DRAFT

REMEDIAL INVESTIGATION WORK PLAN

Anacostia River Sediment Project, Washington, DC

Prepared for

DISTRICT DEPARTMENT OF THE ENVIRONMENT

green forward

District Department of the Environment Government of the District of Columbia

January 29, 2014

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Document Approval Page

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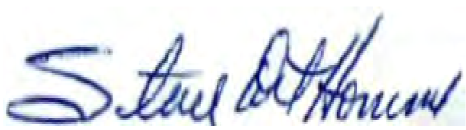

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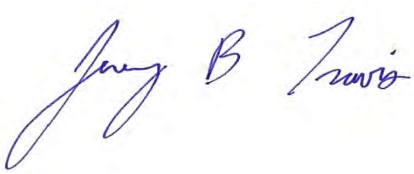

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CONTENTS

FIGURES

TABLES

Abbreviations and Acronyms

AECOM	AECOM Technology Corporation
ALM	Adult Lead Model
ANS	Academy of Natural Sciences
ARD	Assessment and Restoration Division
AST	Aboveground Storage Tank
ASTM	American Society for Testing and Materials
AT	Averaging Time
ATSDR	Agency for Toxic Substances and Disease Registry
AVS	Acid Volatile Sulfides
AWTA	Anacostia Watershed Toxics Alliance
BAF	Bioaccumulation Factors
BERA	Baseline Ecological Risk Assessment
BI	Benthic Invertebrate
B-IBI	Benthic Index of Biotic Integrity
BOD	Biological Oxygen Demand
BSAF	Biota-Sediment Accumulation Factor
BTAG	Biological Technical Assistance Group
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
BW	Adult Body Weight (kg)
C	Chemical Concentration within the Exposure Medium (Risk Assessment)
CalEPA	California Environmental Protection Agency
CC	Chain of Custody
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIP	Community Involvement Plan
CLP	Contract Laboratory Program
COC	Constituents of Concern
COPEC	Chemical of Potential Ecological Concern
CPAH	Carcinogenic Polycyclic Aromatic Hydrocarbon
CQCSM	Comprehensive Quantitative Congener Specific Method
CR	Contact Rate
CSM	Conceptual Site Model
CSS	Combined Sewer System
CSX	CSX Transportation
CTE	Central Tendency Exposure
DC	District of Columbia
DC Water	District of Columbia Water and Sewer Authority
DCL	District of Columbia's Lanham Tree Nursery

DDD	Dichloro-diphenyl-dichloroethane
DDE	Dichloro-diphenyl-dichloroethylene
DDOE	District Department of the Environment
DDT	Dichloro-diphenyl-trichloroethane
DMR	Discharge Monitoring Report
DNAPL	Dense Nonaqueous Phase Liquid
DO	Dissolved Oxygen
DOI	District of Columbia Department of Insurance, Securities, and Banking
DQO	Data Quality Objectives
DRO	Diesel Range Organics
DW	Dry Weight (mg/kg)
ED	Exposure Duration
EF	Exposure Frequency
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ESA	Environmental Site Assessment
ESV	Ecological Screening Values
ET	Exposure Time (hr/day)
FCM	Food Chain Model
FFA	Federal Facilities Agreement
FS	Feasibility Study
FSP	Field Sampling Plan
FWS	United States Fish and Wildlife Service
GC-MS	Gas Chromatography- Mass Spectrometry
GIS	Geographic Information System
GPS	Global Positioning System
GSA	General Services Administration
GS-ECD	Electron Capture Detector
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Tables
HEM	Hydrodynamic Ecosystem Model
HF-NO3	Hydrofluoric - Nitric Acid
HHRA	Human Health Risk Assessment
HI	Hazard Index
HPAH	High Molecular Weight Polynuclear Aromatic Hydrocarbon
HQ	Hazard Quotient
HSPF	Hydrological Simulation Program – Fortran
I	Intake (Risk Assessment)

ICP OES	Inductively Coupled Plasma Optical Emission Spectroscopy
IEUBK	Integrated Exposure Uptake Biokinetic Model
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
KL	Kingman Lake
KPN	Kenilworth Park Landfill North
KPS	Kenilworth Park Landfill South
LNAPL	Light Nonaqueous Phase Liquid
LOAEL	Lowest Observed Adverse Effect Level
LPAH	Low Molecular Weight Polynuclear Aromatic Hydrocarbon
LTCP	Long-Term Control Plan
MCL	Maximum Contaminant Level
MDNR	Maryland Department of Natural Resources
MGP	Manufactured Gas Plant
MRL	Minimal Risk Level
MS4	Municipal Separate Storm Sewer System
NEA	National
NIRIS	Naval Installation Restoration Information Solution (Navy Database)
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRDA	Natural Resources Damage Assessment
NYD	New York District
OERR	Office of Emergency and Remedial Response
ORD	Office of Research and Development
ORP	Oxidation and Reduction Potential
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PA/SI	Preliminary Assessment/Site Investigation
PAH	Polycyclic Aromatic Hydrocarbon
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PBDE	Polybrominated Diphenyl Ethers
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated Dibenzo-p-dioxins
PCDF	Polychlorinated Dibenzofurans
PDMS	Polydimethylsiloxane
PEC	Probable Effect Concentration

PID	Photoionization Detector
PP	Priority Pollutant
PPRTV	Provisional Peer-Reviewed Toxicity Values
PRG	Preliminary Remedial Goals
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance
RAS	Routine Analytical Services
RD/RA	Remedial Design/Remedial Action
REC	Recognized Environmental Condition
RfC	Reference Concentration
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RSL	Regional Screening Level
SEFC	Southeast Federal Center
SEM	Sequentially Extracted Medals
SF	Slope Factor
SIM	Selective Ion Monitoring
SLERA	Screening Level Ecological Risk Assessment
SOW	Scope of Work
SPAWAR	Space and Naval Warfare Systems Center, San Diego
SQuiRTs	NOAA Screening Quick Reference Tables
SUF	Site Use Factor (Unitless)
SVOC	Semivolatile Organic Compounds
2,3,7,8-TCDD	2,3,7,8-Tetrachlorodibenzo-p-Dioxin
TAL	Target Analyte List
TAM	Tidal Anacostia Model
TCL	Target Compound List
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TRV	Toxicity Reference Values
TSS	Total Suspended Solids
UCL	Upper Confidence Limit
URS	URS Corporation
USACE	United States Army Core of Engineers

USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	Underground Storage Tank
VDEQ	Virginia Department of Environmental Quality
VOC	Volatile Organic Compounds
WASP	Water Quality Analysis Simulation Program
WASP5 EUTRO	Water Quality Analysis Simulation Program Eutrophication Model
WC	Washington Channel
WGL	Washington Gas Light Company
WNY	Washington Navy Yard
WP	Work Plan
XRF	X-Ray Fluorescence

1.0 INTRODUCTION

The District Department of the Environment (DDOE) is conducting a Remedial Investigation (RI) of the contaminated sediments within the tidal portion of the Anacostia River in Washington, D.C. The study area for the investigation is shown in **Figure 1.1**. On behalf of DDOE, Tetra Tech, Inc. (Tetra Tech) prepared this work plan (WP) consistent with the Anacostia River Sediments Project Scope of Work (DDOE SOW) posted to http://ddoe.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/Anacostia%20River%20RIFS%20SOW%2004082013.pdf on April 10, 2013. This WP serves as the primary planning document governing characterization of river surface water, biota, and sediments (including the potential effects of groundwater seepage) for the purpose of completing the RI. Other planning documents associated with this WP will be prepared under separate cover and will include a field sampling plan (FSP), quality assurance project plan (QAPP), community involvement plan (CIP), project management plan (PMP), and health and safety plan (HASP). As requested by DDOE, the WP also addresses the environmental media characterization requirements associated with preparing a Natural Resources Damage Assessment (NRDA) for the river.

1.1 Objective

Consistent with the RI and NRDA processes, the objectives of this WP include the following:

- Determine the nature and extent of contaminated environmental media (surface water, sediment, groundwater seepage, and biota) in a manner consistent with the National Oil and Hazardous Substances Contingency Plan (NCP) 40 C.F.R. Part 300 and all applicable guidance and assess the associated risk to human health and the environment.
- Conduct the sampling required to support an NRDA and reduce overall costs for NRDA and RI field characterization by coordinating the NRDA and RI characterization sampling efforts.
- Collect site data to characterize general site conditions to support the completion of the feasibility study (FS).

1.2 Regulatory Background

As required by the DDOE SOW, this WP was prepared consistent with the RI process established in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the implementing regulations in the NCP, and Section 401(a)(2) of the District of Columbia Brownfield Revitalization Act of 2000. The United States Environmental Protection Agency (EPA) guidance document, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988) served as the primary resource for this effort.

A NRDA process is used to determine whether natural resources have been injured and to calculate damages needed to restore or compensate the public for the injured resources. As defined in the CERCLA statute, NRDA is separate from the RI process in that it focuses on injury and restoration of public resources. However, careful planning prior to sampling can integrate data collection so that much of the data collected during an RI can be used to support the NRDA process.

1.3 Natural Resources Damage Assessment Strategy

Tetra Tech will integrate data collection for the NRDA with sampling and analysis for the RI, especially the ecological and human health risk assessments. Concurrent planning and sampling for the RI and NRDA saves time and money by eliminating multiple mobilizations and duplicate sampling. For example, fish and invertebrate tissue concentrations, sediment toxicity, and benthic community structure data are used in both risk assessment and NRDA. Although Tetra Tech will optimize data collection for the NRDA during the RI field activity, the formal NRDA will be conducted at a later date pursuant to a separate work plan. Additional discussion regarding NRDA process and schedule are provided in **Section 9.0**.

1.4 Scope

The current focus of the RI and NRDA is the tidal Anacostia River from its confluence with the Potomac River to its upper tidal limit at the confluence of Northeast Branch and Northwest Branch (**Figure 1.1**). As a result of urban development, the shoreline and channel have been significantly altered from predevelopment conditions. For the purposes of this WP, the scope includes the tidal river from bank to bank and excludes adjacent wetlands and floodplain surface soil. In addition, the surface soils on Kingman and Heritage Islands, mid-channel manmade islands located approximately 3.5 miles from the mouth, are considered to be similar to the floodplain soil and are, therefore, also excluded from this WP. The final boundaries of the study area will be based on the findings of the RI, and will be documented by DDOE in a record of decision (ROD) when the final remedy is selected. It should be noted that, based on the results of the tidal river investigation, additional future investigations, not covered by this work plan, may be performed in the river wetlands and floodplain.

Environmental investigation and cleanup work is underway or contemplated at multiple environmental sites bordering the tidal Anacostia River (**Figure 1.1**). These sites include Pepco Benning Road, CSX Transportation (CSX) Benning Yard, Poplar Point, Kenilworth Park Landfill, Washington Gas Light (WGL) Company, Southeast Federal Center, and Washington Navy Yard (WNY). At each site, it is anticipated that the entity conducting the cleanup will also address sediment contamination in the adjacent impacted segment of the river channel. The sampling approach for this WP incorporates the work already completed or planned at known environmental sites. To avoid duplication of effort, sampling locations defined in this WP were biased away from portions of the river that are associated with the adjacent environmental sites (see **Figure 1.1**).

1.5 Community Relations

DDOE is committed to public participation at every phase of the Anacostia River cleanup through an open process that encourages affected communities and interested organizations to provide input on the critical issues related to the site cleanup. DDOE has prepared a CIP (Tetra Tech 2013a) for the Anacostia contaminated sediments project. As noted above, the CIP is a companion document to this WP. The CIP describes the process the District and Tetra Tech will use to engage in dialogue and collaborate with communities and other key stakeholders. Overall, the goals for the community involvement program are as follows:

- Provide the public with accurate, timely, and understandable information and/or access to the information needed to understand the project as it moves forward;
- Provide the public with the opportunity to give informed and meaningful input;
- Ensure adequate time and opportunity for the public to provide input to be considered;
- Respect and give full consideration to the community input; and
- Assist the public in understanding the project decision-making process during the project design and cleanup and the community's role in that process.

1.6 Work Plan Organization

In addition to this introduction, the WP includes ten sections. Tables and figures cited in each section are provided at the end of the section. A brief description of each is provided below.

Section 1.0 – Introduction. This section discusses the study objectives, regulatory context, project scope, and community involvement strategy for the Anacostia River Sediments RI.

Section 2.0 - Site Background and Physical Setting. This section provides information regarding site location, history, geology, hydrogeology, and sediment transport regimes. In addition, **Section 2.0** summarizes the key previous investigations and assesses data usability.

Section 3.0 - Preliminary Conceptual Model. The preliminary conceptual site model (CSM) discussion in this section includes an assessment of the constituents of concern (COCs) in the investigation and describes contaminant sources, migration pathways, and potential human health and ecological receptors.

Section 4.0 – Work Plan Rationale. This section presents the data quality objectives (DQO) for the sediment investigation. In addition, the results of evaluations of the existing sediment (shallow and deep), surface water, fish tissue, and benthic invertebrate tissue data are presented along with the results of a review of contaminant sources to the tidal Anacostia River. This section identifies the key remaining data gaps that will be addressed during the field phase of the RI.

Section 5.0 - Remedial Investigation. This section discusses the proposed sampling for the field investigation to fill identified data gaps for the RI and NRDA. Maps showing the proposed sampling locations are provided and discussed.

Section 6.0 – Data Evaluation and Reporting. Section 6 discusses the approach for managing, validating, evaluating, and reporting the data collected.

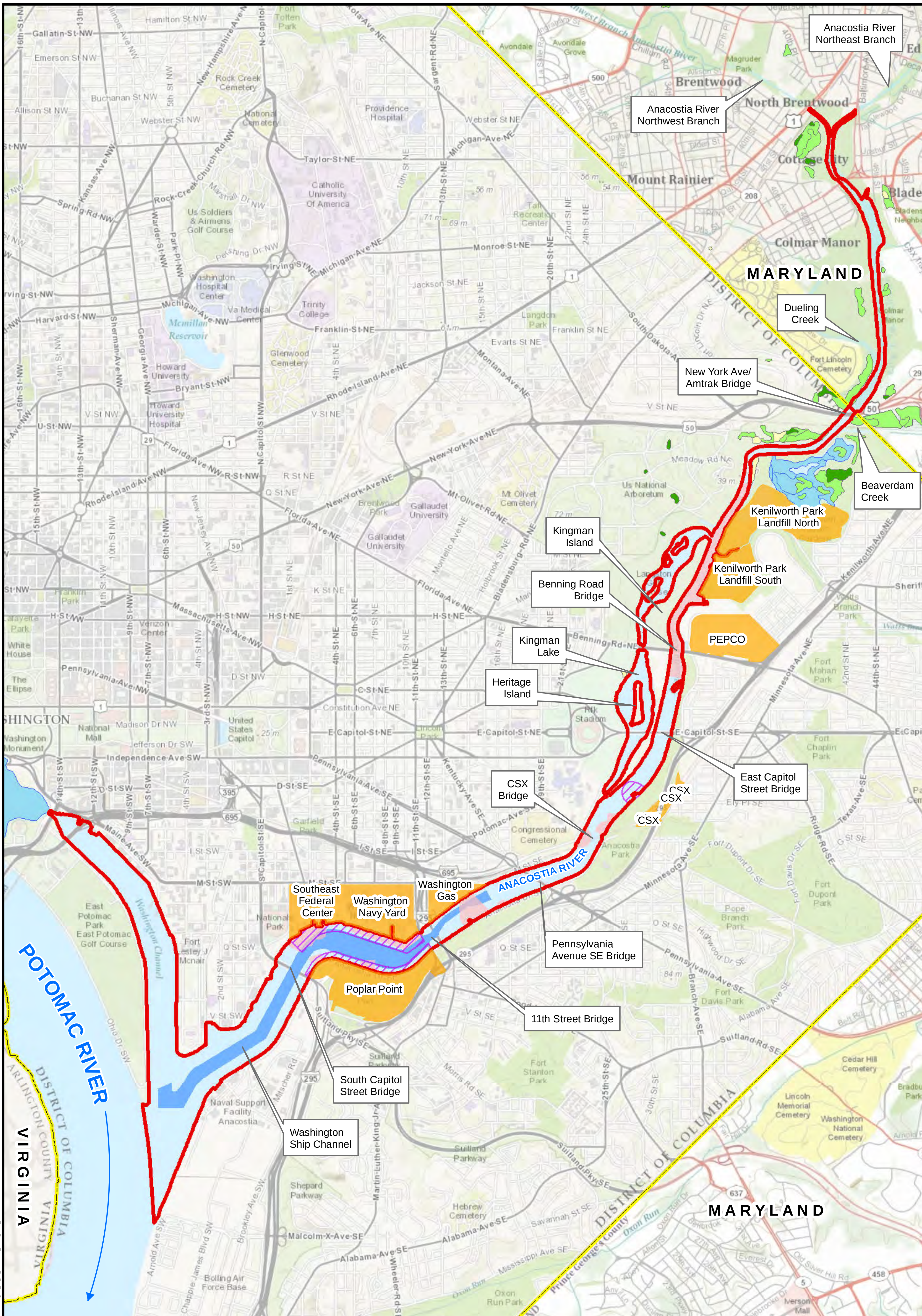
Section 7.0 – Ecological Risk Assessment. The process used to perform screening level and baseline ecological risk assessments (ERA) is discussed.

Section 8.0 – Human Health Risk Assessment. The process used to perform a human health risk assessment (HHRA) is discussed.

Section 9.0 – **Natural Resources Damage Assessment Process.** A description of the tasks that comprise the NRDA process is provided in this section.

Section 10.0 – Schedule. Section 10 presents the schedule for the investigation and major deliverables associated with the RI.

Section 11.0 – References. A listing of the documents cited.



Legend

- SEDIMENT STUDY AREA
- CLEANUP SITE BOUNDARY
- NEW AOC
- AWTA AOC
- WASHINGTON DC BOUNDARY

WETLAND TYPE

- FRESHWATER EMERGENT
- FRESHWATER FORESTED/SHRUB
- FRESHWATER POND
- LAKE

SOURCE: MODIFIED FROM CH2MHILL, 2011, DCGIS, 2012, AND USFWS, 2012.

DRAFT

N S E W

0 1,500 3,000 Feet

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 1.1
SITE LOCATION MAP

TETRA TECH

Date Saved: 10/17/2013 1:19:13 PM User: joel.peters Path: S:\CADD\S\2592\new\WorkPlan\Figure_01_01_Anacostia_11x17_SITE_LOCATION.mxd

2.0 SITE BACKGROUND AND PHYSICAL SETTING

This section provides background information and discusses the physical setting of the tidal Anacostia River study area. Following a general description of the site and location in **Section 2.1**, **Sections 2.2 through 2.5** discuss site history, geologic setting, hydrogeology and hydrology, and sediment transport regimes. **Section 2.6** summarizes the key previous and ongoing investigations in the study area. The usability of the data generated in the previous site investigations is assessed in **Section 2.7**.

2.1 Site Location and Description

The Anacostia River drains an area of approximately 176 square miles (456 square kilometers) in Montgomery and Prince George's Counties in Maryland and Washington, DC. The study area for this investigation (**Figure 1.1**) includes the approximately nine mile tidal portion of the river which begins at the confluence of Northwest Branch and Northeast Branch near Bladensburg Marina in Prince George's County and extends downstream to the confluence of the Anacostia and Potomac rivers. The study area also includes the Washington Channel, an approximately 1.5 mile long channel extending northward from the mouth of the Anacostia at its confluence with the Potomac River. Haines Point separates the Washington Channel from the Potomac River. The upstream terminus of the Washington Channel is at the Tidal Basin, adjacent to the National Mall.

2.2 Site History

Elevated sedimentation rates have characterized the tidal Anacostia since colonial times. Beginning in the early 1600s, the dense hardwood forests originally present in the watershed were cleared for tobacco farming, leading to increasing erosion in the upland watershed and sedimentation in the estuary. In 1742 a port was established in Bladensburg to support the tobacco industry. By 1830, however, the port had become unusable because of channel siltation (USACE 1993). Several dredging events were completed by the late 1800s. Dredge spoils from the Anacostia River have historically been used to reclaim low lying areas including an area of mud flats in what is now a portion of the National Mall (USACE 1993). Urbanization in the District and in neighboring Prince George's and Montgomery Counties accelerated in the 1940s and is ongoing. As discussed in more detail in **Section 2.5**, elevated sedimentation rates persist through the present time (USACE 1993).

In addition to the early dredging activity associated with the port of Bladensburg, other historic dredging activity has occurred including periodic dredging of the Washington Ship Channel in the lower Anacostia River and routine dredging events in the middle and upper reaches of the river. Information regarding the dredging history of the Washington Channel could not be located for inclusion in this discussion.

The following summary regarding Washington Ship Channel and Washington Navy Yard dredging is taken from the Washington Navy Yard RI report (CH2M Hill 2011). The Washington Ship Channel was constructed to provide larger vessel access upstream to a point between the 11th Street and the Pennsylvania Avenue bridges, just upstream of the Washington Navy Yard. The channel width ranges from 800 to 400 feet and the depth ranges from 16 to 22 feet. The earliest dredging of the Washington Ship Channel occurred in the late 1800s. The most recent dredging of the channel occurred in 1985 and up to six feet of sedimentation has occurred in some portions of the dredged channel since that time. The area adjacent to the Washington Navy Yard piers was dredged in approximately 1965 to a depth of 24 to 26 feet below water surface.

Other historic dredging activity has occurred in the middle and upper reaches of the river. The Kingman and Heritage Islands Park website www.kingmanisland.org/?page_id=144 discusses the historical dredging performed to create Kingman Lake and Kingman and Heritage Islands. In the early 1900s, concerns regarding mosquito-borne disease prompted a dredging effort to reclaim tidal flats that had formed upstream from the CSX railroad bridge. The resulting dredging, completed in approximately 1916, resulted in the formation Kingman and Heritage Islands. More recently, USACE performed dredging in 2000 to support wetlands creation in Kingman Lake.

Also in the Kingman Lake vicinity, other river dredging activity performed since the 1940s has resulted in the reclamation of riverside wetlands near the Kenilworth Aquatic Center and the National Arboretum (National Park Service 2010). Various dredging events to maintain the aquatic center ponds were conducted between 1952 and 2002 (National Park Service 2010). Further up river, dredging is performed once every two years to maintain access to the Bladensburg Marina (Anacostia Watershed Toxic Alliance [AWTA] 2002). The spoils from the dredged sediment in Bladensburg have been used to restore tidal emergent wetlands in Kenilworth Marsh.

The USACE estimates that approximately 2,500 acres of tidal emergent wetlands have been destroyed in the Anacostia River between Bladensburg and the confluence with the Potomac River. Less than 100 acres of tidal emergent wetlands currently exist, including the restored Kenilworth Marsh (approximately 32 acres). Moreover, the total area of remaining tidal wetlands is approximately 180 acres (non-open water), constituting an overall loss of more than 90 percent of the originally occurring tidal wetlands from the watershed.

Section 303(d) of the federal Clean Water Act requires states to identify waters that fail to comply with water quality standards. A total maximum daily load (TMDL) is required for each exceeding substance. For the tidal Anacostia River, TMDLs have been established for polychlorinated biphenyls (PCBs), biochemical oxygen demand (BOD), bacteria, organics, metals, sediment, oil and grease, and trash. (www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/Programs/WaterPrograms/TMDL/approvedfinaltmdl/tmdl_final_anacostia_nutrients.aspx).

2.3 Geologic Setting

The Washington, DC area straddles the Fall Line, a northeast-trending physiographic boundary separating the Piedmont province to the west from the Coastal Plain province to the east. The Piedmont is underlain by deeply weathered metamorphic and igneous rocks dipping to the southeast at about 125 feet per mile (Johnston 1964). In the study area, these units are overlain by an eastward thickening wedge of unconsolidated Coastal Plain deposits (Johnston 1964). The study area encompassing the tidal Anacostia River and Washington Channel is entirely underlain by Coastal Plain deposits.

Table 2.1 shows the geologic column for the study area. The Coastal Plain formations range in age from Cretaceous to Recent (Cooke 1952). From youngest to oldest, these units consist of fill material, Quaternary sediments, and Cretaceous age formations belonging to the Potomac Group. The Potomac Group is underlain by Paleozoic age metamorphic and igneous rocks collectively known as basement rock. In the study area, basement rock is encountered at a depth of approximately 400 feet below ground surface (Johnston 1964). The Quaternary deposits include natural river channel and over bank deposits consisting of sand, silt, and clay which generally coarsen toward the upstream limit of the tidal channel and where outfalls and tributaries enter the main stem. In addition to these deposits, dredge spoils and random fill have been used to extend upland areas into the river and adjacent wetlands. Random fill typically consists of building rubble, heterogeneous soils, and other miscellaneous materials.

Underlying the fill and recent deposits are the formations that collectively comprise the clay and silt facies of the Potomac Group. This facies includes the Arundel Clay and the Patapsco Formation which are undifferentiated in the District (D.C. Water Resources Research Center [DCWRRC] 1993). The clay and silt facies is underlain by the sand and gravel facies of the Potomac Group. The thickness of the both Potomac Group facies in tidal Anacostia River vicinity is approximately 350 feet (Koterba, Dieter, and Miller 2010). The clay and silt facies is described as silty clay with interbedded irregular sand and gravel lenses (DCWRRC 1993). Where the Potomac Group attains greater thickness to the east and northeast of the District, this facies is differentiated into an upper, coarser grained unit (Patapsco Formation) and an underlying finer grained unit (Arundel Clay). The sand and gravel facies consists of gravel, sand, and arkosic sediments with occasional sandy clay lenses. This unit correlates with the Potomac Group Patuxent Formation (DCWRRC 1993).

2.4 Hydrogeology and Hydrology

This section provides a brief summary of the hydrogeology of the study area and the hydrology of the tidal Anacostia River.

Hydrogeology. The hydrostratigraphic units in the study area include, with increasing depth, perched groundwater units, the water table aquifer, the Potomac Group confining unit, and the Patuxent aquifer (**Table 2.1**). In the study area, perched groundwater may occur as isolated shallow saturated zones occurring within a depth of six feet below ground surface (DCWRRC 1993). The water table aquifer occurs in the saturated portions of the various permeable units present adjacent to and, in some cases, extending beneath the river channel. Depending on location, the geologic units that comprise the water table aquifer include the random fill units, Quaternary deposits, and Patapsco Formation sediments. The Potomac confining unit, corresponding to the Potomac Group clay and silt facies, is a confining unit separating the water table aquifer and the deeper Patuxent aquifer. As reported by Ecology and Environment, Inc. (2008), the Patuxent aquifer is confined in the study area vicinity. At a National Arboretum aquifer test well located approximately 0.5 miles northeast of the site, the static water level was 12 feet higher than the ambient water table elevation at the Kenilworth Park South Landfill site, an environmental site located nearby and adjacent to the river (Ecology and Environment 2008).

A review of the site characterization results from three cleanup sites located along the tidal Anacostia reveal general characteristics regarding the hydrogeology of the water table aquifer in the immediate vicinity of the Anacostia River. The three sites include the Kenilworth Park South Landfill (Ecology and Environment 2008), CSX Benning Yard (EnviroScience 2013), and the Washington Navy Yard (CH2M Hill 2011). At each site, the lithology of the water table aquifer is quite diverse, ranging laterally and vertically from fill material unique to the each site to alluvium/dredge spoil to coarse grained Quaternary deposits. Interbedded lower conductivity units, primarily consisting of alluvium or alluvium-derived dredge spoil result in the presence of perched or confined groundwater of local extent. At each site, groundwater discharges to the Anacostia River. Tidal influence on water table aquifer groundwater level fluctuations is muted and restricted to wells in close proximity to the river.

Hydrology. Tidal influences in the Anacostia River extend throughout the study area and into the Northeast Branch and Northwest Branch for approximately one mile beyond the upstream limit of the study area. The average variation of the river's water surface over a tidal cycle is three feet (Behm et al. 2003). Tidal level changes occur as a standing wave (AWTA 2002), meaning that tidal changes occur nearly simultaneously throughout the estuary. The entire estuary, however, is freshwater (Behm et al. 2003). The following physical description of the river is excerpted from the document "TAM/WASP Toxics Screening Level Model for the Tidal Portion of the Anacostia River" (Behm et al. 2003):

> *From an analysis by the National Oceanographic and Atmospheric Administration (NOAA) of sounding data taken by the US Army Corps of Engineers prior to a 1999 dredging project combined with additional bathymetry data taken by the Navy in the summer of 2000, the volume of the tidal portion of the river at mean tide is approximately 10,000,000,000 liters (2,642,000,000 gallons), with a surface area of approximately 3,300,000 square meters (m2) (35,521,000 ft2). The width of the river varies from approximately 60 meters (m) (196 ft) in some upstream reaches to approximately 500 m (1,640 ft) near the confluence with the Potomac, and average depths across channel transects vary from approximately 1.2 m (3.9 ft) upstream of Bladensburg to about 5.6 m (18.3 ft) just downstream of the South Capitol Street Bridge. The average daily combined discharge of the Northeast and Northwest Branches into the tidal river is approximately 370,000,000 liter/day. During non-storm conditions, measured flow velocities during the tidal cycle have been in the range of 0 to 0.3 m/sec (0 – 1 ft/sec) (Katz et al. 2000; Schultz and Velinsky 2001)*.

The Northeast Branch and Northwest Branch account for 60 to 70 percent of the total discharge of the Anacostia River with the balance of the flow originating from tidal tributaries, storm sewer outfalls, combined sewer system (CSS) outfalls, overland flow, groundwater seepage, and precipitation. River current velocities and mixing are also discussed by Behm et al. (2003). An investigation by the Space and Naval Warfare Systems Center, San Diego (SPAWAR) (Katz et al. 2001) found that current velocities were primarily directed along the axis of the channel, were relatively homogeneous throughout the water column, and were relatively low. The maximum observed velocity over a tidal cycle (30 cm/sec [1.0 ft/sec]) was measured in the vicinity of the CSX railroad bridge located approximately 3.5 miles upstream from the mouth. The lowest velocity (10 cm/sec [0.33 ft/sec]) was measured downstream from the South Capitol Street Bridge, 1.5 miles from the mouth. Currents were directed primarily along the axis of the channel and homogeneous throughout the water column; cross-channel currents were negligible. AWTA (2002) estimates that the flushing time for the tidal channel averages 23 to 28 days.

2.5 Sediment Transport Regimes

The major physical processes that determine sediment contaminant fate and transport are bed load transport and deposition, sediment burial, and sediment resuspension in the water column. AWTA (2002) provides a general assessment of how these processes interrelate along the tidal Anacostia River and the following discussion summarizes this evaluation. The bulk of sediment transported to the estuary enters where Northeast Branch and Northwest Branch join to form the tidal Anacostia River. Scatena (1986) estimates the sediment contribution from these two tributaries to be 85 percent of the total load delivered to the estuary. Below the Northeast Branch – Northwest Branch confluence, the current is too slow to transport the coarser grain size fractions so these materials deposit in an accretion zone just downstream of the confluence. Finer silt and clay size material, however, remain suspended and continue downstream.

For the approximately 5.5 mile stretch of channel from Bladensburg south to the CSX Railroad Bridge, AWTA characterizes the sediment transport regime as akin to a “conveyor belt” in which fine sediments move downstream in suspension without net deposition or erosion. Localized deltas of coarser grained sediments occur where outfalls and tributary streams discharge to the main channel. Between the CSX Railroad Bridge and the 11^{th} Street Bridge, the sediment transport regime is transitional from general equilibrium transport to total deposition. Here, transport or deposition may dominate depending on local variations in current speed. Below the 11^{th} Street Bridge, the river channel widens and deepens and, as a result of decreased flow velocity, the sediment regime is dominated by total deposition.

Hydrodynamic and sediment contaminant transport modeling suggests that 90 percent of the sediment delivered to the tidal Anacostia River is trapped and deposited. A study of cores taken offshore from the Poplar Point environmental site estimates that the deposition rate in this portion of the river ranges between 3.0 and 7.0 centimeters per year (cm/yr) (Velinsky et al. 2011).

2.6 Previous Environmental Investigations and Ongoing Activities

The Anacostia River has been the subject of numerous previous investigations dating back to the 1980s. This section summarizes the previous specific investigations considered in the development of this WP. In general, each investigation focused on a particular medium, including surface sediment, subsurface sediment, surface water, fish tissue, or benthic invertebrate tissue. Some previous sediment sampling investigations covered the entire study area while others have focused on a limited area such the portion of the channel bordering one of the upland environmental sites noted in **Section 1.4**.

2.6.1 Site-wide Investigations

As a result of general concern regarding the poor quality of the Anacostia Watershed and to coordinate an overall strategy for cleanup, the U.S. Environmental Protection Agency (EPA) Office of Solid Waste and Emergency Response (OSWER) convened in 1999 the Anacostia Watershed Toxic Alliance (AWTA), a public and private consortium of government agencies, institutions, and private stakeholders. As stated on the AWTA website http://mapping.orr.noaa.gov/website/test/anacostia/guide/home/awta.html, AWTA’s mission is “to work together in good faith as partners to evaluate the presence, sources, and impacts of chemical contaminants on the Anacostia River with all stakeholders, both public and private, plus other parties, and to evaluate and take actions to enhance the restoration of the river to its beneficial use to the community and ecosystem as a whole." As a member institution of the AWTA, the National Oceanic and Atmospheric Administration (NOAA) Assessment and Restoration Division (ARD) developed the Anacostia River Watershed Database and Mapping Project (NOAA database).

The NOAA database serves as a publicly accessible, geospatially-referenced data repository for the environmental data generated during key environmental investigations, past and present, conducted in the Anacostia Watershed. The NOAA database was used as the starting point for the development of a project database to support the development of this WP. The database was updated with the sampling results from two recently completed investigations including the work completed at the Washington Navy Yard and CSX Benning Yard and available fish tissue and benthic invertebrate data were also added to the project database.

Table 2.2 lists the previous investigations for which data are available in the project study area for the various environmental media. In addition, **Table 2.2** indicates the 11 previous investigation datasets that are included in the project database. **Figure 2.1** shows the spatial distribution of the surface sediment data for each of the previous investigations considered. Specific reference information for each investigation is shown in the table if this information was attainable. The table also shows the numbers of samples by environmental medium available from each study. The key investigations included in the review are summarized below. Data usability for the data retained for WP development is discussed in **Section 2.7**.

Academy of Natural Sciences (ANS), 2000 (Velinsky and Ashley 2001). Sampling for this investigation was relatively comprehensive for surface sediment. A total of 134 samples were collected providing reasonably good spatial coverage for the entire tidal Anacostia River and the Washington Channel. Samples were analyzed for PCB congeners, pesticides, semivolatile organic compounds (SVOCs) including priority pollutant polycyclic aromatic hydrocarbons (PAHs), and selected metals.

