

## **Appendix D**

### **Human Health Risk Assessment Work Plan**

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# Appendix D

## Human Health Risk Assessment Work Plan

### 1.0 Introduction

This baseline Human Health Risk Assessment (HHRA) Work Plan has been prepared to present the data quality objectives for the field investigation that will be performed to support the HHRA for the Operable Unit 2 (OU2) portion of the Washington Gas (WG) East Station Site (Site, as defined in the OU2 RI/FS Work Plan), in the District of Columbia (District or DC). In addition, this document presents the methodology that will be used to evaluate potential human health risks in the baseline HHRA. The results of the baseline HHRA will be used to help inform the need for any additional evaluation and/or remedial action at the Site.

The OU2 portion of the Site includes groundwater, surface water, and sediments of the Anacostia River (River) where hazardous substances potentially released at or from the WG East Station Property have come to be located. Figure 1 presents the Site layout. Sediments at the Site are included in the HHRA evaluation, as indicated in Figure 2. For the purpose of this Work Plan, an area of the River at the Site has been assumed to be the in-river boundary for initial data collection. This approximately 2.33-acre area is about 1000 feet in length (along the Anacostia River seawall) and extends approximately 100 feet into the River channel. The near-surface soil on the landside portion of the Site is being addressed separately in the OU1 Work Plan (AECOM, 2012). Therefore, this HHRA Work Plan focuses on the in-river evaluation approach (i.e., potential exposures to River media potentially impacted by releases from the WG East Station Site).

#### 1.1 Background

The WG East Station Property on the north side of Water Street Southeast (SE) is the location of a former Manufactured Gas (MG) Plant facility which operated from 1888 to 1948. From 1946 to 1948, WG converted its distribution system entirely to natural gas. From 1948 until January 1983, the plant was operated only for peaking purposes or once a year on a trial-run basis to check equipment. The plant was closed in 1983 and largely demolished between 1983 and 1986.

The general Site location is on the Anacostia River at approximately 1240 12th Street SE in Washington, DC in a highly urbanized area. Current development of the WG East Station Property north of Water Street is characterized by multistory office buildings and parking lots, with additional similar type development planned. The District owns the majority of the land between Water Street SE and the River (the landside portion of the Site). The United States owns and the US Army Corps of Engineers (USACE) manages a small (0.35) acre parcel within the property, and maintains a dock and other facilities. The District-owned and USACE-managed parcels are collectively called the government property. WG understands that the strip of land currently owned by the District between East Station and the River is slated for development within the District Anacostia Waterfront Initiative

with the primary planned use being the development of boathouses for rowing clubs (Boathouse Row) and other recreational uses. The USACE property is mostly paved with an office and dock space for access to the River. A seawall installed by the USACE beginning about 1914 forms the bank of the River in the area of the government property. The seawall is reportedly constructed of squared stones placed on a concrete sill. The concrete sill was placed on timber piles driven into the River sediments (Hydro-Terra, 1999).

An HHRA was previously conducted for both the landside and in-river portions of the Site (Hydro-Terra, 1999). The elements of the 1999 HHRA pertaining to the Anacostia River media are summarized in Section 1.4.

## 1.2 Environmental Setting

The Anacostia River watershed encompasses an area of approximately 176 square miles within the District and Maryland, and lies within two physiographic provinces, the Piedmont Plateau and the Coastal Plain. The River begins in Bladensburg, Maryland, at the confluence of its two major tributaries, the Northwest Branch and the Northeast Branch, and flows a distance of approximately 8.4 miles before it discharges into the Potomac River in Washington, DC (Sullivan and Brown, 1988). Because of its location in the Washington metropolitan area, the majority of the watershed is highly urbanized. The shoreline and nearshore areas in the Site vicinity have been extensively modified with bulkheads and riprap revetments armoring nearly all of the shoreline.

The River in the vicinity of the Site is a freshwater tidal estuary, with tidal influence extending some distance into the Northeast and the Northwest branches. The variation in the River's water surface elevation over a tidal cycle is approximately 3 feet (ft). The width of the River varies from approximately 197 ft in some upstream reaches to approximately 1640 ft near the confluence with the Potomac, and average depths across a transect vary from about 5.2 ft near Bladensburg to about 20.3 ft just downstream of the South Capitol Street Bridge (also called the Fredrick Douglass Memorial Bridge), approximately 1 mile southwest from the Site. In the general area of the Site water depths range from approximately 3.6 ft to 18.6 ft below Mean Lower Low Water (MLLW). During base flow conditions, measured flow velocities during the tidal cycle have been in the range of 0 to 1 ft/second (sec) (Katz et al., 2001). Navigational dredging has occurred in the River, altering the natural bathymetry. As a result of the extensive urban and industrial development, the natural habitat for fish and wildlife is limited and this development has promoted species that can successfully adapt to highly urbanized environments.

Sedimentation has been a problem in the tidal Anacostia River since colonial times (Scatena, 1987). Estimated average annual sediment discharge into the tidal embayment of the River was 134,420 tons for 1963 and 137,600 tons for 1981 (Scatena, 1987). Because of the low flow velocities in the tidal portion of the River, the majority of sediment entering the tidal embayment is thought to settle and remain in the tidal river, rather than being discharged to the Potomac. Based on a variety of methods, including analyses of historical bathymetry records, dredging records, and pollen profiles of sediment bed core samples, Scatena (1987) estimated sedimentation rates in the range of 0.5 to 3.6 inches/year. This is consistent with more recent estimates of Velinsky et al. (2011), who estimated that sedimentation rates (based on radiodating studies) ranged from approximately 1.1 to 2.8 inches/year.

The Anacostia River has been identified for several years by American Rivers as one of the 10 most contaminated rivers in the country and also one of three areas of concern for the Chesapeake Bay (<http://www.americanrivers.org/endangered-rivers/previous/>). The River in the District is currently

under a fish consumption advisory, urging the public to not eat any carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), or American eel (*Anguilla rostrata*) captured in the waters of the District (both the Anacostia and Potomac Rivers) (<http://ddoe.dc.gov/service/fishing-district>), and limiting consumption of fish, such as largemouth bass (*Micropterus salmoides*) and sunfish (*Centrarchidae*) to one-half pound per month. The primary contaminants of concern for the advisory are polychlorinated biphenyls (PCBs) and “other chemical contaminants”. Other contaminants of concern in the River estuary include organochlorine (OC) pesticides, such as dichlorodiphenyltrichloroethane (DDT) and its metabolites (Velinsky and Cummins 1994; Velinsky and Cummins 1996; Pinkney et al. 2001), and polynuclear aromatic hydrocarbons (PAHs).

The National Oceanic and Atmospheric Administration (NOAA) Damage Assessment, Remediation, and Restoration Program (DARRP) has compiled a database including sediment quality data from 35 studies in the River which has been reviewed in development of this Work Plan. The review involved querying select possible contaminants from the NOAA DAARP database and plotting them using GIS software. Primarily, PAH concentrations in the Anacostia River's surficial and sub-surficial sediment were reviewed in a one mile radius around the site. This exercise allowed for analysis of the nature and extent of PAH concentrations in the vicinity of the site, near known outfalls/ combined sewer outfalls (CSOs), and relative to the areas of concern identified by the Anacostia Watershed Toxics Alliance (AWTA).

Based upon these extensive studies, and as summarized in a 2009 NOAA White Paper (NOAA, 2009) it has been demonstrated that PCBs, PAHs, metals, and to a lesser degree volatile organic compounds (VOCs) are found in sediment samples collected throughout the River, upstream and downstream of the WG East Station Site. The WG East Station facility has been cited in certain of these studies as a potential contributing source to some of the contaminants, including PAHs, observed in River sediments. PCBs have been tested for during the East Station landside studies and have never been identified as a landside COPC, as discussed in Section 3.1 of the main text of the Remedial Investigation (RI) and Feasibility Study (FS) Work Plan. PCBs are not a typical MG contaminant and NOAA and others (e.g., NOAA, 2009) have concluded that PCBs in the River are derived from sites other than the WG East Station Site.

Sampling for PCBs will be performed to confirm that they are not present at the Site. PCB Aroclors will be sampled in NAPL accumulating in existing monitoring and recovery wells, and of NAPL saturated soils. If the results of these NAPL samples show that the Site is a potential source of PCBs, PCB congeners will be included in the analysis of other media (i.e., groundwater and sediment) and PCBs may be identified as COPCs.

While PAHs, phenolics, cyanide, certain VOCs (i.e., benzene, toluene, ethylbenzene and xylenes [BTEX]) and various inorganic contaminants are indicative of historical MG operations, they are also associated with urban and industrial activities. Understanding the potential MG contribution to the total load of these contaminants in river sediments (and associated site risk) is an objective of the OU2 RI/FS.

### 1.3 Contaminant Fate and Transport

Based on historical RI efforts, contaminants from the Site include MG-related contaminants, such as PAHs, phenolics, cyanide, BTEX and select inorganics. These MG-related contaminants are therefore the focus of this HHRA. These contaminants may have entered the Anacostia River from overland flow or groundwater discharge. Several other sources of these contaminants in the vicinity of the Site may exist, including:

- Historical discharges through groundwater flow, stormwater outfalls and overland flow from other non-Site related landside areas;
- Storm sewers from other facilities, CSOs, and other sites nearby on the River; and
- Upstream industrial and urban activities in the anthropogenically-impacted River, its main branches and its tributaries.

## 1.4 1999 Risk Assessment

An HHRA was previously conducted for both the landside and in-river portions of the Site (Hydro-Terra, 1999). The purpose of the 1999 HHRA was to evaluate potential health risks to receptors (current and future) on or near the East Station property, the government property, and public streets to the south and west side of the East Station property. The 1999 HHRA assumed that the future use of the government property would be a park similar to the Anacostia Park across the River. The 1999 HHRA evaluated both commercial/industrial and residential future use of the East Station property.

The 1999 HHRA included an evaluation of surface water, sediment, and fish tissue in the Anacostia River at the Site. The elements of the 1999 HHRA pertaining to these Anacostia River media are summarized below.

### **Data Evaluation and Selection of Contaminants of Potential Concern (COPCs)**

The 1999 HHRA evaluated the results of seven surface water and seven surface sediment (0-6 inches) samples collected in June 1996 (locations starting with 96SD) from the locations noted in Figure 3 (Hydro-Terra, 1999; Figure 5-8). Three additional surface water samples were collected in February 1997 (locations starting with 97SD). Locations 96SD-01, 96SD-06, and 97SD-01 were treated as upgradient locations and were not included in the evaluation of potential risks at the Site. The samples were analyzed for Target Compound List (TCL) volatiles and semivolatiles, Target Analyte List (TAL) metals, and cyanide.

Organic contaminants and cyanide were not detected in surface water samples. Metals, including aluminum, barium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc were detected. However, there were no surface water concentrations exceeding United States Environmental Protection Agency (USEPA) Maximum Contaminant Levels (MCLs) (for metals with MCLs). Therefore, surface water was eliminated as a medium of potential concern from the 1999 HHRA.

Inorganic COPCs (arsenic and beryllium) in sediment were selected based on a comparison to the January 1997 USEPA Risk-Based Concentration (RBC) table. Organic COPCs (PAHs and bis(2-ethylhexyl)phthalate) in sediment were selected using a concentration toxicity screen in which the percent contribution to potential Site risks was derived based on toxicity values (reference doses and cancer slope factors) and intake factors. PAHs selected as COPCs included: benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene. Contaminants contributing less than 2% to total site risks were eliminated as COPCs.

A 1992 fish tissue dataset collected by Versar, Inc. and reported by Pinkney et al. (1993) was evaluated in the 1999 HHRA. The 1992 data were collected in response to a January 1992 oil spill. A total of 18 tissue samples were analyzed for cadmium, total mercury (methyl mercury was not analyzed), lead, and PAHs. Mercury was the only one of the inorganics with an FDA action level for

fish; therefore, mercury was the only inorganic evaluated in the HHRA. There was no significant difference in tissue mercury concentrations between the spill area and reference area fish. On this basis, inorganic mercury was eliminated as a COPC. All seven potentially carcinogenic PAHs were included as COPCs for fish tissue, regardless of concentration (i.e., no screening was conducted) and were evaluated in the 1999 HHRA.

### **Exposure Assessment**

The 1999 HHRA evaluated potential current (1999) risks to anglers and adolescents who may occasionally swim or wade in the River assuming potential exposure to the narrow strip of government property and adjoining river extending from beneath the former 11<sup>th</sup> Street Bridge to the vicinity of the USACE Site. The HHRA assumed that anglers and swimmers/waders could periodically be exposed to COPCs in the River, including, but not limited to, those from the Study Area, via ingestion of and dermal contact to sediment (swimmers/waders) and ingestion of fish ingestion (anglers).

The 1999 HHRA also evaluated potential risks to recreational receptors during a future transitional period as well as a future scenario. The transitional period with respect to the River was defined as the time during which the government property is conditioned for use as a park. The future use scenario was defined as the use of the government property as a public park. Off-Site anglers and off-Site swimmers/waders were evaluated under all three land use scenarios. Potential exposures to site-related contaminants in the River were assumed to be the same for these receptors under current (1999) transitional and future scenarios, as described below.

The HHRA assumed that anglers may share their catch with their families in spite of the advisories in place recommending against eating fish from the River. The HHRA indicated that fishing in the River would be considered recreational. The HHRA assumed that an angler would obtain one fish meal for the family on each of ten fishing days per year. Therefore, an adult and child (0 to 6 years) were assumed to ingest ten fish meals of 8 ounces (0.227 kg per event, or 2.27 kilograms [kg] per year). The adult was assumed to weigh 70 kg and the child was assumed to weigh 15 kg (USEPA, 1989). Exposure durations were assumed to be 30 years for the combined adult/child and 6 years for the child (USEPA, 1989). Potentially carcinogenic risks were averaged over a 70 year lifetime, and noncancer hazards were averaged over the exposure duration for each age group. Table HIF-1 from the 1999 HHRA, included in Attachment 1, presents the exposure assumptions.

The swimmer/wader receptors were assumed to be children aged 6 to 18 that might occasionally swim or wade in the River over a period of 12 years. It was assumed that children under age 6 would not swim in the River. The exposure frequency was assumed to be to six days per year for two hours per day, based on professional judgment. The child swimmer/wader was assumed to weigh 43 kg (USEPA, 1989). Swimmers were assumed to ingest 25 milligrams (mg) of resuspended sediment per hour for 2 hours (for a total ingestion rate of 25 mg/hour x 2 hours = 50 mg/event), based on professional judgment. It was assumed for both swimmers and waders that the area of skin exposed to adhering sediment includes the legs and feet, representing 4,900 cm<sup>2</sup>, or 37% of the total body surface (USEPA, 1989). The soil-to-skin adherence factor was assumed to be 1 mg/cm<sup>2</sup> (USEPA, 1992a). Potentially carcinogenic risks were averaged over a 70 year lifetime, and noncarcinogenic hazards were averaged over the exposure duration of 12 years. Tables HIF-2 and HIF-3 from the 1999 HHRA, included in Attachment 1, present the exposure assumptions.

Exposure point concentrations (EPCs) were calculated based on USEPA (1992b) guidance, which recommended the lower of the 95% upper confidence limit (95% UCL) and the maximum detected concentration as the EPC. Fish tissue EPCs for the angler scenario are presented in Attachment 1

(Scenario 1) based on 18 fish tissue samples. EPCs for sediment for the swimmer/wader scenario are also presented in Attachment 1 for the sediment ingestion scenario (Scenario 2) and the dermal contact with sediment scenarios (Scenario 3), based on 7 sediment samples.

### **Toxicity Assessment**

Cancer slope factors (CSFs) and Reference Doses (RfDs) were selected based on the toxicological data current at the time the HHRA was conducted. The cancer slope factor used for benzo(a)pyrene (as well as the other carcinogenic PAHs based on a toxic equivalent approach, see Attachment 1) was  $7.3 \text{ (mg/kg-day)}^{-1}$ , which remains the CSF currently listed on USEPA's primary database of dose-response values (i.e., Integrated Risk Information System [IRIS]). The reference dose used to evaluate the noncarcinogenic effects of Total PAHs was that of pyrene, 0.03 mg/kg-day, an approach consistent with current day practice, as well as the RfD for pyrene currently listed on IRIS. The CSF and RfD for arsenic used in the 1999 HHRA are also the same as those currently listed on IRIS of  $1.5 \text{ (mg/kg-day)}^{-1}$  and 0.0003 mg/kg-day, respectively.

