chromium concentrations in soil up to 9,000 mg/kg (average of 1,300 mg/kg) are not exposed to unacceptable risks. The evaluation included avian receptors that consume fish, aquatic invertebrates, and incidentally ingest sediment. These findings were consistent with the lack of bioaccumulation of chromium in wildlife.

2.5.3 Summary of Exposure Pathways and Receptors

Based on the discussion of receptors and pathways above, the focus of the ERA will be on benthic and water column community exposure. As stated previously, COPR constituents do not biomagnify significantly within the food chain; thus, food chain risks are not evaluated. Exposure of benthic organisms to multiple media (e.g., surface water, pore water and sediment) will be considered for both the trivalent and hexavalent forms of chromium. In accordance with USEPA (2005a) and the ERA Work Plan (CH2M HILL, 2006), the focus will be on exposure to pore water because it is the most direct and well researched pathway. Exposure estimates will consider geochemical conditions governing speciation and toxicity of each form.

2.6 Summary of the Conceptual Site Model

A preliminary ecological CSM is presented in Figure 2-4. The model includes the pathways by which COIs can potentially reach the ecological receptors described in Section 2.5. The potential primary source of Site-related contamination to the Patapsco River from DMT is COPR that was used as fill.

If chromium is released to the Patapsco River from DMT, it may be present in the estuarine environment in a dissolved phase in surface water or pore water. It can also be associated with colloidal particles in the surface water, or sorbed to sediment in the solid phase. Once in the estuarine environment, the fate and toxicity of chromium is highly dependent on its chemical state, as discussed Section 2.3.

The results of the Sediment and Surface Water Study indicate that Cr(VI) is not being transported from DMT to the river via groundwater upwelling (CH2M HILL and ENVIRON, 2009). The study results also demonstrate that historical releases from DMT via storm drain outfalls have not resulted in the accumulation of Cr(VI) in sediment. During wet weather stormwater discharges, the influence of Cr(VI) on the adjacent water body is minimal. Furthermore, there is considerable evidence that the Cr(VI) released to the Patapsco River is rapidly reduced to Cr(III).

The primary exposure pathways and receptors are direct contact of the benthic community with sediment and pore water, and direct contact of pelagic communities with surface water.

2.7 Preliminary Assessment and Measurement Endpoints

Assessment endpoints define ecological entities that are to be protected and attributes that can be used to gauge the degree of impact that has or could occur (USEPA, 1997; 2003). Assessment endpoints most often relate to attributes of biological populations or communities, and focus the risk assessment on particular components of the ecosystem that could be adversely affected by contaminants from the study area (e.g., survival and reproductive abilities of fish populations) (USEPA, 1997). Assessment endpoints often cannot be measured directly, so measurement endpoints focus on measureable attributes that are related to the assessment endpoints and the overall ecological entities and attributes of focus for an ERA (e.g., reproductive survival in laboratory studies of fish).

Table 2-4 presents a summary of assessment and measurement endpoints, representative receptors, measures of exposures, effects, and testable hypotheses. The following assessment endpoints are considered further in this ERA:

- Benthic invertebrate community structure and function
- Water invertebrate community structure and function
- Fish population survival and reproductive ability

Measurement endpoints were developed to address the above risk questions. The following measurement endpoints are proposed to assess the potential for unacceptable risk at DMT:

- *Benthic Invertebrate Community Structure and Function* – (1) Comparison of concentrations of COIs in pore water to USEPA's NRWQC or other ESVs considered protective of survival or reproduction, (2) comparison of concentrations of COIs in bulk surface sediments reported on a dry weight basis (except chromium, see Section 2.8.2) to conservative ESVs considered protective of survival or reproduction, and (3) consideration of the biological community present in the Patapsco River sediments, particularly in areas where COPR constituents were measured.
- *Water Column Invertebrate Community Structure and Function* — comparison of concentrations of COIs in surface water to USEPA's NRWQC or other ESVs considered protective of survival or reproduction.
- *Fish Survival and Reproductive Ability* — comparison of concentrations of COIs in surface water adjacent to DMT to USEPA's NRWQC or other ESVs considered protective of survival or reproduction.

2.8 Ecological Effects Assessment – Selection of Screening Ecotoxicity Values

Potential risks were evaluated for chromium, aluminum, calcium, iron, magnesium, manganese, and vanadium. For chromium, the evaluation focused primarily on determining the exposure of organisms to the more-toxic hexavalent form instead of the less-toxic trivalent form. Risk within each medium was evaluated initially by comparing measured concentrations of Cr(III), Cr(VI), and other COPR constituents to ESVs for each medium.

2.8.1 Screening Ecotoxicity Values for Surface Water and Pore Water

ESVs based upon exposure to surface water are readily available whereas those for exposures to pore water are not. However, the exposure mechanisms for the two media are identical and concentrations in surface water that are detrimental would be similarly so in pore water. Hence, surface water ESVs were employed to evaluate risk attributable to both surface water and pore water exposure pathways.

Saltwater screening criteria are appropriate for the area surrounding DMT; however, marine criteria are only available for Cr(VI). Freshwater criteria are available for Cr(III) and the other COPR constituents and will be used for informative purposes only since freshwater criteria are typically much lower than marine criteria and concentrations exceeding these ESVs do not necessarily result in unacceptable ecological risk in a marine system. In instances where measured values exceed the ESVs, additional information will be incorporated to refine the risk estimate.

The key ESVs used in the initial evaluation are the acute and chronic NRWQC. The chronic or criterion continuous concentration (CCC) is an estimate of the highest concentration of a constituent in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. The acute or criteria maximum is an estimate of the highest concentration of a constituent in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect.

NRWQC for both Cr(III) and Cr(VI) in surface water and pore water are shown in Table 2-5, which are consistent with the MDE Water Quality Standards (MDE, 2005). The freshwater criteria for Cr(III) are based upon a hardness of 100 mg/L $CaCO_3$ and toxicity decreases with increasing hardness. The average hardness for samples proximal to DMT is 2,250 mg/L $CaCO_3$. Should the exposure concentrations exceed these criteria, site-specific criteria would be presented based upon a hardness of 400 mg/L $CaCO_3$, the maximum allowable for the development for ambient water quality criteria using USEPA's recalculation criteria (USEPA, 1994; 2006b). While USEPA acknowledges that increased hardness results in decreased bioavailability, a maximum value of 400 mg/L is recommended for use in the derivation formulae because the formulae are calibrated for a relatively narrow range of hardness values that are more proximate to the freshwater end of the spectrum of naturally occurring hardness values. Given that the lowest site-specific hardness value for DMT is approximately 1,500 mg/L, the use of 400 mg/L is very conservative, as a 1995 publication of the Federal Register even stated "using 400 mg/L to calculate criteria, in waters with an ambient hardness of greater than 400 mg/L, may result in overprotective…" .

The saltwater chronic criterion for Cr(VI) is anticipated to be the critical value and will be used on the basis of the "National Guidance on the Applicability of Freshwater and Saltwater Criteria" (USEPA, 2002). Saltwater values are applicable to waters with salinity greater than 10 ppt, and average salinity at DMT over the duration of the *Sediment and Surface Water Study* was 10.7 ppt.

The surface water ESVs are summarized in Tables 2-5 and 2-6. They are based on the following hierarchy for the designation of a single ESV for use in the ERA. This hierarchy provides greatest emphasis on the USEPA and MDE criteria, as available. The USEPA and MDE criteria are generally the most robust of the available criteria, with a minimum of eight genera included in the overall computation of a protective value (USEPA 2006b). MDE

criteria for chromium are the NRWQC. MDE has not established numeric criteria for the other COPR constituents. The need to use other criteria indicates the overall lack of criteria from the standard sources for the COPR constituents and the difficulty in obtaining ESVs for constituents that comprise seawater.

- USEPA National Recommended Water Quality Criteria (USEPA, 2006b)
- MDE Numerical Criteria for Toxic Substances in Surface Waters: COMAR 26.08.02.03-2
- Suter and Tsao Secondary Acute and Chronic Values (1996)
- Texas Commission on Environmental Quality (TCEQ) Aquatic Life Surface Water Risk-Based Exposure Limits from the Texas Surface Water Quality Standards (TCEQ, 2003)
- USEPA ECOTOX Database (2009)

2.8.2 Screening Ecotoxicity Values for Sediment Chemicals of Interest

There are two primary approaches to evaluating toxicity of sediments from chemical analysis of the sediments. One is to compare concentrations measured in bulk sediments, expressed as mass per unit mass (e.g. mg/kg) to values reported in the literature associated with ecological effects (sediment quality guidelines or SQGs). The other is to measure the concentration of the constituent in the pore water, as expressed as mass per unit volume (e.g. µg/l) and compare it to water quality criteria. As discussed below, the bulk sediment-SQG approach has severe limitations and for the conditions adjacent to DMT the pore water comparison to water quality criteria approach is the more appropriate method for chromium, in accordance with USEPA (2005a).

The SQG approach can sometimes be useful as a screening tool because if the measured concentrations are below the no effects levels reported in the literature, there is a high degree of certainty that the sediments do not represent an unacceptable risk to organisms in close contact with the sediment. However, predicting toxicity using SQGs is highly uncertain due to limitations in the derivation methods (Long et al., 1995). Frequently cited SQGs (e.g., the effect range median (ER-M)) are often derived from large empirical data sets that included sediments containing mixtures of many chemicals. These data sets were statistically manipulated to identify concentrations of individual chemicals that were typically associated with toxicity (or lack of toxicity). Because many chemicals were strongly inter-correlated in these data sets, the resulting sediment-screening values were useful for predicting toxicity of the mixture but were much less useful for identifying the specific chemicals causing toxicity. Long et al. (1995) cautioned that ER-M values do not represent causality and are not intended for regulatory purposes. Long (2005) emphasized this point and clearly stated that the frequently used SWG ER-M does not predict which chemical causes sediment toxicity.

Another limitation of many SQGs is that the speciation of the chemical is not measured or considered in the analysis used to derive the SQG. This is particularly true for total chromium and is apparent from close examination of toxicity response curves. A classical concentration-response curve is shown in Figure 2-5a showing concentrations below which adverse impacts do not occur, and above which adverse impacts do occur. However, in a critical examination of a SQG, the presence of chromium at concentrations greater than the

ER-M have been documented in scientific literature showing no adverse effect (Figure 2-5b), and certainly no discernable concentration-response relative to the SQG (Besser et al., 2004; Berry et al. 2002; Exponent, 1998; McGee et al., 1999; NOAA, 2003/2005). One of these studies (McGee et al., 1999) is focused on Baltimore Harbor and examined toxicity associated with sediments containing mixtures of a wide range of contaminants, including many for which toxic effects are known to occur.

The SQG limitations do not apply when pore water concentrations are compared to water quality criteria. The water quality criteria were derived for individual chemicals using spiked toxicity tests, thus comparing measured concentrations in pore water to the criteria is an appropriate and well documented approach to evaluating toxicity. Also the form of the chemical, particularly chromium can be readily measured in pore water where as it cannot be readily measured in bulk sediment.

As described above, alternative methods using pore water comparisons have been pursued by USEPA and MDE given the limitations in using SQGs to predict chromium toxicity (USEPA, 2005a; MDE, 2004). A breakthrough in identifying specific causes of sediment toxicity was the understanding (1) that toxicity among differing sediments is well correlated, not with total chemical concentrations in whole sediment, but with concentrations observed in the interstitial or pore water; (2) that toxicity thresholds in pore water are essentially equal to those found in water-only exposures (Di Toro et al., 1991): and (3) the form of the chemical (e.g. Cr(III) vs. Cr(VI)) can strongly influence the toxic response. For these reasons, the USEPA EqP approach is used in this ERA to evaluate sediment toxicity and the associated ecological risk. Therefore, comparisons of chromium concentrations in bulk sediment to ecological risk thresholds are not presented in this ERA.

For the purpose of this ERA, for COPR constituents other than chromium the bulk sediment ESVs are considered only as a secondary line of evidence in the screening process. ESVs for bulk surface sediment for other COPR constituents are presented in Table 2-7. Saltwater ESVs for COPR constituents in sediment were selected by consulting the National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference tables ((SQuiRTs), Buchman, 2008). This compendium is a useful tool for identifying values that can be used for screening purposes.

For many constituents which are considered toxic in sediments, such as priority pollutants, lower and upper effects values are presented to reflect the uncertainty in the bulk sediment ESVs. The intent of including two values is to provide a frame of reference for Site-specific sediment concentrations. The upper effects values represent concentrations at which toxicity is often observed and therefore adverse effects to aquatic organism are probable. The lower effects concentrations are concentrations at which adverse effects are infrequently observed. Concentrations below these values would have a low probability of adverse effects. However this is not the case for the COPR constituents and only one effect value was available (Apparent Effects Threshold (AET)). Concentrations were initially compared to these AET values to eliminate COIs for which there is no unacceptable risk.

Table 2-1

Water Quality Characteristics

Dundalk Marine Terminal, Baltimore, Maryland

Location	Statistic	May 2007 through February 2008								
		Temperature °C	Turbidity NTU	pH SU	Dissolved Oxygen mg/L	Oxygen Saturation %	Depth ft	Sigma-theta kg/m^3	Salinity PSU	Specific Conductanc µS/cm
A Transect	Average	15.9	10.6	8.11	7.83	76	3	1,005	8.6	14,859
	Min	2.5	5.8	7.23	1.44	18	1	1,002	4.8	8,577
	Max	24.2	25.9	8.93	15.62	131	5	1,010	12.9	22,266
B Transect	Average	13.4	12.2	8.08	8.94	84	5	1,006	9.4	16,272
	Min	3.4	2.4	7.19	2.31	30	1	1,002	4.2	7,933
	Max	26.3	39.1	8.61	13.06	109	10	1,011	13.6	23,439
C Transect	Average	15.5	11.8	8.25	8.90	86	5	1,005	8.5	14,807
	Min	3.8	7.6	7.27	1.99	26	1	1,002	4.1	7,701
	Max	25.7	26.5	8.93	13.82	128	10	1,011	13.7	23,358
D Transect	Average	14.0	8.8	7.89	7.56	74	20	1,007	11.2	19,160
	Min	3.4	4.3	6.86	0.08	1	1	1,001	3.6	6,655
	Max	28.0	21.2	8.96	14.23	145	42	1,012	16.3	26,590
E Transect	Average	15.2	9.5	7.93	7.09	71	20	1,007	10.9	18,656
	Min	3.1	3.9	6.92	0.09	1	1	1,000	3.1	5,654
	Max	28.1	27.5	9.01	14.06	145	45	1,012	16.3	26,828
F Transect	Average	16.1	9.2	7.94	6.92	72	19	1,007	11.2	19,125
	Min	3.0	4.9	6.89	0.61	6	1	1,002	4.6	8,294
	Max	28.4	19.2	9.07	14.77	176	44	1,012	16.2	27,103
G Transect	Average	16.1	8.3	7.92	7.40	77	20	1,007	10.6	18,190
	Min	3.4	4.0	6.94	0.11	1	1	1,000	3.1	5,705
	Max	28.2	23.5	9.02	14.27	156	43	1,012	16.0	26,530
H Transect	Average	16.1	8.2	7.87	6.25	63	19	1,007	11.0	18,777
	Min	3.2	4.2	6.95	0.08	1	1	1,001	3.8	6,960
	Max	28.1	20.4	8.81	12.54	132	41	1,012	15.6	25,557
I Transect	Average	17.3	8.7	8.25	8.79	90	5	1,005	8.7	15,123
	Min	4.5	4.3	7.38	2.35	32	0	1,001	3.9	7,071
	Max	27.2	35.8	8.98	13.38	151	11	1,011	14.1	23,907
J Transect	Average	4.9	8.7	7.48	10.50	87	2	1,007	9.1	16,155
	Min	4.0	3.5	7.29	7.61	66	1	1,006	8.2	14,547
	Max	7.1	10.3	8.18	11.36	100	5	1,007	9.3	16,437
37 Reference	Average	14.1	7.9	7.93	7.75	75	19	1,007	10.9	18,755
	Min	3.6	4.7	6.96	0.09	1	1	1,002	5.2	9,366
	Max	27.3	13.6	8.82	14.98	125	38	1,011	16.0	26,196
37a Reference	Average	14.3	8.6	7.96	8.28	83	18	1,007	10.9	18,766
	Min	3.1	4.9	6.95	1.85	19	1	1,002	5.2	9,306
	Max	27.3	14.3	8.93	14.26	123	37	1,011	15.0	24,784
37b Reference	Average	14.0	8.6	7.95	8.18	81	19	1,007	11.1	19,140
	Min	2.8	5.2	6.93	0.13	2	1	1,002	5.3	9,460
	Max	27.4	14.9	8.76	14.07	119	37	1,011	16.0	26,235
DMT Overall	Average	15.4	9.1	7.95	7.33	73	17	1,007	10.7	18,262
	Min	2.5	2.4	6.86	0.08	1	0	1,000	3.1	5,654
	Max	28.4	39.1	9.07	15.62	176	45	1,012	16.3	27,103
Reference Overall	Average	14.2	8.4	7.95	8.07	80	19	1,007	11.0	18,886
	Min	2.8	4.7	6.93	0.09	1	1	1,002	5.2	9,306
	Max	27.4	14.9	8.93	14.98	125	38	1,011	16.0	26,235

Notes:

°C	Degrees Celsius.
DMT	Dundalk Marine Terminal.
ft	Feet.
kg/m^3	Kilograms per cubic meter.
max	Maximum.
mg/L	Milligrams per liter.
min	Minimum.
NA	Not analyzed.
NTU	Nephelometric Turbidity Units.
PSU	Practical Salinity Units.
SU	Standard Units.
µS/cm	Microsiemens per centimeter.
%	percent.

Table 2-2

In Situ Sediment Quality Parameters

Dundalk Marine Terminal, Baltimore, Maryland

	May 2007			August 2007			December 2007			February 2008		
Transect	**Date Collected**	**pH**	**Eh (mV)**	**Date Collected**	**pH**	**Eh (mV)**	**Date Collected**	**pH**	**Eh (mV)**	**Date Collected**	**pH**	**Eh (mV)**
A1	5/12/2007	8.08	-283	8/22/2007	7.4	-165	12/5/2007	7.70	100	2/24/2008	7.38	-93
A2	5/17/2007	7.63	58	8/22/2007	7.66	5[a]	12/11/2007	7.71	73	2/24/2008	7.43	224
A3	5/27/2007	7.93	65	8/22/2007	7.6	-48	12/11/2007	7.64	87	2/24/2008	7.42	228
A4	5/27/2007	8.4	106	8/22/2007	7.6	-138	12/11/2007	7.66	-230	2/24/2008	7.46	202
B1	5/17/2007	7.45	-11	8/20/2007	7.19	-300	12/7/2007	6.70	320	2/27/2008	7.03	390
B2	5/18/2007	7.46	147	8/20/2007	7.45	-260	12/7/2007	7.30	-120	2/27/2008	6.96	292
B3	5/13/2007	7.02	-95	8/20/2007	7.39	-250	12/7/2007	7.35	-140	2/26/2008	6.50	35
B4	5/13/2007	6.81	75	8/20/2007	7.36	-240	12/7/2007	7.33	-11	2/25/2008	7.24	75
B5	--	--	--	--	--	--	--	--	--	2/26/2008	7.13	186
C1	5/15/2007	8.07	-232	8/21/2007	7.77	-192	12/6/2007	8.26	50	2/26/2008	8.09	180
C2	5/15/2007	7.94	-47	8/21/2007	7.55	-210	12/7/2007	7.61	71	2/26/2008	7.36	37
C3	5/15/2007	7.26	15	8/21/2007	7.34	-251	12/11/2007	7.19	17	2/26/2008	7.07	287
C4	5/15/2007	7.3	120	8/21/2007	7.36	-295	12/11/2007	7.29	236	2/26/2008	6.78	-95
D1	5/14/2007	8.54	-210	8/16/2007	7.88	-233	12/5/2007	8.71	-320	2/25/2008	8.61	-264
D2	5/12/2007	7.57	-240	8/16/2007	6.94	-263	12/9/2007	7.18	-280	2/25/2008	7.55	-178
D3	5/13/2007	7.22	-168	8/18/2007	6.95	-233	12/10/2007	6.96	-370	2/25/2008	7.49	-273
D4	5/18/2007	7.11	75	8/19/2007	7.3	-202	12/9/2007	6.82	-95	2/25/2008	7.17	140
E1	5/11/2007	8.26	-255	8/16/2007	7.96	-310	12/5/2007	9.78	-311	2/23/2008	9.30	-230
E2	5/14/2007	7.31	-181	8/16/2007	7.42	-265	12/9/2007	7.38	-84	2/23/2008	6.88	-180
E3	5/16/2007	6.67	-249	8/18/2007	6.82	-293	--	--	--	--	--	--
E4	5/18/2007	7.38	-170	8/19/2007	7.72	-165	12/9/2007	7.01	-12	2/25/2008	6.75	35
F1	5/14/2007	7.13	-109	8/19/2007	7.02	-260	--	--	--	--	--	--
F2	5/14/2007	6.99	-79	8/19/2007	7.72	-290	12/12/2007	7.45	-265	2/29/2008	7.53	-327
F3	5/14/2007	7.11	-160	8/19/2007	7.32	-325	--	--	--	--	--	--
F4	5/18/2007	7.47	-231	8/17/2007	7.18	-256	12/10/2007	7.50	-335	2/29/2008	7.59	-240
G1	5/12/2007	7.22	-221	8/15/2007	7.47	-247	--	--	--	--	--	--
G2	5/12/2007	6.9	-140	8/18/2007	7.11	-239	12/12/2007	6.91	-280	2/23/2008	7.46	-201
G3	5/11/2007	7.16	-177	8/18/2007	6.88	-324	--	--	--	--	--	--
G4	5/11/2007	7.27	-208	8/18/2007	7.25	-274	12/12/2008	7.23	210	2/23/2008	7.86	-260
H1	5/8/2007	7.22	-170	8/14/2007	6.71	-346	12/6/2007	7.07	-301	2/19/2008	7.99	-185
H2	5/8/2007	7.1	-163	8/14/2007	7.18	-360	--	--	--	--	--	--
H3	5/11/2007	7.31	-200	8/14/2007	6.33	-330	--	--	--	--	--	--
H4	5/11/2007	7.14	-225	8/14/2007	6.68	-360	12/6/2007	7.00	-340	2/23/2008	6.30	-560
I1	5/9/2007	6.88	-170	8/15/2007	7.11	-240	12/5/2007	7.49	-120	2/19/2008	8.30	50
I2	5/9/2007	6.41	151	8/15/2007	7.35	-335	12/6/2007	7.27	-285	2/19/2008	5.50	175
I3	5/9/2007	6.93	-62	8/15/2007	7.14	-341	12/6/2007	7.30	-50	2/19/2008	7.50	140
I4	5/9/2007	7.18	-175	8/15/2007	7.22	-360	12/5/2007	7.33	-100	2/19/2008	7.20	-140
J1	--	--	--	--	--	--	--	--	--	2/21/2008	8.70	-50
J2	--	--	--	--	--	--	--	--	--	2/21/2008	8.50	-128
J3	--	--	--	--	--	--	--	--	--	2/21/2008	8.45[b]	220
J4	--	--	--	--	--	--	--	--	--	2/21/2008	8.69	70
DMT Min	May-07	6.4	-283	August-07	6.3	-360	December-07	6.7	-370	February-08	5.5	-560
DMT Max	May-07	8.5	151	August-07	8.0	-48	December-07	9.8	320	February-08	9.3	390
DMT Avg	May-07	7.4	-106	August-07	7.3	-263	December-07	7.5	-99	February-08	7.5	-13
DMT Min	Overall	5.5	-560									
DMT Max	Overall	9.8	390									
DMT Avg	Overall	7.4	-122									
Reference Locations												
37	5/16/2007	7.43	-161	8/17/2007	7.06	-300	12/10/2007	7.34	-378	2/24/2008	7.71	-264
37A	5/16/2007	7.45	-244	8/17/2007	6.98	-242	12/11/2007	6.90	-310	2/29/2008	7.70	-89
37B	5/16/2007	7.52	-236	8/17/2007	6.97	-278	12/10/2007	7.42	-282	2/29/2008	7.74	-250
REF Min	May-07	7.4	-244	August-07	7.0	-300	December-07	6.9	-378	February-08	7.7	-264
REF Max	May-07	7.5	-161	August-07	7.1	-242	December-07	7.4	-282	February-08	7.7	-89
REF Avg	May-07	7.5	-214	August-07	7.0	-273	December-07	7.2	-323	February-08	7.7	-201
REF Min	Overall	6.9	-378									
REF Max	Overall	7.7	-89									
REF Avg	Overall	7.4	-253									

Notes:

-- No data.

a This data point may be inaccurate because it was difficult to penetrate the probe into sand and get accurate reading in this sample.

b The temperature when sediment from J3 was collected was very low and below the lower limit of the probe; the pH and eH values may be inaccurate due to the very low temperatures.

AVG Average.
DMT Dundalk Marine Terminal.
Max Maximum.
Min Minimum.
mV Millivolts.
REF Reference.

Table 2-3

Summary of Qualitative Benthic Invertebrate Sampling

Dundalk Marine Terminal, Baltimore, Maryland

Sampling Event	Location	Organism	Abundance*
May 2007	DMT - Northwest	Amphipods	Few
		Polychaetes	Dominant
	DMT - Southeast	Amphipods	Few
		Clams - small	Few
		Polychaetes	Few
		Other arthropods	Few
June 2008	DMT - Southeast	Amphipods	Dominant
		Barnacles	Few
		Crabs	Dominant
		Ctenophore	Few
		Isopods	Several
		Mussels	Few
		Mysid Shrimp	Few
		Oligochaets	Few
		Pipefish	Several
		Polychaetes	Many

Notes:

* Descriptions are intended to qualitatively describe the biological assemblages present at the location, and are not intended to quantitatively describe the number of individuals within a population.

DMT	Dundalk Marine Terminal.
DMT - Northwest	Includes transect H.
DMT - Southeast (2007)	Includes transects A through G.
DMT - Southeast (2008)	Includes Station J-4.

Table 2-4

Assessment Endpoints, Measures of Exposure and Effects, and Risk Hypotheses

Dundalk Marine Terminal, Baltimore, Maryland

Assessment Endpoint	Guild (Food Web)	Exposure Area	Representative Receptor Species[a]	Exposure Routes	Measurement Endpoints		Testable Hypotheses (Risk Questions)
					Measures of Exposure	Measures of Effects	
1. Benthic Invertebrate Community Structure and Function	Benthic Invertebrates	surface sediments and pore water within surface sediments adjacent to DMT	blue crab, clams, polychaetes, arthropods	Direct exposure, ingestion	Measured concentrations of contaminants in bulk surface sediments and pore water	Comparison of concentrations of contaminants in bulk surface sediments (i. e., reported on a dry weight basis) to conservative ESVs considered protective of survival or reproduction.	Are the levels of contaminants in bulk surface sediments adjacent to DMT greater than the sediment quality benchmarks?
						Comparison of concentrations of COIs in pore water to USEPA's NRWQC or other ESVs considered protective of survival or reproduction.	Are the levels of contaminants in pore water from sediments adjacent to DMT greater than the water quality benchmarks?
						Consideration of the biological community present in the Patapsco River sediments, particularly in areas where COPR constituents were measured.	Does the biological community change in response to COPR constituent concentrations?
2. Water Invertebrate Community Structure and Function	Water Column Invertebrates	surface water adjacent to DMT	copepods, amphipods, plankton	Direct exposure, ingestion	Measured concentrations of contaminants in surface water	Comparison of concentrations of COIs in surface water to USEPA's NRWQC or other ESVs considered protective of survival or reproduction.	Are the levels of contaminants in surface water adjacent to DMT greater than the surface water quality benchmarks?
3. Fish Population Survival and Reproductive Ability	Pelagic Fish	surface water adjacent to DMT	bass species, perch, blue fish, sturgeon	Direct exposure, ingestion	Measured concentrations of contaminants in surface water	Comparison of concentrations of COIs in surface water adjacent to DMT to USEPA's NRWQC or other ESVs considered protective of survival or reproduction.	Are the concentrations of contaminants in overlying water adjacent to DMT greater than the surface water quality benchmarks?

Notes:

a Receptors for each guild were selected qualitatively based on the following criteria: 1) high potential for exposure via multiple pathways; 2) potential sensitivity to site contaminants; 3) distribution and range relative to site; and 4) availability of exposure and effects data.

COI Constituent of interest.

COPR Chrome Ore Processing Residue.

DMT Dundalk Marine Terminal.

ESV Ecological Screening Value.

NRWQC National Reccomended Water Quality Criteria.

USEPA United States Environmental Protection Agency.

Table 2-5

Ecological Screening Values for Cr(III) and Cr(VI) in Pore Water and Surface Water

Dundalk Marine Terminal, Baltimore, Maryland

Environment	Salinity (ppt)	$CaCO_3$ Concentration (mg/L)	Cr(III) CMC (Acute FW NRWQC; mg/L)	Cr(III) CCC (Chronic FW NRWQC; mg/L)
Current USEPA Freshwater NRWQC	—	100	0.57	0.074
USEPA Upper Limit Hardness Value [a]	—	400	1.77	0.231
DMT May 2007 (Estuarine)	3–16	1,563 [b]	5.4	0.704
DMT August 2007 (Estuarine)	3–15	2,412 [b]	7.2	1
DMT December 2007 (Estuarine)	11-16	2,480[b]	7.9	1.03
DMT February 2008 (Estuarine)	4–16	2,090[b]	6.9	0.893

	Cr(VI) Acute SW NRWQC (mg/L)	Cr(VI) Chronic SW NRWQC (mg/L)
Chronic dissolved	1.1	0.05

Notes:

a	USEPA's upper limit for the use of hardness values in the equations provided below.
b	Based on mean measured CaCO3 concentration in surface water collected at DMT during specified event.
$CaCO_3$	Calcium carbonate.
CCC	Criteria continuous concentration.
CMC	Criteria maximum concentration.
Cr (III)	Trivalent chromium.
Cr (VI)	Hexavelent chromium.
DMT	Dundalk Marine Terminal.
FW	Freshwater.
mg/L	Milligram per liter.
NRWQC	Nationally Recommended Water Quality Criteria.
ppt	Parts per thousand.
SW	Saltwater.
USEPA	United States Environmental Protection Agency

Example calculation:

Parameters for Calculating Freshwater Dissolved Metals Criteria That Are Hardness-Dependent:

Chemical	m_A	b_A	m_C	b_C	Freshwater Conversion Factors (CF)	
					CMC	CCC
Chromium III	0.819	3.7256	0.819	0.6848	0.316	0.86

Current Water Quality Standards based on 400 mg/L $CaCO_3$

CMC (dissolved) = exp{m_A [*ln* (hardness)]+ b_A} (CF)

CMC (dissolved) = exp{0.819 [*ln* (400)]+ 3.7256} (0.316)

CMC (dissolved) = exp{0.819 [5.99]+ 3.7256} (0.316)

CMC (dissolved) = exp{4.91 + 3.7256} (0.316)

CMC (dissolved) = exp{8.63} (0.316)

CMC (dissolved) = 5597 x 0.316

CMC (dissolved) = 1,769 ug/L = 1.77 mg/L

CCC (dissolved) = exp{m_C [*ln* (hardness)]+ b_C} (CF)

CCC (dissolved) = exp{0.819 [*ln* (400)]+ 0.6848} (0.860)

CCC (dissolved) = exp{0.819 [5.99]+ 0.6848} (0.860)

CCC (dissolved) = exp{4.91 + 0.6848} (0.860)

CCC (dissolved) = exp{5.59} (0.860)

CCC (dissolved) = 268 x 0.860

CCC (dissolved) = 231 ug/L = 0.231 mg/L

Source: http://www.epa.gov/waterscience/criteria/wqcriteria.html

Table 2-6

Ecological Screening Values for the Other COPR Constituents in Pore Water and Surface Water

Dundalk Marine Terminal, Baltimore, Maryland

COPR Constituent	Freshwater Chronic ESV (µg/L)	Source
Aluminum (total) pH range 6.5-9.0	87	National Recommended Ambient Water Quality Criteria
Calcium	NA	NA
Iron	1,000	National Recommended Ambient Water Quality Criteria
Magnesium	3,235	TCEQ, 2003
Manganese	120	Suter and Tsao, 1996 Secondary Acute and Secondary Chronic Values
Vanadium	20	Suter and Tsao, 1996 Secondary Acute and Secondary Chronic Values

Notes:

COPR	Chromite ore processing residue.
ESV	Ecological Screening Values.
NA	Not available for calcium.
TCEQ	Texas Commission on Environmental Quality.
µg/L	Micrograms per liter.

Table 2-7

Ecological Screening Values for Chromium and Other COPR Constituents in Sediment

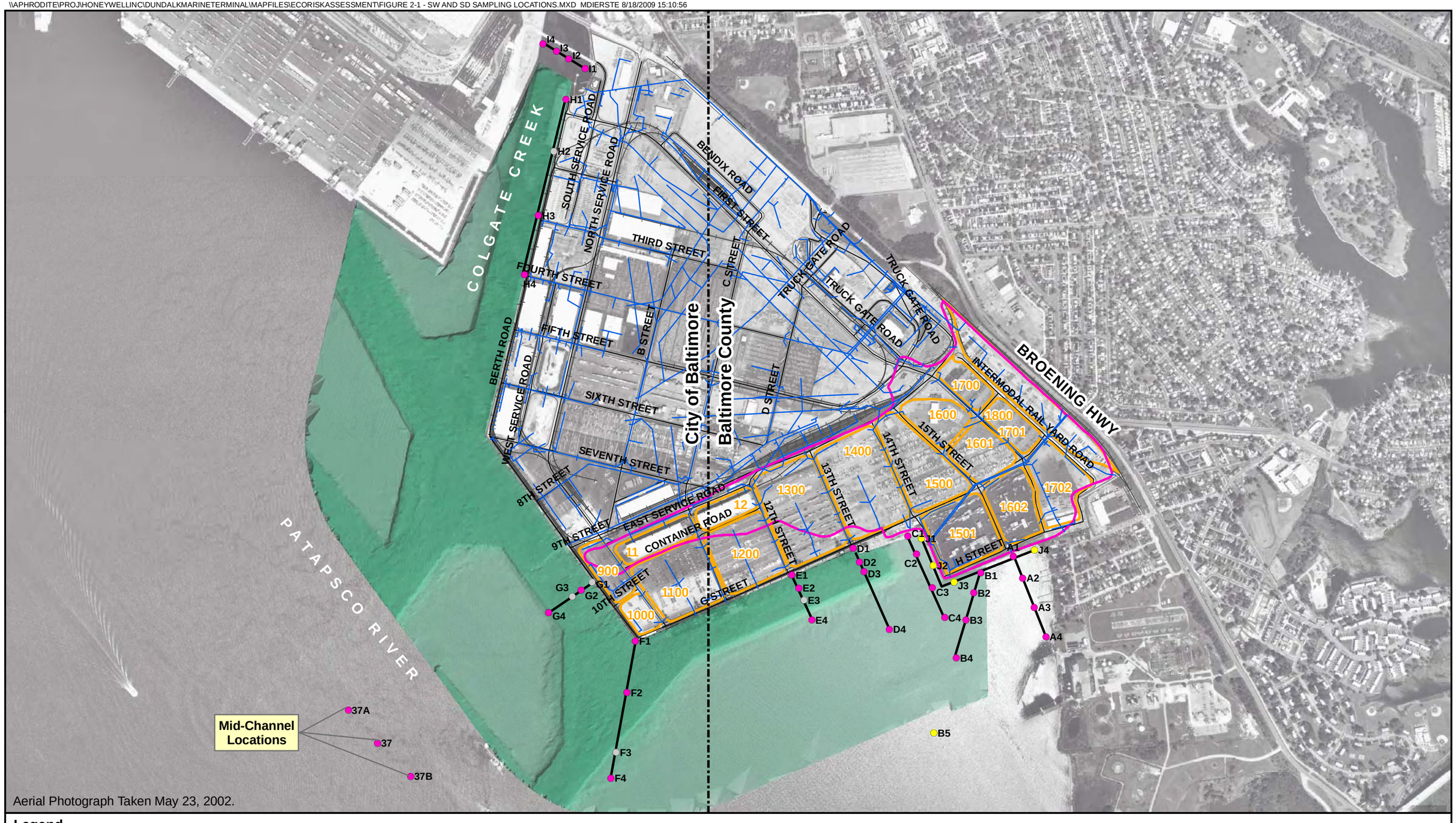
Dundalk Marine Terminal, Baltimore, Maryland

COPR Constituent	Saltwater ESV (mg/kg)	Source
Aluminum	18,000	AET (Buchman, 2008)
Calcium	NA	NA
Iron	220,000	AET (Buchman, 2008)
Magnesium	NA	NA
Manganese	260	AET (Buchman, 2008)
Vanadium	57	AET (Buchman, 2008)

Notes:

AET	Apparent Effects Threshold.
COPR	Chromite Ore Processing Residue.
ESV	Ecological Screening Values.
mg/kg	Milligram per kilogram.
NA	Not available for calcium and magnesium. Not applicable for chromium.

\\APHRODITE\PROJ\HONEYWELLINC\DUNDALKMARINETERMINAL\MAPFILES\ECORISKASSESSMENT\FIGURE 2-1 - SW AND SD SAMPLING LOCATIONS.MXD MDIERSTE 8/18/2009 15:10:56



Legend

- Sample Location
- Sample Location - February 2008 only
- Sample Location - not sampled in December 2007 or February 2008
- COPR Extent
- Storm Sewer Line
- Railroad Centerline
- Areas

Water Depth in Feet (NAVD88)

High : -4

Low : -51

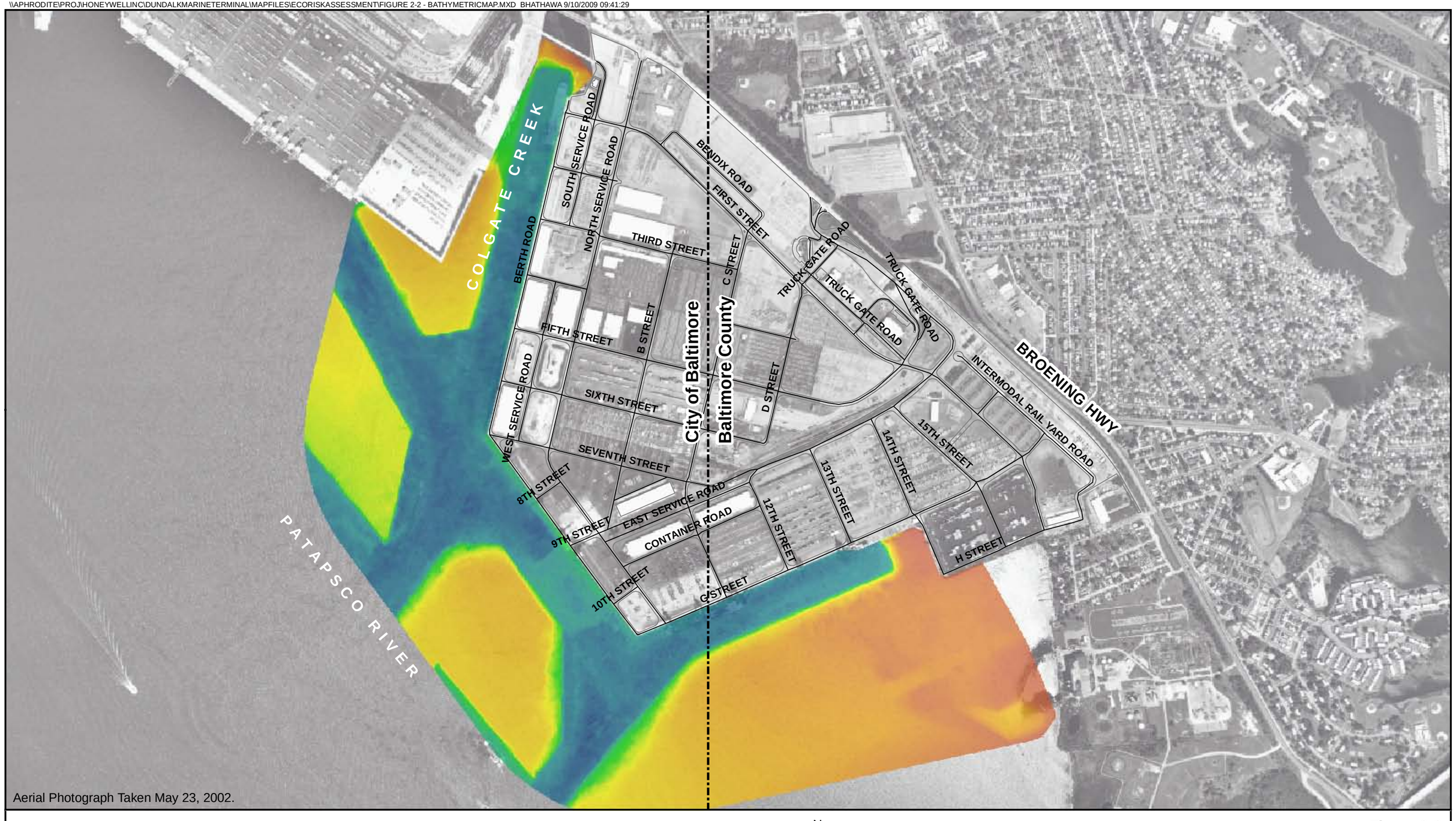
N W E S

0 1,000 2,000 Feet

Figure 2-1
Surface Water and Sediment Sampling Locations
Dundalk Marine Terminal
Baltimore, Maryland

ENVIRON CH2MHILL

\\APHRODITE\PROJ\HONEYWELLINC\DUNDALKMARINETERMINAL\MAPFILES\ECORISKASSESSMENT\FIGURE 2-2 - BATHYMETRICMAP.MXD BHATHAWA 9/10/2009 09:41:29



Aerial Photograph Taken May 23, 2002.

Legend

Water Depth in Feet (NAVD88)

High : -4

Low : -51

Note: Bathymetric survey performed in December 2006 by Ocean Surveys, Inc.

N W E S

0 1,000 2,000 Feet

Figure 2-2
Bathymetric Map
Dundalk Marine Terminal
Baltimore, Maryland

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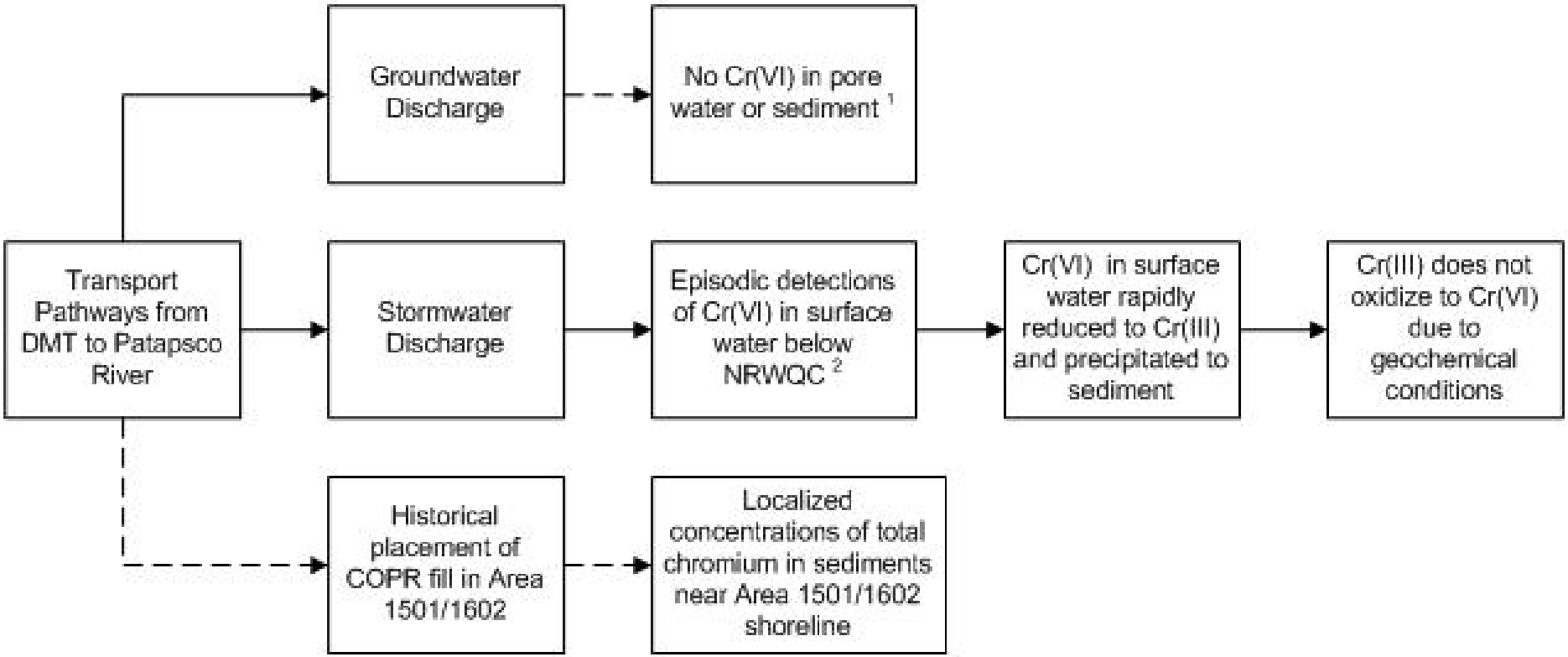

Notes:

[1] If Cr(VI) was present in sediment, it would be detected in pore water

[2] Nationally Recommended Water Quality Criteria

→ Active transport pathway

→ Inactive transport pathway

COPR Chromite are processing residue

Cr(III) Trivalent chromium

Cr(VI) Hexavalent chromium

DMT Dundalk Marine Terminal

Figure 2-3
Fate and Transport Conceptual Site Model for Chromium
Dundalk Marine Terminal
Baltimore, Maryland

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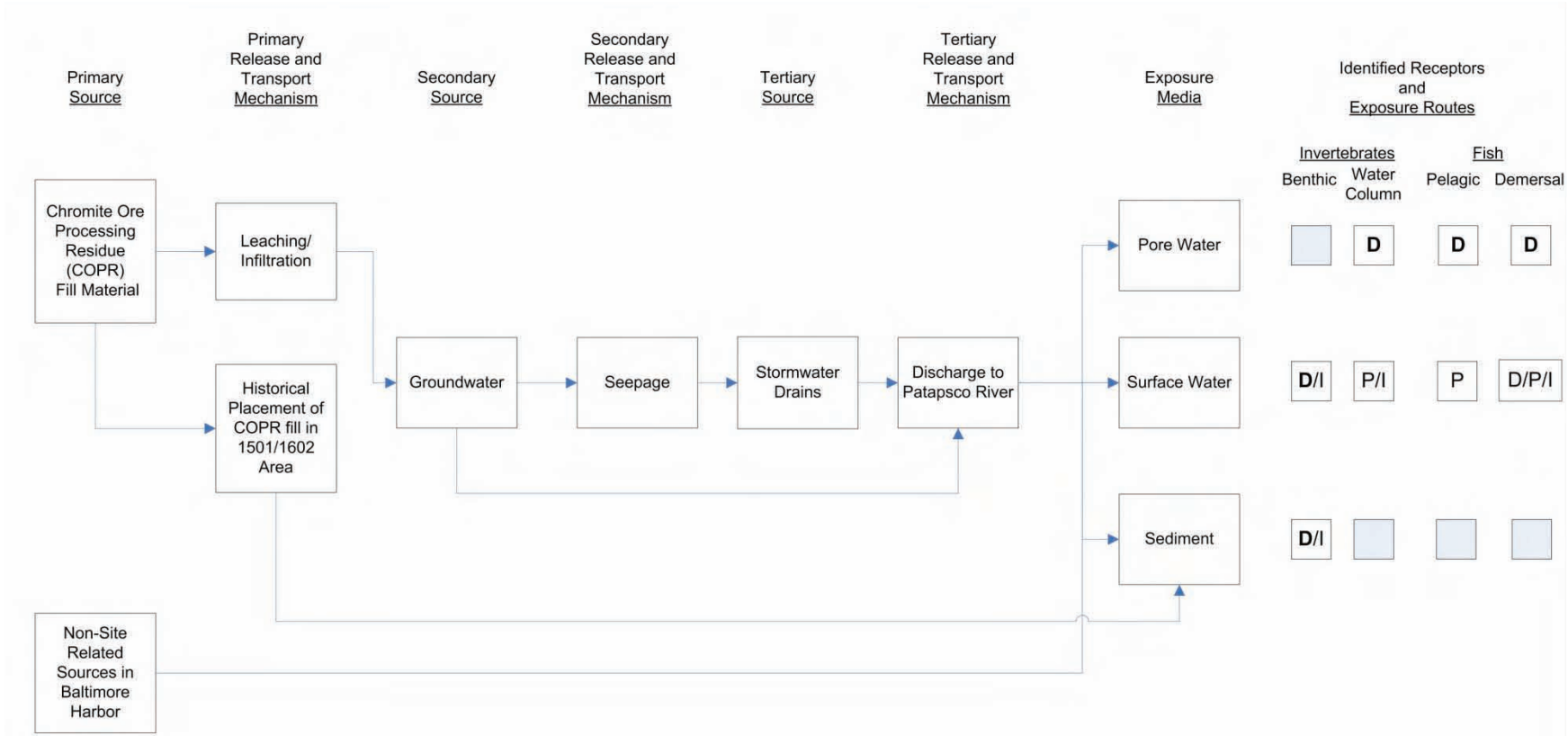

Legend
Complete exposure pathways are indicated as follows:
P = Prey Ingestion
D = direct exposure
I = Incidental ingestion
Significant pathways receiving quantitative evaluation are marked in **Bold Font.**
Pathways not in bold are complete but insignificant and not evaluated quantitatively.
Shaded boxes are not applicable.

Figure 2-4
Preliminary Ecological Conceptual Site Model
Dundalk Marine Terminal
Baltimore, Maryland

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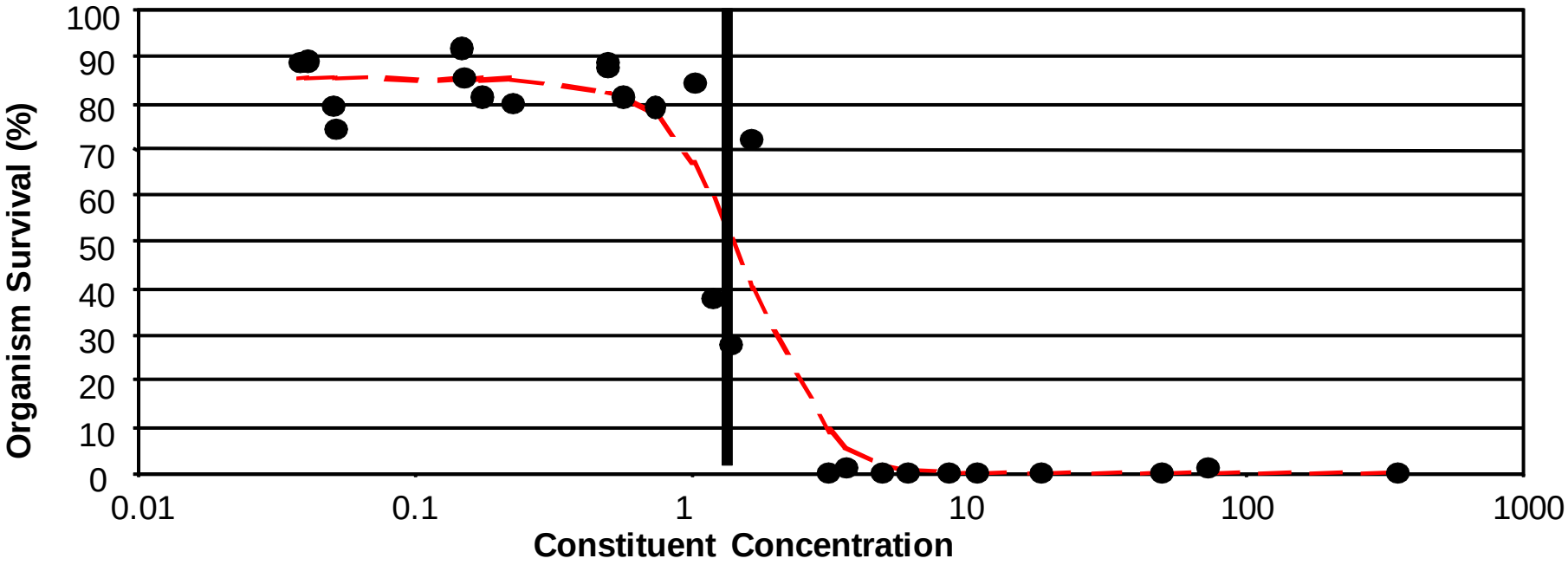

A classic concentration response is seen. Mortality due to chemical-specific response can be reliably predicted at concentrations generally exceeding threshold value.