Phelps, H. L., 2001 (and other studies). Asiatic clams were translocated from a presumably clean site in the Potomac River to Bladensburg Marina and the O Street CSS outfall near the Washington Navy Yard. The objective of the study was to use Asiatic clams as a surrogate to evaluate the bioavailability of sediment contaminants in benthic organisms. Details regarding this investigation are available in **Section 4.2.5.1**.

U.S. Fish and Wildlife Service (Pinkney 2009). Fish tissue (fillets) sampling was conducted at two locations, one in the upper Anacostia River and one in the lower Anacostia River (north and south of the CSX Railroad Bridge, respectively). This investigation focused on evaluating contaminant levels in the tissues of fish species typically caught and consumed by anglers. A description of this investigation is provided in **Section 4.2.5.2**.

DDOE, Ongoing. As a requirement of the District of Columbia Municipal Separate Storm Sewer System (MS4) National Pollutant Discharge Elimination System (NPDES) permit issued by EPA, DDOE historically conducted routine wet and dry weather sampling of nine stations in the Anacostia River watershed (Hawkins 2009). Under the latest MS4 Permit (issued October 2011), sampling is occurring at two stations in the Anacostia watershed on an interim basis. DDOE is in the process of developing a revised monitoring framework which is scheduled to be completed by May 2015. According to sampling protocol, storm water samples are to be collected during the first two hours of a storm event. The water is analyzed for biological oxygen demand (BOD), total dissolved solids (TDS), total suspended solids (TSS), various inorganics, 13 metals, hardness, 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), and bacteria (fecal coliform and fecal streptococcus).

U.S. Environmental Protection Agency, Ongoing. In partnership with DDOE, EPA is conducting a review of TMDL determinations in the Anacostia River, Potomac River, Rock Creek, and selected tributaries to these streams (Tetra Tech 2013). The investigation involved a review of previously collected water, sediment, and fish tissue data from these waterbodies. This review has been completed as of the date of this work plan. Based on the results of this review, EPA will conduct, beginning in the third quarter of 2013, monitoring of 29 locations to assess the TMDL for the constituents of concern (COCs). Fourteen of the locations are sited along the Anacostia River or one of its tributaries. Sampling will occur during one dry and two wet periods for the Anacostia River and tributaries and during one dry period for the Potomac River tributaries and Rock Creek tributaries. Sampling locations with any parameters above the applicable water quality criteria will be evaluated during TMDL development for the waterbody.

2.6.2 Site-Specific Investigations

As noted in **Section 1**, investigations are ongoing or contemplated at six environmental sites that border the river. The current regulatory status of each site, as presented in the DDOE SOW is summarized below. In addition, the available sediment characterization data are summarized. For sites with pending investigations, the planned sampling activities are discussed. Additional details regarding specific contamination issues at each site are provided in **Section 3**.

Kenilworth Park Landfill (The Johnson Company 2012). The Kenilworth Park landfill is a 130 acre site owned by the U.S. government and managed by the National Park Service (NPS), the lead agency carrying out CERCLA actions for the site. The site is located within Kenilworth Park and Aquatic Gardens, which is part of Anacostia Park. The site comprises two geographic areas divided by the Watts Branch (a tributary of the Anacostia River), Kenilworth Park Landfill North (KPN) and Kenilworth Park Landfill South (KPS). Kenilworth Landfill was used as a dump from

1942 to 1968. During this period the landfill extended into the Anacostia River and no barriers were constructed to prevent migration of wastes mixed with soil into the water.

Between 1998 and 2009, a number of environmental investigations were undertaken to determine the nature and extent of contamination at the Kenilworth site, including Preliminary Assessment/Site Inspections (PA/SIs), Remedial Investigations (RIs), and supplemental data collection and reports. The site has been divided into two operable units (OUs): OU1 comprises surface and subsurface soils, including the waste material disposed of within the landfill; OU2 is the shallow groundwater underlying OU1. In April 2012, NPS prepared a FS Report recommending a soil cap for OU1. On March 1, 2013, the Proposed Plan for Cleanup of the Kenilworth Park landfill site (OU1) was released for 60-day public comment period. However, NPS has decided to postpone selecting final remedy for the landfill until more groundwater data are available. To ensure that contaminants are not being transported from the landfill to the adjacent water bodies, NPS will collect additional groundwater data in 2013. The additional data will be used to supplement existing data in order to reevaluate whether the Anacostia River and adjacent surface water bodies may be at risk from contaminants disposed in the landfill. The additional groundwater data also will be used to further inform the selection of the remedy for the landfill.

During the PA/SI conducted in 1998 by Ecology and Environment, Inc. (Ecology and Environment) (2008), 19 sediment samples were collected from the Anacostia River, 11 of which were located adjacent to the site. All samples were collected near the shoreline. The sampling occurred in two rounds. Samples from the first round were analyzed for PAHs, pesticides, PCB Aroclors, and metals while samples from the second round were analyzed for only PAHs, PCBs, and metals. EPA SW846 methods were used for all analyses with PAH, pesticide, PCB Aroclors, and metals analyzed via methods 8270C, 8081A, 8082, and 6010B, respectively.

Sample results were compared with EPA Region 3 Biological Technical Assistance Group (BTAG) screening levels for freshwater sediment. Total PAH concentrations ranged from 2,130 to 13,779 µg/kg with all samples exceeding the screening level for at least one PAH. Ecology and Environment (2008) concluded that the PAH concentration distribution lacked a consistent pattern suggesting multiple sources. All samples analyzed for pesticides contained concentrations of at least four pesticides exceeding their respective screening values. Aroclor 1242, 1254, and 1260 exceeded screening levels at 10, 19, and nine of the sample locations. Maximum pesticide and PCB concentrations were measured near a drainage ditch from the adjacent Pepco site. PCB concentrations at this site were approximately twice the levels observed in the other samples. The levels of lead, cadmium, and mercury exceeded the screening levels at most sample locations.

Pepco Benning Road (AECOM 2012). The Pepco Benning facility is located at 3400 Benning Road NE, Washington DC. Pepco currently uses the 77 acre site to manage operations and maintain equipment associated with their electrical distribution system. Several PCB, petroleum, and metals releases to the environment occurred between 1987 and 2003 resulting from spills of contaminated oil or leaking equipment. Pepco prepared an RI/FS work plan pursuant to a consent decree that was entered by the U.S. District Court for the District of Columbia on December 1, 2011. After an extensive review and comment period, the work plan was approved by DDOE on December 28, 2012. Field work associated with the RI/FS was initiated in January 2013. Analytical results from this investigation were unavailable for discussion herein.

The sediments portion of the investigation will characterize sediment quality horizontally and vertically in the vicinity of the Pepco site. The investigation will cover an area of approximately 10 to 15 acres which will extend approximately 1,500 feet south and 1,000 feet north of the site. A total of 45 surface sediment samples will be collected near the site with 10 additional surface sediment samples collected for background characterization purposes. Surface sediment samples will be analyzed for PCB Aroclors, metals, PAHs, and acid volatile sulfides (AVS)/simultaneously extracted metals (SEM). Selected surface sediment samples (up to 20) will be analyzed for volatile organic compounds (VOCs), SVOCs, pesticides, and polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). In addition, up to eight samples will be analyzed for PCB homologs and/or congeners and PAH fingerprinting analyses.

Subsurface samples will be collected at three depths based on visual inspection at all 55 surface sampling locations. Subsurface sediment will be accessed to a depth of eight to 10 feet via the vibracore drilling method. All subsurface samples will be analyzed for PCB Aroclors and PAHs. A subset of up to seven of the subsurface samples will also be analyzed for PCB homologs and/or congeners. Subsurface samples will also be analyzed for total organic carbon and grain size.

Surface water samples will be collected at 20 locations from a depth of approximately one foot above the sediment surface. In addition to the measurement of field parameters (temperature, dissolved oxygen, pH, turbidity, and specific conductivity), samples will be laboratory-analyzed for PCBs, PAHs, hardness, and total and dissolved metals.

CSX Benning Yard (EnviroScience 2013). CSX Transportation (CSXT) owns and operates Benning Yard located at 225 33rd Street, SE, Washington, DC. Benning Yard is an active railroad switching yard. Historically, a portion of Benning Yard was used to store and dispense diesel fuel to locomotives. In the 2004 timeframe, a new office building and parking facility were constructed in the area where fueling operations had previously been conducted. Subsurface hydrocarbon contamination was observed during this construction and, subsequently, it was determined that hydrocarbon-impacted groundwater was seeping into adjacent Fort Dupont

Creek, a tributary to the tidal Anacostia River. Further investigations revealed the presence of a light nonaqueous phase liquid (LNAPL) plume in the water table aquifer and, on occasion, the presence of a petroleum sheen on Fort Dupont Creek. CSX submitted a corrective action plan to DDOE for cleaning up spill-contaminated soil and groundwater in April 2013.

A sediment investigation including Fort Dupont Creek and the Anacostia River was conducted in 2011. Surface sediment grab samples were collected at 18 locations on Fort Dupont Creek and 35 locations on the Anacostia River. Sediment core samples were collected at 18 of the surface sampling locations. All samples were analyzed for total petroleum hydrocarbons (TPH) diesel range organics (DRO) (Method 8015), VOCs (Method 8260), SVOCs (Method 8270), metals (Method 6020), pesticides (Method 8081), PCB Aroclors (Method 8082), and TOC (Method 9060). Anacostia River samples were also analyzed for 209 PCB congeners (EPA Method 1668) and PAH fingerprinting analyses. Surface sediment and subsurface sediment samples were collected. Subsurface samples were collected from the depths of 0.5 to 1.0 foot, 1.0 to 2.0 feet, and 2.0 to 3.0 feet below the river bottom.

Sediment samples collected in the Anacostia River in close proximity to the Fort Dupont Creek Outfall were generally coarser in grain size and exhibited lower measured constituent concentrations. Within 150 feet of the outfall, total PAH concentrations in surface sediments range from less than 600 to more than 14,000 µg/kg. Concentrations away from the outfall generally exceed 12,000 µg/kg. Similarly, total PCB concentrations (sum of all congeners) were generally less than 100 µg/kg within 150 feet of the outfall, while PCB concentrations in the 200 to 500 µg/kg range were more typical out in the river channel and away from the outfall.

WGL Company Site (EPA 1999; National Capitol Parks-East 2011). The WGL Company site covers an area of approximately 4.2 acres formerly containing the East Station manufactured gas plant. On September 26, 2012, WGL entered into a Consent Decree with the District of Columbia, Department of Interior (DOI) NPS, and EPA to conduct additional landside and sediment studies. The October 2011 Statement of Work (SOW) addresses the impacts to surface soil and subsurface soil (Operating Unit 1 [OU1] as well as to groundwater, surface water, and river sediments [OU2]). A draft Remedial Design/Remedial Action (RD/RA) Work plan for OU1 and a draft Remedial Investigation/Feasibility Study (RI/FS) Work plan for OU2 are under review by NPS and the DDOE.

Surface sediment samples were collected from the Anacostia River at seven locations adjacent to the WGL East Station site in 1996 (NOAA database). VOC concentrations ranged from 150 to 430 and averaged 260 µg/kg (EPA 1999). For PAHs, concentrations ranged from 3,940 to 226,700. PAHs averaged 129,000 µg/kg (EPA 1999).

In accordance with the above noted 2011 RD/RA scope of work, WGL will conduct additional characterization of the nature and extent of site contamination in groundwater discharging to Anacostia River surface water and sediments (National Capitol Parks – East 2011). Groundwater contamination and NAPL characterization will focus on the seawall portion of the site for the purpose of assessing preferential migration pathways to surface water and sediments.

WGL will also conduct a sediment investigation that will include a review of all existing data to identify data gaps, a bathymetric survey, a benthic organism study, the collection of pore water samples, and the delineation of the area and depth of contaminated sediment. Sediment sample analysis will include fingerprinting/forensic analysis of PAHs.

Poplar Point (Ridolfi Engineers 2003). The Poplar Point site is bordered to the north by the Anacostia River. Roadways, ramps and medians for the 11th Street Bridge form the northeast border of the site while roadways and medians for the South Capitol Street Bridge form the northwest edge of the site. The site is bordered to the south by Howard Road. The Poplar Point site encompasses an area of approximately 44 acres. The site includes former tree and plant nurseries that operated from 1927 to 1993. In addition, a separate portion of the site was used by the Navy as the Naval Receiving Station from 1942 through the 1960s (Ridolfi 2003a). In 1980, the Navy completed the decommissioning of this facility with the demolition or transferal of the remaining buildings to the NPS (Dolf 2001). Currently, the NPS is in the process of reviewing the draft RI/FS work plan. Following the approval of the WP, field activities will commence.

Anacostia River surface and subsurface sediments were sampled in the Poplar Point vicinity by Velinsky and others (2011). Sampling was conducted via vibracore to depths ranging from 13 to 16 feet below the sediment surface. Each coring location was from the undredged portion of the channel. Cores were subsampled at an interval of approximately one sample per each 1.3 – 1.5 feet and analyzed for metals, PAHs, 100 PCB congeners, pesticides, grain size, and total organic carbon. Cores were also sampled for lead and cesium isotopes for age dating purposes.

Results of the sampling showed that surface concentrations of PAHs and total PCBs are lower than historical levels. Surface sediment PAH and total PCB concentrations were approximately 10,000 µg/kg and 200 µg/kg, respectively. Maximum PAH concentrations ranged from 10,000 to 30,000 µg/kg with the peak occurring at depths ranging from 3.2 to 8.2 feet below the sediment surface. Maximum total PCB concentrations ranged from 1,700 to 3,000 µg/kg. Peak total PCB concentrations were observed at depths ranging from 3.2 to 13 feet below the sediment surface. Based on the age dating results, calculated sedimentation rates from the core data ranged from 3.0 to 7.0 cm/year.

Washington Navy Yard (CH2M Hill 2011). This site is located on M street SE, near the 11th Street Bridge in southeast Washington, D.C. The southern side of Washington Navy Yard (WNY) is bounded by the Anacostia River. The WNY waterfront has historically consisted of piers, quay walls, slips, and dry dock facilities. A "Notification of Hazardous Waste Activity" was submitted to EPA by WNY in 1985. In 1998, the WNY was placed on the US EPA National Priorities List because of the contamination that was detected in the adjacent Anacostia River as well as on-site sediment and soil. In 1999, the Near-shore Sediment RCRA Facility Investigation (RFI) included the collection of surface sediment samples from 26 locations. The remedial investigation activities of the near-shore sediments (Operating Unit 2, OU2) were conducted in the year 2010 in accordance with the Federal Facilities Agreement (FFA). The Draft Remedial Investigation Report for OU2 is under discussion between DDOE, EPA, and Navy. The RI data have been uploaded to the NOAA Anacostia Watershed Database.

For the 2009 sampling phase documented in the 2011 RI Report, The Washington Navy Yard investigation included the collection of 20 samples to help characterize the surface sediments in and around OU2, to fill existing data gaps, to characterize the sediments near the Navy and D.C.-owned outfall locations, and to complement existing surface sediment results for the previous surface sediment investigation. OU2 includes the entire 2,400 foot site waterfront and extends the length of the facility's piers (approximately 200 feet) into the Anacostia River. In addition, subsurface sediment sampling was conducted at 34 locations within and near the pier area to depths ranging from 10 to 12 feet (middle depth) to approximately 20 feet (deep depth) below the river bottom. The historical dredge depth at the Washington Navy Yard is -22 feet below mean sea level. The middle depth and deep depth samples correspond to the interval above the typical dredging depth versus the deeper interval representing fluvial sediments. Sediment samples were analyzed for Target Analyte List metals (Method 6010B), cyanide (Method 9012B), PCB Aroclors (Method 8082), and PAHs (Method 8270_SIM), total organic carbon, and grain size. Selected samples were also analyzed for VOCs (Method 8260), TCL pesticides (Method 8081A), 129 PCB Congeners (EPA Method 1668A), PCDD/PCDF (Method 8290), and AVS/SEM.

For surface sediment, the highest constituent concentrations are consistently found at the western end of OU2, in the area of former Pier 5 and D.C. Combined Sewer Outfall 14, D.C. Storm Sewer 01, and Washington Navy Yard Outfall 9. Relatively higher constituent concentrations are also found near some of the other Navy Yard outfalls. PAH concentrations in this area range up to 77,690 µg/kg. The average PAH concentration for OU2 was 15,319 µg/kg. Gamma chlordane was the most frequently detected pesticide. Average and maximum gamma chlordane concentrations for OUs were 15.1 and 41 µg/kg, respectively. Total PCB Aroclor concentrations in OU2 surface sediments ranged from 96 to 830 µg/kg, with an average concentration of 219 µg/kg.

In addition, the RI results indicate that for most constituents comparisons of constituent concentrations at individual locations sampled in both 1999 and 2009 were inconclusive; concentrations of PAHs and PCBs were more variable than concentrations of metals, but in general, there were no systematic increases or decreases in concentrations over time.

Active Capping Pilot Study (Horne Engineering 2003). A pilot project was initiated in 2004 to evaluate the performance of active capping technology as an approach to manage contaminated sediments. The project was undertaken at Area of Concern 1 (AOC1) defined by AWTA (2002). AOC1 is an area of elevated PAHs and PCBs located near the O Street Outfall, Southeast Federal Center, and the Washington Navy Yard. The demonstration project was implemented by a team led by Dr. Danny Reible and consisting of AWTA, the DC Department of Health, EPA organizations, and various universities (Reible et al. 2006). Three materials were tested including a bentonite material with a granular core, coke, and apatite. The granular core material physically entraps migrating sediments, coke sequesters organic constituents, and apatite removes metals through mineral deposition. Each material was installed in a pilot-scale, experimental cap specific for that material. After placement, early monitoring indicated that all cap materials were effectively isolating contaminants (Reible et al. 2006). As determined through the profiling of cap pore water, concentrations in all of the caps approached near equilibrium within a few years as a result of surface recontamination and tidal pumping forces (Lampert et al. 2013). However, observed concentrations of seven PAHs in each of the caps were lower than those in the uncapped areas (Lampert et al. 2013).

Prior to placement of the caps, Horne Engineering (2003) characterized the river bottom near O Street Outfall where the caps were to be installed. The characterization included the performance of bathymetric, side-scan sonar, and benthic community surveys. In addition, the investigation included the collection of surface water, pore water, and surface and subsurface sediment samples. Surface sediment samples were collected via gravity corer at eight locations and via Ponar sampler at 60 locations. Subsurface samples were collected from the intervals 0.5 to 1.0 foot, and 1.0 to 3.0 feet from the eight gravity cores. Deep sediment samples were also collected from two locations. At each location, the sampled depths were 10.5 to 12.5 feet, 15.5 to 17.5, and 20 to 22 feet below the sediment surface.

Surface sediment PCB Aroclor concentrations ranged from 25 to 2,400 µg/kg with 1248 and 1254 two of the dominant Aroclors. Total PAH concentrations (16 priority pollutants) ranged from 470 to 82,360 µg/kg with higher values occurring near the outfall. Some metals concentrations were highest at the outfall discharge point and decreased away from that maximum. This pattern was observed (maximum concentration shown) for antimony (5.0 mg/kg), chromium (94.8 mg/kg), lead (726 mg/kg), nickel (69.8 mg/kg), selenium (1.9 mg/kg), silver (22.5 mg/kg), thallium (2 mg/kg), and zinc (892 mg/kg).

Subsurface gravity core sediment PCB Aroclor concentrations ranged from 9,100 µg/kg (0.5 to 1.0 foot) to 400 µg/kg (1.0 to 3.0 foot). PCB congener concentrations in the subsurface gravity core samples are based on 22 congeners defined by EPA Region 2 (EPA 1992a) and ranged from 6,528 to 689 µg/kg. The maximum and minimum PCB congener sample results correspond to two samples in which the maximum and minimum Aroclor concentrations were observed. Total PAHs for the subsurface gravity cores range from 45,300 to 5,110 µg/kg measured at the depths of 0.5 to 1.0 and 1.0 to 2.0 feet, respectively.

With regard to the deep sediment samples, PCB Aroclors and total PAH were not detected at depths greater than seven feet below the sediment surface. For the interval from approximately five to seven feet, PCB Aroclor concentrations ranged from 29 to 2,390 µg/kg and total PAHs ranged from 929 to 10,600 µg/kg.

Southeast Federal Center (URS Group 2000). Southeast Federal Center (SEFC) is a 55.3-acre site located adjacent to and down-river from the Washington Navy Yard. The site was originally a portion of the Navy Yard and was used for manufacturing of naval ordnance, specifically medium and large caliber naval guns. The ordnance production and manufacturing ceased in 1962. The site was transferred to the General Services Administration in 1963. The site has housed a variety of government activities and clients, including administrative offices, warehouses and storage space, laboratories, and light industrial operations. As part of a 1998 consent decree, the Navy and GSA agreed to sample and analyze near shore river sediment along the SEFC waterfront.

On behalf of GSA, URS Group (URS) collected surface sediment samples at 11 locations and analyzed the samples for TAL metals, TCL VOCs, TCL SVOCs, TCL PCBs, PAHs. At three locations, PCDDs/PCDFs, Appendix IX VOCs, Appendix IX SVOCs, and PCB congeners (209 congeners) were also analyzed. The field work for the investigation was conducted in August 1999.

PCB Aroclors were detected in eight of the 11 samples. Aroclor 1254 and 1260 were the only species detected with concentrations ranging from 100 to 310 µg/kg for 1254 and from 98 to 510 µg/kg for 1260. For the three PCB congener analyses locations, total PCBs expressed as the sum of the detected congeners ranged from 1,018 to 2,894 µg/kg. One or more PAHs from each sample exceeded EPA Region 3 BTAG screening levels and the group of detected PAH compounds was consistent across all samples. Based on concentration data for SEFC site in the project database, high molecular weight polycyclic aromatic hydrocarbons (HPAH) concentrations ranged from approximately 2,800 to 52,300 µg/kg while low molecular weight polycyclic aromatic hydrocarbons (LPAH) concentrations ranged from 1,100 to 25,300 µg/kg.

Joint Base Myer-Henderson Hall (Fort McNair). Fort McNair is a 108 acre Army facility situated adjacent to the mouth of the tidal Anacostia River. Fort McNair is part of Joint Base Myer-

Henderson Hall command. The facility occupies the eastern portion of Buzzard Point, the peninsula separating the Anacostia River from the Washington Channel. Initially established in 1794 as an arsenal for defending the Capitol, the facility has since included a federal penitentiary, a general hospital (predecessor to Walter Reed Army Medical Center), and an Army education and training facility (www.jbmhh.army.mil/web/jbmhh/AboutJBMHH/FortMcNairHistory.html). Fort McNair is home to the National Defense University and various army ceremonial units including the Army's official escort to the President and the U.S. Army Band (DDOE 2012). A web search for potential environmental issues at Fort McNair suggests the absence of any significant current or historical environmental issues at the facility. However, the search revealed that several current and former leaking underground petroleum storage tank (LUST) sites exist at Fort McNair (**Table 2.3**). The records show that nine LUST cases involving petroleum products were identified between 1989 and 1996. Specific information regarding the nature and extent of contamination and the various environmental media impacted by these subsurface spills is unavailable. The substances leaked included gasoline, waste/used oil, heating fuel oil, and kerosene. Contamination of soil and/or soil and groundwater resulted from these spills. Seven of the nine cases have been resolved and two remain open as of time of this report (October 2013).

Joint Base Anacostia-Bolling (Naval Support Facility Anacostia). The Naval Support Facility Anacostia (NSFA) is a 905 acre military installation situated along the southern shore of the Anacostia River at the confluence of the Anacostia and Potomac rivers (www.cnic.navy.mil/regions/ndw/installations/jbab/about/history.html). NSFA is part of Joint Base Anacostia-Bolling established by the consolidation of NSFA with adjacent Bolling Air Force Base. Beginning in 1918, NSFA served as a military airfield and was designated as the first headquarters of the United States Air Force in 1941. To ease airspace congestion in the vicinity of National Airport, all fixed wing aircraft operations at the facility ceased in 1962. The facility is currently primarily used by the Navy for administrative purposes. In addition, it is home to organizations such as the Defense Intelligence Agency and the Naval Imaging Command (DDOE 2012). A web search for potential environmental issues at NSFA suggests the absence of any significant current or historical environmental issues at the facility. However, the search revealed that 17 former leaking underground petroleum storage tank (LUST) sites existed at NSFA (**Table 2.3**) and were identified between 1989 and 1997. Specific information regarding the nature and extent of contamination and the various environmental media impacted by these subsurface spills is unavailable. The substances leaked included gasoline, waste/used oil, heating fuel oil, and kerosene. Contamination of soil and/or soil and groundwater resulted from these spills. All 17 cases were resolved by 2003.

2.7 Data Usability

The data collected during previous investigations were screened to determine the usability of the data in the assessment of data gaps and for potential future use in FS and NRDA analyses. As discussed in **Section 6**, in addition to screening the data for the purpose of sample design, additional evaluation of the existing data will occur during the data evaluation phase of the RI. The usability assessment included the following elements.

Sampling Period. Environmental data from as early as 1990 were available for use in the development of this WP. To leverage the extensive spatial coverage of the ANS 2000 data set, data collected post-year 2000 were selected for use in the data gap assessment. Exceptions to the 2000 cutoff are inclusion of the sediment data from two investigations from 1998 and 1999, respectively. Both were included to enhance spatial coverage. The 1998 investigation included the collection of Anacostia River sediment samples in association with an ambient sediment toxicity investigation in the Chesapeake Bay watershed. The 1999 investigation consisted of surface sampling results for the SEFC sampling discussed above. As shown by **Table 2.2**, the data for 11 previous investigations were evaluated for this WP.

An assumption inherent in using data collected from up to 15 years ago is that sediment concentrations from these sampling events will reasonably approximate present day concentrations. In support of this assumption, the above-noted Washington Navy Yard RI data indicate that for most of the data set, systematic differences do not exist between the concentrations measured in 2009 and those measured in in the 2000 event at the same locations. A representative number of the 2000 locations will also be re-sampled for this investigation to assess general usability of the earlier data.

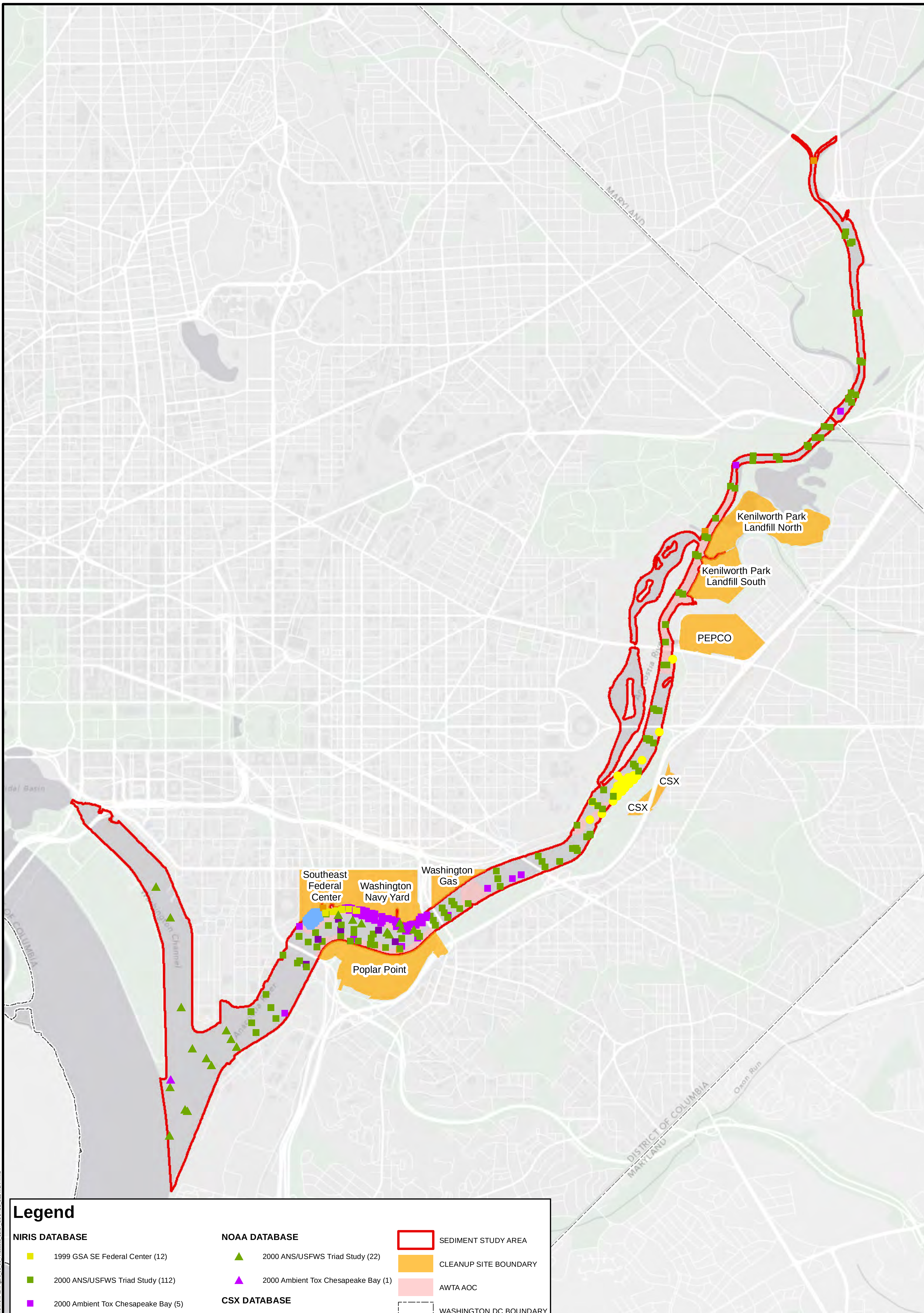
Analytical Methods. Consistency of the analytical methods across the previous investigations included in the project database was assessed. **Table 2.4** shows the analytical methods for the five more significant investigations for which data are available. For the “Washington Navy Yard Sed/TSS,” “GSA SE Federal Center,” “CSX,” and “Active Capping Site Char Rpt” data sources, analytical methods are generally consistent for SVOCs, PAHs, metals, pesticides, and PCB Aroclors. In most cases, the typical SW-846 method was used. PCB congener analysis methods, however, vary somewhat among the investigations as do the numbers of congeners analyzed. The “CSX” and “GSA SE Federal Center” investigations both analyzed for the full suite of 209 PCB congeners while 127, 81, and 57 congeners were measured in the “Washington Navy Yard Sed/TSS,” “ANS 2000,” and “Active Capping Site Char Rpt datasets,” respectively. The various methods listed in **Table 2.4** for each group of analytes, including those used for the “ANS 2000” dataset, are generally comparable. Any discrepancies result from variation in method sensitivities as will be reflected in the associated method detection limits.

Screening Levels. Screening levels were identified for preliminary screening of sediment, soil, and groundwater sampling results in the preparation of this WP. In the discussions of existing sampling results for these media, concentrations are characterized as “elevated” if screening levels are exceeded. Sediment concentration data are compared to the EPA Region 3 Biological Technical Assistance Group Freshwater Screening Benchmarks (**Table 2.5**). These screening levels provide conservative reference levels for initial, preliminary evaluation of sediment quality data and will be re-evaluated as the RI/FS progresses. Soil and groundwater concentration results are compared to EPA Regional Screening Levels (RSLs) for industrial soil and residential tap water, respectively (**Table 2.5**).

Deep Sediments. The year 2000 cutoff for retaining investigations for the WP database applies to all environmental media with the exception of deep sediments. Because they are buried below the horizon where surface sediment transport processes are active, deep sediment data collected in non-dredged areas reflect current conditions even if they are from investigations conducted many years ago. However, for some pre-2000 investigations, the NOAA Database provided insufficient documentation regarding sampling depths, either because specific depth information was absent or the units for depth measurement were unavailable. Only deep sediment data for which accurate depth information was available, which included only the post-2000 investigations were included in the WP database. During the performance of the RI, the WP database will be updated as deep sediment data from sediment investigations for the other sites in the study area becomes available.

Data Validation. Data from the Washington Navy Yard investigation was subjected to Region 3 data validation at an acceptance level sufficient for risk assessment. The CSX data underwent a Stage 2A data validation, a verification and validation process that assesses completeness and compliance checks of sample receipt conditions and only sample-related quality control results. Formal data validation was not performed on the U.S. Fish and Wildlife fish tissue data or the Phelps (2001) benthic invertebrate data. Information regarding validation of the 2000 ANS sampling results or other data contained in NOAA database data is unavailable.

Usability Determination. Review of the 11 selected investigations (**Table 2.2**) resulted in the determination that all are of sufficient quality for use in WP development without qualification with two exceptions. Two clam translocation studies (Phelps 2001 2002) showed that clams accumulated pesticides and PCBs when placed in the Anacostia River for several weeks. However, these studies did not attempt to distinguish between dissolved and particulate constituents as the source of contaminants. Nor were sediment concentrations at the reference and test locations measured. Concentrations of contaminants in overlying water were not measured or discussed. These and other features of the studies limit the usability of the results.



Legend

NIRIS DATABASE

- 1999 GSA SE Federal Center (12)
- 2000 ANS/USFWS Triad Study (112)
- 2000 Ambient Tox Chesapeake Bay (5)
- 2000 USFWS Bioavailability (4)
- 2003 Active Capping Site Char Rpt (77)
- 2003 Poplar Point Cores (8)
- 2006, 2009 Washington Navy Yard Sed/Tiss (66)

NOAA DATABASE

- 2000 ANS/USFWS Triad Study (22)
- 2000 Ambient Tox Chesapeake Bay (1)

CSX DATABASE

- 2011 CSX Sediment Study (28)

- SEDIMENT STUDY AREA
- CLEANUP SITE BOUNDARY
- AWTA AOC
- WASHINGTON DC BOUNDARY

N E S W

0 1,500 3,000 Feet

DRAFT

SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012, DCGIS, 2012, NOAA, 2013, AND DEPARTMENT OF THE NAVY, 2013.