### **Risk Characterization**

As discussed in the 1999 HHRA, potential carcinogenic risks were compared to the USEPA target risk range of  $10^{-4}$  to  $10^{-6}$ . Hazard quotients (HQ) for individual contaminants below 0.1 were considered to indicate a non-hazardous situation, while an HQ above 0.1 was considered to indicate a potential for adverse health effects. The HQs for all COPCs were summed for each scenario to determine the hazard index (HI). An HI below 1 was considered to indicate a non-hazardous situation, while an HI above 1 was considered to indicate a potential for adverse health effects. The derivation of the risk estimates is included in Attachment 1.

The risk characterization results for the current and future land use scenarios are summarized below:

- Current and Future Angler – potential exposure to carcinogenic PAHs in fish tissue
  - Cancer –  $2.8 \times 10^{-7}$  (based on combined adult/child, 6 years as a child and 24 years as an adult).
  - HI – 0.0048 (based on the highest intake factor calculated, for the child; see Table HIF-1 in Attachment 1)
- Current and Future Swimmer/Wader (age 6 to 18) – potential exposure to COPCs in sediment:
  - Cancer
    - Ingestion:  $9.7 \times 10^{-7}$
    - Dermal Contact:  $8.9 \times 10^{-6}$
    - Total:  $9.9 \times 10^{-6}$
  - HI
    - Ingestion: 0.005
    - Dermal Contact: 0.0076
    - Total: 0.013

Potential risks for the angler scenario were below  $1 \times 10^{-6}$ , and potential risks for the swimmer/wader scenario were within USEPA's target risk range of  $1 \times 10^{-6}$  to  $1 \times 10^{-4}$  (USEPA, 1990, 1991), but above the NPS point of departure of  $1 \times 10^{-6}$ . HIs for both receptors were below 1. It should be noted that there are fish consumption advisories for the Anacostia River and at the time of the 1999 risk assessment, swimming and wading were also prohibited, although there are accounts of people swimming and accidentally falling out of boats or rowing skulls.

## **Conclusions**

Based on the results of the 1999 HHRA, it was concluded that potential risks from Site-related contaminants that may be present in River surface water were negligible. Potential risks from incidental ingestion of and dermal contact with Site-related contaminants that may be present in River sediment were found to be within the USEPA target risk range ( $9.9 \times 10^{-6}$ ), but above the low end of the risk range,  $10^{-6}$ . Potential risks from consumption of Site-related contaminants that may be present in Anacostia River fish were below a cancer risk level of  $10^{-6}$  and a HI of 1.

## **1.5 Human Health Risk Assessment Methodology Overview**

Because Site conditions may have changed since the 1999 HHRA, an updated baseline HHRA will be prepared. This baseline HHRA will utilize the results of this RI performed to specifically address the needs of the risk assessment (see Section 2).

As discussed in Section 4.1, the results of the 1999 HHRA have been used to inform the development of the updated conceptual site model (CSM) and guide the identification of exposure scenarios for quantitative evaluation in the baseline HHRA for the Site. The updated CSM reflects the current assessment of exposure scenarios, current and future receptors, and potential exposure pathways.

The District Department of Energy and Environment (DOEE) provides HHRA guidance under the underground storage tank (UST) program (DDOE, 2011). While this guidance will be consulted, its applicability to the River exposure scenarios is limited. Therefore, the baseline HHRA will be conducted in accordance with applicable USEPA guidance including, but not limited to, the following:

- Risk Assessment Guidance for Superfund (RAGS): Volume 1 - Human Health Evaluation Manual (Part A) (USEPA, 1989);
- Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. OSWER 9655.0-30. April, 1991. (USEPA, 1991);
- Guidance for Data Useability in Risk Assessment (Part A) (USEPA, 1992c);
- Guidelines for Exposure Assessment (USEPA, 1992d);
- Guidance Manual for the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children. Publication 9285.7-15-1. February 1994 (USEPA, 1994a), and associated, clarifying, Short Sheets on IEUBK Model inputs, including, but not limited to, OSWER 9285.7-32 through 34, as listed on the OSWER lead internet site at [www.epa.gov/superfund/programs/lead/prods.htm](http://www.epa.gov/superfund/programs/lead/prods.htm);
- Land Use in the CERCLA Remedy Selection Process (USEPA, 1995);
- Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil (USEPA, 1996);

- Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (USEPA, 2002a);
- Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children. Windows version<sup>®</sup>. (USEPA, 2002b);
- Human Health Toxicity Values in Superfund Risk Assessments, OSWER Directive 9285.7-53 (USEPA, 2003a);
- Risk Assessment Guidance for Superfund (RAGS): Volume I. Human Health Evaluation Manual. Part E, Supplemental Guidance for Dermal Risk Assessment (USEPA, 2004);
- Guidelines for Carcinogen Risk Assessment (USEPA, 2005a);
- Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005b);
- Exposure Factors Handbook<sup>1</sup> (EFH) (USEPA, 2011);
- ProUCL Version 5.0.00 (or the most currently available version, available from <http://www.epa.gov/osp/hstl/tsc/software.htm>, Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations (USEPA, 2013a, b, c);
- Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors (USEPA, 2014a).
- USEPA Regional Screening Levels (USEPA, 2015a). RSLs are typically updated in November and June; the most currently available table will be downloaded at the time the HHRA is conducted from the USEPA website [[http://www.epa.gov/reg3hwmd/risk/human/rb-concentration\\_table/Generic\\_Tables/index.htm](http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm)]; and

The baseline HHRA will evaluate potential human health effects using the four step paradigm as identified by the USEPA in the Risk Assessment Guidance for Superfund, Volume I – Human Health Evaluation Manual (USEPA, 1989). The steps are:

- Data Evaluation and Hazard Identification;
- Dose-Response Assessment;
- Exposure Assessment; and
- Risk Characterization.

## 1.6 Work Plan Organization

This document is a work plan for the baseline HHRA for OU2 of the Site. This document presents the data quality objectives (DQOs) for the field investigation that will be performed to support the HHRA as well as the methodology that will be used to evaluate potential human health risks in the baseline HHRA. This document is organized into the following sections.

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<sup>1</sup> The preface of USEPA (2011) indicates that the 2011 document supersedes the Child-Specific EFH (USEPA 2008). In general, the data presented for children are the same in the 2008 document and the 2011 document. Therefore, exposure factor data for children will be obtained from the more recent 2011 EFH.

- **Data Quality Objectives**– Section 2.0 presents DQOs for the collection of new data in support of the HHRA and presents the methods to be used in the data evaluation and hazard identification, including selection of COPCs that will be evaluated quantitatively in the risk assessment.
- **Exposure Assessment** – Section 3.0 presents a discussion of the exposure assessment process. The purpose of the exposure assessment is to provide a quantitative estimate of the magnitude and frequency of potential exposure to COPCs by a receptor. Potentially exposed individuals, and the pathways through which those individuals may be exposed to COPCs are identified based on the physical characteristics of the Site, as well as the current and reasonably foreseeable future uses of the Site and surrounding area. The extent of a receptor's exposure is estimated by constructing exposure scenarios that describe the potential pathways of exposure to COPCs and the activities and behaviors of individuals that might lead to contact with COPCs in the environment.
- **Dose-Response Assessment** – Section 4.0 presents a discussion of the dose-response assessment process. The dose-response assessment evaluates the relationship between the magnitude of exposure (dose) and the potential for occurrence of specific health effects (response) for each COPC. Both potential carcinogenic and noncarcinogenic effects will be considered. The most current USEPA-verified dose-response values will be used when available.
- **Risk Characterization** – Section 5.0 presents a discussion of the risk characterization process and associated uncertainties. Risk characterization combines the results of the exposure assessment and the dose-response assessment to derive site-specific estimates of potentially carcinogenic and noncarcinogenic risks resulting from both current and reasonably foreseeable future potential human exposures to COPCs. The risk characterization results will be compared the NPS point of departure of  $1 \times 10^{-6}$  for potential carcinogens and a target Hazard Index (HI) of 1 for noncarcinogens (that act on the same target endpoint), as defined in USEPA guidance (USEPA 1990, 1991). In addition, to provide additional context and perspective, the risk results will also be compared to the USEPA's target risk range of  $10^{-6}$  to  $10^{-4}$  (USEPA, 1991).
- **Uncertainty Evaluation** – Within any of the steps of the risk assessment process described above, assumptions must be made due to a lack of absolute scientific knowledge. Some of the assumptions are supported by considerable scientific evidence, while others have less support. The assumptions that introduce the greatest amount of uncertainty in this risk evaluation will be discussed in the Risk Characterization section of the HHRA report.
- **References** – Section 6.0 presents the list of references cited in this document.

## 2.0 Data Quality Objectives

This section presents the DQOs for the collection of additional data in support of the baseline HHRA. In addition, this section describes the data evaluation process, a summary of the datasets that will be used in the HHRA, and the hazard identification methods to be used to identify the COPCs for each exposure medium. COPCs are a subset of the complete list of contaminants detected in Site media that are carried through the quantitative risk assessment process. Selection of COPCs focuses the analysis on the most likely risk “drivers.” As stated in USEPA guidance (USEPA, 1993):

“Most risk assessments are dominated by a few compounds and a few routes of exposure. Inclusion of all detected compounds at a Site in the risk assessment has minimal influence on the total risk. Moreover, quantitative risk calculations using data from environmental media that may contain compounds present at concentrations too low to adversely affect public health have no effect on the overall risk estimate for the Site. The use of a toxicity screen allows the risk assessment to focus on the compounds and media that may make significant contributions to overall risk.”

### 2.1 Data Quality Objectives

The seven-step DQO process (USEPA, 2006) specifies anticipated project decisions, the data quality required to support those decisions, specific data types needed, data collection requirements, and analytical techniques necessary to generate the specified data quality. The process also ensures that the resources required to generate the data are justified. This section presents the DQOs which are germane to the HHRA. All DQOs for the RI/FS, including the HHRA, are presented in Section 4.1 of the main text of this RI/FS Work Plan. DQOs pertinent to the HHRA are discussed in detail below.

#### 2.1.1 Step 1 –State the Problem

As noted in Section 1.3, historical industrial use of the waterways in the Anacostia River watershed, including the River itself, has led to a highly impacted water body. This has occurred through shoreline development, channelization of the River, and releases and transport of contaminants from industries and other parties along the watershed. Sediments, surface water, and biota in the River at the Site may be impacted by MG contaminants as a result of overland flow or groundwater discharge from OU1. Exposure to Site-related contaminants in sediments and/or surface water may pose a risk to human receptors who work or recreate at the Site via direct contact or secondary exposure pathways (e.g., consumption of fish). Although an HHRA was prepared in 1999, more recent data are needed to support the completion of a baseline HHRA under current conditions.

As noted above, the results of the 1999 HHRA have been used to inform the development of an updated human health CSM (provided as Figure 4). The updated CSM reflects the current assessment of exposure scenarios, current and future receptors, and potential exposure pathways, which are discussed in more detail in Section 4.1. As discussed in Section 4.1, for the purposes of quantifying exposures and risks in a baseline HHRA, there are two exposure media of primary interest – sediment and surface water.

As described in Section 5.1 of the main text of this RI/FS Work Plan, a Sampling and Analysis Plan (SAP) and a Quality Assurance Project Plan (QAPP) will be prepared following agreement on this

RI/FS Work Plan as part of the Project Operations Plan (POP). Any deviations to the POP relevant to the HHRA will be documented in the HHRA. The SAP that will be developed will include information regarding the planning team members, identification of decision makers, principal data users within the planning team, as well as a summary of available resources and relevant deadlines for the study, including budget, availability of personnel, and schedule.

### **2.1.2 Step 2 – Goal of the Investigation**

The goal of the HHRA is to quantify current or potential future threats to human receptors from Site-related contaminants in sediment and surface water in the absence of any remediation in the River, and to help determine whether remedial efforts are needed. This investigation will collect the necessary data to support the decision-making process for determining whether or not contamination poses a risk to human receptors and if response actions are needed to protect these receptors from Site-related contaminants.

The principal study question is as follows:

*Are Site-related contaminant concentrations in sediment and surface water posing an unacceptable risk to human receptors, under current or future exposure conditions, as a result of historical operations of the MG facility at the Site?*

### **2.1.3 Step 3 – Identify Information Inputs**

The purpose of this step is to identify the data required to answer the principal investigation question stated above and to determine which inputs require environmental measurements. The initial step is to evaluate the quality and usability of existing sources of information and data that could be used to answer to the principal investigation question. The next step is to identify the types of new information and data (e.g., information on specific analytes/contaminants) needed to answer the principal investigation question.

#### **2.1.3.1 Previous Data Usability**

Historical surficial sediment data is available in NOAA's DARRP Anacostia River Watershed Database and Mapping Project database, which contains records from 35 Anacostia River studies spanning 20 years of research.<sup>2</sup> This database includes a number of studies conducted over a wide spatial extent (beyond the boundaries of the Site) and temporal scale. Surface water sample data are available for the Site and were collected during an outgoing tide at seven locations in June 1996 and at three locations in February 1997 as part of RI activities at the Site (Hydro-Terra, 1999). The age of the available RI data suggest that these data may not be representative of current conditions at the Site. Therefore, additional surface water and sediment data that are spatially and temporally representative of site conditions are needed to support the quantitative evaluation in the HHRA.

#### **2.1.3.2 Data to be Collected in Support of the HHRA**

The surface water and sediment data collected during the RI will be used to conduct the HHRA; historical data are not proposed for use in evaluating potential Site risks. However, existing background data will be used to help place the HHRA into context within the larger urbanized Anacostia River system, as discussed in Section 4.3.5 of the RI/FS Work Plan. Based on the results

<sup>2</sup> <http://www.darrp.noaa.gov/partner/anacostia/restore.html>

of the 1999 HHRA, and considering the contaminants that are typically associated with MG facilities, it is anticipated that the human health COPCs are likely to include PAHs, inorganics, cyanide, BTEX, and phenolics. Based on the results of PCB sampling of NAPL and groundwater samples, PCPs may be identified as COPCs.

Measured data needed to support decisions regarding risks to human receptors include the following:

- Measured data are needed which provide representative [i.e., spatially (horizontally and vertically) and temporally] concentrations of COPCs in sediment and surface water in OU2.
- Measured data are needed which provide representative concentrations of COPCs in sediment and surface water in areas that are not impacted by Site-related contamination in order to evaluate risks attributable to the Site versus risk associated with reference conditions.
- For metals in surface water, both total (unfiltered) and dissolved (filtered) concentrations are needed to evaluate human health. Total concentrations are most applicable to ingestion exposure scenarios and dissolved concentrations will be used to refine dermal exposure estimates.

Sampling and analytical techniques will be designed to attain detection limits adequate for risk assessment purposes and high quality data. The SAP will present the field sampling methods as well as the selection of the appropriate analytical methods. Laboratory detection limits will be reviewed to determine whether detection limits will meet the criteria used for COPC selection. If laboratory detection limits do not meet the criteria, the QAPP will identify potential resolutions, including the use of more sensitive methods, if necessary.

In addition to measured concentration data, the baseline HHRA will utilize default and site-specific information on exposure parameters (e.g., exposure frequency and duration, ingestion rates) (see Section 4.0) as well as established human health toxicity values (see Section 3.0) to quantify potential risks. site-specific land use surveys (e.g., interviews with boat clubs and site observations) will be used to develop exposure assumptions that adequately represent potential exposures at the Site.

## **2.1.4 Step 4 – Boundaries of the Investigation**

### **2.1.4.1 Spatial Boundaries**

#### Site Locations

The data that will be collected during the RI are designed to serve multiple purposes supporting both the HHRA and the BERA and the determination of the nature and extent of contamination. The investigation that will be conducted in support of the HHRA will be focused to the “in-river” portion of the Site, no sampling will be conducted on the landside portion. The area that will be investigated to evaluate the Site will be inclusive of the area of the River that is adjacent to the seawall, approximately 1,000 ft. in length adjacent to the government property and extending approximately 100 feet into the River. This area may be expanded or contracted based on the results of the landside investigation or based on the results of the groundwater investigation beneath the River. Specific sampling locations will be selected following, and partially based on, a hydrographic survey and review of results from the landside investigation, including drive point profiling and monitoring well installation and sample analysis.

Surficial sediment will be collected from 0 to 0.5 ft. This depth interval is considered representative of the interval most likely to be encountered by humans under current conditions, unless the sediment stability analysis and dredging plans indicate that deeper exposure depths could be reasonably expected. Additionally, subsurface sediment samples will be collected from between 0.5 ft and 10 ft below the surface, unless a greater sampling depth is appropriate based on the landside and/or sediment investigation results.

These samples will be used to evaluate potential future risks from exposure to sediments that may be exposed from dredging activities, propeller wash, or storms in the uncertainty section of the HHRA.