Figure 2-5a
Classic Concentration-Response Curve
Dundalk Marine Terminal
Baltimore, Maryland

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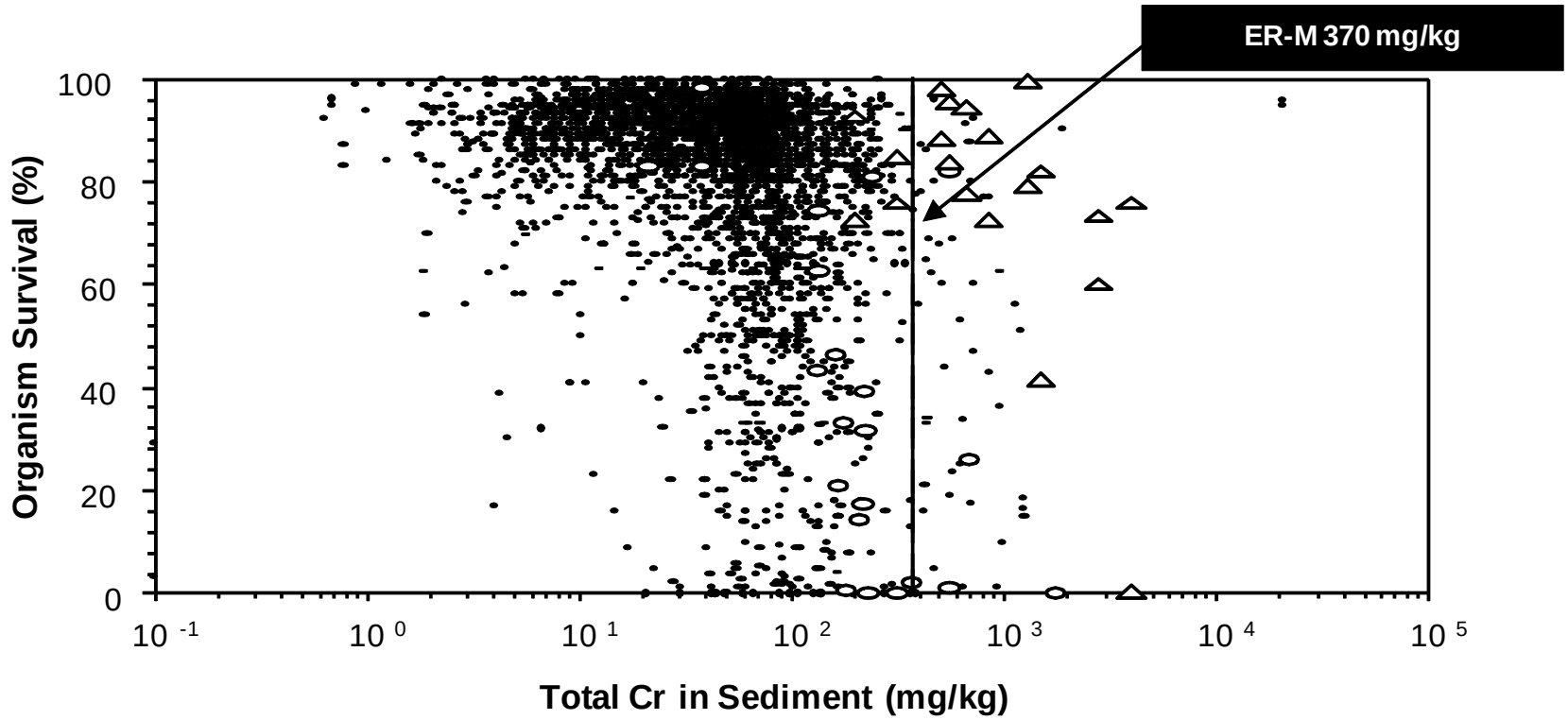

Comparison of total chromium concentrations in sediment and biological response, for sediments potentially containing multiple contaminants. For clarity, only amphipod survival is plotted; however, the results for other species and test endpoints are similar. Symbols indicate: (●) amphipod survival data compiled in the SEDTOX Marine database (NOAA, 2005); (○) amphipod toxicity test results for the Hackensack River Jersey City site (Sorensen, et al. 2007 and P.M. Chapman unpublished data); and (△) amphipod toxicity test results for the Hackensack River Kearny site (Becker et al., 2006).
The ER-M was not derived to identify the chemical causing toxic response (Long et al., 1995; Long, 2005). An evaluation of several studies shows organism survival at a wide range of chromium concentrations greater than the ER-M. In contrast to the classical concentration-response curve, the ER-M does not reliably predict mortality due to chromium.

Notes:

Cr	Chromium
ER-M	Effects Range Median
mg/kg	Milligrams per kilogram

Figure 2-5b
Chromium Concentration vs. Sediment Toxicity
Dundalk Marine Terminal
Baltimore, Maryland

ENVIRON CH2MHILL

SECTION 3

Step 2: Exposure Estimate and Risk Calculation

This section describes the methods and results used to characterize the potential ecological risks posed by the presence of chromium and other COPR constituents in pore water, surface water, and sediment in the vicinity of DMT. In order to make an initial determination of whether the study area posed potentially unacceptable ecological risk, exposure point concentrations (EPCs) were compared to available ESVs. The EPC is the maximum detected concentrations of a constituent in each matrix at each sampling location from the Sediment and Surface Water Study[4]. The EPCs for pore water, surface water, and surface sediment are summarized in Tables 3-1, 3-2, and 3-3, respectively. While the use of maximum concentrations is consistent with the approach outlined by USEPA (1997, 2000), in some cases, the maximum concentrations are not representative of the types of exposures that organisms like fish will experience. However, when considering sessile organisms, like benthic invertebrates, maximum concentrations do accurately indicate the types of exposures that some isolated organisms may experience.

3.1 Available Data

The data used in the risk assessment are the results of chemical analyses of surface water, pore water and sediment samples collected during four rounds of sampling between May 2007 and February 2008. Samples were collected and analyzed as described in the Sediment and Surface Water Study Report (CH2M HILL and ENVIRON, 2009). The complete data set of samples considered in the risk assessment is presented in Appendix C. A summary of available data is presented in Table 3-4.

For sediment and pore water, maximum detected concentrations were obtained from samples the upper 6 inches, which is the biologically active zone in which sediment dwelling organisms are present and potentially exposed to chromium and other COPR constituents. Equivalent data were also collected at three reference locations in the mid-channel of the Patapsco River during all four sampling events. Reference data were collected for the purpose of understanding regional background conditions in the Patapsco River. In accordance with USEPA methodology for screening constituents of potential concern (USEPA, 2001), a comparison of concentrations measured within the study area to those measured in the reference location is discussed further in Section 4 (Step 3a).

3.2 Screening Risk Calculations

Screening level risk calculations are represented by the hazard quotient (HQ) (USEPA 1997; 2000). HQs are the ratio of the EPCs to the ESVs; pore water HQs were generated by comparison to the available aquatic ESVs. HQs that exceed the USEPA threshold of 1 will be

[4] As indicated in Section 2.2, ancillary sediment and pore water sampling results from May 2009 sampling near the 15th Street outfall are addressed in Section 4.3.2.

carried forward to Step 3a. Summaries of the HQs for pore water, surface water, and surface sediment are presented in Tables 3-5, 3-6, and 3-7, respectively. HQs of greater than 1 are shown in bold font. The following constituents generated HQs greater than 1 in pore water, surface water, and surface sediment and will be carried over to Step 3a for further evaluation:

- Pore water: iron, magnesium, and manganese
- Surface water: aluminum, magnesium, and manganese
- Surface sediment: aluminum, manganese, and vanadium.

Table 3-1

Exposure Point Concentrations for Pore Water

Dundalk Marine Terminal, Baltimore, Maryland

Location	Exposure Point Concentrations - µg/L						
	Al	Cr(III)	Cr (VI)	Fe	Mg	Mn	V
A1	ND	ND	ND	69.5	485,000	1,420	5.2
A2	ND	4.3	ND	ND	332,000	513	ND
A3	ND	3.1	ND	54.4	324,000	239	1.7
A4	ND	3.2	ND	ND	313,000	449	ND
B1	ND	3.5	ND	508	488,000	2,860	3.4
B2	ND	ND	ND	135	511,000	3,440	8.5
B3	ND	2.3	ND	3320	496,000	3,350	2.8
B4	ND	ND	ND	3430	467,000	2,630	2.6
B5	ND	ND	ND	ND	334,000	492	2.3
C1	ND	ND	ND	84.3	453,000	743	6.3
C2	ND	2.4	ND	109	469,000	1,620	4.8
C3	ND	3.4	ND	742	465,000	3,130	3.1
C4	ND	3.8	ND	1620	488,000	4,400	4.0
D1	ND	11.7	ND	191	645,000	7,210	9.0
D2	ND	16.2	ND	6830	528,000	25,600	6.5
D3	ND	12.4	ND	8910	547,000	23,200	4.4
D4	ND	3.1	ND	1760	507,000	2,280	ND
E1	ND	6.5	ND	107	599,000	3,100	5.9
E2	ND	12.2	ND	3580	557,000	13,400	11.1
E3	ND	13.5	ND	699	429,000	14,100	6.2
E4	ND	ND	ND	1230	514,000	5,090	ND
F1	ND	7.4	ND	128	472,000	4,440	5.5
F2	ND	6.2	ND	9300	533,000	19,300	4.9
F3	ND	10.1	ND	109	383,000	2,780	10.3
F4	ND	8.2	ND	1060	450,000	5,580	7.2
G1	ND	ND	ND	85.1	424,000	13,300	9.7
G2	ND	11.7	ND	90.3	470,000	3,010	10.0
G3	ND	10.1	ND	1410	458,000	4,230	10.4
G4	ND	13.4	ND	159	482,000	6,130	8.4
H1	ND	11.0	ND	517	504,000	9,890	7.0
H2	ND	4.3	ND	ND	468,000	7,640	8.6
H3	ND	5.5	ND	5280	440,000	5,300	5.4
H4	ND	12.2	ND	4820	556,000	15,900	6.8
I1	ND	3.1	ND	72.7	458,000	1,420	5.1
I2	ND	3.1	ND	68.6	473,000	662	5.3
I3	ND	4.7	ND	77.1	472,000	430	3.7
I4	ND	6.7	ND	64.2	442,000	372	5.5
J1	ND	ND	ND	61.7	327,000	162	4.0
J2	ND	ND	ND	ND	313,000	1,140	3.9
J3	ND	ND	ND	62.3	317,000	1,530	3.0
J4	ND	ND	ND	ND	195,000	43	11.9

Notes:

Data presented in Appendix C. Exposure point concentration equivalent to maximum detected concentrations

ND	Nondetected value.		
Al	Aluminum.	Cr(III)	Trivalent chromium.
Cr(VI)	Hexavalent chromium.	Fe	Iron.
Mg	Magnesium.	Mn	Manganese.
ug/L	Microgram per liter.	V	Vanadium.

Detection limits: (µg/L)

Al	80.2
Cr(III)	2.3
Cr(VI)	5.0
Fe	52.2
V	1.5

Table 3-2

Exposure Point Concentrations for Surface Water

Dundalk Marine Terminal, Baltimore, Maryland

Location	Exposure Point Concentrations - µg/L						
	Al	Cr(III)	Cr(VI)	Fe	Mg	Mn	V
A1	ND	5.6	ND	62.4	469,000	56.4	3.0
A2	ND	2.4	ND	ND	473,000	45.4	2.9
A3	ND	ND	ND	ND	463,000	41.6	2.2
A4	ND	ND	ND	55.7	471,000	47.5	2.6
B1	ND	5.2	ND	ND	463,000	65.8	2.3
B2	89.6	7.3	ND	ND	460,000	61.4	2.5
B3	ND	6.1	6	ND	506,000	54.5	2.7
B4	ND	29.7	34.9	ND	509,000	43.1	4.4
B5	ND	ND	ND	ND	322,000	41.3	ND
C1	ND	8.4	7	ND	499,000	55.6	2.1
C2	118	5.6	ND	ND	483,000	47.0	1.7
C3	117	5.8	ND	ND	466,000	44.6	2.2
C4	101	6.2	ND	ND	499,000	55.9	2.0
D1	ND	17.3	10.5	71.2	579,000	560	2.2
D2	ND	2.8	ND	ND	598,000	956	2.6
D3	145	9.4	6.7	ND	588,000	489	2.1
D4	ND	4.5	ND	ND	491,000	55.5	2.2
E1	ND	37.6	30.4	127	618,000	1,160	2.2
E2	ND	10.2	11	98.5	599,000	708	3.4
E3	ND	3.1	ND	ND	579,000	595	2.0
E4	ND	3.6	ND	ND	523,000	96.5	3.0
F1	ND	ND	ND	ND	496,000	307	3.3
F2	ND	ND	ND	54.6	608,000	384	2.6
F3	ND	ND	ND	ND	512,000	317	3.0
F4	ND	ND	ND	81.1	544,000	148	3.4
G1	ND	ND	ND	ND	536,000	188	2.7
G2	ND	2.6	ND	ND	521,000	386	3.0
G3	ND	ND	ND	ND	516,000	661	2.3
G4	ND	ND	ND	ND	594,000	143	3.0
H1	ND	3.6	ND	75.9	530,000	309	3.5
H2	ND	ND	ND	ND	546,000	597	2.9
H3	ND	ND	ND	ND	540,000	295	3.5
H4	ND	ND	ND	66.7	583,000	657	3.1
I1	ND	2.3	ND	ND	484,000	44.3	1.8
I2	87.7	2.9	ND	ND	506,000	42.5	2.1
I3	ND	ND	ND	52.9	504,000	34.9	2.3
I4	ND	ND	ND	54.4	489,000	41.5	2.6
J1	ND	ND	ND	ND	320,000	31.2	1.8
J2	ND	ND	ND	ND	325,000	45.3	ND
J3	ND	ND	ND	ND	324,000	43.3	ND
J4	ND	ND	ND	ND	301,000	32.2	2.4

Notes:

Data presented in Appendix C. Exposure point concentration equivalen

ND	Non-detected value.		
Al	Aluminum.	Cr(III)	Trivalent chromium.
Cr(VI)	Hexavalent chromium.	Fe	Iron.
Mg	Magnesium.	Mn	Manganese.
ug/L	Micrograms per liter.	V	Vanadium.

Detection limits: (µg/L)

Al	80.2
Cr(III)	2.3
Cr(VI)	5.0
Fe	52.2

Table 3-3

Exposure Point Concentrations for Surface Sediment

Dundalk Marine Terminal, Baltimore, Maryland

Location	Exposure Point Concentrations - mg/kg			
	Al	Fe	Mn	V
A1	7,410	36,800	438	69.7
A2	1,470	7,410	134	15
A3	1,200	6,240	177	9.71
A4	1,770	37,600	185	13.4
B1	6,930	25,900	618	50.3
B2	7,310	24,300	383	38
B3	28,400	48,400	807	90.2
B4	17,200	36,500	463	88.2
B5	3,110	10,800	156	22.9
C1	11,200	29,800	1,120	67.9
C2	9,230	24,300	717	62.6
C3	12,800	29,500	465	58.4
C4	14,200	31,400	477	57.6
D1	27,600	46,100	2,010	89
D2	28,000	49,300	3,550	91.6
D3	30,500	52,900	2,260	93.5
D4	19,600	36,300	428	59.5
E1	28,500	48,400	2,600	86.6
E2	30,200	56,700	1,250	61.3
E3	29,100	47,300	1,220	97.3
E4	12,300	23,400	347	40.9
F1	19,200	39,500	725	66.2
F2	30,400	54,800	803	68.5
F3	35,600	55,900	1,350	107
F4	34,600	55,100	1,790	105
G1	8,680	24,000	255	34.9
G2	23,000	40,700	770	79.4
G3	24,800	43,700	899	86.5
G4	21,500	39,300	1,340	70.8
H1	19,600	28,900	545	55.3
H2	24,000	32,100	521	77
H3	9,860	14,800	242	45.4
H4	23,200	37,500	795	99.6
I1	9,320	19,200	218	70.8
I2	12,300	24,800	274	91.5
I3	20,400	34,400	425	237
I4	21,100	42,500	447	156
J1	7,740	24,300	1,290	67.2
J2	7,010	26,700	670	88.5
J3	6,090	23,700	492	64.1
J4	9,540	28,400	2,070	70

Notes:

Data presented in Appendix C. Exposure point concentration equivalent to maximum

mg/kg	Milligrams per kilogram.		
Al	Aluminum.	Fe	Iron.
Mn	Manganese.	V	Vanadium.

Table 3-4

Summary of Data Considered in the Ecological Risk Assessment

Dundalk Marine Terminal, Baltimore, Maryland

Media	**Surface Water**	**Porewater**	**Bulk Sediment**
Number Samples - DMT	320	136	77
Number Field Duplicates - DMT	4	2	5
Number Samples - Reference	42	12	12
Number Field Duplicates - Reference	1	0	0
Analytical Parameters Considered in the ERA	Aluminum, Total Chromium, Hexavalent Chromium, Iron, Magnesium, Manganese, Vanadium Hardness	Aluminum, Total Chromium, Hexavalent Chromium, Iron, Magnesium, Manganese, Vanadium	Aluminum, Iron, Magnesium, Manganese, Vanadium, Acid Volatile Sulfide Simultaneously Extracted Metals

Notes:

Data used in ERA presented in Appendix C.

DMT Dundalk Marine Terminal.

ERA Ecological Risk Assessment.

Table 3-5

Hazard Quotients for Pore Water

Dundalk Marine Terminal, Baltimore, Maryland

Transect	Hazard Quotient (HQ)[a]				
	Cr(III)	Fe	Mg	Mn	V
A1	--	<1	**150**	**12**	<1
A2	<1	--	**103**	**4**	--
A3	<1	<1	**100**	**2**	<1
A4	<1	--	**97**	**4**	--
B1	<1	<1	**151**	**24**	<1
B2	--	<1	**158**	**29**	<1
B3	<1	**3**	**153**	**28**	<1
B4	--	**3**	**144**	**22**	<1
B5	--	--	**103**	**4**	<1
C1	--	<1	**140**	**6**	<1
C2	<1	<1	**145**	**14**	<1
C3	<1	<1	**144**	**26**	<1
C4	<1	**2**	**151**	**37**	<1
D1	<1	<1	**199**	**60**	<1
D2	<1	**7**	**163**	**213**	<1
D3	<1	**9**	**169**	**193**	<1
D4	<1	**2**	**157**	**19**	NA
E1	<1	<1	**185**	**26**	<1
E2	<1	**4**	**172**	**112**	<1
E3	<1	<1	**133**	**118**	<1
E4	--	1	**159**	**42**	--
F1	<1	<1	**146**	**37**	<1
F2	<1	**9**	**165**	**161**	<1
F3	<1	<1	**118**	**23**	<1
F4	<1	1	**139**	**47**	<1
G1	--	<1	**131**	**111**	<1
G2	<1	<1	**145**	**25**	<1
G3	<1	1	**142**	**35**	<1
G4	<1	<1	**149**	**51**	<1
H1	<1	<1	**156**	**82**	<1
H2	<1	--	**145**	**64**	<1
H3	<1	**5**	**136**	**44**	<1
H4	<1	**5**	**172**	**133**	<1
I1	<1	<1	**142**	**12**	<1
I2	<1	<1	**146**	**6**	<1
I3	<1	<1	**146**	**4**	<1
I4	<1	<1	**137**	**3**	<1
J1	--	<1	**101**	1	<1
J2	--	--	**97**	**10**	<1
J3	--	<1	**98**	**13**	<1
J4	--	--	**60**	<1	<1

Notes:

a Null cells (--) indiate that the parameter was not detected at that location during any of the quarterly sampling events.
The hazard quotient (HQ) is equivalent to the EPC divided by the screening criteria for a given parameter (rounded to one significant figure).
Exposure point concentrations (EPCs) are identified in Table 3-3. Full data set considered in evaluation is provided in Appendix C.

Cr(III) Trivalent chromium. Fe Iron.
Mg Magnesium. Mn Manganese.
ug/L Microgram per liter. V Vanadium.

Marine-based screening criteria for these COPR constituents are not available, therefore the following freshwater aquatic screening values were used:

Cr(III)	704 ug/L
Fe	1000 ug/L
Mg	3235 ug/L
Mn	120 ug/L
Vn	20 ug/L

Bold values exceed 1.

Table 3-6

Hazard Quotients for Surface Water

Dundalk Marine Terminal, Baltimore, Maryland

Transect	Hazard Quotient (HQ)[a]						
	Al	Cr(III)	Cr(VI)	Fe	Mg	Mn	V
A1	--	<1	--	<1	**145**	<1	<1
A2	--	<1	--	--	**146**	<1	<1
A3	--	--	--	--	**143**	<1	<1
A4	--	--	--	<1	**146**	<1	<1
B1	--	<1	--	--	**143**	<1	<1
B2	1	<1	--	--	**142**	<1	<1
B3	--	<1	<1	--	**156**	<1	<1
B4	--	<1	<1	--	**157**	<1	<1
B5	--	--	--	--	**100**	<1	--
C1	--	<1	<1	--	**154**	<1	<1
C2	1	<1	--	--	**149**	<1	<1
C3	1	<1	--	--	**144**	<1	<1
C4	1	<1	--	--	**154**	<1	<1
D1	--	<1	<1	<1	**179**	**5**	<1
D2	--	<1	--	--	**185**	**8**	<1
D3	**2**	<1	<1	--	**182**	**4**	<1
D4	--	<1	--	--	**152**	<1	<1
E1	--	<1	<1	<1	**191**	**10**	<1
E2	--	<1	<1	<1	**185**	**6**	<1
E3	--	<1	--	--	**179**	**5**	<1
E4	--	<1	--	--	**162**	<1	<1
F1	--	--	--	--	**153**	**3**	<1
F2	--	--	--	<1	**188**	**3**	<1
F3	--	--	--	--	**158**	**3**	<1
F4	--	--	--	<1	**168**	1	<1
G1	--	--	--	--	**166**	2	<1
G2	--	<1	--	--	**161**	**3**	<1
G3	--	--	--	--	**160**	**6**	<1
G4	--	--	--	--	**184**	1	<1
H1	--	<1	--	<1	**164**	**3**	<1
H2	--	--	--	--	**169**	**5**	<1
H3	--	--	--	--	**167**	**2**	<1
H4	--	--	--	<1	**180**	**5**	<1
I1	--	<1	--	--	**150**	<1	<1
I2	1	<1	--	--	**156**	<1	<1
I3	--	--	--	<1	**156**	<1	<1
I4	--	--	--	<1	**151**	<1	<1
J1	--	--	--	--	**99**	<1	<1
J2	--	--	--	--	**100**	<1	--
J3	--	--	--	--	**100**	<1	--
J4	--	--		--	**93**	<1	<1

Notes:

a Null cells (--) indiate that the parameter was not detected at that location during any of the quarterly sampling events.

The hazard quotient (HQ) is equivalent to the EPC divided by the screening criteria for a given parameter (rounded to one significant figure).

Exposure point concentrations (EPCs) are identified in Table 3.2. Full data set considered in evaluation is provided in Appendix C.

Al	Aluminum.	Cr(III)	Trivalent chromium.
Cr(VI)	Hexavalent chromium.	Fe	Iron.
Mg	Magnesium.	Mn	Manganese.
ug/L	Microgram per liter.	V	Vanadium.

Marine-based aquatic screening criteria for all COPR constituents except Cr(VI) are not available, therefore the following freshwater screening values were used:

Al	87 ug/L	
Cr(III)	704 ug/L	
Cr(VI)	50 ug/L	(marine value)
Fe	1000 ug/L	
Mg	3235 ug/L	
Mn	120 ug/L	
V	20 ug/L	

Bold values exceed 1.

Table 3-7

Hazard Quotients for Surface Sediment

Dundalk Marine Terminal, Baltimore, Maryland

Transect	Hazard Quotient (HQ)[a]			
	Al	Fe	Mn	V
A1	<1	<1	**2**	1
A2	<1	<1	<1	<1
A3	<1	<1	<1	<1
A4	<1	<1	<1	<1
B1	<1	<1	**2**	<1
B2	<1	<1	1	<1
B3	**2**	<1	**3**	**2**
B4	<1	<1	**2**	**2**
B5	<1	<1	<1	<1
C1	<1	<1	**4**	1
C2	<1	<1	**3**	1
C3	<1	<1	**2**	1
C4	<1	<1	**2**	1
D1	**2**	<1	**8**	**2**
D2	**2**	<1	**14**	**2**
D3	**2**	<1	**9**	**2**
D4	1	<1	2	1
E1	**2**	<1	**10**	**2**
E2	**2**	<1	**5**	1
E3	**2**	<1	**5**	**2**
E4	<1	<1	1	<1
F1	1	<1	**3**	1
F2	**2**	<1	**3**	1
F3	**2**	<1	**5**	**2**
F4	**2**	<1	**7**	**2**
G1	<1	<1	1	<1
G2	1	<1	**3**	1
G3	1	<1	**3**	**2**
G4	1	<1	**5**	1
H1	1	<1	**2**	<1
H2	1	<1	**2**	1
H3	<1	<1	<1	<1
H4	1	<1	**3**	**2**
I1	<1	<1	<1	1
I2	<1	<1	1	**2**
I3	1	<1	**2**	**4**
I4	1	<1	**2**	**3**
J1	<1	<1	**5**	1
J2	<1	<1	**3**	**2**
J3	<1	<1	2	1
J4	<1	<1	**8**	1

Notes:

a Null cells (--) indiate that the parameter was not detected at that location during any of the quarterly sampling events.
The hazard quotient (HQ) is equivalent to the EPC divided by the screening criteria for a given parameter (rounded to one significant
Exposure point concentrations (EPCs) are identified in Table 3.4. Full data set considered in evaluation is provided in Appendix C.

Al Aluminum. Fe Iiron.

mg/kg Milligram per kilogram. Mn Manganese.

V Vanadium.

The following marine screening values were used:

Al	18,000 mg/kg
Fe	220,000 mg/kg
Mn	260 mg/kg
V	57 mg/kg

Bold values exceed 1.

SECTION 4

Step 3a: BERA Problem Formulation

In contrast to the SLERA, the BERA problem formulation (Step 3a) is designed to more realistically identify the nature and extent of ecological risks in order to support informed environmental management decision making (USEPA, 1997, 2000). The BERA problem formulation method presented in this section is consistent with the following guidance:

- Ecological risk assessment guidance for Superfund (USEPA, 1997)
- Guidelines for ecological risk assessment (USEPA, 1998)
- *Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders* (USEPA, 2000)
- *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (USEPA, 2001)

Step 3a is a refinement of the Step 2 exposure estimates and risk characterization, as it is focused on COIs and media that progress beyond the SLERA. Step 3a assumptions are refined from conservative estimates of exposure and toxicological impacts to site-specific estimates of exposures and more relevant ecotoxicity screening values, if available (USEPA, 2001). Risks are recalculated using the refined assumptions. The following evaluation for DMT uses a comparison to reference concentrations, consideration of the spatial extent and magnitude of exposure, a review of ecological screening values, and a qualitative review of biological data from the study area.

4.1 Refined COIs

The refinement of the COIs identified in the SLERA is used to help focus further risk assessment. The outcome of this refined screening is that constituents either are retained as COIs or excluded from further evaluation in the BERA process. The refinement of COIs is based on the comparison of study area concentrations to reference concentrations considering maximum and average values (USEPA, 2001). This evaluation is particularly important for some of the COPR constituents because, as stated previously, magnesium, manganese, iron, and aluminum are natural components of seawater (GEOL, 2008).

For this ERA the refinement of COIs followed a stepwise process whereby concentrations of COPR constituents were compared to reference concentrations with more in-depth analysis included as necessary. Initially, the maximum COI concentrations in samples from each of the 41 locations in proximity to DMT were compared to the maximum reference concentrations. For COIs where the maximum study area concentration exceed the maximum reference concentration, the study area concentration was compared to a value of two times the maximum reference concentration. For COIs where the maximum study area concentration exceeded a value of two times the maximum reference concentration, the total number of samples from all locations across all four sampling events with COI

concentrations exceeding the maximum reference concentration was determined to establish the frequency of exceedance. Along with frequency of exceedance, the locations of exceedances were reviewed to evaluate whether there are any obvious spatial patterns such as a concentration gradient away from DMT. COIs within a given medium were eliminated as COIs if one of the following was observed:

- The maximum concentration at all sampling locations was less than the maximum reference concentration.
- The maximum concentration at all sampling locations was less than two times the maximum reference concentration.
- The frequency of exceedance of the maximum reference concentration across all sampling locations and events was less than 5 percent *and* there was no spatial trend of decreasing concentration with increasing distance from DMT.

4.1.1 Pore Water

The measured concentrations of iron, magnesium, and manganese in pore water are compared to the maximum measured reference concentration (Table 4-1). This comparison clearly illustrates that the pore water concentrations of iron, magnesium, and manganese in pore water samples from DMT are similar to or much lower than concentrations found at the reference locations within the Patapsco River. Figures 4-1, 4-2, and 4-3 compare study area pore water concentrations to the reference stations for iron, magnesium, and manganese, respectively. The distribution of concentrations in DMT pore water overlaps that at reference stations for all three constituents. Maximum reference concentrations are exceeded in only two of 133 samples (1.5 percent) for iron (maximum ratio of 1.2), six of 133 samples (4.5 percent) for magnesium (maximum ratio of 1.2), and one exceedance for manganese. These results indicate that the concentrations of these COIs in pore water are not elevated relative to those at reference locations and may therefore reflect regional conditions. There are no obvious trends in the measured concentrations for these three COIs that would suggest decreasing concentration with increasing distance from DMT (Appendix C). Given the comparability of pore water constituents at DMT and reference locations, the limited frequency (less than 5 percent) and magnitude of any reference exceedances (less than two), and the lack of spatial trends in the data, no pore water constituents are retained as COIs for further evaluation.

4.1.2 Surface Water

The measured concentrations of magnesium, manganese, and aluminum measured in surface water are compared to the reference concentrations in Table 4-2. Concentrations greater than two times the maximum reference concentration are highlighted in bold. Maximum concentrations of magnesium were less than or approximately equal to the reference concentrations at all locations. Figure 4-4 compares magnesium concentrations in DMT surface water to the reference stations showing the overlap between the study area and reference data. Only 3.3 percent (11 of 324 samples) of the DMT samples exceed the maximum reference concentration. All exceedances are less than two times the maximum reference concentration, suggesting that magnesium concentrations in surface water adjacent to the study area are not different than those determined for the reference sites.

Exceedances are primarily located along Transects D and E with concentrations decreasing with distance from DMT for Transect E only. Exceedances at other stations are also farther out on the other transects (e.g., away from DMT). The distribution of magnesium concentrations show no clear pattern of exceeding reference concentrations and thus this may be a regional phenomenon and unrelated to Site activities. Therefore magnesium is not retained as a COI for further evaluation.

Figure 4-5 compares manganese concentrations in DMT surface water to the reference stations. Like magnesium, considerable overlap was seen between concentrations measured at the DMT and reference locations. For manganese, 4.7 percent (15 of 315 samples) of samples exceed the maximum reference concentration. All but three exceedances are below two times the maximum reference concentration suggesting that manganese concentrations in surface water adjacent to the Site are not different than those determined for the reference sites. The observed exceedances are confined to Transects D, E, F, G, and H, with no clear pattern relative to distance from DMT. All but three of the measurements of manganese in excess of the maximum reference concentration are from samples just above the river bottom. These higher measurements could be due to the low DO concentrations at depth particularly during the summer months, when higher temperatures increase the solubility of manganese in the water column. Manganese concentrations elevated for brief periods of time should not have a significant ecological impact if conditions for the remainder of the year are sufficiently low as to not impact benthic organisms in proximity to the berths along the terminal. Furthermore, many of these concentrations occur in an area that is regularly dredged to maintain sufficient depths for the ocean faring vessels using the berths. However, a significant number of the exceedances of reference are along Transect D, so magnesium is retained as a COI for further evaluation.

Dissolved aluminum was not detected in any of the reference samples; therefore, the comparison to reference is not included in Table 4-2. Aluminum was detected at levels above the laboratory method detection limit during only the February 2008 sampling event at six locations. Given the occurrence of aluminum in seawater, combined with the low frequency of detection, and considering that aluminum in sediment (discussed in Section 4.1.3) was detected at maximum concentrations less than reference locations, aluminum is not retained further as a COI.

4.1.3 Sediment

The measured sediment concentration for aluminum, manganese, and vanadium are compared to the maximum measured reference concentration in Table 4-3. Figures 4-6, 4-7, and 4-8 show the comparison of concentrations in surface sediment at the study area to the reference stations for aluminum, manganese, and vanadium, respectively. The distribution of concentrations in DMT sediments overlaps that at reference stations for these three constituents. All DMT aluminum concentrations were lower than the maximum reference concentration; therefore, no further evaluation of aluminum is necessary. Maximum reference concentrations were exceeded in nine of 77 samples for manganese (12 percent), so it is retained as a COI and is considered further in the refined risk characterization discussion.

Vanadium was detected only in three of 82 samples (4 percent) at concentrations that exceed that seen in reference locations (at locations I3 and I4). These three measurements are all less

than two times the maximum reference concentration, and that combined with a frequency of detection less than 5 percent indicates that further consideration of vanadium as a COI in sediment is not warranted.

4.2 Refined Risk Characterization

This section provides a focused discussion of the assessment endpoints identified in Section 2 with regard to the refined COIs (as identified in Section 4.1):

- Pore water— none
- Surface water— manganese
- Sediment— manganese

This COI is related to potential exposures for the benthic invertebrate and aquatic invertebrate communities and the populations of fish frequenting the study area. A refined risk characterization considers a variety of factors that provide insight into whether chemicals at DMT are likely to pose an unacceptable risk, such as the following:

- The spatial extent and magnitude of exposures that receptors are likely to experience
- Expanded consideration of ESVs (as warranted)
- Qualitative biological information from DMT

4.2.1 Spatial Extent and Magnitude of Exposures That Receptors Are Likely to Experience

Given the prevalence of manganese in the marine environment, and an organisms inherent ability to regulate naturally occurring constituents, one of the better ways to address whether the manganese seen at DMT may pose a risk to the environment is to consider how organisms are exposed (e.g., benthic invertebrates versus fish) and the spatial extent of concentrations greater than reference locations. Manganese concentrations in surface water exceeded reference concentrations more than a factor of two at only three locations (D2, E1, and E2). While there were other exceedances of reference concentrations, they were below a factor of two (Table 4-2). Average concentrations of manganese are consistent with the reference locations. Fish are mobile, and as such, exceedances of reference conditions in localized areas are not ecologically relevant. Overall, fish are not likely to experience any adverse impacts to the low detections of manganese in the surface water. Aquatic invertebrates are mobile, but generally over much smaller areas. Nevertheless, given the limited spatial extent of these areas, these are considered de minimis for aquatic invertebrates.

Manganese was detected in sediment at only one location at two times the reference location (D2) (see Figure 2-1). Other locations along the Transect D and one location each along Transects E, F, and J had slightly elevated concentrations compared to reference locations, but overall, less than 1.5 times that seen in reference locations. Locations D2, E1, and E2 are generally near storm water outfalls. Manganese is not particularly elevated in sediment near the 14th and 15th Street outfalls (Transect C and locations J 1 and J2), so any potential influence due to discharge from the outfalls (if any) would be transient (i.e., elevated manganese should be evident in the area of the 14th and 15th Streets outfalls as well, if historic discharge from outfalls had contributed to sediment concentrations greater than

reference locations). This spatial distribution of manganese in sediment indicates that an isolated area is only slightly elevated. As such, manganese present in surficial sediment adjacent to DMT is highly unlikely to have adverse impacts to the overall benthic community or fish populations.

4.2.2 Expanded Consideration of ESVs

A component of the refined risk evaluation is consideration of additional ESVs. Because manganese is the only COI retained for this evaluation, the discussion herein is focused on ESVs related to manganese. Because there are few ESVs related to manganese, this section also discusses the basis of those that are available and explains how the conservative use of these ESVs demonstrates that manganese does not pose unacceptable risks to aquatic organisms via sediment or surface water exposures.

Few empirical association-based sediment screening values have been developed for manganese. The value used in the SLERA is based upon paired biological and chemistry data from investigations of field-collected (as opposed to laboratory-spiked) sediments. Key characteristics of the data sets compiled for this purpose include the presence of numerous chemical contaminants with unknown relative contributions to observed toxicity, high variability of geophysical characteristics (e.g., grain size, organic carbon content, and sulfide content) potentially affecting bioavailability, and unmeasured speciation of metals.

The potential to overpredict toxic effects by relying on paired biological and chemistry data collected from multiple independent sediment sites is great. Therefore there can be a high degree of uncertainty and conservatism when attempting to draw conclusions regarding the nature and extent of sediment contamination, ecological risks, and potential for injury to natural resources. Several studies have shown that the chemical screening values resulting from the synthesis of seemingly disparate sediment data do not necessarily reflect accurately the cause-effect relationships between chemical concentrations in sediment and toxicity or biological response in benthic organisms (Batley et al., 2005; Chapman et al., 1999; Word et al., 2005; Becker and Ginn, 2008). More specifically, the screening values for less-toxic chemicals serve primarily as indicators of the likely presence of more toxic chemicals due to inter-correlation among chemicals in sediment. For instance, many sediment screening values fall within the range of naturally occurring background concentrations (Chapman et al., 1999; Rice, 1999) and thus are not reflective of accurate chemical-specific toxicity thresholds or indicators of risk at the majority of contaminated sediment sites. Despite recognition of these limitations by proponents of both empirical and cause-effect (mechanistic) approaches to sediment quality evaluation association-based sediment screening values have taken on inertia in the sediment management realm and are used, in some cases, in a manner well beyond their original intent and applicability (Wenning et al. 2005).

Manganese was identified as a COI for sediment using empirically derived paired chemistry and biological data, and thus is very conservative. Also there is limited spatial extent and magnitude of reference condition exceedances. Given these two combined limitations and conservative assumptions the weight of evidence is that manganese could not pose an unacceptable risk to the benthic community, aquatic invertebrate community, and fish populations. The ESV for manganese considered in Step 2 of the SLERA is based on a limited data set and suffers some of the constraints of empirically derived benchmarks. The

source of the ESV used was the AET as reported by Buchman (2008). AETs are based on toxicity data solely from Puget Sound and they show the maximum detected concentration that demonstrated no toxicity (Buchmann, 2008). The weakness of this approach is that it does not show a concentration that does cause toxicity (i.e., this is an unbounded no-effects concentration). Thus, the manganese ESV is generally not considered highly predictive of adverse effects. Numerous additional sources of literature and toxicity were evaluated to find additional ESVs for manganese in estuarine surface water or sediments (e.g., Oak Ridge National Laboratories, the toxicology data network (TOXNET), EPA's ECOTOX database (USEPA, 2009), and guidance documents from other states and regions,) with no viable results.

Limited data were readily available for the effects of manganese on marine crustaceans (Table 4-4). Oweson et al. (2006) reported cellular effects, mainly haematopoietic cell death, in the Norway lobster, *Nephrops norvegicus*, at a concentration of 5,000 µg/L manganese. Kimball (1978) reported no adverse effects at 1,100 µg/L manganese in the freshwater planktonic crustacean *Daphnia magna*. Two studies were found that assessed the effects on manganese on mollusks. Calabrese et al. (1973) reported a lethal concentration 50 (LC50) of 16,000 µg/L manganese for the American oyster, *Cassostrea virginica*. A half-maximal effective concentration 50 (EC50) of 30,000 µg/L manganese was reported for larval development of the blue mussel, *Mytilus edulis* (Morgan et al., 1986). The toxicity of manganese to echinoderms was assessed by Hansen et al. (1995), who reported no mortality occurred in starfish *Asterias rubens* after a 7-day exposure to 25,000 µg/L manganese, and Kobayashi (1971), who observed no effects on the development of sea urchin, *Anthocidaris crassisina*, larvae at 6,600 µg/L manganese.

Considering these available data from the literature, the ESV used in the Step 2 screening (120 µg/L manganese) appears to be overly conservative. The average concentration of manganese in surface water at DMT (244 µg/L) is substantially lower than concentrations form the scientific literature associated with adverse effects to marine crustaceans (1,100 to 30,000 µg/L). Manganese is not expected to cause risk from surface water exposure.

4.2.3 Qualitative Biological Information from DMT

An informal, qualitative analysis of the benthos at the study area was performed during the May 2007 field effort, and again in June 2008. Polychaetes, amphipods, clams, and arthropods were observed in sediments from DMT in May 2007, with differences in community composition dependent upon the sediment habitat. The dominant organisms found in June 2008 were amphipods and small crabs, however sampling also resulted in isopods, barnacles, mussels, pipefish, mysid shrimp, and worms (polychaetes and oligochaetes).

The types and varieties of organisms at the study area are indicative of the health of the biological community. As an example, amphipods were among the organisms identified and amphipods are commonly used test organisms in laboratory toxicity assays due to their sensitivity to several chemicals. The findings of the 2008 survey in the shallow water habitat near location J4 are consistent with the findings of the WREC's IBI work in 1996 (Klosterhaus et al., 2007).

4.2.4 Ecological Risk Characterization Summary

Overall, the levels of COIs in pore water, surface water, and surface sediment adjacent to DMT do not pose an unacceptable risk to the benthic invertebrate community, the aquatic invertebrate community, or fish populations based on the following findings:

1. The concentrations of COI(s) at the Site were below the NRWQC for those constituents with estuarine NRWQC, and below freshwater criteria for some constituents lacking estuarine criteria.
2. For the few cases where maximum concentrations of COIs were above the ESVs, most were below concentrations seen at the reference locations.
3. For the very few cases where maximum values in the vicinity of DMT exceeded reference values, the average values were comparable to reference concentrations. Also, conservative ESVs were used in these cases.
4. Qualitative surveys suggest biological diversity indicative of a healthy ecosystem.

4.3 Uncertainty Assessment

Uncertainties are inherent in all risk assessments. The nature and magnitude of the uncertainties depend on the amount and quality of data available, the degree of knowledge concerning study area conditions, and the assumptions made to perform the assessment. A qualitative evaluation of the major uncertainties associated with this assessment is outlined below in general categories.

4.3.1 Effects Assessment Uncertainties

Use of Freshwater Criteria Instead of Marine Criteria: Hardness data suggest that the environment adjacent to DMT should be evaluated as marine and not freshwater. However, with the exception of chromium species, no marine screening criteria are available for fish and aquatic organism. Freshwater criteria are available for the other COPR constituents and were used for informative purposes only. For constituents with both marine and freshwater screening values available, freshwater criteria are often much lower than marine criteria. Comparisons to the freshwater criteria were considered overly protective of marine waters. Concentrations exceeding these benchmarks do not necessarily result in unacceptable ecological risk in a marine system. However, concentrations exceeding these values were compared to reference concentrations as well as an additional line of evidence.

Bulk Sediment versus Pore Water: As discussed in previous sections, for the COI comparison of pore water concentrations to water quality criteria is a more accurate evaluation of risk than use of bulk sediment concentrations and associated criteria. Several uncertainties are associated with the use of bulk sediment comparison, including the assumption of kinetic equilibrium, ignoring potentially competing partitioning factors such as grain size and DOC fraction, and not considering other exposure pathways such as ingestion.

Insufficient Toxicity Data: Direct toxicity data were unavailable for calcium and magnesium in sediment. However, as has been presented in Appendix A, these compounds

are not considered toxic. Only limited sediment screening values are available for vanadium despite considerable effort to identify such criteria as described in the Vanadium white paper submitted to MDE (CH2M HILL, 2007a).

Additive Toxicity: In this assessment, risks for COIs were each considered independently. Because COIs may interact in an additive, antagonistic, or synergistic manner, the evaluation of single-chemical risk may either underestimate or overestimate risk associated with chemical mixtures.

The freshwater screening values that were used, except for magnesium, are all NRWQC. Many of the toxicity studies used to develop these criteria are single chemical laboratory toxicity tests. While directly addressing additive toxicity, these criteria are generally set with a level of conservatism. In addition, all criteria, except for chromium, were for freshwater environments. These criteria are overly conservative for evaluation of marine environments.

Comparison to Reference Concentrations: The screening criteria that were employed for evaluation of risk to fish and benthic organisms do not represent a no-effect or a lowest effect level (i.e., concentration at which no adverse effect or the lowest adverse effect is observed). Instead, these screening concentrations, particularly for sediment, are more indicative of concentrations at which effects occur and are used as a frame of reference as to whether the risk of effects is acceptable. For sediment, typically a lower and upper effects level is available representing levels at which effects are possible and probable. For surface water the concentrations represent levels which may lead to observed effects when exposure of chronic (long term) or acute (short term significantly high dose) duration is experienced. When concentrations are below the lower value, risks are considered acceptable and when in between, they are uncertain. In Step 3a, rather than compare the concentrations exceeding these lower effects levels to upper effects levels or acute surface water criteria, they were compared to maximum reference concentrations. The maximum reference concentrations represent the maximum concentrations observed in four sampling events at three locations within an exposure area with similar conditions to the study area. These reference areas are representative of conditions and concentrations throughout the Patapsco River, and not just adjacent to the study area. Potential contaminant sources for observed concentrations at the reference locations would include numerous anthropogenic sources upstream of these references. Comparing study area concentrations to these references provides an understanding of whether or not conditions within the influence of the sources at DMT differ from those observed throughout the rest of the Patapsco River. Potential risk posed by concentrations at the study area that are within the range of concentrations observed in the reference area should be considered acceptable and no further investigation should be necessary.

4.3.2 Exposure Assessment Uncertainties

Bioavailability: The exposure dose estimates in this screening risk assessment assume that 100 percent of the chemical concentrations to which receptors are exposed is in the bioavailable form. Most chemicals will not be 100 percent bioavailable. In the cases where bioavailability is less than 100 percent, risk is overestimated. Maximum concentrations were used as the EPCs in both the initial screening assessment in Step 2 and in the refined evaluation in Step 3a. The EPCs were assumed to remain constant for the duration of exposure. Physical, chemical, and biological processes that could reduce chemical

concentrations and their bioavailability over time are not factored into the calculation of the EPCs. Use of this additional conservative assumption likely overestimates the exposure to the COIs. AVS measurements in sediment suggest that metals influenced geochemically by reducing conditions in sediments around DMT are not bioavailable (Tables 4-5a and 4-5b).

Total Versus Dissolved Metals: USEPA guidance (USEPA, 1996) indicates that the dissolved metal fraction should be preferentially used rather than the total metal fraction in surface water screening because the dissolved fraction is the bioavailable fraction. Thus only dissolved concentrations were used in the ERA for the surface water screen. High levels of suspended solids and sediment-adsorbed metals would result in overstating bioavailable surface water concentrations and thus potential exposures and risks. Therefore, this uncertainty has been eliminated.

Spatial Distribution of Samples: The number and spatial distribution of surface water and sediment samples were sufficient to adequately estimate potential ecological risks for ecological receptors. A total of 320 surface water, 136 pore water, and 77 surface sediment samples (excluding field duplicates) were collected adjacent to DMT from four quarterly events. An additional 42 surface water, 12 pore water, and 12 surface sediment samples (excluding field duplicates) were collected from the reference area against which to compare measured concentrations impacted by the Site.

Detection Limits: Detection limits for some analytes exceeded applicable screening values in some media; these analytes were not retained as COIs unless they were detected. This approach could underestimate risk, although the analytes for which detection limits were too high are not constituents of COPR.

Area 1501/1602 Side Slope Assessment Data: Sediment and pore water samples collected in May 2009 at the 15th Street outfall following a wet weather event are included in this uncertainty assessment because the samples were collected and data were validated after the majority of the ERA was completed. The results are consistent with those from the Sediment and Surface Water Study. This section addresses how the data affect the ERA conclusions. This analysis shows that these data have no bearing on the final conclusions of this ERA. The data from this targeted study were reported to MDE via a letter from Honeywell to MDE dated September 4, 2009. Sediment and pore water samples were collected from three locations near the 15th Street outfall. Sediment and pore water sample results are summarized with regard to the ERA as follows:

- The sediment and pore water samples were collected at low tide in the intertidal and subtidal zones respectively, within a sandy area of limited areal extent. The sandy substrates that were sampled do not have particularly unique or distinctive characteristics that would make them more attractive to aquatic wildlife.
- The sediment and pore water sample locations included in the side slope study (JMDMT-7, -8, and -9) were bounded on all sides by locations included in the Sediment and Surface Water Study (i.e., the area is bounded by locations J1, C1, and C2, which were included in this ERA).
- Sediment samples were analyzed for total chromium and other COPR constituents. Total chromium concentrations in sediment collected from the side slope study ranged from 875 mg/kg to 1160 mg/kg, which is consistent with the sediment concentrations

from locations J1, C1, and C2. Concentrations of other COPR constituents were also similar to those evaluated in this ERA.

- Cr(VI) was detected in one pore water sample (JMDMT-8) at a concentration of 108 µg/L. This detected concentration is most likely attributable to a wet weather event that occurred prior to sampling, and is not indicative of a persistent or areally extensive condition. Cr(VI) was not detected in pore water from adjacent sample locations JMDMT-7 or JMDMT-9, or in adjacent Sediment and Surface Water Study locations J1, C1, or C2 over four quarters of sampling (CH2M HILL and ENVIRON, 2009).

Although the Cr(VI) concentration of 108 µg/L in the pore water sample from JMDMT-8 is slightly above the chronic NRWQC of 50 µg/L, it is well below the acute criterion of 1,100 µg/L. Given the extremely limited spatial extent of the detected Cr(VI) (as evidenced by the non-detections in immediately adjacent samples), the intermittent nature of the presence of Cr(VI) following a rainfall event (evidenced by numerous sampling results for adjacent locations over time), and consideration of relative species sensitivity distributions (Appendix A, Figure A-1), this isolated detected concentration is not considered indicative of an unacceptable risk to fish populations or benthic community structure. As such, this single detected result does not affect the overall conclusions of the ERA.