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 2.1
SEDIMENT SAMPLING LOCATIONS
BY SOURCE DATABASE

TETRA TECH

TABLE 2.1

Geologic and Hydrostratographic Units Present in the Study Area[1]

Group	Geologic Unit	Lithology	Hydrostratigraphic Unit	Formation Thickness (feet)
Not Applicable	Quaternary Deposits and Fill	Miscellaneous Fill; Orange-tan medium to coarse sand and gravel; silts and clays.	Isolated perched groundwater units	< 6
			Surficial aquifer	< 25
Potomac	Undifferentiated Patapsco, Ann Arundel, and Patuxent Formations	Clay and silt facies: Variegated red, gray, and brown hard and tight clays. Some silty and fine sandy lenses.	Potomac confining unit	< 350[2]
		Sand and gravel facies: Gray and tan gravel, sand, arkose with occasional sandy clay lenses.	Pautuxent Aquifer	
Bedrock	Wissahickon Schist	Schist bedrock	Lower confining	Unknown

Notes:

1. Geologic and hydrostratographic units summarized from D.C. Water Resources Research Center (1993)
2. Thickness taken from Koterba, Dieter, and Miller (2010)

TABLE 2.2

Previous Studies Included in the Project Database and Number of Samples (By Media) in the Tidal Anacostia River

Study Name In WP Database	Reference[1]	Database Source (# of Samples in Study Area)	Year of Sample Collection	Data Used for WP Development	Number of Samples*			
					Surface Sediment	Subsurface Sediment	Fish Tissue	Benthic Tissue
ICPRB/Limno-Tech Sediment Survey	NOAA database	N/A (Sample totals shown at right are from NOAA database only)	1989	No	12	0	0	0
WA Gas Light East Station Property	NOAA database		1988		0	12	0	0
EMAP-Chesapeake Bay	NOAA database		1990		1	0	0	0
FWS Organochlorine Resid/Histopath	NOAA database		1987		0	0	3	0
Bolling AFB - SW Corner Landfill	NOAA database		1992		6	0	0	0
DC Fish Tissue HHR	NOAA database		1989-1992		0	0	2	0
Potomac & Anacostia Sediment Stud	NOAA database		1991		22	0	0	0
Wild Fish Tissue	NOAA database		1993-1995		0	0	2	0
PEPCO	NOAA database		1995, 1997		3	1	0	0
Washington Navy Yard	Clark and Crutchley (1995)		1995		7	0	0	0
FWS PAH/PCB - Mason Neck	NOAA database		1995		3	0	2	0
WA Gas - East Station Project	NOAA database		1996		7	0	0	0
DC Sediment Core Analysis	NOAA database		1995		7	7	0	0
USACE Federal Nav Channel	NOAA database		1998		4	4	0	0
WA Navy Yard RI	CH2M Hill (2011)		1999		34	0	0	0
GSA SE Federal Center	URS Group (2000)	NIRIS[2] (12)	1999	Yes	12	0	0	0
Ambient Tox Chesapeake Bay	NOAA database	NOAA[3] (1) NIRIS (5)	1998		6	0	0	0
ANS 2000 (ANS/USFWS Triad Study)[4]	NOAA database Velinsky and Ashley (2001)	NOAA (22) NIRIS (112)	2000		134	0	0	0
USFWS Bioavailability	Pinkney et al. (2001)	NIRIS (4)	2000		4	0	0	0
Invertebrate	Phelps (2001)	N/A (7)	2000, 2001		0	0	0	7
WA Navy Yard Pier No. 5	CH2M Hill (2011)	NIRIS (16)	2002		0	16	0	0
Poplar Point Cores	NIRIS database	NIRIS (8)	2003		8	0	0	0
Active Capping Site Char Rpt	Horne Engineering Servs., Inc. (2003)	NOAA (8) NIRIS (77)	2003		77	8	0	0
Washington Navy Yard Sed/Tiss	CH2M Hill (2011)	NIRIS (66, 70, 46)	2006, 2009		66	70	46	0
USFWS Fish Tissue	Pinkney (2009)	N/A (2)	2007		0	0	2	0
CSX	EnviroScience (2013)	CSX (28, 38)	2011		28	38	0	0

1. If the original reference for a given study was not available, the Anacostia River database maintained by NOAA is referenced.
2. NIRIS-Navy Installation Restoration Information Solution Database
3. NOAA-National Oceanic and Atmospheric Association Query Manager Database.
4. Referred to in the text as ANS 2000; NOAA database reference is "ANS/USFWS Triad Study."

* Totals include duplicate sampling locations

TABLE 2.3

Summary of Ft. McNair and Naval Support Facility Anacostia LUST Sites[1]

Facility	Contaminant Types	Sites with only Soil Contamination	Sites wth both Soil and Groundwater	Status
Fort McNair	Petroleum - Motor fuels, waste/used oil, heating oil	4	3	Closed
		0	2	Open
Naval Support Facility Anacostia		3	14	Closed
		0	0	Open

1. Source: DDOE website http://ddoe.dc.gov/publication/public-records-related-underground-storage-tank-ust-systems

TABLE 2.4
Comparison of Sediment Analytical Methods

Database	TPH	SVOC	PAH		VOC	Metals	Pesticides	PCDD/PCDF	PCB Aroclors	PCB Congeners	
			Method	Number						Method	Number
Washington Navy Yard Sed/TSS	NA[6]	NA[6]	8270_SIM[4,8]	31	NA[6]	6010B[4]	8081A[4]	8290[4]	8082[4]	1668A[7]	129
GSA SE Federal Center	NA[6]	CLP[1] SVOCs	8310[4]	17	CLP[1] VOCs	CLP[2]	NA[6]	8290[4]	CLP PCBs	8082[3]	209
CSX	8015[4]	8270[4]	8270[4]	51	8260[4]	6020[4]	8081[4]	NA[6]	8082[4]	1668[7]	209
Active Capping Site Char Rpt	8015B[4]	NA[6]	8270C[4]	16	NA[6]	6010[4]	8081[4]	NA[6]	8082[4]	3540C[5] 8082[4]	57
Poplar Point Cores	NA[6]	NA[6]	Soxhlet Extraction/ GC-MS[9]	41	NA[6]	Cold Vapor ICP MS[13] (Hg) Acid digestion (all metals but Hg) Graphite Furnace AAS[14] (Ag, Cd) FAA[15] (Cu, Fe, Mn, Ni, Pb, Zn) ICP-MS[13] (Al, Cr) Hydride AAS[14] (As)	Soxhlet Extraction/ Ni ECD[15]	NA[6]	NA[6]	Soxhlet Extraction/ Ni ECD	100
ANS 2000	NA[6]	NA[6]	Solvent Extraction/ GC-MS[9]	16	NA[6]	HF-HNO3[12] Total Digest/ICP OES[10]	Solvent Extraction/ GC-ECD[11]	NA[6]	NA[6]	Solvent Extraction/ GC-ECD[16]	81

Notes:
1. EPA CLP SOW OLM03.2
2. EPA CLP SOW ILM04.0 - (CLP)
3. SW-846 8082/NEA Comprehensive Quantitative Congener Specific Method
4. SW-846 Method
5. SW-846 Method 3540C Soxhlet Extraction
6. NA: not analyzed
7. EPA Method
8. SIM: Selective ion monitoring
9. GC-MS: Gas chromatography - mass spectrometry
10. ICP OES: Inductively coupled plasma optical emission spectroscopy
11. GC - ECD: Gas chromatography - electron capture detector
12. HF - HNO3: Hydrofluoric - nitric acid
13. ICP MS: Inductively coupled plasma mass specrtometry
14. AAS: Atomic adsorption spectrometry
15. FAA: Flame atomic adsorption
16. Ni ECD: Ni Electron capture detector
17. GC-ECD: Gas chromatograph - electron capture detector

TABLE 2.5

Project Screening Levels for Sediments, Soil, and Groundwater, Page 1 of 3

				EPA Regional Screening Levels[2]							
Analyte	CAS	Group	Sediment BTAG Screening Level[1] (mg/kg)	Industrial Soil 1E-06 Carcinogenic Screening Level (mg/kg)	Industrial Soil HI 0.1 Noncarcinogenic Screening Level (mg/kg)	Residential Tapwater 1E-06 Carcinogenic Screening Level (ug/L)	Residential Tapwater HI 0.1 Noncarcinogenic Screening Level (ug/L)	Fish Tissue Carcinogenic Screening Level (mg/kg)	Fish Tissue Noncarinogenic Screening Level (mg/kg)	Maximum Contaminant Level (ug/L)
Cyanide	57125	Cyano	0.1	NSL	14	NSL	0.14	NSL	0.81	200
2,3,7,8-TCDD	1746016	Dioxin	0.00000085	0.000018	0.00006	0.00000052	0.0000011	0.000000024	0.00000095	0.00003
Antimony	7440360	Metal	2	NSL	41	NSL	0.6	NSL	0.54	6
Arsenic	7440382	Metal	9.8	2.4	38	0.045	0.47	0.0021	0.41	10
Beryllium	7440417	Metal	NSL	6900	200	NSL	1.6	NSL	2.7	4
Cadmium	7440439	Metal	0.99	9300	80	NSL	0.69	NSL	1.4	5
Chromium (III)	16065831	Metal	NSL	NSL	150000	NSL	1600	NSL	2000	NSL
Chromium (VI)	18540299	Metal	NSL	5.6	310	0.031	3.1	0.0063	4.1	NSL
Copper	7440508	Metal	31.6	NSL	4100	NSL	62	NSL	54	1300
Lead	7439921	Metal	35.8	NSL	800	NSL	NSL	NSL	NSL	15
Mercury	7439976	Metal	0.18	NSL	4.3	NSL	0.063	NSL	NSL	2
Nickel	7440020	Metal	22.7	64000	2000	NSL	30	NSL	NSL	NSL
Selenium	7782492	Metal	2	NSL	510	NSL	7.8	NSL	6.8	50
Silver	7440224	Metal	1	NSL	510	NSL	7.1	NSL	6.8	NSL
Thallium	7440280	Metal	NSL	NSL	1	NSL	0.016	NSL	0.014	2
Zinc	7440666	Metal	121	NSL	31000	NSL	470	NSL	410	NSL
Acenaphthene	83329	PAH	0.0067	NSL	3300	NSL	40	NSL	81	NSL
Acenaphthylene	208968	PAH	0.0059	NSL	NSL	NSL	NSL	NSL	NSL	NSL
Anthracene	120127	PAH	0.0572	NSL	17000	NSL	130	NSL	410	NSL
Benzo(a)Anthracene	56553	PAH	0.108	2.1	NSL	0.029	NSL	0.0043	NSL	NSL
Benzo(a)Pyrene	50328	PAH	0.15	0.21	NSL	0.0029	NSL	0.00043	NSL	0.2
Benzo(b)Fluoranthene	205992	PAH	NSL	2.1	NSL	0.029	NSL	0.0043	NSL	NSL
Benzo(ghi)Perylene	191242	PAH	0.17	NSL	NSL	NSL	NSL	NSL	NSL	NSL
Benzo(k)Fluoranthene	207089	PAH	0.24	21	NSL	0.29	NSL	0.043	NSL	NSL
Chrysene	218019	PAH	0.166	210	NSL	2.9	NSL	0.43	NSL	NSL
Dibenzo(a,h)Anthracene	53703	PAH	0.033	0.21	NSL	0.0029	NSL	0.00043	NSL	NSL
Fluoranthene	206440	PAH	0.423	NSL	2200	NSL	63	NSL	54	NSL
Fluorene	86737	PAH	0.0774	NSL	2200	NSL	22	NSL	54	NSL
Indeno(1,2,3-cd)Pyrene	193395	PAH	0.017	2.1	NSL	0.029	NSL	0.0043	NSL	NSL
Naphthalene	91203	PAH	0.176	18	62	0.14	0.61	NSL	27	NSL
Phenanthrene	85018	PAH	0.204	NSL	NSL	NSL	NSL	NSL	NSL	NSL
Pyrene	129000	PAH	0.195	NSL	1700	NSL	8.7	NSL	41	NSL
PCB-1016	12674112	PCB	NSL	21	3.7	0.96	0.11	0.045	0.095	NSL
PCB-1221	11104282	PCB	NSL	0.54	NSL	0.004	NSL	0.0016	NSL	NSL
PCB-1232	11141165	PCB	NSL	0.54	NSL	0.004	NSL	0.0016	NSL	NSL
PCB-1242	53469219	PCB	NSL	0.74	NSL	0.034	NSL	0.0016	NSL	NSL
PCB-1248	12672296	PCB	NSL	0.74	NSL	0.034	NSL	0.0016	NSL	NSL
PCB-1254	11097691	PCB	NSL	0.74	1.1	0.034	0.031	0.0016	0.027	NSL
PCB-1260	11096825	PCB	NSL	0.74	NSL	0.034	NSL	0.0016	NSL	NSL
4,4’-DDD	72548	Pesticide	0.00488	7.2	NSL	0.027	NSL	0.013	NSL	NSL
4,4’-DDE	72559	Pesticide	0.00316	5.1	NSL	0.2	NSL	0.0093	NSL	NSL
4,4’-DDT	50293	Pesticide	NSL	7	43	0.2	0.78	0.0093	0.68	NSL
Aldrin	309002	Pesticide	0.002	0.1	1.8	0.004	0.047	0.00019	0.041	NSL
alpha-BHC	319846	Pesticide	0.006	0.27	490	0.0062	7.3	0.0005	11	NSL
alpha-Endosulfan	959988	Pesticide	0.0029	NSL	NSL	NSL	NSL	NSL	NSL	NSL

TABLE 2.5

Project Screening Levels for Sediments, Soil, and Groundwater, Page 2 of 3

				EPA Regional Screening Levels[2]							
Analyte	CAS	Group	Sediment BTAG Screening Level[1] (mg/kg)	Industrial Soil 1E-06 Carcinogenic Screening Level (mg/kg)	Industrial Soil HI 0.1 Noncarcinogenic Screening Level (mg/kg)	Residential Tapwater 1E-06 Carcinogenic Screening Level (ug/L)	Residential Tapwater HI 0.1 Noncarcinogenic Screening Level (ug/L)	Fish Tissue Carcinogenic Screening Level (mg/kg)	Fish Tissue Noncarinogenic Screening Level (mg/kg)	Maximum Contaminant Level (ug/L)
beta-BHC	319857	Pesticide	0.005	0.96	NSL	0.022	NSL	0.0018	NSL	NSL
beta-Endosulfan	33213659	Pesticide	0.014	NSL	NSL	NSL	NSL	NSl	NSL	NSL
Chlordane	12789036	Pesticide	0.00324	NSL	NSL	NSL	NSL	0.009	0.68	NSL
delta-BHC	319868	Pesticide	6.4	NSL	NSL	NSL	NSL	NSL	NSL	NSL
Dieldrin	60571	Pesticide	0.0019	0.11	3.1	0.0015	0.028	0.0002	0.068	NSL
Endosulfan Sulfate	1031078	Pesticide	0.0054	NSL	NSL	NSL	NSL	NSL	NSL	NSL
Endrin	72208	Pesticide	0.00222	NSL	18	NSL	0.17	NSL	0.41	2
Endrin Aldehyde	7421934	Pesticide	NSL	NSL	NSL	NSL	NSL	NSL	NSL	NSL
gamma-BHC	58899	Pesticide	0.00237	2.1	24	0.036	0.27	0.0029	0.41	0.2
Heptachlor	76448	Pesticide	0.068	0.38	31	0.0018	0.092	0.0007	0.68	0.4
Heptachlor Epoxide	1024573	Pesticide	0.00247	0.19	0.8	0.0033	0.0092	0.00035	0.018	0.2
Toxaphene	8001352	Pesticide	0.0001	1.6	NSL	0.013	NSL	0.0029	NSL	3
1,2,4-Trichlorobenzene	120821	SVOC	2.1	99	27	0.99	0.39	0.11	14	70
1,2-Dichlorobenzene	95501	SVOC	0.0165	NSL	980	NSL	28	NSL	120	600
1,2-Diphenylhydrazine	122667	SVOC	NSL	2.2	NSL	0.067	NSL	0.0039	NSL	NSL
1,3-Dichlorobenzene	541731	SVOC	4.43	NSL	NSL	NSL	NSL	NSL	NSL	NSL
1,4-Dichlorobenzene	106467	SVOC	0.599	12	2500	0.42	47	0.58	95	75
2,4,6-Trichlorophenol	88062	SVOC	0.213	160	62	3.5	0.9	0.29	1.4	NSL
2,4-Dichlorophenol	120832	SVOC	0.117	NSL	180	NSL	3.5	NSL	4.1	NSL
2,4-Dimethylphenol	105679	SVOC	0.029	NSL	1200	NSL	27	NSL	27	NSL
2,4-Dinitrophenol	51285	SVOC	NSL	NSL	120	NSL	3	NSL	2.7	NSL
2,4-Dinitrotoluene	121142	SVOC	0.0416	5.5	120	0.2	3	0.01	2.7	NSL
2,6-Dinitrotoluene	606202	SVOC	NSL	1.2	19	0.042	0.44	0.0021	0.41	NSL
2-Chloronaphthalene	91587	SVOC	NSL	NSL	8200	NSL	55	NSL	110	NSL
2-Chlorophenol	95578	SVOC	0.0312	NSL	510	NSL	7.1	NSL	6.8	NSL
2-Methyl-4,6-Dinitrophenol	534521	SVOC	NSL	NSL	4.9	NSL	0.12	NSL	0.11	NSL
2-Nitrophenol	88755	SVOC	NSL	NSL	NSL	NSL	NSL	NSL	NSL	NSL
3,3'-Dichlorobenzidine	91941	SVOC	0.127	3.8	NSL	0.11	NSL	0.007	NSL	NSL
3-Methyl-4-Chlorophenol	59507	SVOC	NSL	NSL	6200	NSL	110	NSL	140	NSL
4-Bromophenyl Phenyl Ether	101553	SVOC	1.23	NSL	NSL	NSL	NSL	NSL	NSL	NSL
4-Chlorophenyl Phenyl Ether	7005723	SVOC	NSL	NSL	NSL	NSL	NSL	NSL	NSL	NSL
4-Nitrophenol	100027	SVOC	NSL	NSL	NSL	NSL	NSL	NSL	NSL	NSL
Benzidine	92875	SVOC	NSL	0.0075	180	0.000092	4.6	0.000014	4.1	NSL
Bis(2-Chloroethoxy)Methane	111911	SVOC	NSL	NSL	180	NSL	4.6	NSL	4.1	NSL
Bis(2-Chloroethyl)Ether	111444	SVOC	NSL	1	NSL	0.012	NSL	0.0029		NSL
Bis(2-Chloroisopropyl)Ether	108601	SVOC	NSL	22	4100	0.31	55	0.045	54	NSL
Bis(2-Ethylhexyl)Phthalate	117817	SVOC	0.18	120	1200	4.8	31	0.23	27	6
Butylbenzyl Phthalate	85687	SVOC	10.9	910	12000	14	120	1.7	270	NSL
Diethyl Phthalate	84662	SVOC	0.603	NSL	49000	NSL	1100	NSL	1100	NSL
Dimethyl Phthalate	131113	SVOC	NSL	NSL	NSL	NSL	NSL	NSL	NSL	NSL
Di-n-Butyl Phthalate	84742	SVOC	6.47	NSL	6200	NSL	67	NSL	140	NSL
Di-n-Octyl Phthalate	117840	SVOC	NSL	NSL	620	NSL	16	NSL	14	NSL
Hexachlorobenzene	118741	SVOC	0.02	1.1	49	0.042	1.3	0.002	1.1	1
Hexachlorobutadiene	87863	SVOC	NSL	NSL	NSL	NSL	NSL	NSL	NSL	NSL
Hexachlorocyclopentadiene	77474	SVOC	NSL	NSL	370	NSL	2.2	NSL	8.1	50

TABLE 2.5

Project Screening Levels for Sediments, Soil, and Groundwater, Page 3 of 3

Analyte	CAS	Group	Sediment BTAG Screening Level[1] (mg/kg)	EPA Regional Screening Levels[2]						Maximum Contaminant Level (ug/L)
				Industrial Soil 1E-06 Carcinogenic Screening Level (mg/kg)	Industrial Soil HI 0.1 Noncarcinogenic Screening Level (mg/kg)	Residential Tapwater 1E-06 Carcinogenic Screening Level (ug/L)	Residential Tapwater HI 0.1 Noncarcinogenic Screening Level (ug/L)	Fish Tissue Carcinogenic Screening Level (mg/kg)	Fish Tissue Noncarinogenic Screening Level (mg/kg)	
Hexachloroethane	67721	SVOC	1.027	43	43	0.79	0.51	0.079	0.95	NSL
Isophorone	78591	SVOC	NSL	1800	12000	67	300	3.3	270	NSL
Nitrobenzene	98953	SVOC	NSL	24	120	0.12	1.1	NSL	2.7	NSL
N-Nitrosodimethylamine	62759	SVOC	NSL	0.034	0.49	0.00042	0.012	0.000062	0.011	NSL
N-Nitrosodi-n-Propylamine	621647	SVOC	NSL	0.25	NSL	0.0093	NSL	0.00045	NSL	NSL
N-Nitrosodiphenylamine	86306	SVOC	2.68	350	NSL	10	NSL	0.64	NSL	NSL
Pentachlorophenol	87865	SVOC	0.504	2.7	190	0.035	1.6	0.0079	6.8	1
Phenol	108952	SVOC	0.42	NSL	18000	NSL	450	NSL	410	NSL
1,1,1-Trichloroethane	71556	VOC	0.0302	NSL[3]	3800	NSL	750	NSL	2700	200
1,1,2,2-Tetrachloroethane	79345	VOC	1.36	2.8	2000	0.066	28	0.016	27	NSL
1,12-Trichloroethane	79005	VOC	1.24	5.3	0.68	0.24	0.041	0.055	5.4	5
1,1-Dichloroethane	75343	VOC	NSL	17	20000	2.4	290	0.55	270	NSL
1,1-Dichloroethylene	75354	VOC	0.031	NSL	110	NSL	26	NSL	68	7
1,2-Dichloroethane	107062	VOC	NSL	2.2	15	0.15	1.3	0.035	8.1	5
1,2-Dichloropropane	78875	VOC	NSL	4.7	7.1	0.38	0.83	0.088	120	5
1,2-Trans-Dichloroethylene	156605	VOC	1.05	NSL	69	NSL	8.6	NSL	27	100
1,3-Dichloropropylene	542756	VOC	0.0000509	8.3	33	0.41	3.8	0.032	41	NSL
2-Chloroethylvinyl Ether	110758	VOC	NSL	NSL	NSL	NSL	NSL	NSL	NSL	NSL
Acrolein	107028	VOC	NSL	NSL	0.065	NSL	0.0041	NSL	0.68	NSL
Acrylonitrile	107131	VOC	NSL	1.2	7.2	0.045	0.41	0.0058	54	NSL
Benzene	71432	VOC	NSL	5.4	45	0.39	2.9	0.057	5.4	5
Bromoform	75252	VOC	0.654	220	1200	7.9	29	0.4	27	NSL
Carbon Tetrachloride	56235	VOC	0.0642	3	60	0.39	4	0.045	5.4	5
Chlorobenzene	108907	VOC	0.00842	NSL	140	NSL	7.2	NSL	27	100
Chlorodibromomethane	124481	VOC	NSL	3.3	1200	0.15	29	0.038	27	NSL
Chloroethane	75003	VOC	NSL	NSL	6100	NSL	2100	NSL	NSL	NSL
Chloroform	67663	VOC	NSL	1.5	110	0.19	8.4	0.1	14	NSL
Dichlorobromomethane	75274	VOC	NSL	1.4	2000	0.12	29	0.051	27	NSL
Ethylbenzene	100414	VOC	1.1	27	2100	1.3	67	0.29	140	700
Methyl Bromide	74839	VOC	NSL	NSL	3.2	NSL	0.7	NSL	1.9	NSL
Methyl Chloride	74873	VOC	NSL	NSL	50	NSL	19	NSL	NSL	NSL
Methylene Chloride	75092	VOC	NSL	960	310	9.9	8.4	1.6	8.1	5
Tetrachloroethylene	127184	VOC	0.468	110	41	9.7	3.5	1.5	8.1	5
Toluene	108883	VOC	NSL	NSL	4500	NSL	86	NSL	110	1000
Trichloroethylene	79016	VOC	0.0969	6.4	2	0.44	0.26	0.069	0.68	5
Vinyl Chloride	75014	VOC	NSL	1.7	39	0.015	3.6	0.0044	4.1	2

1. US EPA Region III Biological Technical Assistance Group Freshwater Sediment Screening Benchmarks (August 2006)
2. US EPA Regional Screening Level Table, May 2013 version
3. NSL: No screening level is defined for the analyte

3.0 PRELIMINARY CONCEPTUAL SITE MODEL

This section discusses the preliminary conceptual site model (CSM) for sediments contamination in the tidal Anacostia River. A CSM is a functional description of what is known about an area of concern and the contamination known or suspected to be present. The CSM incorporates the available geologic, hydrogeologic, hydrologic, contaminant concentration, and environmental receptor data into an integrated understanding of site conditions. The CSM serves as the primary tool to identify data gaps and is updated as new data become available.

Figure 3.1 shows the general CSM for the sourcing and transport of hazardous constituents in the tidal Anacostia River and potential receptor exposure to these constituents. Contaminants enter the river via tributary inflow, sediment loading, groundwater seepage, and tidal mixing. Contaminants can also enter through direct spillage or wastewater discharges associated with former practices. Contaminants associated with suspended sediment may remain in suspended transport, desorb to surface water, or become deposited on the channel bottom. Deposited sediment may become re-suspended. Surface sediment contamination could result in low benthic species diversity and populations. Benthic organisms that do survive may bioaccumulate hazardous chemicals. Consumption of contaminated benthic fauna by lower tier forage fish could result in further bioaccumulation and disease in both lower tier forage fish and upper tier predatory species. Human exposure can result from contact with contaminated sediment and surface water and from the consumption of fish containing elevated concentrations of constituents of concern.

Section 3.1 discusses the physical elements of the CSM. Sections 3.2 and 3.3 present the ecological and human health-specific CSM elements, respectively.

3.1 Physical Conceptual Site Model

The physical CSM describes the physical processes through which contaminants enter each of the environmental media of concern, the fate and transport processes affecting the distribution of these contaminants, and the potential pathways for exposure to human and ecologic receptors. **Section 3.1.1** discusses the constituents of concern in the investigation. **Sections 3.1.2, 3.1.3, 3.1.4, and 3.1.5** discuss contaminant sources, release mechanisms, exposure media, and transport media, respectively. Watershed modeling that has been performed for the tidal Anacostia is discussed in **Section 3.1.6**.

3.1.1 Constituents of Potential Concern

The constituents of concern for this investigation consist of all VOC, SVOC, metals, pesticide, cyanide, and PCB Aroclor constituents included on the EPA Priority Pollutant List (**Table 3.1**). PCDDs/PCDFs will also be sampled but on a more limited basis. The EPA Priority Pollutant List is comprised of 126 constituents including 28 VOCs, 57 SVOCs, 18 pesticides, 14 metals, seven

PCB Aroclors, total cyanide, and 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). The 57 SVOCs include 16 PAHs which are further classified as being of low or high molecular weight (LPAHs and HPAHs, respectively). HPAHs are the 10 PAHs with four or more aromatic rings and include the carcinogenic PAHs (CPAHs).

A significant amount of sampling has already been conducted for many of the priority pollutant list constituents as reflected by the relatively extensive project database (**Section 2.6**). As will be discussed in the data gap identification portion of **Section 4**, however, additional sampling for priority pollutants is necessary to address uncertainties in the existing characterization. Concentration data are available for surface sediment, deep sediment, fish tissue, and benthic tissue. Previous sediment investigations in the Anacostia have shown that the primary contaminants that make the river unsafe for fishing or swimming are PCBs, PAHs, and selected metals and pesticides.

The priority pollutant list includes all the hazardous constituents whose presence in the river result in its Section 303(d) listing as an impaired water body. As discussed in **Section 2.2**, TMDLs have been established for polychlorinated biphenyls (PCBs), biochemical oxygen demand (BOD), bacteria, organics, metals, sediment, oil and grease, and trash.

3.1.2 Sources

Sources of hazardous constituents to the tidal river include surface water inflow, seepage of groundwater from contaminated sites that border the river, groundwater discharge via seepage into the sewer system, and the loading of contaminated sediments. The predominant sources for contaminated groundwater are likely the environmental cleanup sites (six of which are currently known) that border the river and have documented groundwater contamination issues (**Section 3.1.2.1**). Surface water and sediment sources include tributary streams, CSS outfalls, and storm sewer outfalls (**Section 3.2.2.2**).

Groundwater seepage is a potential source for the observed contamination in Anacostia River sediments. A groundwater modeling investigation of the Anacostia River watershed by Logan (1999) puts into context the potential contaminant contributions from groundwater. The model indicates that average groundwater seepage through the river bottom and from adjacent wetlands is small compared to tributary inflow. Northeast Branch and Northwest Branch are the two largest tributary streams to the tidal Anacostia River. According to Logan (1999) the estimated groundwater discharge to the Anacostia River was approximately 3.8×10^5 ft^3/day or two percent of the combined average discharge of Northeast Branch and Northwest Branch of 1.9×10^7 ft^3/day (average for the period 1938 – 2000 [Miller et al. 2007]). The small groundwater seepage contribution to the river’s discharge is a result of the low hydraulic conductivity of the clayey deposits that predominantly comprise the river bottom and adjacent floodplain.

3.1.2.1 Environmental Cleanup Sites

Contaminants may enter the Anacostia River from the contaminated sites that border the river. Contaminant entry pathways include erosion and transport of contaminated soil, contaminated runoff, and seepage of contaminated groundwater. **Table 3.2** lists the six environmental cleanup sites and the constituents of concern at each site for surface soil, subsurface soil, groundwater, sediments, and surface water. Each of these media could serve as a primary or secondary source of contamination for the site constituents of concern. A brief summary for each site follows. Background information including a summary of the sediment sampling results from previous investigations is provided for each site in **Section 2.6.2**.

Kenilworth Park Landfill. In comparison to the screening levels discussed in **Section 2.7**, surface and subsurface soils at this 130 acre site contain elevated concentrations of PAHs, PCBs and various pesticides and metals. Portions of the fill area directly contact the river or are within 100 feet of the riverbank. In general, the water table occurs in the landfilled wastes. Groundwater migrating through the wastes is contaminated by dissolution of constituents from the wastes and by downward migrating leachate from the overlying unsaturated wastes. Groundwater constituents include metals and various VOCs. Groundwater from the site discharges directly to the river (Ecology and Environment 2007a). A supplemental groundwater investigation will be conducted at this site in 2013.

Pepco Benning Road Facility. The 77-acre Pepco Benning Road facility contains several areas of known soil contamination. According to AECOM (2012), six petroleum USTs were either removed or closed in place. The potential exists that residual petroleum hydrocarbon contamination is present at these sites. In addition, excavation of PCB contaminated soil was conducted at several locations. Relative to the screening levels discussed in **Section 2.7**, residual elevated PCB levels may persist in soil at each location. In addition, elevated PAHs, PCBs, and metals have also been detected in a former sludge dewatering area. As a result of these issues, constituents of concern in soil, groundwater, sediment, and surface water at the Benning Road facility include VOCs, PAHs, PCBs, and metals.

CSX Benning Yard. The primary source of contamination at the CSX Benning Yard is groundwater contamination resulting from a subsurface diesel spill. Based on data provided in Geosyntec (2013a), a NAPL plume with an approximate area of 1.3 acres has resulted in discharge of contaminated groundwater to Fort Dupont Creek and, on occasion, the appearance of a petroleum hydrocarbon sheen in the creek. Downstream from Benning Yard, Fort Dupont Creek flows a distance of 806 feet through a 72-inch diameter reinforced concrete pipe (EnviroScience2013) to an outfall in the tidal Anacostia River. Site constituents of concern in soil include VOCs (benzene, toluene, ethylbenzene, and xylenes [BTEX]) and total petroleum hydrocarbons (TPH) diesel range organics (DRO). TPH DRO includes the range of LPAH and

HPAH priority pollutant compounds. Sediment sampling was conducted in Fort Dupont Creek and in the river near the Fort Dupont Creek outfall. Sediment (downstream from the spill area) and groundwater constituents include metals and PAHs, TPH DRO; SVOCs are also a concern in groundwater.

WGL East Station. The WGL East Station site is a 4.2 acre site with contamination typical for manufactured gas plant (MGP) sites. NAPL has been observed in the fill materials underlying the site. In addition, NAPL migration is currently being controlled and NAPL recovery is ongoing through the use of a pump and treat system. Groundwater discharge to the adjacent Anacostia River is controlled hydraulically through the operation of a pump and treat system. Constituents of concern (COCs) include a range of metals, selected VOCs, PAHs, and complex cyanides.

Poplar Point. A Phase I environmental site assessment (ESA) completed by Ridolfi Engineers (Ridolfi) (2003b) identified a number of recognized environmental conditions (RECs) at the Poplar Point Site. Ridolfi also completed site characterization sampling at the site in 2002 (Ridolfi 2003a). Sampling included soil, sediments, groundwater, and surface water. Soil samples were screened using the lowest screening level obtained from reviewing EPA Region 3 BTAGs, DC Risk-Based Screening Levels (residential and industrial), EPA Region 3 Risk-Based Concentrations (RBCs) (residential and industrial), and EPA Region 3 Site Screening Levels (SSLs) for Soil to Groundwater Migration (dilution attenuation factors 1 and 20). Sediment sampling results were compared to Region 3 BTAGs and National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQuiRTs) sediments screening levels (threshold and probable effects levels). Groundwater samples were screened against EPA maximum contaminant levels (MCLs), DC Groundwater Criteria, DC Risk-Based Screening Levels for Groundwater (residential and industrial), and EPA Region 3 RBCs for tap water.

Benzo(a)pyrene (BaP), 4,4’-DDT, arsenic, and diesel constituents where significantly elevated in some site soil samples. The elevated BaP concentrations were observed in portions of the site formerly used as a tree nursery while the pesticides exceedances primarily occurred near wetland areas. Several soil samples exceeded the total PCB (Aroclors) screening level including one taken adjacent to a wetland and another collected adjacent to a former garage. In addition, groundwater samples from a former burn pit and various former petroleum storage areas exhibited elevated concentrations of benzene, toluene, ethylbenzene, xylene, and methyl tert-butyl ether. Other groundwater contaminants detected above screening levels included metals, pesticides, PCBs, VOCs, and SVOCs. In addition to environmental investigation activities, abandoned drums and inactive underground and above ground storage tanks have been removed during previous site actions.