#### Reference Locations

Additionally, samples will be collected from reference areas upstream of the Site in order to determine Site attribution of risks. Reference locations will be selected such that they are representative of comparable environmental conditions with the Site, but with the absence of Site-related impacts. Ideally, according to USEPA, the reference sediments should be collected near the Site being investigated but outside the zone of potential impacts from the Site. To the extent possible, physical conditions, such as grain size and organic carbon content from the sediment samples collected from the River at the Site, should be matched in the reference sediments. The reference locations have been selected based on information regarding grain size and total organic carbon (TOC) content of available samples from the DARRP database. TOC and grain size (as percent fines; the sum of the silt and clay fractions) in DARRP database surficial sediment samples were mapped (Figures 5 and 6). Samples collected from the River near or adjacent to the government property generally contain 1 to 5% organic carbon and >50% fine grained sediments. This pattern appears to be consistent throughout much of the Anacostia River upstream of the Site. TOC and grain size will be measured in both Site and reference sediments to support an assessment of the representativeness of reference locations.

A review of the AWT (2002) Areas of Concern (AOC) and physical characteristics of sediment samples was conducted. The area between south of Benning Road and John Phillip Sousa Bridge has been identified for collection of reference samples. Reference sample locations are presented in Figure 7. The AWT AOCs in this reach of the Anacostia River will not be sampled. Kingman Lake, located on the west side of the Burnham Barrier (or Kingman Island) may also be investigated for appropriate physical match to the sediments from the River at the Site. Field verification of these stations is absolutely necessary. A field geologist will evaluate the sediments collected from the reference locations and compare the color and texture to those collected from the River at the Site. Should the results of field inspection of these sediments indicate that they are inappropriate for use as reference locations, NPS will be consulted prior to moving to a new location.

#### **2.1.4.2 Temporal Boundaries**

All samples are planned to be collected during one mobilization event (between 1 March and 30 April) unless conditions observed during the sampling events indicate that further investigation may be required. Spring has been selected as the timeframe for sampling to support the ecological risk assessment. Bioavailable concentration of Contaminants of Ecological Potential Concern (COPECs) in sediments would be higher during the spring when acid volatile sulfide concentrations (which have the potential to bind divalent metals) are typically at their lowest following the winter months, due to elevated cold water dissolved oxygen and redox conditions. Additionally, mid-Atlantic macroinvertebrate sampling guidance (e.g., Maryland Biological Stream Survey Guidance, 2013)

requires sampling during the spring index period to representative sample of the community composition and relative abundance.

#### **2.1.4.3 Sampling Unit**

The HHRA is focused on the exposure pathways identified in the CSM for human receptors (see Figure 4). Each of these exposure pathways are discussed in detail in Section 3.1. In brief, the receptor groups to be evaluated include: current and future recreational visitors and workers. Exposure pathways to be addressed quantitatively include incidental ingestion of and dermal contact with sediment and surface water.

#### **2.1.4.4 Decision Unit**

The initial decision unit for the HHRA is OU2 of the Site.

### **2.1.5 Step 5 – Analytical Approach**

The purpose of this section is to define the analytic or evaluation approach that will be used to answer the principal investigation question.

Surface water and sediment analytical data collected during the RI will be compiled and tabulated in a Site-specific database for statistical analysis. The HHRA will be conducted using validated data; the data validation procedures are presented in detail in the QAPP. For the purposes of the HHRA, data for samples and their duplicates will be averaged before summary statistics are calculated, such that a sample and its duplicate are treated as one sample for calculation of summary statistics (including maximum detection and frequency of detection) (USEPA, 1989). Where both the sample and the duplicate are not detected, the resulting values used in the statistics will be the average of the sample-specific quantitation limits (SSQLs). Where both the sample and the duplicate are detected, the resulting values will be the average of the detected results. Where one of the pair is reported as not detected and the other is detected, the detected concentration will be used.

Summary statistic tables for each medium will include the following:

- **Frequency of Detection:** The frequency of detection (FOD) is reported as a ratio of the number of samples reported as detected for a specific contaminant and the total number of samples analyzed. The total number of samples reflects the averaging of duplicates discussed above. The ratio will be presented as the number of detections: total number of samples.
- **Minimum Detected Concentration:** This is the minimum detected concentration for each contaminant/area/medium combination, after duplicates have been averaged. Data qualifiers will be presented where applicable.
- **Maximum Detected Concentration:** This is the maximum detected concentration for each contaminant/area/medium combination, after duplicates have been averaged. Data qualifiers will be presented where applicable.
- **Mean Detected Concentration:** This is the arithmetic mean concentration for each contaminant/area/medium combination, after duplicates have been averaged, based on detected results only.

In the HHRA, risks to human receptors will be estimated for exposure to contaminants in sediment and surface water. In the hazard identification step, the relevant Site data will be compared to

appropriate screening levels to identify COPCs for inclusion in the quantitative risk assessment. The COPC selection process will be conducted on a Site-wide basis. Contaminants that are detected at least once in a medium will be sequentially screened as detailed below. A comparison of detection limits for contaminants that are never detected will be conducted as part of the uncertainty analysis. If contaminants are identified with detection limits above screening levels, the uncertainty analysis will include a quantitative evaluation, assuming the contaminant is present at the detection limit.

The COPC screening steps are as follows:

1. Identify constituents that are essential nutrients. Constituents identified as essential nutrients (i.e., calcium, magnesium, sodium and potassium) will not be included as COPCs (USEPA, 1989).
2. Evaluate frequency of detection.
  - a. For data sets with at least 20 samples, a contaminant detected in 5% or fewer of the samples will not be retained as a COPC (USEPA, 1989) provided samples with detected concentrations do not indicate the presence of potential hot spots.
  - b. Detected contaminants classified by USEPA as known human carcinogens (USEPA, 2005a) will be retained as COPCs regardless of frequency of detection. The weight-of-evidence classification provided on USEPA's Integrated Risk Information System (IRIS) (USEPA, 2015b) will be consulted to identify contaminants classified as known carcinogens based on strong evidence of human carcinogenicity (historically characterized as Category A under the *1986 Guidelines for Carcinogen Risk Assessment* (USEPA, 1986).
  - c. An evaluation of detection limits will also be conducted to ensure that contaminants eliminated based on frequency of detection do not have detection limits above screening levels. If detection limits above screening levels are identified for a given contaminant/media, that contaminant will not be eliminated as a COPC based on frequency of detection.
3. Compare maximum concentrations to health risk-based screening levels. A contaminant with a Site-wide maximum detected concentration above its screening level will be retained as a COPC.
  - *Surface water.* Surface water screening levels protective of human health will be used to identify COPCs in surface water, as indicated below (presented in order of preference):
    - USEPA regional screening levels (RSLs) for ingestion of tap water (USEPA, 2015a)
    - DOEE Water Quality Standards (WQS) for the protection of human health (DDOE, 2006)
    - USEPA National Water Quality Criteria for the protection of human health related to consumption of fish and shellfish and water ingestion (USEPA, 2015b)

The USEPA RSLs for potentially carcinogenic contaminants are based on a target risk level of  $1 \times 10^{-6}$  and a target hazard quotient of 0.1 to account for potential additivity of contaminants with the same toxic endpoint. The use of conservative RSLs for selection of COPCs ensures that all contaminants that may be of concern are included in the risk assessment. RSLs are typically updated by USEPA in May and November of each

year. The most recent version of the table available when the COPC screening is conducted will be used.

- *Sediment*. USEPA RSLs (USEPA, 2015a) for residential soil (hazard quotient 0.1 table) will be used as surrogate risk-based criteria to identify COPCs in sediment, since human health based sediment screening criteria are not available. As noted above, the most recent version of the USEPA RSL table available when the COPC screening is conducted will be used.

Tables documenting the COPC selection process will be presented in the baseline HHRA report, with the rationale for inclusion or elimination clearly stated. Identified COPCs will be further evaluated through the calculation of estimated cancer risks and non-carcinogenic HQs. The dose-response assessment, exposure assessment, and risk characterization methods are described in detail below in Sections 3 through 5, respectively.

## 2.1.6 Step 6 Performance or Acceptance Criteria

### 2.1.6.1 Tolerable Limits for Decision Errors

Data collected as part of this study will be used to evaluate risks to support risk management decision-making for the Site. In making decisions about human health risks, two types of decision errors are possible – false negative and false positive.

- A *false negative decision error* occurs when a risk manager decides an exposure is acceptable when it actually results in unacceptable health risks.
- A *false positive decision error* occurs when a risk manager decides an exposure is unacceptable when it really is acceptable.

Risk managers are most concerned about guarding against the occurrence of false negative decision errors, since an error of this type may leave humans exposed to unacceptable levels of contamination. To minimize chances of underestimating the true amount of exposure and risk, USEPA generally recommends that risk calculations be based on the 95% upper confidence limit (95UCL) of the sample mean (USEPA, 1992). Use of the 95UCL in risk calculations limits the probability of a false negative decision error to no more than 5% ( $\alpha = 0.05$ ).

Risk managers are also concerned with the probability of making false positive decision errors. Although this type of decision error does not result in unacceptable human exposure, it may result in unnecessary expenditure of resources (time, money) that might be better invested elsewhere. For the purposes of this effort, the goal is to seek to ensure that, if the true mean is less than ½ the decision threshold, then risk (calculated based on the 95UCL) will not be deemed unacceptable more than 20% of the time ( $\beta = 0.20$ ). The risk of false positive decision errors can be minimized by increasing the number of samples. The number of samples needed depends on the magnitude of between-sample variability and the proximity of EPC to the decision rule. If between-sample variability is low, or if the EPC is not near a decision rule, then the number of samples needed is usually relatively low. However, if between-sample variability is high and the EPC is relatively near a decision rule, then the number of samples needed is usually higher.

### 2.1.6.2 Data Quality Indicators

As required by USEPA (1992c), the following data quality indicators (DQIs) have been qualitatively identified during development of the DQOs for the Site. The SAP and QAPP will be prepared to meet the DQIs:

- Completeness is measure of the amount of useable data (i.e., those data that are not rejected during data validation) obtained during the RI. The QAPP will indicate the required level of completeness and the measures that will be taken if the completeness target is not met.

Comparability for the data collected during the RI will be high, since the SAP will identify the sampling methods and the analytical procedures to be used. An evaluation of the comparability of the historical background dataset, including sampling methods and analytical methods, will be conducted as part of the background evaluation. Details of the data usability analysis of the background data will be provided in the QAPP.

- Representativeness is the extent to which data can define the “true” risk to human health. Attainment of representative, high quality data is a goal for this project. The representativeness of the data will be ensured by selecting appropriate sampling locations, as well as the use of appropriate field and laboratory techniques, which will be defined in the SAP and QAPP. The proposed sampling locations are representative of the Site at the River and represent locations where people could potentially be exposed.
- Precision is a measure of the variability of the sample results. The results of samples and their duplicates will be used to determine the precision of the data by calculating the relative percent difference (RPD) during data validation. The QAPP will identify acceptable limits for the RPD as well as the measures to be taken if the RPD is outside the acceptable limits.
- Accuracy is a measure of the closeness of the concentration reported by the laboratory to the actual concentration, and is determined by calculating the percent recovery from spiked samples. The QAPP will present the procedures for evaluating spiked samples, will identify acceptable limits for percent recovery as well as the measured to be taken if results are outside the acceptable limits.

### 2.1.6.3 Data Validation

Data validation will be performed on all data generated by analytical laboratories. Laboratories will be required to provide full (Contract Laboratory Program [CLP] – type) data packages for all samples. These data packages will include all raw data required to reproduce the reported values. All data packages will be reviewed and qualifiers will be added, as applicable, to the associated data to indicate data usability. The details of data validation will be included in the QAPP submitted as part of the POP. Data that are rejected during data validation will not be used in the HHRA; non-rejected data are deemed useable for the HHRA.

## 2.1.7 Step 7 Study Design (Plan for Obtaining Data)

### 2.1.7.1 Study Design Overview

The study design, including rationale for sample counts, and a discussion of the possibility of the need to increase the number of samples as a result of the landside investigation is provided in the RI/FS Work Plan.

In brief, concentrations of COPCs (PAHs, RCRA inorganics<sup>3</sup>, cyanide, BTEX, phenolics and potentially PCBs) will be measured in surface water and sediment (surface and subsurface) samples to support the evaluation of potential exposures and human health risks at the Site. In summary, the sample design for the HHRA includes:

- 1) Collection of 22 surficial (0-0.5 ft) sediment samples from the River at the Site for analysis of COPCs, TOC, and grain size
- 2) Collection of 22 subsurface (0.5 ft to a maximum depth of 10 ft) sediment samples from the River at the Site for analysis of COPCs, TOC, and grain size
- 3) Collection of 10 surface water samples (both filtered and unfiltered) from the River at the Site for analysis of COPCs.
- 4) Collection of 3 surficial (0-0.5 ft) sediment samples and 3 surface water samples from reference locations for analysis of COPCs, TOC (sediment only), and grain size (sediment only).

The following sections provide an overview of the study design; detailed information on the study design is provided in the RI/FS Work Plan.

### Sediment

USEPA guidance (USEPA, 2004, page 3-20) indicates that:

“Sediment samples must be located in areas in which individuals are likely to come into direct-contact with the sediments. For wading and swimming, this includes areas which are near shore and in which sediments are exposed at some time during the year. Sediments which are consistently covered by considerable amounts of water are likely to wash off before the individual reaches the shore.”

Figure 2 presents the proposed sediment sample locations. Sediment sampling will be performed along the length of the District property (approximately 1000 feet) as access (e.g., presence of docks and utilities) permits. Sampling is proposed within this area in an approximately 100-ft grid pattern (see Figure 2), which yields approximately 20 sample locations (10 along the shoreline and 10 within the navigational channel). The sampling locations adjacent to the shoreline are at a depth of roughly 3 feet at mean low water (MLW). The samples proposed within the navigational channel are located about 100 feet from the shoreline, with a water depth of about 5 feet at MLW (to be determined by the bathymetric survey). Given the presence of a seawall along the riverbank, the most likely route of exposure to sediments is expected to be from a boat. Therefore, the samples from both the shoreline as well as the navigational channel are considered potentially accessible. As the sediments are located 3 or more feet beneath the water surface, any sediment contacted may be washed off before an individual re-boards a boat or reaches shore (USEPA, 2004). However, the HHRA will conservatively assume that the sediments are available for both dermal contact as well as incidental ingestion.

Sediment samples will be collected from both the surface (0-0.5 ft) and subsurface (0.5-10 ft). Surface sediment samples will support the evaluation of potential risks based on current conditions.

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<sup>3</sup> Including arsenic, barium, cadmium, chromium, lead, selenium, silver and zinc

Subsurface samples will support the evaluation of potential risks in the future, if subsurface sediments were to become exposed (e.g., due to dredging activities). Sediment samples will be analyzed for BTEX, PAHs, phenolics, RCRA inorganics, cyanide, TOC, grain size and potentially PCBs.

#### Surface Water

Surface water samples will be collected from 10 locations indicated on Figure 2. Samples will be analyzed for BTEX, PAHs, phenolics, RCRA inorganics, cyanide and potentially PCBs. Where both total recoverable and dissolved phase data are collected, total (unfiltered) data will be used for the surface water ingestion pathway. For the dermal contact pathway, the total data will be used initially. However, if the dermal contact pathway appears to be driven by particulates in the surface water (i.e., total concentrations are higher than dissolved concentrations for the same sample), the dissolved data may be used, since only the dissolved fraction can pass through the human skin.

#### **2.1.7.2 Field Verification of Sampling Design**

The primary purpose of the Field Verification of Sampling Plan is to ensure that the samples specified in above can be collected, and that the field sampling plan is appropriate and implementable.

The Anacostia River is a large and well-studied water body. Collection of sediment and surface water from the River has been achieved to support the Washington Gas East Station investigations and other projects for several decades. Therefore, sampling of sediment and surface water to support HHRA is implementable.

#### **2.1.7.3 Optimize the Design**

Section 2.7.1.1 presents an overview of the study design, including sampling station locations, number of samples to be collected, etc. In general, the study design will be optimized as necessary based on Site conditions and any deviations would be documented and approved prior to implementation.

Risk characterization requires the collection of reliable and representative measurements of the concentration of contaminants as a function of both time and space. This type of data is valuable both to support risk evaluations as well as to identify sources of contaminant releases. The uncertainties associated with the risk characterization will be decreased by comparison of risk estimates for Site locations to reference locations not impacted by releases from the Site. The study design will be optimized by a conducting a field reconnaissance to identify reference locations.

## 3.0 Exposure Assessment

In the HHRA, potential risks to human receptors will be evaluated from exposures to contaminants in sediment and surface water. As described above, the initial step of the hazard identification process is to identify COPCs (see Section 2.1.5). Identified COPCs will be further evaluated in the exposure assessment.