Table 4-1

Comparison of Pore Water Exposure Point Concentrations to Reference Concer

Dundalk Marine Terminal, Baltimore, Maryland

Transect	Ratio of Porewater EPCs to Reference Concentrations[a]		
	Fe	Mg	Mn
A1	<1	<1	<1
A2	--	<1	<1
A3	<1	<1	<1
A4	--	<1	<1
B1	<1	<1	<1
B2	<1	<1	<1
B3	<1	<1	<1
B4	<1	<1	<1
B5	--	<1	<1
C1	<1	<1	<1
C2	<1	<1	<1
C3	<1	<1	<1
C4	<1	<1	<1
D1	<1	1.2	<1
D2	<1	<1	1.0
D3	1.1	1.0	<1
D4	<1	<1	<1
E1	<1	1.1	<1
E2	<1	1.0	<1
E3	<1	<1	<1
E4	<1	<1	<1
F1	<1	<1	<1
F2	1.2	<1	<1
F3	<1	<1	<1
F4	<1	<1	<1
G1	<1	<1	<1
G2	<1	<1	<1
G3	<1	<1	<1
G4	<1	<1	<1
H1	<1	<1	<1
H2	--	<1	<1
H3	<1	<1	<1
H4	<1	1.0	<1
I1	<1	<1	<1
I2	<1	<1	<1
I3	<1	<1	<1
I4	<1	<1	<1
J1	<1	<1	<1
J2	--	<1	<1
J3	<1	<1	<1
J4	--	<1	<1

Notes:

a Null fields (--) indicate that the parameter was not detected in the pore water during any of the sampling events.

The ratios presented in this table are determined by dividing the EPC for each location (maximum detected concentration) and parameter by the maximum reference concentration. The reference values for the four parameters are as follows:

Iron (Fe) 8040 µg/L

Magnesium (Mg) 547,000 µg/L

Manganese (Mn) 24,600 µg/L

Table 4-2

Comparison of Surface Water Exposure Point Concentrations to Reference

Dundalk Marine Terminal, Baltimore, Maryland

Transect	Ratio of Surface Water EPCs to Reference	
	Mg	Mn
A1	<1	<1
A2	<1	<1
A3	<1	<1
A4	<1	<1
B1	<1	<1
B2	<1	<1
B3	<1	<1
B4	<1	<1
B5	<1	<1
C1	<1	<1
C2	<1	<1
C3	<1	<1
C4	<1	<1
D1	1.0	1.6
D2	1.0	**2.8**
D3	1.0	1.4
D4	<1	<1
E1	1.1	**3.3**
E2	1.0	2.0
E3	1.0	1.7
E4	<1	<1
F1	<1	<1
F2	1.1	1.1
F3	<1	<1
F4	<1	<1
G1	<1	<1
G2	<1	1.1
G3	<1	1.9
G4	1.0	<1
H1	<1	<1
H2	<1	1.7
H3	<1	<1
H4	1.0	1.9
I1	<1	<1
I2	<1	<1
I3	<1	<1
I4	<1	<1
J1	<1	<1
J2	<1	<1
J3	<1	<1
J4	<1	<1

Notes:

(a) The ratios presented in this table are determined by dividing the EPC for each location (maximum detected concentration) and parameter by the maximum reference concentration. The reference values for the four parameters are as follows:

Magnesium (Mg) 571,000 µg/L

Manganese (Mn) 347 µg/L

Table 4-3

Comparison of Surface Sediment Exposure Point Concentrations to Reference Concentrations

Dundalk Marine Terminal, Baltimore, Maryland

Transect	Ratio of EPC to Reference Value[a]		
	Al	Mn	V
A1	<1	<1	<1
A2	<1	<1	<1
A3	<1	<1	<1
A4	<1	<1	<1
B1	<1	<1	<1
B2	<1	<1	<1
B3	<1	<1	<1
B4	<1	<1	<1
B5	<1	<1	<1
C1	<1	<1	<1
C2	<1	<1	<1
C3	<1	<1	<1
C4	<1	<1	<1
D1	<1	1.1	<1
D2	<1	**2.0**	<1
D3	<1	1.3	<1
D4	<1	<1	<1
E1	<1	1.5	<1
E2	<1	<1	<1
E3	<1	<1	<1
E4	<1	<1	<1
F1	<1	<1	<1
F2	<1	<1	<1
F3	<1	<1	<1
F4	<1	1.0	<1
G1	<1	<1	<1
G2	<1	<1	<1
G3	<1	<1	<1
G4	<1	<1	<1
H1	<1	<1	<1
H2	<1	<1	<1
H3	<1	<1	<1
H4	<1	<1	<1
I1	<1	<1	<1
I2	<1	<1	<1
I3	<1	<1	1.9
I4	<1	<1	1.2
J1	<1	<1	<1
J2	<1	<1	<1
J3	<1	<1	<1
J4	<1	1.2	<1

Notes:

[a]The ratios presented in this table are determined by dividing the EPC for each location (maximum detected concentration) and parameter by the maximum reference concentration. The reference values for the four parameters are as follows:

	Aluminum (Al)	41,400 mg/kg
	Manganese (Mn)	1770 mg/kg
	Vanadium (V)	127 mg/kg
EPC	Exposure Point Concentrations .	
mg/kg	Milligrams per kilogram.	

Bold values exceed 2.

Table 4-4

Summary of Manganese Toxicity Studies

Dundalk Marine Terminal, Baltimore, Maryland

Environment	Organism		Summary		Reference
	Common name	Scientific name	Concentration (µg/L)	Effect	
Freshwater	Water flea	*Daphnia magna*	1,100	No adverse effects.	Kimball, 1978
Marine	Norway lobster	*Nephrops norvegicus*	5,000	Cellular effects (heamatopoietic cell death).	Oweson et al., 2006
Marine	American oyster	*Cassostrea virginica*	16,000	Lethal concentation 50 (LC50).	Calabrese et al., 1973
Marine	Blue mussel	*Mytilus edulis*	30,000	Half-maximal effective concentration 50 (EC50) for larval development.	Morgan et al., 1986
Marine	Starfish	*Asterias rubens*	25,000	No mortality after 7-day exposure.	Hansen et al., 1995
Marine	Sea urchin	*Anthocidaris crassisina*	6,600	No effects on larval development.	Kobayashi, 1971

Notes:

µg/L Micrograms per liter.

Table 4-5a

Summary of AVS-SEM Results by Location

Dundalk Marine Terminal, Baltimore, Maryland

Transect	May 07			Aug 07		
	Total AVS (µmoles/g)	Total SEM[a] (µmoles/g)	Excess AVS (AVS-SEM) (µmoles/g)	Total AVS (µmoles/g)	Total SEM[a] (µmoles/g)	Excess AVS (AVS-SEM) (µmoles/g)
A1	0.44	2.81	-2.37	12.1	2.12	9.98
A2[b]	0.39	0.66	-0.27	0.57	0.772	No excess AVS
A3	0.52	0.37	0.15	0.99	0.987	0.003
A4[b]	0.39	0.49	-0.10	1.4	0.36	1.04
B1	0.44	2.35	-1.91	10.4	1.88	8.52
B2	0.53	1.82	-1.29	3.2	1.19	2.01
B3	7.7	2.18	5.52	11.6	2.78	8.82
B4[c]	4.3	2.46	1.84	3.8	2.94	0.86
C1	12.6	2.25	10.4	14.3	2.93	11.4
C2	13.1	2.30	10.8	16	2.21	13.8
C3	9.8	2.62	7.18	6.5	2.49	4.01
C4	4.9	2.58	2.32	7.1	2.62	4.48
D1	28.8	1.46	27.3	18.7	1.39	17.3
D2	16.6	1.38	15.2	32.7	1.19	31.5
D3	15.3	1.32	14.0	11.4	1.82	9.58
D4	13.2	1.82	11.4	10.3	2.86	7.44
E1	22.9	1.09	21.8	19	1.13	17.9
E2	6.8	0.99	5.81	20.1	1.4	18.7
E3	27.5	1.79	25.7	25.1	1.5	23.6
E4	0.93	0.79	0.137	7.6	1.29	6.31
F1	12.9	0.87	12.0	19.9	2.18	17.7
F2	9.5	0.89	8.61	4.2	0.837	3.36
F3	22	1.84	20.2	41.5	1.57	39.9
F4	20.6	1.64	19.0	8.4	1.08	7.32
G1	6.8	0.52	6.28	21.2	1.38	19.8
G2	29.1	1.06	28.0	17.1	1.29	15.8
G3	23.9	1.35	22.6	25.6	1.65	24
G4	22.2	1.53	20.7	10.2	1.13	9.07
H1	51.2	3.01	48.2	16.9	0.935	16
H2	20.8	1.36	19.4	32.2	1.34	30.9
H3	36.5	1.25	35.3	16.4	1.14	15.3
H4	24.5	1.46	23.0	38.3	2.01	36.3
I1	3.2	6.55	-3.35	26.5	3.97	22.5
I2	10.6	4.74	5.86	23.8	4.08	19.7
I3	24.4	4.93	19.5	21.5	6.26	15.2
I4	42.7	6.44	36.3	11.9	3.86	8.04
Reference Locations						
37	29.8	1.10	28.7	20.3	0.846	19.5
37A	24.9	1.10	23.8	14.7	1.00	13.7
37B	9.7	1.53	8.17	22	0.863	21.1

Notes:

Where duplicate samples were present, they were counted as one sample, and the greatest value for each analyte was used to calculate range and average.

a Total SEM refers to the sum of all divalent metals simultaneously extracted (cadmium, copper, lead, mercury, nickel, zinc). The max Hg concentration was used for rejected Hg data (0.000029 µmol/g).

b AVS was ND (0.39 µmol/g)

c Used the higher of the duplicate values for sample B4 for AVS and SEM.

µmoles/g Micromoles per gram.

AVS Acid Volatile Sulfide.

SEM Simultaneously Extracted Metals.

Table 4-5b

Summary of AVS-SEM Results by Transect

Dundalk Marine Terminal, Baltimore, Maryland

	Acid Volatile Sulfide (AVS)	Cadmium	Copper	Lead	Nickel	Mercury	Zinc	SEM (sum of metals)	Excess AVS (AVS-SEM)	Iron	Excess Fe (Iron-Excess AVS)
	µmoles/g	µmoles/g	µmoles/g	µmoles/g	µmoles/g	µmoles/g	µmoles/g	µmoles/g	µmoles/g	µmoles/g	µmoles/g
Averages											
Overall	13.5	0.0145	0.181	0.121	0.279	0.00000649	1.4	2	11.5	80.2	68.7
Sediment < 0.5' Deep	14.8	0.016	0.178	0.121	0.293	0.00000649	1.4	2.01	12.8	81.9	69.1
Sediment > 0.5' Deep	3.57	0.00354	0.205	0.126	0.166	NA	1.41	1.91	1.66	67.3	65.6
Transect A	2.05	0.00104	0.0864	0.0397	0.224	0.0000154	0.721	1.07	0.98	36.8	35.8
Transect B	3.97	0.00196	0.219	0.0772	0.33	0.0000215	1.09	1.72	2.25	77	74.8
Transect C	10.5	0.00451	0.237	0.145	0.313	0.00000381	1.8	2.5	8	107	99
Transect D	18.4	0.00213	0.164	0.0953	0.238	0.00000378	1.16	1.66	16.7	106	89.3
Transect E	16.2	0.00231	0.125	0.0744	0.26	0.00000538	0.8	1.26	14.9	85.5	70.6
Transect F	17.4	0.00217	0.178	0.0808	0.249	0.00000385	0.855	1.36	16	102	86
Transect G	19.5	0.00202	0.121	0.0677	0.263	0.00000388	0.785	1.24	18.3	74.4	56.1
Transect H	29.6	0.0155	0.145	0.105	0.226	0.00000383	1.07	1.56	28	59.6	31.6
Transect I	20.6	0.119	0.298	0.398	0.445	0.00000381	3.92	5.18	15.4	57.8	42.4
Transect J	4.97	0.00486	0.23	0.137	0.239	NA	1.76	2.37	2.6	91.8	89.2
Near Bulkhead (1)	15.3	0.0149	0.227	0.139	0.35	0.00000764	1.53	2.26	13	85	72
Mid Near (2)	13.5	0.0119	0.164	0.103	0.257	0.00000912	1.27	1.81	11.7	75.7	64
Mid Far (3)	16	0.0169	0.153	0.126	0.275	0.00000382	1.38	1.95	14.1	75.7	61.6
Away From Bulkhead (4)	9.89	0.0144	0.181	0.117	0.239	0.00000457	1.42	1.97	7.92	83.9	76

Notes:

Where duplicate samples were present, the maximum value of each constituent is used.

Analytes that were not detected are presented here as present at 1/2 of the detection limit.

AVS Acid volatile sulfides.

NA Not analyzed.

SEM Simultaneously extracted metals.

µmoles/g Micromoles per gram.

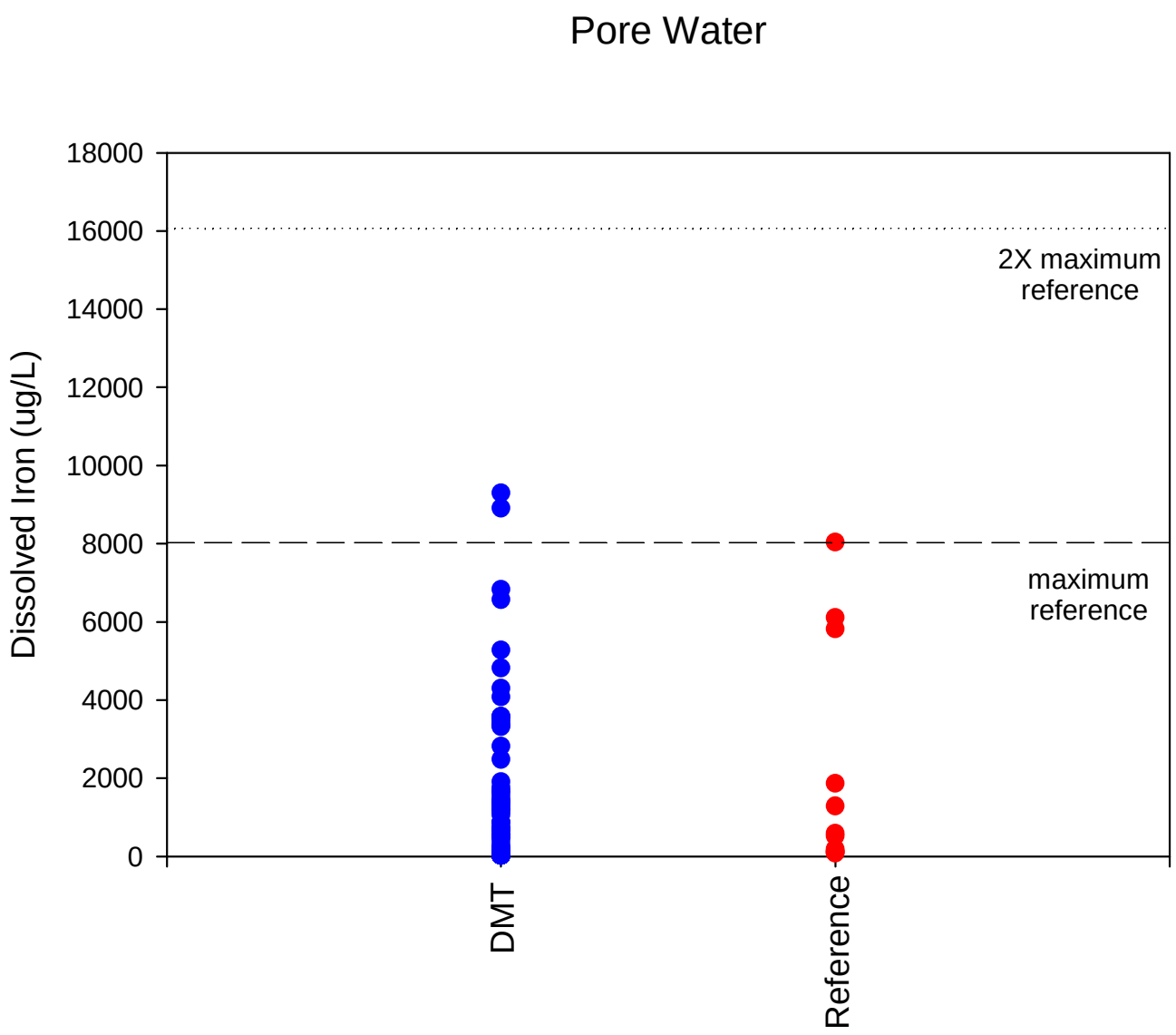

Figure 4-1
Comparison of Detected Concentrations of Dissolved Iron in Pore Water Between DMT and Reference Stations
Dundalk Marine Terminal
Baltimore, Maryland

Notes:
DMT Dundalk Marine Terminal
µg/L micrograms per liter

ENVIRON CH2MHILL

ES022008025MKE Fig_4-1_v2 09.10.09 sls

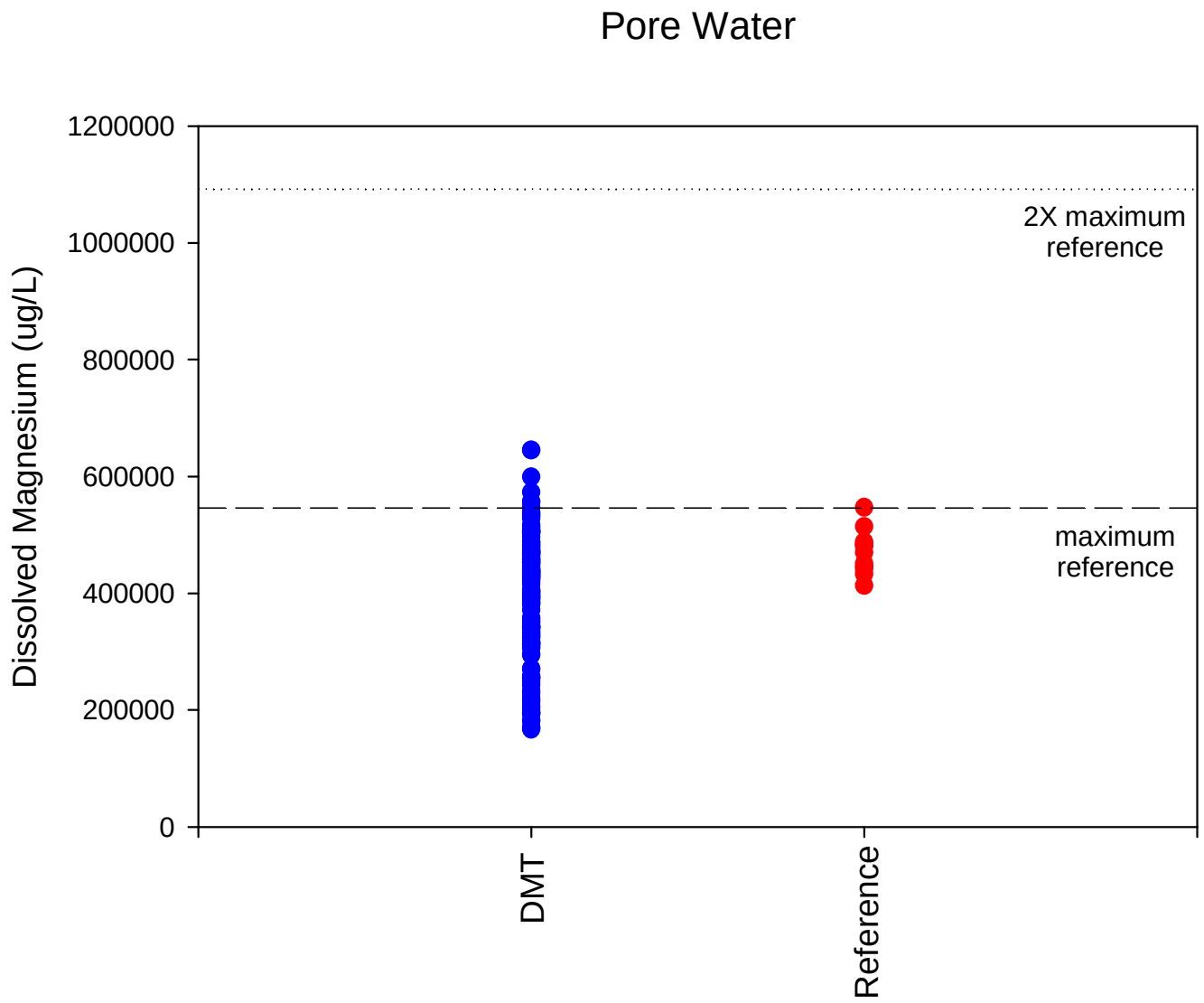

Figure 4-2
Comparison of Detected Concentrations of Dissolved Magnesium in Pore Water Between DMT and Reference Stations
Dundalk Marine Terminal
Baltimore, Maryland

Notes:
DMT Dundalk Marine Terminal
µg/L micrograms per liter

ENVIRON CH2MHILL

ES022008025MKE Fig_4-2_v2 09.10.09 sls

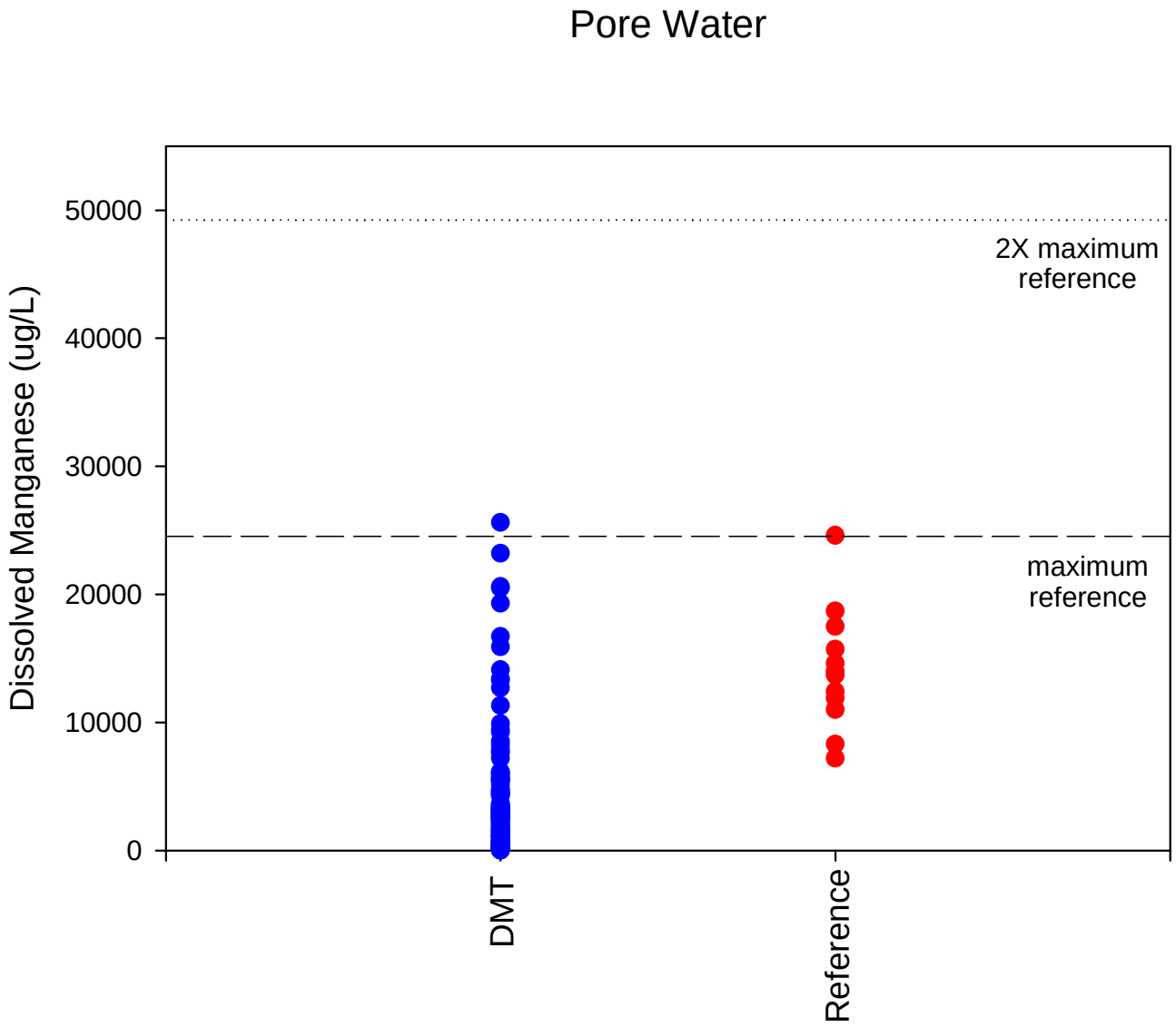

Figure 4-3

Comparison of Detected Concentrations of Dissolved Manganese in Pore Water Between DMT and Reference Stations
Dundalk Marine Terminal
Baltimore, Maryland

Notes:
DMT Dundalk Marine Terminal
µg/L micrograms per liter

ENVIRON CH2MHILL

ES022008025MKE Fig_4-3_v2 09.10.09 sls

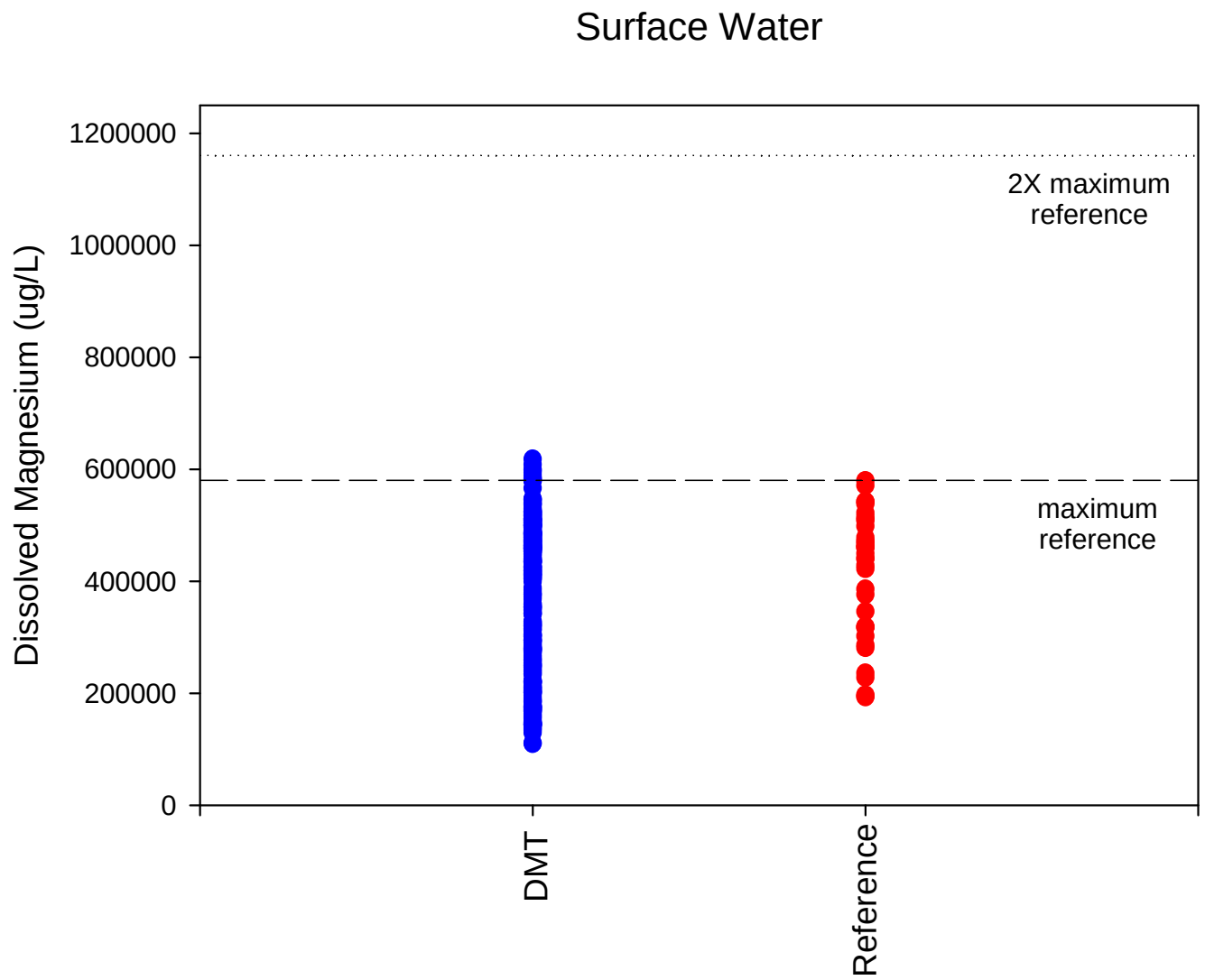

Figure 4-4

Comparison of Detected Concentrations of Dissolved Magnesium in Surface Water Between DMT and Reference Stations

Dundalk Marine Terminal

Baltimore, Maryland

Notes:

DMT Dundalk Marine Terminal

µg/L micrograms per liter

ENVIRON CH2MHILL

ES022008025MKE Fig_4-4_v2 09.10.09 sls

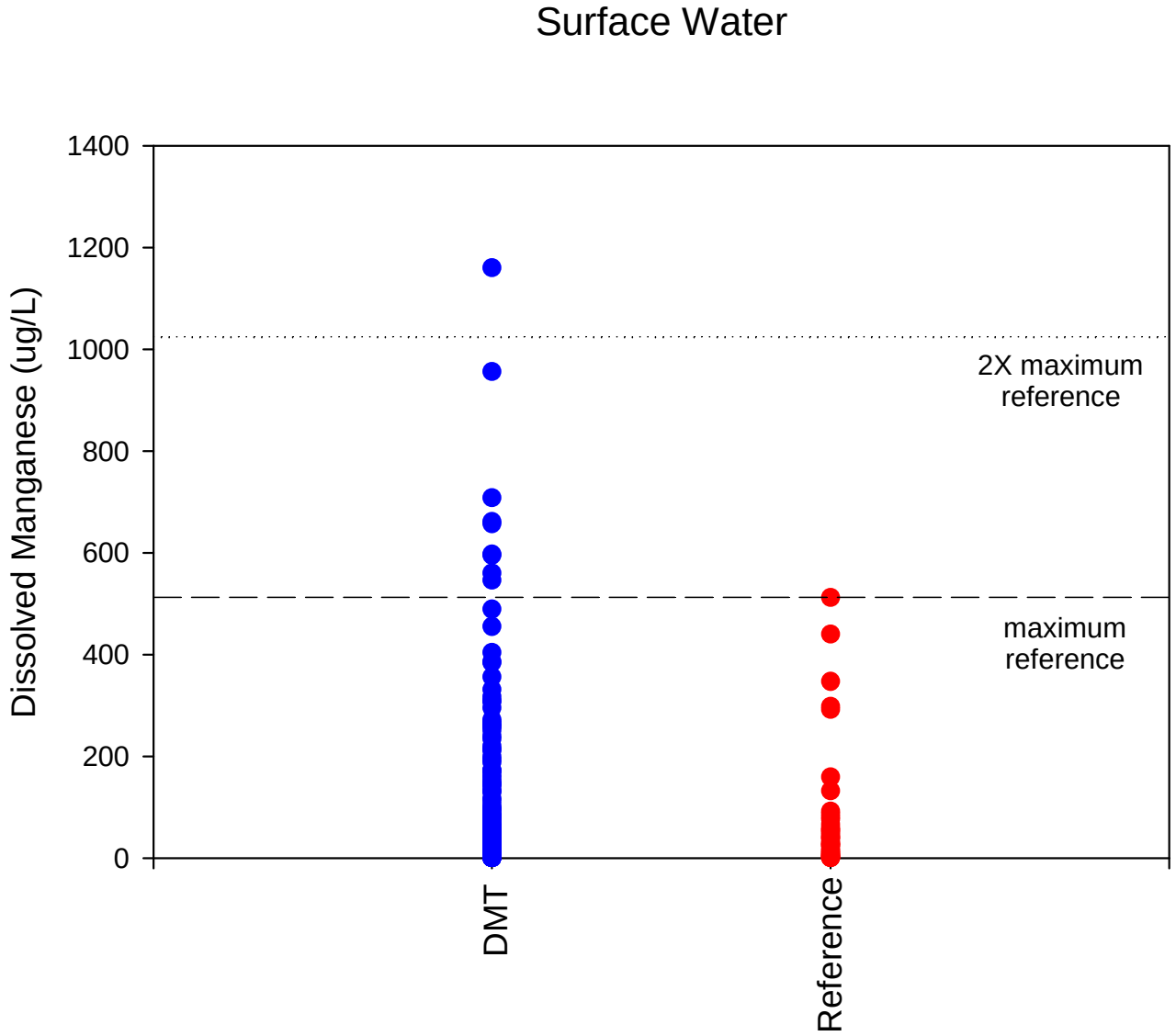

Figure 4-5

Comparison of Detected Concentrations of Dissolved Manganese in Surface Water Between DMT and Reference Stations

Dundalk Marine Terminal

Baltimore, Maryland

Notes:

DMT Dundalk Marine Terminal

µg/L micrograms per liter

ENVIRON CH2MHILL

ES022008025MKE Fig_4-5_v2 09.10.09 sls

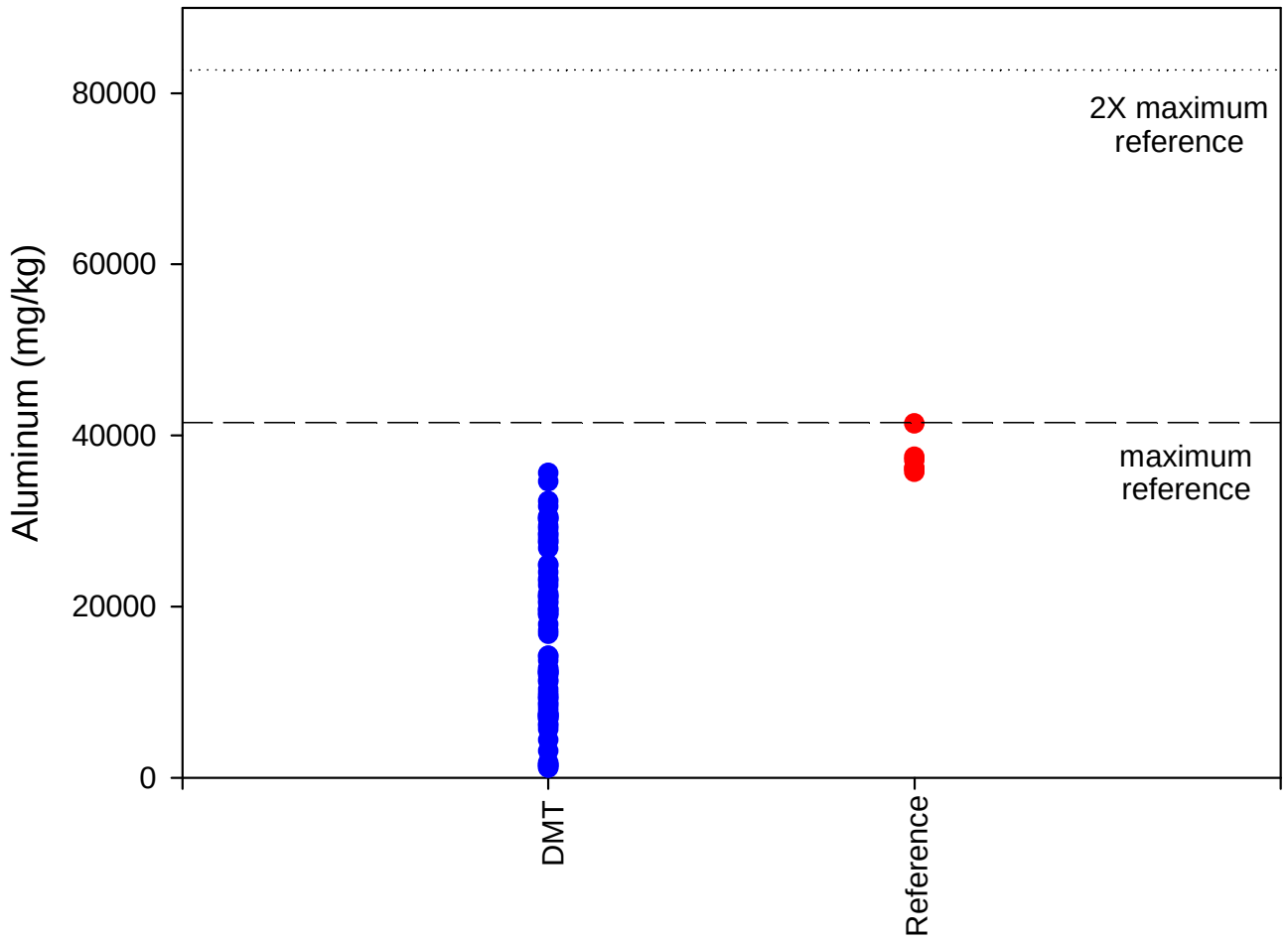

Figure 4-6
Comparison of Detected Concentrations of Aluminum in Sediment Between DMT and Reference Stations
Dundalk Marine Terminal
Baltimore, Maryland

Notes:
DMT Dundalk Marine Terminal
mg/kg milligrams per kilogram

ENVIRON CH2MHILL

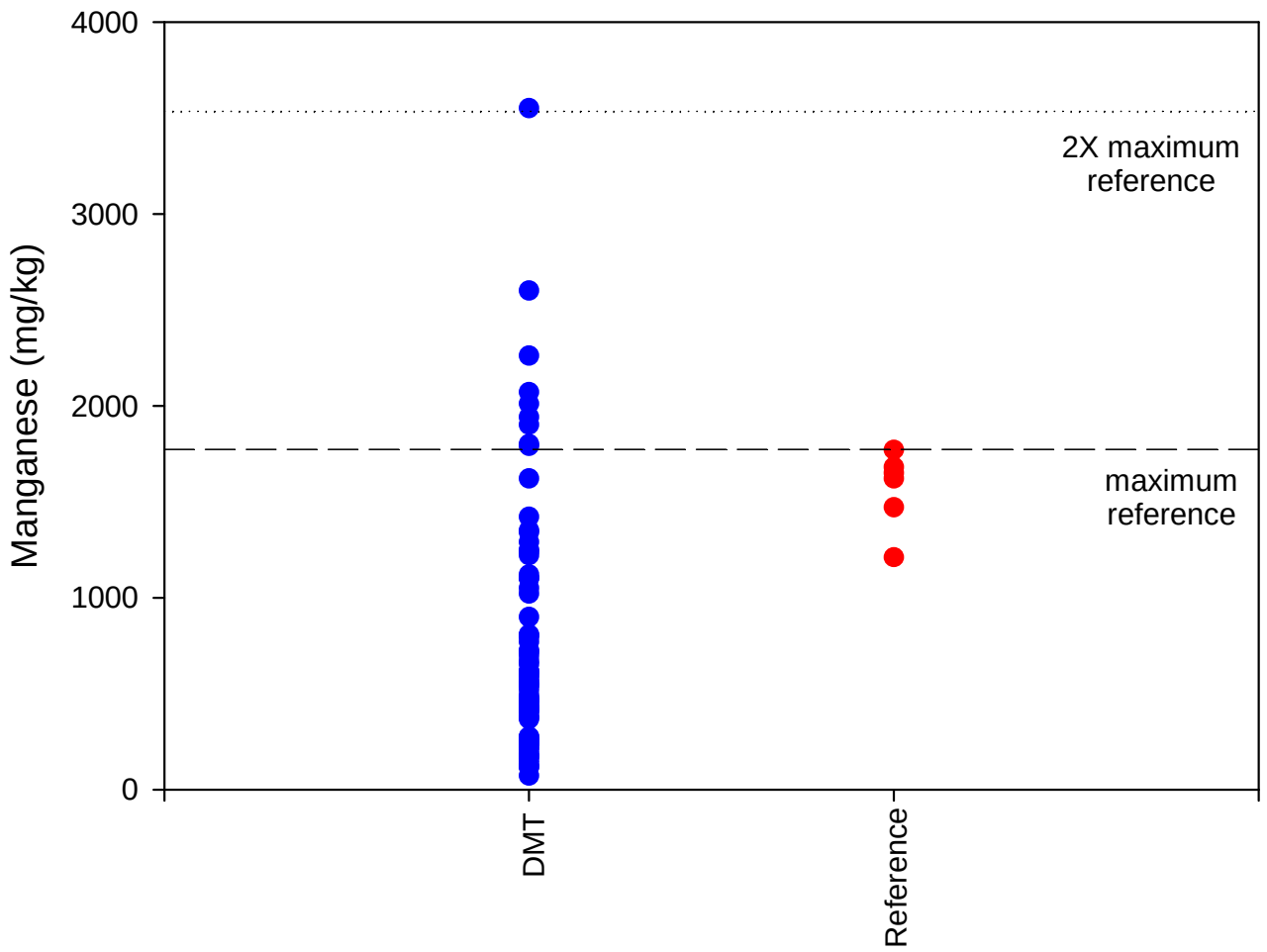

Figure 4-7
Comparison of Detected Concentrations of Manganese in Sediment Between DMT and Reference Stations
Dundalk Marine Terminal
Baltimore, Maryland

Notes:
DMT Dundalk Marine Terminal
mg/kg milligrams per kilogram

ENVIRON CH2MHILL

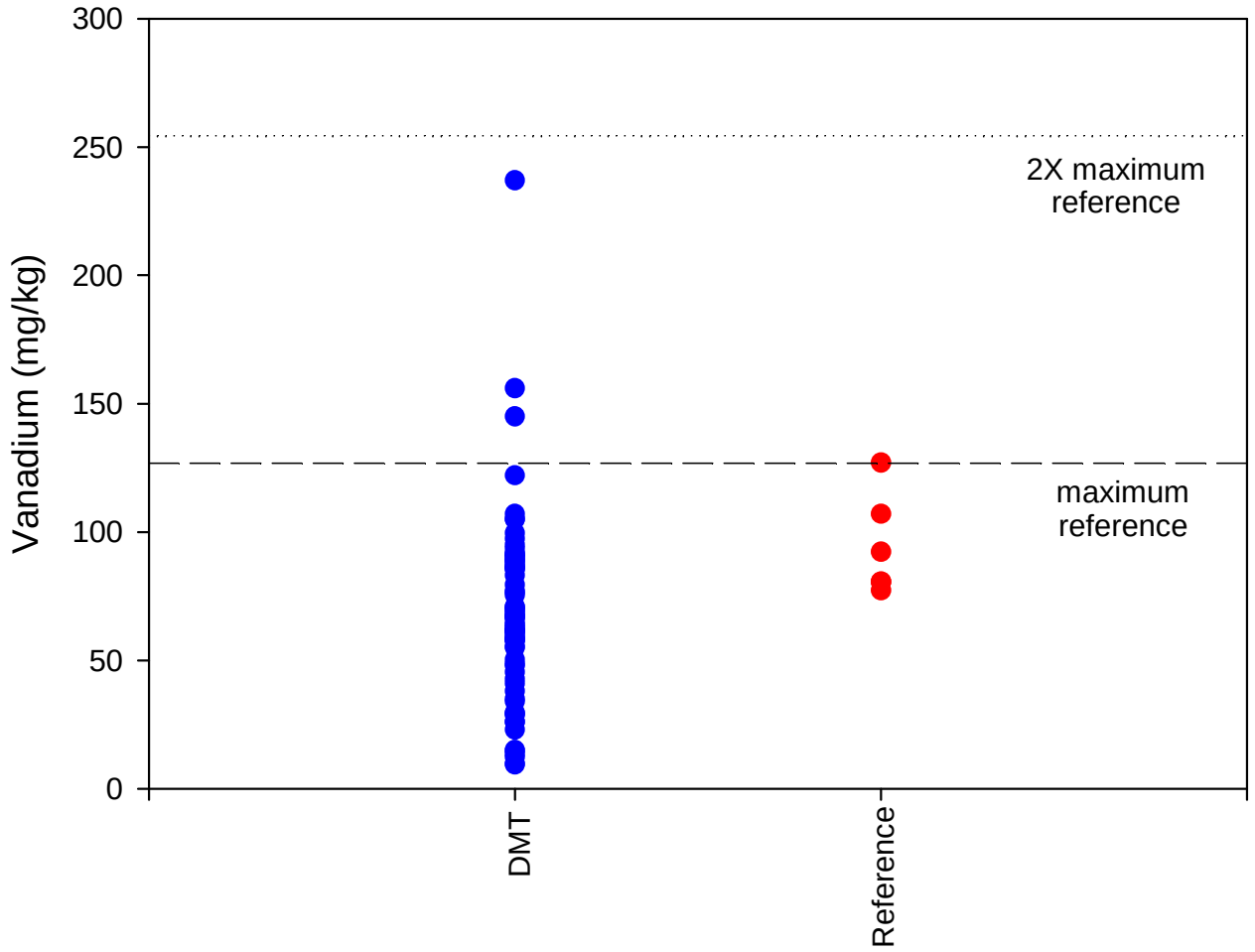

Figure 4-8
Comparison of Detected Concentrations of Vanadium in Sediment Between DMT and Reference Stations
Dundalk Marine Terminal
Baltimore, Maryland

Notes:
DMT Dundalk Marine Terminal
mg/kg milligrams per kilogram

ENVIRON CH2MHILL

SECTION 5

Summary and Conclusions

The basic approach for the ERA presented in this report is consistent with USEPA guidance (1997, 1998, 2000, 2001, 2005a), which provides an eight-step process with built-in critical management and decision points. Steps 1 and 2 are the SLERA, while Step 3 is the initial step of the BERA. Step 1 consisted of the screening level problem formulation and effects evaluation. Step 2 comprised a screening level exposure estimate and risk calculation. In Step 2 of the ERA, chemical concentration data for pore water, surface water, and sediment for four quarterly sampling events conducted at DMT were compared to conservative ESVs. All measured concentrations of Cr(III) and Cr(VI) in pore water and surface water were below ESVs. Thus, in accordance with the USEPA's approach, chromium was not retained for further evaluation.

Based on the results of Step 2, the following COIs and media were evaluated in Step 3a: iron, magnesium, and manganese in pore water; magnesium and manganese in surface water; and aluminum, manganese, and vanadium in surface sediment. In Step 3a, concentrations of these COIs measured within the study area were compared to those concentrations measured at reference locations. Concentrations of COIs within the study area were similar to those from reference locations for all of the COIs except manganese in surface water and sediment. A refined risk analysis considered the spatial extent and magnitude of exposure, a more detailed review of the ESVs for manganese, and a qualitative review of biological data from the study area with respect to manganese. These lines of evidence illustrate that the manganese concentrations in surface water and bulk sediment do not pose an unacceptable ecological risk to receptors adjacent to DMT. In summary, the Step 3a evaluation did not identify any refined COIs. Ancillary sampling conducted in May 2009 was addressed as an uncertainty of the ERA and this evaluation showed that the single detection of Cr(VI) in pore water was most likely related to transient storm water discharge in an isolated area bounded by other locations where Cr(VI) was not detected over space and time.

5.1 Scientific Management Decision Point

The ERA data are sufficient to establish that chromium and other COPR constituents do not pose unacceptable risk to ecological receptors near DMT. The data and conclusions presented in the ERA meet the requirements stipulated in the Consent Decree. No further action is required to assess the environmental impacts of COPR constituents from the Site.

SECTION 6

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Appendix A
Chemical-Specific Fate, Transport, and Ecotoxicological Data Profiles

Chemical-Specific Fate, Transport, and Ecotoxicological Data Profiles

1. Chemical Fate and Transport of COPR Constituents

This section describes the chemical processes that influence the fate, transport, and stability of chromium and other chromite ore processing residue (COPR) constituents in the estuarine environment. Site-specific data from DMT are also provided as applicable.

Aluminum

Aluminum Geochemistry

Aluminum is the most abundant metal and the third most abundant element in the earth's crust and occurs ubiquitously in natural waters as a result of the weathering of aluminum-containing rocks and minerals. Anthropogenic releases are in the form of air emissions, waste water effluents, and solid waste primarily associated with industrial processes, such as aluminum production. The behavior of aluminum in the environment depends upon its coordination chemistry and the characteristics of the local environment, especially pH. The major features of the biogeochemical cycle of aluminum include leaching of aluminum from geochemical formations and soil particulates to aqueous environments, adsorption onto soil or sediment particulates, and wet and dry deposition from the air to land and surface water. Dissolved aluminum concentrations in surface and groundwater vary with pH and the humic acid content of the water. High aluminum concentrations in natural water occur only when the pH is <5; therefore, concentrations in most surface water are very low. Due to toxicity to many aquatic organisms, including fish, aluminum does not bioconcentrate in aquatic organisms to any significant degree; however, some plants have been shown to accumulate high concentrations of aluminum (ATSDR, 2008).

Aluminum partitions between solid and liquid phases by reacting and complexing with water molecules and anions such as chloride, fluoride, sulfate, nitrate, phosphate, and negatively charged functional groups on humic materials and clay. The transport and partitioning of aluminum in the environment is determined by its chemical properties, as well as the characteristics of the environmental matrix that affect its solubility. At a pH >5.5, naturally occurring aluminum compounds exist predominantly in an undissolved form such as gibbsite, $Al(OH)_3$, or as aluminosilicates except in the presence of high amounts of dissolved organic material or fulvic acid, which binds with aluminum and can cause increased dissolved aluminum concentrations in streams and lakes. In general, decreasing pH (acidification) results in increased mobility for monomeric forms of aluminum (ATSDR, 2008).

Fate and Transport of Aluminum at DMT

Dissolved aluminum was not detected in any of the pore water samples collected during the Sediment and Surface Water Study, and was only infrequently detected in surface water

samples at levels just above the detection limit of 80.2 μg/L. The low and non-detected dissolved aluminum concentrations are not unexpected given the pH values measured during the field collections. Measured pH values in the water column ranged from 6.9 to 9.1, and in this range aluminum is expected to be in the form of a relatively insoluble hydroxide or bound to particulates such as clay minerals or organic matter.

Aluminum concentrations in bulk surface sediment ranged from 1,140 to 35,600 mg/kg; sediments with lowest aluminum concentrations were from the A, B, and J transects, which are relatively sandy locations. The highest aluminum concentrations in surface sediment were from the D, E, and F transects, where the sediment contains appreciable amounts of clays.

Calcium and Magnesium

Geochemistry of Calcium and Magnesium

Calcium and magnesium are both prevalent in seawater as they are each one of the six major dissolved salts that comprise salinity. Calcium has an average concentration in seawater of approximately 400 ppm and the average concentration of magnesium in seawater is 1,350 ppm. The two elements make up 1.2 percent and 3.7 percent of the salinity in average seawater (CBP, 2008; Turekian, 1968). Further, the western side of the Chesapeake Bay watershed consists of sandstones, shales, and siltstones, underlain by limestone. The limestone bedrock contributes calcium and magnesium to groundwater and surface water flowing over and through it (NOAA, 2007). Since both elements are highly soluble, are considered macronutrients, and are critical components to the exoskeletons formed by shellfish, a detailed discussion of the fate and transport and nutrient cycling characteristics was not been included at this juncture;. The cycling and fate and transport of these two elements was deferred to Step 3a, with the intention of developing the discussion only if the Site-specific data indicates that these constituents are present in concentrations adjacent to DMT that are significantly greater than at the reference locations.

Fate and Transport of Calcium and Magnesium at DMT

Dissolve calcium concentrations in surface water collected adjacent to DMT ranged from 47,300 to 333,000 μg/L (or 47.3 to 333 ppm). This range of concentrations is lower than that of average seawater (400 ppm Ca) and is not unexpected since the environment surrounding DMT is estuarine and is influenced by the influx of freshwater from the Patapsco River and other creeks surrounding the area. The highest Ca concentration observed in surface water at the reference location in the Patapsco River was 199,000 μg/L. The reason for these measurements is uncertain but could be due to increased flow and influence of freshwater in the central channel of the river. The maximum dissolved calcium concentrations in pore water adjacent to DMT ranged from 19,700 to 233,000 μg/L; the local reference concentration observed was 186,000 μg/L. Concentrations of dissolved calcium in seawater and pore water were generally uniform.