Washington Navy Yard. The Washington Navy Yard encompasses 63 acres and is located adjacent to the WGL East Station. Residual sediment present in since-renovated sewer lines at the site contained, in comparison to **Section 2.7** screening levels, elevated PCBs, PAHs, and metals. PCB contamination exists in several areas including the former power plant. Soil containing elevated lead concentrations originating from lead-based paint has been removed during cleanup of site soils. In addition, mercury contaminated soil was remediated at one location. Elevated arsenic and lead concentrations are widespread in site groundwater. Low-level chlorinated VOC plumes have been identified at various locations. Trichloroethene, cis-dichloroethene, trans-dichloroethene, and vinyl chloride concentrations are typically below or slightly above the respective drinking water maximum contaminant level (MCL) for each compound (**Section 2.7**). COCs in soils include VOCs, PAHs, non-PAH SVOCs, PCBs, pesticides, and metals. Metals and chlorinated VOCs are of concern in groundwater. Sediment constituents include metals, PCBs, and PAHs. Polychlorinated dibenzo-p-dioxins/furans (PCDD/Fs) were detected in site sediments but were not determined to be drivers of human health or ecological risk (CH2M Hill 2011).

3.1.2.2 Outfalls and Tributary Streams

With the exception of some isolated woodland areas which are mostly associated with parkland, the Anacostia watershed has been developed resulting in the covering of a high proportion of the land area with impervious surfaces (e.g., pavement in roads and parking lots, sidewalks, and residential/ commercial/industrial structures). As a result of reduced infiltration, surface water discharge from the outfalls and tributary streams to the Anacostia River is characterized by high sediment content and rapid velocities, particularly during storm events.

A large proportion of the contaminants contained in outflow and tributary discharge are associated with non-point source, low level “urban background” contamination levels present throughout the watershed. CSS outfalls, storm sewer outfalls, and tributary streams are all sources for this contamination.

PAHs, PCBs, pesticides, and metals are typical contaminants characteristic of urban background. PAHs are present in petroleum based fuels, lubricants, asphalt and combustion particles (soot) and are characteristic of the runoff from roads and other urban surfaces. Although widespread use of PCBs in electrical equipment and various other products was banned in 1976, these compounds persist as surface water and sediment contaminants. Pesticide contaminants originate from current and previous citywide pest management campaigns and from general household use of these compounds. Metals are present in native soils and can originate from other diverse sources. For example, historical use of leaded gasoline has caused elevated lead levels in surface soil in urban areas.

Combined Sewer System Outfalls. Significant sources of contaminated surface water and sediment to the tidal Anacostia River are the combined sewer system (CSS) outfalls operated by the District of Columbia Water and Sewer Authority (DC Water). Based on information obtained from the DC Water database, up to 16 CSS outfalls discharge or have discharged to the tidal river (**Figure 3.2**). Most of these outfalls are located in the lower Anacostia River, downstream from the CSX railroad bridge. DC Water indicates that 15 CSS outfalls currently discharge to the Anacostia River (DC Water 2012). **Table 3.3** summarizes the information available for each outfall included in the DC Water database. Each CSS outfall is permitted by EPA through the National Pollutant Discharge Elimination System (NPDES).

CSS outfalls discharge a mixture of sewage and storm water to surface water during high runoff periods such as a storm event. Under normal precipitation conditions, sewer capacity is sufficient to convey wastewater and runoff discharge volumes to a treatment facility (Blue Plains Advanced Wastewater Treatment Plant for the DC Water system). To avert flooding during a storm when the combined wastewater and storm water flows exceed the wastewater system capacity, CSS outfalls divert a mixture of raw sewage and storm water directly to the receiving surface water body, an event termed a CSS overflow. For the CSS outfalls that discharge to the tidal Anacostia River, sanitary flow capacity is exceeded even after moderate storm events. Combined discharge to the river occurs for precipitation events as low as 0.27 inches over a 24 hour period (AWTA 2002). Averaging about 82 releases per year, the Anacostia CSS outfall discharge volume equates to approximately 2.142 billion gallons of contaminated waste-water entering the river annually (AWTA 2002).

As shown on **Table 3.3**, drainage area data are available for some of the Anacostia CSS outfalls. Over 93 percent of the CSS outfall flow volume was contributed by two CSS outfalls: the Main and O Streets (NPDES 12) CSS outfall near the Washington Navy Yard and the Northeast Boundary Facility "Swirl Concentrator" CSS outfall (NPDES 019) (AWTA 2002). The drainage areas for these two CSS outfalls are 1,153.83 and 4,242.39 acres, respectively. For the 10 other CSS outfalls for which data are available, drainage areas range from 13.56 to 259.91 acres and average 94.89 acres.

In addition to the contaminant loading common for all outfalls and tributaries in the Anacostia watershed, CSS outfall discharges also degrade water quality by causing elevated levels of pathogenic bacteria and increased biological oxygen demand (BOD). Elevated BOD can result in oxygen-depleted zones unable to support aquatic life.

In accordance with a 2005 consent decree between EPA and DC Water, DC Water has developed a comprehensive plan called the Long Term Control Plan (LTCP). As part of this plan, DC Water initiated construction in 2011 on a tunnel and pumping system that will substantially reduce CSS outfall discharges (DC Water originally predicted a 98 percent reduction) by collecting and storing excess storm water flows for treatment at the Blue Plains facility (DC Water 2012). The 2005 consent decree has been the subject of recent discussion between EPA, DC Water, and the District, as the feasibility of modifying the consent decree to incorporate aggressive implementation of green infrastructure is under evaluation. Pending court-approved modification of the consent decree, the reductions and implementation schedule originally specified in the LTCP may change.

Storm Sewer Outfalls. Storm sewer outfalls (referred to herein as MS4 outfalls) solely discharge storm water runoff from the District's Municipal Separate Storm Sewer System (MS4) without contributions from the sanitary sewer system. Together with the CSS outfalls, the MS4 outfalls, drain the surrounding urbanized area that, prior to development, was drained by native streams. **Figure 3.2** shows the 60 MS4 outfalls that the DC Water database lists as tributary to the tidal Anacostia River. Also shown are 13 Prince George's County MS4 outfalls (labeled for the purposes of this report as "PG-TMP-#") preliminarily identified from available data. MS4 outfalls are present mostly south of Benning Road and are most numerous in the Anacostia River from South Capitol Street to the river mouth and in the Washington Channel. **Table 3.4** lists the MS4 outfalls that discharge to the tidal Anacostia River. The drainage areas for the MS4 outfalls are undefined in the DC Water database and in the available data for the Prince George's County outfalls. As shown in this table, several outfalls originate as surface streams including Stickfoot Creek, Fort Davis Creek, Texas Avenue Tributary, Fort Dupont Creek, and Fort Chaplin Creek.

Tributaries. Table 3.5 lists the 14 streams that are tributary to the tidal Anacostia River within the study area. The three largest tributaries are Northwest Branch, Northeast Branch, and Lower Beaverdam Creek which account for 45, 32, and 17 percent, respectively of the total flow of the river (Warner et al. 1997).

A number of investigations have been conducted to assess the relative contributions of contaminants from the tributaries to the tidal river. The results from a 1997 study of Northwest Branch and Northeast Branch indicated that Northeast Branch total and dissolved concentrations of trace metals were consistently higher than those observed in Northwest Branch (AWTA 2002). Miller et al. (2007) evaluated total and dissolved trace metal concentrations for Northwest Branch and Northeast Branch for the period 2003 through 2005. Results of this study indicated that similar metals concentrations were measured in each stream and that concentrations in both streams were similar to the Susquehanna River and other rivers in the U.S. Total arsenic, cadmium, and lead concentrations from Miller et al. (2007) are compared to the NOAA Screening Quick Reference Tables (SQuiRTs) chronic freshwater screening levels of 150, 0.25, and 2.5 µg/L, respectively (http://archive.orr.noaa.gov/book_shelf/122_NEW-SQuiRTs.pdf). Arsenic and cadmium average total concentrations are less than the screening level for both Northeast Branch and Northwest Branch. Average total concentrations for lead from both streams exceed the screening level. Average concentrations for arsenic, cadmium, and lead (total) for Northwest Branch were 1.4, 0.16, and 20 µg/L, respectively. Average concentrations for arsenic, cadmium, and lead in the Northeast Branch were 1.4, 0.16, and 14 µg/L, respectively.

Hwang and Foster (2008) monitored total and dissolved PCB concentrations in Lower Beaverdam Creek, Watts Branch, and Hickey Run for the period April 2002 through August 2002. Eighty-five PCB congeners were monitored in this study. Their results indicated that total PCBs (dissolved and particle-bound) were up to 80 times higher for storm flow in comparison to base flow concentrations and that more than 90 percent of the total PCB loading is associated with sediment particle transport. Dissolved phase concentrations were more enriched in the less chlorinated PCBs (e.g., PCB 28) relative to more chlorinated congeners (e.g., PCB 180). In addition, their results suggest that Lower Beaverdam Creek is a much more significant source of PCB contamination than are Northwest Branch and Northeast Branch. Compared to the SQuiRT surface water chronic screening level (0.014 µg/L), Lower Beaverdam Creek total PCB concentrations were lower for base flow (0.0118 µg/L) and elevated for storm flow (0.211 µg/L).

3.1.3 Release Mechanisms

Release mechanisms and the fate and transport of the various constituents of concern depend on the chemical properties of respective constituents.

The principal constituents of concern, PCBs, PAHs, pesticides, and metals, enter the Anacostia River primarily via the loading of contaminated sediments. These constituents, particularly metals, may also be present to some extent in the dissolved phase. As a result of the relatively low current velocity in the tidal Anacostia River, sediments delivered by outfalls and tributaries are size-differentiated with the coarser grained fractions forming bars and deltas at the entry point and the finer grained fractions remaining in suspension for continued transport. Fine suspended particles have a greater sorptive capacity than do coarse grained sediments because finer particles have greater surface area compared with their weight and volume. The greater surface area coupled with the organic carbon fraction present in the sediment (as discussed further in **Section 3.1.5**) provides for more sorptive capacity, i.e., the ability to gather contaminants through absorption and/or adsorption. PCBs, PAHs, and pesticides are hydrophobic and tend to sorb to fine sediments. Metals also sorb to varying degrees depending on the metal and ambient geochemical conditions (pH, oxidation potential [Eh], solubilities of associated ions, etc.). Hydrophobic compounds and metals are thus transported downstream with the suspended sediment. These constituents are then removed from the Anacostia River either by deposition in the lower portion of the estuary or exit with discharging surface water to the Potomac River, although, as suggested by the modeling discussed in **Section 2.5**, most suspended sediment is trapped in the Anacostia and deposited.

VOCs and LPAHs are also potential constituents of concern. These constituents have greater solubilities, are more volatile, and may be more vulnerable to degradation processes. VOCs and LPAHs may be released to the river via contaminated groundwater seepage from one of the environmental sites that border the river. Once exposed to the atmosphere or oxygenated surface water, the concentrations for VOCs and some LPAHs would be expected to decrease in the river system through volatilization or degrade through other processes.

3.1.4 Exposure Media

Contaminated media within the Anacostia River study area consist of surface water, surface sediment, deep sediment, fish tissue, and benthic tissue. Contaminated suspended sediments are likely an important medium for exposures of ecologic and human health receptors to PCBs, PAHs, pesticides, and metals. Upon deposition, suspended sediments also become a contaminant source for benthic organisms and to fish that feed on these organisms.

PCBs, PAHs, pesticides, and metals, though significantly elevated in the suspended phase particulate fraction, can also be present in the surface water dissolved phase (Gruessner et al. 1997). For example, Paul and Ghosh (2010) measured total PCB concentrations ranging up to 0.008 µg/L in Lower Beaverdam Creek. Total detected PCB congeners (57 measured) in Anacostia River water samples collected from mid water column near the O Street Outfall (adjacent to the Washington Navy Yard) averaged 0.005 µg/L (Horne Engineering 2003). Exposure, therefore, can occur through contact or ingestion of dissolved phase contaminants. An additional concern for surface water in the Anacostia River is human and ecologic exposure to pathogenic bacteria.

3.1.5 Transport Media and Mechanisms

The dominant transport medium for the constituents of concern is the downstream migration of contaminants sorbed to suspended sediment. The transport of hydrophobic organic chemicals such as PCBs, PAHs, and pesticides is likely controlled by the amount of organic matter present in the sediment. Greater organic concentrations (or organic carbon fraction [f_{oc}]) result in a greater capacity to accumulate hydrophobic compounds through sorption. Champ (1979) measured dissolved and particulate average yearly organic carbon concentrations of 2.81 and 5.02 mg/L near the South Capitol Street Bridge. Velinsky et al. (1999) observed that particulate organic carbon concentrations in the water column increased in the vicinity of Kenilworth Aquatic Center and the CSX Railroad Bridge and declined downstream from these areas. In a 2011 sampling of Anacostia River surface sediments from near the Fort Dupont Creek outfall, the most recent event for which data are available, EnviroScience (2013) measured the organic carbon fraction (foc) in 28 samples. The f_{oc} in these samples ranged from 0.13 to 70 and averaged 7.8 percent. Foster et al. (2000) measured f_{oc} concentrations in storm water particulates from the upper Anacostia River that ranged from three to 10 percent. Behm et al. (2003) assumed an foc value of nine percent for the purposes of sediment fate and transport modeling.

A number of environmental conditions including pH, biochemical controls, and redox state affect the partitioning of trace metals between sorbed and dissolved phases. Prestegaard et al. (2010) investigated lead, zinc, cadmium, and copper mobilization and deposition in the Anacostia watershed. Results of this investigation indicated that the upper tributaries receive sediments from both surface and stream bank erosion and that metals are transported in both the sorbed and dissolved phases. Sediment contamination with trace metals is highest at the river's mouth where most metals are present as sorbed species. Dissolved concentrations are low in the lower Anacostia River likely as a result of the high pH (7-9) of urban runoff conveyed in cement-lined channels to the lower watershed (Prestegaard et al. 2010).

3.1.6 Watershed Modeling

The Anacostia watershed has been the subject of several modeling studies dating back to the 1980s (Mandel and Schultz 2000). The Tidal Anacostia Model (TAM) was developed for the Metropolitan Washington Council of Governments in the late 1980s to evaluate CSS outfall abatement options and water quality management strategies for the watershed. The model included a hydrodynamic component for simulating flow velocities and tide heights and a water quality component for simulating dissolved oxygen dynamics and eutrophication. The TAM was based on the Hydrodynamic Ecosystem Model (HEM) developed by the Virginia Institute of Marine Science (Mandel and Schultz 2000). HEM is a one-dimensional hydrodynamic and water quality model developed to simulate small tidal embayments.

In 2000, EPA's Water Quality Analysis Simulation Program (WASP5) EUTRO model was incorporated into the TAM framework to simulate dissolved oxygen and eutrophication. The TAM/WASP Toxics Screening Level Model (TAM/WASP model) was completed in 2003 and included greater hydrodynamic resolution and the capability to simulate sediment quality and velocity-dependent deposition and resuspension of sediments. The model simulates daily changes in sediment concentrations in both the water column and the bed sediment by simulating the processes of advective transport, dispersive transport, deposition, and erosion. The TAM/WASP model was used to simulate loading, fate, and transport of zinc, lead, copper, arsenic, PCBs, PAHs, chlordane, heptachlor epoxide, dieldrin, and DDT in the tidal portion of the Anacostia River (Behm et al. 2003). In addition, the TAM WASP model was used to support District TMDL determinations for water quality parameters in the Anacostia River (DC Department of Health 2003).

Subsequent to the 2003 calibration, Kim et al. (2007) conducted an additional TAM/WASP assessment in support of Anacostia River watershed TMDL determinations for the Maryland Department of the Environment. They used the Hydrological Simulation Program – Fortran (HSPF) to simulate upland tributary sediment loading and updated the TAM/WASP model calibration using data from the three year period 1995 – 1997.

The TAM/WASP model results are summarized below for the modeling discussed in Schultz (2003) and Behm et al. (2003). The calibration period for the model was January 1, 1988 through December 31, 1990. In addition, this modeling considered the comprehensive sediment quality data set generated by the surface sediment sampling event conducted by the Academy of Natural Sciences in 2000.

Hydrodynamic Modeling and Simulation of Contaminant Loading. Consistent with the low flow velocities observed in the tidal Anacostia River, the model represents the estuary as a primarily depositional environment (Schultz 2003). For the calibration period, the modeled flow velocities are generally less than 0.1 m/sec in the portions of the channel near the head and mouth of the estuary. Flow velocities are moderately higher in the four mile channel reach beginning two miles downstream from the upper tidal limit (Schultz 2003). The model estimates that approximately 90 percent of the sediment entering the tidal river is deposited. Predicted accumulation rates are highest in the upper and lower portions of the river. The sedimentation rates are predicted to range from 0.6 to 3 cm/year for the upper portion of the estuary and 0.6 to 1.3 cm/year from 11th Street Bridge to the mouth of the river. As discussed in **Section 2.5**, sediment core analyses suggest that the estimated sedimentation rate in the Poplar Point vicinity (just upstream from the 11th Street Bridge ranges from 3 to 7 cm/year. In comparison to this result, the model estimate appears biased low.

Sediment transport model loading for the constituents of concern is required for the TAM/WASP model. Daily sediment load was specified in the model using measured or estimated flows and estimated sediment concentrations. Depending on the source, sediment loads were obtained from direct monitoring results, from streams with available data, or from modeling results. For PCBs, PAHs, and pesticide loading, concentrations were estimated from data collected for Northwest Branch and Northeast Branch. Data that were more outfall or tributary-specific were available for metals.

Contaminant Fate and Transport. The TAM/WASP model simulated spatial trends for metals and organic contaminants. A general increase in concentration of most constituents is predicted with distance traveled downriver. Overlaying this pattern are locally elevated areas that typically appear to correspond to an outfall or tributary entry point.

The TAM/WASP model indicated that the upstream tributaries are the predominant sources for metals found in the tidal river bed sediments (Behm et al. 2003). In addition, the model indicates that Lower Beaverdam Creek contributes a disproportionately high metals load to the tidal river.

The model estimates that two-thirds of the metals and PCBs that enter the tidal Anacostia River are deposited in the bed sediments. With regard to PAHs, the model predicts that approximately half of the inbound mass is deposited; for chlordane and heptachlor epoxide, the deposited amounts are 56 and 27 percent of the mass loadings, respectively (Behm et al. 2003).

3.2 Ecological Conceptual Site Model

The ecological CSM describes the processes that link contamination sources to ecological receptors through complete exposure routes in the study area. The ecological CSM for the current investigation is summarized in the following sections.

3.2.1 Previous Screening Level Ecological Risk Assessment

A screening level ecological risk assessment (SLERA) of the tidal Anacostia River conducted by Syracuse Research Corporation et al. (2000) serves as a starting point for the current analysis. The SLERA indicated that concentrations of chromium, lead, mercury, nickel, zinc, PAHs, PCBs, and several pesticides are sufficiently elevated in sediments in some reaches of the river to be harmful to benthic invertebrates. In addition, the 2000 SLERA indicated that elevated PAH concentrations pose a risk to fish. This SLERA provided a framework for the preliminary CSM for this RI.

3.2.2 Potential Ecological Receptors

Although the Anacostia River is a highly impacted urban river, a variety of ecological receptors exist within the project area. The tidal estuary is habitat for benthic and epibenthic invertebrates; pelagic and benthic fish; amphibians; shallow-water piscivorous and omnivorous birds; and carnivorous and omnivorous mammals. The distribution of these species within the project area is influenced by food supply, water depth and quality, current, shoreline habitat, and other features.

The primary exposure pathways for aquatic receptors are (1) ingestion of contaminated surface water, sediments, and food items and (2) direct contact with surface water and sediments. Benthic and epibenthic invertebrates and fish likely experience the greatest exposure as they are in near constant direct contact with sediment and water and tend to ingest contaminated food from a limited area. Higher trophic level receptors such as omnivorous and carnivorous birds and mammals are exposed principally through ingestion of contaminated plants and prey, sediment, and water. Contaminants may bioaccumulate in higher trophic level animals that consume prey that have ingested contaminants.

Fishes in the Anacostia River include typical mid-Atlantic freshwater resident fish species (such as sunfishes, catfishes, and American eel) , as well as anadromous runs of white perch, blueback herring, and alewife. Omnivorous and carnivorous birds that forage in the river include wading birds (herons and egrets), double-crested cormorant, osprey, and gulls. Omnivorous mammals known to forage in or near the river include river otter, mink, and raccoon.

Epibenthic invertebrates that likely contribute to contaminant transport from sediment to vertebrate predators include the introduced red swamp crayfish. Native and introduced freshwater clams as well as mussels likely occur in the river. The benthic community reflects the degraded water quality of the river from decades of industrial and urban activities, with low diversity, low abundance, and dominance by pollution-tolerant worms (AWTA 2002).

3.2.3 Potential Exposure Pathways

Benthic and epibenthic invertebrates and fish are potentially exposed to chemicals in the sediments through direct contact and ingestion. Important exposure routes for filter-feeding and particulate feeding bivalve invertebrates include ingestion of sediment and contaminated food particles, as well as direct contact with sediment, surface water, and pore water. Epibenthic invertebrates such as crayfish ingest sediment as well as prey that are closely associated with sediment. Like crayfish, benthic fish are exposed to chemicals through direct contact with sediments, incidental ingestion of sediment during feeding, and consumption of contaminated prey.

Pelagic fishes include both planktivorous species like the blueback herring (which is exposed predominately to water and the sediment and plankton suspended in it) and carnivorous species like the largemouth bass that consumes fish and crayfish. Carnivorous birds and mammals are exposed to bioaccumulative chemicals in the tissues of contaminated prey, such as fish and crayfish.

3.3 Human Health Conceptual Site Model

The human health risk assessment CSM describes the inputs of hazardous constituents to the river, the physical and chemical fate and transport processes for these constituents, and the human receptors and relevant exposure pathways. The human health CSM for the current investigation is summarized in the following sections. **Sections 3.3.1, 3.3.2, and 3.3.3** discuss a previously completed human health screening assessment, potential human receptors, and exposure pathways, respectively.

3.3.1 Previous Human Health Risk Screening

As was done for ecological risk, Syracuse Research Corporation et al. (2000) also performed a human health risk screening of sediment, surface water, and fish tissue from the tidal Anacostia River. The Syracuse screening will serve as a starting point for the current analysis. Based on conservative assumptions, the screening identified dioxins and furans, pesticides, PCBs, arsenic, cadmium, lead, and mercury as constituents of concern (COCs) for human consumption of fish tissue. COCs for direct contact with sediment were arsenic, PCBs, and PAHs; COCs for surface water (direct contact and incidental ingestion) were arsenic, PCBs, and various pesticides.

3.3.2 Potential Human Receptors

The Anacostia River flows through a heavily-populated section of the District. Potential human health risks associated with the river include ingestion of fish and direct contact with and incidental ingestion of sediment, surface water, and surface water-contaminated soil exposed along the river banks. Although warning signs are posted along the Anacostia River, subsistence fishing and human contact (related to various recreational activities) with media in and along the river is well documented.

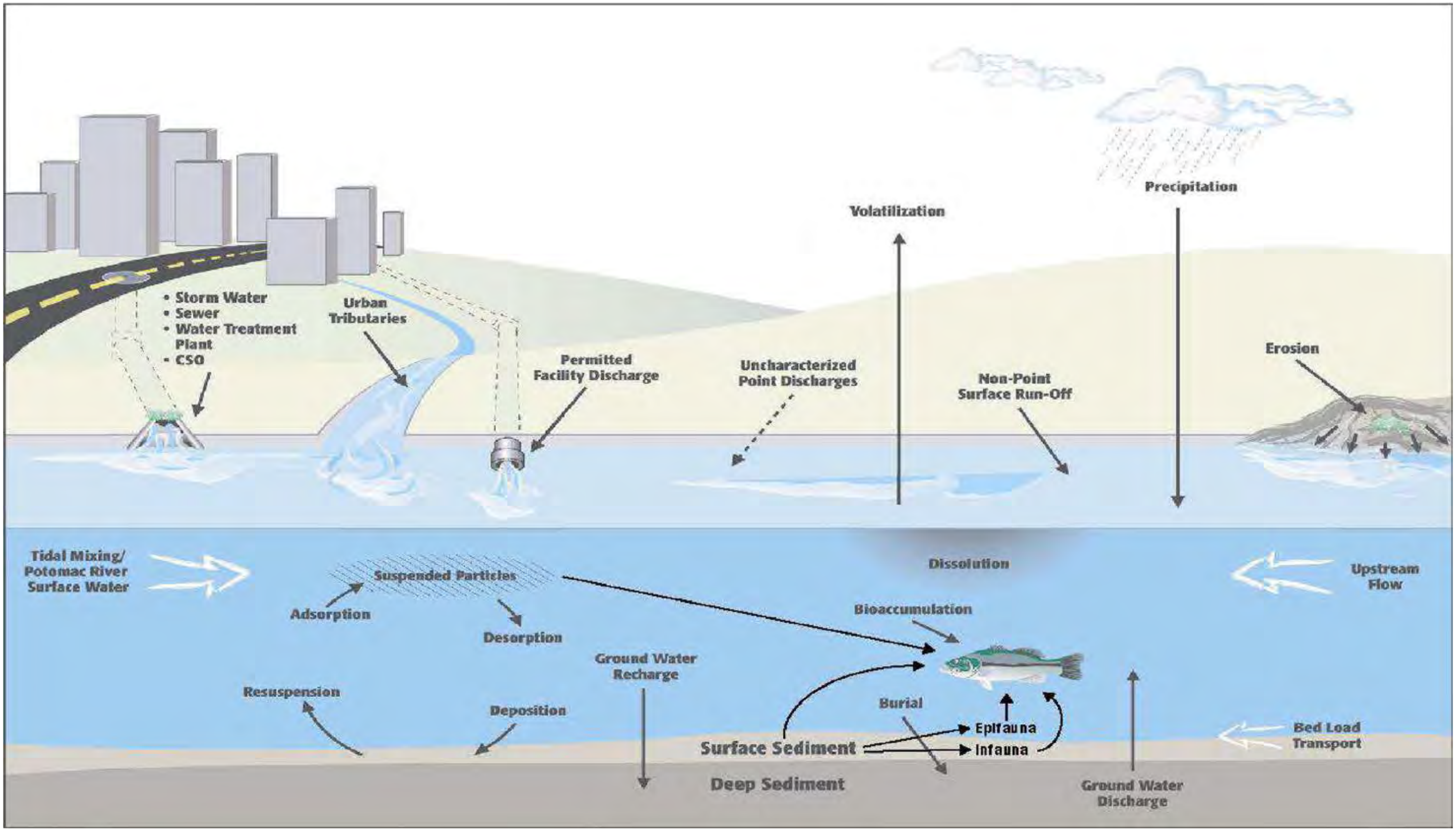
Since the late 1980's, there has been a fish consumption advisory in effect for the Anacostia for PCBs and pesticides. Liver tumors, most likely from exposure to PAHs, are also very common in bottom-dwelling fish, running as high as 56% in one study. This is evidence that elevated levels of toxics are present in the river environment and are entering the food chain (AWTA 2002).

In addition to subsistence anglers and recreational receptors, construction and utility workers may also be exposed. Specifically, workers engaged in construction and utility-related activities may be exposed to contaminated sediment, surface water, and soil.

3.3.3 Potential Exposure Pathways

The principal exposure pathway is recreational fishing of mid-level and top-level predator fish such as largemouth bass and channel catfish. Because these fish species have a relatively large home range, they have greater chance of accumulating contaminants from sources far from the location they are ultimately caught. Fishing locations tend to be near public access areas, such as parks, golf courses, and bridges. Although clams and other mollusks are known to inhabit the river, collection of these species for human consumption is not believed to be extensive.

Additional exposure pathways include direct contact with and incidental ingestion of contaminated sediment and surface water near the river's banks, as well as to soil that has been contaminated due to river flooding. Much of the existing shoreline on the Anacostia River is a public access park or other land used primarily for recreational purposes. This exposure could be in conjunction with fishing activity, or independent recreational activity. Construction and utility workers may be exposed while engaged in construction and utility installation and repair activities that require exposure to sediment, surface water, and soil within the banks of the Anacostia River.



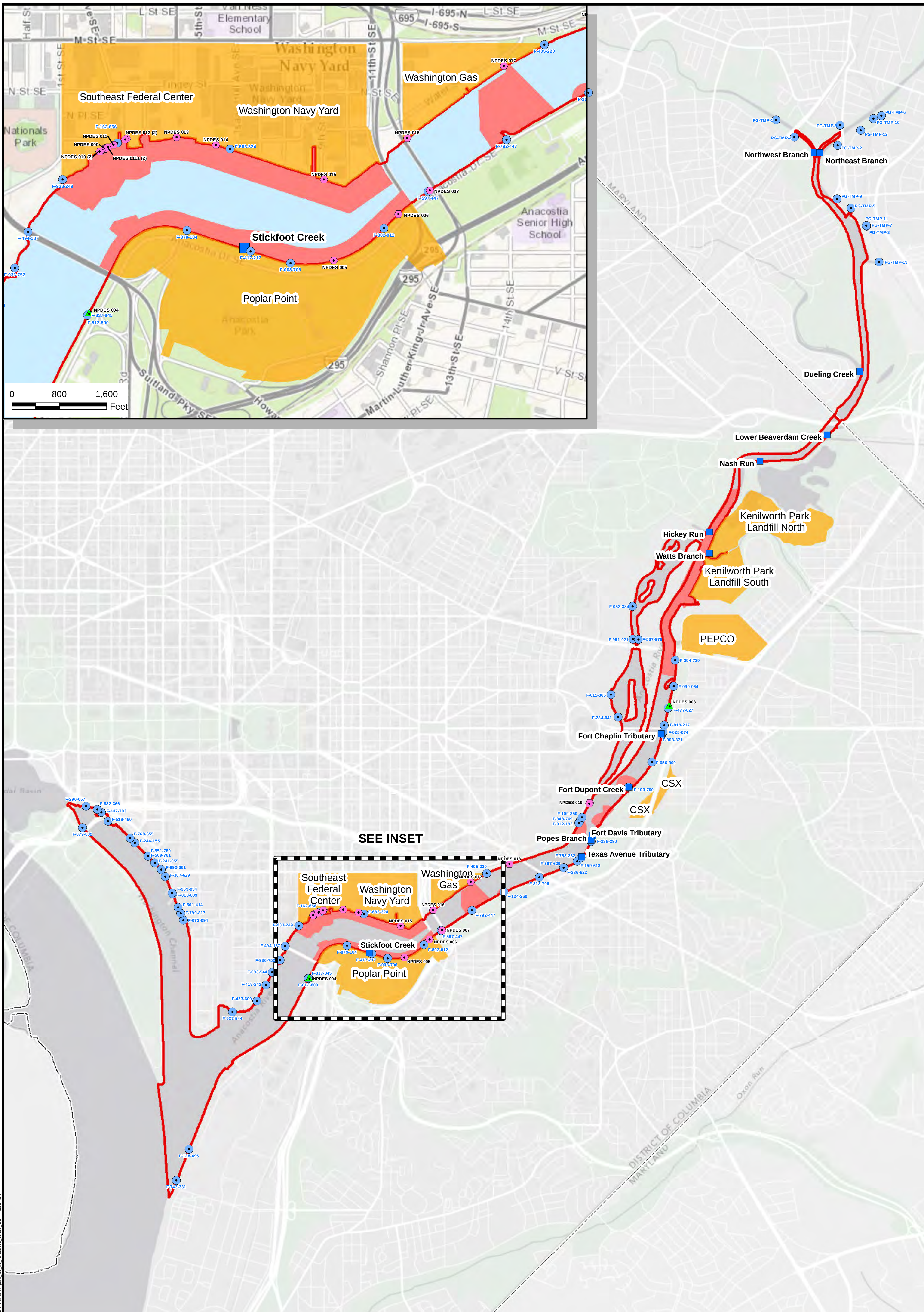
NOTE: FIGURE 3.1 WAS MODIFIED FROM FIGURE 2 OF THE UNDATED ANACOSTIA WATERSHED TOXICS ALLIANCE REPORT ENTITLED "CHARTING A COURSE TOWARD RESTORATION: A TOXIC CHEMICAL MANAGEMENT STRATEGY FOR THE ANACOSTIA RIVER."

DRAFT

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORK PLAN

FIGURE 3.1: ANACOSTIA RIVER CONCEPTUAL SITE MODEL

TETRA TECH



Legend

CSS OUTFALL	SEDIMENT STUDY AREA
EMERGENCY RELIEF OUTFALL	WASHINGTON DC BOUNDARY
MS4 OUTFALL	CLEANUP SITE BOUNDARY
TIDAL TRIBUTARY CONFLUENCE	AWTA AOC

DRAFT

N W E S

0 1,500 3,000 Feet

SOURCE: MODIFIED FROM CH2MHILL, 2011, AND DCGIS 2012, AND 2013.