The purpose of the exposure assessment is to estimate the magnitude and frequency of potential human exposure to the COPCs retained for quantitative evaluation in the baseline HHRA. The first step in the exposure assessment process is the characterization of the setting of the location and surrounding area. Current and reasonably foreseeable potential future land uses, potential receptor populations (i.e., those who may contact the impacted environmental media of interest), and exposure scenarios are then identified. Potential exposure scenarios appropriate to current and reasonably foreseeable potential future uses and receptors are then developed. Those potential exposure pathways for which COPCs are identified and are judged to be complete will be evaluated quantitatively in the baseline risk assessment.

### 3.1 Identification of Potential Exposure Scenarios

Exposure scenarios are developed on the basis of the HHRA CSM summarized in Section 3 of the RI/FS Work Plan, site setting and use information provided in Section 1 of this document, as well as the results of the prior HHRA conducted on the Site (Hydro-Terra, 1999). Figure 4 presents the CSM for the HHRA. The baseline HHRA is focused on the exposure pathways associated with the River, including groundwater discharge from the Site to the River (see Figure 4).

For an exposure pathway to be complete, the following conditions must exist (USEPA, 1989):

1. A source and mechanism of contaminant release to the environment;
2. An environmental transport medium (e.g., air, water, soil);
3. A point of potential receptor contact with the medium; and
4. A human exposure route at the contact point (e.g., inhalation, ingestion, dermal contact).

The first step in developing the CSM is the characterization of the site setting and surrounding area. This includes characterization of current and reasonably foreseeable future land uses and potential receptors (e.g., residential, recreational, commercial/industrial). Potential exposure scenarios identifying appropriate environmental media and exposure pathways for current and reasonably foreseeable future land uses and receptors are then developed. Those potential exposure pathways for which COPCs are identified and which are complete are evaluated quantitatively in the risk assessment. The CSM is meant to be a “living” model that can be updated and modified as appropriate when additional data become available.

Some receptor populations may be exposed to COPCs by more than one pathway. Although there may be more than one potential exposure pathway, USEPA guidance (USEPA, 1989) cautions that the first step is to identify reasonable exposure pathway combinations, and then to determine “whether it is likely that the same individuals would consistently face the reasonable maximum

exposure by more than one pathway." With this in mind, the CSM is developed by constructing potential exposure scenarios and identifying the hypothetical receptors to be used in evaluating these exposures. It is important to note that the exposure scenarios are typically constructed for hypothetical receptors who are assumed to be the most frequently exposed. The receptors are not intended to represent specific individuals.

Direct contact pathways involving groundwater (e.g., ingestion, dermal contact) will not be evaluated, as these pathways are not considered complete. According to the 2006 Record of Decision (ROD) for the Site (NPS, 2006), there are no wells in any aquifer used beneath the Site or within four miles that are used for drinking water (NPS, 2006), and therefore no drinking water wells are at risk of being contaminated by chemicals originating at the East Station Site. Furthermore, the District does not permit the construction of potable wells in this area. The RI/FS Work Plan includes sampling of both groundwater and River surface water to obtain the data needed to evaluate the groundwater discharge pathway and mass flux, but these data will not be used to characterize exposures in the baseline HHRA for OU2.

The Site is located in a highly urbanized area. A seawall present along the banks of the River at the Site prevents direct access to the River from the shore. However the seawall is not continuous along the government property. Workers may access the River from boats. Several boat and crew clubs are located along the River. In accordance with the overall plan for the Anacostia River (DDOE, 2008), it is assumed that future recreational uses include swimming, while current and future recreational use includes boating.

WG understands that the strip of land currently owned by the District between East Station and the River is slated for development within the District Anacostia Waterfront Initiative with the primary planned use being the development of boathouses for rowing clubs (Boathouse Row) and other recreational uses, such as walking and biking trails. However, while walking and biking trails could increase recreational uses along the river bank, exposure to surface water and sediment from walking and biking is not anticipated along the Site due to the presence of the seawall.

Therefore, the primary potential for human exposure to river sediment and surface water is via occupational exposure or recreational use, which is expected to include boating and occasional or accidental wading/swimming under the current scenario and boating and recreational wading/swimming under the future scenario. Since there is no access to the River from the shoreline, it is assumed that people may access the River from boats or from other access points and swim along the River.

#### *Fish Consumption*

Consumption of aquatic biota (e.g., finfish) is not proposed for quantitative evaluation in the baseline HHRA for several reasons. The majority of MG-related contaminants (i.e., PAHs, BTEX) are not highly bioaccumulative, such that exposure via fish consumption is expected to be minimal. PAH compounds are known to readily metabolize in finfish; because of this efficient metabolism, there is a low potential for PAHs to accumulate in muscle tissue, and consequently a low potential for transfer of PAHs up the food chain to human consumers (Stein, 2010). The 1999 HHRA, described in Section 1.4, evaluated the fish ingestion pathway using a 1993 fish tissue chemistry dataset, and found potential consumption risks to be negligible. The potential cancer risk from consumption of River fish was in the  $10^{-7}$  range, and the potential non-cancer risk was well below the target HI of 1. Based on the scientific literature and the prior quantitative evaluation of risk from consumption of River fish, a quantitative evaluation of the fish ingestion pathway in the baseline HHRA is not warranted.

However, if Site-related PCBs are shown to be present in the Anacostia River, this scenario will be reevaluated in an addendum to this Work Plan.

The following potentially complete exposure scenarios are identified as warranting evaluation in the baseline HHRA:

#### *Recreational Visitor Receptor*

It is assumed that recreational visitors may be exposed to COPCs via direct contact (incidental ingestion and dermal contact) with surface sediment and surface water at the Site while wading, swimming, or boating in the River. Exposure to surface water and sediment will be evaluated for recreational adults, adolescents, and young children. All age groups are assumed to participate in wading. Adult and adolescent age groups are assumed to participate in swimming boating. It is unlikely that young children participate in boating or swimming. Therefore, young children will not be assumed to participate in boating or swimming unless Site-specific information suggests otherwise. As there is no River access adjacent to the government property, it is assumed that waders or swimmers enter the River via boat or from other access points.

#### *Worker Receptor*

It is assumed that workers may be potentially exposed to surface water and sediment at the Site via ingestion and dermal contact during dock repairs, utility repairs and/or shoreline maintenance activity. The maintenance/utility worker will be assumed to contact sediment only during these repairs, not on a daily basis. USACE staff who work off of boats to skim debris from the surface water may be potentially exposed to surface water on a daily (work day) basis, and it is possible that other workers are exposed to surface water and/or sediment on daily (work day) basis. Therefore, the HHRA will evaluate both an on-Site worker who is assumed to be exposed to surface water and sediment on a regular basis, as well as a maintenance/utility worker who is exposed on an occasional basis.

Workers could be exposed to subsurface soils during construction activities on landside portions of the Site; however, potential exposure to contaminants in subsurface soils is addressed in the OU1 HHRA.

The potential for workers to be exposed to vapors from groundwater is not proposed for evaluation in the baseline HHRA for OU2, which is focused on potential exposures within the River. The potential for workers to be exposed to vapors from surface water will be evaluated in the HHRA if BTEX contaminants are identified as COPCs in surface water. If that occurs, an addendum to this Work Plan will be submitted to NPS outlining a proposed approach for modeling outdoor air concentrations of BTEX contaminants from surface water concentrations. As there are few areas of exposed sediment, volatilization of contaminants from exposed sediment to outdoor air is negligible. The potential for ebullition from sediments will be explored during the RI, but is more relevant to the evaluation of remedial alternatives during a feasibility study than potential human exposure.

### **3.2 Quantification of Potential Exposures**

To estimate the potential risk to human health that may be posed by exposures to COPCs, it is first necessary to estimate the potential exposure dose of each COPC. The exposure dose is estimated for each contaminant via each exposure pathway by which a receptor is assumed to be exposed. Exposure dose equations combine the estimates of contaminant concentration in the environmental medium of interest with assumptions regarding the type and magnitude of each receptor's potential

exposure to provide a numerical estimate of the exposure dose. The exposure dose is defined as the amount of COPC taken into the receptor and is expressed in units of milligrams of COPC per kilogram of body weight per day (mg/kg-day).

Exposure doses are defined differently for potential carcinogenic and noncarcinogenic effects. The Chronic Average Daily Dose (CADD) is used to estimate a receptor's potential intake from exposure to a COPC with noncarcinogenic effects. According to USEPA (1989), the CADD should be calculated by averaging the dose over the period of time for which the receptor is assumed to be exposed. Therefore, the averaging period is the same as the exposure duration.

For COPCs with potential carcinogenic effects, however, the Lifetime Average Daily Dose (LADD) is employed to estimate potential exposures. In accordance with USEPA (1989) guidance, the LADD is calculated by averaging exposure over the receptor's assumed lifetime (70 years). Therefore, the averaging period is assumed to be the same as the receptor's lifetime.

The standardized equations for estimating a receptor's average daily dose (both lifetime and chronic) are presented below, followed by descriptions of receptor-specific exposure parameters and contaminant-specific parameters.

### 3.2.1 Estimating Potential Exposures to COPCs in Sediment

The following equations are used to calculate the estimated exposures to sediment.

Average Daily Dose (Lifetime and Chronic) Following Incidental Ingestion of Sediment (mg/kg-day):

$$ADD = \frac{CS \times SIR \times FI \times EF \times ED \times AAF_o \times CF}{BW \times AT}$$

where:

ADD	=	Average Daily Dose (mg/kg-day)
CS	=	Sediment Concentration (mg/kg sediment)
SIR	=	Sediment Ingestion Rate (mg sediment/day)
FI	=	Fraction Ingested from Potentially Impacted Source (unitless)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (year)
AAF <sub>o</sub>	=	Oral Sediment/Absorption Adjustment Factor (contaminant-specific)
CF	=	Unit Conversion Factor (kg sediment/10 <sup>6</sup> mg sediment/soil)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days)

Average Daily Dose (Lifetime and Chronic) Following Dermal Contact with Sediment (mg/kg-day):

$$ADD = \frac{CS \times SA \times AF \times FI \times EF \times ED \times DAF \times CF}{BW \times AT}$$

where:

ADD	=	Average Daily Dose (mg/kg-day)
CS	=	Sediment/Soil Concentration (mg/kg sediment)
SA	=	Exposed Skin Surface Area (cm <sup>2</sup> /day)

AF	=	Sediment/Soil to Skin Adherence Factor (mg sediment/cm <sup>2</sup> )
FI	=	Fraction Contacted from Potentially Impacted Source (unitless)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (year)
DAF	=	Dermal Absorption Fraction (contaminant-specific) (unitless)
CF	=	Unit Conversion Factor (kg sediment/soil/10 <sup>6</sup> mg sediment)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days)

For potential carcinogenic effects associated with mutagenic carcinogens, the lifetime ADD will be multiplied by the age weighted ADAF.

### 3.2.2 Estimating Potential Exposures to COPCs in Surface Water

The following equations are used to calculate the estimated exposures (USEPA 1989, 2004).

Average Daily Dose (lifetime and chronic) following incidental ingestion of surface water (mg/kg-day):

$$ADD = \frac{CW \times IR_w \times ET \times EF \times ED}{BW \times AT}$$

where:

ADD	=	average daily dose (mg/kg-day)
CW	=	water concentration (mg/L)
IR <sub>w</sub>	=	ingestion rate of water (L/hour)
ET	=	exposure time (hr/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (year)
BW	=	body weight (kg)
AT	=	averaging time (days)

Calculation of the dose from dermal exposure to surface water will follow USEPA guidance (2004), which differentiates between organic and inorganic contaminants, as presented below. The following equations will be used to estimate the dermally absorbed dose following dermal contact with surface water:

Dermally absorbed dose (lifetime and chronic) following dermal contact with surface water (mg/kg-day):

$$DAD = \frac{DA_{\text{event}} \times EF \times ED \times SA}{BW \times AT}$$

where:

DAD	=	dermally absorbed dose (mg/kg-day)
DA <sub>event</sub>	=	absorbed dose per event (mg/cm <sup>2</sup> -event)
SA	=	body surface area (cm <sup>2</sup> )
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (years)

The calculation of the dose absorbed per unit area per event ( $DA_{\text{event}}$ ) is as follows for inorganics or highly ionized organics:

$$DA_{\text{event}} = CW \times PC \times ET \times CF$$

where:

$DA_{\text{event}}$	=	absorbed dose per event (mg/cm <sup>2</sup> -event)
CW	=	concentration in water (mg/L)
PC	=	permeability constant (cm/hr)
ET	=	exposure time (hr/event)
CF	=	conversion factor (L/1000 cm <sup>3</sup> )

The calculation of  $DA_{\text{event}}$  is as follows for organics:

$$\text{If } ET < t^*, \text{ then: } DA_{\text{event}} = 2FA \times PC \times CW \times CF \sqrt{\frac{6T \times ET}{\pi}}$$

$$\text{If } ET > t^*, \text{ then: } DA_{\text{event}} = FA \times PC \times CW \times CF \times \left[ \frac{ET}{1+B} + 2T \left( \frac{1+3B+3B^2}{(1+B)^2} \right) \right]$$

where:

$DA_{\text{event}}$	=	absorbed dose per event (mg/cm <sup>2</sup> -event)
FA	=	fraction absorbed water (dimensionless)
PC	=	permeability constant (cm/hour)
CW	=	concentration in water (mg/L)
T	=	lag time per event (hr/event)
ET	=	exposure time (hr/event)
$t^*$	=	time to steady state (hr) = 2.4t
B	=	dimensionless ratio of the PC of a contaminant through the stratum corneum relative to its permeability constant across the viable epidermis
CF	=	conversion factor (l L/1000 cm <sup>3</sup> )

For potential carcinogenic effects associated with mutagenic carcinogens, the lifetime ADD will be multiplied by the age weighted ADAF.

### 3.2.3 Receptor-Specific Parameters

For every exposure pathway of potential concern, it is expected that there will be differences between different individuals in the level of exposure at a specific location due to differences in exposure time, exposure frequency, and exposure duration. Thus, there is normally a wide range of average daily exposures between different individuals of an exposed population. Because of this, all exposure calculations must specify what part of the exposure range is being estimated. Typically, attention is focused on exposures that are "average" or are otherwise near the central portion of the range, and on exposures that are near the upper end of the range (e.g., the 95th percentile). These two exposure estimates are referred to as central tendency exposure (CTE) and reasonable maximum exposure (RME), respectively.

In the baseline HHRA, RME and CTE exposure parameters will be based on appropriate USEPA guidance (including but not limited to, USEPA, 2011, USEPA, 2014a) and site-specific information (see below). As noted above, the RME provides an estimate of the upper range of exposure in a population (the 90th percentile or greater of expected exposure) expected to occur under both current and future land use conditions, and is based on a combination of the upper-bound and central estimates of exposure parameters. It is not appropriate to set all RME exposure factor inputs to upper-percentile values, inasmuch as the resulting exposure estimates may exceed RMEs for the population of interest (USEPA, 2004). The intent of the RME is to estimate a conservative exposure case that is above the average case, but still within the range of possible exposures (USEPA, 1989, 1992d). The CTE uses average exposure parameters to estimate an average exposure case that may be more representative of the majority of the population. Both RME and CTE analyses will be presented for each exposure scenario. Site-specific data, to the extent possible, will be used in addition to USEPA guidance to determine exposure assumptions, as discussed below.

Consistent with USEPA's guidance, the exposure assessment will rely on site-specific approaches and assumptions to the extent possible, including review of local or regional data, discussions with local boat clubs, and observations during sampling and Site visits to determine current recreational use of the River. Use of default or surrogate assumptions as a basis for remedial decision-making is inconsistent with USEPA guidance documents, which stress the importance of using data that represent the characteristics of the local population(s) and Site (USEPA, 1989, 2011). Due to the site-specific nature of the exposure pathways considered (i.e., recreational use of the River), numerical exposure assumptions have not been included in this Work Plan. Information including local or regional data, literature, USEPA guidance (USEPA, 2011), as well as characteristics of the River, and public access will be reviewed prior to determining exposure factors. Information regarding recreational use of the River will be gathered from local boating clubs and from observations during sampling and Site visits. A technical memorandum will be submitted prior to conducting the risk assessment to present the proposed exposure assumptions.

### **3.2.4 Contaminant-Specific Parameters**

The dermal and oral absorption parameters identified in the equations presented above are contaminant-specific, and are described below.

#### Dermal Absorption Fractions

The dermal absorption fraction (DAF) accounts for lower absorption of contaminants in soil or sediment through the skin. USEPA contaminant-specific DAFs will be used where available (USEPA, 2004). DAFs for potentially MG-related contaminants are available for PAHs and a limited number of inorganics. For the inorganics lacking DAFs in USEPA (2004), the default value of 0.001 (0.1%) for inorganics recommended by USEPA Region 4 (2000), or other appropriate default DAFs, will be used. DAFs will not be applied to VOCs, consistent with USEPA (2004) and the approach used by USEPA to derive RSLs (USEPA, 2015a).