Measured calcium concentrations in bulk sediment ranged from 198 to 139,000 mg/kg; sediments exhibiting the lowest calcium concentrations were those collected at Stations A2, A3, and A4. These three stations are located in the shallow area near the southeast corner of the terminal and the sediment is dominantly sandy. Sediment Ca concentrations along the

shoreline adjacent to the 1501/1602 area were generally high, ranging from 12,900 to 63,500 mg/kg. The highest observed Ca concentration in sediment was at Station H1, which is located in the shipping berth on the northern side of the terminal. This high value was observed during the August 2007 sampling event, the value measured during the May event from the same location was 3,000 mg/kg. The sediment calcium concentrations at Stations H2 and H4 were also greater during the August 2007 sampling than the May 2007 sampling.

All pore water and surface water samples analyzed contained measurable concentrations of dissolved magnesium, ranging from 195,000 µg/L to 645,000 µg/L and 301,000 to 618,000 µg/L, respectively. The magnesium concentrations in the surface water are within the range that would be expected for water characterized as brackish or marine (seawater has an average concentration of approximately 1,350 ppm or ~1,350,000 µg/L). This conclusion is further supported when data from the reference locations are considered; the measured magnesium concentrations in both surface water and pore water adjacent to the Site are similar or lower than those observed at the reference location.

In surface sediments, magnesium concentrations ranged from 378 to 30,200 mg/kg; the highest concentrations of magnesium in bulk sediment were measured in sediments collected along the shoreline of the 1501/1602 areas (Stations C1, C2, J1, J2, and J4) and immediately adjacent to the terminal on Transects D and E (Stations D1 and E1, respectively). The magnesium concentrations in surface sediment at these seven stations were higher than those measured at the reference location.

There is no apparent relationship between the pore water concentrations and the total magnesium concentrations in bulk sediment, which indicates that the magnesium measured in the pore water is likely largely influenced by the composition of the overlying surface waters.

Iron

Iron Geochemistry

Iron (Fe) is the fourth most abundant element in the earth's crust and concentrations in surface waters commonly range between 0.01 and 1.4 ppm (Jorgensen et al., 1991; as cited in Gerhardt, 1994), with occurrence increasing in the presence of humic acids (Gerhardt, 1993). In pure form, iron is highly reactive and corrodes (e.g., oxidizes to rust) in moist air and warm temperatures. Historically, iron has been alloyed with other metals to make it stronger, but malleable, and it is used to produce steel. Therefore, its widespread industrial use has increased levels of environmental contamination. Thus the steel mills once found at Sparrow's Point represent a likely source of iron in the Patapsco River.

Dissolved concentrations in water are dependent upon redox conditions and pH. Iron occurs as elemental iron, iron (II) or iron (III) with speciation from iron (II) to iron (III) tending to occur between pH 4.5 and 7. However, photoreduction from iron (III) to iron (II), and the destabilization of weaker iron complexes may increase toxicity of iron in acidic conditions (Gerhardt, 1994). The most common dissolved inorganic form of iron is iron hydroxide ($Fe(OH)_2^+$) (Dave, 1984). Iron is ubiquitous in the environment, and as an essential nutrient, it is generally not considered a concern.

Fate and Transport of Iron at DMT

Dissolved iron in pore water collected from the transects adjacent to DMT ranged from nondetected to 9,300 μg/L (at location F2); and was generally lowest in shoreline stations around the 1501/1602 area in the southeast corner of the Site, as well as in the stations located along Transect I within Colgate Creek. The highest dissolved Fe concentrations in pore water were measured at sampling locations within the shipping berths adjacent to the terminal, where the surface sediment was generally reducing, regardless of season. The concentrations of dissolved Fe in pore water adjacent to the terminal were similar to, or below those measured at the reference locations in the Patapsco River.

Surface water concentrations of dissolved iron were generally below the analytical detection limits. Dissolved iron was detected in only 15 surface water samples collected during the duration of the of Sediment and Surface Water study, with most of the detected concentrations occurring during the February 2008 sampling event (eleven samples from nine locations). During the May and December sampling events there were two samples from each event which contained detectable levels of dissolved iron; dissolved iron was not detected in the water column adjacent to DMT during the August 2007 event. None of the surface water samples collected from the reference locations contained detectable concentrations of dissolved iron.

Iron concentrations in bulk surface sediment range from 6240 to 57,600 mg/kg; with the lower concentrations generally occurring in the sandier, shallower areas and the highest concentrations typically being measured in samples collected from within the berths adjacent to the terminal. All surface sediment samples collected adjacent to the terminal exhibited lower total iron concentrations than sediment collected from the reference location.

Manganese

Manganese Geochemistry

Manganese makes up about 0.1 percent of the earth's crust and occurs naturally in virtually all soils: concentrations of dissolved manganese in natural waters that are essentially free of anthropogenic sources can range from 10 to >10,000 μg/L. Manganese in its reduced form, Mn(II), is bioavailable and can be readily taken up by benthic fauna and manganese in water may be significantly bioconcentrated at lower trophic levels. The available data indicate that lower organisms such as algae have larger BCFs than higher organisms. Transport and partitioning of manganese in water is controlled by the solubility of the specific chemical form present, which is dominated by the pH, Eh (oxidation-reduction potential), and the characteristics of the available anions. Mn can exist in aqueous solutions in one of four oxidation states. Manganese(II) predominates in most waters (pH 4–7) but may become oxidized at a pH >8 or 9. The principal anion associated with Mn(II) in water is usually carbonate (CO_{3-2}), and the concentration of manganese is limited by the relatively low solubility (65 mg/L) of $MnCO_3$. In relatively oxidized water, the solubility of Mn(II) may be controlled by manganese oxide equilibria, with manganese being converted to the Mn(II) or Mn(IV) oxidation states. In reducing environments, manganese tends to be controlled by formation of a poorly soluble sulfide. The oxidation state of Mn in surface water and sediment may also be influenced by microbial activity (ATSDR, 2000a).

The tendency of soluble manganese compounds to adsorb to soils and sediments depends mainly on the cation exchange capacity and the organic composition of the soil content and the ion exchange capacity of the soil; thus, adsorption may be highly variable. In some cases, adsorption of manganese to soils may not be a readily reversible process. It is generally thought that there are two primary mechanisms that explain the retention of Mn by sediments and soils: cation exchange reactions and adsorption to other oxides via ligand exchange reactions (ATSDR, 2000a).

Fate and Transport of Manganese at DMT

The station-specific maximum manganese concentrations in surface water ranged from 31 to 1,160 μg/L. Dissolved Mn concentrations were lowest along the shoreline of the 1501/1602 area (Transects A, B, C, and J) as well as along Transect I, which is situated within the confluence of Colgate Creek and the Patapsco River. The highest concentrations of Mn in surface water were observed along the berthing areas on the north and south sides of the terminal, with the highest concentrations typically having been observed in deeper portions of the water column. On the southern side of the terminal, the Mn concentrations exhibit a trend of decreasing concentration with increasing distance from the terminal; on both Transects D and E, observed Mn concentrations were comparable to or below the reference concentration of 347 μg/L at the furthest sampling location from DMT.

Measured concentrations of Mn in pore water exhibited a similar trend to that seen in the surface water, however, the range of observed concentrations was much greater, ranging from 43 to 25,600 μg/L. The lowest concentrations of Mn in pore water were observed in the sandy, shoreline area around the 1501/1602 area of DMT. The highest pore water concentrations were observed on the D transect at stations that were positioned within the berthing area. Pore water collected from the reference location contained 24,600 μg/L Mn.

Maximum measured manganese concentrations in surface sediment ranged from 134 to 3,550 mg/kg, with the highest concentrations observed within the berthing area on the southern side of the terminal (station D2). The concentrations in the sandier, shallow areas on the south side of the terminal and along the northern edge of the terminal are generally lower than those measured in the reference area (1,770 mg/kg).

Vanadium

Vanadium Geochemistry

Vanadium and chromium are chemically similar; they are adjacent to each other in the periodic table, and chemists historically referred to vanadium as "pan-chromium." It is likely that vanadium and chromium behavior in the environment will not be significantly different. Historically, vanadium has been used in steel mills as vanadium pentoxide and in cleaning boilers fired by oil containing vanadium (HSDB, 2009).

Transport and partitioning of vanadium in water and soil is influenced by pH, redox potential, and the presence of particulates. If released into water, vanadium is expected to exist primarily in the tetravalent and pentavalent forms. Both species are known to bind strongly to mineral or biogenic surfaces by adsorption or complexing. Although vanadium forms complexes with organic matter, it is generally not incorporated into organic compounds. In fresh water, vanadium generally exists in solution as the vanadyl ion (V^{4+})

under reducing conditions and the vanadate ion (V^{5+}) under oxidizing conditions, or as an integral part of, or adsorbed onto, particulate matter. Both V^{4+} and V^{5+} species bind strongly to mineral including manganese oxide and ferric hydroxide or biogenic surfaces by adsorption or complexing. Sorption and biochemical processes are thought to contribute to the removal of vanadium from sea water. Upon entering the ocean, almost all vanadium is deposited on the sea floor, and only about 0.001 percent of vanadium persists in soluble form (ATSDR, 1992).

Fate and Transport of Vanadium at DMT

Concentrations of dissolved vanadium in pore water ranged from below the detection limits to 11.9 µg/L and those in surface water ranged from below the detection limit to 4.4 µg/L. In both media, the maximum concentrations measured adjacent to DMT were similar to those observed at the reference location.

Vanadium concentrations in surface sediment were generally uniform around DMT, and ranged from 9.7 to 231 mg/kg. The highest concentration was measured at location I3, and Stations A2, A3, and A4 exhibited the lowest concentrations. With the exception of two locations on the I transect (I3 and I4), vanadium concentrations in surface sediment were comparable to, or lower than, the measured reference concentrations.

2. Mechanisms of Toxicity

Chromium

As previously discussed, chromium is most commonly found in either the trivalent or hexavalent oxidation state (HSDB, 2006). Chromium speciation is dependent on geochemical conditions (USEPA, 2005; Rifkin et al., 2004). Cr(III) is relatively insoluble and nontoxic, whereas Cr(VI) is much more soluble and considerably more toxic (USEPA, 1985; ATSDR, 2000b). Cr(VI) is highly reactive and thermodynamically unstable, and is readily reduced to Cr(III) in anaerobic conditions typical of the estuarine environment. Cr(III) has very low solubility at estuarine midrange pH values (6–8) due to the formation of chromium hydroxide $Cr(OH)_3$. The oxidation of Cr(III) to Cr(VI) does not readily occur in natural environments (Barnhart, 1997; NPS, 1997). As such, Cr(III) is very stable and is the dominant form present in the sediments of estuarine environments.

As shown in the species sensitivity distributions shown in Figure A-1, Cr(VI) is more toxic than Cr(III) in aquatic systems. These distributions were derived using data from USEPA's ambient water quality criteria (USEPA, 1985). These graphics indicate that polychaetes and crustaceans are the most sensitive saltwater species, whereas fish and some mollusks are much less sensitive to Cr(VI) (ENVIRON, 2005). In addition, these graphics show that certain freshwater species are much more sensitive to Cr(VI) than are saltwater species. Ambient water quality criteria are available for Cr(VI) in saltwater and both Cr(VI) and Cr(III) in freshwater. Cr(III) is generally nontoxic to aquatic organisms in seawater owing to the limited solubility. Indeed, USEPA has not derived an ambient water quality criterion for Cr(III) in saltwater because of the low solubility. Studies that have attempted to dissolve sufficient Cr(III) in salt water, and even fresh water, were often at pH levels that lacked ecological relevance, and when pH was increased to relevant levels, Cr(III) precipitated out

of solution (Pickering and Henderson, 1966; Rehwoldt et al., 1973; Calabrese et al., 1973; Negilski, 1976; Stevens and Chapman, 1984; Martin and Holdich, 1986).

Cr(VI) is also more toxic than Cr(III) in sediment, and often this is characterized by geochemical conditions or the presence of Cr(VI) in pore water or both. As described by USEPA (2005), the speciation of chromium in sediment can be inferred from the presence or absence of AVS. Cr(VI) converts rapidly to Cr(III) under reducing (or even mildly oxidizing) conditions. Because AVS occurs only under reducing conditions, the presence of AVS indicates a greatly reduced load of Cr(VI) (Ankley, 1996; USEPA, 2005). Further, because Cr(III) is essentially nontoxic in saltwater exposures, the presence of AVS indicates that toxicity due to chromium is unlikely. Indeed, polychaetes (*Neanthes arenaceodentata*) that constructed tubes from and ingested pure chromium hydroxide precipitate exhibited no adverse effects on reproduction, feeding behavior, or survival during a 293-day exposure (Oshida et al., 1976, 1981). This result is particularly notable because the polychaete *Neanthes spp.* is among the most sensitive taxa to Cr(VI) in aqueous saltwater environments, as shown in species sensitivity distributions shown in Figure A-1. Similarly, amphipods that lived in and ingested chromium hydroxide precipitate also showed no adverse effects (Berry et al., 2004).

Similarly, Becker et al. (2006) found no toxicity to amphipods at total chromium sediment concentrations as high as 1,310 mg/kg. Sediment chromium was found to be associated with phases in which chromium has limited bioavailability (i.e., chromite and iron oxide). This observation is consistent with USEPA's (2005) position on chromium, that chromium in sediments is nontoxic where there are measurable amounts of AVS because AVS forms only in anoxic sediments, and Cr(VI) is thermodynamically unstable in these conditions.

USEPA has advocated using geochemical measures and measures of chromium in pore water for an evaluation of potential chromium sediment toxicity because total chromium sediment quality goals (SQGs) do not accurately predict chromium toxicity (USEPA, 2005). Pore water represents the potential worst case of chemical concentrations in overlying water due to limited dilution and flow; as such, the use of pore water compared to water quality criteria is protective of sediment-dwelling organisms and organisms in the water column.

MDE presented an approach consistent with the USEPA in the 2004 study of Baltimore Harbor, where sediment geochemistry, pore water sampling, and sediment toxicity testing results were used to evaluate potential chromium toxicity. The data, according to MDE (2004), indicated that " . . . in situ environmental conditions (i.e., low dissolved oxygen, high biological oxygen demand (BOD) produced sulfide concentrations within the sediments at levels well in excess of what would be needed to convert the Cr present in the Northwest Branch/Inner Harbor and Bear Creek sediments from Cr VI to Cr III and render it unavailable.… As a result, the sediment chemistry present in the Northwest Branch/Inner Harbor and Bear Creek creates an environment where chromium cannot be determined as the specific cause of the observed toxicity."

Calcium

There is no readily available information regarding the mechanism of toxicity for calcium. Calcium is an essential macronutrient to many organisms. Calcium is not considered toxic in any of the media evaluated as part of this risk assessment. Furthermore, calcium is one of

the major elements comprising salinity in seawater and is expected to be present in the media evaluated.

Iron

Studies have shown that acute toxicity values for freshwater fish and invertebrates following iron exposure range from 0.3 to 2.0 mg/L (Dave, 1984). Survival of brown trout alevin (swim-up fry) and eyed-eggs was reduced at an average iron concentration of 5.170 mg/L (Geertz-Hansen and Mortensen, 1983). Common carp (*Cyprinus carpio*) and guppy exposed to iron (as iron ammonium alum) resulted in LC_{50} values of 1,200 and 1,125 mg/L, respectively (Yarzhombek et al., 1991).

Mullick and Konar (1991) found the 48 hour LC_{50} value of copepod (*Diaptomus forbesi*) to be 86.5 mg/L iron (as iron sulfate). After 30 days of exposure to 10, 20 or 50 mg/L iron (as $FeSO_4$ at pH 4.5), mayfly (*Leptophlebia marginata*) exhibited decreased activity and food consumption at all concentrations (pH 4.5) (Gerhardt, 1992). Uptake of and survival to iron was dose-dependent in mayflys (*Leptophlebia marginata L.*) when exposed to 10–500 mg/L iron. The pH had little effect on the rate of uptake, but played an important role in survivability of the mayfly to iron exposure. The 96-hour LC_{50} values obtained during this study were 106.3 and 89.5 mg/L at pH 7 and 4.5, respectively. The EC_{50} values (escape behavior) were 70 and 63.9 mg/L at pH 7 and 4.5, respectively (Gerhardt, 1994). Reproduction of Daphnia magna was stimulated at concentrations up to 0.001 mg/L, and reproduction and survival were inhibited by iron at 0.158 mg/L and 0.256 mg/L, respectively (Dave, 1984). This is considerably lower than the 4.380 mg/L concentration causing 16 percent reproductive decrement in a 3-week test with Daphnia magna (Biesinger and Christensen, 1972). Dave argued that his result was more applicable to a situation in which "an acidic iron-containing waste water is discharged into a lake or a river" where it is neutralized, but Biesinger and Christensen's (1972) result "is probably more close to the steady-state situation in natural freshwater without any point source of iron."

The National Oceanic and Atmospheric Administration (NOAA) identifies a "severe" effects level for iron of 4 percent for freshwater sediment (Buchman, 2008). In addition, the screening ecological benchmark for iron in sediments is the lowest effects level, or LEL of 20,000 mg/kg (Persaud et al., 1993) and that for surface water is the national recommended ambient water quality criteria of 1 mg/L.

Magnesium

It is normally found in seawater and few published studies exist concerning the ecotoxicity of magnesium in aquatic environments. As essential nutrients, calcium and magnesium are generally not considered to be toxic to aquatic life. However, concentrations of these metals in the water can affect water quality parameters that may increase or decrease the toxicity of other metals. For example, increased calcium hardness reduced the toxicity of copper to channel catfish (Perschbacher and Wurts, 1999).

Manganese

Acute exposure to manganese is not considered to be a severe threat to fish, and the range of 96-hour LC_{50} values is much higher than concentrations typically found in surface waters. Some acute toxicity values range from a 96-hour LC_{50} value of 3,230.0 mg/L for the tropical

perch *(Colisa fasciatus)* (Nath and Kumar, 1987) to a 48-hour EC_{50} value of 9.8 mg/L for *D. magna* (Biesinger and Christensen, 1972).

Acute toxicity tests using fathead minnows and *Daphnia magna* were conducted in relatively hard water. Acute toxicity values for manganese ranged from 19.4 mg/L for *D. magna* to 33.80 mg/L for fathead minnow (Kimball, 1978). Manganese toxicity was increased by the presence of food during the *D. magna* acute toxicity tests. Biesinger and Christensen (1972) reported an LC_{50} value of 9.80 mg/L for *D. magna* without food added. In addition, there was an EC_{50} value for *D. magna* (reproductive impairment) of 5.2 mg/L and a 3-week LC_{50} value of 5.7 mg/L. The chronic toxicity value (3 weeks) of 4.10 mg/L resulted in 16 percent reproductive impairment for *D. magna*.

After a 30-day exposure to 0.36 and 1.08 mg/L manganese, brown trout showed a decreased body calcium concentration and impaired development (Reader et al., 1988). The chronic toxicity value resulting from this study was 0.21 mg/L manganese. The ecological screening benchmarks for manganese in surface waters and sediments (lowest effects level, or LEL) are 0.120 mg/L (EPA Region 3 recommended value) and 460 mg/kg (Persaud et al., 1993), respectively. Furthermore, body residues of manganese in benthic macroinvertebrates are correlated to the concentration of the metal in the surficial sediments (Bendell-Young and Harvey, 1986).

Vanadium

Following 96 hours, goldfish *(Carassius auratus)* retained 0.05 percent of a 0.05 mg/L vanadium (as NH_4VO_3) exposure concentration in their intestines (Edel and Sabbioni, 1993). The significant presence of vanadium in the intestine suggests that it might be secreted with urine. Furthermore, the liver, gill, heart and kidney also retained significant amounts of vanadium. Ray et al. (1990) found similar accumulation target organs in the catfish *(Clarias batrachus*). However, after a 96-hour exposure to 5 to 15 mg/L vanadium, retention was highest in the kidney, followed by the liver, gill, and intestine. Acute toxicity endpoints range from 16.5 mg/L (LC_{50} value) for the Chinook salmon *(Oncorhynchus tshawytscha)* to 1.52 (48-hour EC_{50} value) for *Daphnia magna* (Suter and Tsao, 1996). Knudtson (1979) compared the acute toxicity of four vanadium compounds to guppies *(Lebistes reticulatus)* and goldfish *(Carassius auratus)*. The guppy was most tolerant to vanadium as NH_4VO_3, yielding a 144-hour LC_{50} value of 1.49 mg/L. *L. reticulatus* was most sensitive to vanadium as $VOSO_4$ with a 144-hour LC_{50} value of 0.37 mg/L. The goldfish was most tolerant to vanadium as V_2O_5 with a 144 hour LC_{50} value of 8.08 mg/L, and most sensitive to vanadium as $NaVO_3$ with a 144-hour LC_{50} value of 2.45 mg/L.

Daphnia magna yielded a lethal chronic toxicity value of 1.9 mg/L vanadium as sodium metavanadate following a 23-day exposure (Beusen and Neven, 1987).

The screening ecological benchmark for vanadium in surface water is the Tier 2 Secondary Chronic Value of 0.020 mg/L from Suter and Tsao (1996).

3. Food Chain Exposure and Bioaccumulation Potential

Chromium

Cr(III) is an essential nutrient for biological organisms; however, chromium does not biomagnify in the food web. Flora and fauna have natural mechanisms to regulate uptake and elimination of Cr(III). Specifically, Cr(III) plays a role in sugar and protein metabolism (Eisler, 1986; Newman, 1998; NPS, 1997). As a result of bioregulation, the extent to which Cr(III) is accumulated is expected to be concentration dependent. That is, the ratio of chromium in tissue to bioavailable chromium in environmental media will be highest when bioavailable chromium is scarce and lowest when bioavailable chromium is relatively abundant.

Like many other metals, chromium exhibits biodiminution (decreasing concentration at higher trophic levels) through the food web. Eisler (1986) indicated the following:

> ….Although chromium is abundant in primary producers, there is little evidence of biomagnification through marine food chains consisting of herbivores and carnivores. [Previous researchers] followed the transfer of assimilated and unassimilated radiochromium through an experimental food chain that included phytoplankton, brine shrimp, post larval fish, and adult fish. When chromium was successively transferred through each of the four trophic levels, concentrations declined after each transfer.

A study more directly related to DMT is of chromium bioaccumulation from sediment assessed for a wetland site along the Hackensack River surrounded by COPR (Hall and Pulliam, 1995). Researchers found that metals (including chromium) were detected at concentrations nine times greater in the COPR-influenced wetland study site than in a reference site. They also found no statistically significant differences between sample concentrations of total chromium collected from the area of interest and reference sites for blue crab (*Callinectes sapidus*) muscle tissue, whole-body killifish (*Fundulus sp.*), or giant reed tissue (*Phragmites spp.*). Although there was a statistically significant difference seen in chromium in blue crab hepatopancreas organ tissues between the investigation area and the reference site (Hall and Pulliam, 1995), researchers indicated that this was likely due to foraging strategies of crabs and the role of their hepatopancreas. Crabs ingest sediments while gleaning food and the hepatopancreas's function is to filter foreign materials from the blood. Researchers concluded that the lack of statistically significant differences in total chromium concentrations in the muscle tissue samples provides evidence of total chromium's tight binding to the study site sediments and low bioavailability (Hall and Pulliam, 1995). These results are also consistent with the bioregulation of chromium as an essential nutrient.

As has been discussed, Cr exists as Cr(III) and Cr(VI). There is abundant evidence that unlike Cr(III), Cr(VI) does not persist in biological tissues (IRIS, 2003; ATSDR, 2000b; NPS, 1997). Cr(VI) is rapidly taken up by cells through the sulfate transport system and is quickly reduced to Cr(III) in all tissues (IRIS, 2003, NPS, 1997; ATSDR, 2000b). There is no evidence that Cr(III) is converted to Cr(VI) in biological systems (IRIS, 2003). Thus, Cr(VI) exerts toxicity through direct contact mechanisms rather than bioaccumulation to a critical concentration in tissue.

These studies (IRIS, 2003, NPS, 1997; ATSDR, 2000b) and general information from scientific literature indicate that prey consumption by aquatic-feeding wildlife is not a major exposure pathway for either Cr(III) or Cr(VI).

Aluminum

Aluminum is not bioaccumulated to a large degree (BCF < 300) in most fish and shellfish. Brook trout have been shown to accumulate slightly more aluminum (measured as whole-body residues) at pH 5.6-5.7 than at pH 6.5-6.6 (Cleveland et al., 1989). The estimated steady-state BCF values for aluminum in brook trout, (which were inversely related to pH), were 215 at pH 5.3, 123 at pH 6.1, and 36 at pH 7.2 (Cleveland et al., 1989). The maximum BCFs were 232 at pH 5.3, 153 at pH 6.1, and 46 at pH 7.2 (Cleveland et al., 1989). When transferred to water of the same pH without added aluminum, brook trout eliminated aluminum from tissues more rapidly at pH 5.3 than at pH 6.1 and 7.2 (Cleveland et al., 1989). In tissues of smallmouth bass, aluminum concentrations were higher and more variable in gill tissue than in other tissues (Brumbaugh and Kane, 1985). Aluminum concentrations in rainbow trout from an alum treated lake, an untreated lake, and a hatchery were highest in gill tissue and lowest in muscle (Buergel and Soltero, 1983). Aluminum residue analyses in brook trout have shown that whole-body aluminum content decreases as the fish advance from larvae to juveniles (Cleveland et al., 1989). These result simply that the aging larvae begin to decrease their rate of aluminum uptake, to eliminate aluminum at a rate that exceeds uptake, or to maintain approximately the same amount of aluminum while the body mass increases. The decline in whole-body aluminum residues in juvenile brook trout may be related to growth and dilution by edible muscle tissue that accumulated less aluminum than did the other tissues (Cleveland et al., 1989). Concentrations of aluminum in whole-body tissue of the Atlantic salmon exposed to high concentrations of aluminum ranging from 3 µg/g (for fish exposed to 33 µg/L) to 96 µg/g (for fish exposed to 264 µg/L) at pH 5.5 (Buckler et al., 1995). After 60 days of exposure, BCFs ranged from 76 to 190 and were directly related to the aluminum exposure concentrations (Buckler et al., 1995).

Bioconcentration of aluminum has also been reported for aquatic insects. Aluminum accumulation in mayfly nymphs (*Heptagenia sulphureu*) was reported at pH 4.5 (Frick and Herrmann, 1990). The nymphs were exposed at two concentrations (0.2 and 2 mg inorganic aluminum per liter) and for two exposure times (2 and 4 weeks), the longer time period including a molting phase (Frick and Herrmann, 1990). When nymphs were exposed to the higher concentration of aluminum for two instar periods, with a molt in between, the aluminum content (2.34 mg Al/g dry weight) nearly doubled compared with that of a one-instar treatment (1.24 mg Al/g dry weight) (Frick and Herrmann, 1990). The major part of the aluminum was deposited in the exuviae of the nymphs, as the aluminum determination in the nymphs showed a 70 percent decrease in aluminum content after molting (Frick and Herrmann, 1990).

As previously indicated, the behavior of aluminum in the environment depends upon its coordination chemistry and the characteristics of the local environment, especially pH. Specifically, high aluminum concentrations in natural water occur only when the pH is <5; therefore, concentrations in most surface water are very low. The bioconcentration of aluminum in fish is dependent on pH, as well as total organic carbon (ATSDR, 2008).

Several studies reported in ATSDR (2008) have shown an inverse relationship with pH and bioconcentration factors (i.e., bioconcentration increases with decreasing pH). This is not surprising given that higher concentrations of dissolved (and therefore more bioavailable) aluminum are expected as waters become more acidic. Because aluminum is toxic to many aquatic organisms, including fish, aluminum does not tend to bioconcentrate in aquatic organisms to any significant degree. However, some plants and aquatic invertebrates have been shown to accumulate high concentrations of aluminum (ATSDR, 2008). One study in Sweden reported impaired breeding of pied flycatchers (*Ficedula hypoleuca*) related to levels of aluminum in the bone marrow of the birds. The author suggests that aluminum accumulation in stoneflies provided the food chain link between aluminum in a lake and this terrestrial bird species. This information suggests that aluminum may bioaccumulate in to some degree, though this bioaccumulation is most likely at low pH values (less than 5). Since pH values in surface water, sediment, and pore water surrounding DMT are not at these low levels, indicate that prey consumption by aquatic-feeding wildlife is not a major exposure pathway for aluminum.

Calcium and Magnesium

Calcium is an essential element and is present in living organisms as a constituent of bones, teeth, shell and coral (Peterson, 1992). Calcium accounts for approximately 2 percent of body weight with the mineral in bones and teeth being mostly hydroxyapatite (Peterson, 1992). The bioaccumulation of calcium in organisms is highly dependent on its availability for uptake by the organisms (Janssen et al., 1997). Chemical properties which would affect the availability of calcium uptake include pH, ionic strength and concentration of other solutes in the aqueous media. Sulfates and phosphates in solution will tend to precipitate calcium from solution (Lide, 1998) and make it less available for bioaccumulation. Magnesium is an essential element and widespread in living cells (Aikawa, 1991) and does not bioconcentrate in aquatic organisms.

Calcium and magnesium are both prevalent in seawater. Additionally, both elements are highly soluble, are considered macronutrients, and are critical components to the exoskeletons formed by shellfish. Unlike other metals that may bioaccumulate in marine invertebrates via passive processes, cellular mechanisms that regulate the uptake and elimination of calcium and magnesium exist in marine invertebrates, as well as other marine plants and animals (Rainbow, 1990). Therefore, these constituents generally do not accumulate to toxic levels, and are unlikely to be a concern for food chain exposures.

Iron, Manganese, and Vanadium

Iron, manganese, and vanadium are among several naturally occurring metals that are considered essential nutrients for marine biota. As such, aquatic organisms have developed mechanisms for the sequestration, transport, and utilization of these metals, and have a general capacity for metal tolerance (Langston, 1990). However, there is a threshold at which these systems are overloaded and toxic effects can occur.

Manganese in its reduced form, Mn(II), is bioavailable and can be readily taken up by benthic fauna and manganese in water may be significantly bioconcentrated at lower trophic levels. The available data indicate that lower organisms such as algae have larger BCFs than higher organisms. In contrast to water, manganese may adsorb to sediments, but

this is dependent on the cation exchange capacity and the organic composition of the sediments. Some have found that low concentrations of manganese may be "fixed" by clays and are not readily released into solution. However, at high concentrations, manganese may be desorbed by ion exchange mechanisms with other ions and in solution. Therefore, uptake of manganese into the food chain either from water or sediment (at high concentrations) is a complete exposure pathway.

Bioconcentration data for all of these inorganics is uncertain. Bioconcentration factors found in the EPA's ECOTOX database range from less than 10 to several thousand for all three inorganics for a few categories of organisms including moss and algae, crustaceans, fish, and worms. However, there is not a substantial amount of published data available for any compound within these categories. The studies that have been completed may not necessarily be for species found near the DMT or for similar environmental conditions (e.g., TOC, pH, salinity, redox, AVS). Thus the ability to use this information to determine potential uptake and the need to complete a quantitative assessment of exposure to wildlife is uncertain. Although, marine plants and invertebrates contain higher levels of vanadium than terrestrial plants and animals, no data are available regarding biomagnification of vanadium within the food chain. However, vanadium in terrestrial vertebrates is very low and human studies suggest that biomagnification is unlikely (ATSDR, 1992). Thus the general information from scientific literature indicates that prey consumption by aquatic-feeding wildlife is not a major exposure pathway for vanadium. Similar conclusions can be drawn for iron and manganese. Given the uncertainty of biomagnifications and the fact that most if not all upper trophic level wildlife likely foraging near DMT receives only a small portion of their diet from the Site, exposure dose modeling will not be completed.

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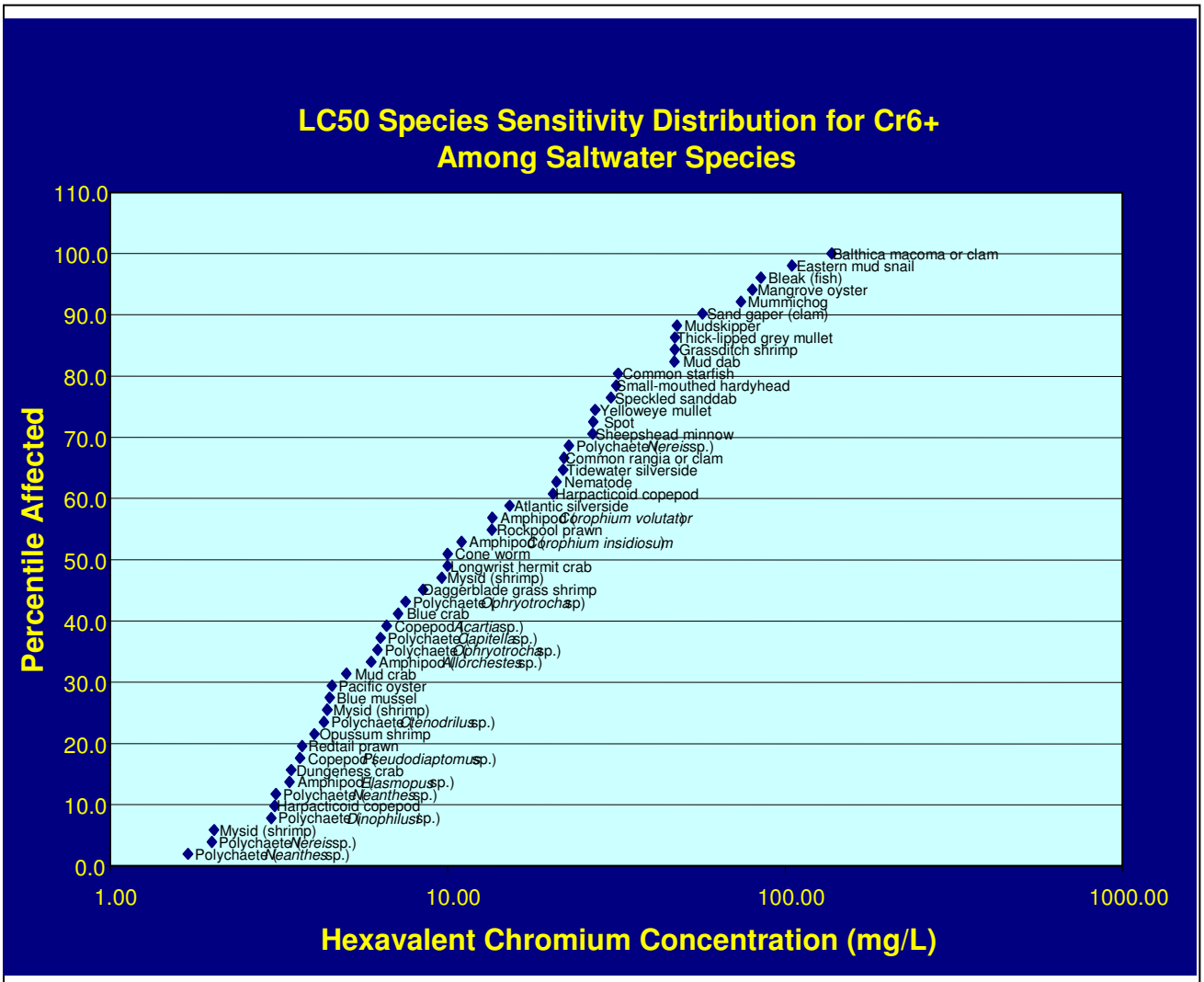

FIGURE A-1

Honeywell

Dundalk Marine Terminal

Species-specific Toxicity Sensitivity Distributions to Hexavalent Chromium

CH2MHILL ENVIRON

Appendix B
Qualitative Benthos Analysis

Qualitative Benthos Analysis

Executive Summary

An informal, qualitative analysis of the benthos in the Patapsco River and Colgate Creek adjacent to the Dundalk Marine Terminal (hereafter referred to as DMT, or the Site) was performed during the May 2007 field effort, and again in June 2008, to observe the organisms present and determine whether the organisms observed represented a freshwater or saltwater community. A detailed description and photographs of biological assemblages observed at DMT are provided below.

Polychaetes, amphipods, clams, and arthropods were observed in sediments from DMT in May 2007, with differences in community composition dependent upon the sediment habitat. The dominant organisms found in June 2008 were amphipods and small crabs; however, sampling also yielded isopods, barnacles, mussels, pipefish, mysid shrimp, and worms (polychaetes and oligochaetes). Although many of the organisms observed can tolerate freshwater, they are more typical of estuarine species assemblages. Additionally, the salinity data for the area indicates that the salinity regime is polyhaline/mesohaline, which would exclude the vast majority of freshwater organisms.

1. Introduction

An informal, qualitative analysis of the benthos at the Site was performed in order to observe the organisms present. The purpose of this analysis was twofold:

- To help decide if marine or freshwater regulatory criteria are more appropriate for DMT
- To evaluate what benthos are present in the area to guide potential future benthic community assessment

2. Methods

During the May 2007 sampling effort, a certified ecologist and Ph.D. in Marine Biology with a technical and academic background in marine science and benthic ecology assisted with sediment sampling. During this time she recorded observations of the benthic organisms from the H and I transects on the northwest side of DMT. As a grab sample of sediment was brought onto the boat, a few readily observable organisms were removed by hand (if possible), stored live in water from the Site, and then photographed.

Additionally, approximately 2 L of sediment from location B-4 on the southeast side of DMT was inspected for benthic organisms. The sediment was frozen on-Site, shipped on ice, and slowly defrosted. Organisms were retrieved by gently sieving the sediment through a 500-µm net using Instant Ocean artificial seawater at approximately 10 parts per thousand (ppt) salinity. Organisms were photographed, and stored in 70 percent ethyl alcohol at 4°C.

In June of 2008, a qualitative biological analysis was conducted at DMT to provide descriptions of biological assemblages at the southeast side of the site. This type of analysis had not previously been conducted on transect J. Analysis was specifically conducted at location J4 because this location had the highest detected concentration of total chromium in surficial sediment (0–1.0 foot) at DMT. Total chromium was detected at a concentration of 2,360 mg/kg in the sediment at a depth of 0–0.5 foot, and was detected at a concentration of 8,140 mg/kg in the sediment at a depth of 0.5–1.0 foot.

Samples were collected using a D-frame net with a 500-µm mesh to observe the benthic organisms present at location J4. Upon collection of the samples, organisms were sorted, identified, and counted in order to make a qualitative assessment of diversity and abundance.

3. Results

Sediments from the H and I transects were visually similar, and indicative of a low-energy depositional environment. These sediments consisted of soft clay and silt mud, with a trace of sand, and perhaps 2–10 percent shell marl and gravel. Based on visual observations of the sediment, the sediment was generally anoxic below 2 cm in depth. Sediment from the B transect was typical of a higher-energy environment than the H and I transect, and is apparently not a depositional environment. Sediment from the B transect consisted of medium sand, with perhaps 5–15 percent shell marl.

Measured salinity ranged from 5 to 13 ppt and indicates that both areas are mesohaline. This is in agreement with the Maryland Department of Natural Resources (MDNR) monthly monitoring data that indicates that salinity in the area generally ranges from 5 to 18 ppt (MDNR, 2007).

The most abundant organisms observed in the sediment from the H and I transects were large polychaetes. The polychaetes observed were typically large 2- to 7-cm predatory polychaetes that were visually similar to nereid polychaetes typical in this type of clayey sediment. A few small amphipods were also noted. Also, small polychaetes (1 millimeter or less in width) were visible in the sediment, particularly within 2 cm of the sediment surface, but were not recovered. These small polychaetes were occasionally locally abundant, but were not visible in every sample, and may have a patchy distribution in the area.

There were a variety of organisms observed in the sediment from the B transect, but no one type of organism dominated the observed community. Clams, polychaetes, amphipods, and a few other arthropods were recovered from the samples. The clams recovered were small—the largest was no more than 2 cm in its largest dimension. The few polychaetes observed were much smaller than the ones observed in the H and I transects, and were generally less than 2 cm long. Amphipods observed were generally 3 to 5 mm long. A small variety of other arthropods were also observed, but were not identified. They were generally vermiform, armored taxa that may have been cumaceans or small stomatopods.

In June of 2008, a qualitative biological analysis was conducted at DMT to provide descriptions of biological assemblages at the southeast side of the site, specifically location J4. Sediment at location J4 consisted of medium sand and some shell marl, which are typical of a higher-energy environment. The dominant organisms found within the first few inches

of the sediment were amphipods and small crabs (approximately 1–2 cm long). Other organisms found at J4 were isopods, barnacles, mussels, pipefish, mysid shrimp, and worms (polychaetes and oligochaetes).

4. Conclusions

Organisms observed in the sediments near DMT are more typical of estuarine or marine organisms than they were of freshwater organisms. Although many of these organisms can tolerate freshwater, they are more typical of estuarine species assemblages. Additionally, the salinity data for the area indicates that the salinity regime is polyhaline/mesohaline and would exclude many freshwater organisms.

This qualitative analysis indicates that there are at least two types of benthic communities in the area, which is likely predicated by the two very different types of bottom sediment. The clayey mud on the northwest side of DMT most likely supports a community of soft-bodied polychaetes that are probably a mix of deposit feeders, suspension feeders, detritivores, and large carnivores. Nearly all polychaetes (in terms of the number of species) are marine organisms, but some are polyhaline or freshwater (Brusca and Brusca, 1990). There are probably various smaller crustaceans, including amphipods, associated with this community, as well as other worms (including oligochaetes).

The sandy bottom on the southeast side of DMT most likely supports a community of armored organisms that burrow within the sand as a refuge from fish predation and wave energy. Clams and other suspension feeders may survive well here as the increase in water velocity renews the supply of labile allochthonous detritus in the water column. Other organisms in this community are likely types that specialize in burrowing in the sandy sediment. This may include amphipods, isopods, copepods, and other armored arthropods that either deposit feeders or predators.

A qualitative biological analysis was conducted in June 2008 at DMT to provide descriptions of biological assemblages at location J4. Analysis was specifically conducted at this location because the highest detected total chromium concentration in surficial sediment occurred at J4. Sediment type and benthic community found at location J4 in June 2008 are consistent with the findings across the DMT site (CH2M HILL and ENVIRON, 2009). The types of organisms at the site are indicative of the health of the biological community. As mentioned in Section 3, amphipods and polychaetes were among the organisms found at J4. Amphipods are commonly used test organisms in laboratory toxicity assays due to their sensitivity to several chemicals and polychaetes have been shown to be particularly sensitive to hexavalent chromium [Cr(VI)].

An evaluation of the data used by USEPA to derive the NRWQC show that species are not equally sensitive to chemicals, particularly chromium (USEPA, 1985). The acute sensitivity of saltwater species to Cr(VI) spans two orders of magnitude. Polychaetes and crustaceans (like the ones described at the site) are the most sensitive species, while fish and certain mollusks are relatively insensitive to Cr(VI) (USEPA, 1985).

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Figure B-1

Typical Sediment from H and I Transects

Honeywell

DUNDALK MARINE TERMINAL
MARYLAND

ENVIRON

CH2MHILL

Figure B-2

Honeywell DUNDALK MARINE TERMINAL MARYLAND

Live Polychaetes from H & I Transects

ENVIRON CH2MHILL

Figure B-3

Honeywell DUNDALK MARINE TERMINAL MARYLAND

Sediment Typical of the Southeast Side of DMT

ENVIRON CH2MHILL

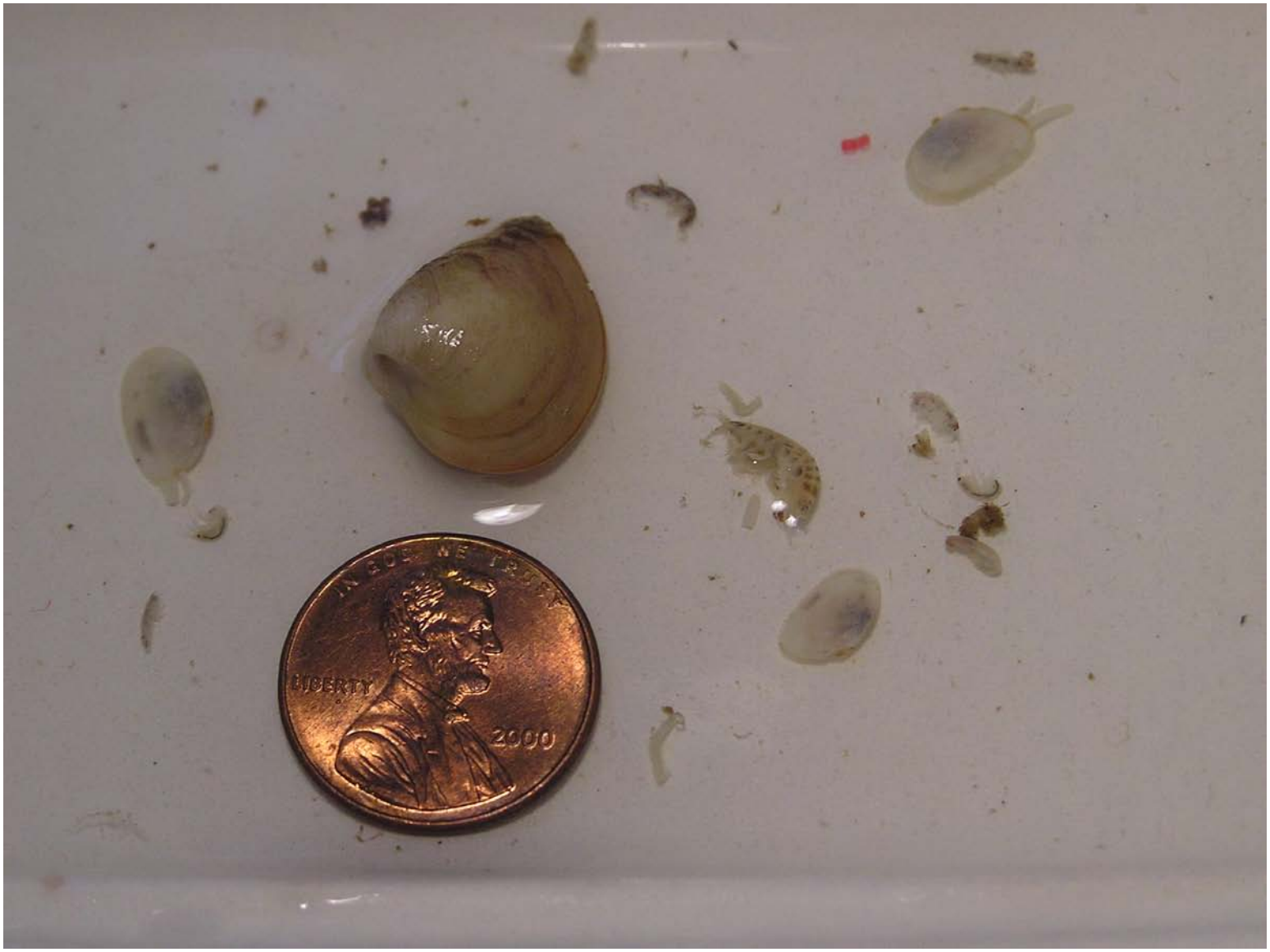

Figure B-4

Organisms Collected from Location B-4

Honeywell

DUNDALK MARINE TERMINAL
MARYLAND

ENVIRON

CH2MHILL

Appendix C
Pore Water, Surface Water, and Sediment Sampling Results

Appendix C-1a
Data from Pore Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Chromium, dissolved µg/L		Hexavalent Chromium µg/L		Aluminum, dissolved µg/L		Calcium, dissolved mg/L		Iron, dissolved µg/L		Magnesium, dissolved mg/L		Manganese, dissolved µg/L		Vanadium, dissolved µg/L		Chromium µg/L		Aluminum µg/L		Calcium mg/L		Iron µg/L	
Transect A	A1	Q1	2.3	U	5	U	80.2	U	76		52.2	U	167		1420		3.8	J	162		162		81.3		9460	
		Q2	2.3	U	5	U	80.2	U	159		69.5	J	485		1090		5.2		77.6		1420		155		4100	
		Q3	2.3	U	5	U	80.2	U	158		52.2	U	453		728		1.9	J	207	L	4490		170		10500	
		Q4	2.3	U	5	U	80.2	U	121		52.2	U	296		735		2.6	J	68		2,540		119		5,190	
	A2	Q1	2.3	U	5	U	80.2	U	81.4		52.2	U	218		498		1.5	U	19		19		88.2		827	
		Q2	NV		NV		NV		NV		NV		NV		NV		NV		NV		NV		NV		NV	
		Q3	4.3	J	5	U	80.2	U	120		52.2	U	307		21.9		1.5	U	2,630		61900		131		169000	
		Q4	2.3	U	5	U	80.2	U	139		52.2	U	332		513		1.5	U	5	J	80.2	U	136		245	
	A3	Q1	2.3	U	5	U	80.2	U	82.3		52.2	U	214		239		1.5	U	33.3		33.3		89.9		3680	
		Q2	NV		NV		NV		NV		NV		NV		NV		NV		NV		NV		NV		NV	
		Q3	3.1	J	5	U	80.2	U	123		52.2	U	314		20.8		1.5	U	2.3	U	80.2	U	119		52.2	U
		Q4	2.9	J	5	U	80.2	U	138		54.4	J	324		55.2		1.7	J	32	L	1,480		135		5,590	
	A4	Q1	NV		NV		NV		NV		NV		NV		NV		NV		NV		NV		NV		NV	
		Q2	NV		NV		NV		NV		NV		NV		NV		NV		NV		NV		NV		NV	
		Q3	3.2	J	5	U	80.2	U	122		52.2	U	311		449		1.5	U	509		19500		128		47700	
		Q4	2.3	U	5	U	80.2	U	132		52.2	U	313		44.8		1.5	U	56.7	L	2,360		136		5,710	
Transect B	B1	Q1	2.3	U	5	U	80.2	U	94		52.2	U	207		2860		2.3	J	9.1	J	9.1	J	94.1		671	
		Q2	3.5	J	5	U	80.2	U	156		508		457		1900		3.4	J	44.7		1040		154		4690	
		Q3	2.3	U	5	U	80.2	U	182		75.4	J	488		2420		1.5	U	50.9		2750		151		4410	
		Q4	2.3	U	5	U	80.2	U	91.3		52.2	U	229		1,120		1.7	J	42.9		3,420		93.6		3,500	
	B2	Q1	2.3	U	5	U	80.2	U	87.8		52.2	U	221		1070		1.5	U	13.2	J	13.2	J	91.4		1120	
		Q2	2.3	U	5	U	80.2	U	144		52.2	U	385		2540		8.5		8.7	J	1020		150		2080	
		Q3	2.3	U	5	U	80.2	U	192		135	J	511		3440		1.5	U	74.1		4700		166		7020	
		Q4	2.3	U	5	U	80.2	U	105		65.1	J	256		974		1.5	U	52		3,640		107		4,670	
	B3	Q1	2.3	U	5	U	80.2	U	83.8		637		196		2460		1.5	U	5.6	J	5.6	J	88.3		2810	
		Q2	2.3	U	5	U	80.2	U	150		715		421		3330		2.8	J	4.5	J	104	J	149		4080	
		Q3	2.3	J	5	U	80.2	U	171		507		496		3350		1.5	U	19.1		651		134		4130	
		Q4	2.3	U	5	U	80.2	U	141		3,320		341		3,060		2.4	J	11.6	J	233		139		4,540	
	B4	Q1	2.3*	U	5	U	80.2	U	81.8		692		194		2150		1.8	J	6.2	J	6.2	J	87.6		4120	
		Q1-Dup	5	J	5*	U	86.8	J	86.1		549		204		2230		2.9	J	5.8*	J	5.8	J	85.6		3340	
		Q2	2.3	U	5	U	80.2	U	141		1330		406		2530		2.6	J	10.9	J	284		149		6600	
		Q3	2.3	U	5	U	80.2	U	168		874		467		2630		1.5	U	10	J	725		159		4200	
		Q4	2.3	U	5	U	80.2	U	138		3,430		383		2,590		1.8	J	17.9		1,230		139		6,070	
	B5	Q4	2.3	U	5	U	80.2	U	128		52.2	U	334		492		2.3	J	46.8		4,330		136		6,230	