ANACOSTIA RIVER SEDIMENTS REMEDIAL INVESTIGATION WORKPLAN

FIGURE 3.2
LOCATION OF OUTFALLS IN THE ANACOSTIA RIVER STUDY AREA

TETRA TECH

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TABLE 3.1
Priority Pollutant List

Constituent	Group	Constituent	Group	Constituent	Group	Constituent	Group	Constituent	Group
1,1,1-trichloroethane	VOC	1,2,4-trichlorobenzene	SVOC	Bis(2-chloroethoxy) methane	SVOC	4,4-DDD	Pesticide	Antimony	Metal
1,1,2,2-tetrachloroethane	VOC	1,2-dichlorobenzene	SVOC	Bis(2-chloroethyl) ether	SVOC	4,4-DDE	Pesticide	Arsenic	Metal
1,1,2-trichloroethane	VOC	1,2-diphenylhydrazine	SVOC	Bis(2-chloroisopropyl) ether	SVOC	4,4-DDT	Pesticide	Asbestos	Metal
1,1-dichloroethane	VOC	1,3-dichlorobenzene	SVOC	Bis(2-ethylhexyl) phthalate	SVOC	Aldrin	Pesticide	Beryllium	Metal
1,1-dichloroethylene	VOC	1,4-dichlorobenzene	SVOC	Butyl benzyl phthalate	SVOC	Alpha-BHC	Pesticide	Cadmium	Metal
1,2-dichloroethane	VOC	2,4,6-trichlorophenol	SVOC	Chrysene	SVOC	Alpha-endosulfan	Pesticide	Chromium	Metal
1,2-dichloropropane	VOC	2,4-dichlorophenol	SVOC	Dibenzo(,h) anthracene	SVOC	Beta-BHC	Pesticide	Copper	Metal
1,2-dichloropropylene	VOC	2,4-dimethylphenol	SVOC	Diethyl Phthalate	SVOC	Beta-endosulfan	Pesticide	Lead	Metal
1,2-trans-dichloroethylene	VOC	2,4-dinitrophenol	SVOC	Dimethyl phthalate	SVOC	Chlordane	Pesticide	Mercury	Metal
2-chloroethyl vinyl ethers	VOC	2,4-dinitrotoluene	SVOC	Di-N-Butyl Phthalate	SVOC	Delta-BHC	Pesticide	Nickel	Metal
Acrolein	VOC	2,6-dinitrotoluene	SVOC	Di-n-octyl phthalate	SVOC	Dieldrin	Pesticide	Selenium	Metal
Acrylonitrile	VOC	2-chloronaphthalene	SVOC	Fluoranthene	SVOC	Endosulfan sulfate	Pesticide	Silver	Metal
Benzene	VOC	2-chlorophenol	SVOC	Fluorene	SVOC	Endrin	Pesticide	Thallium	Metal
Bromoform	VOC	2-nitrophenol	SVOC	Hexachlorobenzene	SVOC	Endrin aldehyde	Pesticide	Zinc	Metal
Carbon tetrachloride	VOC	3,3-dichlorobenzidine	SVOC	Hexachlorobutadiene	SVOC	Gamma-BHC	Pesticide	2,3,7,8-TCDD [1]	Dioxin
Chlorobenzene	VOC	4,6-dinitro-o-cresol	SVOC	Hexachlorocyclopentadiene	SVOC	Heptachlor	Pesticide	Cyanide, Total	Cyano
Chlorodibromomethane	VOC	4-bromophenyl phenyl ether	SVOC	Hexachloroethane	SVOC	Heptachlor epoxide	Pesticide		
Chloroethane	VOC	4-chlorophenyl phenyl ether	SVOC	Indeno (1,2,3-cd) pyrene	SVOC	Toxaphene	Pesticide		
Chloroform	VOC	4-nitrophenol	SVOC	Isophorone	SVOC	PCB–1016 (Arochlor 1016)	PCB		
Dichlorobromomethane	VOC	Acenaphthene	SVOC	Naphthalene	SVOC	PCB–1221 (Arochlor 1221)	PCB		
Ethylbenzene	VOC	Acenaphthylene	SVOC	Nitrobenzene	SVOC	PCB–1232 (Arochlor 1232)	PCB		
Methyl bromide	VOC	Anthracene	SVOC	N-nitrosodimethylamine	SVOC	PCB–1242 (Arochlor 1242)	PCB		
Methyl chloride	VOC	Benzidine	SVOC	N-nitrosodi-n-propylamine	SVOC	PCB–1248 (Arochlor 1248)	PCB		
Methylene chloride	VOC	benzo(a) anthracene	SVOC	N-nitrosodiphenylamine	SVOC	PCB–1254 (Arochlor 1254)	PCB		
Tetrachloroethylene	VOC	Benzo(a)pyrene	SVOC	Parachlorometa cresol	SVOC	PCB–1260 (Arochlor 1260)	PCB		
Toluene	VOC	Benzo(b) fluoranthene	SVOC	Pentachlorophenol	SVOC				
Trichloroethylene	VOC	Benzo(ghi) perylene	SVOC	Phenanthrene	SVOC				
Vinyl chloride	VOC	Benzo(k) fluoranthene	SVOC	Phenol	SVOC				
				Pyrene	SVOC				

Notes:
1. 2,3,7,8-TCDD refers to 2,3,7,8-Tetrachlorodibenzo-p-dioxin

TABLE 3.2
Summary of Constituents of Concern Associated with Potentially Responsible Party Sites along the Anacostia River Study Area, Page 1 of 3

Site	Site Constituents of Concern				
	Surface Soil	Subsurface Soil	Groundwater	Sediments	Surface Water
CSX Benning Yard [1] (Reference: Geosyntec 2013a, Geosyntec 2013b; EnviroScience 2013)	Priority pollutant metals, PAHs, PCB Aroclors, pesticides, VOCs, Total petroleum hydrocarbons diesel-range organics (TPH-DRO), Total petroleum hydrocarbons gasoline-range organics (GRO-DRO)	Priority pollutant metals, PAHs, PCB Aroclors, pesticides, VOCs, Total petroleum hydrocarbons diesel-range organics (TPH-DRO), Total petroleum hydrocarbons gasoline-range organics (GRO-DRO)	As, Ba, Cd, Cr, Fe, Pb, Hg, Se, Ag, Priority pollutant PAHs, 4,4'-DDD, 4.4'-DDE, 4,4'-DDT, alpha chlordane, gamma-BHC, BTEX[5] and selected VOCs, selected SVOCs	Priority pollutant metals, PAHs, PCB Aroclors, pesticides, VOCs, Total petroleum hydrocarbons diesel-range organics (TPH-DRO), Total petroleum hydrocarbons gasoline-range organics (GRO-DRO)	Priority pollutant metals, PAHs, PCB Aroclors, pesticides, VOCs, Total petroleum hydrocarbons diesel-range organics (TPH-DRO), Total petroleum hydrocarbons gasoline-range organics (GRO-DRO)
Kenilworth Park North & South Landfills (Reference: Ecology and Environment, 2007a)	Al, Sb, As, Cd, Cu, Fe, Pb, Hg, Ag, Tl, V Aroclor 1254 Aroclor 1260 Dieldrin gamma- Chlordane Benz(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Dibenzo(a,h)anthracene Indeno(1,2,3-c,d)pyrene	Al, Sb, As, Cd, Cu, Fe, Pb, Mn, Hg, Ag, Tl, V Aroclor 1242 Aroclor 1248 Dieldrin Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Dibenzo(a,h)anthracene Indeno(1,2,3-c,d)pyrene	Al, As, Ba, Cd, Cr, Fe, Pb, Sb Benzene Chloroform 1,4-dichlorobenzene Methylene chloride	Al, As, Fe, Tl, V Aroclor 1254 Benz(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene Dibenzo(a,h)anthracene Indeno(1,2,3-c,d)pyrene	Surface water impacts to be further evaluated in conjunction with the shallow groundwater (OU2) remedial investigation
Pepco Benning Road Facility [2] (Reference: AECOM, 2012)	VOCs, TPH, 16 PAH Priority Pollutants, Metals (Pb, Cu, Ni, V, Zn), PCBs, Pesticides, Dioxins/Furans	VOCs, TPH, PAHs, Semi-volatile organic compounds (SVOCs), Metals, PCBs, Pesticides, Dioxins/Furans	VOCs, TPH, 16 PAH Priority Pollutants, SVOCs, Metals, PCBs, Pesticides, Dioxins/Furans	VOCs, TPH, 16 PAH Priority Pollutants, Metals, PCBs, Pesticides, Dioxins/Furans	VOCs, TPH, 16 PAH Priority Pollutants Metals, PCBs, Pesticides

TABLE 3.2
Summary of Constituents of Concern Associated with Potentially Responsible Party Sites along the Anacostia River Study Area, Page 2 of 3

Site	Site Constituents of Concern				
	Surface Soil	Subsurface Soil	Groundwater	Sediments	Surface Water
Poplar Point Site (Reference: Ridolfi, 2003)	As Benzo(a)pyrene 4,4'-DDT TPH-DRO	As, Pb Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(g,h,i)perylene Benzo(k)fluoranthene Chrysene Dibenzo(a,h)anthracene Fluoranthene Indeno(1,2,3-c,d)pyrene 4,4'-DDE TPH-DRO Pyrene Total PCBs	As, Mn, Pb Benzene Methyl tertiary-butyl ether TPH-DRO, TPH-Gasoline range organics (GRO), TPH-Motor range organics (MRO) Vinyl chloride	As, Cd, Ni, Pb Benzo(a)anthracene Benzo(a)pyrene Benzo(g,h,i)perylene Benzo(k)fluoranthene Chrysene 4,4'-DDD 4,4'-DDE 4,4'-DDT Dibenzo(a,h)anthracene Dieldrin Fluoranthene Phenanthrene Pyrene Total PCBs	Cu, Mn. Zn Benzene
Washington Gas East Station [3] (Reference: Ecology and Environment, 2006)	Coal tar and wastes from production of town gas Al, Ar, Sb, Be, Cd, Cr, Cu, Co, Fe, Pb, Mn, Hg, Ni, Se, Ag, Th, V, Zn Benzene, ethylbenzene, toluene, xylenes (total) 16 PAH Priority Pollutants, 2-Methylnapthalene Complex cyanides	Coal tar and wastes from production of town gas Al, Ar, Sb, Be, Cd, Cr, Cu, Co, Fe, Pb, Mn, Hg, Ni, Se, Ag, Th, V, Zn Benzene, ethylbenzene, toluene, xylenes (total) 16 PAH Priority Pollutants, 2-Methylnapthalene Complex cyanides	Coal tar and wastes from production of town gas Al, Ar, Sb, Be, Cd, Cr, Cu, Co, Fe, Pb, Mn, Hg, Ni, Se, Ag, Th, V, Zn Benzene, ethylbenzene, toluene, xylenes (total) 16 PAH Priority Pollutants, 2-Methylnapthalene Complex cyanides	Coal tar and wastes from production of town gas 16 PAH Priority Pollutants Di(ethylhexyl) phthalate Dibenzofuran	Al, Hg, Pb

TABLE 3.2
Summary of Constituents of Concern Associated with Potentially Responsible Party Sites along the Anacostia River Study Area, Page 3 of 3

Site	Site Constituents of Concern				
	Surface Soil	Subsurface Soil	Groundwater	Sediments	Surface Water
Washington Navy Yard [4] (Reference: CH2MHILL, 2011)	VOCs, SVOCs, PAHs, Metals, PCBs, Pesticides, Dioxins/Furans, Explosives	VOCs, SVOCs, PAHs, Metals, PCBs, Pesticides, Dioxins/Furans, Explosives	As, Fe, Hg Cis and trans-dichloroethene Trichloroethene Vinyl Chloride	As, Cr, Pb Aroclor-1260 Benzo(a)pyrene Non-dioxin like PCBs	Ag, Ba, Fe, Mn

Notes:

1. Listed constituents are those tested for as indicated in the referenced documents.
2. Information obtained from the July 2012 Remedial Investigation and Feasibility Study (RI/FS) Work Plan.
3. COCs for each media are based upon chemicals identified in Tables 4 and 5 of the August 2006 Record of Decision.
4. COCs for surface soil, subsurface soil, and groundwater are based on summary of contamination discussion given in the referenced document.
5. BTEX: benzene, ethylbenzene, toluene and xylene.

TABLE 3.3
Summary of Combined Sewer and Sanitary Sewer Outfalls Located in the Anacostia River Study Area

Name	Reach	X-Coordinate[1]	Y-Coordinate[1]	Type	Drainage Area (Acres)	Location Description
NPDES 004	S. Capital St. - Mouth	133205.054	399602.366	Sanitary	0	Howard Rd and Robbins Rd. S.E.
NPDES 005	11th St. - S. Capital St.	133413.428	400586.399	Combined	65.51	Across from Navy Yard, aligned with Parsons Ave, S.E.
NPDES 006	11th St. - S. Capital St.	133599.515	400846.748	Combined	13.56	Good Hope Rd and Welsh Memorial Bridge, S.E.
NPDES 015	11th St. - S. Capital St.	133737.646	400546.666	Combined	30.82	On Navy Yard property, aligned with 9th and M Sts, S.E.
NPDES 010	11th St. - S. Capital St.	133849.849	399646.535	Combined	0	Main St./O St. P.S., S.E.
NPDES 009	11th St. - S. Capital St.	133859.62	399665.495	Combined	41.27	Main St./O St. P.S., S.E.
NPDES 011	11th St. - S. Capital St.	133876.525	399702.348	Combined	0	Main St./O St. P.S., S.E.
NPDES 014	11th St. - S. Capital St.	133876.629	400113.344	Combined	128.06	On Navy Yard property, aligned with 6th and M Sts, S.E.
NPDES 012	11th St. - S. Capital St.	133897.86	399747.866	Combined	1153.83	Main St./O St. P.S., S.E.
NPDES 013	11th St. - S. Capital St.	133907.087	399955.436	Combined	20.1	In S.E. Federal Center, aligned with 4th Street S.E.
NPDES 007	Penn. Ave. - 11th St.	133694.349	400972.278	Combined	188.13	Between 11th St. and Anacostia Bridges, S.E.
NPDES 016	Penn. Ave. - 11th St.	133904.223	400882.603	Combined	152.58	12th and O Streets S.E.
NPDES 017	Penn. Ave. - 11th St.	134192.206	401269.196	Combined	259.91	M and Water Sts, S.E.
NPDES 018	Penn. Ave. - 11th St.	134376.57	401669.63	Combined	48.93	Barney Circle and PA Ave., S.E.
NPDES 019	E. Capitol St. - CSX	134997.934	402490.267	Combined	4242.39	Adjacent to Service Drive behind Swirl facility and D.C. General
NPDES 008	Benning Rd. - E. Capital St.	136008.902	403310.148	Sanitary	0	Anacostia and Blaine, N.E.

1. Coordinates in North American Datum of 1983, Maryland State Plane, feet

TABLE 3.4

Summary of Storm Sewer Outfalls Located in the Anacostia River Study Area, Page 1 of 2

Name	Reach	X-Coordinate[1]	Y-Coordinate[1]	Tributary
F-073-094	Washington Channel	133796.18	398309.658	
F-799-817		133867.853	398280.685	
F-561-414		133926.963	398255.513	
F-018-809		134065.278	398198.211	
F-969-934		134077.656	398193.076	
F-307-629		134245.649	398123.103	
F-892-361		134317.906	398080.032	
F-241-055		134385.913	398013.434	
F-569-761		134454.928	397944.758	
F-551-780		134456.855	397942.835	
F-246-155		134591.425	397809.423	
F-768-655		134640.411	397760.547	
F-879-832		134747.344	397269.151	
F-518-460		134815.94	397531.58	
F-882-366		134905.039	397466.046	
F-447-703		134937.83	397421.78	
F-290-057		134970.651	397305.349	
F-743-331	S. Capital St. - Mouth	131117.653	398235.236	
F-128-495		131436.97	398366.81	
F-937-544		132852.043	398816.767	
F-433-609		132963.956	399064.03	
F-418-242		133129.35	399158.92	
F-812-800		133194.83	399597.02	
F-837-845		133199.349	399599.383	
F-093-544		133261.07	399223.55	
F-936-752		133383.68	399305.13	
F-494-187		133528.302	399357.799	
F-008-706	11th St. - S. Capital St.	133403.27	400412.22	
F-417-217		133450.869	400252.029	Stickfoot Creek
F-879-104		133533.987	399996.365	
F-802-012		133542.22	400788.63	
F-933-249		133737.66	399497.153	
F-683-324		133859.944	400169.665	
F-162-656		133883.144	399716.967	
F-597-447	11th ST. CSX Bridge	133689.571	400964.898	
F-792-447		133896.58	401279.96	
F-124-260		134085.078	401609.111	
F-818-706		134237.788	401975.282	
F-405-220		134277.25	401433	
F-336-622		134334.815	402224.97	
F-367-629		134335.66	402228.069	
F-758-282		134403.983	402365.714	
F-159-618		134438.39	402405.07	Texas Avenue Tributary
F-238-290		134607.906	402509.276	Fort Davis Creek

TABLE 3.4

Summary of Storm Sewer Outfalls Located in the Anacostia River Study Area, Page 2 of 2

Name	Reach	X-Coordinate[1]	Y-Coordinate[1]	Tributary
F-012-192	E. Capital St. - CSX	134795.42	402382.51	
F-109-350		134811.38	402391.89	
F-348-769		134853.81	402414.87	
F-193-790		135166.51	402892.63	Fort Dupont Creek
F-656-309		135423.69	403133.29	
F-819-217		135717.01	403243.18	Fort Chaplin Tributary
F-903-371		135732.523	403251.299	Fort Chaplin Tributary
F-025-074	Benning Rd. - E. Capital St.	135803.068	403261.969	
F-477-827		135979.318	403303.321	
F-090-064		136204.359	403359.691	
F-294-739		136472.252	403374.215	
PG-TMP-1	Upper Tidal Limit - Benning Rd.	1326820.022	465993.0663	Prince George's County Storm Water Outfalls
PG-TMP-2		1328895.366	465129.5874	
PG-TMP-3		1329879.272	462401.0984	
PG-TMP-4		1327439.272	465411.5353	
PG-TMP-5		1329345.272	463017.7232	
PG-TMP-6		1330376.272	466138.9725	
PG-TMP-7		1329876.522	462414.6296	
PG-TMP-8		1328981.522	465816.3163	
PG-TMP-9		1328882.147	463321.2856	
PG-TMP-10		1330109.459	466036.41	
PG-TMP-11		1329873.772	462427.7857	
PG-TMP-12		1329680.522	465645.0663	
PG-TMP-13		1330302.313	461189.1609	
F-567-976	Kingman Lake	136687.73	402996.71	
F-991-021		136690.93	402938.98	
F-052-384		137027.24	402937.78	
F-284-041		135889.347	402785.807	
F-611-365		136120.31	402713.5	

1. Coordinates in North American Datum of 1983, Maryland State Plane, feet

TABLE 3.5
Summary of Anacostia River Study Area Tidal Tributary Confluences, Page 1 of 2

Tributary Name	X-Coordinate	Y-Coordinate	Approximate Drainage Area (units as shown)	Watershed Land Use Characteristics
Northwest Branch[1, 4, 7]	-76.944	38.943	53 sq. mi.	Northeast and Northwest Branches comprise approximately 72% of the total drainage area for the watershed
Northeast Branch[1, 4, 7]	-76.944	38.943	76 sq. mi.	
Lower Beaverdam Creek[1, 4, 8]	-76.943	38.917	15.7 sq. mi.	Approximately 58% resdiential or commercial areas, 32% forested or park areas, 5% agricultural, and 4% industrial
Watts Branch[1, 4, 8]	-76.957	38.906	3.8 sq. mi.	Approximately 80% urban residential and commercial areas, 15% forested, and 5% light industrial property. Approximately 47% of the watershed is in DC with the remainder in Maryland.
Hickey Run[1, 4, 8]	-76.957	38.908	1.8 sq. mi.	Approximately 20% forest or U.S. Department of the Interior parkland; remainder of the watershed includes residential, commercial, and industrial areas, including railroad easements and a large bus parking and maintenance yard
Nash Run[1, 5, 8]	-76.951	38.915	460 acres	Approximately 95% urban residential and commercial areas drained by storm drains; Approximately two-thirds of the watershed is located in DC, remainder is in Deanwood Park, Prince George's County
Fort Dupont Creek[1, 5, 8]	-76.967	38.884	376 acres	Primary headwater receives urban runoff from residential areas; majority of the stream is buffered on both sides by forested parkland
Fort Chaplin Tributary[1, 5, 8]	-76.963	38.889	270 acres	90% Residential / 10% Parkland; Generally buffered by 200 feet of forest on each side
Popes Branch[1, 5, 8]	-76.971	38.880	249 acres	Approximately 85% residential and light commercial areas and 15% forested parkland; Fed by headwaters from many storm sewer lines

TABLE 3.5
Summary of Anacostia River Study Area Tidal Tributary Confluences, Page 2 of 2

Tributary Name	X-Coordinate	Y-Coordinate	Approximate Drainage Area (units as shown)	Watershed Land Use Characteristics
Fort Stanton Tributary[3, 5, 8]	-76.983	38.875	180 acres	Approximately 50% National Park Service parkland and 50% residential and commerical areas
Texas Avenue Tributary[1, 5, 8]	-76.972	38.878	110 acres	Approximately 60% residential and light commercial areas and 40% forested parkland; Fed by a network of storm water pipes
Fort Davis Tributary[1, 5, 8]	-76.971	38.879	70 acres	Approximately 50% forested National Parkland and 50% urban residential
Stickfoot Creek[2, 6, 8]	-76.997	38.869	367 acres	30 to 70% impervious
Dueling Creek[2]	-76.939	38.922	no data	no data

Notes:

1. Coordinates (Word Geographic System 1984 decimal degrees) obtained by utilizing the District of Columbia Online Maps Listing website (July 2013):
   http://octo.dc.gov/DC/OCTO/Maps+and+Apps/Online+Mapping/All+Online+Maps
2. Coordinates (World Geographic System 1984 decimal degrees) estimated from aerial photography
3. Coordinates (World Geographic System 1984 decimal degrees) obtained from US EPA website
   http://iaspub.epa.gov/tmdl_waters10/attains_waterbody.control?p_list_id=DCTFS01R_00&p_cycle=2010&p_report_type=
4. Drainage area obtained from http://www.anacostia.net/subwatershed.html#
5. Drainage area obtained from DDOE (2012)
6. Drainage area obtained from EA Engineering, Science, and Technology, Inc. (2006)
7. Watershed land use characteristics obtained from Kim et al. (2007)
8. Watershed land use characteristics obtained from D.C. Dept. of Health, Environmental Health Admin., Bureau of Environmental Water Quality Division (2003)

4.0 WORK PLAN RATIONALE

This section defines and provides justification for the data quality objectives (DQO) that will govern the collection and use of data in the RI and NRDA, describes the existing information on the nature and extent of contamination in each of the environmental media of concern, and identifies data gaps for each medium and pathway. The sampling approaches for sediments, benthic invertebrates, and fish are broadly described; some aspects of sampling will be determined based on conditions encountered at each sample location. Preliminarily defined sediment management areas are also discussed in this section.

4.1 Data Quality Objectives

DQOs are qualitative and quantitative statements that clarify investigation objectives, define the appropriate types of data to collect, determine the appropriate conditions from which to collect the data, and specify acceptable decision errors associated with each sampling approach. The DQOs for the RI and NRDA are defined in **Section 4.1.1**. The supporting DQO development process is discussed in **Section 4.1.2**.

The data collected will support the objectives of this WP which are to determine the nature and extent of contaminated environmental media and assess the associated risk to human health and the environment, conduct the sampling required for an NRDA, and characterize general site conditions sufficient for the performance of the FS. Previous sampling completed in the Anacostia River has been concentrated near environmental sites where known releases have occurred. Additional surface and subsurface sediment sampling is necessary to confirm current concentrations of constituents in sediment (which may or may not validate prior results); identify potential sources of COCs in sediment; and evaluate the potential for risk to human health and the environment. Additional data are also required to support the NRDA process and provide information needed to assess remedial options in a FS, including development of preliminary remedial goals (PRG).

4.1.1 Data Quality Objective Statement

The following DQOs were developed for this investigation:

- Characterize environmental conditions within the study area and refine the CSM,
- Update existing datasets from previous investigations in the study area so that current nature and extent of impacts can be defined,
- Identify potential site-wide or site-specific sources of COCs in sediment and surface water,
- Improve characterization of the sediments at the storm drain system and tributary network outfalls and the Anacostia River,

- Generate a dataset sufficient for updating and revising the existing watershed model,
- Assess the human health and ecological risks associated with elevated levels of contaminants in surface sediment, subsurface sediment, surface water, sediment pore water, benthic invertebrate tissue, and fish tissue,
- Characterize site environmental media sufficient to support a NRDA, and
- Characterize site environmental media sufficient to support development and evaluation of remedial alternatives and PRGs.

Several analytical levels of data quality available to achieve the DQOs are designated as follows:

- **Level I** – Field screening or analysis using portable instruments, calibrated to non-compound-specific standards,
- **Level II** – Field analysis using portable instruments, calibrated to specific compounds,
- **Level III** – USEPA recommended performance based methodologies such as those outlined in EPA SW-846,
- **Level IV** – USEPA Contract Laboratory Program (CLP) Routine Analytical Services (RAS) methods, and
- **Level V** – Other internationally-recognized and/or non-standard analytical methods.

Field-screening data will be used to better understand the depth of the water column, better understand the configuration of the river bottom and identify the presence of potential utilities in the proposed investigation area.

Field screening data will be used as part of a weight-of-evidence approach in conjunction with laboratory data and geologic information to delineate impacts in the context of the CSM (see **Section 3.0**). Additionally, field screening and observations will be used by the field team to evaluate and adjust sampling depths and locations as needed. This approach to the field investigation is a key component of this dynamic work plan.

Field screening activities will be conducted under Level I data quality protocol. Field measurements [i.e., pH, temperature, turbidity, x-ray fluorescence (XRF)] will be completed under Level II data quality protocol. Samples submitted for fixed-base laboratory analysis and accredited on-site mobile laboratory will be analyzed, at a minimum, under Level III data quality protocol. Level IV or V could be applied for specialty methods such as high resolution PCB analysis or forensic analysis.

4.1.2 Data Quality Objective Development Process

The DQOs for the study area were developed using the EPA's DQO process, a multi-step, iterative process that ensures that the type, quantity, and quality of environmental data used in the decision making process are appropriate for its intended application. Each of the seven steps of the process is discussed in **Table 4.1** (below) with respect to the development of specific DQOs for the Anacostia River contaminated sediments project.

TABLE 4.1
DATA QUALITY OBJECTIVES

STEP 1: State the Problem
• The release of hazardous substances into the Anacostia River has the potential to adversely impact human health and the environment, including natural resources. A RI/FS and NRDA are required to evaluate risks to the environment and human health and to verify a potential injury, respectively.
• Based on prior sediment sampling completed in the Anacostia River, several COCs, including PCBs, PAHs, pesticides, and metals, were detected at concentrations above regulatory criteria or toxicological benchmarks. Previous sampling in the Anacostia River was concentrated near environmental areas of concern along the banks of the river. Additional sampling is necessary to validate past sampling, identify potential sources of COCs in sediment, and evaluate the potential for risk to human health and the environment.
STEP 2: Identify the goals of the study
• The primary goal of the remedial investigation is to determine, for human health and the environment, the current risk and potential future risk posed by the Anacostia River. This will first involve verifying or updating past surface sediment analytical results, obtaining additional data to complete the spatial coverage of the site, and identifying potential sources of COCs in the sediment. Measures of direct and indirect toxicity and bioaccumulation of contaminants by organisms is necessary to complete the risk assessment portion of the RI.
• A second goal is to gather information on historical, current, and ongoing injury to natural resources to support the NRDA process.
• A third goal is to gather information to support the FS.
• A fourth goal is to initiate the development of data that can be used to support efforts to update the TAM/WASP model or the development of alternative sediment modeling tools.
STEP 3: Identify information inputs
• The ERA and HHRA process will require measuring concentrations of priority pollutants in sediment (surface and sub-surface), sediment pore water, and surface water from within the study area. Results of specialized analyses, such as PCB congeners, dioxins and furans, and acid-volatile sulfide/simultaneously extracted metals (AVS/SEM), will be completed on a subset of the sediment samples. Some surface sediment samples will be tested using laboratory bioassays to assess direct risk to benthic invertebrates. Results of fish and invertebrate tissue sample analyses will be used in the ERA and HHRA (as appropriate).
• The NRDA process will require all of the data collected for the RI. Data interpretation varies between the RI and NRDA, but the same results are used.
• The FS will require the results of the bathymetric and utility survey and sediment geotechnical results as well as the data collected for ERA, HHRA, and NRDA to develop remedial alternatives to address risk and injury. Data available from the six environmental sites identified in the river will be evaluated as part of the overall characterization of the river.

STEP 4: Define the boundaries of the study
• The study area is the Anacostia River in Washington, D.C extending from the confluence with the Potomac River to the division into the northeast and northwest branches in Prince George's County, Maryland. The study area includes the Washington Channel (see **Figure 1.1**). The investigation will primarily address sediment conditions within an area of the Anacostia River approximately 700 acres in size and 9 miles in length. The project area is divided into nine sediment management units: Reaches 1-7, Reach KL (Kingman Lake) and Reach WC (Washington Channel) (**Figure 4.1**). Six environmental sites within the Anacostia River are being address by others (see **Section 2**). The results of environmental investigations conducted at these sites will be incorporated into the investigation as they become available.
STEP 5: Develop the analytical approach
• Sediment sample results will be used to characterize the vertical and lateral nature and extent of contamination and assess risk to ecological and human health receptors. Subsurface sediment sampling horizons will be determined in the field and sediment samples from each horizon will be collected. Samples from up to three horizons within each core will be selected for immediate analyses; the remaining sample horizons will be archived for potential future analysis. Surface water and sediment pore water sample results serve as indicators of direct exposure and uptake by benthic invertebrates and as evidence of potential transfer of contaminants from the sediment to other organisms in the aquatic ecosystem. • Sediment, surface water, and sediment pore water data will be analyzed by EPA or equivalent methods. Samples will be analyzed for a broad range of constituents including priority pollutant VOCs, SVOCs, metals, PCB Aroclors, pesticides, and dioxins. Selected samples will also be analyzed for PCB congeners and alkylated PAHs. The analytical data for the sediment samples will be compared to Region 3 benchmarks. Tissue concentrations in field-collected invertebrates and fish serve dual purposes, as indicators of direct exposure and lifetime accumulation by organisms and as evidence of potential transfer of contaminants from the sediment (and water) to other organisms in the aquatic ecosystem. Fish will be collected along the river at various locations suitable for human and ecological exposure. Although fish tissue concentrations cannot be tied to a particular sediment location because fish move throughout the area, tissue concentrations are useful in estimating ingested doses of chemicals to animals (and people) that eat fish. Specific locations and analytical requirements for each sample are shown in **Tables 5.1 and 5.2**. The ERA and HHRA will use the sediment, pore water, surface water, and tissue data to calculate risks. The data collected will also be used to develop remedial goals for the site. If new potential sources of contaminants or hotspots are identified, additional sampling may be warranted.
• Geotechnical analyses of surface and subsurface samples will contribute to the FS. Results from analyzing grain size and other physical parameters will be used to assess the feasibility of dredging, dewatering, capping, and other potential remedies.
STEP 6: Specify performance or acceptance criteria
• The data quality indicators for screening and definitive data are defined in terms of the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters. The assessment of the data quality indicators is necessary to determine data usability and involves the evaluation of the PARCC parameters. To ensure the quality and integrity of the project data, the precision and accuracy of the analysis, the representativeness of the results, the completeness of the data, the comparability of the data to existing data will be evaluated. Data that meet the DQOs and fulfill project goals will be deemed acceptable. Data that do not meet objectives and goals will be reviewed on a case-by-case basis to ascertain its usefulness. To limit errors made based upon analytical data,

	the reporting limits (practical quantitation limits) for target analytes will be established at a level at least one half the applicable screening level whenever technically feasible. In general, statistical analysis will not be used to determine decision error tolerance limits.
•	Sediment, pore water, surface water, and tissues will be analyzed by EPA or equivalent methods. Sediment toxicity tests will follow ASTM methods. All data will be validated by a subject-matter expert and the data's usability assessed.
•	Survey information will be collected by a licensed surveyor with experience in bathymetric surveying. Survey information will be compared to previous surveys to verify that the elevations and other survey information are reasonable. Geotechnical data will be analyzed by ASTM or equivalent methods.
•	The specific criteria for the PARCC parameters will be determined in the Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) to be developed. As part of the RI, historic data will be assessed against the criteria to determine usability for the various aspects of the RI (ERA, HHRA, nature and extent, updating the TAM/WASP model, and other analyses)
STEP 7: Develop the plan for obtaining data	
•	Sampling will be dynamic and tailored to the conditions observed in the field. A bathymetric and utility survey will be completed to provide a basis for understanding the depth of the water column and the configuration of the river bottom and will be used to prepare a contour map of the top of the sediment surface in and around the investigation areas. Samples of environmental media will be collected from various locations within the study area. (See Figures 5-1 and 5-2). Sediment sampling locations defined in this plan may be revised based on geomorphic evaluation of the bathymetric survey results. Sediment, surface water, and sediment pore water samples will be collected over a multi-week period.
•	Various types of sampling equipment will be used to gather the required samples. Surface sediment samples will be collected for laboratory-based toxicity testing (i.e., bioassays) using either the amphipod (*Hyalella azteca*) or midge (*Chironomus dilutus*). At half of the surface sediment sampling locations (opportunistically selected as described in **Section 5.1**), benthic invertebrates will be collected in the field for analysis of body burdens (bioaccumulation). Fish sampling locations were selected to provide spatial coverage of all reaches of the river within the Study Area. Within each reach of the river, sample locations were biased toward outfalls, inlets, and areas with known fishing piers. Backwater areas were also targeted. Sample collection locations may be shifted in the field to accommodate logistical requirements of the selected sample collection methods.
•	Geotechnical data required for the assessment of potential remedial actions will be collected at sediment sampling locations. Grain size information will be obtained at every sediment sampling location. Bulk density, moisture content, and Atterberg Limits will be obtained from 20% of the sediment sampling locations. Geotechnical samples will be collected in conjunction with sediment samples collected for chemical analysis. Additional utility and debris survey information deemed relevant to the FS will be collected in the field.

As discussed in **Section 2.6**, previous sediment studies in the Anacostia River were reviewed for use in the current RI. During initial scoping meetings with DDOE and a review of historical databases, Tetra Tech determined that to ensure sufficient spatial coverage of the tidal Anacostia study area, the available sediment data collected since 2000 (with some minor exceptions as noted in **Section 2.7**) and thus including the comprehensive ANS 2000 sampling, will be used for identifying data gaps and defining new sampling locations. Other considerations regarding data usability are discussed **Section 2.7**.

Additional sampling is required to confirm current chemical concentrations in sediment, verify past surface sediment results, and update and expand tissue results to support the ERA, HHRA, and NRDA. The additional data will also provide representative spatial coverage of the site and support identification of potential sources of COCs in the sediment and biota. The additional data will also be used to support the FS and development of PRGs. An assessment of data gaps is provided in **Section 4.2.7**.

4.2 Nature and Extent of Contamination

This section summarizes the existing information regarding the nature and extent of contamination in each environmental medium considered in this investigation. To assist in the evaluation of the existing data, the study area was subdivided into nine channel reaches (**Figure 4.1**). The channel reach descriptions and associated two-character identifier are listed below.

- Washington Channel (WC)
- Mouth of River to South Capitol Street Bridge (R1)
- South Capitol Street Bridge to 11th Street Bridge (R2)
- 11th Street Bridge to CSX Bridge (R3)
- CSX Bridge to East Capitol Street Bridge (R4)
- East Capitol Street Bridge to Benning Road Bridge (R5)
- Benning Road Bridge to Amtrak Bridge (New York Avenue) Bridge (R6)
- Amtrak Bridge (New York Avenue) to Upper tidal limit (R7)
- Kingman Lake (KL)

The existing data assessment consisted of spatially reviewing the distribution of sampling points for each medium by sample year and data source. In addition, the data were evaluated regarding spatial coverage. For constituents with site-wide coverage, plots were constructed to review the numbers of constituents analyzed for each of the major constituent groups including PCB congeners, LPAHs, HPAHs, pesticides, and metals. The available data for some constituent groups such as PCB Aroclors, PCDDs, and PCDFs were highly localized primarily to the Washington Navy Yard and/or the CSX environmental cleanup sites. These constituent groups, therefore, were not included in the spatial data review.