#### Oral Absorption Adjustment Factors

Absorption adjustment factors (AAFs) are used in risk assessment to account for absorption differences between humans exposed to substances in environmental situations and experimental animals in the laboratory studies used to derive dose-response values. Support for use of AAFs is provided in USEPA guidance (1989, 1992d). The AAF is the ratio between the estimated human absorption factor for the specific medium and route of exposure, and the known or estimated

absorption factor for the laboratory study from which the dose-response value was derived. The use of an AAF allows the risk assessor to make appropriate adjustments if the efficiency of absorption between environmental exposure and experimental exposure is known or expected to differ because of physiological effects and/or matrix or vehicle effects. When the dose-response curve is based on administered dose data, and if it is estimated that the fraction absorbed from the site-specific exposure is the same as the fraction absorbed in the laboratory study, then the AAF is 1. In the absence of detailed toxicological information on every contaminant, it is common practice to use a default oral AAF value of 1. However, use of AAFs in standard risk assessment calculations can provide more accurate and more realistic estimates of potential human health risk.

A default oral AAF of 1 will be used for all COPCs, with the exception of arsenic. The cancer slope factor for arsenic is based on drinking water studies, and in the absence of site-specific data, it has typically been assumed that relative bioavailability (RBA) of arsenic from soil or sediment is the same as absorption from drinking water (USEPA, 2012). However, recent *in-vivo* bioavailability studies show that this is not the case for arsenic, and that the bioavailability of arsenic in soil or sediment is less than the bioavailability of arsenic dissolved in drinking water (USEPA, 2012). Therefore, the assumption of 100% RBA results in an overestimate of risk via the oral pathway. USEPA recommends a default arsenic RBA of 60% for soils based on a review of over 100 arsenic RBA estimates (USEPA, 2012). Therefore, a default oral-sediment AAF of 0.6 will be used for arsenic. The uncertainty associated with assuming 100% RBA (with the exception of arsenic) will be discussed in the uncertainty section of the risk assessment.

It should be noted that the bioavailability of MG-related contaminants is likely to be less than 100%. In particular, it should be noted that cyanide from MG wastes is often present in ferrocyanide complexes that are not bioavailable or toxic. Both free cyanide and physiologically available cyanide will be analyzed in groundwater, surface water, and sediment. The use of an oral AAF of one for total cyanide is therefore a conservative assumption.

#### Dermal Water Parameters

The estimation of exposure resulting from incidental dermal contact with surface water requires the use of a dermal permeability constant (PC) in units of centimeters per hour (cm/hr). This method assumes that the behavior of contaminants dissolved in water is described by Fick's Law. In Fick's Law, the steady-state flux of the solute across the skin ( $\text{mg}/\text{cm}^2/\text{hr}$ ) equals the permeability constant (PC cm/hr) multiplied by the concentration difference of the solute across the membrane ( $\text{mg}/\text{cm}^3$ ). This approach is discussed by USEPA (USEPA 1989, 2004).

The PC values will be obtained from USEPA (2004) Exhibit B-3. For the COPCs lacking PCs in the USEPA guidance, PCs will be calculated using the USEPA (2004) algorithms. In addition to PCs, several other parameters are necessary to calculate dermal dose from exposure to organic contaminants in water. These parameters, also to be obtained from USEPA (2004), Exhibit B-3, include the ratio of the permeability coefficient of a contaminant through the stratum corneum relative to its permeability coefficient across the viable epidermis (B, dimensionless), lag time ( $\tau$ , hours/event), and time to steady state ( $t^*$ , hours). Parameters for contaminants not available from USEPA (2004) will be calculated using the USEPA (2004) algorithms.

### 3.2.5 Calculation of Exposure Point Concentrations

Exposure points are located where potential receptors may contact COPCs at or from the Site. The concentration of COPCs in the environmental medium that receptors may contact must be estimated in order to determine the magnitude of potential exposure.

The exposure point concentration (EPC) will be defined as the 95UCL (USEPA, 2002a) for both the RME and CTE scenarios, with the exception of lead. The surface water and sediment datasets described in Section 2 will be used to calculate the EPCs. UCLs will be calculated using USEPA's ProUCL Version 5.0.00 (USEPA, 2013a,b,c), or the version available at the time UCLs are calculated. The UCL recommended by ProUCL will be used unless determined to be inappropriate based on a statistical review, or if it exceeds the maximum detected concentration (USEPA, 2002a). If the UCL recommended by ProUCL exceeds the maximum detected concentration, alternative UCLs identified by ProUCL will be reviewed to determine whether an alternate UCL is appropriate. If lead is identified as a COPC, the arithmetic mean will be selected as the EPC, in accordance with USEPA guidance (USEPA, 1996, USEPA, 2002b), and as discussed on USEPA's website (<http://www.epa.gov/superfund/health/contaminants/lead/almfaq.htm#equation>).

## 4.0 Dose-Response Assessment

The purpose of the dose-response assessment in the HHRA is to identify the types of adverse health effects a COPC may potentially cause, and to define the relationship between the dose of a contaminant and the likelihood of an adverse effect (response). Adverse effects are defined by USEPA as potentially carcinogenic or noncarcinogenic (i.e., potential effects other than cancer). The USEPA has defined the dose-response values for potentially carcinogenic effects as Cancer Slope Factors (CSFs) or Unit Risk Factors (URFs), and dose-response values for noncarcinogenic effects as Reference Doses (RfDs) or Reference Concentrations (RfCs). Subchronic RfDs and RfCs apply to substantially less than lifetime exposures (USEPA, 1989), generally exposures less than seven years in duration (i.e., 1/10th of the average lifetime of 70 years). Chronic RfDs and RfCs apply to exposures greater than seven years duration.

The USEPA's guidance for sources of human health dose-response values in risk assessment will be followed in selecting dose-response values (USEPA, 2003a). Sources of published dose-response values that may be used in the HHRA include USEPA's IRIS database (USEPA, 20115c) and the USEPA National Center for Environmental Assessment (NCEA) in Cincinnati, Ohio. In accordance with USEPA (2003a), when dose-response values are not available from those sources, other sources of information may include California Environmental Protection Agency (CalEPA), the Agency for Toxic Substances and Disease Registry (ATSDR), and the Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997).

Dose-response values used in the risk assessment will be presented in tabular format. For each COPC the table will present the Chemical Abstracts Service (CAS) registry number, dose-response value, source, study animal, study method, and where appropriate, target endpoint, critical effect, uncertainty factors, and confidence level.

Dose-response values are available for oral and inhalation exposures. Oral dose-response values will be used to evaluate dermal exposures using appropriate adjustment factors from USEPA (For carcinogens presumed to act via a mutagenic mode of action, dose-response values are generally based on the linearized multistage model, which assumes that cancer risks are linear in the low-dose region (USEPA, 2005a, b). Consistent with the *Cancer Guidelines and Supplemental Guidance for Assessing Susceptibility for Early-Life Exposure to Carcinogens* (USEPA, 2005b), the application of age-dependent adjustment factors (ADAF) for contaminants with a mutagenic mode of action will be used in the calculation of risk from specific contaminants, such as potentially carcinogenic PAHs. As recommended by USEPA (2005b), the ADAFs are as follows:

- Ages 0-2: ADAF = 10;
- Ages 2-6: ADAF = 3;
- Ages 6-16: ADAF = 3;
- Ages >16: ADAF = 1.

Age-weighted ADAFs (ADAF<sub>AW</sub>) will be calculated for each receptor based on the assumed age and exposure duration. For example, an age-weighted ADAF for a child aged 1 to 6 with an exposure duration of 6 years is calculated as follows:

<b>Age Range</b>	<b>ADAF</b>
1<2	10
2<3	3
3<4	3
4<5	3
5<6	3
6<7	3
<b>ADAF<sub>AW</sub></b>	<b>4.2</b>

The potential contribution to lifetime risk from early life exposures to potentially carcinogenic PAHs and other contaminants with mutagenic modes of action will be discussed in the risk characterization and uncertainty sections of the report.

In the event that lead is identified as a COPC, it should be noted that potential risks from lead are not assessed using the RfD or CSF approach (USEPA, 2015c). As discussed in Section 5.3, lead will be evaluated using available pharmacokinetic models, as appropriate (e.g., IEUBK Model and Adult Lead Model (ALM) [<http://www.epa.gov/superfund/lead/products>]).

## 5.0 Risk Characterization

The purpose of the risk characterization is to provide estimates of the potential risk to human health from exposure to COPCs. The results of the exposure assessment are combined with the results of the dose-response assessment to derive quantitative estimates of risk. Each exposure pathway for each receptor will be evaluated for potential carcinogenic or noncarcinogenic effects.

### 5.1 Carcinogenic Risk Characterization

The purpose of carcinogenic risk characterization is to estimate the upper-bound likelihood, over and above the background cancer rate, that a receptor will develop cancer in his or her lifetime as a result of exposure to a contaminant in an environmental medium. This likelihood is a function of the dose of a contaminant (described in the Exposure Assessment) and the CSF (described in the Dose-Response Assessment) for that contaminant. The excess lifetime cancer risk (ELCR) is expressed as a probability (e.g.,  $10^{-6}$ , or one in one million). An ELCR of  $10^{-6}$  indicates that an individual would have a 1 in one million chance of developing cancer. The relationship between the ELCR and the estimated lifetime average daily dose (LADD) of a contaminant may be expressed as:

$$\text{ELCR} = 1 - e^{-(\text{CSF} \times \text{LADD})}$$

If the product of the CSF and the LADD is much greater than 1, the ELCR approaches 1 (i.e., 100 percent probability). If the product is less than 0.01 (one chance in 100), the equation can be closely approximated by:

$$\text{ELCR} = \text{LADD (mg/kg-day)} \times \text{CSF (mg/kg-day)}^{-1}$$

The product of the CSF and the LADD is unitless, and provides an upper-bound estimate of the potential carcinogenic risk associated with a receptor's exposure to a contaminant or an exposure pathway. Current USEPA risk assessment guidelines (USEPA, 2005a) assume that cancer risks are additive or cumulative. The potential carcinogenic risk for each COPC and exposure pathway is calculated for each receptor then pathway-specific total risks are summed to estimate the total potential carcinogenic risk for each receptor group. Summaries of the total carcinogenic risks for each receptor group will be compared to the NPS point of departure risk of  $10^{-6}$  per NPS direction in comments dated 1/31/2014. In addition, to provide additional context and perspective, the risk results will also be compared to the USEPA's target risk range of  $10^{-6}$  to  $10^{-4}$  (USEPA, 1991). The results of that comparison will be used for informational purpose only. A summary of the total cancer risks for each receptor group will be presented in the Risk Characterization section of the HHRA.

### 5.2 Noncarcinogenic Risk Characterization

The potential for adverse noncarcinogenic health effects is estimated for each receptor by comparing the CADD for each COPC with the RfD for that COPC. The resulting ratio, which is unitless, is known as the Hazard Quotient (HQ) for that contaminant. The HQ is calculated using the following equation:

$$\text{HQ} = \frac{\text{CADD (mg/kg-day)}}{\text{RfD (mg/kg-day)}}$$

The target HQ is defined as an HQ of less than or equal to 1 (USEPA, 1989). When the HQ is less than or equal to 1, the RfD has not been exceeded, and no adverse noncarcinogenic effects are expected. If the HQ is greater than 1, there may be a potential for adverse noncarcinogenic health effects to occur; however, the magnitude of the HQ cannot be directly equated to a probability or effect level.

The total Hazard Index (HI) is calculated for each exposure pathway by summing the HQs for each individual contaminant. The total HI will be calculated for each potential receptor by summing the HIs for each pathway associated with the receptor. If the total HI is greater than 1 for any receptor, a more detailed evaluation of potential noncarcinogenic effects based on specific target endpoints/health endpoints will be performed (USEPA, 1989).

A summary of HIs for each receptor group will be presented and compared to the target HI of 1. If the cumulative target endpoint HIs for a receptor are less than one, then no further evaluation or action is warranted based on potential non-carcinogenic risks.

Using the results of the RME and CTE risk calculations, contaminants of concern (COCs) will be identified, which are those COCs that cause exceedance of the noncancer target HI of 1 per target endpoint.

### 5.3 Risk Characterization for Lead

Exposure and risk characterization for lead in environmental media will be evaluated using available pharmacokinetic models, as appropriate (e.g., IEUBK Model and ALM [<http://www.epa.gov/superfund/lead/products>]).

The IEUBK model (USEPA, 2010, 1994a, 1994b) will be used to evaluate the young child. Children 0-7 years of age are considered by USEPA to be sensitive receptors for lead exposure because, compared to older receptors, young children ingest more soil, absorb more lead from the gastrointestinal tract, and are more sensitive to the effects of lead in the bloodstream (USEPA 1994a, 1994b). The IEUBK model predicts blood lead levels due to exposure to lead from multiple sources, including air, water, diet, soil, and maternal sources, and considers differing exposure patterns and physiological changes in the various age groups. The model also predicts the probability (risk) that a typical child, exposed to specified media lead concentrations, will have a blood lead level greater or equal to the level associated with adverse health effects (i.e. neurological effects, impaired mental and physical development) of 10 ug/dL (USEPA, 1994a, 1994b). Key assumptions for the use of the IEUBK for this recreational scenario are discussed below:

- The young child will be assumed to ingest sediment;
- Inhalation of lead from sediment will not be evaluated, as it is assumed that lead in sediment does not become entrained as dust;
- a time-weighted surface water concentration will be calculated based on the estimated fraction of total surface water ingestion that occurs in the River. The equation below shows the fundamental equation for time-weighting exposures to surface water (USEPA, 2003c).

$$Pb_{sw} = C_{sw} \frac{t_{event} \times \frac{1}{24} \text{ hours}}{EF_{sw}} \quad (1)$$

where:

$Pb_{sw}$	=	Time-weighted surface water concentration (ug/L)
$C_{sw}$	=	Average surface water concentration (ug/L)
$t_{event}$	=	Event Duration (hours/event)
$EF$	=	Exposure Frequency (days/year)

The ALM will be used for adults, for both recreational and occupational exposures. Recreational exposures will be evaluated by adjusting the exposure assumptions in the ALM; as stated previously, numerical exposure assumptions will be provided in a later technical memorandum. The ALM uses a methodology that relates soil lead intake to lead concentrations in women of childbearing age. The predicted blood lead concentration is then used to predict the blood lead concentration of an exposed fetus. The USEPA assumes that cleanup goals protective of a fetus will also protect male or female adult workers (USEPA, 2001a). The USEPA ALM is useful for assessing most sites where exposures other than residential are (or will) occur; however, the ALM spreadsheet provided on the USEPA website (USEPA, 2009a) addresses only the soil pathway. The basic algorithms for the Bowers et al. (1994) model were used to form the basis for the current ALM. In order to evaluate potential exposures to lead that address surface water as well as sediment, the adult lead exposure model of Bowers et al. (1994) was adapted to calculate the PRG and to estimate the blood lead concentration in an adult resident.