Appendix C-1a
Data from Pore Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Chromium, dissolved µg/L		Hexavalent Chromium µg/L		Aluminum, dissolved µg/L		Calcium, dissolved mg/L		Iron, dissolved µg/L		Magnesium, dissolved mg/L		Manganese, dissolved µg/L		Vanadium, dissolved µg/L		Chromium µg/L		Aluminum µg/L		Calcium mg/L		Iron µg/L	
Transect C	C1	Q1	2.3	U	5	U	80.2	U	80.7		52.2	U	169		110		6.3		21.6		21.6		80.6		345	
		Q2	2.3	U	5	U	80.2	U	134		52.2	U	344		557		2.8	J	38.6		404		128		995	
		Q3	2.3	U	5	U	80.2	U	165		84.3	J	453		743		3.4	J	222		3240		174		6700	
		Q4	2.3	U	5	U	80.2	U	122		52.2	U	271		509		1.5	U	149		970		123		2,340	
	C2	Q1	2.3	U	5	U	80.2	U	82.1		52.2	U	171		1150		4.8	J	26.7		26.7		82.5		886	
		Q2	2.3	U	5	U	80.2	U	146		52.2	U	393		1320		4.8	J	331		3620		147		8900	
		Q3	2.3	U	5	U	80.2	U	172		109	J	469		1620		1.5	U	520		11400		165		18500	
		Q4	2.4	J	5	U	80.2	U	113		52.2	U	233		291		3.8	J	632		13,300		119		27,600	
	C3	Q1	2.3	U	5	U	80.2	U	91.4		538		181		2550		2.2	J	17.2		17.2		93.1		2630	
		Q2	2.3	U	5	U	80.2	U	149		742		402		3130		3.1	J	22		519		146		2750	
		Q3	3.4	J	5	U	80.2	U	166		86.9	J	465		2770		1.6	J	53.5		1120		167		4240	
		Q4	2.3	U	5	U	80.2	U	131		533		316		1,950		2	J	37.5		728		128		3,180	
	C4	Q1	2.3	U	5	U	80.2	U	89.7		230		183		2490		4	J	5.3	J	5.3	J	93.2		2260	
		Q2	2.3	U	5	U	80.2	U	162		1620		435		4400		3.3	J	9.5	J	596		153		4710	
		Q2-Dup	2.3*	U	5*	U	80.2	U	155		902		417		3510		3	J	2.3*	U	177	J	154		2590	
		Q3	3.8	J	5	U	80.2	U	170		1410		488		3590		1.5	U	11.5	J	278		159		4800	
		Q4	2.3	U	5	U	80.2	U	143		1,150		351		3,600		1.7	J	6.7	J	498		150		3,100	
Transect D	D1	Q1	3.3	J	5	U	80.2	U	124		76.2	J	476		3320		8.4		6.1	J	6.1	J	128		770	
		Q2	11	J	5	U	80.2	U	153		191	J	645		7210		9		13	J	318		143		1850	
		Q3	11.7	J	5	U	80.2	U	143		161	J	645		6030		6		13.6	J	271		147		1750	
		Q4	4.3	J	5	U	80.2	U	76		62.4	J	478*		763		3.2*	J	8.2*	J	672*		76.9*		692*	
		Q4-Dup	2.3*	U	5*	U	80.2*	U	75.9*		52.2*	U	527		665*		3.6	J	8.7	J	739		78.8		857	
	D2	Q1	3.3	J	5	U	80.2	U	170		89.6	J	452		9430		6.5		11.1	J	11.1	J	154		6550	
		Q2	16.2	J	5	U	80.2	U	208		6830		528		25600		4.4	J	13.4	J	245		197		19800	
		Q3	9	J	5	U	80.2	U	175		4080		507		20500		1.5	U	23.7		342		184		12200	
		Q4	4.4	J	5	U	80.2	U	191		2,480		506		8,520		5		10.7	J	835		193		7,380	
	D3	Q1	8.5	J	5	U	80.2	U	142		417		438		8310		4.1	J	11.4	J	11.4	J	163		3890	
		Q2	12.4	J	5	U	80.2	U	168		4300		436		16700		4.4	J	16.2		162	J	168		12200	
		Q3	6.6	J	5	U	80.2	U	199		6570		538		20600		3.4	J	13.5	J	95.6	J	111		9490	
		Q4	3.7	J	5	U	80.2	U	183		8,910		547		23,200		4.1	J	12.9	J	945		184		15,100	
	D4	Q1	2.3	U	5	U	80.2	U	81.2		875		202		1650		1.5	U	42.4		42.4		84.7		5760	
		Q2	3.1	J	5	U	80.2	U	156		1680		390		2280		1.5	U	9.6	J	350		147		5410	
		Q3	2.3	U	5	U	80.2	U	173		1760		507		1910		1.5	U	24.2		NV		174		5800	
		Q3-Dup	2.3*	U	5*	U	80.2	U	171		348		503		1730		1.5	U	13.7*	J	NV		177		4070	
		Q4	2.3	U	5	U	80.2	U	130		1,350		351		1,600		1.5	U	21.2		1,270		140		5,060	

Appendix C-1a
Data from Pore Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Chromium, dissolved µg/L		Hexavalent Chromium µg/L		Aluminum, dissolved µg/L		Calcium, dissolved mg/L		Iron, dissolved µg/L		Magnesium, dissolved mg/L		Manganese, dissolved µg/L		Vanadium, dissolved µg/L		Chromium µg/L		Aluminum µg/L		Calcium mg/L		Iron µg/L	
Transect E	E1	Q1	4.8	J	5	U	80.2	U	113		56.5	J	573		3100		5.9		3.4*	J	3.4	J	116		469	
		Q1-Dup	4.8*	J	5*	U	80.2	U	103		73.8	J	595		2230		4.9	J	7.1	J	7.1	J	106		496	
		Q2	6.5	J	5	U	80.2	U	66.7		107	J	503		1020		5.8		7.5	J	236		61.2		410	
		Q3	4	J	5	U	80.2	U	19.7		52.2	U	479		106		1.7	J	118	L	624		20.7		517	
		Q4	2.3	U	5	U	80.2	U	29.6		52.2	U	599		253		1.5	U	91.1		984		30.3		1,030	
	E2	Q1	2.3	U	5	U	80.2	U	159		3580		481		281		1.5	U	5.9	J	5.9	J	174		9830	
		Q2	12.2	J	5	U	80.2	U	187		76.1	J	446		9250		11.1		10.2	J	200	J	164		1380	
		Q3	8.1	J	5	U	80.2	U	233		3580		557		13400		1.5	U	10.1	J	NV		233		6060	
		Q4	5.7	B	5	U	80.2	U	224		3,350		537		7,700		2.2	J	8.5	B	441		227		5,150	
	E3	Q1	3.2	J	5	U	80.2	U	177		699		429		5540		6.2		5.8	J	5.8	J	185		3420	
		Q2	13.5	J	5	U	80.2	U	152		301		427		14100		5.6		17.6		264		156		4400	
	E4	Q1	2.3	U	5	U	80.2	U	104		52.2	U	258		2310		1.5	U	35.1		35.1		105		6320	
		Q2	2.3	U	5	U	40100	U	144		26100	U	391		3330		750	U	4.4	J	223		149		2820	
		Q3	2.3	U	5	U	80.2	U	177		52.2	U	514		5090		1.5	U	6.5	J	NV		182		1570	
		Q4	2.3	U	5	U	80.2	U	141		1,230		358		2,790		1.5	U	2.3	U	785		141		2,260	
Transect F	F1	Q1	3	J	5	U	80.2	U	154		128	J	472		3070		3.6	J	3	J	3	J	152		3260	
		Q2	7.4	J	5	U	80.2	U	143		52.2	U	402		4440		5.5		8.8	J	119	J	161		2180	
	F2	Q1	2.3	U	5	U	80.2	U	161		3510		460		4360		1.5	J	3.8	J	3.8	J	162		8230	
		Q2	3.2	J	5	U	80.2	U	191		9300		428		5550		1.5	U	5.6	J	408		194		19800	
		Q3	3.5	J	5	U	80.2	U	188		1910		532		5790		1.5	U	7.4	J	1440		190		5240	
		Q4	6.2	J	5	U	80.2	U	187		1,210		533		19,300		4.9	J	10.7	J	518		182		7,040	
	F3	Q1	4.7	J	5	U	80.2	U	119		109	J	383		2750		6.4		11.5	J	11.5	J	126		2690	
		Q2	10.1	J	5	U	80.2	U	130		106	J	339		2780		10.3		14.5	J	215		132		2640	
		Q2-Dup	9.1*	J	5*	U	80.2	U	145		526		376		3590		7.6		10.4*	J	217		135		2770	
	F4	Q1	3.2	J	5	U	80.2	U	102		52.2	U	326		5580		3.6	J	4.6	J	4.6	J	109		1820	
		Q2	8.2	J	5	U	80.2	U	136		1060		371		5440		7.2		8	J	311		123		3610	
		Q3	2.3	U	5	U	80.2	U	159		52.2	U	439		4690		5.8		9.3	J	343		164		1670	
		Q4	5.7	J	5	U	80.2	U	152		93.2	J	450		4,710		6.3		9.4	J	638		156		1,240	
Transect G	G1	Q1	2.3	U	5	U	80.2	U	157		56.5	J	405		13300		9.7		5	J	5	J	146		349	
		Q2	2.3	U	5	U	80.2	U	140		85.1	J	424		2870		6.1		8.2	J	427		151		4740	
	G2	Q1	2.3	U	5	U	80.2	U	154		52.2	U	401		3010		6.8		6.3	J	6.3	J	157		1200	
		Q2	11.7	J	5	U	80.2	U	157		73.8	J	435		1770		10		14.9	J	374		148		647	
		Q3	10.2	J	5	U	80.2	U	155		85.6	J	470		2140		8		14.5	J	619		161		901	
		Q4	5	B	5	U	80.2	U	89.6		90.3	J	256		1,420		4.3	J	7.6	B	337		90.5		651	
	G3	Q1	2.6	J	5	U	80.2	U	144		1410		458		4230		2.2	J	6.2	J	6.2	J	154		5900	
		Q2	10.1	J	5	U	80.2	U	150		97	J	432		2890		10.4		15.3		355		144		1090	
	G4	Q1	4.2	J	5	U	80.2	U	128		103	J	394		6030		3.9	J	7.9	J	7.9	J	133		3460	
		Q2	13.4	J	5	U	80.2	U	136		159	J	381		6130		8.4		15.1		297		145		1530	
		Q3	8.1	J	5	U	80.2	U	153		112	J	482		5700		6.4		9.8	J	209		156		1280	
		Q4	3.2	B	5	U	80.2	U	90.5		52.2	U	270		3,130		3.3	J	8	B	285		93.2		818	

Appendix C-1a
Data from Pore Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Chromium, dissolved µg/L		Hexavalent Chromium µg/L		Aluminum, dissolved µg/L		Calcium, dissolved mg/L		Iron, dissolved µg/L		Magnesium, dissolved mg/L		Manganese, dissolved µg/L		Vanadium, dissolved µg/L		Chromium µg/L		Aluminum µg/L		Calcium mg/L		Iron µg/L	
Transect H	H1	Q1	2.8	J	5	U	80.2	U	164		98.5	J	396		4680		7		12.5	J	12.5	J	153		2440	
		Q2	4.4	J	5	U	80.2	U	159		517		432		6090		6.1		19.2		737		165		5750	
		Q3	11	J	5	U	80.2	U	190		114	J	505		7950		6.9		17.4		384		184		3610	
		Q3-Dup	11*	J	5*	U	80.2	U	182		107	J	488		7770		6.2		16.8*		489		180		3230	
		Q4	5.1	J	5	U	80.2	U	187	J	59.5	J	504	J	9,890		6.5		14.4	J	1,420		183	J	4,600	
	H2	Q1	4.3	J	5	U	80.2	U	136		52.2	U	468		7640		4.8	J	9.1	J	9.1	J	146		1910	
		Q2	3.5	J	5	U	80.2	U	152		52.2	U	416		2650		8.6		12	J	330		146		582	
	H3	Q1	5.5	J	5	U	80.2	U	133		60.3	J	432		3600		5.4		10.2	J	10.2	J	138		1280	
		Q2	3.2	J	5	U	80.2	U	179		5280		440		5300		4.8	J	13.2	J	376		182		13700	
	H4	Q1	3.1	J	5	U	80.2	U	134		71.7	J	427		4450		4	J	6.3	J	6.3	J	135		3470	
		Q2	4.8	J	5	U	80.2	U	156		58.4	J	439		11300		6.8		16.2		347		156		2960	
		Q3	12.2	J	5	U	80.2	U	192		4820		517		12700		5.5		14.6	J	184	J	193		15400	
		Q4	6.5*	B	5*	U	80.2*	U	192		1510*		556		15900*		4.4*	J	16.9		988		191		7400*	
		Q4-Dup	10.2	B	5	U	80.2	U	187*		3,780		526*		16,700		7.1		15.7*		630*		184*		8,470	
Transect I	I1	Q1	2.3	U	5	U	80.2	U	86.9		72.7	J	194		174		2.6	J	23.9		23.9		90.7		1590	
		Q2	2.3	U	5	U	80.2	U	139		52.2	U	342		281		4.3	J	10.2	J	204		144		384	
		Q3	3.1	J	5	U	80.2	U	166		52.2	U	458		742		5.1		52.2	L	1840		169		4050	
		Q4	2.3	U	5	U	80.2	U	111		52.2	U	294		1,420		1.5	U	12.5	J	624		118		4,170	
	I2	Q1	2.6	J	5	U	80.2	U	100		52.2	U	248		136		3.2	J	11.2	J	11.2	J	101		149	
		Q2	2.3	U	5	U	80.2	U	132		52.2	U	343		201		3.2	J	14.1	J	459		134		481	
		Q3	3.1	J	5	U	80.2	U	170		68.6	J	473		662		3	J	12.2	J	248		176		754	
		Q4	2.3	U	5	U	80.2	U	126		52.2	U	331		521		5.3		49.8		4,180		130		5,830	
	I3	Q1	2.3	U	5	U	80.2	U	101		52.2	U	253		189		3.1	J	21.3		21.3		103		737	
		Q2	2.7	J	5	U	80.2	U	128		77.1	J	341		224		2.9	J	13.5	J	338		134		535	
		Q3	4.7	J	5	U	80.2	U	171		60.9	J	472		430		3.1	J	15.6		509		180		826	
		Q4	2.3	U	5	U	80.2	U	147	J	52.2	U	397	J	354		3.7	J	16.3		954		146	J	937	
	I4	Q1	2.7	J	5	U	80.2	U	105		63.7	J	243		133		3.5	J	27		27		101		520	
		Q2	5.8	J	5	U	80.2	U	118		64.2	J	307		204		5.5		25		349		119		664	
		Q3	6.7	J	5	U	80.2	U	178		52.2	U	442		372		4.8	J	24.3	L	1030		180		980	
		Q4	2.3	U	5	U	80.2	U	132		52.2	U	356		215		3.9	J	34.7		1,470		135		1,230	
Transect J	J1	Q4	2.3	U	5	U	80.2	U	134		61.7	J	327		162		4	J	96.5		1,580		144		2,590	
	J2	Q4	2.3	U	5	U	80.2	U	127		52.2	U	313		1,140		3.9	J	112		4,930		126		7,720	
	J3	Q4	2.3	U	5	U	80.2	U	132		62.3	J	317		1,530		3	J	61.4		2,870		134		4,770	
	J4	Q4	2.3	U	5	U	80.2	U	110		52.2	U	195		42.9		11.9		1,880		2,340		109		3,730	

Appendix C-1a
Data from Pore Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Magnesium		Manganese		Vanadium		Acidity As CaCO3, Dissolved		Ammonia-Nitrogen, dissolved		Ferrous Iron, dissolved		Hardness, total dissolved		Organic Carbon, dissolved		Oxidation Reduction Potential		pH		Sulfide	
			mg/L		µg/L		µg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mv		SU		mg/L	
Transect A	A1	Q1	178		1770		26.8		NV		NV		0.053	J	NV		NV		NV		NV		NV	
		Q2	471		1150		14		NV		NV		0.2	U	2,560		16.1		NV		NV		NV	
		Q3	476		1040		31		2,500		NV		1.3		NV		29.6		556		7.8		NV	
		Q4	292		859		16.6		NV		NV		0.04	J	1,620		8.2		593		9		NV	
	A2	Q1	231		638		3.1	J	NV		NV		NV		NV		23.8		NV		8		NV	
		Q2	NV		NV		NV		NV		NV		NV		NV		NV		NV		NV		NV	
		Q3	331		7350		350		NV		NV		0.012	J	NV		11.2		610		7.8		NV	
		Q4	322		506		2.6	J	NV		NV		0.013	J	NV		4.3		668		7.6		NV	
	A3	Q1	233		578		8.7		NV		NV		NV		NV		23.6		NV		NV		NV	
		Q2	NV		NV		NV		NV		NV		NV		NV		NV		NV		NV		NV	
		Q3	305		18.4		1.5	U	NV		NV		0.016	U	NV		12.1		609		7.8		NV	
		Q4	316		126		9.2		NV		NV		0.08	U	NV		5		684		7.8		NV	
	A4	Q1	NV		NV		NV		NV		NV		NV		NV		NV		NV		NV		NV	
		Q2	NV		NV		NV		NV		NV		NV		NV		NV		NV		NV		NV	
		Q3	325		2340		108		NV		NV		0.019	J	NV		7.3		605		7.7		NV	
		Q4	322		233		15.1		NV		NV		0.008	U	NV		17.3		698		7.8		NV	
Transect B	B1	Q1	207		2890		3.5	J	NV		NV		0.019	J	NV		NV		NV		NV		NV	
		Q2	475		1960		9		NV		2.6		0.5		2,470		8.4		640		7.9		0.054	U
		Q3	435		1900		11.6		2,810		NV		0.079	J	NV		18.6		521		7.7		NV	
		Q4	236		1,210		11.1		NV		NV		0.047	J	1,320		5.8		591		7.9		NV	
	B2	Q1	227		1150		3.4	J	NV		0.54		0.011	J	NV		13.5		NV		7.9		NV	
		Q2	418		2730		11.4		NV		2.9		0.019	J	NV		13.1		557		8		0.054	U
		Q3	469		2800		15.9		NV		NV		0.12		NV		12.7		524		7.7		NV	
		Q4	260		1,070		12.8		NV		NV		0.11		NV		5.6		587		7.9		NV	
	B3	Q1	188		2680		2.1	J	NV		1.1		0.55		NV		19.6		NV		8.1		54	U
		Q2	430		3390		3.3	J	NV		2.1		0.44		NV		16.5		634		7.8		0.054	U
		Q3	412		2420		4.3	J	NV		NV		0.48		NV		13.2		521		7.7		NV	
		Q4	335		3,040		4.1	J	NV		NV		3.6		NV		6.1		571		7.8		NV	
	B4	Q1	187		2340		3.9	J	NV		2.3*		0.095	J	NV		25.3*		NV		8		54	U
		Q1-Dup	184		2250		3.8	J	NV		2.4		0.31		NV		33.6		NV		8*		54*	U
		Q2	435		2720		4.8	J	NV		3.1		1.2		NV		17		617		7.9		0.054	U
		Q3	466		2280		4.1	J	NV		NV		0.74		NV		14.7		518		7.6		NV	
		Q4	386		2,650		6.4		NV		NV		3.6		NV		7.3		619		7.8		NV	
	B5	Q4	355		731		17.3		NV		NV		0.0095	J	NV		14.3		601		7.9		NV	

Appendix C-1a
Data from Pore Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Magnesium		Manganese		Vanadium		Acidity As CaCO3, Dissolved		Ammonia-Nitrogen, dissolved		Ferrous Iron, dissolved		Hardness, total dissolved		Organic Carbon, dissolved		Oxidation Reduction Potential		pH		Sulfide	
			mg/L		µg/L		µg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mv		SU		mg/L	
Transect C	C1	Q1	170		116		8		NV		11.7		0.12		NV		19.8		NV		8.4		54	U
		Q2	344		594		4.8	J	NV		8.6		0.078	J	1,820		8.7		624		8.4		0.054	U
		Q3	467		1260		20.6		2,560		NV		0.042	J	NV		15.3		557		8.1		NV	
		Q4	268		586		9.7		NV		NV		0.082	J	1,660		9.5		623		8.1		NV	
	C2	Q1	171		1190		8.7		NV		2.7		0.043	J	NV		21		NV		8.3		54	U
		Q2	412		1600		31.2		NV		NV		0.18		NV		11.1		NV		8.2		0.054	U
		Q3	463		1880		51.5		NV		NV		2.3		NV		11.3		595		7.9		NV	
		Q4	239		1,240		63.9		NV		NV		NV		NV		NV		644		7.8		NV	
	C3	Q1	183		2630		8.9		NV		1		0.4		NV		22.9		NV		7.8		54	U
		Q2	415		3170		4.9	J	NV		3.8		0.91		NV		8.9		646		8		0.054	U
		Q3	467		2850		7.4		NV		NV		0.13		NV		16.2		642		7.9		NV	
		Q4	304		1,950		5.7		NV		NV		0.64		NV		8.8		574		8		NV	
	C4	Q1	190		2620		6.4		NV		1		0.14		NV		42		NV		7.9		54	U
		Q2	434		4330		4.8	J	NV		2.9		1.2		NV		11.2		646*		7.8		0.054	U
		Q2-Dup	435		3590		3.6	J	NV		2.5*		0.99*		NV		10.3*		648		7.8*		0.054*	U
		Q3	457		3410		2.7	J	NV		NV		1.3		NV		14.1		636		7.7		NV	
		Q4	358		3,800		3.3	J	NV		NV		1.3		NV		9		558		7.9		NV	
Transect D	D1	Q1	408		3570		9.5		NV		21.2		0.12		NV		22.1		NV		8.4		54	U
		Q2	598		7080		12.3		NV		48.4		0.13	J	2,890		36.6		557		8.1		0.054	U
		Q3	626		6390		6.2		3,230		NV		0.19	J	NV		38.5		551		8.1		NV	
		Q4	484*		812		5.9*		NV		NV		0.13		2210*		20.5		643		8.4*		NV	
		Q4-Dup	545		737*		6.2		NV		NV		0.13*		2,450		18.1*		628*		8.5		NV	
	D2	Q1	465		9540		8		NV		26.4	J	0.0092	J	NV		23.1	J	NV		8		54	U
		Q2	562		28400		8.3		NV		68.8		4.7	J	NV		25.8		544		7.8		0.054	U
		Q3	593		23600		4.9	J	NV		NV		4.7		NV		24.1		439		8		NV	
		Q4	511		8,890		7.3		NV		NV		3		NV		14.2		636		7.8		NV	
	D3	Q1	415		9860		7.1		NV		27.7		0.44		NV		20.5		NV		8		54	U
		Q2	432		16900		5.5		NV		39.5		2.8		NV		24.6		394		7.7		0.054	U
		Q3	304		16700		2.5	J	NV		NV		10.5		NV		21		618		7.7		NV	
		Q4	546		24,200		7.5		NV		NV		10.3		NV		16.9		634		7.7		NV	
	D4	Q1	206		1790		9.7		NV		0.91		0.78		NV		32.1		NV		7.9		54	U
		Q2	367		2180		3.7	J	NV		1.5		1.4		NV		19.1		603		7.8		0.054	U
		Q3	489		2020		3.6	J	NV		NV		0.39		NV		20.1		548		7.8*		NV	
		Q3-Dup	494		1870		2.9	J	NV		NV		0.36*		NV		16.8*		462*		7.9		NV	
		Q4	378		1,750		6.3		NV		NV		1.4		NV		8.1		630		7.7		NV	

Appendix C-1a
Data from Pore Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Magnesium		Manganese		Vanadium		Acidity As CaCO3, Dissolved		Ammonia-Nitrogen, dissolved		Ferrous Iron, dissolved		Hardness, total dissolved		Organic Carbon, dissolved		Oxidation Reduction Potential		pH		Sulfide	
			mg/L		µg/L		µg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mv		SU		mg/L	
Transect E	E1	Q1	577		3100		9.2		NV		47.4*		0.09	J	NV		35*		NV		8.4		54	U
		Q1-Dup	613		2320		5.3		NV		67.8		0.09	J	NV		35.5		NV		8.3*		54*	U
		Q2	534		995		7.5		NV		74.3		0.087	J	2,290		42		531		8.8		0.054	U
		Q3	509		212		7.4		2,010		NV		0.091	J	NV		36.8		382		9.5		NV	
		Q4	677		355		10		NV		NV		0.085	J	2,750		25.2		395		9.3		NV	
	E2	Q1	434		14200		5	J	NV		3.8		0.041	J	NV		16.1		NV		7.7		54	U
		Q2	446		8530		12.5		NV		16.8		0.1	J	NV		23.4		548		7.9		0.054	U
		Q3	560		13600		4.8	J	NV		NV		3.9		NV		12.9		590		7.8		NV	
		Q4	544		7,850		4.4	J	NV		NV		3.4		NV		4.9		557		7.5		NV	
	E3	Q1	445		5900		7		NV		16.8		0.6		NV		12.2		NV		7.9		54	U
		Q2	415		12400		8.6		NV		31.5		0.28		NV		24.6		448		7.8		0.054	U
	E4	Q1	259		2460		13.1		NV		1.3		0.029	J	NV		29.8		NV		8		54	U
		Q2	408		3230		4.2	J	NV		3.6		0.28		NV		23.7		638		7.9		0.054	U
		Q3	510		5310		3.5	J	NV		NV		0.08	J	NV		13.9		593		8		NV	
		Q4	358		2,810		3.6	J	NV		NV		1.2		NV		17.3		626		7.7		NV	
Transect F	F1	Q1	383		3110		4.6	J	NV		16.4		0.26		NV		18.5		NV		7.9		54	U
		Q2	407		4570		7.1		NV		23.9		0.11		2,420		21.3		603		8		0.054	U
	F2	Q1	381		4460		3.8	J	NV		6.1		3.8		NV		14.8		NV		7.7		54	U
		Q2	435		5660		2.3	J	NV		NV		7.4		NV		NV		NV		NV		0.054	U
		Q3	537		5920		4.3	J	NV		NV		1.9		NV		14.8		593		7.6		NV	
		Q4	517		3,850		7.8		NV		NV		1.3		2,890		13.8		570		7.9		NV	
	F3	Q1	348		2990		9.8		NV		13.4		0.18		NV		17.4		NV		8		74	J
		Q2	342		2900		11.4		NV		15.6		0.065*	J	NV		23.5		596		8		0.054	U
		Q2-Dup	350		3410		8.3		NV		13.1*		0.46		NV		22.5*		595*		8*		0.054*	U
	F4	Q1	348		6050		4.6	J	NV		11.6		0.081	J	NV		10.6		NV		8.1		54	U
		Q2	377		5160		10.2		NV		12.6		0.84		NV		20.4		539		7.9		0.054	U
		Q3	465		5160		5.1		NV		NV		0.076	J	NV		15.6		625		8		NV	
		Q4	459		4,840		6.7		NV		NV		0.15		NV		10		565		8		NV	
Transect G	G1	Q1	384		12400		9.5		NV		19.4	J	0.15		NV		20	J	NV		8.2		54	U
		Q2	438		3030		9.5		NV		33.4		0.13		2,230		21.9		363		8.2		0.054	U
	G2	Q1	405		3210		7.7		NV		10.3	J	0.14		NV		16.4	J	NV		8		54	U
		Q2	407		1680		11.4		NV		10.8		0.067	J	NV		16.2		423		8.1		0.061	J
		Q3	486		2250		10.3		NV		NV		0.083	J	NV		20.1		607		8.1		NV	
		Q4	258		1,440		4.1	J	NV		NV		0.16		2,650		9.1		601		8		NV	
	G3	Q1	481		4590		4.3	J	NV		4.4		1.4		NV		26.4		NV		7.8		54	U
		Q2	412		2790		12		NV		13.8		0.069	J	NV		21.2		439		8		0.054	U
	G4	Q1	402		6380		5.6		NV		12.5		0.19		NV		29.1		NV		7.8		54	U
		Q2	406		6630		10.2		NV		14.3		0.14		NV		20.5		404		7.9		0.054	U
		Q3	487		5830		7.1		NV		NV		0.094	J	NV		14.6		603		7.8		NV	
		Q4	279		3,350		4.7	J	NV		NV		0.15		NV		8.8		609		7.9		NV	

Appendix C-1a
Data from Pore Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Magnesium		Manganese		Vanadium		Acidity As CaCO3, Dissolved		Ammonia-Nitrogen, dissolved		Ferrous Iron, dissolved		Hardness, total dissolved		Organic Carbon, dissolved		Oxidation Reduction Potential		pH		Sulfide	
			mg/L		µg/L		µg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mv		SU		mg/L	
Transect H	H1	Q1	372		4670		9.7		NV		21.1		0.2	K	NV		31.6		NV		7.8		54	U
		Q2	450		6490		9.7		NV		51.8		0.45		2,580		29.2		414		8		0.054	U
		Q3	488		7900		8.1		2580*		NV		0.1*		NV		23.6		567		7.9		NV	
		Q3-Dup	481		7830		8.5		2,640		NV		0.12		NV		22.8*		567*		7.7*		NV	
		Q4	489	J	10,900		9.8		NV		NV		0.19		2,800		26.3		675		7.8		NV	
	H2	Q1	488		8240		7.1		NV		34.3		0.1		NV		31.3		NV		8.1		54	U
		Q2	406		2580		10.1		NV		28.6		0.12		NV		18.9		406		8.1		0.054	U
	H3	Q1	441		3770		7.5		NV		22.2		0.16		NV		34.1		NV		7.9		300	
		Q2	459		5620		9.8		NV		42.8		4.3		NV		24.8		410		7.8		0.054	U
	H4	Q1	423		4640		6.1		NV		8.5		0.18		NV		21		NV		7.9		54	U
		Q2	423		11000		9.2		NV		36.5		0.098	J	NV		23.8		411		8		0.054	U
		Q3	513		12900		7.8		2,790		NV		5.2		NV		24.1		566		7.5		NV	
		Q4	549		15600*		11.3		NV		NV		1.5		NV		12.9*		665		7.5*		NV	
		Q4-Dup	514*		16,800		9.1*		NV		NV		4.2		NV		15.1		645*		7.5		NV	
Transect I	I1	Q1	199		204		8.5		NV		2		0.1	K	NV		20.6		NV		8.1		54	U
		Q2	349		288		7.1		NV		6.8		0.079	J	1,880		12		427		8.2		0.077	J
		Q3	455		821		19.2		2,480		NV		0.069	J	NV		10		555		8.1		NV	
		Q4	302		1,520		5.2		NV		NV		0.074	J	1,670		15.2		676		7.9		NV	
	I2	Q1	246		145		6.8		NV		12.5		0.11	K	NV		49.4		NV		8.1		160	
		Q2	364		217		8.9		NV		19.4		0.062	J	NV		14.9		361		8.1		0.76	
		Q3	489		696		4.9	J	NV		NV		0.12		NV		13.2		563		7.9		NV	
		Q4	335		607		22.4		NV		NV		0.1		NV		15		681		8		NV	
	I3	Q1	254		210		9.2		NV		16.7		0.11	K	NV		35.9		NV		8.1		54	U
		Q2	324		228		7.2		NV		14.7		0.093	J	NV		19.1		342		8.1		0.42	
		Q3	490		460		7.2		NV		NV		0.063	J	NV		18.4		567		7.6		NV	
		Q4	393	J	363		9.8		NV		NV		0.13		NV		19.4		681		8		NV	
	I4	Q1	233		140		11.5		NV		13.3		0.073	J	NV		42.3		NV		8.1		63	J
		Q2	294		229		7.8		NV		27		0.081	J	NV		10.1		351		8.1		0.47	
		Q3	447		395		9.4		2,380		NV		0.071	J	NV		20.4		554		8		NV	
		Q4	361		235		18		NV		NV		0.18		NV		18.6		677		8		NV	
Transect J	J1	Q4	347		652		8.6		NV		NV		0.008	U	1,910		5.5		569		8		NV	
	J2	Q4	310		1,440		21.3		NV		NV		0.011	J	NV		10.9		551		8		NV	
	J3	Q4	323		1,650		13.9		NV		NV		0.027	J	NV		18.5		594		7.8		NV	
	J4	Q4	195		451		23.6		NV		NV		0.055	J	NV		14.7		603		8.8		NV	

Laboratory ORP data are suspect because they are inconsistent with field measurements of ORP
* = datum not used (because it is the lower pair of a duplicate, or the datum was rejected

B = Bottom sample
$CaCO_3$ = Calcium carbonate
mg/L = Milligram per Liter
mv = Millivolt
NV = No Value, no analysis performed
SU = Standard Units
µg/L = Microgram per Liter

Qualifiers:
J = Estimated value
L = Off-scale high. Actual value is known to be greater than value given
U = Not detected

Appendix C-1b
Data from Pore Water Reference Location Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Chromium, dissolved		Hexavalent Chromium		Aluminum, dissolved		Calcium, dissolved		Iron, dissolved		Magnesium, dissolved		Manganese, dissolved		Vanadium, dissolved		Chromium		Aluminum		Calcium	
			µg/L		µg/L		µg/L		mg/L		µg/L		mg/L		µg/L		µg/L		µg/L		µg/L		mg/L	
Transect 37	37	Q1	5	J	5	U	80.2	U	148		523		451		12400		9.7		6.2	J	149	J	153	
		Q2	9.7	J	5	U	80.2	U	167		91.9	J	470		11900		8.7		7.9	J	215		152	
		Q3	2.3	U	5	U	80.2	U	179		590		483		14000		3.8	J	14.7	J	229		192	
		Q4	9.6	B	5	U	80.2	U	178		122	J	514		15,700		9.8		14.3	J	1,260		175	
	37A	Q1	4.1	J	5	U	80.2	U	143		6110		413		11000		8.5		2.9	J	123	J	146	
		Q2	11.4	J	5	U	80.2	U	160		138	J	433		17500		11.3		10.8	J	370		151	
		Q3	4.8	J	5	U	80.2	U	161		1290		488		7210		5.7		8.9	J	338		167	
		Q4	6.1	J	5	U	80.2	U	166		187	J	484		14,600		5.4		10.2	J	852		167	
	37B	Q1	8.4	J	5	U	80.2	U	152		8040		446		24600		10.9		8.1	J	80.2	U	155	
		Q2	11.6	J	5	U	80.2	U	162		5820		442		18700		6.9		8	J	195	J	154	
		Q3	2.3	U	5	U	80.2	U	176		89	J	481		13700		5.5		13.7	J	483		196	
		Q4	5	J	5	U	80.2	U	186		1,870		547		8,300		5.6		12.6	J	1,380		184	

Appendix C-1b
Data from Pore Water Reference Location Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Iron	Magnesium	Manganese	Vanadium	Acidity As CaCO3, Dissolved	Ammonia-Nitrogen, dissolved	Ferrous Iron, dissolved	Hardness, total dissolved	Organic Carbon, dissolved	Oxidation Reduction Potential	pH	Sulfide
			µg/L	mg/L	µg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mv	SU	mg/L
Transect 37	37	Q1	4680	462	17,000	10.7	NV	19.1	0.46	NV	17.2	NV	8	54 U
		Q2	2100	487	12,465	10.7	NV	20.6	0.088 J	2,350	23.4	548	8	0.054 U
		Q3	12300	531	23,000	7.1	2,810	NV	4.1	NV	19.9	615	7.8	NV
		Q4	4,360	504	16,400	13.6	NV	NV	0.21	2,700	13.2	599	7.9	NV
	37A	Q1	11800	418	15,000	8.9	NV	7.9	6.2	NV	12.1	NV	7.7	54 U
		Q2	2860	465	18,216	15.1	NV	17.3	0.12	2,150	23.8	557	7.9	0.054 U
		Q3	4550	506	7,640	7.3	NV	NV	1.4	NV	15.7	642	7.9	NV
		Q4	6,650	483	15,100	8	NV	NV	0.24	NV	12.8	558	7.9	NV
	37B	Q1	15800	455	26,000	12.1	NV	13.7	7.6	NV	18.7	NV	7.9	54 U
		Q2	12600	478	20,561	10.6	NV	20.6	4.2	2,270	25	553	7.8	0.054 U
		Q3	4740	551	15,700	7.8	NV	NV	0.16	NV	19.1	627	8	NV
		Q4	6,490	538	8,320	9.7	NV	NV	2	NV	10.8	578	7.8	NV

B = Bottom sample
$CaCO_3$ = Calcium carbonate
mg/L = Milligram per Liter
mv = Millivolt
SU = Standard Units
µg/L = Microgram per Liter

Qualifiers:
J = Estimated value
U = Not detected

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Chromium, dissolved		Hexavalent Chromium		Aluminum, dissolved		Calcium, dissolved		Iron, dissolved		Magnesium, dissolved		Manganese, dissolved		Vanadium, dissolved		Chromium		Aluminum	
			feet	µg/L		µg/L		µg/L		mg/L		µg/L		mg/L		µg/L		µg/L		µg/L		µg/L	
Transect A	A1	Q1	2	2.3	U	5	U	80.2	U	71.3		52.2	U	188		18.2		1.5	U	6.8	J	347	
		Q2	2	2.3	U	5	U	80.2	U	155		52.2	U	469		38.6		1.5	U	2.3	U	80.2	U
		Q2	4	2.3	U	5	U	80.2	U	154		52.2	U	464		56.4		3	J	2.8	J	97.5	J
		Q3	1.5	5.6	J	5	U	80.2	U	165		52.2	U	462		8.5		1.5	U	9.8	J	231	
		Q4	1.5	2.3	U	5	U	80.2	U	103		52.2	U	286		28.7		1.5	U	2.3	U	129	J
		Q4	4	2.3	U	5	U	80.2	U	106		62.4	J	295		30		1.5	U	2.3	U	171	J
	A2	Q1	2	2.3*	U	5	U	80.2	U	70.4		52.2	U	185		21.6		1.5	U	3.4*	J	144	J
		Q1-Dup	2	2.5	B	5*	U	80.2	U	73.2		52.2	U	185		25.1		1.5	U	4.2	J	134	J
		Q2	1.5	2.3	U	5	U	80.2	U	156		52.2	U	473		44		2.9	J	2.3	U	80.2	U
		Q2	3.5	2.3	U	5	U	80.2	U	154		52.2	U	467		45.4		2.4	J	2.3	U	82.4	J
		Q3	2	2.3	U	5	U	80.2	U	106		52.2	U	277		3.8	J	1.5	U	2.3	U	88.7	J
		Q4	2.4	2.4	J	5	U	80.2	U	115		52.2	U	321		40.9		1.5	U	2.3	U	84.8	J
	A3	Q1	2	2.3	U	5	U	80.2	U	74.3		52.2	U	201		30.1		1.5	U	3.5	J	203	
		Q2	2.5	2.3	U	5	U	80.2	U	153		52.2	U	463		29.4		2.2	J	2.3	U	80.2	U
		Q3	2	2.3	U	5	U	80.2	U	109		52.2	U	291		4.1	J	1.5	U	2.3	U	130	J
		Q4	2.3	2.3	U	5	U	80.2	U	117		52.2	U	328		41.6*		1.5	U	2.3	U	80.2*	U
		Q4-Dup	2.3	2.3*	U	5*	U	80.2*	U	117*		52.2*	U	328*		41.7		1.5*	U	2.3*	U	99.2	J
	A4	Q1	2	2.3	U	5	U	80.2	U	74		55.7	J	196		47.3		1.5	U	3	J	98.9	J
		Q2	2.2	2.3	U	5	U	80.2	U	155		52.2	U	471		47.5		2.6	J	2.3	U	80.2	U
		Q2 - Dup	2.2	2.3*	U	5*	U	80.2	U	155		52.2	U	470		47.6		2.8	J	2.3*	U	80.2	U
		Q3	2	2.3	U	5	U	80.2	U	109		52.2	U	296		4.4	J	1.5	U	2.3	U	127	J
		Q4	2.5	2.3	U	5	U	80.2	U	111		52.2	U	312		38.6		1.5	U	2.3	U	83.5	J
Transect B	B1	Q1	2.5	2.3	U	5	U	80.2	U	79.4		52.2	U	201		25.6		1.5	U	2.3	U	89.5	J
		Q2	2	3.8	J	5	U	80.2	U	157		52.2	U	458		35.7		2.3	J	5.8	J	80.2	U
		Q2	5	5.2	J	5	U	80.2	U	158		52.2	U	463		65.8		1.6	J	11.1	J	439	
		Q3	2	2.3	U	5	U	80.2	U	152		52.2	U	452		10.9		1.5	U	2.3	U	102	J
		Q3	6.5	NV		NV		NV		NV		NV		NV		NV		NV		NV		NV	
		Q3-Dup	6.5	NV		NV		NV		NV		NV		NV		NV		NV		NV		NV	
		Q3	7	2.3	U	5	U	80.2	U	153		52.2	U	461		11.8		1.5	U	2.3	U	101	J
		Q4	3	2.3	U	5	U	80.2	U	65.7		52.2	U	163		17		1.5	U	2.3	U	182	J
		Q4	7	4.2	J	5	U	80.2	U	96.9		52.2	U	261		33.7		1.5	U	4	J	153	J
	B2	Q1	3	2.3	U	5	U	80.2	U	83.5		261	U	211		56.7		1.5	U	2.6	J	111	J
		Q1	7	2.3	U	5	U	80.2	U	86.3		261	U	219		61.4		1.6	J	2.6	J	101	J
		Q2	3	5.7	J	5	U	80.2	U	157		52.2	U	458		24		1.8	J	7.4	J	80.2	U
		Q2	6	7.3	J	5	U	80.2	U	157		52.2	U	460		30.5		1.7	J	10.2	J	106	J
		Q3	2	2.3	U	5	U	80.2	U	151		52.2	U	448		9.7		1.5	U	2.3	U	103	J
		Q3	8	NV		NV		NV		NV		NV		NV		NV		NV		NV		NV	
		Q3	9	3.3	J	5	U	80.2	U	151		52.2	U	453		11.5		1.5	U	3.3	J	81.1	J
		Q4	3	2.3	U	5	U	80.2	U	72		52.2	U	155		18.9		1.6	J	2.3	U	257	
		Q4	9	2.3	U	5	U	89.6	J	115		52.2	U	294		43.2		2.5	J	5.5	J	467	
	B3	Q1	3	2.3	U	5	U	80.2	U	73.9		52.2	U	183		18.6		1.5	U	6.2	J	135	J
		Q1	7	2.3	U	5	U	80.2	U	74.9		52.2	U	186		21.2		1.5	U	4	J	234	
		Q2	3	6.1	J	6	J	80.2	U	163		52.2	U	469		13.6		2.7	J	9.4	J	88.4	J
		Q2	7	6	J	5	U	80.2	U	167		52.2	U	478		11		1.5	U	7.3	J	87.6	J
		Q3	1.5	2.3	U	5	U	80.2	U	168		52.2	U	483		10.7		1.5	U	2.3	U	80.2	U
		Q3	10	2.3	U	5	U	80.2	U	179		52.2	U	506		15.2		1.5	U	3.2	J	80.2	U
		Q3	5.5	2.3	U	5	U	80.2	U	176		52.2	U	500		14.9		1.5	U	2.3	U	80.2	U
		Q4	3	2.3	U	5	U	80.2	U	71.1		52.2	U	150		18.8		1.5	U	2.3	U	296	
		Q4	9.5	2.3	U	5	U	80.2	U	122		52.2	U	301		54.5		2.2	J	2.3	U	213	

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Chromium, dissolved		Hexavalent Chromium		Aluminum, dissolved		Calcium, dissolved		Iron, dissolved		Magnesium, dissolved		Manganese, dissolved		Vanadium, dissolved		Chromium		Aluminum	
			feet	µg/L		µg/L		µg/L		mg/L		µg/L		mg/L		µg/L		µg/L		µg/L		µg/L	
Transect B	B4	Q1	3	2.3	U	5	U	80.2	U	77.1		52.2	U	191		23.6		1.5	U	2.3	U	80.2	U
		Q1	6	2.3	U	5	U	80.2	U	72.5		52.2	U	178		19		1.5	U	2.3	U	162	J
		Q1-Dup	6	2.3*	U	5*	U	80.2	U	77.1		52.2	U	192		22.6		1.5	U	2.3*	U	198	J
		Q2	3	29.7		34.9		80.2	U	159		52.2	U	471		10.9		4.4	J	35.1		80.2	U
		Q2	5.5	26*	J	32.9		80.2	U	159		52.2	U	472		13.1		3.6	J	31.3		94.1	J
		Q2-Dup	5.5	30.8	J	30.7*		80.2	U	160		52.2	U	471		12.8		3.1	J	29.8*		80.2	U
		Q2	8.5	29		32		80.2	U	162		52.2	U	486		8.6		3	J	32.9		90.7	J
		Q3	1.5	2.3	U	5	U	80.2	U	174		52.2	U	487		12.7		1.5	U	2.3	U	80.2	U
		Q3	10.4	3.1	J	5	U	80.2	U	180		52.2	U	504		16.2		1.5	U	5	J	92.2	J
		Q3	5.5	2.3	U	5	U	80.2	U	181		52.2	U	509		17.7		1.5	U	4.2	J	80.2	U
		Q4	1.5	2.3	U	5	U	80.2	U	81		52.2	U	213		23.1		1.5	U	2.3	U	106	J
		Q4	5.5	2.3	U	5	U	80.2	U	89.6		52.2	U	242		28.4		1.5	U	3.7	J	152	J
		Q4	10	2.3	U	5	U	80.2	U	112		52.2	U	315		43.1		1.5	U	2.7	J	102	J
	B5	Q4	2.5	2.3	U	5	U	80.2	U	125		52.2	U	322		41.3		1.5	U	2.3	U	174	J
		Q4	7	2.3	U	5	U	80.2	U	124		52.2	U	320		40.6		1.5	U	2.3	U	235	
Transect C	C1	Q1	2	2.3	U	5	U	80.2	U	72.9		52.2	U	174		5.3		1.5	U	3.2	J	236	
		Q2	2	7.6	J	5	U	80.2	U	172		52.2	U	481		55.6		2	J	12.2	J	294	
		Q2	4	8.4	J	5	U	80.2	U	168		52.2	U	482		54.8		2.1	J	14.1	J	322	
		Q2-Dup	4	7.9*	J	5*	U	80.2	U	172		52.2	U	478		56.9		1.9	J	12.5*	J	148	J
		Q3	2	6.6*	J	7	J	80.2	U	182		52.2	U	499		15.2		1.5	U	8.6	J	80.2	U
		Q3-Dup	2	9.4	J	6.9*	J	80.2	U	179		52.2	U	492		15.2		1.5	U	7.9*	J	80.2	U
		Q4	2.2	2.3	U	5	U	80.2	U	64.1		52.2	U	138		19.6		1.5	U	2.3	U	251	
	C2	Q1	2	2.3	U	5	U	80.2	U	71.9		52.2	U	171		5.4		1.5	U	2.3	U	80.2	U
		Q1	4	2.3	U	5	U	80.2	U	72.2		52.2	U	172		5.8		1.5	U	2.3	U	93	J
		Q2	2	4.2	J	5	U	80.2	U	175		52.2	U	483		44.3		1.5	J	8.9	J	112	J
		Q2	5	5.6	J	5	U	80.2	U	175		52.2	U	482		47		1.5	J	9.3	J	205	
		Q3	2	2.3	U	5	U	80.2	U	152		52.2	U	460		10.7		1.5	U	2.3	U	122	J
		Q3	5.5	NV		NV		NV		NV		NV		NV		NV		NV		NV		NV	
		Q3	6	2.3	U	5	U	80.2	U	159		52.2	U	478		11.8		1.5	U	2.3	U	88.6	J
		Q4	3	2.3	U	5	U	118	J	62.9		52.2	U	143		19.1		1.7	J	2.3	U	354	
	C3	Q1	3	2.3	U	5	U	80.2	U	71.1		52.2	U	168		6.8		1.5	U	2.3	U	105	J
		Q1	6	2.3	U	5	U	80.2	U	73.5		52.2	U	175		9.1		1.5	U	2.3	U	92.5	J
		Q2	2	5.6	J	5	U	80.2	U	165		52.2	U	456		18.2		1.5	U	5.7	J	114	J
		Q2	5	4.5	J	5	U	80.2	U	168		52.2	U	466		16.9		1.6	J	5.2	J	91.7	J
		Q2	8	5.8	J	5	U	80.2	U	166		52.2	U	459		16.6		2.2	J	7.5	J	129	J
		Q3	2	2.9	J	5	U	80.2	U	110		52.2	U	283		4.4	J	1.5	U	2.3	U	120	J
		Q3	8	2.3	U	5	U	80.2	U	122		52.2	U	342		5.8		1.5	U	2.3	U	143	J
		Q4	2	2.3	U	5	U	117	J	61.3		52.2	U	144		19.1		1.9	J	2.3	U	331	
		Q4	8.5	2.3	U	5	U	102	J	105		52.2	U	258		44.6		1.5	U	2.3	U	353	
	C4	Q1	3	2.3	U	5	U	80.2	U	74		52.2	U	175		5.8		1.5	U	2.3	U	80.2	U
		Q1	7	2.3	U	5	U	80.2	U	71.8		52.2	U	171		6.2		1.5	J	2.3	U	80.2	U
		Q2	2	5.5	J	5	U	80.2	U	164		52.2	U	457		9.7		2	J	5	J	80.2	U
		Q2	5.5	6.2	J	5	U	80.2	U	176		52.2	U	489		9.7		1.5	U	5.1	J	80.6	J
		Q2	9	2.6		5	U	80.2	U	179		52.2	U	499		17		1.6	J	2.3	U	96.7	J
		Q3	2	2.3	U	5	U	80.2	U	109		52.2	U	294		4.2	J	1.5	U	2.3*	U	80.2	U
		Q3-Dup	2	2.3*	U	5*	U	80.2	U	110		52.2	U	300		4.5	J	1.5	U	3.1	J	107	J
		Q3	8	2.3	J	5	U	80.2	U	121		52.2	U	341		5.2		1.5	U	2.3	U	113	J
		Q4	3	2.3	U	5	U	101	J	65.6		52.2	U	147		20		1.5	U	2.3	U	649	
		Q4	9	2.3	U	5	U	94	J	112		52.2	U	275		55.9		1.5	U	2.3	U	297	