For each of the channel reaches, the available data were reviewed with regard to spatial coverage, entry points for each CSS outfall, SSO, and tributary stream, and resampling of pre-existing locations. Visually-evident patterns or trends within each reach were assessed with a focus on LPAHS, HPAHs, total PCB congeners, and trace metals. Geographic information system (GIS) shapefiles were developed to facilitate concurrent review of multiple constituents. With a site aerial photo as background, the GIS allowed the review of the existing concentration data and the identification of channel areas with observable geomorphologic features (e.g., sediment deltas and bars).

4.2.1 Surface Sediment

Although coverage is somewhat variable by constituent group, metals, PAHs, PCBs, and pesticides in surface sediment have been sampled at numerous locations throughout the tidal Anacostia River. Comparatively better coverage exists in the Anacostia River than in the Washington Channel. To provide an overview of the nature and extent of contamination in surface sediment, LPAH, HPAH, total PCBs, and chlordane concentrations are shown on **Figures 4.2 to 4.5**, respectively. In addition, concentrations for aluminum, arsenic, cadmium, copper, chromium, lead, mercury, nickel, selenium, and zinc are shown on **Figures 4.6 to 4.15**, respectively.

In the following discussion, the general trend in the observed surface sediment distribution is discussed followed by an assessment of specific concentration ranges. Overall, the concentration distributions exhibited consistent trend characteristics from the upstream tidal limit to the lowermost reach from South Capitol Street Bridge downstream to the mouth. Most constituents in the lowermost reach of the Anacostia are at relatively lower concentrations, possibly related to the influence of the Potomac River (this area is referred to below as the Potomac mixing zone). Upstream from the lowermost tidal reach, constituent concentration trends in surface sediments can be grouped as follows:

- Increasing downstream: a generally increasing trend with distance down-river. Localized hotspots with much higher concentrations overlay this general trend, primarily near outfalls and adjacent upland environmental cleanup sites.
- Elevated without observable trend: concentrations are in general elevated everywhere and show no observable trends; localized hotspots exist near some outfalls and upland environmental cleanup sites.
- Data are insufficient to assess trends: the sampling distributions for several of the reviewed constituents were too sparse to assess general trends.

In addition, the term "elevated" is used where appropriate to characterize the observed concentrations. Concentrations are considered elevated if they exceed the EPA Region 3 BTAG freshwater sediment benchmarks screening levels shown in **Table 2.5**. However, the concentrations noted as elevated in this discussion may be below effects-based levels if other less conservative benchmarks were used. Although the BTAG levels are very conservative, they provide an appropriate initial reference for comparison.

- **LPAHs.** LPAHs concentrations are non-trending in most of the tidal Anacostia River. A general reduction in concentration is observed from the South Capitol Street Bridge to the mouth and in Washington Channel (**Figure 4.2**). For the sampled locations, LPAH concentrations typically range from 300 to 4,400 µg/kg. Below South Capitol Street and in the Washington Channel, concentrations range from 300 to 1,700 µg/kg. LPAH concentrations appear elevated in the vicinity of the O Street Outfall and the Washington Navy Yard. Concentrations in these areas range up to 21,000 µg/kg. Concentrations in the 1,700 to 2,600 µg/kg range are observed in the reach from the AmTrak/New York Avenue bridges to the upstream tidal limit of the study area.
- **HPAHs.** The HPAH concentration trend is similar to that described above for LPAHs –no observable trend in the river upstream from the South Capitol Street Bridge and a general reduction downstream from the South Capitol Street Bridge to the mouth and in Washington Channel (**Figure 4.3**). HPAH concentrations typically range from 4,400 to 13,000 µg/kg. Downstream from South Capitol Street Bridge, the concentrations range from approximately 4,400 to 8,500 µg/kg. Concentrations generally exceed 8,500 µg/kg from the Washington Navy Yard to the upper tidal limit of the study area with higher concentrations observed at the O Street Outfall (up to 52,300 µg/kg) and locally in the vicinity of some of the sewer outfalls and tributary confluences. Outfall F-819-217 and Hickey Run are examples.
- **PCBs.** Total PCBs, calculated by summing all congener concentrations measured at a given location, are shown on **Figure 4.4**. Since the ANS 2000 sampling is the most spatially comprehensive, most PCB sampling results available are based on the ANS 2000 list of 81 congeners. PCB concentrations are non-trending and elevated throughout the study area. Concentrations typically range from 34 to 500 µg/kg. Two sampling points from Kingman Lake yielded concentrations of 300 and 500 µg/kg. Maximum total PCBs range from 2,600 to 6,500 µg/kg and are localized to the O Street outfall and the Washington Navy Yard.
- **Pesticides.** Beta-chlordane is an indicator pesticide constituent that is of concern in the tidal Anacostia River. The District and the Metropolitan Washington Council of Governments issued a fish consumption advisory in part because of elevated chlordane concentrations in fish tissue (Syracuse Research Corporation 2000). **Figure 4.5** shows the distribution of beta-chlordane in surface sediments. In general, beta-chlordane is elevated and non-trending (concentrations ranging from less than 0.17 to 30 µg/kg) from the upper tidal limit to the vicinity of the Washington Navy Yard and Poplar Point. In the channel reach opposite from these two sites, detected concentrations typically range from 15 to 70 µg/kg. Below the South Capitol Street Bridge beta-chlordane concentrations fall to the 10 to 15 µg/kg range. Beta-chlordane data is unavailable for the river mouth vicinity and for the Washington Channel.

- **Metals.** Ten metals that have been relatively widely sampled in shallow sediment from the river include aluminum, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc.
- **Aluminum. Figure 4.6** shows the distribution of aluminum concentrations in surface sediment. From the upstream tidal limit to the Washington Navy Yard, aluminum concentrations are non-trending and range from 2,800 to 44,600 mg/kg. Maximum concentrations occur near the O Street outfall (in the range from 56,000 to 94,600 mg/kg), in the Washington Channel, in the lowermost reach of the Anacostia, and at the Washington Channel confluence.
- **Arsenic. Figure 4.7** shows the distribution of arsenic concentrations in surface sediment. Arsenic was not included in the group of metals analyzed in the 2000 ANS sampling effort and consequently the arsenic sampling distribution is of insufficient density for the assessment of general trends. The maximum concentrations (25 to 90 mg/kg range) observed occur opposite from the Fort Dupont Creek outfall and at the MS4 outfall F-294-739 located south of the Benning Road Bridge. Elevated concentrations in the range of 20 to 25 mg/kg are present in the O Street outfall/Washington Navy Yard vicinity.
- **Cadmium. Figure 4.8** shows the distribution of cadmium concentrations in surface sediment. Cadmium concentrations are non-trending throughout the study area, including the lowermost reach of the tidal Anacostia River and Washington Channel. Any reduction in the Potomac mixing zone is muted relative to most other metals. Concentrations generally range from 1.0 to 2.6 mg/kg. The maximum concentrations range from 2.0 to 8.0 mg/kg and occur at the O Street outfall, the eastern portion of the Navy Yard, opposite from the Fort Dupont Creek outfall, and at the MS4 outfall F-294-739 located south of the Benning Road Bridge.
- **Chromium. Figure 4.9** shows the distribution of chromium concentrations in surface sediment. Chromium exhibits a general increasing trend in concentration downstream to the Potomac mixing zone. Concentrations appear elevated (87 to 114 mg/kg range) in the reach extending between the confluence with Dueling Creek downstream to the New York Avenue bridge. From New York Avenue downstream to the WGL site, concentrations are generally below the BTAG level (43.4 mg/kg) with the exception of several isolated samples and an exceedance cluster at the mouth of Fort Dupont Creek. From WGL to the Potomac mixing zone, concentrations are elevated ranging up to 169 mg/kg. The maximum chromium concentrations encountered are at the O Street outfall and range between 141 and 169 mg/kg.
- **Copper. Figure 4.10** shows the distribution of copper concentrations in surface sediment. Copper exhibits an increasing trend in concentration downstream to the Potomac mixing zone where there is a reduction. From the upper tidal limit downstream to Benning Road, concentrations typically range from 5.0 to 30 mg/kg and increase to

the range of 30 to 90 mg/kg in the reach from Benning Road to the vicinity of the WGL site. From this point south to the Potomac mixing area, concentrations range from 60 to 120 mg/kg. Localized hotspots exist at the O Street outfall (350 – 900 mg/kg) and in the small embayment/wetland area bordering Kenilworth Park South Landfill.

- **Lead. Figure 4.11** shows the distribution of lead concentrations in surface sediment. Lead concentrations are elevated (ranging from 35 to 100 mg/kg) but appear non-trending from the upper tidal limit to the vicinity of the Fort Dupont Creek outfall south of the East Capitol Street Bridge. Below Fort Dupont Creek, samples with concentrations ranging from 100 to 200 mg/kg increase in frequency. From the Washington Navy Yard south to the Potomac mixing zone, a further increase in the number of samples in the 100 to 200 mg/kg range suggest the continuation of a general increasing trend in this portion of the river. The maximum lead concentrations, in the range from 500 to 1,000 mg/kg occur adjacent to the O Street Outfall and the Washington Navy Yard.
- **Mercury. Figure 4.12** shows the distribution of mercury concentrations in surface sediment. Mercury concentrations appear to increase with distance downstream from the upper tidal limit. Upstream from the Benning Road Bridge, concentrations ranged from 0.009 to 0.4 mg/kg; downstream from this point, concentrations are typically elevated and range from 0.18 to 0.4 mg/kg. Any reduction in the Potomac mixing zone is muted relative to most other metals. Maximum concentrations occur at the O Street outfall and Washington Navy Yard (3.0 to 10 mg/kg). Elevated concentrations also exist in the vicinity of the Fort Dupont Creek outfall (0.4 to 0.9 mg/kg).
- **Nickel. Figure 4.13** shows the distribution of nickel concentrations in surface sediment. Nickel exhibits a general increasing trend in concentration downstream to the Potomac mixing zone. Upstream from the Kenilworth Park Landfills, concentrations range from 0.2 to 64 mg/kg. Below this point to the vicinity of the WGL site, levels increase to the 23 to 64 mg/kg range. From WGL to the Potomac mixing zone, concentrations range between 47 and 100 mg/kg. The maximum nickel concentrations encountered are at the O Street outfall and range between 100 and 149 mg/kg.
- **Selenium. Figure 4.14** shows the distribution of selenium concentrations in surface sediment. Selenium was not included in the group of metals analyzed in the 2000 ANS sampling effort and consequently the sampling distribution is of insufficient density for the assessment of general trends. The maximum concentrations (5 to 12 mg/kg range) occur in the in the O Street outfall vicinity. Selenium was detected in the range of 0.3 to 1.6 mg/kg range near the Fort Dupont Creek outfall.
- **Zinc. Figure 4.15** shows the distribution of zinc concentrations in surface sediment. Zinc concentrations are generally elevated and show an increasing trend from the upper tidal limit downstream to the Potomac mixing zone. Concentrations typically range from 17 to 280 mg/kg to the vicinity of the Pepco site, below which, the general range increases

to between 120 and 400 mg/kg. Downstream from the Poplar Point and the Washington Navy Yard, the range increases to 280 to 400 mg/kg. The maximum zinc concentrations are in the range of 900 to 1,800 mg/kg and occur in the vicinity of the O Street outfall.

4.2.2 Subsurface Sediment

Within the study area, subsurface sediment sampling is limited to two general locations (**Figure 4.16**), the Washington Navy Yard and in the vicinity of the Fort Dupont Creek outfall, downstream from CSX Benning Yard. For both investigations, subsurface samples were collected via vibracoring drilling methods.

Washington Navy Yard. CH2M Hill (2011) describes the characterization of subsurface sediments at the Washington Navy Yard. Sampling was conducted at 34 locations within and near the pier area to depths ranging from 10 to 12 feet (middle depth) to approximately 20 feet (deep depth) below the river bottom. The historical dredge depth at the Washington Navy Yard is -22 feet below mean sea level. The middle depth and deep depth samples correspond to the interval above the typical dredging depth versus the interval representing older fluvial sediments.

- **VOCs.** VOCs were analyzed in deep sediments and were infrequently detected. Four compounds, including benzene, carbon disulfide, and cis-1,2-dichloroethene were detected at concentrations ranging from 1 and 15 µg/kg in a sample collected near DC CSS outfall 15. A concentration of 1,200 µg/kg for vinyl chloride was measured in this sample while VOCs were non-detect in a sample taken from the same depth at a lateral distance of approximately 50 feet away. The available data thus indicate that given the 34 locations sampled, elevated occurrences of VOCs, though observed, are relatively isolated.
- **PAHs.** Total PAHs calculated as the sum of the 16 priority pollutant PAHs in middle depth samples ranged from 1,362 to 92,280 µg/kg with a mean concentration of 20,349 µg/kg. Middle depth samples were elevated with respect to surface and deep zone samples. The most elevated concentrations were measured near the DC CSS outfall 15, near Washington Navy Yard outfalls, and immediately downstream of the neighboring WGL East Station site. Total PAH concentrations were generally lower and more often below detection levels in the deep sediments. Deep sediment total PAHs ranged from 320 to 27,719 and averaged 6,212 µg/kg. The most elevated concentrations were observed near facility outfalls.
- **Pesticides.** The most frequently detected pesticides included 4,4'-DDD, 4,4'-DDE, alpha-chlordane, dieldrin, gamma-chlordane, and heptachlor expoxide. Gamma-chlordane, which CH2M Hill (2011) determined to be a potentially significant contributor to risk in surface sediments, ranged from 5.2 to 58 and averaged 18.5 µg/kg in middle depth

samples. Middle depth samples were generally elevated in comparison to surface and deep zone samples. In general, elevated gamma-chlordane concentrations occurred near facility outfalls and DC CSS outfall 15. More elevated gamma-chlordane concentrations (27 and 30 µg/kg) were observed at two deep sediment locations, both in close proximity to facility outfalls.

- **PCBs.** PCB congeners were analyzed in a subset of the deep sediment sampling locations, 10 middle-depth and eight deep-depth samples. Middle depth total PCBs were elevated with respect to surface and deep-zone samples. The average concentrations total PCB congeners (sum of the 102 congeners analyzed) was 3508 µg/kg for the middle depth and 316 µg/kg for the deep horizon. Maximums were 26,129 and 2,277, respectively. The most elevated concentrations occurred near DC CSS outfall 15 and outfalls for the facility.
- **Metals.** The list of 24 EPA target analyte list (TAL) metals was analyzed in all subsurface sediment samples. Most of the TAL metals were detected in all middle and deep-depth samples. Antimony, cadmium, thallium, selenium, and silver were exceptions and were detected in a subset of samples. Barium, chromium, copper, lead, and zinc were detected in all samples and indicate the general distribution of metals in the subsurface sediment samples. In comparison to surface sediments and deep zone sediments, the most elevated occurrences of these five metals were observed in the middle-depth sediments. Barium concentrations averaged 200 mg/kg in the middle sediments and 162 mg/kg in the deep sediments. Chromium averaged 125 mg/kg in the middle zone and 34 mg/kg in the deep zone. Similarly, the average concentrations for copper, lead, and zinc were 95, 268, and 399 mg/kg, respectively for middle depth samples compared to 54, 102, and 168 mg/kg in the deep sediments.

CSX Benning Yard. Shallow subsurface samples were collected in the Anacostia River at 35 locations for the Benning Yard investigation. Twenty-two samples were collected at and in the general vicinity of the Fort Dupont Creek outfall (**Figure 4.16**). The remaining samples were collected to evaluate conditions in the river channel away from the Fort Dupont Creek outfall and at selected MS4 outfalls in the general vicinity upstream and downstream from Fort Dupont Creek. Samples were collected from the depths of 0.5 to 1.0 foot (upper interval), 1.0 to 2.0 feet (middle interval), and 2.0 to 3.0 feet (deep interval) below the river bottom. Sediments in the immediate vicinity of the outfall tend to contain more sand while those at distance from the outfall have larger silt and clay fractions.

- **LPAH.** Concentrations tend to increase with depth and are variable away from the Fort Dupont Creek outfall. Average concentrations in the upper interval were 1,384 µg/kg. For the middle and deep sample intervals, the average concentrations were 1,556 and 1,613 µg/kg. Concentrations also tended to increase with decreasing grain size. The maximum LPAH concentration (2,800 µg/kg) was observed in the shallow subsurface interval sample collected near the shoreline in close proximity to the Fort Dupont Creek outfall. The sample contained a large silt fraction. Coarser grained samples in the outfall vicinity generally exhibited lower concentrations. A mid-channel sample collected approximately 1,000 feet upstream is indicative of concentrations away from the outfall area. At this location, an LPAH concentration of approximately 1,200 µg/kg were observed in the shallow depth interval sample.

- **HPAH.** Concentrations exhibit a decreasing trend with depth. The averages for the sampled zones decrease from 9,547 µg/kg for the upper zone to 6,956 and 5,592 µg/kg for the middle and deep zones, respectively. As was true for LPAH, concentrations appear to be inversely correlated with grain size. The maximum HPAH concentration (21,600 µg/kg) was observed in a middle interval sample collected near the shoreline approximately 600 feet downstream from the Fort Dupont Creek outfall. Coarser grained samples in the outfall vicinity generally exhibited lower concentrations. As noted above for LPAH concentrations, the mid-channel sample collected approximately 1,000 feet upstream is indicative of concentrations away from the outfall area. At this location, an HPAH concentration of approximately 10,000 µg/kg was observed in the shallow depth-interval sample.
- **PCBs.** PCBs for the Benning Yard Anacostia River dataset exhibit an increasing trend with depth. Total PCBs for the Benning Yard dataset were calculated by summing the result reported for all 209 PCB congeners and, thus, are not directly comparable to the results discussed above for total PCBs for the ANS 2000 data set (summed results for 81 congeners). From an average concentration of 848 µg/kg in the upper interval, concentrations increase to 1,205 µg/kg in the middle interval and to 2,039 µg/kg in the deep interval. The maximum total PCB concentration was observed in a deep zone sample collected near the shoreline approximately 750 feet upstream from the Dupont Creek outfall. In general, total PCB concentrations are lower in close proximity to the outfall.
- **Pesticides.** Chlordane is used as an indicator compound to summarize the pesticide concentrations. Chlordane was detected in 29 of 39 samples. Chlordane concentrations exhibit an increasing trend with depth. The averages for the sampled zones increase from 71 µg/kg for the upper zone to 123 and 146 for the middle and deep intervals, respectively. The maximum chlordane concentration was observed in a middle depth interval sample located near the shoreline and approximately 300 feet downstream from the Fort Dupont Creek outfall. Elevated chlordane concentrations also are present near the outfall and in some samples with a large sand size fraction.
- **Metals.** Arsenic, cadmium, lead, mercury, and selenium concentration distributions generated from the Benning Yard investigation were reviewed. With the exception of

selenium, each of these metals were detected in essentially all of the 38 samples (one sample was non-detect for mercury) included in the dataset. Results for approximately half of the selenium analyses were below the detection level. Among the three sampling intervals, average concentrations for each metal were typically most elevated for the deep interval. Deep interval averages for arsenic and cadmium were 12.38 and 2.33 mg/kg. Lead, mercury, and selenium deep interval average concentrations were 194, 0.54, and 3.89, respectively. The maximum concentrations for arsenic, cadmium, and selenium (12, 2.7, and 1.3 (estimated) mg/kg) were in a mid-channel, deep interval sample collected 1,000 feet upstream from the Fort Dupont Creek outfall. A lead concentration of 120 mg/kg) was measured in the upper interval sampling at this location. The maximum mercury concentration (1.6 mg/kg) occurred in a sample located in mid-channel, 200 feet from the outfall. In general, mercury concentrations in the immediate vicinity (within 100 feet) of the outfall were very low (average 0.04 mg/kg) in comparison to the concentrations (average of 0.3 mg/kg) measured at more distant sampling locations (greater than 100 feet).

4.2.3 Pore Water and Surface Water

Pore water data and surface water data are not available in the project database. With respect to surface water, analytical data are available from discharge monitoring reports compiled for selected tributary streams and outfalls to the tidal Anacostia River. In addition, CH2M Hill (2011) report field parameter measurements for surface water samples collected for the Washington Navy Yard RI.

DMR Sampling. As a requirement of the District of Columbia Municipal Separate Storm Sewer System National Pollutant Discharge Elimination System (NPDES) permit issued by EPA, DDOE conducts routine wet and dry weather sampling of nine stations located in the Anacostia River watershed (Hawkins 2009). According to sampling protocol, storm water samples are to be collected during the first two hours of a storm event. Regarding dry weather monitoring, sampling is conducted sufficient to estimate the frequency and volume of dry weather discharges. The water is analyzed for biological oxygen demand (BOD), total dissolved solids (TDS), total suspended solids (TSS), various inorganics, 13 metals and hardness, 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), and bacteria (fecal coliform and fecal streptococcus). Monitoring of the Anacostia stations occurs once each three years with 2011 the last year in which monitoring was performed. Based on monitoring results from 2008, TSS ranged from 5 mg/L (Hickey Run) to 853 mg/L at the O Street NPDES Outfall located adjacent to the Washington Navy Yard. In addition, 2,3,7,8-TCDD, pesticides, and all metals with the exception of cadmium, copper, lead, and zinc were below the detection level.

Washington Navy Yard. As a part of a sediment triad investigation in the tidal Anacostia River near the Washington Navy Yard, CH2M Hill (CH2M Hill 2011) measured surface water parameters at a height of one foot above the sediment surface. This sampling was conducted in August, 2009. The samples were collected at locations adjacent to the Navy Yard piers and outfalls and in reference areas located away from the immediate area of the Navy Yard but still in the general vicinity of the facility. The maximum, minimum, and average pH, dissolved oxygen (DO), oxidation and reduction potential (ORP) and specific conductivity for the 18 locations sampled are summarized in Table 4.2, below. Additional investigation is necessary to confirm these sampling results.

TABLE 4.2
FIELD-MEASURED SURFACE WATER QUALITY PARAMETERS, WASHINGTON NAVY YARD

	pH	Dissolved Oxygen (mg/L)	Oxidation/ Reduction Potential (mV)	Specific Conductivity (mS/cm^3)
Average	7.33	6.22	-29.34	0.286
Maximum	7.78	8.06	4.8	0.327
Minimum	7.13	2.44	-59.2	0.250

4.2.4 Groundwater

The tidal Anacostia River is a regional discharge zone for groundwater. As such, the river receives groundwater inflow from throughout the watershed.

Elevated concentrations of groundwater contaminants are present or have the potential to be present at the six currently identified environmental cleanup sites that border the river. A summary of the specific constituents for each site was provided in **Section 3.1.2.1** and **Table 3.2**. Although these sites do not represent every source of contaminated groundwater entering the river, they collectively include the known sources of significant groundwater contamination to the river. If additional investigation reveals the presence of other environmental sites bordering the river, they will be considered in the RI and the NRDA.

4.2.5 Invertebrate and Fish Studies

Field studies addressing potential exposure of benthic invertebrates and fish to contaminants in the Anacostia River are summarized below. Two types of studies are available: (1) bioavailability studies using transplanted Asiatic clams, and (2) tissue concentrations and physical evaluation of recreationally important fish. Both of these study programs provide data on potential impacts to humans ingesting contaminated organisms from the Anacostia River. However, neither of the studies was designed to support an ecological risk assessment.

4.2.5.1 Clam Bioaccumulation Studies

Studies conducted by the University of the District of Columbia used translocated Asiatic clams (non-native *Corbicula fluminea*) to evaluate bioavailability of contaminants at 45 locations in the Anacostia watershed in Washington, DC and Maryland (Phelps 2000, 2001, 2008, 2011, 2013). In several studies, clams were collected from reference or control sites in the Potomac River and moved to selected sites in the tidal and nontidal Anacostia River (Phelps 2001, 2008). Asiatic clams are exposed to dissolved contaminants in surface water and to contaminants associated with the suspended particulate matter that they ingest. Suspended particulates may carry adsorbed organic contaminants such as PAHs, PCBs, and pesticides. In a study focused on active biomonitoring of contaminant sources in the upper Anacostia watershed, tissue concentrations in translocated clams were compared with 40 clams from the Fort Foote reference area in the Potomac River (Phelps 2008).

In general, the clam translocation studies did not show strong correlation between sediment and tissue concentrations of most contaminants. However, it should be noted that sediment concentrations in the vicinity of the sampled clams and the level of bioaccumulated contaminants found in the clams may not necessarily correlate. The level of correlation found between sediment samples and clam tissue samples is related to several factors including the depositional environment in the vicinity of the clams, the bioavailability of the contaminants being studied, and the turbidity of the water being filtered by the clam.

The highest PCB concentrations in sediment were reported at the Bladensburg Marina site; however, concentrations of PCBs in clam tissues were highest near the Washington Navy Yard and the supposedly “clean” Potomac River locations (Phelps 2000). A clam translocation study associated with dredging and wetland creation at Kingman Island indicated that clams accumulated pesticides and PCBs following dredging. Clams at the dredging sites did not bioaccumulate metals to any substantial extent, compared with control samples in the Potomac River (Phelps 2001). This result may indicate that the metals found in sediment in the dredging sites had a low bioavailability or that low levels of metals were present in the sediment being transported.

Additional bioaccumulation studies using translocated clams at tributaries and other river locations provide similar corroborating evidence that hotspots of PAHs and chlordane may occur in the upper Anacostia River (above Bladensburg Marina) (Phelps 2011, 2013). However, these studies do not incorporate the controlled exposure scenarios necessary to support development of bioaccumulation factors usable in ERAs. (Phelps 2011, 2013).

4.2.5.2 Fish Tissue Concentrations and Physical Effects

The most recent analysis of contaminants in fish tissue from the Anacostia River was conducted in 2007 to support development of fish consumption advisories (Pinkney 2009). Collection efforts focused on species caught and consumed by anglers in the Anacostia and Potomac Rivers: American eel (*Anguilla rostrata*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), blue catfish (*Ictalurus furcatus*), and largemouth bass (*Micropterus salmoides*). Fish were collected using an electroshocking boat from two locations in the Anacostia River designated only as “above” and “below” the CSX Railroad bridge. Fish samples were also collected from two locations in the Potomac River (above and below the 14th street Bridge). No specific sampling locations were noted in the study. All samples were fillets prepared for human consumption (with or without skin, as the species was normally consumed); most samples were composites of several fish. Six samples were collected at each Anacostia River location, for a total of 12 samples.

Fish samples were analyzed for lipid and moisture content, metals, PAHs, organochlorine pesticides, total PCBs (including Aroclor analysis), 119 PCB congeners, and polybrominated diphenyl ethers (PBDE). The two measures of total PCBS yielded similar results; total PCBs measured as the sum of Aroclors were within 15 percent of totals calculated as the sum of the congeners (see Table 5 in Pinkney 2009).

Every fish sample analyzed exceeded the 0.02 ppm screening level for total PCBs. At least one sample exceeded human health screening levels for PCBs, DDTs, chlordane, dieldrin, heptachlor epoxide, hexachlorobenzene, PAHs, and mercury. Of these, total PCBs, total chlordane, total DDT, dieldrin, heptachlor epoxide, and total PAHs are considered to pose the greatest risk.

Temporal trends in fish tissue were analyzed for PCBs and chlordane between 2000 and 2007. Median concentrations of both PCBs and chlordane increased in American eel, carp, and largemouth bass, but decreased in channel catfish. Concentrations in sunfish decreased slightly. Concentrations of PCBs and chlordane were generally higher in the Anacostia River than the Potomac River. In general, older fish tissue data are not reliably representative of current conditions (Pinkney 2009).

4.2.5.3 Human Consumption of Contaminated Fish

The Anacostia Watershed Society and other local and federal partners conducted a year-long study (2011-2012) to determine to what extent people are catching, sharing and eating fish from the Anacostia River. Both the District of Columbia and Maryland advise the public to avoid eating certain fish species (for example, carp and channel catfish) and to limit consumption of other fish species to prevent long-term health effects. The interviews revealed that anglers and other community members have limited knowledge of the consumption advisories and poor understanding of the health risks associated with eating Anacostia River fish. People generally believe that they can tell whether a fish is harmful by looking at external signs. Anglers routinely share their catch with people who would otherwise not have sufficient protein to eat. People who receive fish from anglers are often unaware of the location of the catch. The study concluded that anglers and others either are not receiving or not heeding the available consumption advisory information (Anacostia Watershed Society 2012).

4.2.5.4 Tumors and Lesions on Fish

The FWS conducted three studies of brown bullhead (*Ameiurus nebulosus*) in the Anacostia River between 2009 and 2011 to assess the incidence of liver and skin tumors. Liver tumors typically are associated with exposure to PAHs, although the causal agent of lip tumors is less certain. The occurrence of tumors on brown bullhead in the Anacostia River was first documented by FWS in 1996; subsequent research provided extensive supporting evidence that the tumors were strongly correlated with exposure to PAHs in sediment. The incidence of lip and liver tumors in Anacostia River brown bullheads has decreased since 1996, but is still markedly higher than in rural "reference" areas of the Chesapeake Bay. Surveys from 2009 to 2011 indicated that 42 percent of brown bullhead females and 14 percent of brown bullhead males had liver tumors (U.S. Fish and Wildlife Service 2013). Brown bullheads remain in a relatively small area throughout their lives and are closely associated with sediment; these traits suggest that contaminants in Anacostia River sediments may contribute to the incidence of tumors (FWS 2013).

4.2.5.5 Benthic Invertebrate Bioassay and Index of Biotic Integrity

A series of 20 sediment locations in the tidal Anacostia River were evaluated using a sediment triad approach comprised of chemical analysis, direct toxicity tests, and measures of benthic community health (McGee et al. 2009) (the data from this study were unavailable for incorporation into the project database). Sample locations were distributed from Bladensburg down to the confluence with the Potomac River, excluding the Washington Channel. Physical and chemical analyses included grain size, total organic carbon content, trace metals (aluminum, cadmium, chromium, copper, iron, mercury, nickel, lead, silver, and zinc), 81 PCB congeners or groups of congeners, select organochlorine pesticides, and PAHs. A 10-day survival and growth test using *Hyalella azteca* (an amphipod) and *Chironomus dilutes* (a midge) measured direct toxicity of sediment. Benthic community health was described using the Benthic Index of Biotic Integrity (B-IBI).

Overall levels of contaminants, measured as the mean probable effect concentration (PEC) quotient, were highest near the O Street CSS outfall, decreasing both downstream and upstream of this point. The PEC quotient was not significantly correlated with any measure of benthic community health or toxicity. About 40 percent of the sample locations were considered "degraded," indicated by an B-IBI of less than 3. Both the amphipod and the midge exposed to this sample showed inhibited growth; in addition, contaminant levels were high, and measures of benthic community health were low. Subsequent analyses using toxicity identification evaluation suggested that the adverse impacts may have been caused by organic compounds (McGee et al. 2009).

4.2.6 Bathymetric Data

Bathymetric data characterizes the spatial variation of the sediment surface also referred to as the "mud line." Bathymetric data are needed to help confirm and finalize proposed sampling locations. Elevated areas may indicate areas of deposition while low areas suggest potential erosion or scour. In addition, bathymetric data are needed for logistical and remedial design purposes.

The existing bathymetric data for the tidal Anacostia River are limited the river reach extending from approximately the downstream limit of the Southeast Federal Center to the 11th Street Bridge (approximately 80 percent of Reach R2 [**Figure 4.1**]). The Washington Navy Yard and the O Street Outfall investigations conducted prior to the placement of the experimental active sediment caps (described in **Section 2.6**) both included a bathymetric survey of all or a portion of this reach. The O Street Outfall survey was limited to the immediate vicinity of the outfall while the Navy Yard survey encompassed the entire area. Bathymetric data are unavailable for either the Washington Channel or other portions of the tidal Anacostia River.

4.2.7 Data Gap Assessment for Environmental Media

The review of existing information in the literature and databases led to the identification of several data gaps that will need to be filled before or during the RI and NRDA processes. At this time, data gaps exist in the following three general areas:

- Bathymetric and utility survey data,
- Collection of sediment and sediment pore water samples for chemical and physical property tests, and
- Collection of biological samples for risk assessment and NRDA purposes.

These data needs are described in the following subsections along with the rationale and priority for acquisition.

4.2.7.1 Bathymetric Survey Data

With the exception of the Washington Navy Yard and the adjacent pilot test for the active capping site near the O Street Outfall, existing river bottom elevation data are inadequate with regard to accuracy and coverage. A bathymetric survey of the river bottom is needed to locate the sediment sample locations both horizontally and vertically with relation to the river. Survey information will be used to establish riverbed topography and sample elevations in relation to the waterway and the project vertical datum, support the development of potential remedial alternatives (estimation of dredging and capping quantities), and evaluate logistical options with regard to site access.

4.2.7.2 Collection of Sediment and Sediment Pore Water Samples

As discussed in **Section 2**, previous sediment sampling events on the Anacostia River have ranged from comprehensive campaigns encompassing the entire estuary to smaller, targeted efforts at discrete areas within the tidal footprint. Discrete sampling has generally been performed in conjunction with investigations at one of the six environmental cleanup sites that border the river.

The most comprehensive sampling effort in the river was the 2000 ANS sampling event. ANS primarily sampled the river in transects from the mouth at the Potomac River to the upper tidal limit north of the DC, Maryland border. Selection of transect locations does not appear to have been based on any site specific conditions, such as potential source areas or areas of likely sediment deposition. ANS only collected surface sediment samples from the top 6 inches of sediment.

For the sites where previous environmental investigations have been completed, the existing characterization data ranges from extensive at sites undergoing active cleanup (e.g. the Washington Navy Yard and CSX Benning Yard) to sites with limited (Pepco Benning Road) or minimal data (Poplar Point). At some data-limited sites such as Pepco Benning Road, investigations are ongoing at the date of this WP. Reduced sampling will occur near the six environmental cleanup sites to minimize duplication of effort and cost while providing complimentary data.