The model incorporates ingestion and absorption rates specific to each potential exposure pathway and is based on the assumption that there is a baseline blood lead level in the adult population of the United States that reflects typical exposures, primarily due to lead in the diet. It is assumed that there is a relationship between uptake of lead into the body and blood lead levels. To address this assumption, a BKSF is used to represent lead biokinetics and a relatively simple exposure model in which all exposure pathways, other than soil ingestion, are represented by a background PbB concentration. The ALM differs from the child model in that the BKSF is used to relate total uptake of lead in adults to blood lead rather than the multi-compartment distribution model used in the IEUBK model (Bowers et al. 1994). The Bowers model defines the Adult PbB as the Baseline Blood Lead Level + Increase in Blood Lead as implemented with the following algorithms:

$$PbB_{adult} = \left( BKSF \times \sum_{i=1}^n uptake_i \right) + PbB_0$$

where:

$PbB_{adult}$	=	Geometric mean of adult blood lead concentration (ug/dL)
$Pb_{sed}$	=	Sediment lead concentration (mg/kg)
$Uptake_i$	=	Media-specific lead incidental ingestion uptake (ug/day, see below)
$BKSF$	=	Biokinetic Slope Factor [(ug/dL) per (ug/day)]
$PbB^0$	=	Baseline blood lead concentration (ug/dL)

$$uptake_i = \frac{Pb_i \times IR_i \times AF_i \times EF_i}{AT_i}$$

where:

$i$	=	Media: sediment, surface water
$Pb_i$	=	Average media lead concentration (mg/kg) or (ug/L)
$IR_i$	=	Media ingestion rate (g/day) or (L/day)
$AF_i$	=	Media Absorption fraction (dimensionless)
$EF_i$	=	Media- specific Exposure frequency (days/year)
$AT_i$	=	Media- specific Averaging time (days/year)

The 95th percentile fetal blood lead concentration is then predicted by:

$$PbB_{fetal,0.95} = PbB_{adult} \left( R_{fetal/maternal} \times GSD^{1.645} \right)$$

where:

$PbB_{fetal,0.95}$	=	95th percentile blood lead concentration among fetuses of adults (ug/dL)
$R_{fetal/maternal}$	=	Fetal/maternal blood lead ratio (dimensionless)
$GSD$	=	Geometric standard deviation of blood lead concentration (dimensionless)

The methods described above will also be used to evaluate adolescent receptors. According to USEPA's website (<http://www.epa.gov/superfund/health/contaminants/lead/almfaq.htm#trespass>), the ALM may be used with appropriate adjustments to evaluate adolescents:

“The adolescent population may be considered sensitive since exposures during these years may result in a body burden of lead that is available to transfer to the fetus later in life. Given the limitations of currently available modeling tools, it is reasonable to apply the ALM to adolescent receptors (e.g., trespasser scenarios), provided that appropriate values can be selected for the following important model parameters:

- exposure frequency (EF)
- exposure duration (ED)
- baseline blood lead ( $PbB_0$ )
- absorption fraction (AF)”

As discussed previously, exposure parameters including EF and ED will be presented in a subsequent technical memorandum. The baseline blood lead level ( $PbB_0$ ) recommended value of 1.0 ug/dL for entire US population (USEPA, 2009b) will be used. USEPA's default AF is 12% for adults (USEPA, 2003b). For adolescents, 30% will be used, based on USEPA recommendation (<http://www.epa.gov/superfund/health/contaminants/lead/almfaq.htm#shortest>).

## 5.4 Risk Assessment Refinement

The baseline HHRA will be conducted using reasonable but conservative exposure and dose-response assumptions, and will follow a deterministic (i.e., point estimate) approach. As appropriate, the HHRA may include additional refinements, such as the use of site-specific bioavailability factors, if available, and probabilistic (or Monte Carlo) analysis. Should more refined approaches be warranted, a separate work plan or addendum presenting the technical bases and methods of the specific refinements will be submitted to NPS prior to conducting the additional analyses. The goal of any proposed refinements will be to provide additional information that risk managers and stakeholders may use to more accurately characterize the range of potential Site risks and to communicate with the public. The use of tiered approaches for evaluating Site risks is consistent with guidance (USEPA, 2001b).

## 5.5 Uncertainty Analysis

Uncertainty is introduced into the risk assessment throughout the process when an assumption is made. In accordance with USEPA guidance (USEPA, 1989), the uncertainty associated with each step of the risk assessment will be discussed qualitatively in this section of the report.

There are many potential sources of uncertainty in the risk assessment process; some are more important than others. The major areas of uncertainty include: the quality of the analytical data, assumptions about the frequency, duration, and magnitude of exposure, the receptors identified, and the availability and accuracy of dose-response data. The uncertainties, including steps taken to compensate for uncertainty, and the impact on the risk assessment results will be evaluated quantitatively where possible and qualitatively where quantitative estimates are not possible or feasible given available information. Two specific topics the uncertainty analysis will evaluate include potential exposures to sediments deeper than 6 inches and the characterization of background risks.

### 5.5.1 Potential Exposure to Sediment at Depth

The potential for human exposures to sediments deeper than 6 inches will be evaluated, including a quantitative comparison of concentrations at the surface and at deeper depths.

### 5.5.2 Characterization of Background/Reference Risks

The HHRA will also consider the context of the Site within the anthropogenically impacted Anacostia River watershed. As described in the RI/FS Work Plan, background and reference data will be gathered for sediment from existing literature sources (background data) and from surface sediment samples collected from reference locations to support the risk assessments. Reference locations will be selected such that they are representative of comparable environmental conditions with the Site, but with the absence of Site-related impacts.

Concentrations of COPCs in upstream sections of the River provide insight into contaminant loading from off-site sources, and provide reference data to put Site conditions into context with other similar water bodies in the greater region. While USEPA guidance does not allow for elimination of COPCs on the basis of consistency with background, COPCs that appear to be influenced by regional urban background concentrations will be noted in the risk characterization (USEPA 2002c,d). Site data collected for the HHRA will be reviewed relative to the available background data. Site-specific reference data, supplemented, as appropriate, with background data from other projects on the River (e.g., background data collected as part of the investigation of sites such as the Kenilworth Landfill,

Poplar Point, and Washington Navy Yard), as well as NOAA DARRP data, will be used to determine the background conditions. Details of this are presented in Section 4.3.5 of the RI/FS Work Plan.

Reference data will also be used to evaluate Site-related risks; however, because the number of reference samples to be collected is not sufficient for rigorous statistical analysis these data may be used in a more qualitative fashion.

The risk characterization will include an estimation of incremental risk (IR) by comparing potential risks associated with Site-impacted sediments in the River compared to River-specific reference and background concentrations of COPCs in this highly impacted system. IRs are the difference between risks and hazards from the Site and River reference and/or background risks/hazards, calculated as a ratio of Site to reference and/or background. IRs greater than 0 may be considered directly related to the Site, and not attributable to background conditions. This will allow clear communication of overall risk, and the potential risks from the Site versus background risk, to the risk managers and the public for consideration in risk management decisions.

## **5.6 Summary and Conclusions**

The final section of the baseline HHRA will present an overall summary of the risk characterization and risk assessment conclusions. Conclusions of the HHRA will include a synopsis of any of the receptor/exposure scenarios that result in unacceptable risks associated with exposure to Site-related contaminants at OU2. For exposure scenarios that exceed acceptable cancer or noncarcinogenic target levels, COCs will be identified.

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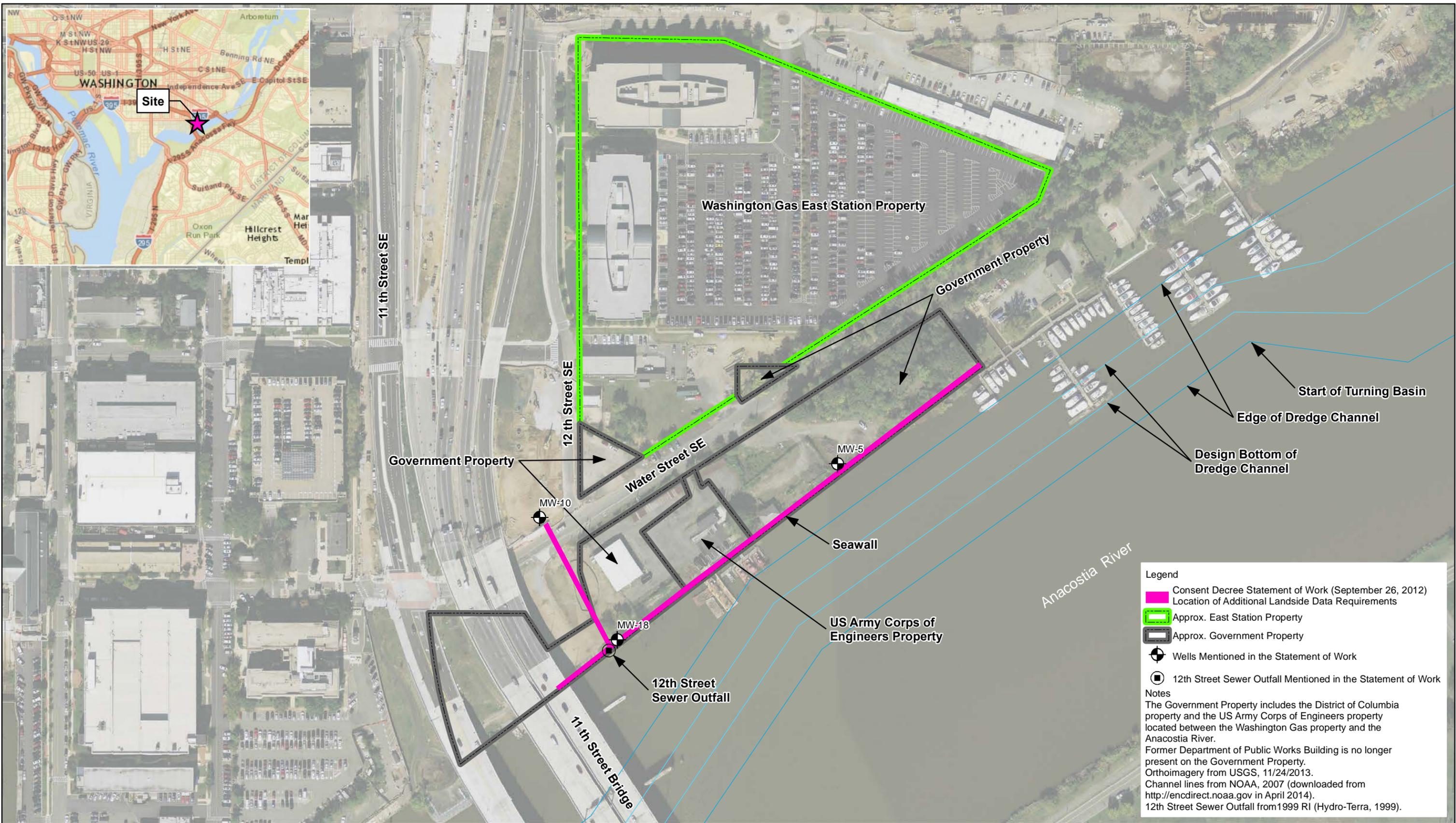
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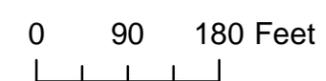
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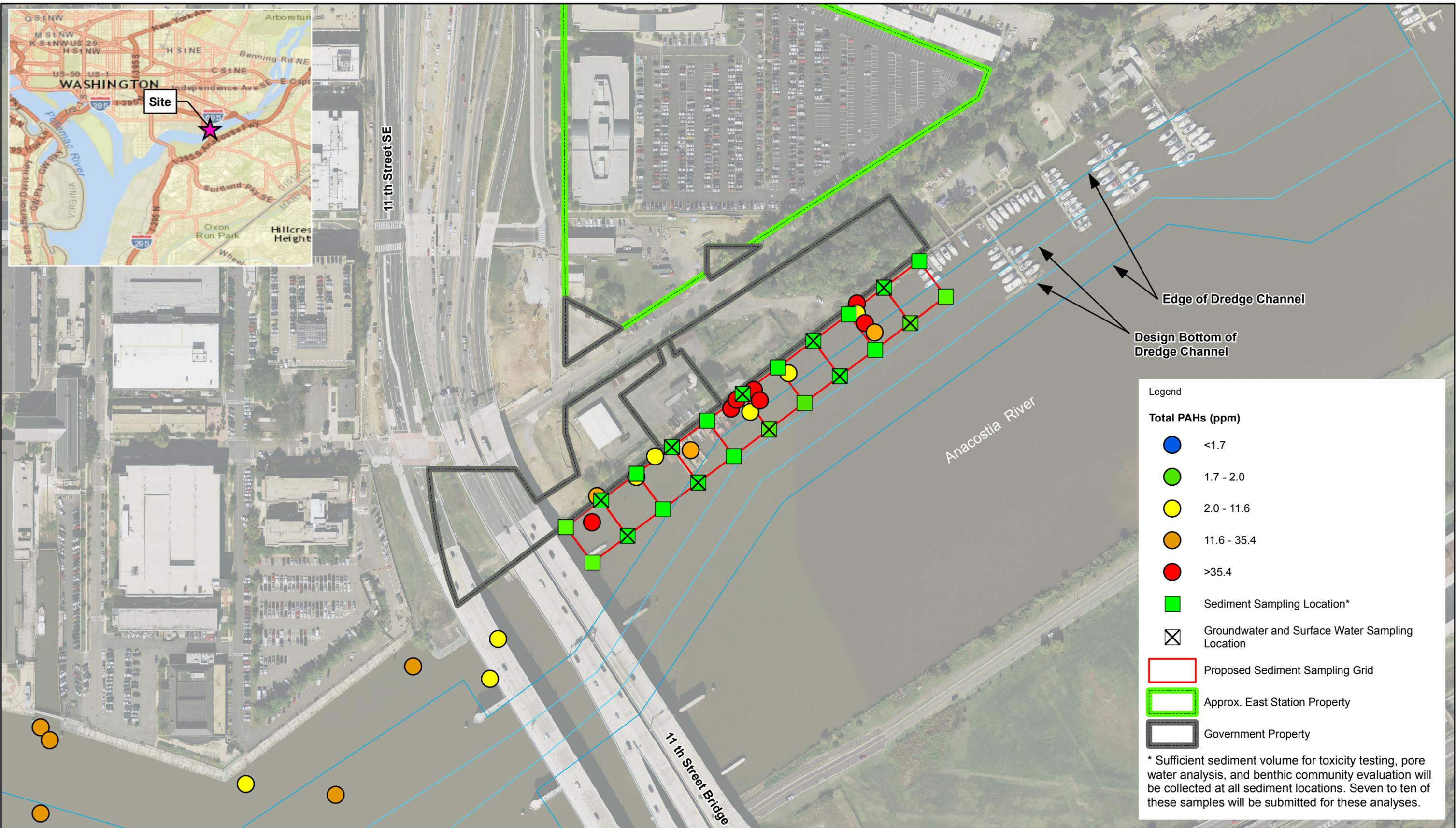
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## Figures



**Figure 1 Property Locations**  
**Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan**  
**Washington Gas East Station Site**





**Figure 2**  
**Location of In-River Data Collection and Surficial Sediment PAH Data**  
**Operable Unit 2 – Remedial Investigation and**  
**Feasibility Study Work Plan**  
**Washington Gas East Station Site**

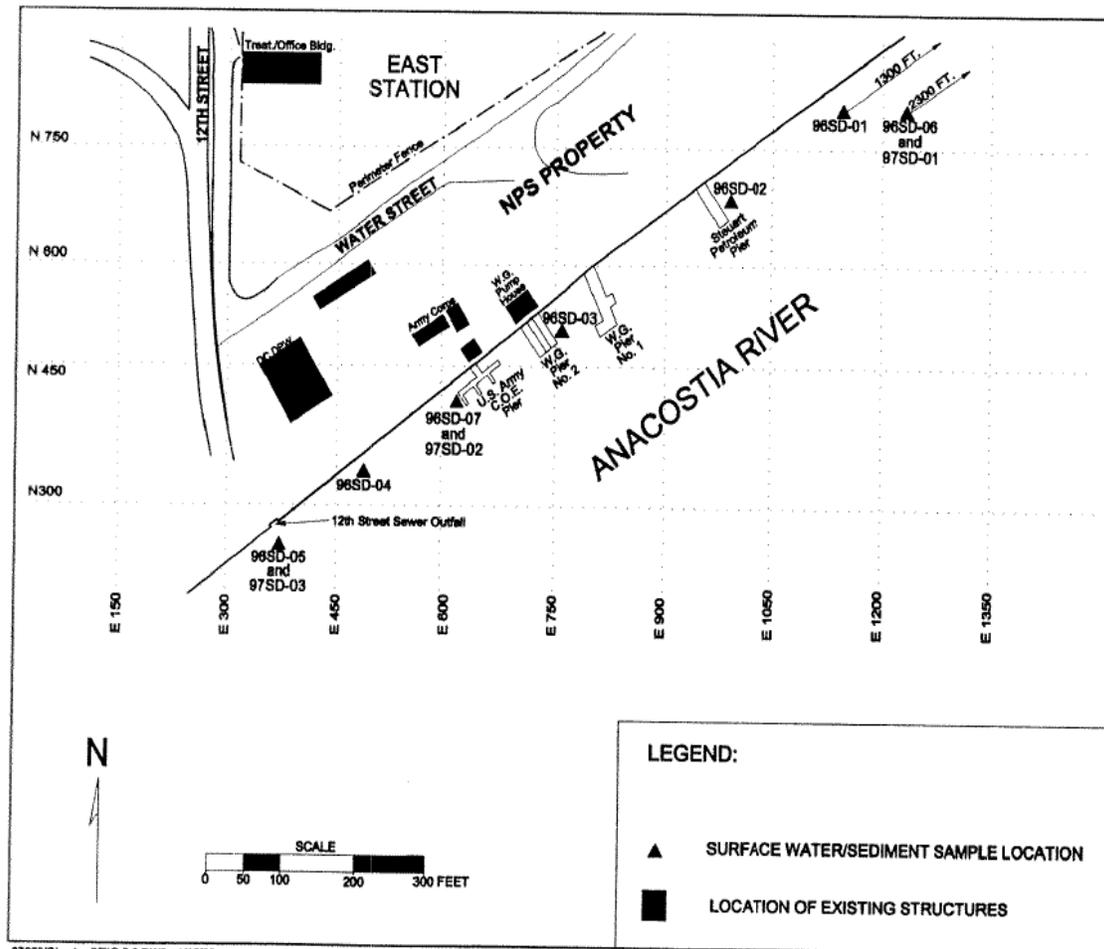
Note  
 Sample locations will be adjusted based on accessibility and the presence of utilities.  
 Orthoimagery from USGS, 11/24/2013.  
 Channel lines from NOAA, 2007 (downloaded from  
<http://encdirect.noaa.gov> in April 2014).