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Chromium, dissolved		Hexavalent Chromium		Aluminum, dissolved		Calcium, dissolved		Iron, dissolved		Magnesium, dissolved		Manganese, dissolved		Vanadium, dissolved		Chromium		Aluminum	
			feet	µg/L		µg/L		µg/L		mg/L		µg/L		mg/L		µg/L		µg/L		µg/L		µg/L	
Transect D	D1	Q1	3	2.3	U	5	U	80.2	U	84.7		52.2	U	204		14.9		1.5	U	3.1	J	140	J
		Q1	18	2.3	U	5	U	80.2	U	138		52.2	U	372		171		1.5	U	2.3	U	150	J
		Q1	34	2.3	U	5	U	80.2	U	167		52.2	U	477		268		1.5	U	2.3	U	151	J
		Q2	0.3	2.3	U	5	U	80.2	U	160		52.2	U	481		10.2		2.2	J	2.3	U	80.2	U
		Q2	20	2.3	U	5	U	80.2	U	171		52.2	U	528		258		1.5	U	2.3	U	80.2	U
		Q2	40	2.3	U	5	U	80.2	U	201		52.2	U	579		560		1.5	U	2.3	U	80.2	U
		Q3	1.5	6.5	J	5	U	80.2	U	175		52.2	U	486		15.1		1.5	U	7.9	J	80.2	U
		Q3	19	4.8	J	5	U	80.2	U	175		52.2	U	486		14		1.5	U	4.4	J	80.2	U
		Q3	37.5	2.5	J	5	U	80.2	U	186		52.2	U	523		9.2		1.5	U	4.2	J	181	J
		Q4	2.5	17.3	J	10.5		80.2	U	82.5		52.2	U	219		25		1.5	U	16.6	J	153	J
		Q4	20	2.3	U	5	U	80.2	U	143		52.2	U	419		117		1.5	U	2.3	U	98.6	J
		Q4	40.5	2.7	J	5	U	80.2	U	167		71.2	J	501		263		2	J	2.3	U	240	
	D2	Q1	3	2.3	U	5	U	80.2	U	56.7		52.2	U	133		1.1	J	1.6	J	2.3	U	80.2	U
		Q1	22	2.3	U	5	U	80.2	U	99		52.2	U	278		96		2.1	J	2.3	U	80.2	U
		Q1	42	2.3	U	5	U	80.2	U	178		52.2	U	547		331		2.3	J	2.3	U	80.2	U
		Q2	22	2.3	U	5	U	80.2	U	165		52.2	U	499		4.8	J	1.6	J	2.3	U	112	J
		Q2	3	2.3	U	5	U	80.2	U	161		52.2	U	486		26.2		2.6	J	6	J	310	
		Q2	42	2.3	U	5	U	80.2	U	211		52.2	U	518		956		2.2	J	2.3	U	80.2	U
		Q3	2	2.3	U	5	U	80.2	U	133		52.2	U	352		3.6	J	1.5	U	2.3	U	198	J
		Q3	22	2.3	U	5	U	80.2	U	184		52.2	U	524		16.9		1.5	U	2.3	U	181	J
		Q3	42	2.5	J	5	U	80.2	U	207		52.2	U	598		46.7		1.5	U	2.3	U	301	
		Q4	2.5	2.8	J	5	U	80.2	U	109		52.2	U	305		59.2		1.5	U	3.8	J	187	J
		Q4	21	2.3	U	5	U	80.2	U	147		52.2	U	432		133		1.5	U	2.3	U	117	J
		Q4	43.5	2.3	U	5	U	80.2	U	173		52.2	U	520		356		1.5	U	2.3	U	275	
	D3	Q1	3	2.3	U	5	U	80.2	U	70.8		52.2	U	173		9.2		1.5	U	6.2	J	107	J
		Q1	23	2.3	U	5	U	80.2	U	114		52.2	U	314		105		1.5	U	2.3	U	145	J
		Q1	40	2.3	U	5	U	80.2	U	176		52.2	U	511		455		1.5	U	2.3	U	127	J
		Q2	25	2.3	U	5	U	80.2	U	172		52.2	U	507		1	J	2.1	J	2.5	J	80.2	U
		Q2	3	3.2	J	5	U	80.2	U	156		52.2	U	454		1.1	J	1.9	J	3.9	J	80.2	U
		Q2	39	2.3	U	5	U	80.2	U	195		52.2	U	581		489		1.5	U	2.3	U	80.2	U
		Q3	2	2.3	U	5	U	80.2	U	105		52.2	U	289		4.1	J	1.7	J	2.9	J	80.2	U
		Q3	22	2.3	U	5	U	80.2	U	165		52.2	U	510		21.3		1.5	U	2.3	U	80.2	U
		Q3	40	2.3	U	5	U	80.2	U	211		52.2	U	588		17.5		2.1	J	3.7	J	80.2	U
		Q4	2.5	9.4	J	6.3*	J	145	J	82.7		235		217		35.7		1.5	U	9.7*	J	80.2*	U
		Q4-Dup	2.5	8.9*	J	6.7	J	80.2*	U	78.7*		52.2*	U	207*		22.1*		1.5*	U	10.7	J	126	J
		Q4	21	2.3	U	5	U	80.2	U	145		52.2	U	425		129		1.5	U	2.3	U	88.1	J
		Q4	42.5	2.3	U	5	U	80.2	U	171		52.2	U	512		251		1.5	U	2.3	U	151	J
	D4	Q1	3	2.3	U	5	U	80.2	U	79.1		261	U	202		35		2.2	J	2.3	U	80.2	U
		Q1	5	2.3	U	5	U	80.2	U	78.1		261	U	200		34.6		2.2	J	2.3	U	81.8	J
		Q1-Dup	5	2.3*	U	5*	U	80.2	U	79.3		261	U	202		34.6		1.8	J	2.3*	U	82.3	J
		Q1	8	2.3	U	5	U	80.2	U	80.6		261	U	204		43.1		2.1	J	2.3	U	80.2	U
		Q2	3	2.3	U	5	U	80.2	U	131		52.2	U	407		10.9		1.6	J	3.6	J	144	J
		Q2	5	2.3	U	5	U	80.2	U	126		52.2	U	415		10.4		1.9	J	5.9	J	276	
		Q2	8.5	2.3	U	5	U	80.2	U	128		52.2	U	399		14.4		2.1	J	4.1	J	124	J
		Q3	2	2.7	J	5	U	80.2	U	121		52.2	U	359		3.1	J	1.5	U	2.3	U	80.2	U
		Q3	9	4.5	J	5	U	80.2	U	171		52.2	U	491		17.3		1.5	U	2.3	U	178	J
		Q3-Dup	9	2.9*	J	5*	U	80.2	U	170		52.2	U	480		16.7		1.5	U	2.3*	U	260	
		Q4	1.5	2.3	U	5	U	80.2	U	79.7		52.2	U	211		23.1		1.5	U	2.3	U	155	J
		Q4	5	2.3	U	5	U	80.2	U	84		52.2	U	222		24.3		1.5	U	2.6	J	115	J
		Q4	10	2.3	U	5	U	80.2	U	121		52.2	U	342		55.5		1.5	U	3.2	J	128	J

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Chromium, dissolved		Hexavalent Chromium		Aluminum, dissolved		Calcium, dissolved		Iron, dissolved		Magnesium, dissolved		Manganese, dissolved		Vanadium, dissolved		Chromium		Aluminum	
			feet	µg/L		µg/L		µg/L		mg/L		µg/L		mg/L		µg/L		µg/L		µg/L		µg/L	
Transect E	E1	Q1	21.5	2.3	U	5	U	80.2	U	90.8		52.2	U	246		49.8		1.5	U	2.3	U	80.2	U
		Q1	41	2.3	U	5	U	80.2	U	166		52.2	U	496		272		1.5	U	2.3	U	80.2	U
		Q1	3	2.3	U	5	U	80.2	U	49.5		52.2	U	111		1.9	J	1.5	U	2.3	U	80.2	U
		Q1-Dup	3	2.3*	U	5*	U	80.2	U	47.3		52.2	U	105		2.3	J	1.5	U	2.3*	U	80.2	U
		Q2	22	2.3	U	5	U	80.2	U	153		52.2	U	462		8.4		2	J	2.3	U	136	J
		Q2	3	21.3		25.7		80.2	U	146		52.2	U	435		4.2	U	2.2	J	37.5		197	J
		Q2	42	2.3	U	5	U	80.2	U	197		52.2	U	618		1,160		1.5	U	2.3	U	80.2	U
		Q3	1.5	37.6		30.4		80.2	U	176		52.2	U	484		13.9		1.5	U	44.4		80.2	U
		Q3	17	5.5	J	5	U	80.2	U	177		52.2	U	487		12.5		1.5	U	5.4	J	80.2	U
		Q3	37	2.7	J	5	U	80.2	U	197		52.2	U	546		6.4		1.5	U	3	J	80.2	U
		Q4	2.5	6.1	J	8.1	J	80.2	U	103		52.2	U	279		26.7		1.5	U	11.8	J	80.2	U
		Q4	19	2.4	J	5	U	80.2	U	137		127	J	388		99.3		2.2	J	3.1	J	130	J
		Q4	43.5	2.3	U	5	U	80.2	U	167		52.2	U	488		234		1.5	U	2.3	U	186	J
	E2	Q1	3	2.3	U	5	U	80.2	U	68.1		52.2	U	170		5.1		1.5	U	2.3	U	80.2	U
		Q1	22	2.3	U	5	U	80.2	U	123		52.2	U	354		193		1.5	U	2.3	U	80.2	U
		Q1	42	2.3	U	5	U	80.2	U	158		52.2	U	473		546		1.5	U	2.3	U	80.2	U
		Q2	22	2.3	U	5	U	80.2	U	162		52.2	U	500		8.4	U	1.8	J	2.3	U	120	J
		Q2	3	2.3	U	5	U	80.2	U	153		52.2	U	459		6.4		3.4	J	4.4	J	279	
		Q2	42	2.3	U	5	U	80.2	U	184		52.2	U	583		708		2	J	2.3	U	80.2	U
		Q3	2	10.2	J	11	J	80.2	U	126		52.2	U	348		3.8	J	1.5	U	5.2	J	80.2	U
		Q3	22	3	J	5	U	80.2	U	184		52.2	U	539		18.9		1.5	U	3.7	J	80.2	U
		Q3	42	2.3	U	5	U	80.2	U	201		52.2	U	599		41.5		1.5	U	2.3	U	102	J
		Q4	2.5	2.3	U	5	U	80.2	U	102		72.6	J	279		31.4		1.5	U	2.3	U	126	J
		Q4-Dup	2.5	2.3*	U	5*	U	80.2*	U	98.6*		52.2*	U	271*		26.8*		1.5*	U	2.3*	U	122*	J
		Q4	19	2.7	B	5	U	80.2	U	130		97.7	J	376		78.7		1.5	U	2.3	U	146	J
		Q4	41	2.3	U	5	U	80.2	U	164		98.5	J	487		199		1.5	U	2.3	U	154	J
	E3	Q1	3	2.3	U	5	U	80.2	U	72.4		52.2	U	177		4.3	J	1.5	U	2.3	U	80.2	U
		Q1	25	2.3	U	5	U	80.2	U	120		52.2	U	343		211		1.5	U	2.3	U	80.2	U
		Q1	39	2.3	U	5	U	80.2	U	155		52.2	U	470		404		1.5	U	2.3	U	80.2	U
		Q2	28	2.3	U	5	U	80.2	U	174		52.2	U	517		1.4	J	1.5	U	2.4	J	80.2	U
		Q2	3	3.1	J	5	U	80.2	U	155		52.2	U	453		9.7		2	J	3.8	J	80.2	U
		Q2	40	2.3	U	5	U	80.2	U	194		52.2	U	579		595		1.5	U	2.3	U	80.2	U
	E4	Q1	3	3.3	J	5	U	80.2	U	83.6		261	U	208		28.9		1.9	J	2.3	U	80.2	U
		Q1	6	3.2	J	5	U	80.2	U	87.7		261	U	220		36.7		1.5	U	2.6	J	91.8	J
		Q1	11	2.3	U	5	U	80.2	U	96.5		261	U	250		96.5		1.5	U	3.9	J	151	J
		Q2	12	2.3	U	5	U	80.2	U	165		52.2	U	477		23.2		3	J	5.6	J	390	
		Q2	3	2.4	J	5	U	80.2	U	162		52.2	U	464		6		1.7	J	3.3	J	210	
		Q2	7	2.3	U	5	U	80.2	U	165		52.2	U	475		24.6		2.2	J	NV		99.9	J
		Q3	13	2.3	U	5	U	80.2	U	169		52.2	U	523		22.8		1.5	U	3.1	J	80.2	U
		Q3	2	3.6	J	5	U	80.2	U	123		52.2	U	359		3.7	J	1.5	U	3.4	J	80.2	U
		Q3	9	2.3	U	5	U	80.2	U	152		52.2	U	463		10.1		1.5	U	2.5	J	80.2	U
		Q4	2	2.3	U	5	U	80.2	U	79.3		52.2	U	208		22.5		1.5	U	2.3	U	177	J
		Q4	9	2.3	U	5	U	80.2	U	94.9		52.2	U	259		37.6		1.5	U	2.3	U	169	J
		Q4	15.5	2.8	J	5	U	80.2	U	131		52.2	U	379		81		1.5	U	5.6	J	174	J

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Chromium, dissolved		Hexavalent Chromium		Aluminum, dissolved		Calcium, dissolved		Iron, dissolved		Magnesium, dissolved		Manganese, dissolved		Vanadium, dissolved		Chromium		Aluminum	
			feet	µg/L		µg/L		µg/L		mg/L		µg/L		mg/L		µg/L		µg/L		µg/L		µg/L	
Transect F	F1	Q1	3	2.3	U	5	U	80.2	U	75.4		52.2	U	175		14.8		1.5	U	2.3	U	80.2	U
		Q1	18	2.3	U	5	U	80.2	U	120		52.2	U	328		143		1.5	U	2.3	U	80.2	U
		Q1	34	2.3	U	5	U	80.2	U	147		52.2	U	426		307		1.5	U	2.3	U	187	J
		Q2	25	2.3	U	5	U	80.2	U	164		52.2	U	494		37.1		3.3	J	2.3	U	80.2	U
		Q2	3	2.3	U	5	U	80.2	U	148		52.2	U	435		4.1	J	3.1	J	2.3	U	80.2	U
		Q2	35	2.3	U	5	U	80.2	U	166		52.2	U	496		63		2.7	J	2.3	U	80.2	U
		Q2-Dup	35	2.3	U	5	U	80.2	U	171		52.2	U	511		73.9		2.7	J	NV		80.2	U
	F2	Q1	3	2.3	U	5	U	80.2	U	69.4		52.2	U	176		8		2	J	2.3	U	80.2	U
		Q1	15	2.3	U	5	U	80.2	U	103		52.2	U	264		88.3		1.5	U	2.3	U	94.1	J
		Q1	42	2.3	U	5	U	80.2	U	182		52.2	U	522		384		1.5	U	2.3	U	299	
		Q2	25	2.3	U	5	U	80.2	U	168		52.2	U	504		11.9		1.8	J	2.3	U	80.2	U
		Q2	3	2.3	U	5	U	80.2	U	147		52.2	U	433		1.7	J	2.6	J	2.3	U	80.2	U
		Q2	43	2.3	U	5	U	80.2	U	185		52.2	U	566		259		2.4	J	2.3	U	80.2	U
		Q3	2	2.3	U	5	U	80.2	U	182		52.2	U	509		11.5		1.5	U	2.3	U	80.2	U
		Q3	20	2.3	U	5	U	80.2	U	166		52.2	U	508		23.6		1.5	U	2.3	U	80.2	U
		Q3	40	2.3	U	5	U	80.2	U	198		52.2	U	608		4.9	J	1.5	U	2.3	U	80.2	U
		Q4	2.5	2.3	U	5	U	80.2	U	123		52.2	U	348		48.7		1.5	U	2.3	U	152	J
		Q4	22	2.3	U	5	U	80.2	U	158		54.6	J	469		75.3		1.5	U	3.8	J	357	
		Q4	43	2.3	U	5	U	80.2	U	170		52.2	U	509		81.8		1.5	U	2.3	U	395	
	F3	Q1	3	2.3	U	5	U	80.2	U	67.8		52.2	U	167		8.9		1.5	U	2.3	U	80.2	U
		Q1	16	2.3	U	5	U	80.2	U	109		52.2	U	305		158		1.5	U	2.3	U	88.2	J
		Q1	30	2.3	U	5	U	80.2	U	156		52.2	U	459		317		1.5	U	2.3	U	117	J
		Q2	20	2.3	U	5	U	80.2	U	163		52.2	U	485		2.3	J	2.3	J	2.3	U	80.2	U
		Q2	3	2.3	U	5	U	80.2	U	146		52.2	U	427		4.1	J	3	J	2.3	U	80.2	U
		Q2	35	2.3	U	5	U	80.2	U	169		52.2	U	512		3.1	J	2.4	J	2.3	U	80.2	U
	F4	Q1	3	2.3	U	5	U	80.2	U	74.1		52.2	U	201		23.3		1.5	U	2.3	U	88.3	J
		Q1	15	2.3	U	5	U	80.2	U	78.1		52.2	U	221		48.2		1.5	U	2.3	U	135	J
		Q1-Dup	15	2.3*	U	5*	U	80.2	U	76.7		52.2	U	212		42.7		1.5	U	2.3*	U	153	J
		Q1	24	2.3	U	5	U	80.2	U	91.8		68.5	J	277		148		1.5	U	3.8	J	291	
		Q2	10	2.3	U	5	U	80.2	U	150		52.2	U	465		4.4	J	3.4	J	2.3	U	103	J
		Q2	24	2.3	U	5	U	80.2	U	172		52.2	U	544		10.3		2.1	J	2.3	U	164	J
		Q2	3	2.3	U	5	U	80.2	U	147		52.2	U	456		2.3	J	2.7	J	2.3	U	80.2	U
		Q3	15	2.3	U	5	U	80.2	U	173		52.2	U	459		23.1		1.5	U	2.3	U	131	J
		Q3	2	2.3	U	5	U	80.2	U	113		52.2	U	279		3.7	J	1.5	U	2.3	U	122	J
		Q3	25	2.3	U	5	U	80.2	U	192		52.2	U	516		35		1.5	U	2.3	U	157	J
		Q4	2.5	2.3	U	5	U	80.2	U	119		81.1	J	354		51.2		1.7	J	2.3	U	99.9	J
		Q4	15	2.3	U	5	U	80.2	U	133		52.2	U	412		65.7		1.5	U	2.3	U	111	J
		Q4	26	2.3	U	5	U	80.2	U	159		52.2	U	512		70.8		1.5	U	2.3	U	240	
Transect G	G1	Q1	17	2.3	U	5	U	80.2	U	83.8		52.2	U	222		26.3		2.1	J	2.3	U	80.2	U
		Q1	3	2.3	U	5	U	80.2	U	58.1		52.2	U	136		0.76	J	1.9	J	2.3	U	80.2	U
		Q1	32	2.3	U	5	U	80.2	U	141		52.2	U	419		188		2.1	J	2.3	U	80.2	U
		Q2	20	2.3	U	5	U	80.2	U	159		52.2	U	501		27.7		2.1	J	2.3	U	80.2	U
		Q2	3	2.3	U	5	U	80.2	U	134		52.2	U	412		3.6	J	2.7	J	3	J	80.2	U
		Q2	35	2.3	U	5	U	80.2	U	170		52.2	U	536		173		1.9	J	3.3	J	80.2	U
	G2	Q1	19.5	2.3	U	5	U	80.2	U	97.6		52.2	U	272		74.3		3	J	2.3	U	80.2	U
		Q1	3	2.3	U	5	U	80.2	U	64.9		52.2	U	160		1.4	J	1.5	J	2.3	U	80.2	U
		Q1	37	2.3	U	5	U	80.2	U	164		52.2	U	498		214		1.5	U	2.3	U	80.2	U
		Q2	20	2.3	U	5	U	80.2	U	136		52.2	U	445		0.84	U	1.6	J	2.3	U	80.2	U
		Q2	3	2.3	U	5	U	80.2	U	130		52.2	U	410		0.84	U	1.6	J	2.3	U	80.2	U
		Q2	37	2.3	U	5	U	80.2	U	153		52.2	U	521		386		1.5	U	2.3	U	80.2	U
		Q3	18	2.3	U	5	U	80.2	U	231		52.2	U	411		37.5		1.5	U	2.3	U	80.2	U
		Q3	2	2.3	U	5	U	80.2	U	138		52.2	U	384		10.7		1.5	U	3.5	J	80.2	U
		Q3	38	2.3	U	5	U	80.2	U	273		52.2	U	472		17.5		1.5	U	4.6	J	678	
		Q4	2.5	2.3	U	5	U	80.2	U	102		52.2	U	281		28.4		1.5	U	2.3	U	132	J
		Q4	20	2.3	U	5	U	80.2	U	140		52.2	U	404		84.7		1.5	U	2.3	U	120	J
		Q4	39	2.6	J	5	U	80.2	U	160		52.2	U	473		146		1.5	U	2.3	U	113	J

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Chromium, dissolved		Hexavalent Chromium		Aluminum, dissolved		Calcium, dissolved		Iron, dissolved		Magnesium, dissolved		Manganese, dissolved		Vanadium, dissolved		Chromium		Aluminum	
			feet	µg/L		µg/L		µg/L		mg/L		µg/L		mg/L		µg/L		µg/L		µg/L		µg/L	
Transect G	G3	Q1	22	2.3	U	5	U	80.2	U	92.5		52.2	U	249		113		1.5	U	2.3	U	140	J
		Q1	2	2.3	U	5	U	80.2	U	49.1		52.2	U	110		0.62	J	1.5	U	2.3	U	80.2	U
		Q1	41.5	2.3	U	5	U	80.2	U	174		52.2	U	516		240		2.3	J	2.3	U	131	J
		Q2	25	2.3	U	5	U	80.2	U	145		52.2	U	466		17.5		1.5	U	2.3	U	80.2	U
		Q2	3	2.3	U	5	U	80.2	U	131		52.2	U	414		0.84	U	1.5	U	2.3	U	80.2	U
		Q2	40	2.3	U	5	U	80.2	U	156		52.2	U	512		661		1.5	U	2.3	U	80.2	U
	G4	Q1	14.5	2.3	U	5	U	80.2	U	78.9		52.2	U	206		30.7		1.5	U	2.3	U	80.2	U
		Q1	27	2.3	U	5	U	80.2	U	123		52.2	U	355		143		1.5	U	2.3	U	114	J
		Q1	3	2.3	U	5	U	80.2	U	55.8		52.2	U	129		1.2	J	1.5	U	2.3	U	80.2	U
		Q2	13	2.3	U	5	U	80.2	U	166		52.2	U	463		0.84	U	2.7	J	2.3	U	80.2	U
		Q2	24	2.3	U	5	U	80.2	U	184		52.2	U	525		50.1		2.9	J	4	J	382	
		Q2	3	2.3	U	5	U	80.2	U	156		52.2	U	435		0.84	U	3	J	2.3	U	80.2	U
		Q3	17	2.3	U	5	U	80.2	U	203		52.2	U	594		31.6		1.5	U	2.3	U	80.2	U
		Q3	2	2.3	U	5	U	80.2	U	114		52.2	U	304		6.7		1.5	U	3.8	J	80.2	U
		Q3	34	2.3	U	5	U	80.2	U	333		52.2	U	417		21.6		1.5	U	2.3	U	80.2	U
		Q4	2.5	2.3	U	5	U	80.2	U	106		52.2	U	294		31.6		1.5	U	2.3	U	131	J
		Q4	17	2.3	U	5	U	80.2	U	132		52.2	U	376		63.2		1.5	U	2.3	U	107	J
		Q4	35	2.3	U	5	U	80.2	U	155		52.2	U	457		132		1.5	U	2.3	U	156	J
Transect H	H1	Q1	15	2.3	U	5	U	80.2	U	83.7		52.2	U	221		50		1.5	U	2.3	U	80.2	U
		Q1	28	2.3	U	5	U	80.2	U	140		52.2	U	409		220		1.5	U	2.3	U	80.2	U
		Q1	3	2.3	U	5	U	80.2	U	59.1		52.2	U	141		2	J	1.9	J	2.3	U	80.2	U
		Q2	22	2.3	U	5	U	80.2	U	148		52.2	U	453		1.6	J	2.8	J	2.3	U	86	J
		Q2	3	2.3	U	5	U	80.2	U	143		52.2	U	439		5.6		3.3	J	2.3	U	80.2	U
		Q2	35	2.3	U	5	U	80.2	U	166		52.2	U	518		309		3.5	J	2.3	U	80.2	U
		Q3	1.5	3.6	J	5	U	80.2	U	182		52.2	U	498		33.6		1.5	U	2.5	J	80.2	U
		Q3	16.5	2.7	J	5	U	80.2	U	185		52.2	U	510		25.5		1.5	U	2.3	U	80.2	U
		Q3-Dup	16.5	2.6*	J	5*	U	80.2	U	181		52.2	U	499		25		1.5	U	2.3*	U	80.2	U
		Q3	32.5	2.3	U	5	U	80.2	U	180		52.2	U	524		34.7		1.5	U	2.3	U	80.2	U
		Q4	2.5	2.3	J	5	U	80.2	U	94.5	J	75.9	J	253	J	35.8		1.8	B	4.2	J	109	J
		Q4	18	2.3	U	5	U	80.2	U	132	J	52.2	U	368	J	49.4		1.5	U	2.3	U	147	J
		Q4	34.5	2.3	U	5	U	80.2	U	181	J	52.2	U	530	J	93.5		1.5	U	2.3	U	255	
	H2	Q1	16	2.3	U	5	U	80.2	U	86.7		52.2	U	234		45.1		1.5	U	2.3	U	80.2	U
		Q1	3	2.3	U	5	U	80.2	U	60		52.2	U	144		2.8	J	1.5	U	2.3	U	80.2	U
		Q1	30	2.3	U	5	U	80.2	U	153		52.2	U	457		171		1.5	U	2.3	U	80.2	U
		Q2	25	2.3	U	5	U	80.2	U	154		52.2	U	479		10.5		2.2	J	2.3	U	80.2	U
		Q2	3	2.3	U	5	U	80.2	U	140		52.2	U	425		1.8	J	2.9	J	2.3	U	80.2	U
		Q2	35	2.3	U	5	U	80.2	U	173		52.2	U	546		597		2.7	J	2.3	U	80.2	U
	H3	Q1	16	2.3	U	5	U	80.2	U	91.4		52.2	U	240		35.5		1.5	U	2.3	U	80.2	U
		Q1	3	2.3	U	5	U	80.2	U	66.1		52.2	U	157		2.7	J	1.5	U	2.3	U	80.2	U
		Q1	30	2.3	U	5	U	80.2	U	141		52.2	U	419		163		1.5	U	2.3	U	80.2	U
		Q2	22	2.3	U	5	U	80.2	U	154		52.2	U	474		17.1		1.5	J	2.3	U	80.2	U
		Q2	3	2.3	U	5	U	80.2	U	141		52.2	U	425		6.1		3.1	J	2.3	U	80.2	U
		Q2	36	2.3	U	5	U	80.2	U	175		52.2	U	540		295		3.5	J	2.3	U	80.2	U
	H4	Q1	18	2.3	U	5	U	80.2	U	91.3		52.2	U	247		81.7		1.5	U	2.3	U	80.2	U
		Q1	3	2.3	U	5	U	80.2	U	57.5		52.2	U	143		1.4	J	1.5	U	2.3	U	80.2	U
		Q1	34	2.3	U	5	U	80.2	U	157		52.2	U	479		151		1.5	U	2.6	J	80.2	U
		Q2	20	2.3	U	5	U	80.2	U	158		52.2	U	484		4.8	J	1.8	J	2.3	U	255	
		Q2	3	2.3	U	5	U	80.2	U	146		52.2	U	436		3.2	J	2	J	2.3	U	80.2	U
		Q2	38	2.3	U	5	U	80.2	U	188		52.2	U	583		657		1.5	U	2.3	U	178	J
		Q3	19	2.3	U	5	U	80.2	U	180		52.2	U	499		26.1		1.5	U	2.3	U	80.2	U
		Q3	2	2.3	U	5	U	80.2	U	180		52.2	U	497		24.5		1.5	U	2.3	U	80.2	U
		Q3	38	2.3	U	5	U	80.2	U	191		52.2	U	537		24.5		1.5	U	2.7	J	85.8	J
		Q4	2.5	2.3	U	5	U	80.2	U	111		52.2	U	302		30.8		1.5	U	2.3	U	80.2	U
		Q4	19	2.3	U	5	U	80.2	U	125		52.2	U	353		45.1		1.5	U	2.3	U	80.2	U
		Q4	40	2.3	U	5	U	80.2	U	154		66.7	J	448		84.5		3.1	J	2.3	U	80.2	U

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Chromium, dissolved		Hexavalent Chromium		Aluminum, dissolved		Calcium, dissolved		Iron, dissolved		Magnesium, dissolved		Manganese, dissolved		Vanadium, dissolved		Chromium		Aluminum	
			feet	µg/L		µg/L		µg/L		mg/L		µg/L		mg/L		µg/L		µg/L		µg/L		µg/L	
Transect I	I1	Q1	2.1	2.3	U	5	U	80.2	U	59.8		52.2	U	145		3.5	J	1.5	U	21.3		460	
		Q2	2	2.3	U	5	U	80.2	U	147		52.2	U	439		4.5	J	1.6	J	2.3	U	80.2	U
		Q2	4	2.3	U	5	U	80.2	U	145		52.2	U	434		5.3		1.8	J	2.3	U	80.2	U
		Q3	1.5	2.3	J	5	U	80.2	U	171		52.2	U	484		20.2		1.5	U	3	J	80.2	U
		Q4	2.1	2.3	U	5	U	80.2	U	92*	J	52.2	U	234*	J	44.3*		1.5	U	2.8	J	202*	
		Q4-Dup	2.1	2.3*	U	5*	U	80.2*	U	97.5	J	52.2*	U	246	J	46		1.5*	U	2.7*	J	218	
	I2	Q1	3	2.3	U	5	U	80.2	U	60.1		52.2	U	146		2.2	J	1.5	U	2.3	U	125	J
		Q1	7	2.3	U	5	U	80.2	U	61.4		52.2	U	148		3.5	J	1.5	U	2.3	U	145	J
		Q2	3	2.3	U	5	U	80.2	U	147		52.2	U	441		3.7	J	2.1	J	2.3	U	80.2	U
		Q2	5.5	2.3	U	5	U	80.2	U	145		52.2	U	438		4.4	J	1.7	J	2.3	U	80.2	U
		Q2	9	2.3	U	5	U	80.2	U	146		52.2	U	436		5.1		1.8	J	2.3	U	80.2	U
		Q3	2	2.9	J	5	U	80.2	U	181		52.2	U	506		28.6		1.5	U	2.3	U	80.2	U
		Q3	6	2.3	U	5	U	80.2	U	181		52.2	U	502		27.2		1.9	J	2.3	J	80.2	U
		Q4	2.5	2.3	U	5	U	80.2	U	99.2	J	52.2	U	254	J	42.5		1.5	U	2.3	U	201	
		Q4	7	2.3	U	5	U	87.7	J	105		52.2	U	281	J	33.2		1.5	U	2.3	U	170	J
	I3	Q1	3	2.3	U	5	U	80.2	U	59.7		52.2	U	143		2.8	J	1.5	U	2.3	U	159	J
		Q1	5.3	2.3	U	5	U	80.2	U	60.2		52.2	U	145		4.3	J	1.5	U	2.3	U	135	J
		Q1	8.5	2.3	U	5	U	80.2	U	68.2		52.2	U	168		27.8		1.5	U	3.7	J	289	
		Q2	3	2.3	U	5	U	80.2	U	140		52.2	U	422		19		2.3	J	3.3	J	80.2	U
		Q2	5.5	2.3	U	5	U	80.2	U	137		52.2	U	418		20.4		2.3	J	2.3	U	80.2	U
		Q2	9	2.3	U	5	U	80.2	U	139		52.2	U	423		4.4	J	2.3	J	2.3	U	80.2	U
		Q3	2	2.3	U	5	U	80.2	U	182		52.9	J	504		28		1.5	U	2.3	U	80.2	U
		Q3	6.5	2.3	U	5	U	80.2	U	182		52.2	U	504		24.9		1.5	U	2.3	U	80.2	U
		Q4	2.5	2.3	U	5	U	80.2	U	97	J	52.2	U	249		32.2		1.5	U	2.3	U	211	
		Q4	7.5	2.3	U	5	U	80.2	U	102	J	52.2	U	274	J	34.9		1.5	U	2.3	U	187	J
	I4	Q1	3	2.3	U	5	U	80.2	U	60.7		52.2	U	145		1.8	J	1.5	U	2.3	U	103	J
		Q1	6	2.3	U	5	U	80.2	U	60.8		52.2	U	147		1.6	J	1.5	U	2.3	U	97	J
		Q2	3	2.3	U	5	U	80.2	U	134		52.2	U	404		19.5		1.7	J	2.3	U	90.8	J
		Q2	5.5	2.3	U	5	U	80.2	U	134		52.2	U	405		20		2.6	J	3	J	109	J
		Q2	9	2.3	U	5	U	80.2	U	138		52.2	U	413		27.4		1.5	U	4.1	J	165	J
		Q3	1.5	2.3	U	5	U	80.2	U	175		54.4	J	489		26.9		1.5	U	2.8	J	80.2	U
		Q3	6.5	2.3	U	5	U	80.2	U	174		52.2	U	485		27.9		1.5	U	4	J	97.4	J
		Q4	2.5	2.3	U	5	U	80.2	U	95.1	J	52.2	U	238	J	41.5		1.5	U	2.3	U	189	J
		Q4	7.5	2.3	U	5	U	80.2	U	99.3		52.2	U	267		29.1		1.5	U	2.3	U	187	J
Transect J	J1	Q4	0.8	2.3	U	5	U	80.2	U	127		52.2	U	320		31.2		1.8	J	22.8		805	
	J2	Q4	2	2.3	U	5	U	80.2	U	129		52.2	U	325		45.3		1.5	U	2.7	J	216	
	J3	Q4	2.2	2.3	U	5	U	80.2	U	129		52.2	U	324		43.3		1.5	U	2.8	J	274	
	J4	Q4	1	2.3	U	5	U	80.2	U	120		52.2	U	301		32.2		2.4	J	16.9		299	

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Calcium	Iron		Magnesium	Manganese		Vanadium		Acidity As CaCO3	Ferrous Iron		Hardness, total	Organic Carbon, dissolved		Organic Carbon, total	
			feet	mg/L	µg/L		mg/L	µg/L		µg/L		mg/L	mg/L		mg/L	mg/L		mg/L	
Transect A	A1	Q1	2	71.1	556		192	66.4		1.7	J	NV	0.023	J	NV	1.7	J	2.1	
		Q2	2	160	174	J	488	NV		4.5	J	NV	NV		NV	3.8		2.6	
		Q2	4	159	254		485	525	U	3.6	J	NV	0.011	J	2,620	3.7		2.7	
		Q3	1.5	165	490		471	54.8		1.5	U	2,530	0.026	J	2,530	1.7	J	2.6	
		Q4	1.5	112	52.2	U	277	40.1		1.5	U	NV	NV		NV	1.4	J	1.8	J
		Q4	4	104	52.2	U	289	36.7		1.6	J	NV	0.014	J	1,660	1.2	J	1.8	J
	A2	Q1	2	70.6	263		191	57.8		1.5	U	NV	0.008	U	NV	1.9	J	2.1*	
		Q1-Dup	2	71.9	236		178	51.4		1.5	U	NV	.008*	U	NV	1.6*	J	2.4	
		Q2	1.5	164	207		506	NV		3.9	J	NV	NV		NV	3.6		2.5	
		Q2	3.5	161	222		493	525	U	3.6	J	NV	0.0089	J	NV	3.5		2.8	
		Q3	2	108	52.2	U	267	11.9		1.5	U	NV	0.008	U	NV	2	J	2.8	
		Q4	2.4	116	52.2	U	311	50.9		1.5	J	NV	0.015	J	NV	1.4	J	1.7	J
	A3	Q1	2	74.1	362		197	73.5		1.6	J	NV	0.01	J	NV	1.8	J	2.3	
		Q2	2.5	157	202		482	525	U	2.5	J	NV	0.008	U	NV	3.4		2.6	
		Q3	2	120	52.2	U	299	13.4		1.5	U	NV	0.0095	J	NV	1.6	J	2.9	
		Q4	2.3	115*	52.2	U	304	52.4*		1.5*	U	NV	0.012	J	NV	1.5	J	1.7	J
		Q4-Dup	2.3	117	52.2*	U	301*	53		2.8	J	NV	0.0095*	J	NV	1.2*	J	1.7*	J
	A4	Q1	2	73	229		194	86		1.5	U	NV	0.008	U	NV	1.8	J	2.3	
		Q2	2.2	162	213		500	525	U	3.4	J	NV	0.008*	U	NV	3.7		2.9	
		Q2 - Dup	2.2	160	213		490	525*	U	2.5	J	NV	0.0089	J	NV	3.3*		2.3*	
		Q3	2	119	52.2	U	300	13		1.5	U	NV	0.023	J	NV	1.8	J	2.8	
		Q4	2.5	115	52.2	U	314	50.9		1.5	U	NV	0.0095	J	NV	1.3	J	1.7	J
Transect B	B1	Q1	2.5	75.4	167	J	199	63		1.5	U	NV	0.008	U	NV	1.8	J	2.2	
		Q2	2	157	218		460	NV		2.7	J	NV	NV		NV	1.7	J	3.2	
		Q2	5	159	790		464	525	U	3.2	J	NV	0.02	J	2,480	1.7	J	2.7	
		Q3	2	153	86.8	J	457	17.7		1.5	U	NV	NV		NV	1	U	2.2	
		Q3	6.5	NV	NV		NV	NV		NV		2700*	0.008	U	2,700	1*	U	2.3	
		Q3-Dup	6.5	NV	NV		NV	NV		NV		2,700	0.008*	U	2,700	1	U	2.2*	
		Q3	7	152	83.2	J	459	18.3		1.5	U	NV	NV		NV	NV		NV	
		Q4	3	69	302		171	30.9		1.5	U	NV	NV		NV	1.5	J	2	
		Q4	7	90.9	270		244	40.3		1.5	U	NV	0.014	J	1,260	1.1	J	1.9	J
	B2	Q1	3	79.2	163	J	210	90.8		1.5	U	NV	NV		NV	1.9	J	1.9	J
		Q1	7	82.2	173	J	224	105		1.5	U	NV	0.008	U	NV	1.6	J	2	
		Q2	3	156	232		456	NV		3	J	NV	NV		NV	1.6	J	2.7	
		Q2	6	161	343		473	525	U	2.2	J	NV	0.008	U	NV	1.6	J	2.7	
		Q3	2	155	84.1	J	459	17		1.5	U	NV	NV		NV	1	U	2.2	
		Q3	8	NV	NV		NV	NV		NV		NV	0.008	U	NV	1	U	2.3	
		Q3	9	154	80.3	J	463	19.4		1.5	U	NV	NV		NV	NV		NV	
		Q4	3	71.9	170	J	155	31.4		1.5	U	NV	NV		NV	1.8	J	2.1	
		Q4	9	119	436		268	69.4		3.9	J	NV	0.027	J	NV	1.3	J	1.7	J
	B3	Q1	3	76.3	247		184	63.3		1.5	U	NV	NV		NV	1.9	J	2	
		Q1	7	70.8	460		196	71.5		1.5	U	NV	0.52		NV	1	U	1.9	J
		Q2	3	159	253		457	NV		3.6	J	NV	NV		NV	1.7	J	2.9	
		Q2	7	168	251		479	525	U	3.1	J	NV	0.008	U	NV	1.7	J	3	
		Q3	1.5	168	157	J	485	22.1		1.5	U	NV	NV		NV	1.5	J	2.5	
		Q3	10	179	135	J	508	25.4		1.5	U	NV	NV		NV	1.4	J	2.4	
		Q3	5.5	174	124	J	497	24		1.5	U	NV	0.021	J	NV	1.6	J	2.3	
		Q4	3	72.9	181	J	157	34.2		2.2	J	NV	NV		NV	1.4	J	2	J
		Q4	9.5	120	124	J	297	64.7		1.8	J	NV	0.014	J	NV	1.3	J	1.7	J

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Calcium	Iron		Magnesium	Manganese		Vanadium		Acidity As CaCO3	Ferrous Iron		Hardness, total	Organic Carbon, dissolved		Organic Carbon, total	
			feet	mg/L	µg/L		mg/L	µg/L		µg/L		mg/L	mg/L		mg/L	mg/L		mg/L	
Transect B	B4	Q1	3	75.5	52.2	U	179	22.9		1.5	U	NV	NV		NV	1.7	J	1.6	J
		Q1	6	73.6	284		180	70.9		1.5	U	NV	0.041	J	NV	2.7		2.4	
		Q1-Dup	6	74	363		181	74.1		1.5	U	NV	.035*	J	NV	2.4*		2.1*	
		Q2	3	157	180	J	468	NV		3.2	J	NV	NV		NV	1.8	J	3.3	
		Q2	5.5	159	211		472	525	U	4.7	J	NV	0.008*	U	NV	1.9	J	4.1	
		Q2-Dup	5.5	158	204		465	525*	U	4.2	J	NV	0.014	J	NV	1.7*	J	2.9*	
		Q2	8.5	159	249		476	NV		4.4	J	NV	NV		NV	1.5	J	3.4	
		Q3	1.5	174	125	J	490	21.5		1.5	U	NV	NV		NV	1.2	J	2.3	
		Q3	10.4	184	344		519	42.1		1.5	U	NV	NV		NV	1.4	J	2.3	
		Q3	5.5	177	151	J	503	30.1		1.5	U	NV	0.019	J	NV	1.2	J	2.3	
		Q4	1.5	80.3	224		211	34.1		1.5	U	NV	NV		NV	1.7	J	2.1	
		Q4	5.5	97.7	277		264	43.1		2	J	NV	0.008	U	NV	1.2	J	1.8	J
		Q4	10	118	226		332	56.9		1.5	U	NV	NV		NV	1.2	J	1.8	J
	B5	Q4	2.5	123	203		325	49.7		1.5	U	NV	NV		NV	1.2	J	1.7	J
		Q4	7	121	108	J	326	50.4		1.8	J	NV	0.008	U	NV	1.2	J	1.6	J
Transect C	C1	Q1	2	71.8	269		173	43.3		1.5	U	NV	0.027	J	NV	2.7		3.1	
		Q2	2	149	572		480	NV		4.2	J	NV	NV		NV	1.7	J	2.2	
		Q2	4	158	652		499	525	U	4.9	J	NV	0.017	J	2,580	1.6	J	2.1	
		Q2-Dup	4	156	344		502	525*	U	3.6	J	NV	0.017*	J	2570*	1.5*	J	2*	J
		Q3	2	179	112	J	492	26		1.5	U	2,760	0.008	U	2,760	1.5	J	2.1*	
		Q3-Dup	2	178	101	J	490	25.8		1.5	U	2760*	0.008*	U	2,760	1.3*	J	2.3	
		Q4	2.2	65.2	121	J	142	32.2		1.5	U	NV	0.0095	J	802	1.5	J	1.9	J
	C2	Q1	2	73	120	J	175	42		1.5	U	NV	NV		NV	2.3		3.4	
		Q1	4	71.5	121	J	170	41.3		1.5	U	NV	0.019	J	NV	2.4		3.4	
		Q2	2	155	251		495	NV		3.6	J	NV	NV		NV	1.4	J	2.2	
		Q2	5	154	466		494	525	U	3.5	J	NV	0.008	U	NV	1.8	J	2.5	
		Q3	2	156	101	J	475	18.3		1.5	U	NV	NV		NV	1	U	2.4	
		Q3	5.5	NV	NV		NV	NV		NV		NV	0.008	U	NV	1	U	2.5	
		Q3	6	155	81.5	J	466	18.4		1.5	U	NV	NV		NV	NV		NV	
		Q4	3	61	162	J	143	32.9		2.5	J	NV	0.008	U	NV	1.5	J	1.9	J
	C3	Q1	3	71	125	J	170	41.3		1.5	U	NV	NV		NV	2.9		3.2	
		Q1	6	71.5	106	J	171	42.2		1.5	U	NV	0.049	J	NV	3.3		3.2	
		Q2	2	156	250		500	NV		2.8	J	NV	NV		NV	1.3	J	1.9	J
		Q2	5	154	195	J	494	525	U	3.5	J	NV	0.008	U	NV	1.5	J	2.3	
		Q2	8	154	283		494	NV		3.7	J	NV	NV		NV	1.5	J	2.2	
		Q3	2	104	52.2	U	263	11.1		1.5	U	NV	NV		NV	1.8	J	2.5	
		Q3	8	138	95	J	357	16.9		1.5	U	NV	0.0085	J	NV	1.3	J	2.4	
		Q4	2	64.4	170	J	141	33.2		1.5	J	NV	NV		NV	1.5	J	1.9	J
		Q4	8.5	97.6	163	J	249	55.8		1.5	U	NV	0.017	J	NV	1.2	J	1.8	J
	C4	Q1	3	73.5	102	J	174	40.7		1.5	U	NV	NV		NV	2.2		3.5	
		Q1	7	71.4	119	J	174	40.4		1.5	U	NV	0.051	J	NV	2.5		3.4	
		Q2	2	155	153	J	498	NV		3.4	J	NV	NV		NV	1.4	J	2.3	
		Q2	5.5	152	153	J	493	525	U	3.5	J	NV	0.008	U	NV	1.5	J	2.2	
		Q2	9	163	223		529	NV		3.6	J	NV	NV		NV	1.9	J	2.6	
		Q3	2	109	52.2	U	270	11.7		1.5	U	NV	NV		NV	2		2.8	
		Q3-Dup	2	108	52.2	U	284	12.3		2.1	J	NV	NV		NV	1.7*	J	2.7*	
		Q3	8	130	52.2	U	336	14.7		1.5	U	NV	0.008	U	NV	1.4	J	2.4	
		Q4	3	71.1	137	J	160	34.8		4.5	J	NV	NV		NV	1.4	J	2	
		Q4	9	112	144	J	277	67.8		3.3	J	NV	0.022	J	NV	1.3	J	1.8	J

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Calcium	Iron		Magnesium	Manganese		Vanadium		Acidity As CaCO3	Ferrous Iron		Hardness, total	Organic Carbon, dissolved		Organic Carbon, total	
			feet	mg/L	µg/L		mg/L	µg/L		µg/L		mg/L	mg/L		mg/L	mg/L		mg/L	
Transect D	D1	Q1	3	87.7	179	J	211	52.3		1.5	U	NV	NV		NV	2.5		1.7	J
		Q1	18	154	229		422	218		1.5	U	NV	0.032	J	NV	1	J	1.8	J
		Q1	34	218	250		347	362		1.5	U	NV	NV		NV	1	U	1.7	J
		Q2	0.3	182	128	J	542	NV		3	J	NV	NV		NV	2.2		4.3	
		Q2	20	176	134	J	533	525	U	2.5	J	NV	0.019	J	NV	1.5	J	3.5	
		Q2	40	194	74.3	J	616	NV		1.7	J	NV	NV		2,790	1	U	2.6	
		Q3	1.5	178	149	J	495	30.7		1.5	U	NV	NV		NV	1.4	J	2.3	
		Q3	19	175	204		486	36.3		1.5	U	NV	0.008	U	NV	1.2	J	2.1	
		Q3	37.5	194	362		541	42.8		1.5	U	2,830	NV		2,830	1.1	J	2.1	
		Q4	2.5	82.5	251		218	36.2		1.5	U	NV	NV		NV	1.5	J	2	J
		Q4	20	144	180	J	420	115		1.5	U	NV	0.008	U	NV	1	U	1.5	J
		Q4	40.5	178	379		533	327		1.5	U	NV	NV		2,870	1	U	1.4	J
	D2	Q1	3	52.9	80	J	129	25.1		1.5	U	NV	NV		NV	1	U	2.2	
		Q1	22	102	217		273	129		1.5	U	NV	0.041	J	NV	1	U	2.3	
		Q1	42	168	178	J	516	316		1.5	U	NV	NV		NV	1	U	2.6	
		Q2	22	167	196	J	510	525	U	2.6	J	NV	0.019	J	NV	1.2	J	3.3	
		Q2	3	154	443		463	NV		5.2		NV	NV		NV	1.7	J	4.3	
		Q2	42	207	60.2	J	539	NV		1.6	J	NV	NV		NV	1.7	J	3.7	
		Q3	2	118	61.9	J	314	12.2		1.5	U	NV	NV		NV	1.1	J	2.6	
		Q3	22	184	92	J	525	32.6		1.7	J	NV	0.008	U	NV	1	U	2	J
		Q3	42	200	243		573	69		1.8	J	NV	NV		NV	1	U	1.9	J
		Q4	2.5	79.6	293		208	35.7		1.5	U	NV	NV		NV	1.5	J	2	
		Q4	21	145	225		422	109		1.5	U	NV	0.0095	J	NV	1	J	1.7	J
		Q4	43.5	176	458		529	361		2	J	NV	NV		NV	1	U	1.4	J
	D3	Q1	3	77.4	199	J	172	53.9		1.5	U	NV	NV		NV	2.3		1.9	J
		Q1	23	114	232		303	142		1.5	U	NV	0.054	J	NV	1.5	J	1.5	J
		Q1	40	169	273		477	410		1.5	U	NV	NV		NV	1	U	2	J
		Q2	25	174	109	J	512	525	U	2.1	J	NV	0.008	U	NV	1.6	J	2.1	
		Q2	3	155	153	J	453	NV		1.8	J	NV	NV		NV	1.8	J	2.5	
		Q2	39	198	138	J	592	NV		1.5	U	NV	NV		NV	1	J	1.7	J
		Q3	2	116	106	J	308	13.9		1.5	U	NV	NV		NV	1.1	J	2.7	
		Q3	22	177	158	J	528	32.5		1.5	U	NV	0.016	J	NV	1	U	1.8	J
		Q3	40	187	137	J	564	28.4		1.5	U	NV	NV		NV	1	U	2.2	
		Q4	2.5	78.9*	52.2*	U	206*	22.3*		1.5	U	NV	NV		NV	2	J	2.1*	
		Q4-Dup	2.5	90.6	237		241	39		1.5*	U	NV	NV		NV	1.7*	J	2.2	
		Q4	21	140	201		404	98.9		1.8	J	NV	0.024	J	NV	1.1	J	1.7	J
		Q4	42.5	176	287		529	315		1.5	U	NV	NV		NV	1	U	1.5	J
	D4	Q1	3	80	111	J	207	79		1.5	U	NV	NV		NV	1.6	J	2.2	
		Q1	5	77.6	115	J	203	76.5		1.5	U	NV	0.008	U	NV	2.1		2.2	
		Q1-Dup	5	79	112	J	206	78.3		1.5	U	NV	.008*	U	NV	1.4*	J	2.1*	
		Q1	8	79.9	87.1	J	212	81.3		1.5	U	NV	NV		NV	1.8	J	2.1	
		Q2	3	131	279		410	NV		2.8	J	NV	NV		NV	2.5		3.3	
		Q2	5	127	510		423	525	U	3.1	J	NV	0.084	J	NV	1.5	J	2.5	
		Q2	8.5	128	280		407	NV		3.2	J	NV	NV		NV	1.6	J	2.6	
		Q3	2	122	77.9	J	360	11.3		1.5	U	NV	NV		NV	1.2	J	2.5	
		Q3	9	160	134	J	482	27.4		1.5	U	NV	0.011*	J	NV	1	U	2.1*	
		Q3-Dup	9	166	143	J	471	27.1		1.5	U	NV	0.015	J	NV	1*	U	2.2	
		Q4	1.5	81	278		214	35.3		2.3	J	NV	NV		NV	1.7	J	2	
		Q4	5	89.3	227		240	38.7		1.5	U	NV	0.008	U	NV	1.5	J	1.9	J
		Q4	10	128	255		364	77.7		2.1	J	NV	NV		NV	1.4	J	1.7	J