Regulatory involvement at the environmental sites will help to foster an appropriate level of sediment investigation coordination at each site so that the objectives of this WP are achieved. It should be noted that the lead regulatory agency (e.g., U.S. EPA Region 3, NPS, etc.) and DDOE's regulatory role may vary by site. At the Washington Navy Yard and CSX sites, the sites most advanced with respect to characterization, the characterization completed to date appears generally consistent with the objectives for this investigation. Both sites, however, require additional review with regard to potential remaining data gaps. The planned investigation at the Pepco site appears to be congruent with this WP. Although the broad objectives of the WGL East Station RD/RA include the characterization of sediments in the adjacent Anacostia River, specific details regarding the extent of this investigation are under discussion. Information regarding planned sediment investigations is currently unavailable for the Kenilworth Park Landfill and Poplar Point. For this WP, sampling locations are defined within the river segments adjacent to the WGL and the Kenilworth Park landfill sites. These sample locations, however, will be adjusted if WGL or NPS (oversight authority for the Kenilworth Park Landfill) finalize the respective work plans for these sites prior to the commencement of field work for this WP.

Although the existing post-2000 sediment characterization data set is invaluable with regard to estimating the current nature and extent of contamination, additional samples need to be collected throughout the project area to achieve the DQOs within most river reaches. Outside the third-party-investigated environmental cleanup sites, there are substantially fewer data points. The focus of the sample design in this work plan is this larger portion of the river.

Surface Sediment. Current assessments of depth-based variations in constituent concentrations, essentially limited to the Washington Navy Yard (CH2M Hill 2011), indicate the absence of specific trends for most constituents. The absence of a trend suggests that, outside of random variation between surface versus shallow subsurface concentrations, no systematic increase or decrease was observed. Surface sediment samples will be collected from a percentage of the ANS locations to verify that the results from that 2000 sampling effort are generally representative of current conditions. As discussed in the data usability section, the ANS 2000 data is a key component of the current site database; should the sampling results for the planned effort show a poor correlation to the ANS 2000 data and the existence of a consistent trend between the two sample horizons, an additional surface sediment sampling phase will be necessary. Selection of the ANS re-sample points will be spread within the project area to achieve adequate spatial coverage, and biased toward likely sediment deposition areas, as identified from the bathymetric survey results. New surface sediment sampling locations will be sited near contaminant source areas, primarily the MS4 outfalls, CSS outfalls, and tributaries. Surface sediment sampling will also be conducted to improve overall spatial coverage, particularly in Washington Channel and Kingman Lake, and will focus on depositional areas. In addition, a portion of the surface sediment samples will be tested under laboratory conditions for direct toxicity to benthic invertebrates (either amphipod or midge) as described in **Section 5.2**.

Subsurface Sediment. As discussed in **Section 4.2.2**, subsurface sediment data are limited to the near shore areas adjacent to the Washington Navy Yard and the Fort Dupont Creek outfall downstream from CSX Benning Yard. To address this major data gap, subsurface sampling will be performed at most surface sediment samples throughout the study area.

Sediment Pore Water. Sediment pore water data was generally not collected in any of the investigations which served as data sources for the project database. Pore water data is necessary for assessing the general condition of the benthic habitat and provides a more direct measure of contaminant bioavailability. Pore water data is thus an important input to both the ERA and NRDA. In addition, pore water data will be used to support remedy assessment in the FS, particularly with regard to the consideration of geochemical conditions in the evaluation of sediment capping options.

4.2.7.3 Biological Sample Collection

Targeted collection of invertebrates and fish from the tidal Anacostia River will support the ERA, HHRA, and NRDA. The only available data on body burdens (tissue concentrations) in biota are fish fillets collected to support fish consumption advisories (Pinckney 2009). Fish sampling will be coordinated to address the data needs of all three investigations (ERA, HHRA, and NRDA) to the extent possible. Fish fillets of the species and sizes allowable under angling regulations will be used to evaluate exposure in the HHRA. Whole fish of species and sizes representative of food sources for birds and mammals will be sampled for the ERA to support food chain analyses. All fish data will be used in the NRDA. Benthic and epibenthic invertebrates will also be collected from numerous locations in the Anacostia River, principally to support the ERA and NRDA. The body burden of benthic and epibenthic invertebrates is an important line of evidence in the ERA for three reasons: (1) invertebrates are key components of the ecological food web; (2) they are directly exposed to both sediment and water; and (3) they are known to bioaccumulate contaminants. As discussed in **Section 5.2**, a large number of sample locations is required to achieve adequate spatial coverage of the project area.

4.2.7.4 Sediment Geotechnical Properties

Insufficient data regarding the engineering properties of the sediment are currently available. Geotechnical data are necessary in the evaluation of remedial alternatives analysis and design. The data will be used to determine the range of equipment and the capacity of the sediments to support such equipment. Specific analysis parameters will include Atterberg limits, percent solids, and specific gravity. Additional engineering property tests, such as in-situ shear strength, laboratory consolidation, column settling, or column consolidation may also be required during later project phases.

4.3 Sources, Pathways, and Source Control

The sampling and other characterization activities discussed in this plan will focus on closing data gaps identified regarding contaminant sources, migration pathways, and source control. Potential sources addressed by the investigation are discussed in **Section 4.3.1**. Source control efforts and remaining data gaps are discussed in **Sections 4.3.2 and 4.3.3**.

4.3.1 Potential Sources

As noted in the CSM discussion in Section 3, the most significant ongoing sources of sediment contamination to the tidal Anacostia River are the environmental sites, CSS outfalls, SSOs, and tributaries which collectively deliver suspended sediments laden with PCBs, PAHs, pesticides, metals, and pathogenic bacteria. In addition, these constituents in surface water in both total and dissolved phases are hazardous to biota, human ingestion, and human contact.

4.3.2 Institutional and Source Control Efforts

Institutional control efforts include the imposition of an advisory for human consumption of fish from the Anacostia River. The source control efforts that have so far been implemented include localized hydraulic control of contaminated groundwater discharge and the DC Water Capitol project directed at curbing CSS outfall discharges.

An institutional control that has been in place since 1989 is the issuance of a fish consumption advisory. The advisory was issued in response to observed levels of PCB and chlordane that exceeded Food and Drug Administration action levels. Through signage, web-postings, and other means, the District government conducts an active campaign to warn anglers of the hazards of consuming fish from the river. However, frequently, the warnings are unheeded by the general population.

The characterization of the nature and extent of contaminated groundwater is underway or in the planning phase for each of the six environmental sites that border the river and, in some cases, groundwater source control measures have been implemented. A groundwater pump and treat system and dense nonaqueous phase liquid (DNAPL) recovery system have been operating at the WGL East Station since 2000. Depending on the results of planned or ongoing investigations at the Washington Navy Yard and the other sites along the river, additional groundwater remediation operations may be conducted.

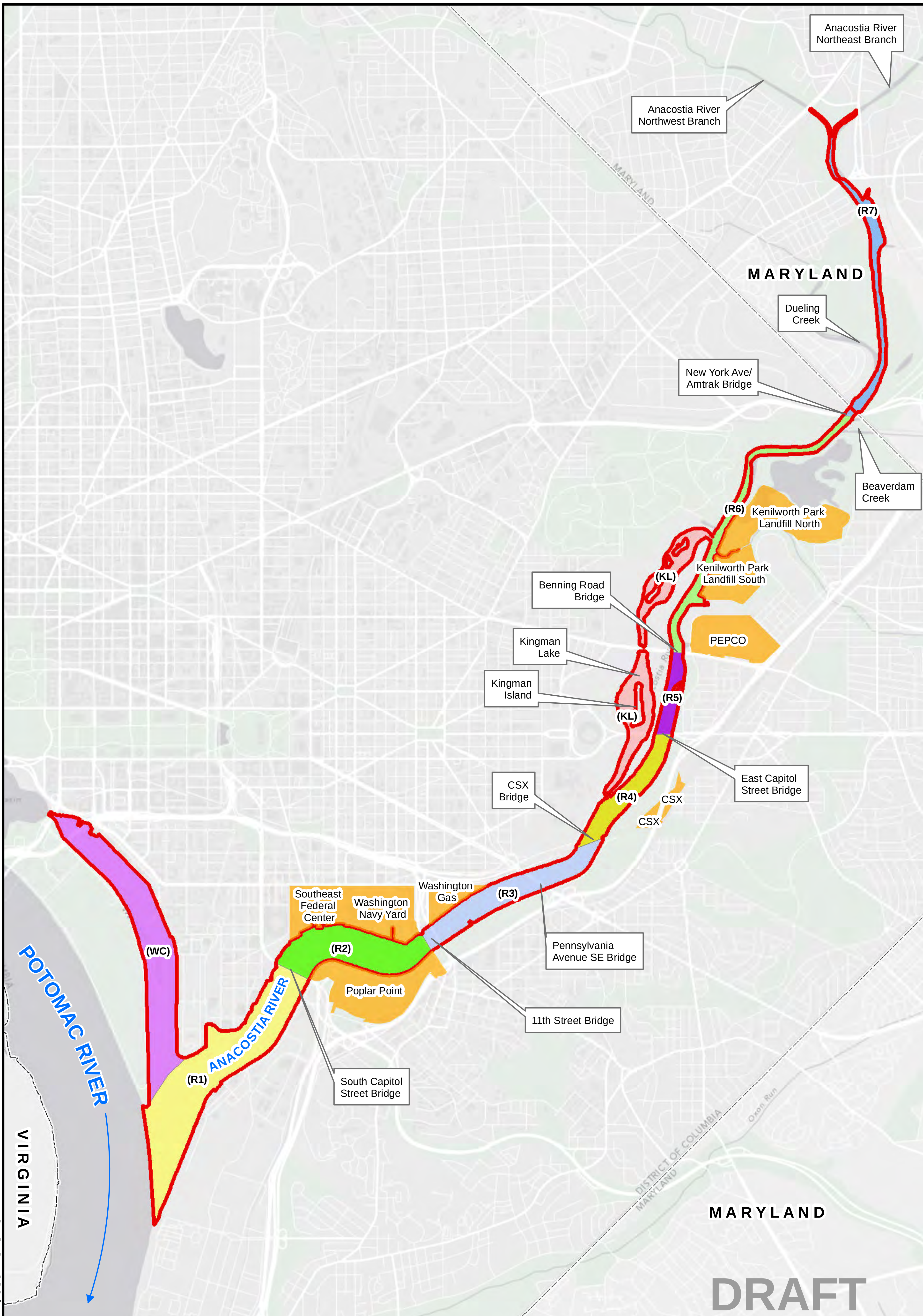
An additional source control effort is the ongoing DC Water project to minimize CSS outfall discharges through the containment and treatment of storm water flows. As a result of inadequate storm water and sewage system infrastructure, CSS outfall discharges have been sources of contamination to the river for decades. As noted in **Section 3.1.2.2**, in accordance with a 2004 consent decree between EPA and DC Water, DC Water has developed the Long Term Control Plan for addressing CSS outfall discharges. As part of this plan, DC Water initiated construction in 2011 on a tunnel and pumping system that will substantially reduce CSS outfall discharges by collecting and storing excess storm water flows for treatment at the Blue Plains facility (DC Water 2012).

4.3.3 Data Gap Assessment for Contaminant Sources

Data gaps exist regarding sources, pathways, and source control, as discussed previously. Data gaps associated with tissue concentrations in invertebrates and fish were discussed previously (**Section 4.2.5**). Data gaps regarding the potentially significant sources of groundwater contamination will be addressed through the investigation and remediation of the six environmental sites. With regard to sources of contaminated sediment and surface water, a major focus of the sampling planned for the RI will be to characterize the potential contributions from the various outfalls and tributaries.

4.4 Define Sediment Management Areas

Based on preliminary analysis of the physical site conditions and waterway setting, sediment management during the RI will be defined for the river reaches as shown in **Figure 4.1**. The reaches are defined on a preliminary basis consistent with observations regarding site geography; final sediment area designations will be based on further evaluation and discussion with DDOE. The reaches are defined consistent with the study area subdivisions presented in **Section 4.2**.



Legend

SEDIMENT STUDY AREA	
CLEANUP SITE BOUNDARY	
WASHINGTON DC BOUNDARY	

RIVER REACH

- WASHINGTON CHANNEL
- (R1) - S. CAPITOL ST BRIDGE TO MOUTH OF RIVER
- (R2) - 11TH ST. BRIDGE TO S. CAPITOL ST BRIDGE
- (R3) - CSX BRIDGE TO 11TH ST. BRIDGE
- (R4) - E. CAPITOL ST BRIDGE TO CSX BRIDGE
- (R5) - BENNING RD. BRIDGE TO E. CAPITOL ST BRIDGE
- (R6) - AMTRAK BRIDGE TO BENNING RD. BRIDGE
- (R7) - UPPER TIDAL LIMIT TO AMTRAK BRIDGE
- KINGMAN LAKE

N W E S

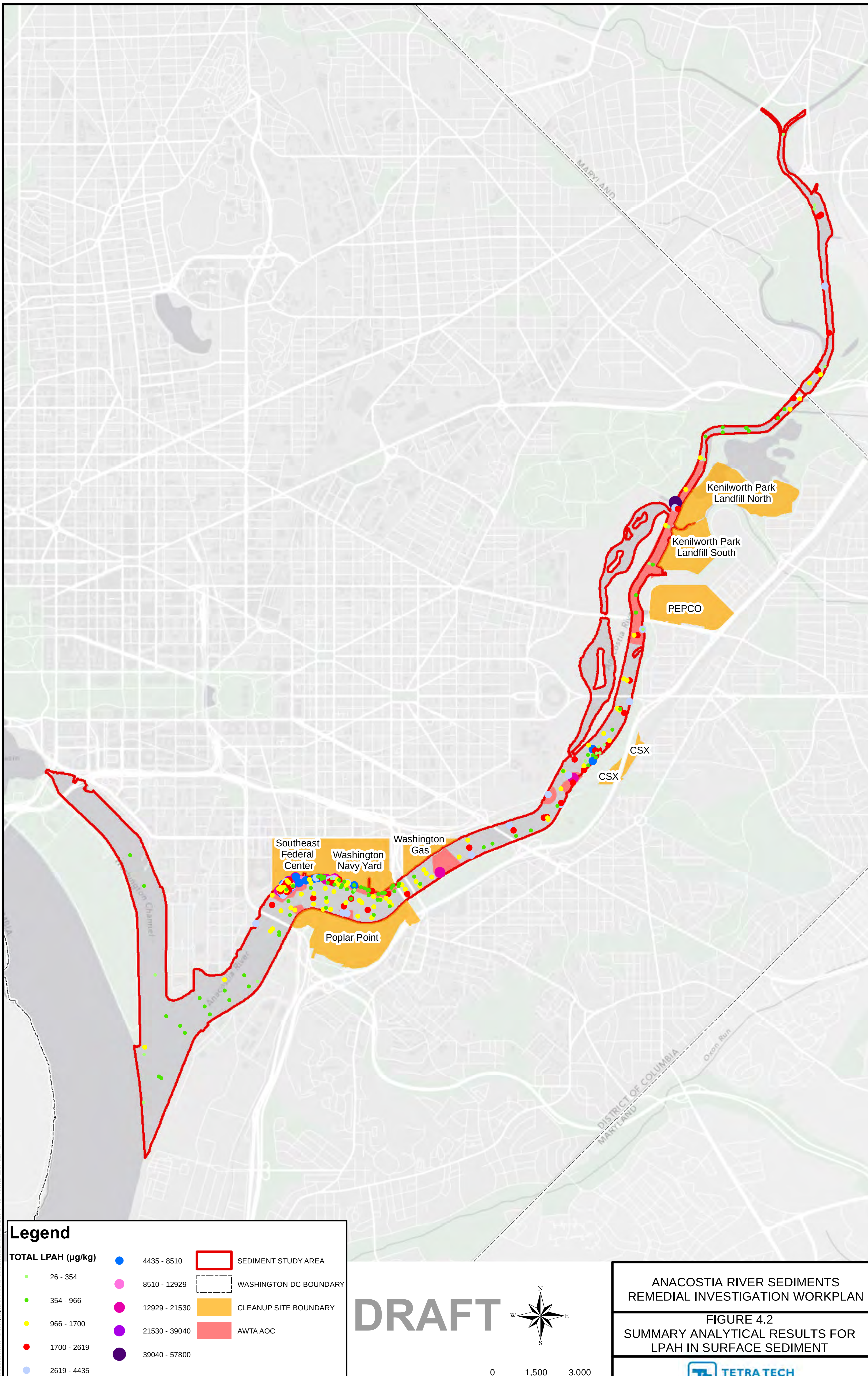
0 1,500 3,000 Feet

SOURCE: MODIFIED FROM DCGIS, 2012.

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.1
LOCATIONS OF RIVER REACHES

TETRA TECH



SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012, DCGIS, 2012, NOAA, 2013, AND DEPARTMENT OF THE NAVY, 2013.

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.2
SUMMARY ANALYTICAL RESULTS FOR LPAH IN SURFACE SEDIMENT

TETRA TECH

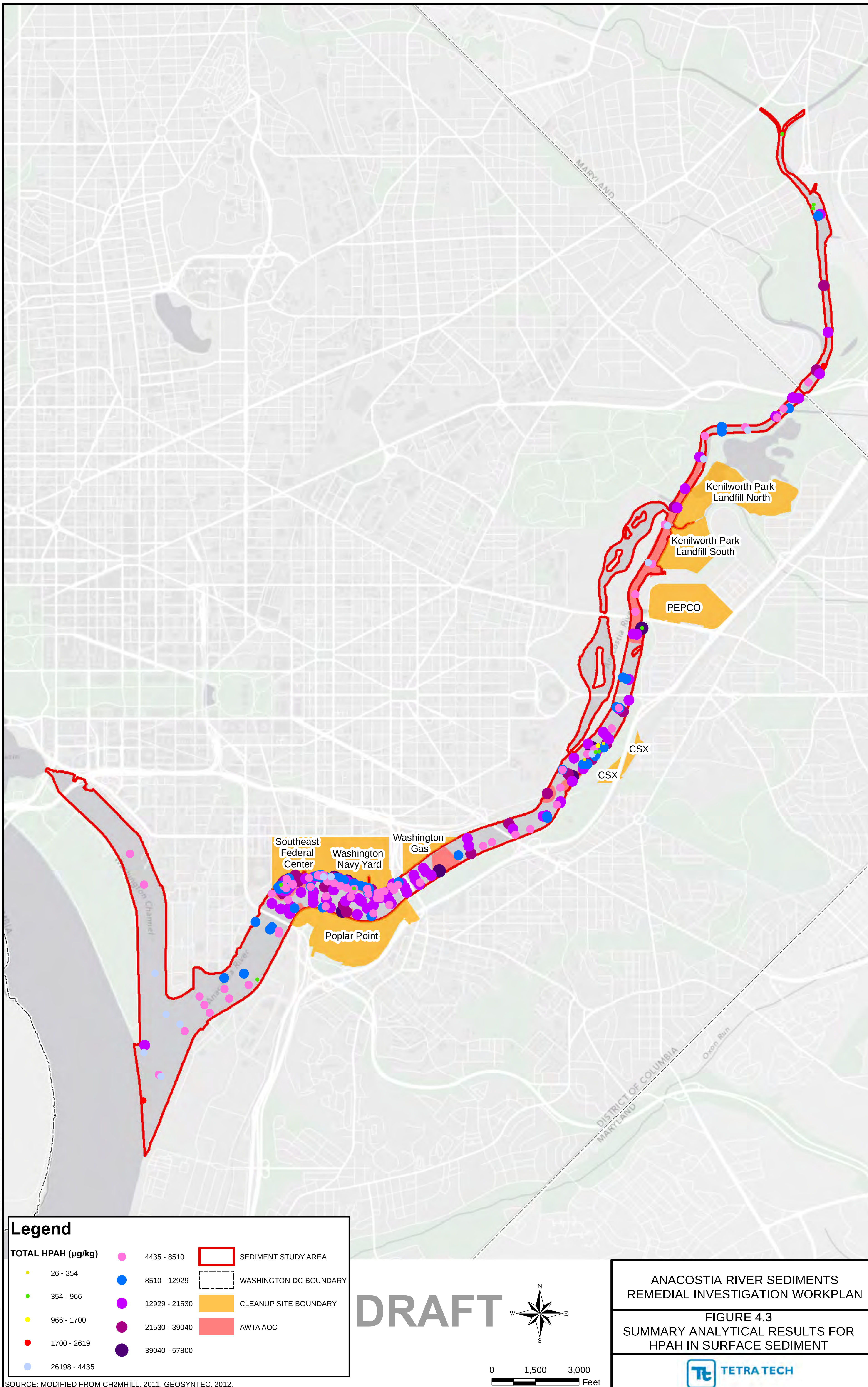
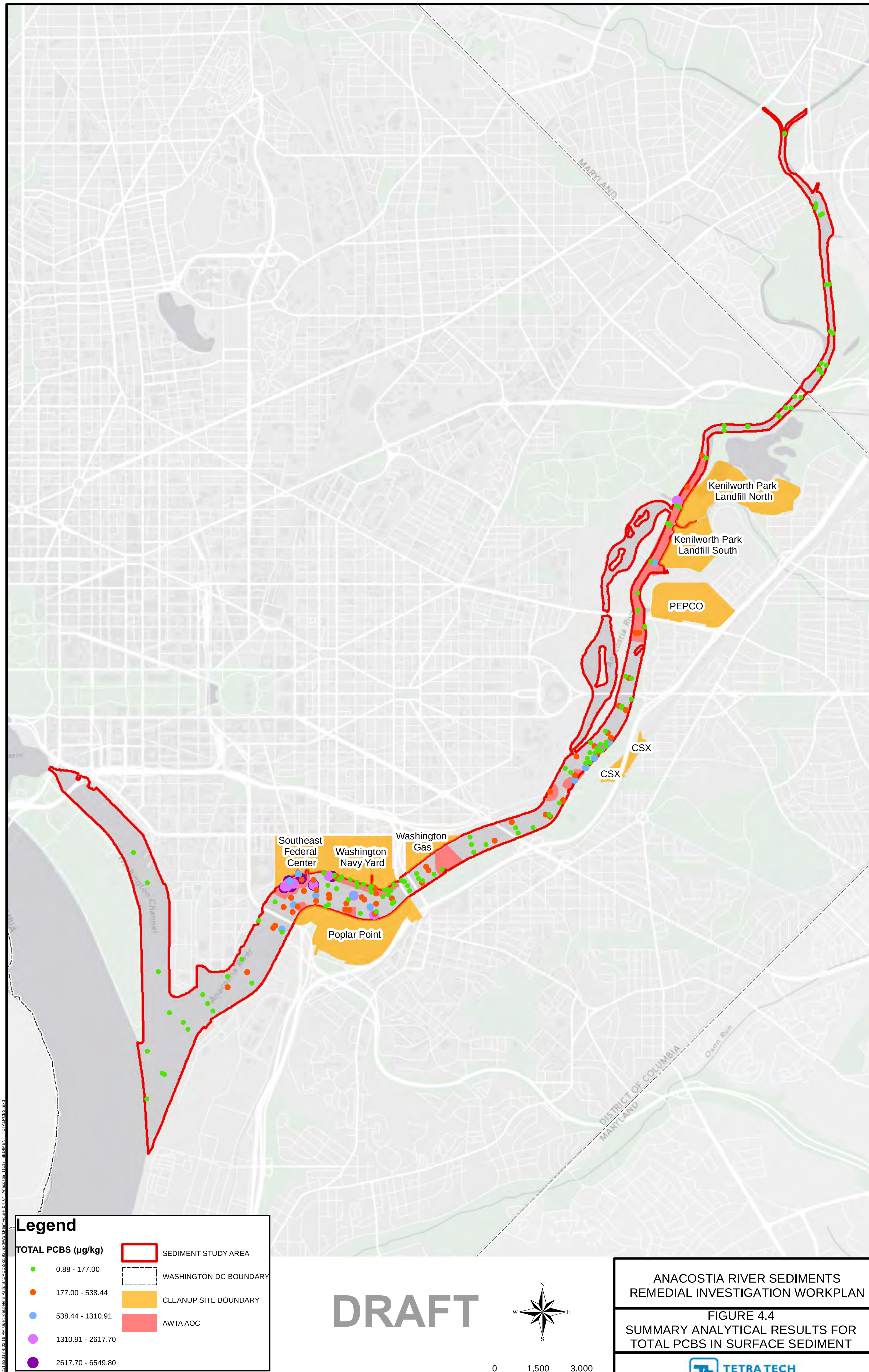


FIGURE 4.3
SUMMARY ANALYTICAL RESULTS FOR
HPAH IN SURFACE SEDIMENT

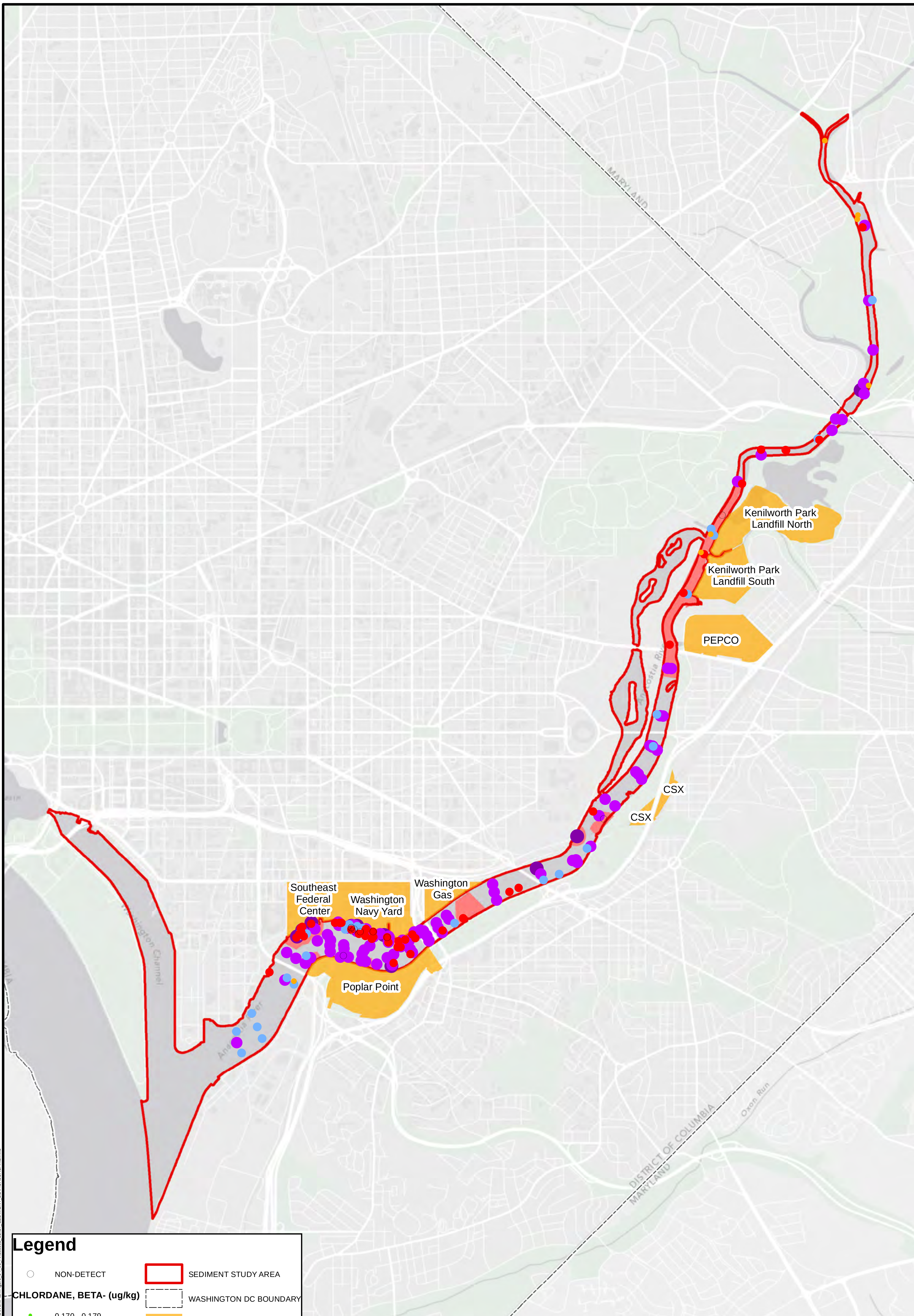


SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012, DCGIS, 2012, NOAA, 2013, AND DEPARTMENT OF THE NAVY, 2013.

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.4
SUMMARY ANALYTICAL RESULTS FOR TOTAL PCBS IN SURFACE SEDIMENT

TETRA TECH

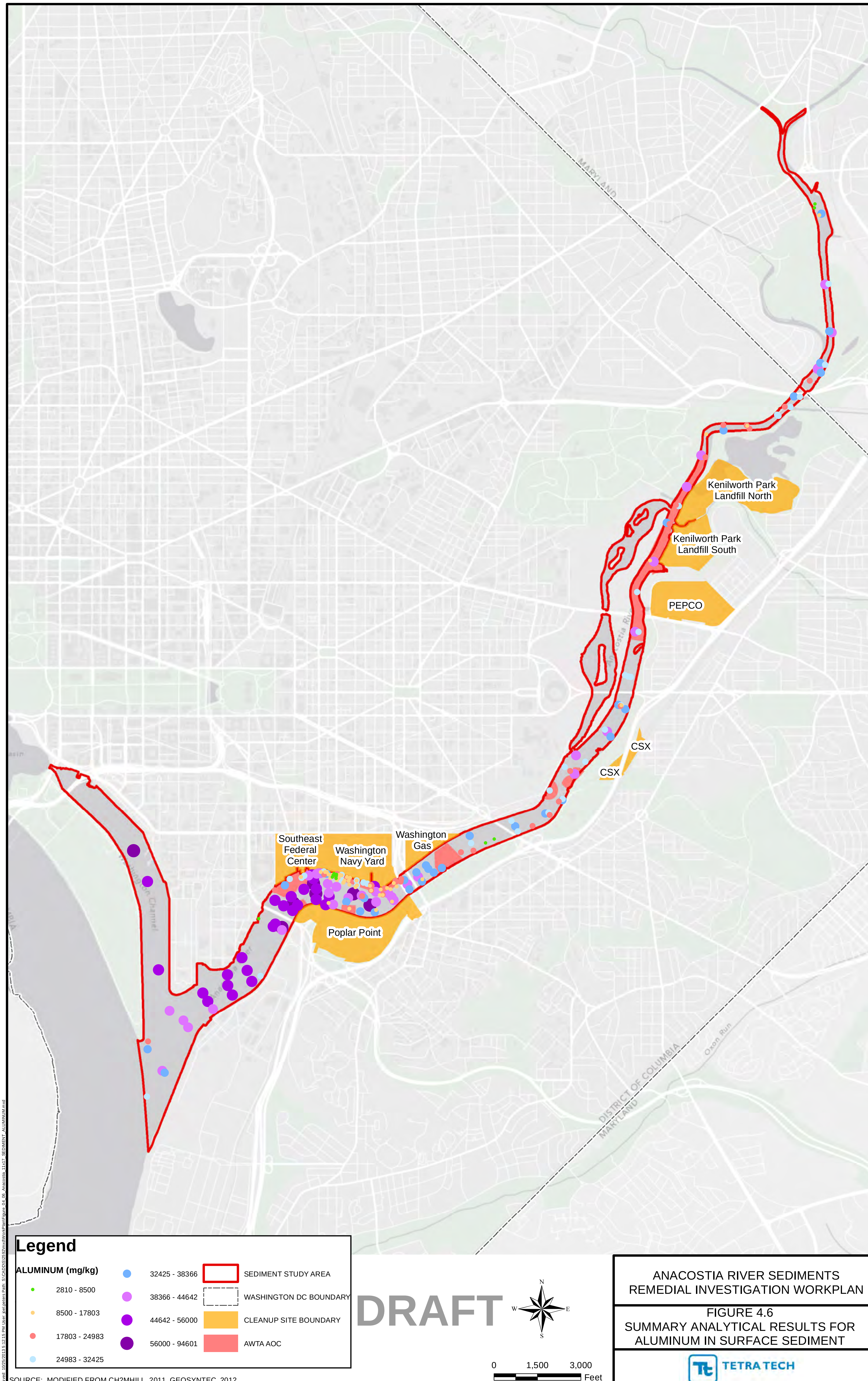


SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012, DCGIS, 2012, NOAA, 2013, AND DEPARTMENT OF THE NAVY, 2013.

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.5
SUMMARY ANALYTICAL RESULTS FOR BETA CHLORDANE IN SURFACE SEDIMENT

TETRA TECH



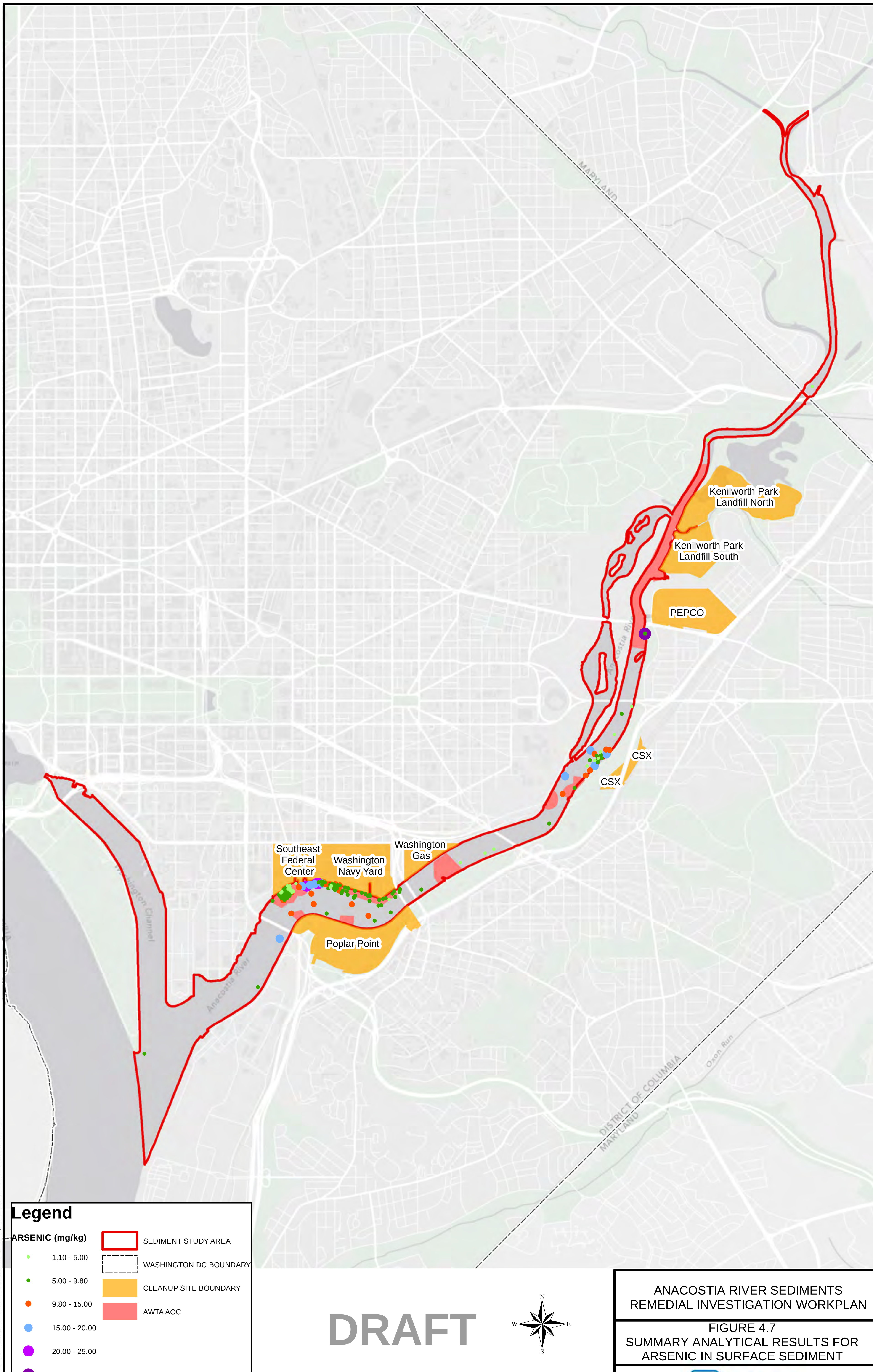
ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.6
SUMMARY ANALYTICAL RESULTS FOR ALUMINUM IN SURFACE SEDIMENT

TETRA TECH

SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012, DCGIS, 2012, NOAA, 2013, AND DEPARTMENT OF THE NAVY, 2013.