0 100 200 400 Feet



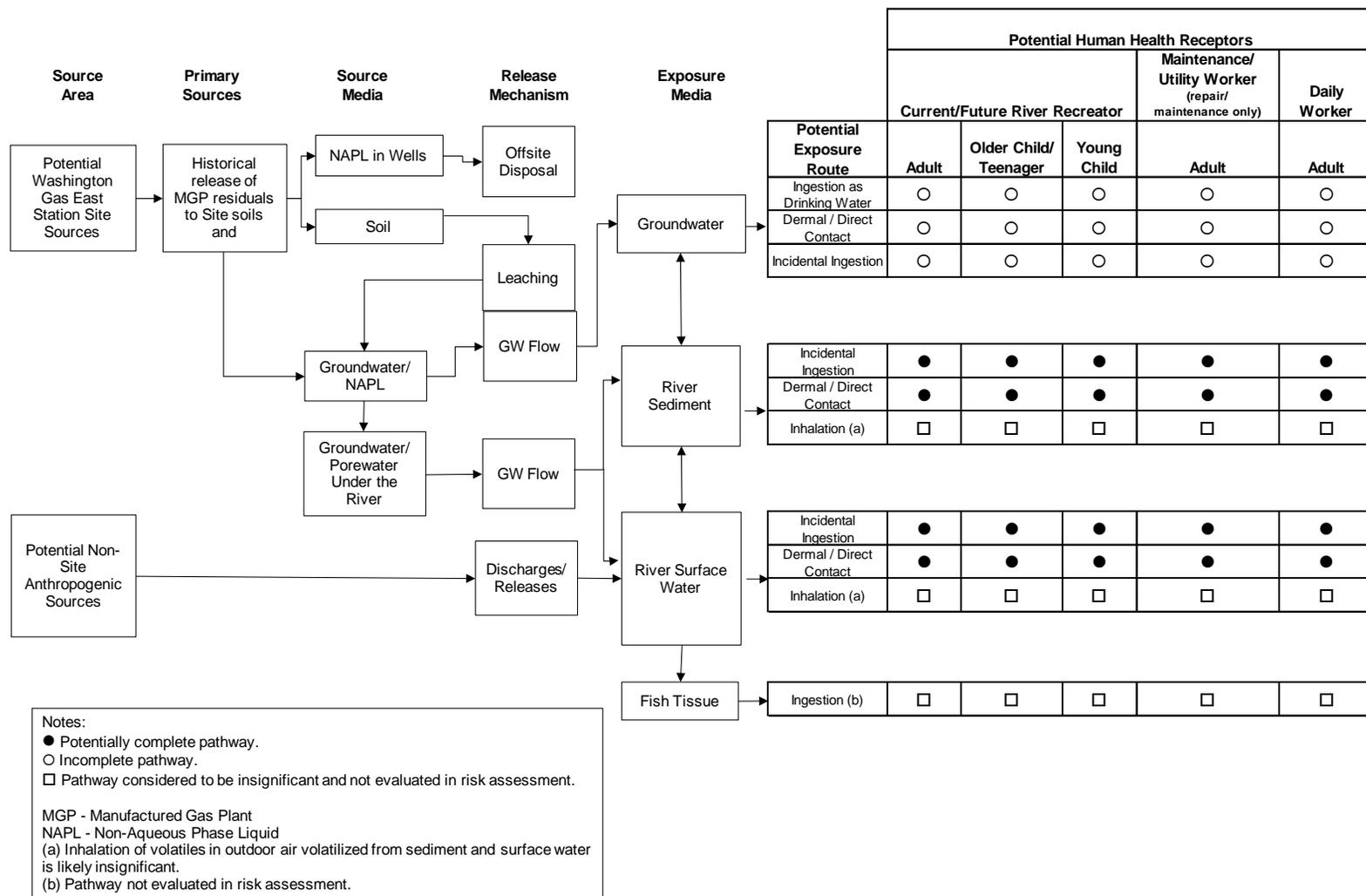
Path: \\Uswtf1fp001\JOBS\Indl\_Service\Project Files\Washington Gas MGPIGISMXD\RI\_FS\_Work\_Plan\MXD\HHRA\Fig\_2\_Loc\_of\_InRiver\_Data\_Collection.mxd

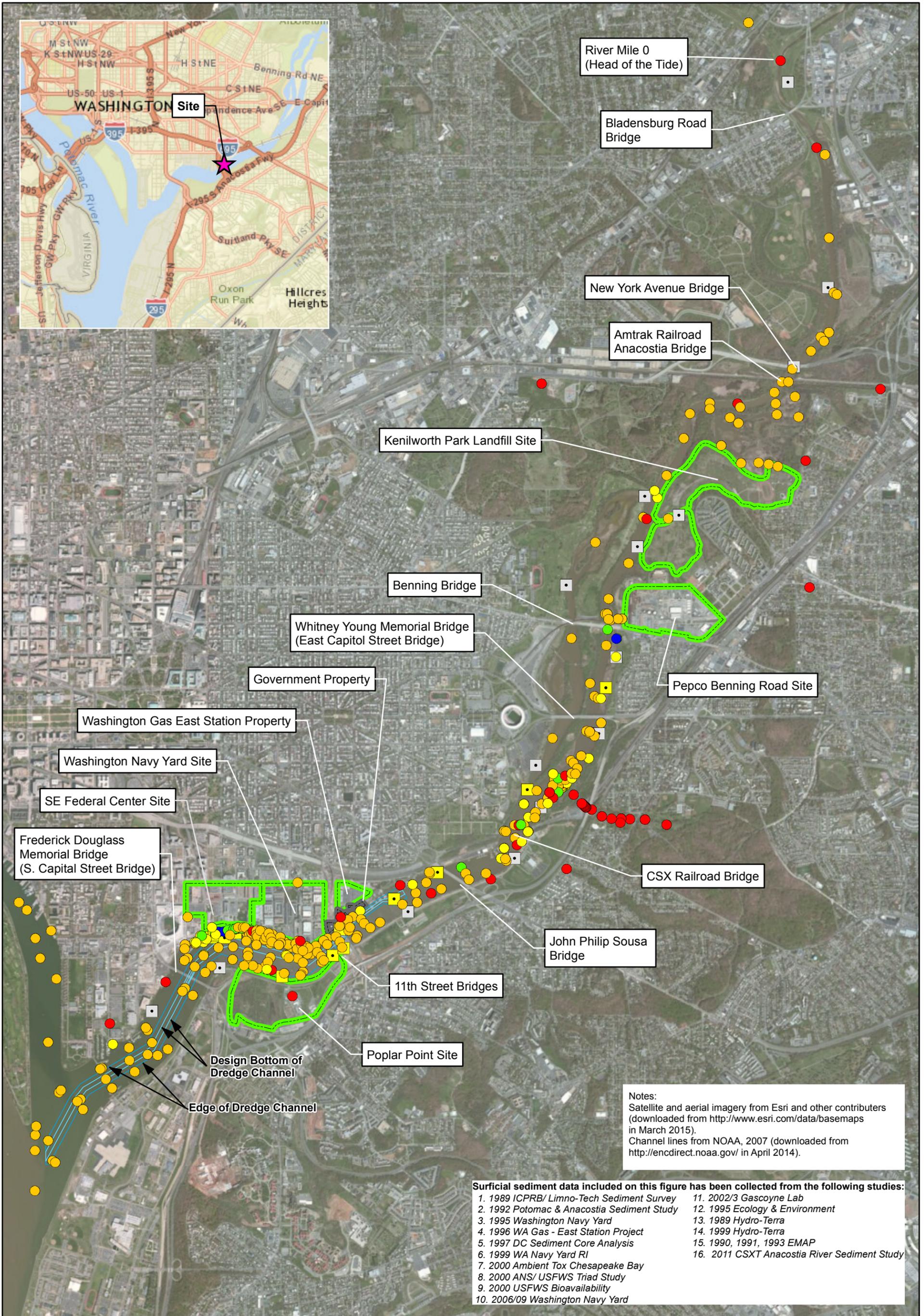
**Figure 3**  
**Location of Surface Water and Sediment Samples – 1999 HHRA**



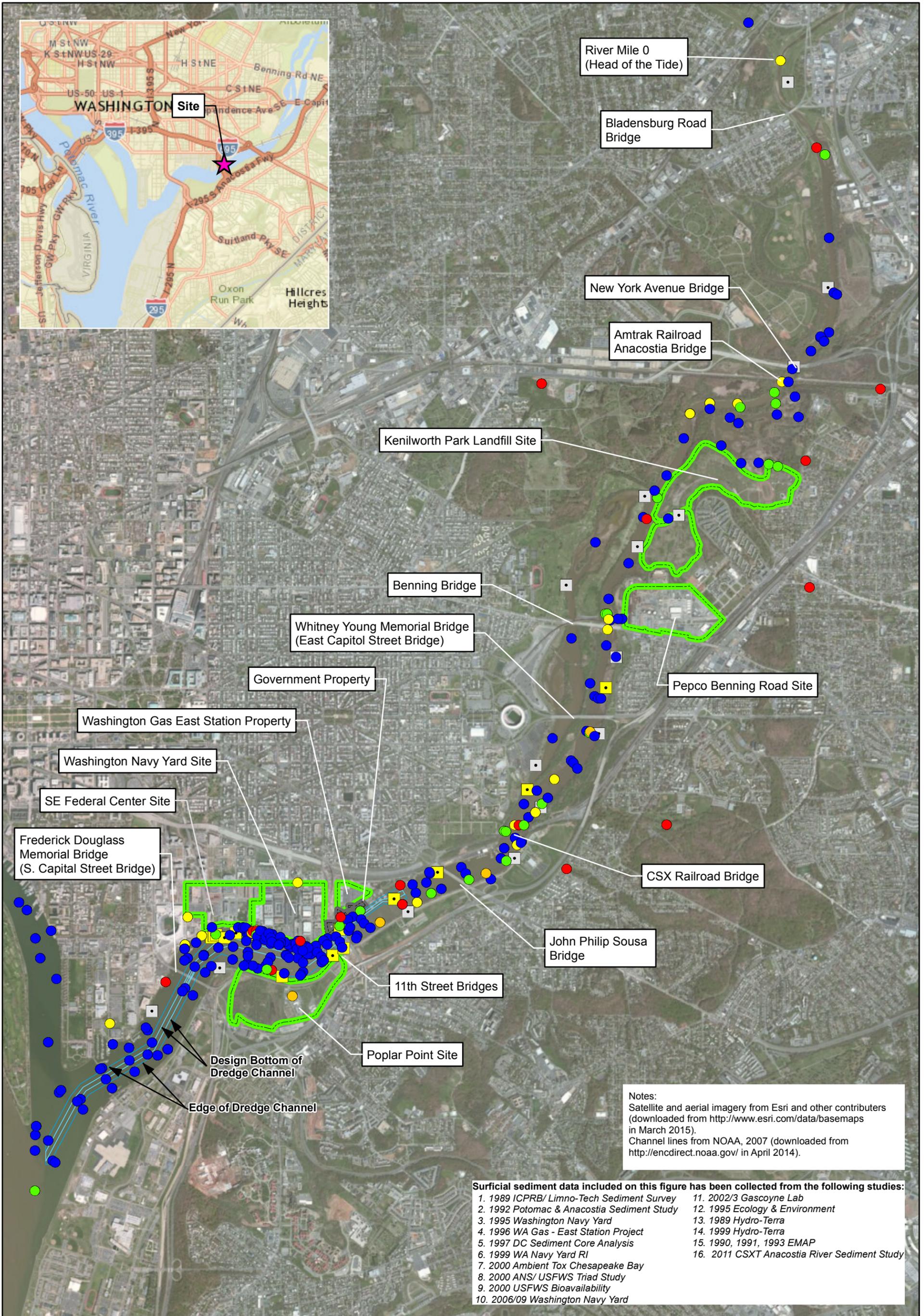
Source: Hydro-Terra, 1999; Figure 5-8

**Figure 4 Human Health Conceptual Site Model  
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan  
Washington Gas East Station Site**



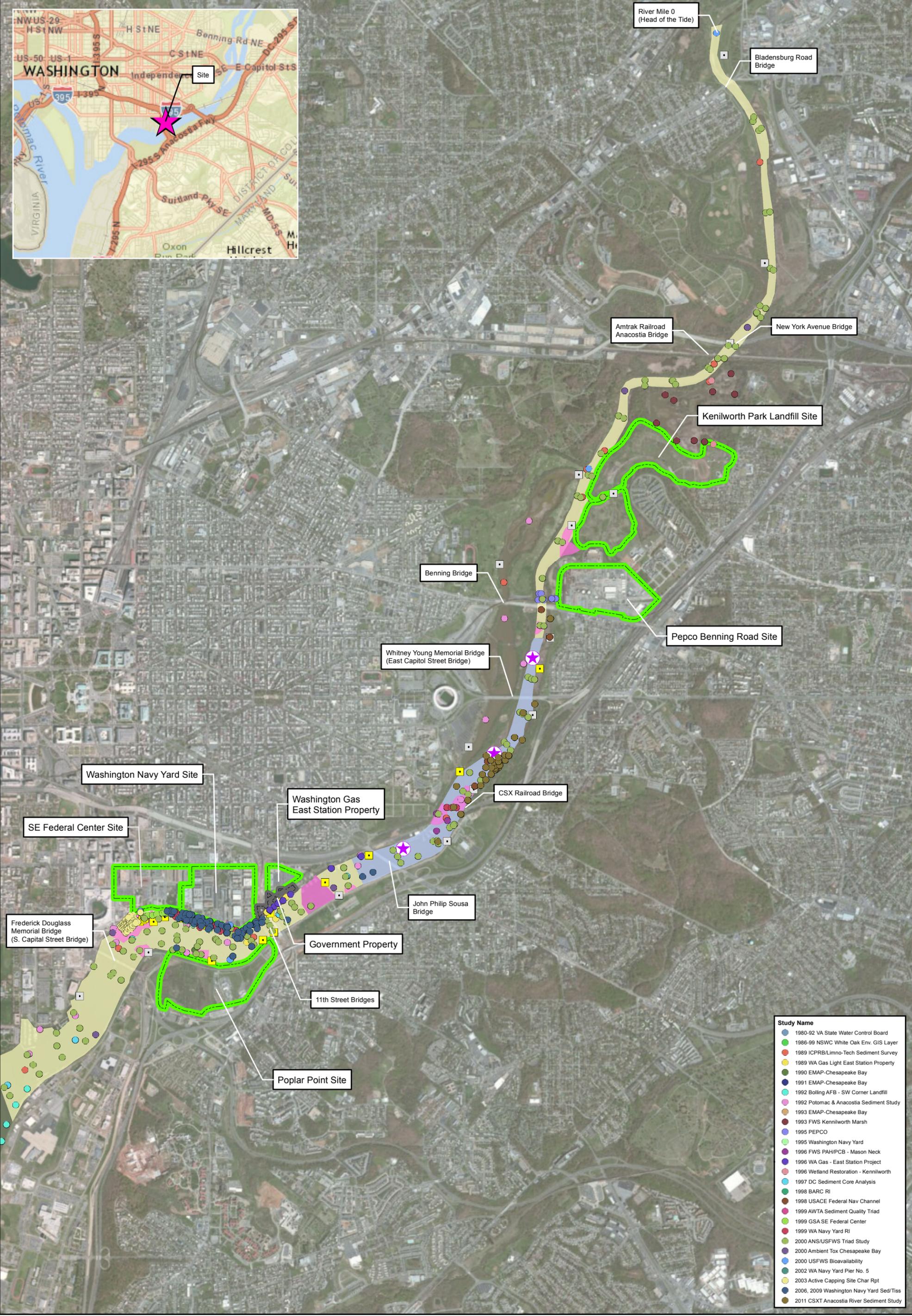


**Figure 5**  
**Anacostia River Surficial Sediment Total Organic Carbon (TOC)**  
**Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan**  
**Washington Gas East Station Site**



**Figure 6**  
**Anacostia River Surficial Sediment Grainsize (% Fines)**  
**Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan**  
**Washington Gas East Station Site**





Study Name	
●	1980-92 VA State Water Control Board
●	1986-99 NSWC White Oak Env. GIS Layer
●	1989 ICPRB/Limno-Tech Sediment Survey
●	1989 WA Gas Light East Station Property
●	1990 EMAP-Chesapeake Bay
●	1991 EMAP-Chesapeake Bay
●	1992 Bolling AFB - SW Corner Landfill
●	1992 Potomac & Anacostia Sediment Study
●	1993 EMAP-Chesapeake Bay
●	1993 FWS Kennilworth Marsh
●	1995 PEPCO
●	1995 Washington Navy Yard
●	1996 FWS PAH/PCB - Mason Neck
●	1996 WA Gas - East Station Project
●	1996 Wetland Restoration - Kennilworth
●	1997 DC Sediment Core Analysis
●	1998 BARC RI
●	1998 USACE Federal Nav Channel
●	1999 AWTA Sediment Quality Triad
●	1999 GSA SE Federal Center
●	1999 WA Navy Yard RI
●	2000 ANS/USFWS Triad Study
●	2000 Ambient Tox Chesapeake Bay
●	2000 USFWS Bioavailability
●	2002 WA Navy Yard Pier No. 5
●	2003 Active Capping Site Char Rpt
●	2006, 2009 Washington Navy Yard Sed/Tiss
●	2011 CSXT Anacostia River Sediment Study

**Figure 7**  
**Anacostia River Sediment Sample Locations**  
**and Proposed Reference Locations**  
**Operable Unit 2 - Remedial Investigation**  
**and Feasibility Study Work Plan**  
**Washington Gas East Station Site**

- ★ Reference Location
  - CSOs\*
  - Storm Sewer Outfalls\*
- \* Locations approximate based on information from WNY Background Evaluation

- Sediment Area of Concern - as defined by AWTA
- Area Excluded from Background Sediment Evaluation
- Area Proposed to be Included in Background Sediment Evaluation

Notes  
 Satellite and aerial imagery from Esri other contributors  
 (downloaded from <http://www.esri.com/data/basemaps> in March 2015).