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Calcium	Iron		Magnesium	Manganese		Vanadium		Acidity As CaCO3	Ferrous Iron		Hardness, total	Organic Carbon, dissolved		Organic Carbon, total	
			feet	mg/L	µg/L		mg/L	µg/L		µg/L		mg/L	mg/L		mg/L	mg/L		mg/L	
Transect E	E1	Q1	21.5	93	173	J	252	96		1.5	U	NV	0.008	U	NV	1	J	1.8	J
		Q1	41	168	140	J	503	283		1.5	U	NV	NV		NV	1	U	2	
		Q1	3	48.7	52.2	U	109	19.8		1.5	U	NV	NV		NV	2.1		1.9	J
		Q1-Dup	3	49.5	52.2	U	111	20		1.5	U	NV	NV		NV	2*	J	1.7*	J
		Q2	22	155	253		468	525	U	2.8	J	NV	0.033	J	NV	1.5	J	3.2	
		Q2	3	183	316		551	NV		3.6	J	NV	NV		NV	1.8	J	3.9	
		Q2	42	199	103	J	628	NV		1.5	U	NV	NV		2,950	1	J	2.7	
		Q3	1.5	175	141	J	483	29.9		1.5	U	NV	NV		NV	1.4	J	2.3	
		Q3	17	178	157	J	494	29.4		1.5	U	NV	0.008	U	NV	1.4	J	2	
		Q3	37	193	182	J	537	35.6		1.5	U	2,870	NV		2,870	1.4	J	2.1	
		Q4	2.5	103	242		279	37.1		2	J	NV	NV		NV	1.1	J	1.7	J
		Q4	19	140	408		396,000	108		2	J	NV	0.053	J	NV	1	U	1.7	J
		Q4	43.5	166	451		485	242		2.8	J	NV	NV		2,520	1	U	1.5	J
	E2	Q1	3	65.9	69.9	J	164	34.8		1.5	U	NV	NV		NV	2.6	B	2.5	B
		Q1	22	121	156	J	348	203		1.5	U	NV	0.032	J	NV	1	U	1.5	B
		Q1	42	165	139	J	493	498		1.5	U	NV	NV		NV	1	U	1.7	B
		Q2	22	163	167	J	504	525	U	3.2	J	NV	0.021	J	NV	1.6	J	3.4	
		Q2	3	151	404		450	NV		4.5	J	NV	NV		NV	1	J	4.7	
		Q2	42	197	54.8	J	567	NV		2.4	J	NV	NV		NV	1	U	2.3	
		Q3	2	150	144	J	433	19.7		1.5	U	NV	NV		NV	1.1	J	2.7	
		Q3	22	185	139	J	545	32.1		1.5	U	NV	0.015	J	NV	1	U	1.9	J
		Q3	42	203	250		580	61.9		1.5	U	NV	NV		NV	1	U	1.8	J
		Q4	2.5	98.6*	207		272*	37.1*		1.5	U	NV	NV		NV	1.1	J	1.8*	J
		Q4-Dup	2.5	102	195*	J	282	38.1		1.5*	U	NV	NV		NV	1.1*	J	1.9	J
		Q4	19	130	249		379	87.8		1.5	U	NV	0.02	J	NV	1	U	1.7	J
		Q4	41	161	262		479	190		1.5	U	NV	NV		NV	1	U	1.5	J
	E3	Q1	3	71.7	231		175	44.7		1.6	J	NV	NV		NV	2.2		3.3	
		Q1	25	116	192	J	334	233		1.5	U	NV	0.008	U	NV	1	U	1.3	J
		Q1	39	156	204		477	418		1.5	U	NV	NV		NV	1	U	1.7	J
		Q2	28	172	124	J	510	525	U	1.5	U	NV	0.008	U	NV	1.2	J	1.9	J
		Q2	3	155	199	J	451	NV		2.5	J	NV	NV		NV	1.9	J	2.6	
		Q2	40	196	147	J	587	NV		1.5	U	NV	NV		NV	1.2	J	1.7	J
	E4	Q1	3	76.8	58.9	J	205	69.4		1.5	U	NV	NV		NV	1.6	J	2.1	
		Q1	6	76.2	102	J	216	71.9		1.5	U	NV	0.008	U	NV	1.4	J	2	J
		Q1	11	87.8	288		251	132		1.5	U	NV	NV		NV	1.1	J	1.7	J
		Q2	12	164	740		473	NV		5.3		NV	NV		NV	1.5	J	2.8	
		Q2	3	155	415		460	NV		4.3	J	NV	NV		NV	1.7	J	2.7	
		Q2	7	166	314		479	525	U	3.2	J	NV	0.0099	J	NV	1.7	J	2.8	
		Q3	13	180	340		554	44.7		1.5	U	NV	NV		NV	1	U	2	J
		Q3	2	124	116	J	357	12.6		1.5	U	NV	NV		NV	1.1	J	2.6	
		Q3	9	152	191	J	462	18.3		1.5	U	NV	0.011	J	NV	1.1	J	2.2	
		Q4	2	79.3	276		209	35.8		1.5	U	NV	NV		NV	1.5	J	1.9	J
		Q4	9	82.9	272		220	37.2		1.5	U	NV	0.008	U	NV	1.5	J	1.9	J
		Q4	15.5	126	282		360	79.8		1.5	U	NV	NV		NV	1	U	1.5	J

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Calcium		Iron		Magnesium		Manganese		Vanadium		Acidity As CaCO3		Ferrous Iron		Hardness, total		Organic Carbon, dissolved		Organic Carbon, total	
			feet	mg/L		µg/L		mg/L		µg/L		µg/L		mg/L		mg/L		mg/L		mg/L		mg/L	
Transect F	F1	Q1	3	69.2		98.5	J	164		45.2		1.5	U	NV		NV		NV		2.4		1.9	J
		Q1	18	119		186	J	329		168		1.5	U	NV		0.019	J	NV		1.3	J	1.6	J
		Q1	34	195		333		545		408		1.5	U	NV		NV		NV		1	U	1.6	J
		Q2	25	165		159	J	513		525	U	1.5	J	NV		0.034	J	NV		1.3	J	1.8	J
		Q2	3	150		58.2	J	457		NV		1.5	J	NV		NV		NV		1.6	J	2.3	
		Q2	35	171		217		535		NV		2.5	J	NV		NV		2,850		1.2	J	2	J
		Q2-Dup	35	172		238		544		NV		1.9	J	NV		NV		NV		NV		NV	
	F2	Q1	3	79.6		59.1	J	184		44.9		1.5	U	NV		NV		NV		2.4		1.9	J
		Q1	15	104		146	J	267		124		1.5	U	NV		0.028	J	NV		1.6	J	1.4	J
		Q1	42	181		343		517		407		1.5	U	NV		NV		NV		1	U	1.6	J
		Q2	25	163		141	J	510		525	U	1.7	J	NV		0.027	J	NV		1.5	J	2	
		Q2	3	147		52.2	U	449		NV		1.8	J	NV		NV		NV		1.9	J	2.4	
		Q2	43	180		113	J	572		NV		1.5	U	NV		NV		NV		1.1	J	1.9	J
		Q3	2	105		60.1	J	296		13.5		1.5	U	NV		NV		NV		1.8	J	3	
		Q3	20	167		136	J	524		32		1.5	U	NV		0.02	J	NV		1	U	2	J
		Q3	40	193		170	J	586		23.8		1.9	J	1,560		NV		1,560		1.2	J	2.6	
		Q4	2.5	123		260		346		60		1.5	U	NV		NV		NV		1.4	J	1.9	J
		Q4	22	151		498		445		92.7		2.4	J	NV		0.008	U	NV		1.1	J	1.7	J
		Q4	43	167		510		500		113		1.5	U	NV		NV		2,750		1	U	1.5	J
	F3	Q1	3	68		84.3	J	167		39.8		1.5	U	NV		NV		NV		2.4	B	2.6	B
		Q1	16	105		310		291		174		1.5	U	NV		0.068	J	NV		1.3	B	1.6	B
		Q1	30	157		274		462		344		1.5	U	NV		NV		NV		1	U	1.5	J
		Q2	20	157		136	J	483		525	U	2	J	NV		0.024	J	NV		1.6	J	2.1	
		Q2	3	150		75.1	J	457		NV		1.8	J	NV		NV		NV		1.9	J	2.4	
		Q2	35	172		135	J	540		NV		1.5	J	NV		NV		NV		1.7	J	1.9	J
	F4	Q1	3	73.4		169	J	200		70.4		1.5	U	NV		NV		NV		1.7	J	2	J
		Q1	15	79.2		261		227		105		1.5	U	NV		.008*	U	NV		1.3*	J	1.9	J
		Q1-Dup	15	80.8		273		230		111		1.5	U	NV		0.012	J	NV		1.8	J	1.9*	J
		Q1	24	91.8		520		276		167		1.5	U	NV		NV		NV		1.2	J	1.7	J
		Q2	10	158		127	J	493		525	U	3.4	J	NV		0.048	J	NV		2	J	2.6	
		Q2	24	166		255		522		NV		2.4	J	NV		NV		NV		1.1	J	1.9	J
		Q2	3	146		52.2	U	454		NV		2.6	J	NV		NV		NV		1.8	J	2.4	
		Q3	15	183		135	J	484		36.9		1.5	U	NV		0.008	U	NV		1	U	2.3	
		Q3	2	112		72.3	J	277		12.3		1.5	U	NV		NV		NV		1.4	J	3	
		Q3	25	186		140	J	505		42.2		1.5	U	NV		NV		NV		1	U	2.2	
		Q4	2.5	130		276		358		63		1.5	U	NV		NV		NV		1.4	J	2	J
		Q4	15	140		264		392		75.2		1.5	U	NV		0.008	U	NV		1.1	J	1.8	J
		Q4	26	174		498		505		99.5		1.5	U	NV		NV		NV		1	U	1.4	J
Transect G	G1	Q1	17	79.4		118	J	215		69.3		1.5	U	NV		0.012	J	NV		1	U	2	
		Q1	3	54.3		71.8	J	129		22.5		1.5	U	NV		NV		NV		1.1	J	2.2	
		Q1	32	133		142	J	396		182		1.5	U	NV		NV		NV		1	U	2.4	
		Q2	20	197		222		586		525	U	2.9	J	NV		0.02	J	NV		1.3	J	2.7	
		Q2	3	180		99.2	J	524		NV		1.6	J	NV		NV		NV		1.8	J	4	
		Q2	35	265		214		492		NV		1.7	J	NV		NV		2,910		1	J	2.8	
	G2	Q1	19.5	92.7		98.2	J	249		104		1.5	U	NV		0.021	J	NV		1	U	1.7	J
		Q1	3	58.4		85.4	J	156		30.1		1.5	U	NV		NV		NV		1	U	2	J
		Q1	37	155		183	J	460		217		1.5	U	NV		NV		NV		1	U	2.3	
		Q2	20	133		123	J	438		525	U	1.7	J	NV		0.008	U	NV		1.2	J	2.2	
		Q2	3	128		90.3	J	415		NV		1.7	J	NV		NV		NV		1.5	J	2.2	
		Q2	37	150		96.7	J	514		NV		1.5	U	NV		NV		NV		1	U	1.7	J
		Q3	18	161		176	J	497		38.8		1.5	U	NV		0.028	J	NV		1	J	2.2	
		Q3	2	104		107	J	291		13.2		1.5	U	NV		NV		NV		1.6	J	2.8	
		Q3	38	195		1,460		585		146		5.2		1,540		NV		1,540		1	U	2	J
		Q4	2.5	101		208		281		38.4		1.5	U	NV		NV		NV		1.1	J	1.8	J
		Q4	20	133		249		388		89.4		1.6	J	NV		0.0085	J	NV		1	U	1.6	J
		Q4	39	161		164	J	479		158		1.5	U	NV		NV		2,620		1	U	1.6	J

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Calcium		Iron		Magnesium		Manganese		Vanadium		Acidity As CaCO3		Ferrous Iron		Hardness, total		Organic Carbon, dissolved		Organic Carbon, total	
			feet	mg/L		µg/L		mg/L		µg/L		µg/L		mg/L		mg/L		mg/L		mg/L		mg/L	
Transect G	G3	Q1	22	92.9		243		249		153		1.5	U	NV		0.02	J	NV		1.4	J	1.8	J
		Q1	2	49.5		77.2	J	110		21.7		1.5	U	NV		NV		NV		2.8		1.8	J
		Q1	41.5	174		208		516		245		1.5	U	NV		NV		NV		1	U	1.9	J
		Q2	25	145		94	J	467		525	U	1.6	J	NV		0.008	U	NV		1	J	1.8	J
		Q2	3	128		73.1	J	407		NV		1.6	J	NV		NV		NV		1.7	J	2.4	
		Q2	40	157		89.3	J	525		NV		1.5	U	NV		NV		NV		1	U	1.7	J
	G4	Q1	14.5	76.6		169	J	196		72.7		1.5	U	NV		0.027	J	NV		2.4		1.6	J
		Q1	27	124		243		356		173		1.5	U	NV		NV		NV		1	U	1.7	J
		Q1	3	53		52.2	U	122		25.1		1.5	U	NV		NV		NV		2.1		1.6	J
		Q2	13	159		57	J	443		525	U	3.7	J	NV		0.012	J	NV		1.4	J	2.2	
		Q2	24	191		856		547		NV		5.5		NV		NV		NV		1.2	J	1.9	J
		Q2	3	154		52.2	U	433		NV		3.4	J	NV		NV		NV		2	J	2.9	
		Q3	17	156		172	J	475		35.7		1.5	U	NV		0.024	J	NV		1	U	2.7	
		Q3	2	104		104	J	290		13.4		1.5	U	NV		NV		NV		1.5	J	2.8	
		Q3	34	192		109	J	572		31.4		1.5	U	NV		NV		NV		1	U	1.9	J
		Q4	2.5	103		217		288		40		1.5	U	NV		NV		NV		1.3	J	2	J
		Q4	17	126		233		364		68.2		1.9	J	NV		0.011	J	NV		1	U	1.6	J
		Q4	35	150		265		446		144		2	J	NV		NV		NV		1	U	1.6	J
Transect H	H1	Q1	15	86.7		171	J	229		91		1.5	U	NV		0.014	K	NV		2.5	J	1.9	J
		Q1	28	136		160	J	398		225		1.5	U	NV		NV		NV		2.6	J	1.5	J
		Q1	3	59.1		68.5	J	141		23.9		1.5	U	NV		NV		NV		2.9	J	2.3	J
		Q2	22	146		123	J	442		525	U	2.3	J	NV		0.012	J	NV		1.3	J	3.2	
		Q2	3	142		82.9	J	426		NV		2.3	J	NV		NV		NV		2.1		3.8	
		Q2	35	170		76.3	J	520		NV		2	J	NV		NV		2,640		5.1		8.9	
		Q3	1.5	174		189	J	478		43		1.5	U	NV		NV		NV		1.4	J	2.2	
		Q3	16.5	182		157	J	507		36.7		1.5	U	NV		0.0092	J	NV		1	U	2.1	
		Q3-Dup	16.5	179		148	J	496		35.3		1.5	U	NV		0.008*	U	NV		1*	U	2.1*	
		Q3	32.5	182		150	J	525		46.9		1.5	U	2,890		NV		2,890		1	J	2	
		Q4	2.5	91.8	J	219		246	J	40.4		2.1	B	NV		NV		NV		1.9	J	2	J
		Q4	18	127	J	52.2	U	354	J	54.7		1.5	U	NV		0.0095	J	NV		1.3	J	1.6	J
		Q4	34.5	177	J	140	J	520	J	103		1.5	U	NV		NV		3,020		1	U	1.5	J
	H2	Q1	16	87.8		164	J	237		88.9		1.5	U	NV		0.04	K	NV		2.6	J	1.7	J
		Q1	3	66.1		94.2	J	157		26.3		1.5	U	NV		NV		NV		3.2	J	1.7	J
		Q1	30	138		114	J	410		160		1.5	U	NV		NV		NV		2.5	J	1.7	J
		Q2	25	160		92.1	J	487		525	U	1.8	J	NV		0.008	U	NV		1.5	J	3.8	
		Q2	3	153		99.8	J	454		NV		2.7	J	NV		NV		3.6		1.7	J	NV	
		Q2	35	181		67.8	J	552		NV		1.7	J	NV		NV		NV		1.6	J	5.1	
	H3	Q1	16	87.4		204		233		79.6		1.5	U	NV		0.022	K	NV		2.5	J	1.7	J
		Q1	3	66.2		73.6	J	157		20.9		1.5	U	NV		NV		NV		2.5	J	1.7	J
		Q1	30	137		245		408		167		1.5	U	NV		NV		NV		2.4	J	1.7	J
		Q2	22	163		118	J	495		525	U	2	J	NV		0.008	U	NV		1.1	J	3	
		Q2	3	143		57	J	424		NV		2.1	J	NV		NV		NV		1.8	J	3.4	
		Q2	36	180		119	J	548		NV		2.1	J	NV		NV		NV		1.2	J	2.6	
	H4	Q1	18	88.9		135	J	236		99.8		1.5	U	NV		0.023	J	NV		1.9	J	1.6	J
		Q1	3	57		95.9	J	141		22.5		1.5	U	NV		NV		NV		2.5		1.9	J
		Q1	34	156		200		488		168		1.5	U	NV		NV		NV		2.2		1.6	J
		Q2	20	154		326		471		525	U	2.8	J	NV		0.008	U	NV		1.5	J	3.1	
		Q2	3	141		96.9	J	424		NV		1.9	J	NV		NV		NV		1.5	J	3.3	
		Q2	38	184		350		574		NV		1.9	J	NV		NV		NV		1.5	J	4.7	
		Q3	19	184		143	J	508		38		1.8	J	NV		0.0092	J	NV		1.2	J	2	
		Q3	2	179		139	J	495		34.2		2	J	NV		NV		NV		1.2	J	2.3	
		Q3	38	192		234		533		39.7		1.5	U	NV		NV		NV		1.1	J	2	J
		Q4	2.5	107		209		292		39.1		1.5	U	NV		NV		NV		1	J	1.8	J
		Q4	19	127		177	J	358		52.9		1.9	J	NV		0.018	J	NV		1	U	1.6	J
		Q4	40	160		198	J	470		98.9		1.5	J	NV		NV		NV		1	U	1.5	J

Appendix C-2a
Data from Surface Water Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Calcium		Iron		Magnesium		Manganese		Vanadium		Acidity As CaCO3		Ferrous Iron		Hardness, total		Organic Carbon, dissolved		Organic Carbon, total	
			feet	mg/L		µg/L		mg/L		µg/L		µg/L		mg/L		mg/L		mg/L		mg/L		mg/L	
Transect I	I1	Q1	2.1	60.4		989		147		46.8		4	J	NV		0.098	J	NV		2.8		1.9	J
		Q2	2	146		77.3	J	436		NV		1.8	J	NV		NV		NV		2.1		5.2	
		Q2	4	142		76.3	J	427		525	U	2.6	J	NV		0.016	J	2,300		1.8	J	3.7	
		Q3	1.5	177		146	J	496		31.2		1.5	U	2,680		0.0082	J	2,680		1.5	J	2.9	
		Q4	2.1	90.5*	J	103*	J	228*	J	51.8*		1.5	U	NV		0.029	J	1,330		2.3*		2.2*	
		Q4-Dup	2.1	94.5	J	134	J	233	J	54.7		1.5*	U	NV		0.015*	J	1330*		2.4		2.3	
	I2	Q1	3	60.2		148	J	146		25.4		1.5	U	NV		NV		NV		2.6		1.8	J
		Q1	7	61.6		181	J	152		28.2		1.5	U	NV		0.035	J	NV		2.7		1.7	J
		Q2	3	146		74.3	J	438		NV		2.6	J	NV		NV		NV		2		3.6	
		Q2	5.5	146		55.6	J	436		525	U	2	J	NV		0.019	J	NV		1.7	J	3.2	
		Q2	9	148		79.4	J	442		NV		2.3	J	NV		NV		NV		1.8	J	4.9	
		Q3	2	178		180	J	499		36.5		1.5	U	NV		NV		NV		1	J	2.5	
		Q3	6	179		172	J	501		35.6		1.7	J	NV		0.011	J	NV		1.1	J	2.3	
		Q4	2.5	94.4	J	81.8	J	240	J	46.7		1.5	U	NV		NV		NV		1.7	J	2.1	
		Q4	7	105		52.2	U	280	J	38.6		1.5	U	NV		0.024	J	NV		1.3	J	1.6	J
	I3	Q1	3	61.3		219		148		27.6		1.5	U	NV		NV		NV		2.7		1.9	J
		Q1	5.3	61.2		166	J	147		26.3		1.5	U	NV		0.041	J	NV		2.7		2	J
		Q1	8.5	62.4		429		153		39.2		2.3	J	NV		NV		NV		2.5		2	
		Q2	3	198		175	J	573		NV		2.3	J	NV		NV		NV		1.5	J	3.8	
		Q2	5.5	176		147	J	512		525	U	2.1	J	NV		0.03	J	NV		1.7	J	3.2	
		Q2	9	156		82	J	452		NV		1.5	U	NV		NV		NV		1.7	J	3.8	
		Q3	2	177		147	J	498		36.4		1.5	U	NV		NV		NV		1.2	J	2.3	
		Q3	6.5	177		165	J	494		34.2		1.5	U	NV		0.011	J	NV		1	U	2.1	
		Q4	2.5	95.7	J	84.7	J	253		35.9		1.5	U	NV		NV		NV		1.5	J	1.9	J
		Q4	7.5	101	J	74.4	J	272	J	40.2		1.5	U	NV		0.016	J	NV		1.4	J	1.8	J
	I4	Q1	3	60.9		110	J	145		23.4		1.5	U	NV		NV		NV		2.4		1.8	J
		Q1	6	60.9		112	J	146		23.2		1.5	U	NV		0.014	J	NV		3		1.9	J
		Q2	3	197		232		569		NV		2.7	J	NV		NV		NV		1.8	J	3.1	
		Q2	5.5	197		228		567		525	U	2.2	J	NV		0.031	J	NV		1.7	J	4.6	
		Q2	9	184		422		532		NV		3.5	J	NV		NV		NV		1.7	J	3.3	
		Q3	1.5	172		229		484		33.1		1.5	U	NV		NV		NV		1.6	J	2.4	
		Q3	6.5	174		439		487		51.4		1.7	J	NV		0.11		NV		1.3	J	2.4	
		Q4	2.5	89.9	J	55.7	J	226	J	46.2		1.5	U	NV		NV		NV		1.8	J	2	J
		Q4	7.5	106		52.2	U	284		39.7		1.5	U	NV		0.012	J	NV		1.6	J	1.8	J
Transect J	J1	Q4	0.8	128		834		320		118		3.8	J	NV		0.008	U	2,030		1.1	J	1.9	J
	J2	Q4	2	132		101	J	334		54.2		1.5	U	NV		0.008	U	NV		1	U	1.7	J
	J3	Q4	2.2	122		143	J	324		53		1.5	U	NV		0.008	U	NV		1.1	J	1.8	J
	J4	Q4	1	121		292		304		57		3.6	J	NV		0.013	J	NV		1.2	J	2.1	

* = datum not used (because it is the lower pair of a duplicate, or the datum was rejected)

B = Bottom sample
$CaCO_3$ = Calcium carbonate
mg/L = Milligram per Liter
NV = No Value, no analysis performed
µg/L = Microgram per Liter

Qualifiers:
J = Estimated value
U = Not detected

Appendix C-2b
Data from Surface Water Reference Location Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Chromium, dissolved		Hexavalent Chromium		Aluminum, dissolved		Calcium, dissolved		Iron, dissolved		Magnesium, dissolved		Manganese, dissolved		Vanadium, dissolved		Chromium		Aluminum	
			feet	µg/L		µg/L		µg/L		mg/L		µg/L		mg/L		µg/L		µg/L		µg/L		µg/L	
Transect 37	37	Q1	22	2.3	U	5	U	80.2	U	103		52.2	U	281		132		1.5	U	2.3	U	82.4	J
		Q1	3	2.3	U	5	U	80.2	U	79.1		52.2	U	193		15.1		1.5	U	2.3	U	80.2	U
		Q1	37	2.3	U	5	U	80.2	U	159		52.2	U	465		347		1.5	U	2.3	U	91.7	J
		Q2	14	2.3	U	5	U	80.2	U	154		52.2	U	440		4.3	J	2.5	J	2.3	U	80.2	U
		Q2	3	2.3	U	5	U	80.2	U	156		52.2	U	441		1.2	J	3	J	2.3	U	80.2	U
		Q2	37	2.3	U	5	U	80.2	U	196		52.2	U	580		440		3.3	J	2.3	U	80.2	U
		Q3	17	2.3	U	5	U	80.2	U	152		52.2	U	478		29.8		1.5	U	3.4	J	99.8	J
		Q3	2	2.3	U	5	U	80.2	U	100		52.2	U	286		4.2	J	1.8	J	2.9	J	80.2	U
		Q3	37	2.3	U	5	U	80.2	U	181		52.2	U	571		40		2.5	J	3	J	178	J
		Q4	2.5	2.3	U	5	U	80.2	U	113		52.2	U	317		54.7		1.5	U	2.3	U	80.2	U
		Q4	19	2.3	U	5	U	80.2	U	134		52.2	U	386		75.7		1.5	U	2.3	U	133	J
		Q4	38	2.3	U	5	U	80.2	U	172		52.2	U	515		86.7		1.5	U	2.3	U	227	
	37A	Q1	20	2.3	U	5	U	80.2	U	91.5		52.2	U	236		80.5		1.5	U	2.3	U	91.8	J
		Q1	3	2.3	U	5	U	80.2	U	79.4		52.2	U	195		10.1		1.5	U	2.3	U	80.2	U
		Q1	35	2.3	U	5	U	80.2	U	144		52.2	U	422		298		1.5	U	2.3	U	113	J
		Q2	19	2.3	U	5	U	80.2	U	164		52.2	U	472		2	J	3.9	J	2.3	U	80.2	U
		Q2	3	2.3	U	5	U	80.2	U	157		52.2	U	449		0.84	U	3.1	J	2.3	U	80.2	U
		Q2	35	2.3	U	5	U	80.2	U	199		52.2	U	542		512		2.9	J	2.3	U	107	J
		Q3	18	2.7	J	5	U	80.2	U	166		52.2	U	470		23.7		1.5	U	2.3	U	200	
		Q3	2	3.4	J	5	U	80.2	U	121		52.2	U	319		8.6		1.5	U	2.3	U	154	J
		Q3	36	2.3	U	5	U	80.2	U	184		52.2	U	538		24.9		1.5	U	2.3	U	307	
		Q4	2.5	3.3	J	5	U	80.2	U	125		52.2	U	376		50.4		1.5	U	3.5	J	104	J
		Q4	18	2.3	U	5	U	80.2	U	155		52.2	U	460		41.1		1.5	U	2.3	U	387	
		Q4	36	2.3	U	5	U	80.2	U	155		52.2	U	462		37.8		1.5	U	2.7	J	327	
	37B	Q1	20	2.3	U	5	U	80.2	U	89.2		52.2	U	228		66.3		1.5	U	2.3	U	80.2	U
		Q1	3	2.3	U	5	U	80.2	U	78.3		52.2	U	197		15.8		1.5	U	2.3	U	80.2	U
		Q1	34	2.3	U	5	U	80.2	U	152		52.2	U	428		292		1.5	U	2.3	U	80.2	U
		Q2	19	2.3	U	5	U	80.2	U	97.8		52.2	U	302		159		1.5	U	2.3	U	80.2	U
		Q2	3	2.3	U	5	U	80.2	U	153		52.2	U	460		0.84	U	1.5	U	2.3	U	80.2	U
		Q2	35	2.3	U	5	U	80.2	U	167		52.2	U	522		91.8		1.5	U	2.3	U	98.1	J
		Q3	17	2.3	U	5	U	80.2	U	162		52.2	U	498		25.2		1.5	U	3	J	135	J
		Q3	2	2.3*	U	5	U	80.2	U	113		52.2	U	318		8.1		1.5	U	2.3*	U	80.2	U
		Q3-Dup	2	2.6	J	5*	U	80.2	U	108		52.2	U	310		8.6		2.8	J	2.6	J	80.2	U
		Q3	35	2.3	U	5	U	80.2	U	183		52.2	U	542		29.8		1.5	U	4.5	J	95.5	J
		Q4	2.5	2.3*	U	5	U	80.2	U	116		52.2	U	346*		46.3*		1.5	U	3.2	J	80.2*	U
		Q4-Dup	2.5	3.1	J	5*	U	80.2*	U	115*		52.2*	U	347		46.5		1.5*	U	2.3*	U	85.4	J
		Q4	19	2.3	U	5	U	80.2	U	163		52.2	U	508		59.6		1.5	U	2.3	U	179	J
		Q4	37	2.3	U	5	U	80.2	U	163		52.2	U	511		55.2		1.5	U	3.4	J	205	

Appendix C-2b
Data from Surface Water Reference Location Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Calcium		Iron		Magnesium		Manganese		Vanadium		Acidity As CaCO3		Ferrous Iron		Hardness, total		Organic carbon, dissolved		Organic carbon, total	
			feet	mg/L		µg/L		mg/L		µg/L		µg/L		mg/L		mg/L		mg/L		mg/L		mg/L	
Transect 37	37	Q1	22	98.8		149	J	278		200	J	2.3	J	NV		0.013	J	NV		1.3	J	1.9	J
		Q1	3	73.9		74.7	J	193		NV		1.5	U	NV		NV		NV		2.1		2.4	
		Q1	37	151		196	J	452		NV		2.7	J	NV		NV		NV		1	U	2.4	
		Q2	14	154		52.2	U	438		525	U	3.2	J	NV		0.008	U	NV		1.4	J	2.3	
		Q2	3	156		52.2	U	443		NV		3.8	J	NV		NV		NV		1.5	J	2.3	
		Q2	37	205		60.8	J	586		NV		2.1	J	NV		NV		2,990		1	U	1.7	J
		Q3	17	179		205		499		41.4		1.5	U	NV		0.012	J	NV		1	U	2.3	
		Q3	2	111		80.4	J	289		11.3		1.5	U	NV		NV		NV		1.4	J	2.7	
		Q3	37	191		248		545		59		1.5	U	2,990		NV		2,990		1	U	2.2	
		Q4	2.5	123		52.2	U	312		70		1.7	J	NV		NV		NV		1.9	J	2	J
		Q4	19	139		98.7	J	385		97		2.3	J	NV		0.025	J	NV		1.3	J	1.6	J
		Q4	38	175		252		510		118		1.5	U	NV		NV		2,830		1	U	1.4	J
	37A	Q1	20	95		146	J	259		1,000	U	1.5	U	NV		0.011	J	NV		1.1	J	2	
		Q1	3	74.6		76.8	J	192		NV		1.5	U	NV		NV		NV		2.1		2.8	
		Q1	35	140		217		415		NV		2	J	NV		NV		NV		1	U	2.3	
		Q2	19	157		53.2	J	458		525	U	3.5	J	NV		0.018	J	NV		1.2	J	2.1	
		Q2	3	154		52.2	U	443		NV		3.3	J	NV		NV		NV		1.7	J	2.3	
		Q2	35	186		146	J	572		NV		3.5	J	NV		NV		2,860		1	U	1.6	J
		Q3	18	175		169	J	484		37.1		1.5	U	NV		0.008	U	NV		1.2	J	2.2	
		Q3	2	132		52.2	U	352		22.3		1.5	U	NV		NV		NV		1.5	J	2.7	
		Q3	36	199		305		555		54.3		1.6	J	NV		NV		NV		1	U	2.4	
		Q4	2.5	123		268		349		61.5		1.5	U	NV		NV		NV		1.2	J	1.7	J
		Q4	18	151		427		444		66.5		1.5	U	NV		0.008	U	NV		1	U	1.4	J
		Q4	36	168		466		502		67.7		1.5	U	NV		NV		NV		1	U	1.6	J
	37B	Q1	20	88.6		93.7	J	241		1,000	U	2.2	J	NV		0.008	U	NV		1.9	J	2	
		Q1	3	75.2		74.4	J	197		NV		1.5	U	NV		NV		NV		2.1		2.2	
		Q1	34	140		183	J	414		NV		2.8	J	NV		NV		NV		1	U	1.7	J
		Q2	19	124		58.9	J	376		525	U	1.8	J	NV		0.008	U	NV		1.3	J	2	
		Q2	3	148		52.2	U	447		NV		2	J	NV		NV		NV		1.7	J	2.5	
		Q2	35	184		164	J	568		NV		2	J	NV		NV		2,830		1.1	J	1.7	J
		Q3	17	167		175	J	481		33.7		1.5	U	NV		0.0095	J	NV		1	U	2.4	
		Q3	2	112		98.5	J	293		13		1.5	U	NV		NV		NV		1	J	2.8	
		Q3-Dup	2	117		88.5	J	303		12.9		1.5	U	NV		NV		NV		1*	U	2.7*	
		Q3	35	214		141	J	542		43.1		1.5	U	NV		NV		NV		1	U	2.1	
		Q4	2.5	124*		259		338*		58.7*		1.5	U	NV		NV		NV		1.3*	J	1.9	J
		Q4-Dup	2.5	125		249*		342		59.4		1.5*	U	NV		NV		NV		1.4	J	1.8*	J
		Q4	19	165		289		477		68.4		1.5	U	NV		0.008	U	NV		1	U	1.6	J
		Q4	37	171		424		501		94.7		1.5	U	NV		NV		NV		1	J	1.4	J

* = datum not used (because it is the lower pair of a duplicate, or the datum was rejected

$CaCO_3$ = Calcium carbonate
mg/L = Milligram per Liter
NV = No Value, no analysis performed
µg/L = Microgram per Liter

Qualifiers:
J = Estimated value
U = Not detected

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Chromium		Calcium		Ferrous Iron		Iron		TOC		Aluminum		Magnesium		Manganese		Manganese, Divalent		Vanadium		Sulfide		Acid Volatile Sulfide	
			feet	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		µmoles/g	
Transect A	A1	Q1	0.0-0.5	698		12,900		600		30,800		17,000		4,390		4,830		406		0.5	U	42.7		33.2	U	0.44	J
		Q2	0.0-0.5	1,200		5,500		5,140		36,800		480	U	7,410		5,550		438		2.237	U	69.7		328		12.1	
		Q2	0.9-1.4	1,330	K	1,280		4,130		35,700		4,900		6,450		1,930		145		1.464	U	75		603		NV	
		Q2	2.5-3.0	17	K	10.3		85.8		1,570		260	U	227		24.1		1.89		1.478	U	1.42		23.4	U	NV	
	A2	Q1	0.0-0.5	363		317		85.1		7,410		390	J	1,470		372		134		0.5	U	15		25.6	U	0.39	U
		Q2	0.0-0.5	347		275		500		6,950		270	U	1,420		422		70.9		2.181	U	14.8		45.3		0.57	J
		Q2	0.9-1.4	315	K	374		NV		33,600		NV		11,400		1,470		83.1		NV		32		NV		NV	
		Q2	2.5-3.0	78.3	K	10.5		NV		316		NV		272		16.2		1.69		NV		2.02		NV		NV	
	A3	Q1	0.0-0.5	96.6		341		334		6,240		710	J	1,140		269		177		0.5	U	9.4		41.3		0.52	J
		Q2	0.0-0.5	110		198		250		6,180		270	U	1,200		378		120		2.144	U	9.71		200		0.99	J
		Q2	1.0-1.5	2.91	K	89.3		NV		20,400		NV		1,200		233		15.1		NV		2.98		NV		NV	
		Q2	2.5-3.0	3.94	K	51.2		NV		5,110		NV		1,530		200		2.96		NV		3.28		NV		NV	
	A4	Q1	0.0-0.5	89.6		416		103		37,600		200	U	1,770		305		185		0.5	U	13.4		25.7	U	0.39	U
		Q2	0.0-0.5	97.4		294		129		25,600		260	U	1,520		423		116		2.194	U	12.3		386		1.4	J
		Q2	1.0-1.5	12.8	K	88.1		NV		8,240		NV		3,250		344		8.08		NV		12.5		NV		NV	
		Q2	2.5-3.0	34.1	K	150		NV		6,030		NV		12,700		953		25.3		NV		32.3		NV		NV	
Transect B	B1	Q1	0.0-0.5	640		3,280		NA		25,900		15,000		6,930		3,880		618		0.5	U	50.3		33.8	U	0.44	J
		Q2	0.0-0.5	595		5,310		4,280		25,200		11,000		5,650		3,830		275		2.252	U	48.6		77.3		10.4	
		Q2	0.8-1.3	80.9		3,380		1,990		19,100		6,800		12,200		2,610		221		1.612	U	33.8		67.3		NV	
		Q2	2.5-3.0	29.4		341		655		15,500		490	J	18,500		2,920		76.4		4.793		40.8		24.9		NV	
	B2	Q1	0.0-0.5	369		13,100		802		24,300		12,000		7,310		2,540		383		0.5	U	38		401		0.53	J
		Q2	0.0-0.5	236		1,990		2,220		20,600		6,600		6,260		1,940		254		2.224	U	29.5		92		3.2	
		Q2	0.6-1.1	22.7		299		NV		12,700		NV		18,100		2,620		61.3		NV		31.4		NV		NV	
		Q2	1.9-2.4	1.97		59.2		NV		1,600		NV		889		177		3.86		NV		2.3		NV		NV	
	B3	Q1	0.0-0.5	683		3,110		731		39,300		18,000	J	19,700		5,030		559		2.55	U	86.2		65		7.7	J
		Q2	0.0-0.5	637	K	2,240		2,030		48,400		24,000		28,400		6,710		807		2.211	U	90.2		1,420		11.6	
		Q2	1.0-1.5	94		1,470		NV		14,100		NV		9,440		2,420		203		NV		22.5		NV		NV	
		Q2	2.5-3.0	1.15	J	41.5		NV		274		NV		227		98.3		3.01		NV		1.26		NV		NV	
	B4	Q1	0.0-0.5	424		2,210		29.2*	U	36,500		14,000	J	17,200		4,050		462		0.5*	U	90		142*		3.4*	J
		Q1-Dup	0.0-0.5	355*		3,770		657		31,300		10000*	J	16,500		3,660		457		0.823		78.9		145		4.3	J
		Q2	0.0-0.5	404	K	2,510		1,850		34,600		11,000		16,800		4,070		463		2.345	U	88.2		528		3.8	
		Q2	1.0-1.5	2,290		2,570		NV		129,000		NV		27,400		4,900		357		NV		367		NV		NV	
		Q2	2.5-3.0	690		1,650		NV		50,400		NV		31,900		7,110		516		NV		78.1		NV		NV	
	B5	Q4	0.0 - 0.5	54.3*		5,510		410		10800*		838		3110*		863*		156		NV	U	22.9*		NV		0.63*	
		Q4-Dup	0.0 - 0.5	58.2		3340*		238*		11,100		614*		3,190		951		125*		NV		23.5		NV		0.74	
		Q4	0.5-1.0	43.6	J	920		589		12,900		672	U	3,840		794	J	78		NV		24.7	J	NV		0.63	UJ
		Q4	2.3-2.9	37.9	J	229		221		14,700		670	U	4,690		939		84.8		NV		24.9		NV		0.63	U

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Chromium		Calcium		Ferrous Iron		Iron		TOC		Aluminum		Magnesium		Manganese		Manganese, Divalent		Vanadium		Sulfide		Acid Volatile Sulfide	
			feet	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		µmoles/g	
Transect C	C1	Q1	0.0-0.5	1,160		49,100		5,840		25,100		17,000		10,300		21,500		1,100		0.5	U	61.8		1,090		12.6	
		Q2	0.0-0.5	1,310		45,100		10,600		29,800		25,000		11,200		22,500		1,120		2.298	U	67.9		1,780		14.3	
		Q2	0.8-1.3	2,090		23,300		24,400		47,800		24,000		19,000		NV		546		1.544	U	112		1,300		NV	
		Q2	0.8-1.3	NV		NV		21300*		NV		NV		NV		15,300		NV		NV		NV		NV		NV	
		Q2	2.3-2.8	1440*		29,500		21,300		46,200		9,800		8,560		15,500		249		1.485	U	86.5		1,910		NV	
		Q2-Dup	2.3-2.8	1,800		29,200		NV		23,300		2500*		9,740		19,000		566		NV		107		NV		NV	
	C2	Q1	0.0-0.5	1,080		23,000		4,670		24,300		25,000		9,230		11,700		717		0.5	U	62.4		73.5		13.1	
		Q2	0.0-0.5	1,070		24,000		5,570		22,900		20,000		8,200		12,500		652		2.267	U	62.6		509		16	
		Q2	1.0-1.5	91.5		137		NV		2,390		NV		955		270		19.7		NV		6.77		NV		NV	
		Q2	2.0-2.5	3.62		90.6		NV		1,390		NV		440		171		9.02		NV		1.65		NV		NV	
	C3	Q1	0.0-0.5	582		4,640		3,430		27,500		9,500		11,400		4,440		420		0.5	U	57.9		96.4		9.8	
		Q2	0.0-0.5	618		2,900		6,470		29,500		18,000		12,800		4,830		465		2.272	U	58.4		313		6.5	
		Q2	1.0-1.5	250		1,740		NV		30,300		NV		24,300		5,200		533		NV		48.1		NV		NV	
		Q2	2.4-2.9	78.3		1,200		NV		23,400		NV		18,700		3,710		305		NV		38.2		NV		NV	
	C4	Q1	0.0-0.5	357		3,210		3,150		31,400		9,700		13,700		3,730		477		0.5	U	61.3		33.8		4.9	
		Q2	0.0-0.5	315*		2,810		6,500		31,200		14,000		14,200		4,290		600		2.346	U	57.6		54.4*		3.3*	
		Q2-Dup	0.0-0.5	328		2,060		6370*		36,300		14000*		16,500		5,280		738		2.313*	U	66.6		158		7.1	
		Q2	1.0-1.5	57		1,930		NV		48,800		NV		37,600		10,500		2,010		NV		74.6		NV		NV	
		Q2	2.5-3.0	2.32		56.4		NV		865		NV		1,120		201		7.94		NV		2.05		NV		NV	
Transect D	D1	Q1	0.0-0.5	304		18,500		9,770		44,100		25,000		27,600		17,800		2,010		5.924		89		1,880		28.8	
		Q2	0.0-0.5	310		9,750		14,400		46,100		29,000		27,500		10,700		1,800		19.578		85.6		2,040		18.7	
		Q2	1.0-1.5	372		21,200		16,400		36,400		51,000		23,700		55,000		2,760		10.285		85.6		2,330		NV	
		Q2	2.5-3.0	251		79,700		10,500		36,800		32,000		23,400		10,200		1,540		2.496	U	71.3		418		NV	
	D2	Q1	0.0-0.5	239	J	4,030		13,000		42,200		29,000		24,900		7,390		1,900		7.75		76.4		2,020		16.6	
		Q2	0.0-0.5	258		4,910		8,830		49,300		34,000		28,000		7,940		3,550		10.47		91.6		2,760		32.7	
		Q2	1.0-1.5	237		4,030		NV		45,000		NV		28,400		6,950		1,420		NV		86.9		NV		NV	
		Q2	2.5-3.0	66.1		2,850		NV		50,600		NV		28,500		5,950		770		NV		65.8		NV		NV	
	D3	Q1	0.0-0.5	306		3,680		1,290		48,600		25,000	J	29,400		7,890		1,940		2.678		91		476		15.3	J
		Q2	0.0-0.5	253		3,730		5,870		52,900		28,000		30,500		8,010		2,260		34.002		93.5		2,090		11.4	
		Q2	1.0-1.5	218		3,510		NV		44,600		NV		28,400		7,180		1,360		NV		85		NV		NV	
		Q2	2.5-3.0	95.8		2,870		NV		52,400		NV		31,100		6,760		1,200		NV		60.6		NV		NV	
	D4	Q1	0.0-0.5	198		7,690		5,120		28,700		13,000		12,000		3,110		428		0.5	U	48		36.5	U	13.2	
		Q2	0.0-0.5	214		1,470		3,060		36,300		15,000		19,600		4,310		415		2.318		59.5		261		10.3	
		Q2	0.8-1.3	78.1		2,060		NV		47,500		NV		42,600		7,790		675		NV		82.5		NV		NV	
		Q2	2.5-3.0	60.2		2,010		NV		51,000		NV		39,200		10,600		2,280		NV		79.3		NV		NV	

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Chromium		Calcium		Ferrous Iron		Iron		TOC		Aluminum		Magnesium		Manganese		Manganese, Divalent		Vanadium		Sulfide		Acid Volatile Sulfide	
			feet	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		µmoles/g	
Transect E	E1	Q1	0.0-0.5	223	K	25,600		82.6		37,100		30,000		20,600		11,300		2,600		2.785		67.2		658		22.9	
		Q1-Dup	0.0-0.5	200*	K	10,500		41.1*		36,300		20000*		19,800		12,300		2,150		0.5*	U	63.5		305*		12.1*	
		Q2	0.0-0.5	253		22,800		10,700		48,400		23,000		28,500		25,900		1,620		2.449	U	86.6		1,680		19	
		Q2	1.0-1.5	217		9,650		11,200		42,600		41,000		27,500		12,100		1,780		2.494	U	80.8		1,210		NV	
		Q2	2.5-3.0	68.2		2,500		4,700		48,800		30,000		27,700		7,180		911		2.244	U	59.9		125		NV	
	E2	Q1	0.0-0.5	66.9		2,010		5,320		53,400		19,000		30,200		7,660		1,250		4.848		57.9		708		6.8	
		Q2	0.0-0.5	64.9		1,550		5,910		56,700		25,000		30,200		7,550		1,050		7.304		61.3		1,900		20.1	
		Q2	1.0-1.5	61.4		2,880		NV		55,900		NV		31,600		6,800		879		NV		60.3		NV		NV	
		Q2	2.5-3.0	62.1		2,940		NV		56,500		NV		30,800		6,350		839		NV		61.2		NV		NV	
	E3	Q1	0.0-0.5	238		3,770		13,600		47,300		18,000		29,100		7,500		1,020		8.539		97.3		1,320		27.5	
		Q2	0.0-0.5	197		3,100		11,200		45,900		21,000		26,800		7,210		1,220		10.258		83.1		2,120		25.1	
		Q2	1.0-1.5	262		3,260		NV		45,300		NV		25,400		6,680		2,050		NV		90.2		NV		NV	
		Q2	2.5-3.0	259		3,550		NV		46,400		NV		28,200		7,290		1,850		NV		106		NV		NV	
	E4	Q1	0.0-0.5	61.2		1,770		1,010		14,800		7,300		6,890		1,840		253		0.5	U	26		28.5	U	0.93	J
		Q2	0.0-0.5	114	K	3,290		1,150		23,400		16,000		12,300		3,850		374		2.18	U	40.9		361		7.6	
		Q2	1.0-1.5	52.1		2,200		NV		31,900		NV		27,800		4,920		532		NV		55.3		NV		NV	
		Q2	2.5-3.0	125		1,750		NV		37,500		NV		30,100		5,290		325		NV		65.7		NV		NV	
Transect F	F1	Q1	0.0-0.5	97.9		10,300		5,810		39,500		15,000		19,200		4,640		591		3.225		64.1		570		12.9	
		Q2	0.0-0.5	117		4,220		4,840		38,100		20,000		19,200		5,130		725		2.372	U	66.2		1,160		19.9	
		Q2	1.0-1.5	76.7		82,400		8,810		20,400		15,000		13,100		3,740		524		2.807	U	40.6		1,050		NV	
		Q2	2.5-3.0	159		10,800		15,200		40,900		30,000		25,300		6,090		1,210		1.651	U	94.9		2,380		NV	
	F2	Q1	0.0-0.5	65.8		1,190		3,640		54,800		20,000		30,400		6,170		803		1.483		68.5		38.2	U	9.5	
		Q2	0.0-0.5	33.1		515		808		30,000		3,000		12,600		2,080		471		2.219	U	33.9		224		4.2	
		Q2	1.0-1.5	49.3	K	794		NV		28,300		NV		17,600		1,920		41.5		NV		61.1		NV		NV	
		Q2	2.5-3.0	36.9	K	782		NV		18,300		NV		15,100		1,590		36.1		NV		41.8		NV		NV	
	F3	Q1	0.0-0.5	152		2,410		13,400		52,000		25,000		35,600		8,890		1,350		0.5	U	94.9		1,720		22	
		Q2	0.0-0.5	211*		2,510		8890*		55,900		24000*		31,700		8,340		1,240		2.418	U	107		1050*		41.5	
		Q2-Dup	0.0-0.5	261		2,530		11,500		61,900		25,000		34,600		8,520		1,280		4.005		118		2,350		21.5*	
		Q2	1.2-1.7	56		2,020		NV		46,800		NV		36,500		10,700		1,960		NV		70.3		NV		NV	
		Q2	2.5-3.0	56.2		1,980		NV		45,700		NV		36,800		10,700		1,640		NV		67.7		NV		NV	
	F4	Q1	0.0-0.5	211		3,090		7,580		54,200		26,000		32,300		8,180		1,790		0.778		105		555		20.6	
		Q2	0.0-0.5	190		3,950		11,300		55,100		20,000		34,600		8,570		1,420		2.431	U	105		2,000		8.4	
		Q2	1.0-1.5	120*		1,890		NV		47,100		NV		38,500		8,260		1,260		NV		85.7		NV		NV	
		Q2-Dup	1.0-1.5	159		2,650		NV		64,500		NV		50,500		11,700		1,860		NV		115		NV		NV	
		Q2	2.5-3.0	55.1		1,830		NV		44,600		NV		33,700		9,230		1,390		NV		65.5		NV		NV	
		Q2-Dup	2.5-3.0	54*		1,880		NV		45,000		NV	J	34,600		9,280		1,410		NV		66.9		NV		NV	

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Chromium		Calcium		Ferrous Iron		Iron		TOC		Aluminum		Magnesium		Manganese		Manganese, Divalent		Vanadium		Sulfide		Acid Volatile Sulfide	
			feet	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		µmoles/g	
Transect G	G1	Q1	0.0-0.5	67	J	1,910		1,250		16,700		5,900		7,240		2,250		236		0.5	U	26		152		6.8	
		Q2	0.0-0.5	67.1		3,260		4,340		24,000		7,200		8,680		2,700		255		1.521	U	34.9		1,170	J	21.2	
		Q2	1.1-1.6	33.1		7,650		3,700		28,500		22,000		14,300		3,190		131		1.526	U	41.7		102		NV	
		Q2	2.5-3.0	28.8		2,070		5,170		28,600		9,700		12,300		2,760		183		1.505	U	34.9		128		NV	
	G2	Q1	0.0-0.5	123	J	2,540		6,210		32,700		14,000		19,000		5,410		614		1.525		61.4		896		29.1	
		Q2	0.0-0.5	153		2,270		6,410		40,700		28,000		23,000		6,300		770		2.458	U	79.4		1,500		17.1	
		Q2	0.8-1.3	144	K	2,260		NV		32,900		NV		19,400		4,640		466		NV		61.8		NV		NV	
		Q2	2.5-3.0	50	K	1,310		NV		24,800		NV		13,300		3,550		148		NV		48.1		NV		NV	
	G3	Q1	0.0-0.5	148	K	13,700		28	J	38,000		17,000		22,500		5,740		698		4.083		75.4		449		23.9	
		Q2	0.0-0.5	164		3,010		8,510		43,700		13,000		24,800		6,620		899		2.421	U	86.5		1,900		25.6	
		Q2	1.0-1.5	29.8	K	1,210		NV		20,300		NV		12,700		2,750		133		NV		39.3		NV		NV	
		Q2	2.5-3.0	29.6	K	2,290		NV		32,100		NV		13,400		3,240		200		NV		40.2		NV		NV	
	G4	Q1	0.0-0.5	121	K	3,890		14.7	J	39,300		17,000		21,500		5,720		1,100		13.992		66.5		1,430		22.2	
		Q2	0.0-0.5	140		2,390		4,170		36,700		9,100		21,100		5,470		1,340		2.371	U	70.8		1,650		10.2	
		Q2	1.0-1.5	182		2,740		NV		45,100		NV		27,600		6,650		1,200		NV		91.2		NV		NV	
		Q2	2.5-3.0	197		2,490		NV		42,200		NV		25,700		6,120		1,570		NV		94.3		NV		NV	
Transect H	H1	Q1	0.0-0.5	114	K	139,000		11,100		23,100		25,000		14,200		6,220		544		10.439		55.3		2,630		51.2	
		Q2	0.0-0.5	89.5		3,000		7,410		28,900		21,000		19,600		5,040		545		2.404	U	55		2,690	J	16.9	
		Q2	1.0-1.5	182		6,110		9,980		30,500		35,000		18,800		6,450		653		2.342	U	87.6		2,400		NV	
		Q2	2.5-3.0	29.2		2,050		493		3,460		860		5,420		803		61.4		1.441	U	20		35.1		NV	
	H2	Q1	0.0-0.5	47.1	K	14,900		1,900		12,100		8,700		7,290		2,080		171		0.5	U	29.3		203		20.8	
		Q2	0.0-0.5	134		4,690		2,180		32,100		29,000		24,000		6,440		521		2.403	U	77		1,040	J	32.2	
		Q2	1.0-1.5	43.2		49,900		NV		8,490		NV		5,710		2,180		119		NV		24.2		NV		NV	
		Q2	2.5-3.0	88.4		1,500		NV		14,500		NV		5,660		1,780		215		NV		99		NV		NV	
	H3	Q1	0.0-0.5	49.3	K	4,820		8,330		11,900		12,000		8,550		2,700		240		0.785		28.7		1,480		36.5	
		Q2	0.0-0.5	71.8		2,780		6,100		14,800		9,800		9,860		2,840		242		9.836		45.4		1,870	J	16.4	
		Q2	1.0-1.5	71.7		4,560		NV		17,200		NV		11,300		3,710		318		NV		44.2		NV		NV	
		Q2	2.5-3.0	101		3,460		NV		20,800		NV		14,300		3,670		370		NV		57.6		NV		NV	
	H4	Q1	0.0-0.5	107	K	2,570		12,800		31,900		20,000		21,300		5,570		573		3.842		60.8		732		24.5	
		Q2	0.0-0.5	207		17,400		13,200		37,500		48,000		23,200		9,340		795		13.377		99.6		3,470	J	38.3	
		Q2	1.0-1.5	80.7		1,210		NV		22,500		NV		18,000		3,020		295		NV		48.4		NV		NV	
		Q2	2.5-3.0	27.9		514		NV		5,910		NV		12,300		1,260		63		NV		25.5		NV		NV	

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Chromium		Calcium		Ferrous Iron		Iron		TOC		Aluminum		Magnesium		Manganese		Manganese, Divalent		Vanadium		Sulfide		Acid Volatile Sulfide	
			feet	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		µmoles/g	
Transect I	I1	Q1	0.0-0.5	316	K	7,110		6,660		19,200		20,000		9,320		5,690		218		0.5	U	59.1		311		3.2	
		Q2	0.0-0.5	700		9,370		4,490		18,100		14,000		7,350		8,320		207		1.508	U	70.8		1,240	J	26.5	
		Q2	1.0-1.5	16.7		371		5,270		7,550		3,100		6,250		1,330		168		1.453	U	17.2		815		NV	
		Q2	2.5-3.0	22		588		6,100		12,700		11,000		9,190		2,130		296		1.498	U	22.1		1,060		NV	
	I2	Q1	0.0-0.5	254	K	6,360		2,410		23,500		40,000		12,300		5,830		274		0.5	U	85.5		292		10.6	
		Q2	0.0-0.5	315		9,030		5,580		24,800		34,000		12,200		7,600		260		1.531	U	91.5		1,600	J	23.8	
		Q2	1.0-1.5	308		8,710		NV		29,600		NV		15,600		7,490		332		NV		95.7		NV		NV	
		Q2	2.5-3.0	575		5,320		NV		39,600		NV		19,700		5,890		345		NV		170		NV		NV	
	I3	Q1	0.0-0.5	357	K	7,560		3,630		34,400		36,000		17,900		7,530		425		0.582		122		1,140		24.4	
		Q2	0.0-0.5	425		6,280		5,960		34,200		39,000		20,400		6,830		411		5.431	U	237		2,070	J	21.5	
		Q2	1.0-1.5	327		5,160		NV		32,700		NV		19,900		6,470		393		NV		153		NV		NV	
		Q2	2.5-3.0	332		5,760		NV		27,300		NV		15,700		5,460		284		NV		134		NV		NV	
	I4	Q1	0.0-0.5	374	K	35,900		8,210		32,700		33,000		12,400		5,980		368		0.5	U	156		1,000		42.7	
		Q2	0.0-0.5	542		10,400		4,570		42,500		39,000		21,100		7,830		447		1.836	U	145		1,690	J	11.9	
		Q2	0.8-1.3	1,390		7,020		NV		50,300		NV		19,900		6,190		323		NV		229		NV		NV	
		Q2	2.1-2.6	508		2,880		NV		28,700		NV		12,600		3,240		131		NV		287		NV		NV	
Transect J	J1	Q4	0.0 - 0.5	1,830		63,500		2,690		24,300		21,500		7,740		22,000		1,290		NV		67.2		NV		5	
		Q4	0.8-1.3	1,620		46,500		6,340		53,000		10,900		9,860		12,200		233		NV		95		NV		7.1	
		Q4	2.5-3.0	2,730		21,800		11,900		36,800		18,000		15,500		17,000		567		NV		134		NV		10	
	J2	Q4	0.0 - 0.5	1,840		41,600		2,050		26,700		9,640		7,010		13,400		670		NV		88.5		NV		16.8	
		Q4	1.0-1.5	605		1,270		1,060		21,500		10,900		10,100		2,240		207		NV		52.5		NV		4.8	
		Q4	2.5-3.0	303		420		701		6,450		679		2,560		752		65.5		NV		13.5		NV		5	
	J3	Q4	0.0 - 0.5	1,260		17,800		4,910		23,700		13,600		6,090		6,430		492		NV		64.1		NV		0.63	
		Q4	0.6-1.0	28.2		190		144		10,400		769		1,200		138		23.7		NV		20.8		NV		6.6	
		Q4	2.5-3.0	567		1,430		176		29,400		9,590		10,400		2,150		214		NV		89.2		NV		0.63	
	J4	Q4	0.0 - 0.5	2,360		13,300		818		28,400		9,670		9,540		30,200		2,070		NV		70		NV		2.4	
		Q4	0.5-1.0	8,140	J	12,500		1,550		37,200		762	U	12,000		17,600		919		NV		146		NV		0.63	U
		Q4	2.5-3.0	114	J	32.6		22		1,180		572	U	846		116		5.77		NV		2.36		NV		0.63	U

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Cadmium		Copper		Iron		Lead		Nickel		Mercury		Zinc		Moisture	Total Solids	0.001 mm	0.002 mm	0.005 mm	0.02 mm
			feet	µmoles/g		µmoles/g		µmoles/g		µmoles/g		µmoles/g		µmoles/g		µmoles/g		%	%	% passing	% passing	% passing	% passing
Transect A	A1	Q1	0.0-0.5	0.00446		0.27		92.8		0.0865		0.585		0.000028	J	1.86		NV	NV	2	2	3	4.5
		Q2	0.0-0.5	0.00187		0.0632		71.9		0.0874		0.179		NV		1.79		38.5	51.9	1	1	1	5
		Q2	0.9-1.4	NV		NV		NV		NV		NV		NV		NV		22	73.3	0.5	4	14	23
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		23.4	85.3	0.5	0.5	0.5	3
	A2	Q1	0.0-0.5	0.000661	J	0.0546		20		0.0287		0.112		0.000026	J	0.468		NV	NV	0.5	0.5	0.5	0.5
		Q2	0.0-0.5	0.000142	U	0.059		25.4		0.0351		0.133		NV		0.545		20.9	76.6	0.5	0.5	0.5	1.5
		Q2	0.9-1.4	NV		NV		NV		NV		NV		NV		NV		19.4	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		22.1	NV	NV	NV	NV	NV
	A3	Q1	0.0-0.5	0.000468	J	0.0389		17.5		0.0199		0.0265		0.0000077	U	0.288		NV	NV	1	1	1	1
		Q2	0.0-0.5	0.000142	U	0.119		20.1		0.0163		0.633		NV		0.219		24.6	79.9	0.5	0.5	0.5	2
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		22.7	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		17.2	NV	NV	NV	NV	NV
	A4	Q1	0.0-0.5	0.000652	J	0.0529		29.2		0.0216		0.106		0.0000076	U	0.313		NV	NV	1	1	1	1.5
		Q2	0.0-0.5	0.000143	U	0.0335		17.2		0.0221		0.0214		NV		0.283		24.9	79.2	0.5	0.5	0.5	2
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		23.5	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		23	NV	NV	NV	NV	NV
Transect B	B1	Q1	0.0-0.5	0.00164		0.301		82		0.0826		0.569		0.000014	J	1.4		NV	NV	2.5	2.5	4	6.5
		Q2	0.0-0.5	0.00265		0.11		73.7		0.0655		0.483		NV		1.22		37	59.6	1.5	2	4	8
		Q2	0.8-1.3	NV		NV		NV		NV		NV		NV		NV		31.1	66.7	4	7	10	19
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		20.7	80.3	20	28	41	64
	B2	Q1	0.0-0.5	0.00145		0.28		74.4		0.0609		0.5		0.000029	J	0.974		NV	NV	2.5	2.5	4	8
		Q2	0.0-0.5	0.00164		0.163		52.1		0.0606		0.0629		NV		0.906		30.6	64.6	1.5	1.5	2.5	11
		Q2	0.6-1.1	NV		NV		NV		NV		NV		NV		NV		17.8	NV	NV	NV	NV	NV
		Q2	1.9-2.4	NV		NV		NV		NV		NV		NV		NV		17.3	NV	NV	NV	NV	NV
	B3	Q1	0.0-0.5	0.00369		0.159	J	102		0.115	J	0.429	J	0.0000077*	R	1.47	J	NV	NV	10	21	35.5	59
		Q2	0.0-0.5	0.00388		0.342		107		0.128		0.685		NV		1.62		59.3	45.2	18	29	46	69
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		32.1	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		17.6	NV	NV	NV	NV	NV
	B4	Q1	0.0-0.5	0.000648	J	0.395*	J	125		0.136		0.0898*	K	0.0000075*	R	1.7		NV	NV	8	14	23*	41*
		Q1-Dup	0.0-0.5	0.000364*	J	0.403	J	122*		0.122*		0.397	K	0.0000078*	R	1.54*		NV	NV	8*	14*	26.5	45
		Q2	0.0-0.5	0.00455		0.463		121		0.145		0.4		NV		1.93		53.2	49.4	13	19	28.5	48
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		69.4	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		65.5	NV	NV	NV	NV	NV
	B5	Q4	0.0 - 0.5	0.000926		0.1		39.4		0.0282		0.0393		NV		0.508		28*	NV	0.5	0.5	0.5	2
		Q4-Dup	0.0 - 0.5	0.000799*		0.0914*		35.7*		0.0275*		0.0363*		NV		0.484*		28.5	NV	0.5*	0.5*	0.5*	1*
		Q4	0.5-1.0	0.00038	J	0.0724	L	45.2	J	0.0239	J	0.0411	J	NV		0.209	J	14.7	NV	1	1	1.5	2.5
		Q4	2.3-2.9	0.000143	U	0.0177		25.3		0.0038		0.0272		NV		0.0318		14.7	NV	0.5	0.5	0.5	0.5

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Cadmium		Copper		Iron		Lead		Nickel		Mercury		Zinc		Moisture	Total Solids	0.001 mm	0.002 mm	0.005 mm	0.02 mm
			feet	µmoles/g		µmoles/g		µmoles/g		µmoles/g		µmoles/g		µmoles/g		µmoles/g		%	%	% passing	% passing	% passing	% passing
Transect C	C1	Q1	0.0-0.5	0.00174		0.143		136		0.13		0.372		0.0000075	U	1.6		NV	NV	0.5	2	5.5	11
		Q2	0.0-0.5	0.00573		0.218		109		0.18		0.679		NV		1.85		43.4	51.1	3	4	7	12
		Q2	0.8-1.3	NV		NV		NV		NV		NV		NV		NV		46.6	47.8	5.5	9	17	34.5
		Q2	0.8-1.3	NV		NV		NV		NV		NV		NV		NV		41.2*	NV	NV	NV	NV	NV
		Q2	2.3-2.8	NV		NV		NV		NV		NV		NV		NV		17.8*	47.2	4	7	11	21
		Q2-Dup	2.3-2.8	NV		NV		NV		NV		NV		NV		NV		28.8	NV	3*	5*	9*	15*
	C2	Q1	0.0-0.5	0.00529		0.136		92.6		0.171		0.247		0.0000078	U	1.74		NV	NV	1.5	3	6.5	12
		Q2	0.0-0.5	0.00432		0.152		98.6		0.167		0.208		NV		1.68		34.7	61.7	2	5	8	12
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		21.3	NV	NV	NV	NV	NV
		Q2	2.0-2.5	NV		NV		NV		NV		NV		NV		NV		20.8	NV	NV	NV	NV	NV
	C3	Q1	0.0-0.5	0.00483		0.185		101		0.127		0.428		0.0000077	U	1.88		NV	NV	2	8	16.5	28
		Q2	0.0-0.5	0.00467		0.294		84		0.123		0.108		NV		1.96		43.2	56.3	7	9	16	31
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		55.6	NV	NV	NV	NV	NV
		Q2	2.4-2.9	NV		NV		NV		NV		NV		NV		NV		46.3	NV	NV	NV	NV	NV
	C4	Q1	0.0-0.5	0.00511		0.401		125		0.132		0.184		0.0000075	U	1.86		NV	NV	5	12.5	21	35
		Q2	0.0-0.5	0.0044*		0.352*		107		0.132		0.279		NV		1.81*		42.3*	54.6*	9	15	23	38.5
		Q2-Dup	0.0-0.5	0.0044		0.364		92*		0.132*		0.0838*		NV		1.84		46.8	56.4	4*	8*	16*	24*
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		59.2	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		19.2	NV	NV	NV	NV	NV
Transect D	D1	Q1	0.0-0.5	0.000951	J	0.0469		103		0.0889		0.155		0.0000075	U	1.17		NV	NV	4	10.5	18	29.5
		Q2	0.0-0.5	0.00242		0.126		74.7		0.0784		0.163		NV		1.02		72.1	25.4	2	9	18.5	31
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		76.3	28.6	3	8	13	24
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		61.5	38.3	6	18	31	49
	D2	Q1	0.0-0.5	0.000972	J	0.195		82.5		0.0875		0.058		0.0000076	U	1.04		NV	NV	11	15.5	31	48
		Q2	0.0-0.5	0.00272		0.029		87.9		0.0815		0.0915		NV		0.989		72.4	28.3	5	10.5	18	35
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		69.1	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		41.1	NV	NV	NV	NV	NV
	D3	Q1	0.0-0.5	0.000964	J	0.129	J	80.4		0.0869		0.115	K	0.0000076*	R	0.991		NV	NV	15	22	33	57
		Q2	0.0-0.5	0.00322		0.154		86.7		0.101		0.36		NV		1.2		69.2	30.6	7	15	28	43
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		74	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		50.1	NV	NV	NV	NV	NV
	D4	Q1	0.0-0.5	0.00175		0.254		170		0.0912		0.372		0.0000076	U	1.1		NV	NV	4	10	18	26
		Q2	0.0-0.5	0.00405		0.382		162		0.147		0.586		NV		1.74		48.6	46.8	9.5	15	22	34.5
		Q2	0.8-1.3	NV		NV		NV		NV		NV		NV		NV		61.1	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		59.3	NV	NV	NV	NV	NV

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Cadmium		Copper		Iron	Lead	Nickel	Mercury		Zinc	Moisture	Total Solids	0.001 mm	0.002 mm	0.005 mm	0.02 mm
			feet	µmoles/g		µmoles/g		µmoles/g	µmoles/g	µmoles/g	µmoles/g		µmoles/g	%	%	% passing	% passing	% passing	% passing
Transect E	E1	Q1	0.0-0.5	0.000831	J	0.0604*		75.1	0.0769	0.0574*	0.0000078	U	0.893	NV	NV	13	18	21*	32*
		Q1-Dup	0.0-0.5	0.000801*	J	0.0992		47.9*	0.0445*	0.132	0.0000076*	U	0.801*	NV	NV	9*	17*	25	39
		Q2	0.0-0.5	0.00248		0.0465		68.5	0.0745	0.0557	NV		0.947	73.4	32	8	14.5	22	36
		Q2	1.0-1.5	NV		NV		NV	NV	NV	NV		NV	66.8	30.1	9	14	24	45
		Q2	2.5-3.0	NV		NV		NV	NV	NV	NV		NV	44.1	55.2	30	39	55	79
	E2	Q1	0.0-0.5	0.00199	J	0.135		139	0.0415	0.254	0.0000078	U	0.562	NV	NV	28	41	68	83
		Q2	0.0-0.5	0.00391		0.0947		77.6	0.0597	0.558	NV		0.684	49.2	29	19	36	53	73.5
		Q2	1.0-1.5	NV		NV		NV	NV	NV	NV		NV	41.5	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV	NV	NV	NV		NV	40.9	NV	NV	NV	NV	NV
	E3	Q1	0.0-0.5	0.00351		0.196		105	0.0833	0.43	0.0000076	U	1.08	NV	NV	11	19.5	32	54
		Q2	0.0-0.5	0.00293		0.0469		97.4	0.087	0.335	NV		1.03	72.1	29.2	5	14	23	36
		Q2	1.0-1.5	NV		NV		NV	NV	NV	NV		NV	69.6	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV	NV	NV	NV		NV	70.8	NV	NV	NV	NV	NV
	E4	Q1	0.0-0.5	0.00107	J	0.178		60.4	0.0867	0.0421	0.0000099	J	0.485	NV	NV	3.5	4	9	16
		Q2	0.0-0.5	0.00178		0.206		61	0.0855	0.277	NV		0.72	41.7	60.6	3	7	11	19.5
		Q2	1.0-1.5	NV		NV		NV	NV	NV	NV		NV	31	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV	NV	NV	NV		NV	50.4	NV	NV	NV	NV	NV
Transect F	F1	Q1	0.0-0.5	0.000484	J	0.127		69.4	0.0526	0.0468	0.0000078	U	0.643	NV	NV	4.5	11	19	29
		Q2	0.0-0.5	0.00251		0.192		91.6	0.0692	1	NV		0.917	60.8	42.4	8	10.5	17	33
		Q2	1.0-1.5	NV		NV		NV	NV	NV	NV		NV	55.3	49.9	0.5	24	33	40.5
		Q2	2.5-3.0	NV		NV		NV	NV	NV	NV		NV	60.7	37.8	8	17	26	41
	F2	Q1	0.0-0.5	0.000518	J	0.168		80.6	0.0526	0.0498	0.0000078	U	0.615	NV	NV	31	40.5	60	82.5
		Q2	0.0-0.5	0.000825	J	0.151		109	0.0255	0.499	NV		0.161	26	77.1	17	22.5	31	42
		Q2	1.0-1.5	NV		NV		NV	NV	NV	NV		NV	37.9	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV	NV	NV	NV		NV	38.3	NV	NV	NV	NV	NV
	F3	Q1	0.0-0.5	0.0038	J	0.288		172	0.15	0.0715	0.0000076	U	1.33	NV	NV	19	26	37.5	54.5
		Q2	0.0-0.5	0.00369		0.165		110	0.111	0.0784*	NV		1.13	71.4	26.3*	14	21	33	51
		Q2-Dup	0.0-0.5	0.00278*		0.105*		94.2*	0.0759*	0.163	NV		0.85*	71.2*	28.3	12*	19.5*	29.5*	45*
		Q2	1.2-1.7	NV		NV		NV	NV	NV	NV		NV	61.4	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV	NV	NV	NV		NV	61.6	NV	NV	NV	NV	NV
	F4	Q1	0.0-0.5	0.00293		0.273		107	0.103	0.115	0.0000076	U	1.15	NV	NV	10	24	35	50
		Q2	0.0-0.5	0.00257		0.0602		75.1	0.0823	0.0434	NV		0.895	72.2	26.8	8	15	25	41
		Q2	1.0-1.5	NV		NV		NV	NV	NV	NV		NV	63.7*	NV	NV	NV	NV	NV
		Q2-Dup	1.0-1.5	NV		NV		NV	NV	NV	NV		NV	64.5	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV	NV	NV	NV		NV	61.1*	NV	NV	NV	NV	NV
		Q2-Dup	2.5-3.0	NV		NV		NV	NV	NV	NV		NV	61.2	NV	NV	NV	NV	NV

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Cadmium		Copper		Iron		Lead		Nickel		Mercury		Zinc		Moisture		Total Solids		0.001 mm		0.002 mm		0.005 mm		0.02 mm	
			feet	µmoles/g		µmoles/g		µmoles/g		µmoles/g		µmoles/g		µmoles/g		µmoles/g		%		%		% passing		% passing		% passing		% passing	
Transect G	G1	Q1	0.0-0.5	0.000141	U	0.0698		48.7		0.0213		0.17		0.0000076	U	0.262		NV		NV		8		9.5		11.5		16	
		Q2	0.0-0.5	0.00239	J	0.0995	J	68.7	J	0.053	J	0.648	J	NV		0.574	J	32.5		61.5		1		4		6.5		12	
		Q2	1.1-1.6	NV		NV		NV		NV		NV		NV		NV		41.7		60.1		11		13		22		39	
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		34.6		61.6		10		15		24		44	
	G2	Q1	0.0-0.5	0.00115		0.0881		80.7		0.0737		0.0571		0.0000078	U	0.844		NV		NV		6.5		9		15.5		26	
		Q2	0.0-0.5	0.00294		0.2		68.4		0.0712		0.157		NV		0.858		68.8		31.5		7		11		18.5		35	
		Q2	0.8-1.3	NV		NV		NV		NV		NV		NV		NV		56.7		NV		NV		NV		NV		NV	
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		34.5		NV		NV		NV		NV		NV	
	G3	Q1	0.0-0.5	0.00155		0.137		74.3		0.0753		0.288		0.0000078	U	0.846		NV		NV		8		15		23		43.5	
		Q2	0.0-0.5	0.00357		0.151		81.9		0.0821		0.443		NV		0.968		70.6		30.4		3		12		20		31	
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		30.9		NV		NV		NV		NV		NV	
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		29.9		NV		NV		NV		NV		NV	
	G4	Q1	0.0-0.5	0.0015		0.131		100		0.0892		0.285		0.0000078	U	1.02		NV		NV		8		12		20		36	
		Q2	0.0-0.5	0.00297		0.0892		72.2		0.076		0.0556		NV		0.907		64.6		39.3		5		11		18		30	
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		71.2		NV		NV		NV		NV		NV	
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		66.9		NV		NV		NV		NV		NV	
Transect H	H1	Q1	0.0-0.5	0.0363		0.427		71		0.182		0.501		0.0000078	U	1.86		NV		NV		2		8		17		29	
		Q2	0.0-0.5	0.00704	J	0.00789	J	61	J	0.0749	J	0.0444	J	NV		0.801	J	61.7		28.5		6		12		19		37	
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		66.6		44.6		9		14		21		38	
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		21.8		83.8		4		7		11		23	
	H2	Q1	0.0-0.5	0.0149		0.23		48.7		0.0951		0.0391		0.0000077	U	0.976		NV		NV		4		4		5.5		13.5	
		Q2	0.0-0.5	0.0109	J	0.0214	J	57.9	J	0.0958	J	0.269	J	NV		0.947	J	68.8		54.2		3		4		7		12	
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		29.5		NV		NV		NV		NV		NV	
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		34.8		NV		NV		NV		NV		NV	
	H3	Q1	0.0-0.5	0.00948		0.141		60.7		0.0928		0.0511		0.0000076	U	0.951		NV		NV		2		7		10		20	
		Q2	0.0-0.5	0.0114	J	0.0181	J	36.2	J	0.0765	J	0.31	J	NV		0.721	J	49.4		29		8		17		26		39	
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		54.4		NV		NV		NV		NV		NV	
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		50		NV		NV		NV		NV		NV	
	H4	Q1	0.0-0.5	0.00437		0.225		82.6		0.0685		0.34		0.0000075	U	0.822		NV		NV		3		7.5		15		32	
		Q2	0.0-0.5	0.0294	J	0.0916	J	58.9	J	0.151	J	0.252	J	NV		1.49	J	77.6		22.6		4.5		7		11.5		45	
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		41.6		NV		NV		NV		NV		NV	
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		15.8		NV		NV		NV		NV		NV	

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Cadmium		Copper		Iron		Lead		Nickel		Mercury		Zinc		Moisture	Total Solids	0.001 mm	0.002 mm	0.005 mm	0.02 mm
			feet	µmoles/g		µmoles/g		µmoles/g		µmoles/g		µmoles/g		µmoles/g		µmoles/g		%	%	% passing	% passing	% passing	% passing
Transect I	I1	Q1	0.0-0.5	0.142		1.02		63.4		0.387		0.306		0.0000076	U	4.69		NV	NV	0.5	2	6	17.5
		Q2	0.0-0.5	0.0746	J	0.000765	R	78.1	J	0.23	J	0.476	J	NV		3.19	J	32.5	72.1	0.5	2.5	8	15
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		25.7	59.3	3	4	7	13
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		34.2	48.4	5	7	10	14
	I2	Q1	0.0-0.5	0.088		0.533		59.9		0.349		0.626		0.0000077	U	3.14		NV	NV	3	6	9.5	20
		Q2	0.0-0.5	0.0856	J	0.0147	J	57.8	J	0.233	J	0.74	J	NV		3.01	J	53.1	51.2	3.5	5	7	15.5
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		56.8	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		59.6	NV	NV	NV	NV	NV
	I3	Q1	0.0-0.5	0.121		0.122		55.5		0.537		0.545		0.0000075	U	3.6		NV	NV	12	12	15.5	39
		Q2	0.0-0.5	0.169	J	0.000776	R	32.7	J	0.493	J	0.0415	J	NV		5.56	J	68.8	27.9	6	16	29	47
		Q2	1.0-1.5	NV		NV		NV		NV		NV		NV		NV		65.2	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV		NV		NV		NV		NV		NV		NV		60.6	NV	NV	NV	NV	NV
	I4	Q1	0.0-0.5	0.192		0.0928		74.4		0.631		0.536		0.0000077	U	4.99		NV	NV	4	15	27	45
		Q2	0.0-0.5	0.0759	J	0.00458	J	40.8	J	0.324	J	0.293	J	NV		3.16	J	60.2	43.6	10	15	31	50.5
		Q2	0.8-1.3	NV		NV		NV		NV		NV		NV		NV		69.5	NV	NV	NV	NV	NV
		Q2	2.1-2.6	NV		NV		NV		NV		NV		NV		NV		62.2	NV	NV	NV	NV	NV
Transect J	J1	Q4	0.0 - 0.5	0.00907		0.296		162		0.214		0.295		NV		2.53		33.8	NV	0.5	0.5	0.5	1
		Q4	0.8-1.3	0.00848		0.657		104		0.559		0.307		NV		1.6		19.1	NV	6	8	13	26
		Q4	2.5-3.0	0.00478		0.226		79.8		0.121		0.175		NV		1.39		46.8	NV	11	20	34	60
	J2	Q4	0.0 - 0.5	0.00571		0.154		127		0.0646		0.414		NV		1.2		32	NV	1	2	4	10
		Q4	1.0-1.5	0.00545		0.352		104		0.131		0.156		NV		2.29		31.6	NV	5	10	17	30
		Q4	2.5-3.0	0.0115		0.24		45.8		0.186		0.176		NV		3.12		18.9	NV	1	1	1	5
	J3	Q4	0.0 - 0.5	0.00138		0.151		89.4		0.0539		0.22		NV		0.946		35.6	NV	1	1	2	6
		Q4	0.6-1.0	0.00261		0.187		63.8		0.0736		0.0847		NV		1.16		20.9	NV	2	3	6	8
		Q4	2.5-3.0	0.000142		0.0335		12.1		0.0037		0.00362		NV		0.0122		31.2	NV	16	23	33	58
	J4	Q4	0.0 - 0.5	0.00718		0.19		121		0.0814		0.345		NV		2.57		34	NV	0.5	0.5	0.5	1
		Q4	0.5-1.0	0.00189		0.261		192		0.154		0.686		NV		4.24		23.3	NV	1	1	1	3
		Q4	2.5-3.0	0.00014	U	0.00699		1.11		0.0018		0.00429		NV		0.0092		15	NV	1	1	1	2

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	0.05 mm	0.064 mm	0.075 mm	0.15 mm	0.3 mm	0.6 mm	1.18 mm	2.36 mm	3.35 mm	4.75 mm	19 mm	37.5 mm	75 mm
			feet	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing
Transect A	A1	Q1	0.0-0.5	13	21.5	27.2	67.9	93.3	97.8	99.4	99.9	100	100	100	100	100
		Q2	0.0-0.5	25	44	53.7	74.5	96.3	98.7	99.5	99.8	99.9	100	100	100	100
		Q2	0.9-1.4	32	38	40.6	50.9	62.1	77.6	91.6	99.4	99.8	99.9	100	100	100
		Q2	2.5-3.0	3	2	2.2	2.4	55.9	99.4	99.8	99.9	100	100	100	100	100
	A2	Q1	0.0-0.5	3	3.5	3.9	5.5	55.4	99.3	99.8	99.9	100	100	100	100	100
		Q2	0.0-0.5	2	2	2.2	3.6	60.1	99.4	99.9	100	100	100	100	100	100
		Q2	0.9-1.4	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	A3	Q1	0.0-0.5	2	2	2.1	3.4	56.1	97.8	99.9	100	100	100	100	100	100
		Q2	0.0-0.5	2	2.5	2.7	3.6	50.7	95.4	98.8	100	100	100	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	A4	Q1	0.0-0.5	1.5	1.5	1.9	9	70.4	98.1	99.4	99.9	100	100	100	100	100
		Q2	0.0-0.5	2.5	2.5	2.9	9	64.2	98.2	99.8	99.8	100	100	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Transect B	B1	Q1	0.0-0.5	28	45.5	55.4	90	95.2	97.1	99	99.9	100	100	100	100	100
		Q2	0.0-0.5	37.5	58	71.9	90.8	96.9	98.8	99.5	99.9	100	100	100	100	100
		Q2	0.8-1.3	28	34	35.8	43.6	57.5	84.5	97.7	99.8	99.9	100	100	100	100
		Q2	2.5-3.0	94	96	96.7	98.4	98.8	99.3	99.4	99.4	99.9	100	100	100	100
	B2	Q1	0.0-0.5	17.5	25	29.4	43.9	68.7	92.5	98.5	99.9	100	100	100	100	100
		Q2	0.0-0.5	23	31	34.8	49.3	73.3	95.1	99.2	99.9	100	100	100	100	100
		Q2	0.6-1.1	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	1.9-2.4	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	B3	Q1	0.0-0.5	75	80.5	85	93.8	96.5	98	98.9	99.2	99.8	99.9	100	100	100
		Q2	0.0-0.5	81	86	88.4	94.2	96.9	99.2	99.7	99.7	100	100	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	B4	Q1	0.0-0.5	60.5*	68.5*	76.4*	92.6	95.9	97.4	98.9	99.2	99.8	99.9	100	100	100
		Q1-Dup	0.0-0.5	62	69	76.5	92.2*	95.8*	97.2*	98.4*	99.2*	99.7*	99.9*	100*	100*	100*
		Q2	0.0-0.5	65	71	76.6	93.1	96.1	97.8	99.2	99.8	100	100	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	B5	Q4	0.0 - 0.5	3	3.5	4.5*	17.5*	57.1*	90.5*	99	100	100	100	100	100	100
		Q4-Dup	0.0 - 0.5	2*	2.5*	4.7	19.8	58.7	90.7	99*	100*	99.9*	100*	100*	100*	100*
		Q4	0.5-1.0	6.5	8.5	9.4	17.9	46.1	80.8	95.7	100	100	100	100	100	100
		Q4	2.3-2.9	2	3.5	4.5	9.5	33.1	81	98.5	100	99.9	100	100	100	100

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	0.05 mm	0.064 mm	0.075 mm	0.15 mm	0.3 mm	0.6 mm	1.18 mm	2.36 mm	3.35 mm	4.75 mm	19 mm	37.5 mm	75 mm
			feet	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing
Transect C	C1	Q1	0.0-0.5	23	34	38.9	58.9	77.4	94.6	98.5	99.3	99.9	99.9	100	100	100
		Q2	0.0-0.5	31	40.5	47.8	72.6	86	96.7	99.3	99.8	100	100	100	100	100
		Q2	0.8-1.3	48	54.5	57.6	65.2	75.8	87.2	95	99.3	99.9	99.9	100	100	100
		Q2	0.8-1.3	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.3-2.8	27	29	30.9	38	56.4*	80.4*	91.6*	99.7	99.9	99.9*	100	100	100
		Q2-Dup	2.3-2.8	20*	25*	25.8*	33.9*	57.4	89.3	97.2	99.7*	99.9*	100	100*	100*	100*
	C2	Q1	0.0-0.5	23	30	35.1	64.8	86.8	97.8	99	99.7	99.9	99.9	100	100	100
		Q2	0.0-0.5	19.5	24	27.8	56.5	83.4	97.1	99.1	99.9	100	100	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.0-2.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	C3	Q1	0.0-0.5	41.5	50	54.2	69.4	80.3	97.4	98.9	99.3	99.9	100	100	100	100
		Q2	0.0-0.5	49.5	60	64.5	76.1	85.4	93.3	98.6	99.6	99.9	99.9	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.4-2.9	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	C4	Q1	0.0-0.5	55	61	64.6	78.9	87.7	94.3	98.7	99.5	99.8	99.9	100	100	100
		Q2	0.0-0.5	56	61	65.2	78.7	87.2	94.2*	98.8*	99.9	100	100	100	100	100
		Q2-Dup	0.0-0.5	38.5*	48*	52.3*	64.3*	73.6*	98	99.6	99.6*	99.9*	100*	100*	100*	100*
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Transect D	D1	Q1	0.0-0.5	45.5	53	55.8	60.2	66.5	76.4	93.3	98.9	99.3	99.6	100	100	100
		Q2	0.0-0.5	50	62	67.8	71.8	77.2	86	98	99.6	99.9	99.9	100	100	100
		Q2	1.0-1.5	38	46	48.3	54.3	62.2	74	92.3	99.7	99.8	99.9	100	100	100
		Q2	2.5-3.0	64	70	72.2	75.8	80.1	86.9	95.8	99.4	99.8	99.9	100	100	100
	D2	Q1	0.0-0.5	68	70	82	84.5	87.4	92.3	98.7	99.5	99.8	99.9	100	100	100
		Q2	0.0-0.5	55	67	73	76.3	80.4	87.6	97.9	99.5	99.9	99.9	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	D3	Q1	0.0-0.5	76	85	89.5	91.1	92.6	95.2	98.5	99.5	99.8	99.9	100	100	100
		Q2	0.0-0.5	67	80	88.5	91.2	93.6	96.8	99.2	99.4	99.8	99.9	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	D4	Q1	0.0-0.5	36.5	41.5	44.5	53.5	68	93.3	98.6	99.7	99.9	99.9	100	100	100
		Q2	0.0-0.5	44	48	50	59	72.2	93.4	98.8	99.8	100	100	100	100	100
		Q2	0.8-1.3	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	0.05 mm	0.064 mm	0.075 mm	0.15 mm	0.3 mm	0.6 mm	1.18 mm	2.36 mm	3.35 mm	4.75 mm	19 mm	37.5 mm	75 mm
			feet	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing
Transect E	E1	Q1	0.0-0.5	50*	62*	67.4*	72.6*	80.4*	88.6*	97.1*	99.6	99.8*	99.9	100	100	100
		Q1-Dup	0.0-0.5	56.5	67	71.3	76.6	83.3	89.9	97.7	99.5*	99.9	99.9*	100*	100*	100*
		Q2	0.0-0.5	48	56	59	63.1	70.1	78.5	92.5	99.8	99.9	100	100	100	100
		Q2	1.0-1.5	58	65	68.7	73.4	79.5	85.7	90.9	91.8	92	92.1	92.2	92.2	100
		Q2	2.5-3.0	92	95	96.6	97.7	98.7	99.3	99.5	99.5	99.9	99.9	100	100	100
	E2	Q1	0.0-0.5	92.5	94	95	96.7	98	98.7	99.2	99.5	99.9	99.9	100	100	100
		Q2	0.0-0.5	86	91	93.1	95	97.4	99	99.3	99.4	99.9	99.9	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	E3	Q1	0.0-0.5	65	67.5	68.5	74.1	81.5	88.9	97.1	99.8	100	100	100	100	100
		Q2	0.0-0.5	58	72	81.2	85.9	90.9	95.4	99	99.5	99.9	99.9	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	E4	Q1	0.0-0.5	21	22	25.2	39.3	63.8	87.4	97.4	99.9	100	100	100	100	100
		Q2	0.0-0.5	28.5	32	35	46.2	66.2	88	97.8	99.9	100	100	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Transect F	F1	Q1	0.0-0.5	39	42.5	44.1	49.1	61.1	86.3	97.9	99.6	99.9	99.9	100	100	100
		Q2	0.0-0.5	40	43	44.9	51	65	89.4	98.1	99.9	100	100	100	100	100
		Q2	1.0-1.5	54	61	63.5	67.4	75.2	90.3	98.4	99.6	99.9	100	100	100	100
		Q2	2.5-3.0	54	59	61.1	65.1	73.3	86.8	96.9	99.5	99.9	100	100	100	100
	F2	Q1	0.0-0.5	89	90	90.3	91.1	92	94.7	98	99.6	99.9	99.9	100	100	100
		Q2	0.0-0.5	46	47	47.1	49.4	55	72.9	90.3	99.3	99.7	99.7	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	F3	Q1	0.0-0.5	73	83.5	88.2	90.3	93.1	96.5	99.2	99.5	99.8	99.9	100	100	100
		Q2	0.0-0.5	64	69	71.6	74.8	80.3	88.3	97.2	99.5*	100	100	100	100	100
		Q2-Dup	0.0-0.5	57.5*	63*	66.8*	70*	75.4*	84*	94.1*	99.6	99.9*	100*	100*	100*	100*
		Q2	1.2-1.7	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	F4	Q1	0.0-0.5	69	71	85.1	86.8	89.2	93	98.4	99.6	99.9	99.9	100	100	100
		Q2	0.0-0.5	65	75	82.1	84.6	88	93.1	98.6	99.5	99.9	99.9	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2-Dup	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2-Dup	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	0.05 mm	0.064 mm	0.075 mm	0.15 mm	0.3 mm	0.6 mm	1.18 mm	2.36 mm	3.35 mm	4.75 mm	19 mm	37.5 mm	75 mm
			feet	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing
Transect G	G1	Q1	0.0-0.5	19.5	21	21.9	26.5	41.4	84.4	97.1	99.9	100	100	100	100	100
		Q2	0.0-0.5	15	16	16.5	20.9	35.2	84.2	97.9	99.8	100	100	100	100	100
		Q2	1.1-1.6	67	71	74.1	89.3	93	97.2	99.1	99.5	99.9	99.9	100	100	100
		Q2	2.5-3.0	61	71	76.5	93.8	96.2	97.2	98	98.3	98.8	98.8	98.9	100	100
	G2	Q1	0.0-0.5	40	42	56	65	79.8	93.4	97.6	98.6	99.5	99.7	100	100	100
		Q2	0.0-0.5	55	67	74.9	81.3	88.9	95.8	99.1	99.5	99.9	99.9	100	100	100
		Q2	0.8-1.3	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	G3	Q1	0.0-0.5	55	61.5	64.9	76.9	86.6	95.4	98.5	99.6	99.8	99.9	100	100	100
		Q2	0.0-0.5	53	66	74	79.3	86.4	93.3	98.5	99.4	99.9	100	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	G4	Q1	0.0-0.5	51.5	59	62.3	71.2	84.4	92.7	96.5	97.1	97.6	99.9	100	100	100
		Q2	0.0-0.5	45	51	54.8	66.7	83.1	96.6	99.2	99.5	99.8	99.9	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Transect H	H1	Q1	0.0-0.5	50	62	70.5	78.1	87.2	93	97.7	99.4	99.9	99.9	100	100	100
		Q2	0.0-0.5	53	61.5	66.5	74.2	81.7	89.1	97.6	99.6	99.9	100	100	100	100
		Q2	1.0-1.5	57	68	73.1	80.1	87.2	92.7	97.9	99.3	99.7	99.8	100	100	100
		Q2	2.5-3.0	32	39	41.2	55.2	75.5	94.9	98.7	99.4	99.9	99.9	100	100	100
	H2	Q1	0.0-0.5	18	19.5	20.3	26.5	54.9	90.7	98.4	99.8	99.9	100	100	100	100
		Q2	0.0-0.5	19	26	29.6	35.5	58.1	89.3	97.4	99.7	99.9	99.9	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	H3	Q1	0.0-0.5	35	43	47.5	57.1	69	91.7	98.1	99.6	99.8	99.9	100	100	100
		Q2	0.0-0.5	57	64	68.6	76	87.2	94.5	98.8	99.5	99.9	100	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	H4	Q1	0.0-0.5	44	49.5	52.3	57.2	70.4	88.5	99.6	99.6	99.9	99.9	100	100	100
		Q2	0.0-0.5	55	58	59.5	64	72.2	83.6	95.5	99.6	99.9	99.9	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV

Appendix C-3a
Data from Sediment Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	0.05 mm	0.064 mm	0.075 mm	0.15 mm	0.3 mm	0.6 mm	1.18 mm	2.36 mm	3.35 mm	4.75 mm	19 mm	37.5 mm	75 mm
			feet	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing
Transect I	I1	Q1	0.0-0.5	26	32.5	35.9	49.9	77.9	97.3	99.3	99.7	99.9	99.9	100	100	100
		Q2	0.0-0.5	26	31.5	35.9	54.3	82.8	97.8	99.1	99.2	99.9	99.9	100	100	100
		Q2	1.0-1.5	21	28	32.2	54.3	88.9	98.3	99.3	99.6	99.9	99.9	100	100	100
		Q2	2.5-3.0	20	25	27.4	43.6	79.7	98.5	99.5	99.7	100	100	100	100	100
	I2	Q1	0.0-0.5	36.5	43.5	47.2	63.6	87	97.2	98.9	99.4	99.8	99.9	100	100	100
		Q2	0.0-0.5	33	46.5	52.1	72.6	89.9	97.3	99.3	99.7	99.9	99.9	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	I3	Q1	0.0-0.5	48	50	51.4	57.9	66.3	75.4	88.4	99.3	99.8	99.9	100	100	100
		Q2	0.0-0.5	65	73	77.7	82.8	90	95.9	99.4	99.8	100	100	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	I4	Q1	0.0-0.5	60	65.5	68.6	72.9	78.5	89.5	96.8	99.4	99.7	99.8	100	100	100
		Q2	0.0-0.5	68	76	79.7	85.3	89.7	94.4	99.2	99.4	99.9	100	100	100	100
		Q2	0.8-1.3	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.1-2.6	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Transect J	J1	Q4	0.0 - 0.5	2	5	7.8	40.3	81.5	97.2	98.9	100	99.9	100	100	100	100
		Q4	0.8-1.3	34	37	39.4	49.5	68.8	90.1	97.9	100	99.9	99.9	100	100	100
		Q4	2.5-3.0	72	76	78.1	91.1	96.2	98.6	99.6	100	99.7	99.9	100	100	100
	J2	Q4	0.0 - 0.5	18	25	29.6	58.7	83.7	94	98	100	99.8	100	100	100	100
		Q4	1.0-1.5	38	40	41.6	48.7	68.7	98.3	99.6	100	99.9	99.9	100	100	100
		Q4	2.5-3.0	7	8	8.5	10.2	33.4	98.1	99.7	100	100	100	100	100	100
	J3	Q4	0.0 - 0.5	23	33	38.1	62.7	82.3	94.2	98.3	100	99.8	99.9	100	100	100
		Q4	0.6-1.0	15	23	26.9	73.4	98.5	99.5	99.7	100	99.8	100	100	100	100
		Q4	2.5-3.0	79	86	88.5	93.8	96.8	98.8	99.5	100	99.5	99.9	100	100	100
	J4	Q4	0.0 - 0.5	3	4	6.8	36.5	91.2	98.7	99.6	100	99.9	100	100	100	100
		Q4	0.5-1.0	4	5.5	7.1	33.2	90.5	98.7	99.8	100	99.9	100	100	100	100
		Q4	2.5-3.0	2	2	2.5	4.1	58.3	98.6	99.7	100	99.9	100	100	100	100

* = datum not used (because it is the lower pair of a duplicate, or the datum was rejected

mg/kg = Milligram/Kilogram
mm = Millimeters
NV = No Value, no analysis performed
TOC = Total organic carbon
µmoles/g = Micromoles per Gram

Qualifiers:
J = Estimated value
K= Analyte is present but flagged as a high bias, usually associated with MS/MSD, LCS, LCSD spike recoveries.
U = Not detected

Appendix C-3b
Data from Sediment Reference Location Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Aluminum	Calcium	Magnesium	Iron	Divalent Manganese	Chromium	Ferrous Iron	Manganese	Vanadium
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Transect 37	37	Q1	0.0-0.5	37,500	200	8,280	49,800	0.97	127	10,800	1,470	80.5
		Q2	0.0-0.5	41,400	7,570	10,000	72,600	6.704	161	10,800	1,770	127
		Q2	1.0-1.5	31,500	2,440	8,120	48,400	NV	147	NV	1,550	98
		Q2	2.5-3.0	34,700	1,940	9,750	46,300	NV	84.9	NV	1,470	74.8
	37A	Q1	0.0-0.5	36,200	2,660	7,990	47,800	3.773	95.6	7,950	1,210	80.5
		Q2	0.0-0.5	37,100	2,520	9,430	54,900	2.445 U	124	11,000	1,650	92.2
		Q2	1.0-1.5	36,200	1,930	9,100	46,700	NV	99.4	NV	1,290	76.8
		Q2	2.5-3.0	36,100	1,870	10,100	45,200	NV	55.3	NV	1,490	67.9
	37B	Q1	0.0-0.5	35,700	1,900	8,370	47,200	0.658	89.2	9,170	1,620	77.2
		Q2	0.0-0.5	36,100	2,530	8,850	56,200	2.44 U	166	2,230	1,680	107
		Q2	1.2-1.7	37,900	2,090	9,980	45,500	2.353 U	55.8	4,200	1,670	71
		Q2	2.5-3.0	37,600	1,860	9,460	45,800	2.32 U	75.4	4,710	1,560	75.2

Appendix C-3b
Data from Sediment Reference Location Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	Sulfide	TOC	Acid Volatile Sulfide	Cadmium	Copper	Iron	Lead	Nickel	Mercury	Zinc	Moisture	Total Solids
				mg/kg	mg/kg	µmoles/g	µmoles/g	µmoles/g	µmoles/g	µmoles/g	µmoles/g	µmoles/g	µmoles/g	%	%
Transect 37	37	Q1	0.0-0.5	2,110	27,000	29.8	0.00273	0.109	103	0.069	0.14	7.7E-06 U	0.775	61.9	22.6
		Q2	0.0-0.5	2,490	22,000	20.3	0.0015	0.0374	66.4	0.0565	0.166	NV	0.585	74	20.8
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	74.4	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	60.3	NV
	37A	Q1	0.0-0.5	2,960	27,000	24.9	0.00286	0.159	87.8	0.075	0.0663	7.8E-06 U	0.792	67.8	19.2
		Q2	0.0-0.5	1,260	29,000	14.7	0.0019	0.0914	69.5	0.0681	0.161	NV	0.681	73.5	22
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	64.9	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	59.4	NV
	37B	Q1	0.0-0.5	775	25,000	9.7	0.00312	0.262	115	0.0913	0.185	7.7E-06 U	0.992	62.5	27.6
		Q2	0.0-0.5	1,540	23,000	22	0.00163	0.0676	75.9	0.0635	0.081	NV	0.649	71.4	24.6
		Q2	1.2-1.7	656	26,000	NV	NV	NV	NV	NV	NV	NV	NV	55.7	39.3
		Q2	2.5-3.0	692	26,000	NV	NV	NV	NV	NV	NV	NV	NV	52.9	46.8

Appendix C-3b
Data from Sediment Reference Location Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	0.001 mm	0.002 mm	0.005 mm	0.02 mm	0.05 mm	0.064 mm	0.075 mm	0.15 mm	0.3 mm
				% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing
Transect 37	37	Q1	0.0-0.5	41	43	56	71	84	88.5	90.6	91.7	93.5
		Q2	0.0-0.5	9	17	28.5	43	65	76	82.6	84.2	87.2
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV
	37A	Q1	0.0-0.5	23	36	50	78	81	88	89.8	90.6	91.8
		Q2	0.0-0.5	13	26	41	49	69	79	85.2	86.6	89.1
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV	NV
	37B	Q1	0.0-0.5	21	34	48	61	83	90	92.7	93.5	94.8
		Q2	0.0-0.5	8	18	31.5	46	70	84	91.3	92.4	94.6
		Q2	1.2-1.7	36	48	62	85	94.5	98.5	99.2	99.3	99.4
		Q2	2.5-3.0	39	51.5	64.5	82.5	93.5	98	98.1	98.4	98.8

Appendix C-3b
Data from Sediment Reference Location Sampling Events
Dundalk Marine Terminal, Baltimore, Maryland

Transect	Sample	Quarter	Depth	0.6 mm	1.18 mm	2.36 mm	3.35 mm	4.75 mm	19 mm	37.5 mm	75 mm
				% passing	% passing	% passing	% passing	% passing	% passing	% passing	% passing
Transect 37	37	Q1	0.0-0.5	96.1	98.8	99.7	99.9	100	100	100	100
		Q2	0.0-0.5	92.7	98.5	99.4	99.7	99.8	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV
	37A	Q1	0.0-0.5	94	97.2	99.6	99.9	99.9	100	100	100
		Q2	0.0-0.5	93.1	98.2	99.6	99.9	99.9	100	100	100
		Q2	1.0-1.5	NV	NV	NV	NV	NV	NV	NV	NV
		Q2	2.5-3.0	NV	NV	NV	NV	NV	NV	NV	NV
	37B	Q1	0.0-0.5	96.5	98.8	99.6	99.9	99.9	100	100	100
		Q2	0.0-0.5	97.5	99.3	99.4	99.8	99.9	100	100	100
		Q2	1.2-1.7	99.5	99.6	99.7	99.9	99.9	100	100	100
		Q2	2.5-3.0	99.3	99.6	99.6	99.9	99.9	100	100	100

mg/kg = Milligram/Kilogram
mm = Millimeters
NV = No Value, no analysis performed
TOC = Total organic carbon
µmoles/g = Micromoles per Gram

Qualifiers:
U = Not detected