0    0.25    0.5    1 Miles

# **Attachment 1**

## **Exposure Assumptions**

**TABLE HIF-1**  
**HIF CALCULATIONS FOR CONSUMPTION OF CATCHES**  
**FROM RECREATIONAL FISHING**

Basic HIF Equation:<sup>(a)</sup> (day<sup>-1</sup>) = 
$$\frac{IR_1 \times EF \times ED_1}{BW_1 \times AT}$$

Time-Weighted HIF Equation:<sup>(b)</sup> (day<sup>-1</sup>) =

$$\frac{[(IR_1 \times EF \times ED_1 / BW_1) + (IR_2 \times EF \times ED_2 / BW_2)]}{AT}$$

Symbol <sup>(c)</sup>	Units	Child Chronic	Child Lifetime	Adult Chronic	Adult Lifetime
IR <sub>1</sub>	kg/event	0.227	0.227	0.227	0.227
IR <sub>2</sub>	kg/event	NA <sup>(d)</sup>	NA <sup>(d)</sup>	0.227	0.227
EF	events/year	10	10	10	10
ED <sub>1</sub>	yr	6	6	6	6
ED <sub>2</sub>	yr	NA	NA	24	24
BW <sub>1</sub>	kg	15	15	15	15
BW <sub>2</sub>	kg	NA	NA	70	70
AT	yr (days)	6 (2,190)	70 (25,550)	30 (10,950)	70 (25,550)
HIF	day <sup>-1</sup>	4.15e-04	3.55e-05	1.54e-04	6.60e-05

(a) Equation for the child consumer.

(b) Equation for the adult consumer.

(c) Symbols: IR = Ingestion Rate; EF = Exposure Frequency; ED = Exposure Duration; BW = Body Weight; AT = Averaging Time (use days here); HIF = Human Intake Factor.

(d) NA = Not Applicable for the child exposure scenario.

**TABLE HIF-2**  
**HIF CALCULATIONS FOR INGESTION OF SUSPENDED SEDIMENT IN SURFACE**  
**WATER - OFFSITE WADER/SWIMMER**

Basic HIF Equation:  $(\text{day}^{-1}) = \frac{\text{IR} \times \text{ET} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$

Symbol <sup>(a)</sup>	Units	Juvenile Chronic	Juvenile Lifetime
IR	kg/hour	2.5e-5	2.5e-5
ET	hours/event	2	2
EF	events/year	6	6
ED	year	12	12
BW	kg	43	43
AT	year (days)	12 (4,380)	70 (25,550)
HIF	(day)-1	1.91e-08	3.28e-09

(a) Symbols: IR = Ingestion Rate; ET = Exposure Time; EF = Exposure Frequency; ED = Exposure Duration; BW = Body Weight; AT = Averaging Time (use days here); HIF = Human Intake Factor.

(b) The IR value is a reasonable guess.

**TABLE HIF-3**  
**HIF CALCULATIONS FOR DERMAL EXPOSURE TO SEDIMENT**  
**OFFSITE SWIMMER/WADER**

$$\text{Basic HIF (day}^{-1}\text{)} = \frac{\text{SA} \times \text{CF} \times \text{AF} \times \text{EF} \times \text{ED} \times \text{ABS}}{\text{BW} \times \text{AT}}$$

Symbol <sup>1</sup>	Units —	Chronic	Lifetime
SA <sup>(b)</sup>	cm <sup>2</sup> /event	4,900	4,900
CF	kg/mg	10 <sup>-6</sup>	10 <sup>-6</sup>
AF	mg/cm <sup>2</sup>	1.0	1.0
EF	events/year	6	6
ED	year	12	12
BW	kg	43	43
AT	yr (days)	12 (4,380)	70 (25,550)
HIF <sup>c</sup>	day <sup>-1</sup>	1.87e-06 ABS	3.21e-07 ABS

(a) Symbols: SA = Surface Area; CF = Conversion Factor (to translate mg to kg); AF = Adherence Factor; EF = Exposure Frequency; ED = Exposure Duration; BW = Body Weight; AT = Averaging Time (use days here); HIF = Human Intake Factor; ABS = chemical-specific absorption term.

(b) SA = Percentage of a 12-year-old child's total body surface area in legs and feet x total body surface area (see USEPA, 1989. U.S. Environmental Protection Agency. Exposure Factors Handbook. Washington, D.C.: Office of Health and Environmental Assessment. EPA/600/8-89/043.)

(c) The HIF expression includes the chemical-specific absorption (ABS) term.

## SCENARIO 1

### INTERPRETATION OF ANALYTICAL RESULTS ON FISH IN THE 1992 OIL SPILL AREA OF THE ANACOSTIA RIVER

References: a. Versar, Inc. 1993. *An Assessment of Potential Residual Effects of the January 1992 Oil Spill in the Anacostia River.*

b. USEPA. 1995. *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Volume 1. Fish Sampling and Analysis, Second Edition, EPA 823-R-95-007, United States Environmental Protection Agency, Office of Water, Washington, DC.*

The following 95% Upper Confidence Limit (UCL) values and maximum values, their potencies relative to benzo[a]pyrene (BAP), and their BAP equivalent concentrations are derived from the data obtained by Versar (Reference a):

Analyte	95% UCL Conc. in Fish (mg/kg)	Relative Potency	BAP Equivs. (mg/kg)
Benzo[a]anthracene	0.0014652	0.1	0.00014652
Chrysene	0.0413	0.0001	0.00000413
Benzo[b]fluoranthene	0.0002646	0.1	0.00002646
Benzo[k]fluoranthene	0.000212	0.01	0.00000212
Benzo[a]pyrene (BAP)	0.0001869	1.0	0.00018693
Indeno[1,2,3-cd]pyrene	0.00009	0.1	0.00000900
Dibenzo[a,h]anthracene	0.0002059	1.0	0.00020591
<b>Total Benzo[a]pyrene</b>			<b>0.000581</b>

Total spill area and downstream PAHs (95% UCL, mg/kg) = 0.346

The sum of 95% Upper Confidence Limits for the BAP equivalents for the seven carcinogenic PAHs found by Versar in the spill area (See figure on Page D-396) and downstream fish tissues (see Group 12 analytical results Pages D-369 to D-395) is 0.000581 mg/kg. (Note that corresponding sum for upstream fish tissues, 0.000940 mg/kg, is actually higher than the spill area/downstream value; however, this 95% UCL value may have been affected by the number of samples.)

Human intake factors (see Table HIF-1 on Page D-144 for derivations):

Highest carcinogenic HIF =  $6.60e-05 \text{ d}^{-1}$  (adult).

Highest noncarcinogenic HIF =  $4.15e-04 \text{ d}^{-1}$  (child).

BAP Slope Factor =  $7.3 \text{ (mg/[kg}\cdot\text{d})}^{-1}$  (USEPA Region III).

PAH RfD (that of pyrene) =  $0.03 \text{ mg/[kg}\cdot\text{d]}$ .

Cancer risk =  $(0.000581 \text{ mg/kg}) (6.6e-05 \text{ d}^{-1}) \{7.3 \text{ (mg/[kg}\cdot\text{d})}^{-1}\}$   
=  $2.8e-07$

Hazard quotient =  $(0.346 \text{ mg/kg}) (4.15e-04 \text{ d}^{-1})/0.03 \text{ mg/[kg}\cdot\text{d]}$   
=  $4.8e-03$

## SCENARIO 2

### EVALUATION OF ANALYTICAL RESULTS ON SEDIMENT IN THE AREA OF THE ANACOSTIA RIVER NEAR THE WASHINGTON GAS EAST STATION SITE WITH REGARD TO CONSUMPTION OF SUSPENDED SEDIMENT PARTICLES

Reference: a. Smith, R.L., 1996. EPA Region III Risk-Based Concentration Table, United States Environmental Protection Agency, Philadelphia, PA.

Sediment samples taken from the Anacostia River at and below the WG East Station site (See figure on Page D-397) were analyzed, and the 95% upper confidence level for each analyte was calculated (see Group 7 data on pages D-270 to D-297):

Human (juvenile) intake factors (HIFs) for ingestion of suspended sediment (see Table HIF-2 on Page D-145) were as follows:

Ingestion carcinogenic HIF =  $3.28e-09 \text{ d}^{-1}$   
 Ingestion noncarcinogenic HIF =  $1.91e-08 \text{ d}^{-1}$

Ninety-five percent upper confidence levels of the means (or highest levels) for the indicator analytes were multiplied by  $CPS_0$  values (see Reference a) and by the HIF value appropriate for carcinogens ( $3.28e-09 \text{ d}^{-1}$ ) to obtain the cancer risk by ingestion for each compound:

Analyte	95% UCL Conc. in Sed. (mg/kg)	$CPS_0$ (kg · d/mg)	Cancer Risk
Benz[a]anthracene	16.000	0.73	$3.83e-08$
Chrysene	16.000	0.0073	$3.83e-10$
Benzo[b]fluoranthene	9.200	0.73	$2.20e-08$
Benzo[k]fluoranthene	9.500	0.073	$2.27e-09$
Benzo[a]pyrene	27.000	7.3	$6.46e-07$
Indeno[1,2,3-cd]pyrene	6.300	0.73	$1.51e-08$
Dibenz[a,h]anthracene	6.900	7.3	$1.65e-07$
Bis(2-ethylhexyl) phthalate	7.200	0.014	$3.31e-10$
Arsenic	11.85	1.5	$5.83e-08$
Beryllium	1.59	4.3	$2.24e-08$
<b>Total Cancer Risk =</b>			<b><math>9.7e-07</math></b>

Ninety-five percent upper confidence levels of the means (or highest levels) for all polynuclear aromatic hydrocarbons (PAHs), carcinogenic or not, were summed to get a total 95% UCL for the PAHs, i.e., 232.14 mg/kg. It is assumed here that all these PAHs have the reference dose (RfD) of pyrene, namely 0.03 mg/(kg-day). To obtain hazard quotients, one multiplies concentration in the sediment by the non-carcinogenic HIF ( $1.91 \times 10^{-8} \text{ d}^{-1}$ ) and divides by the appropriate RfD.

Analyte	95% UCL Conc. in Sed. (mg/kg)	RfD <sub>o</sub> (mg/kg/d)	Hazard Quotient
Total PAHs	252.44	0.03	1.61e-04
Bis(2-ethylhexyl) phthalate	7.200	0.02	6.88e-06
Aluminum	22,900	1.00	4.37e-04
Arsenic	11.85	0.0003	7.54e-04
Beryllium	1.59	0.005	6.07e-06
Chromium	63.73	0.005	2.43e-04
Copper	324.0	0.04	1.55e-04
Iron	39,400	0.3	2.51e-03
Manganese	678.00	0.023	5.63e-04
Vanadium	65.21	0.007	1.78e-04
Sum of hazard quotients = hazard index =			5.0e-03

## SCENARIO 3

### EVALUATION OF ANALYTICAL RESULTS ON SEDIMENT IN THE AREA OF THE ANACOSTIA RIVER NEAR THE WASHINGTON GAS EAST STATION SITE WITH REGARD TO DERMAL CONTACT

Reference: a. Smith, R.L., 1996, EPA Region III Risk-Based Concentration Table, United States Environmental Protection Agency, Philadelphia, PA.

Sediment samples taken from the Anacostia River at and below the WG East Station site (see figure Page D-398) were analyzed, and the 95% upper confidence level for each organic analyte was calculated (see Group 7 data Pages D-270 to D-297).

Human (juvenile) intake factors (HIFs) for dermal exposure to sediment (see Table HIF-3 on Page D-146) were as follows:

Dermal carcinogen HIF =  $3.21e-07 \text{ d}^{-1}$  ABS  
 Dermal noncarcinogen HIF =  $1.87e-06 \text{ d}^{-1}$  ABS

The dermal absorption factors (ABS) for the indicator analytes are: 0.1 for organics, 0.032 for arsenic, and 0.01 for all other inorganics.

Ninety-five percent upper confidence levels of the means for the indicator analytes were multiplied by  $CPS_o$  values (see Reference a), by the HIF value appropriate for carcinogens ( $3.21e-07 \text{ d}^{-1}$ ) and by the appropriate ABS value to obtain the cancer risk by dermal contact for each analyte:

Analyte	95% UCL Conc. in Sed. (mg/kg)	ABS Factor	$CPS_o$ (kg · d/mg)	Cancer Risk
Benz[a]anthracene	16.000	0.1	0.73	3.75e-07
Chrysene	16.000	0.1	0.0073	3.75e-09
Benzo[b]fluoranthene	9.200	0.1	0.73	2.16e-07
Benzo[k]fluoranthene	9.500	0.1	0.073	2.23e-08
Benzo[a]pyrene	27.000	0.1	7.3	6.33e-06
Indeno[1,2,3-cd]pyrene	6.300	0.1	0.73	1.48e-07
Dibenz[a,h]anthracene	6.900	0.1	7.3	1.62e-06
Bis(2-ethylhexyl) phthalate	7.200	0.1	0.014	3.24e-09
Arsenic	11.85	0.032	1.5	1.83e-07
Beryllium	1.59	0.01	4.3	2.19e-08
Total Cancer Risk =				8.9e-06

Ninety-five percent upper confidence levels of the means for all polynuclear aromatic hydrocarbons (PAHs), carcinogenic or not, were summed to get a total 95% UCL for the PAHs, i.e., 232.14 mg/kg. It is assumed here that all these PAHs have the reference dose (RfD) of pyrene, namely 0.03 mg/(kg·day). To obtain hazard quotients, one multiplies concentration in the sediment by the non-carcinogenic HIF ( $1.87 \times 10^{-6} \text{ d}^{-1}$ ) and the corresponding ABS value and then divides by the appropriate RfD.

Analyte	95% UCL Conc. in Sed. (mg/kg)	ABS Factor	RfD <sub>o</sub> (mg/kg/d)	Hazard Quotient
Total PAHs	252.44	0.1	0.03	1.57e-03
Bis(2-ethylhexyl) phthalate	7.200	0.1	0.02	6.73e-05
Aluminum	22,900	0.01	1.00	4.28e-04
Arsenic	11.85	0.01	0.0003	7.39e-04
Beryllium	1.59	0.01	0.005	5.95e-06
Chromium	63.73	0.01	0.005	2.38e-04
Copper	324.0	0.01	0.04	1.51e-04
Iron	39,400	0.01	0.3	2.46e-03
Manganese	678.00	0.032	0.023	1.76e-03
Vanadium	65.21	0.01	0.007	1.74e-04
<b>Sum of hazard quotients = hazard index =</b>				<b>7.6e-03</b>