Date Saved: 10/25/2013 5:12:15 PM User: joel.peters Path: S:\CADD\S\2592\mxd\WorkPlan\Figure_04_06_Anacostia_11x17_SEDIMENT_ALUMINUM.mxd

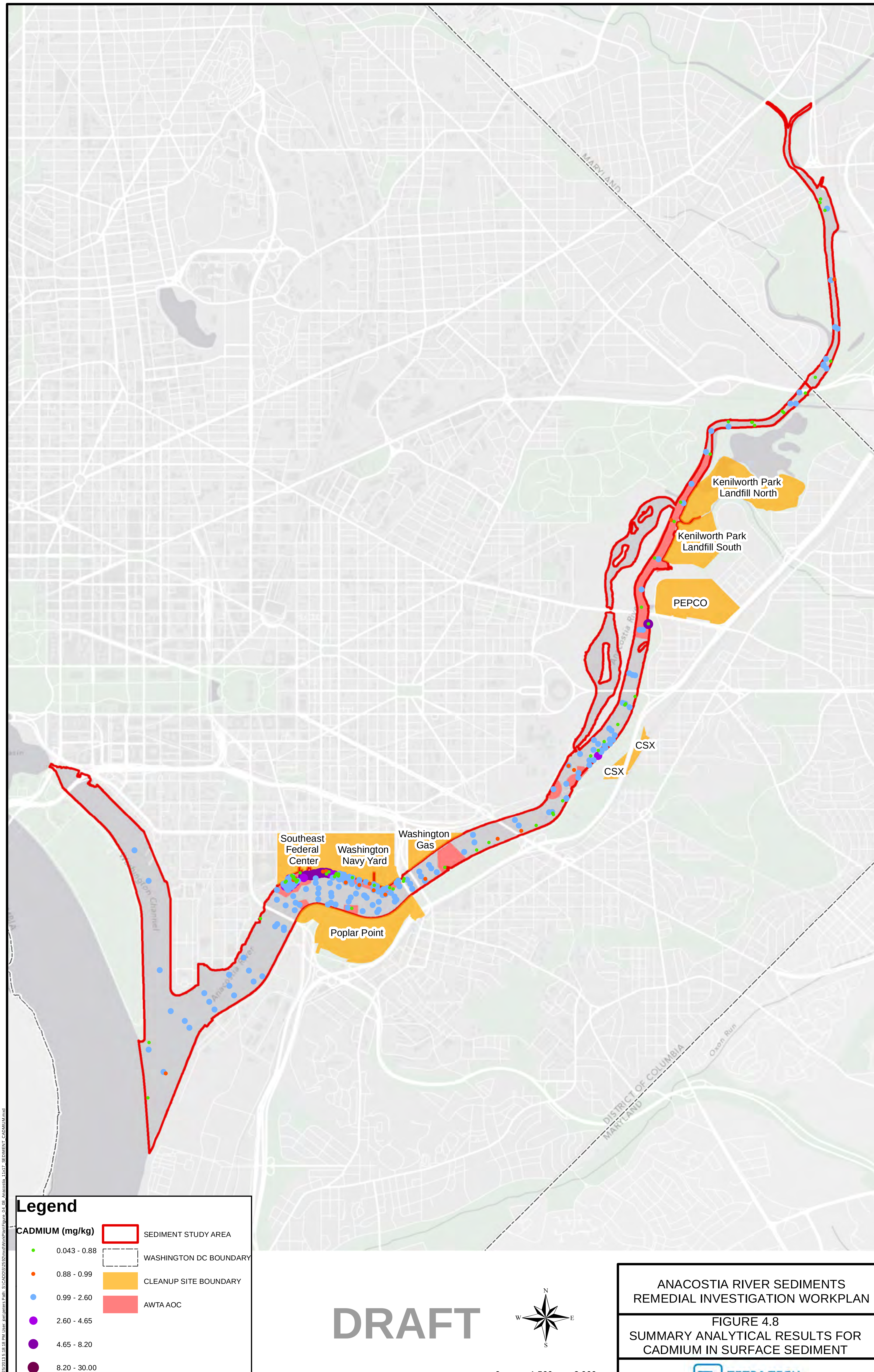


ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.7
SUMMARY ANALYTICAL RESULTS FOR
ARSENIC IN SURFACE SEDIMENT

TETRA TECH

SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012, DCGIS, 2012, NOAA, 2013, AND DEPARTMENT OF THE NAVY, 2013.

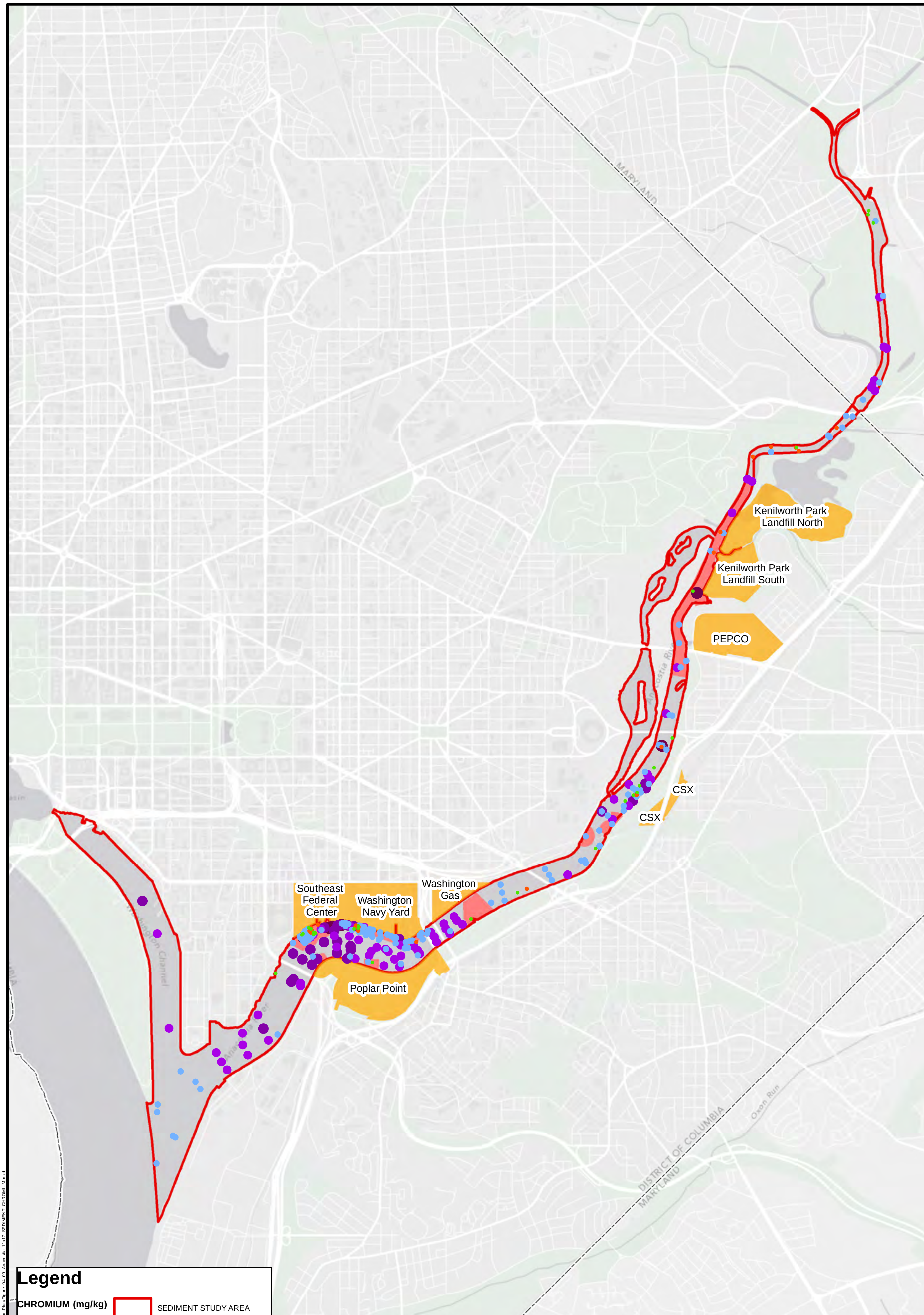


SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012, DCGIS, 2012, NOAA, 2013, AND DEPARTMENT OF THE NAVY, 2013.

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.8
SUMMARY ANALYTICAL RESULTS FOR CADMIUM IN SURFACE SEDIMENT

TETRA TECH



Legend

CHROMIUM (mg/kg)

- 4.8 - 32.2
- 32.2 - 43.4
- 43.4 - 86.9
- 86.9 - 114.3
- 114.3 - 141.6
- 141.6 - 169.0

- SEDIMENT STUDY AREA
- WASHINGTON DC BOUNDARY
- CLEANUP SITE BOUNDARY
- AWTA AOC

SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012, DCGIS, 2012, NOAA, 2013, AND DEPARTMENT OF THE NAVY, 2013.

DRAFT

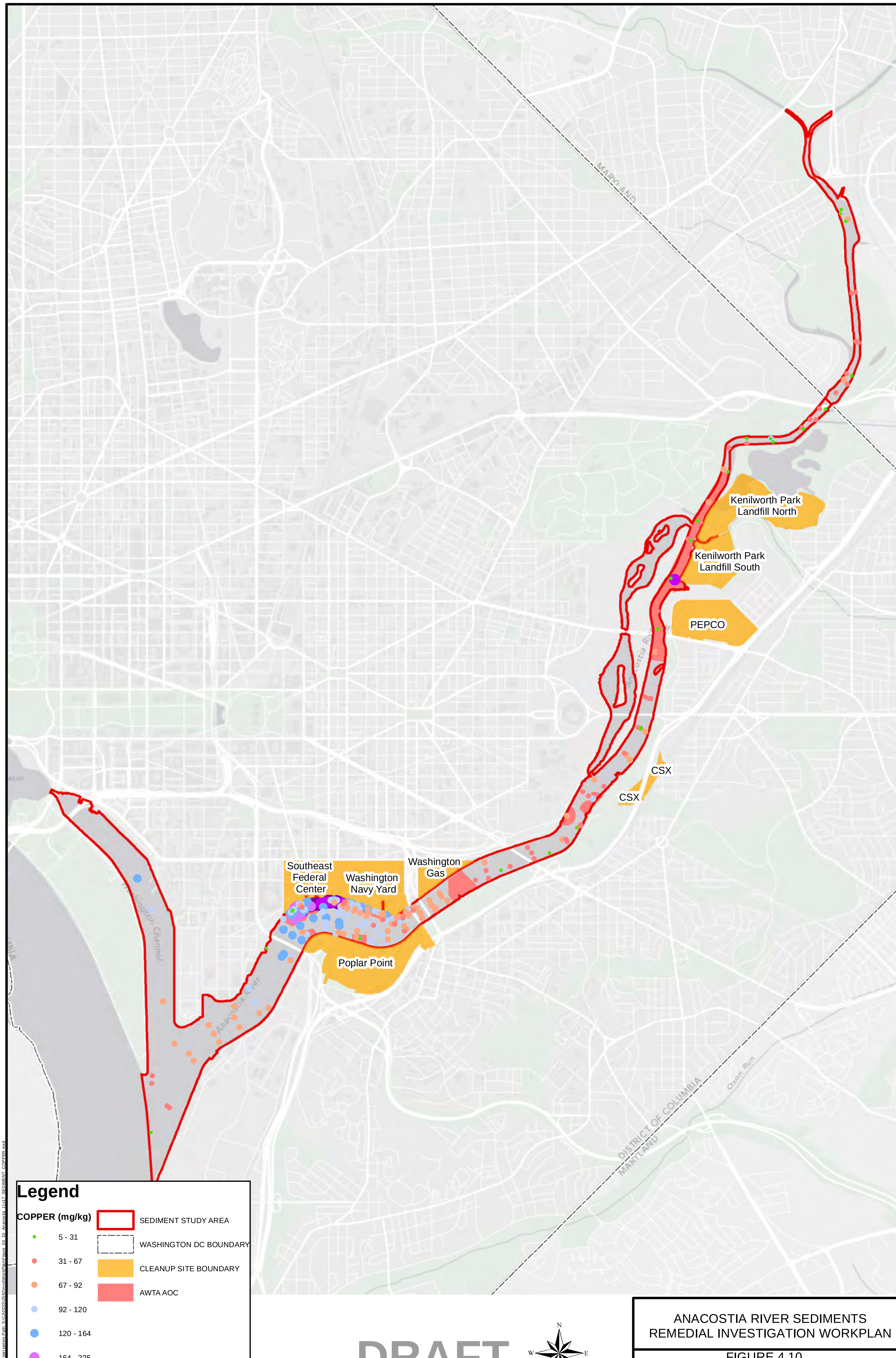
N W E S

0 1,500 3,000 Feet

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.9
SUMMARY ANALYTICAL RESULTS FOR
CHROMIUM IN SURFACE SEDIMENT

TETRA TECH



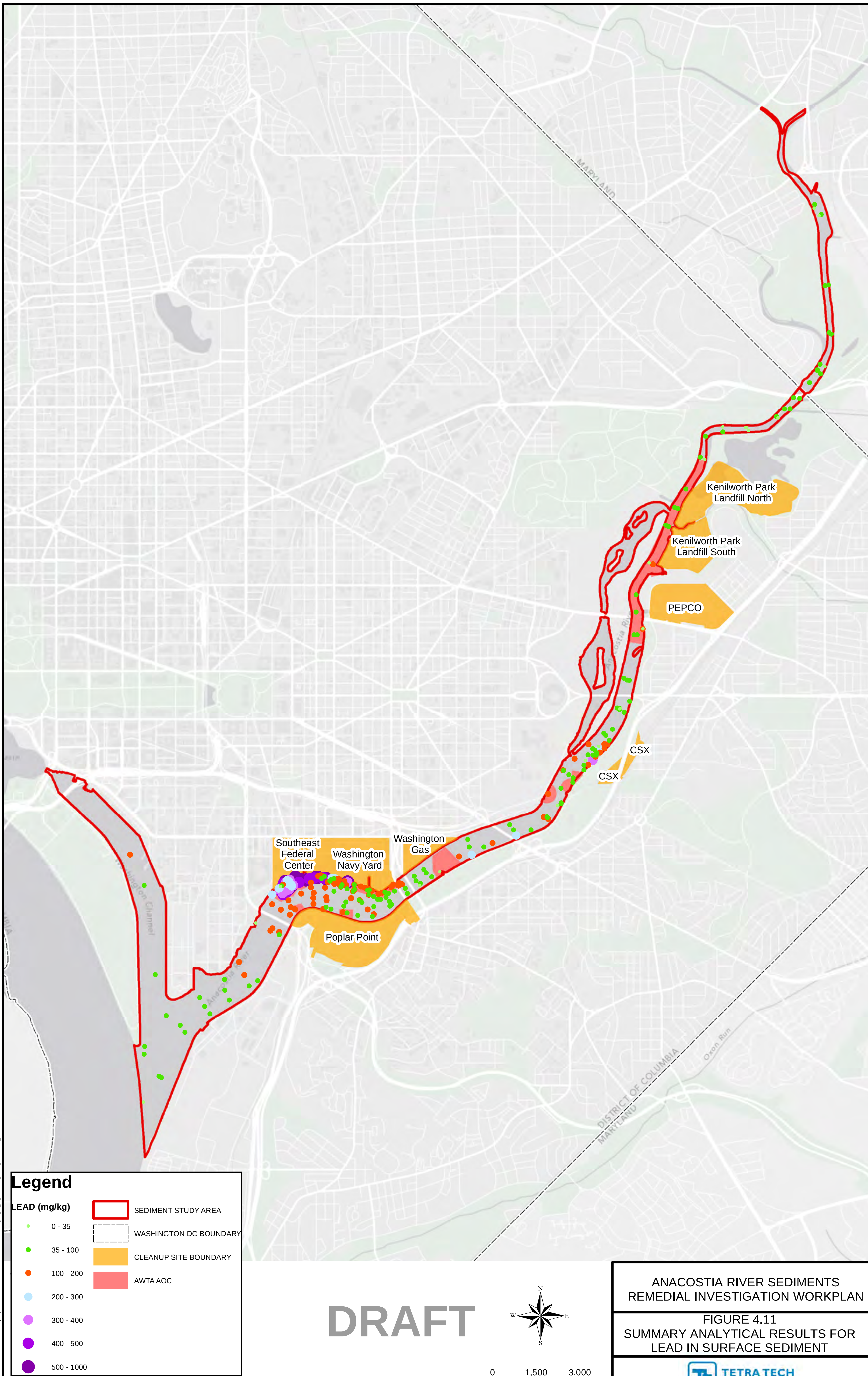
SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012, DCGIS, 2012, NOAA, 2013, AND DEPARTMENT OF THE NAVY, 2013.

DRAFT

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.10
SUMMARY ANALYTICAL RESULTS FOR
COPPER IN SURFACE SEDIMENT

TETRA TECH

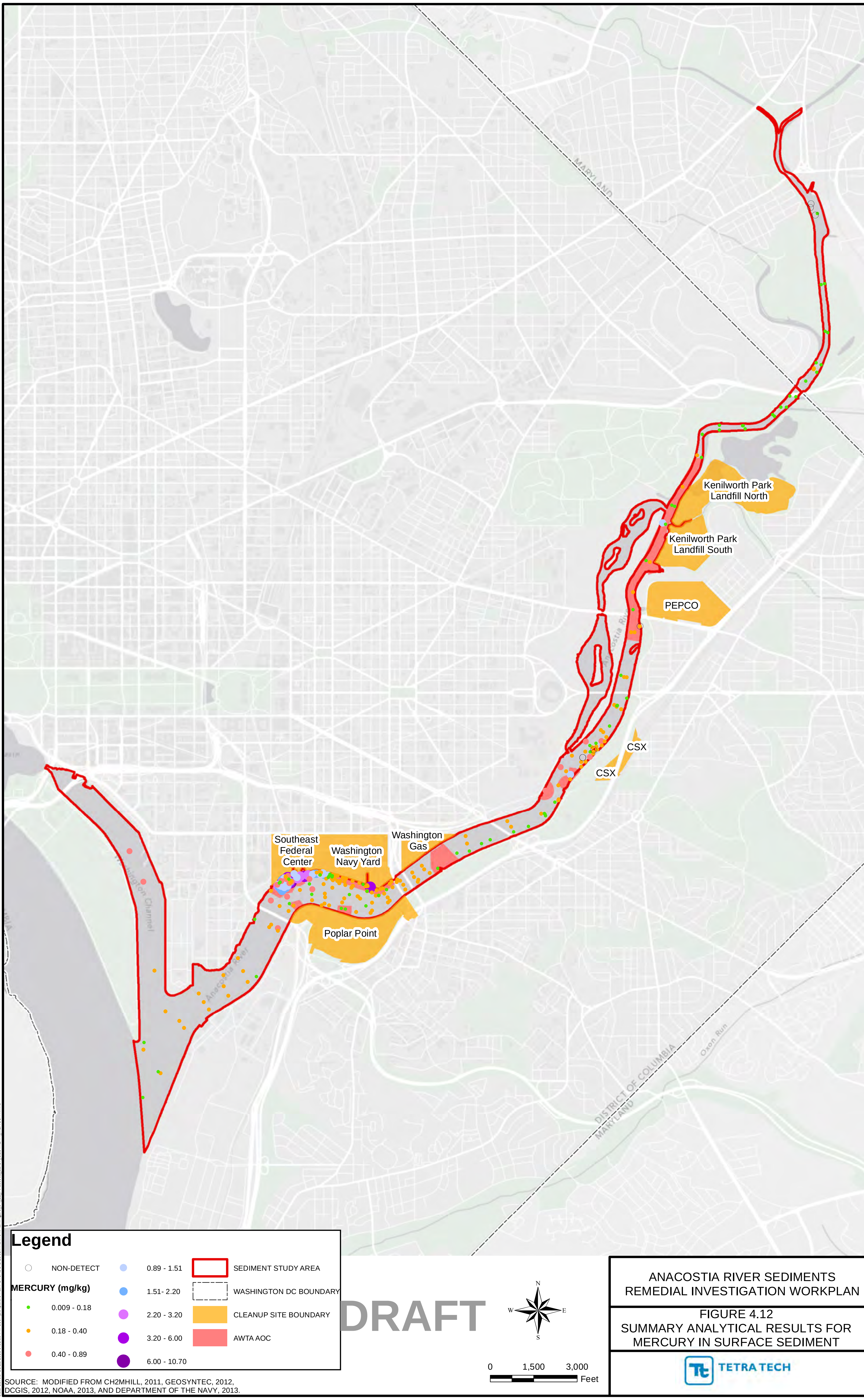


SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012, DCGIS, 2012, NOAA, 2013, AND DEPARTMENT OF THE NAVY, 2013.

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.11
SUMMARY ANALYTICAL RESULTS FOR LEAD IN SURFACE SEDIMENT

TETRA TECH

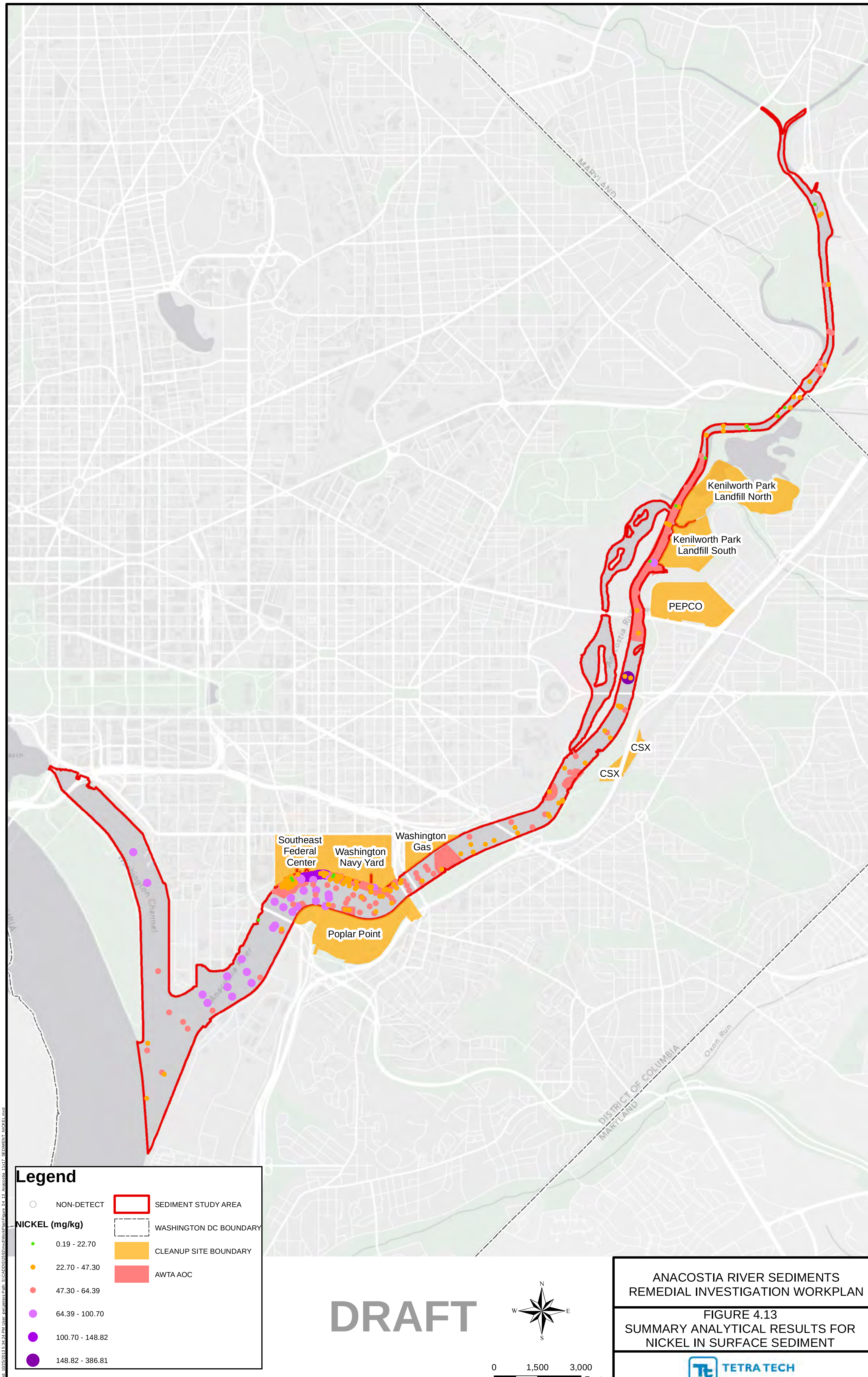


SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012, DCGIS, 2012, NOAA, 2013, AND DEPARTMENT OF THE NAVY, 2013.

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.12
SUMMARY ANALYTICAL RESULTS FOR MERCURY IN SURFACE SEDIMENT

TETRA TECH



DRAFT

N W E S

0 1,500 3,000 Feet

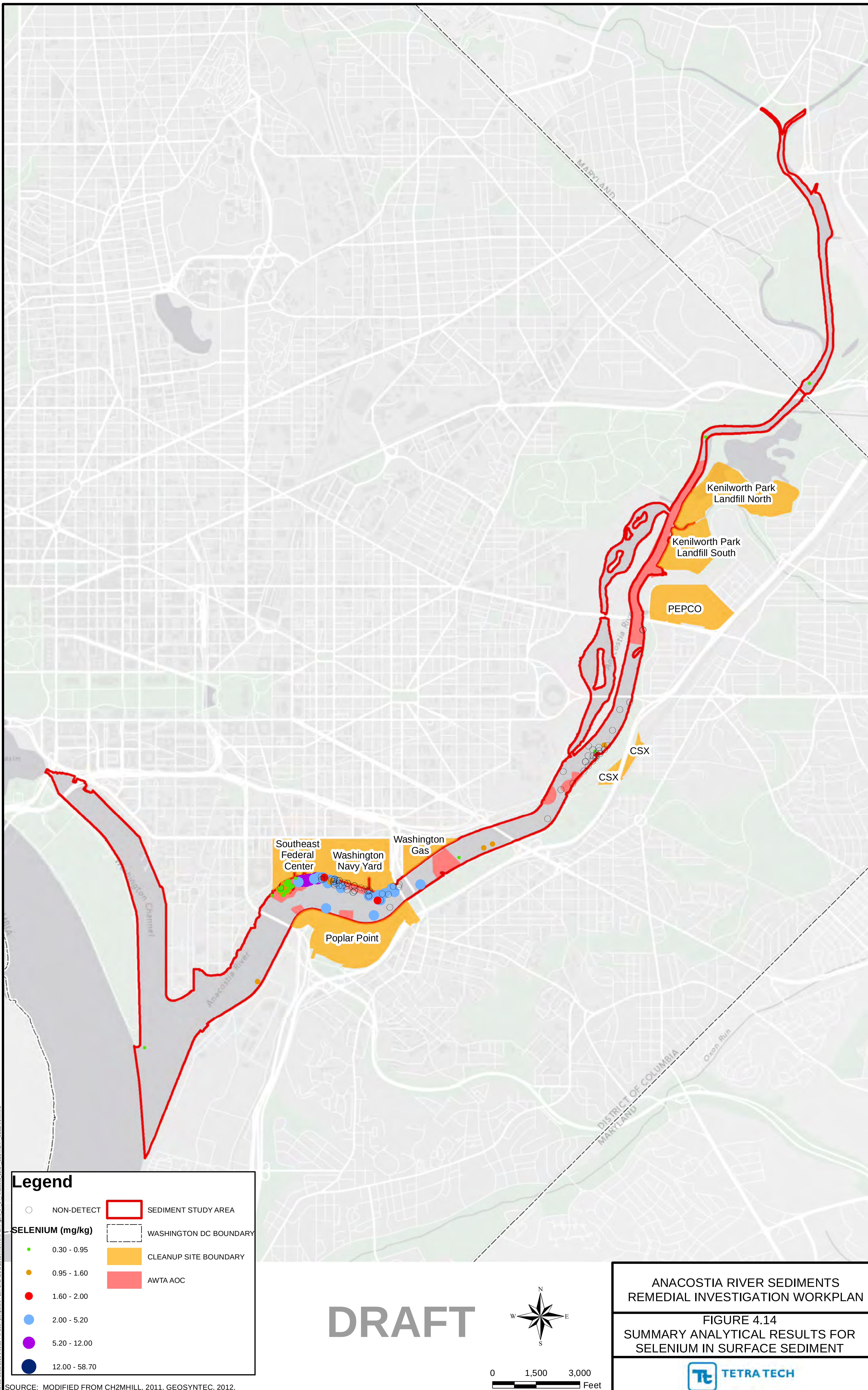
ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.13
SUMMARY ANALYTICAL RESULTS FOR
NICKEL IN SURFACE SEDIMENT

TETRA TECH

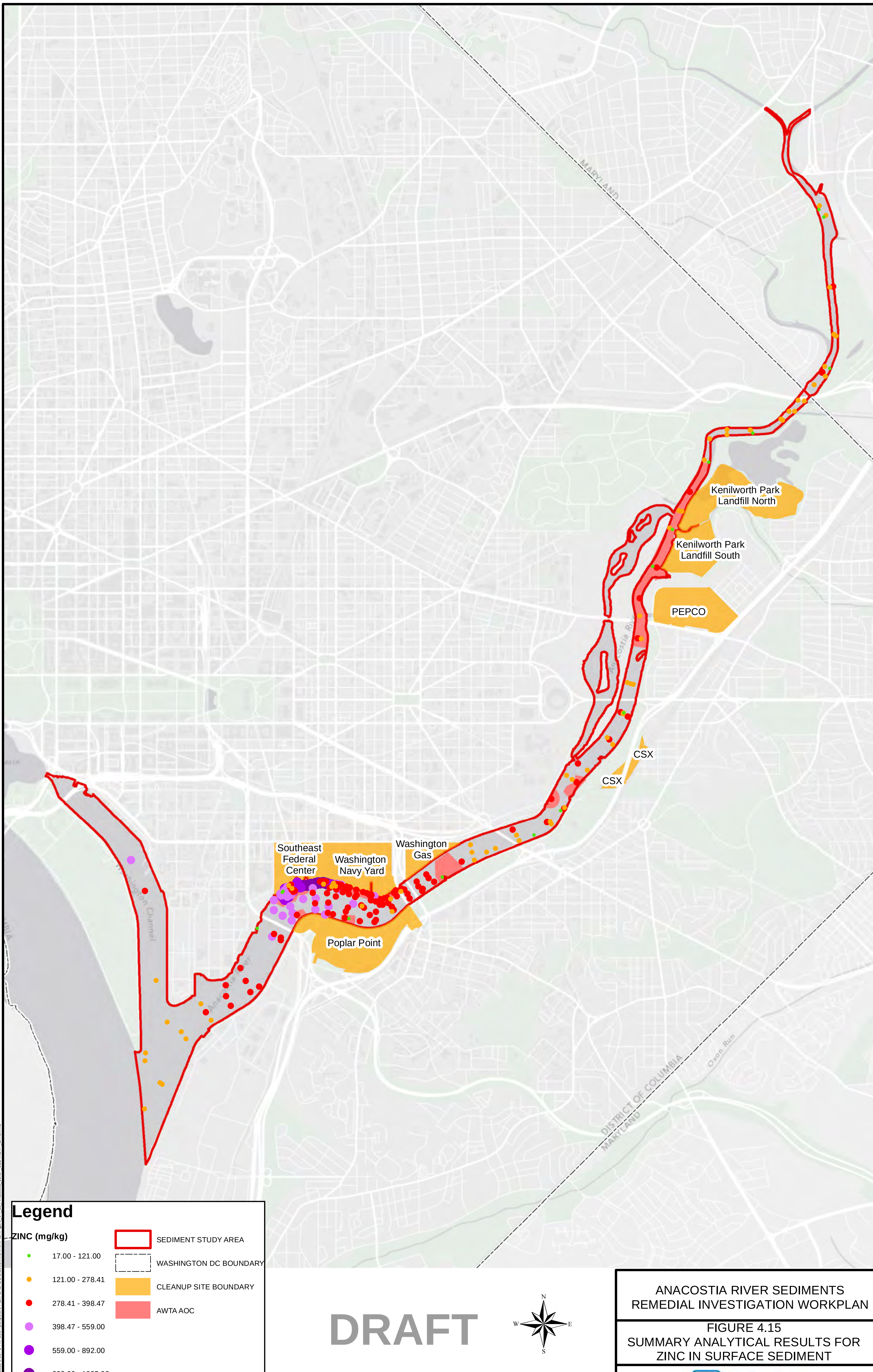
SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012,
DCGIS, 2012, NOAA, 2013, AND DEPARTMENT OF THE NAVY, 2013.

Date Saved: 10/25/2013 5:34:24 PM User: joel.peters Path: S:\CADD\S\2592\mxd\WorkPlan\Figure_04_13_Anacostia_11x17_SEDIMENT_NICKEL.mxd



ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.14
SUMMARY ANALYTICAL RESULTS FOR SELENIUM IN SURFACE SEDIMENT

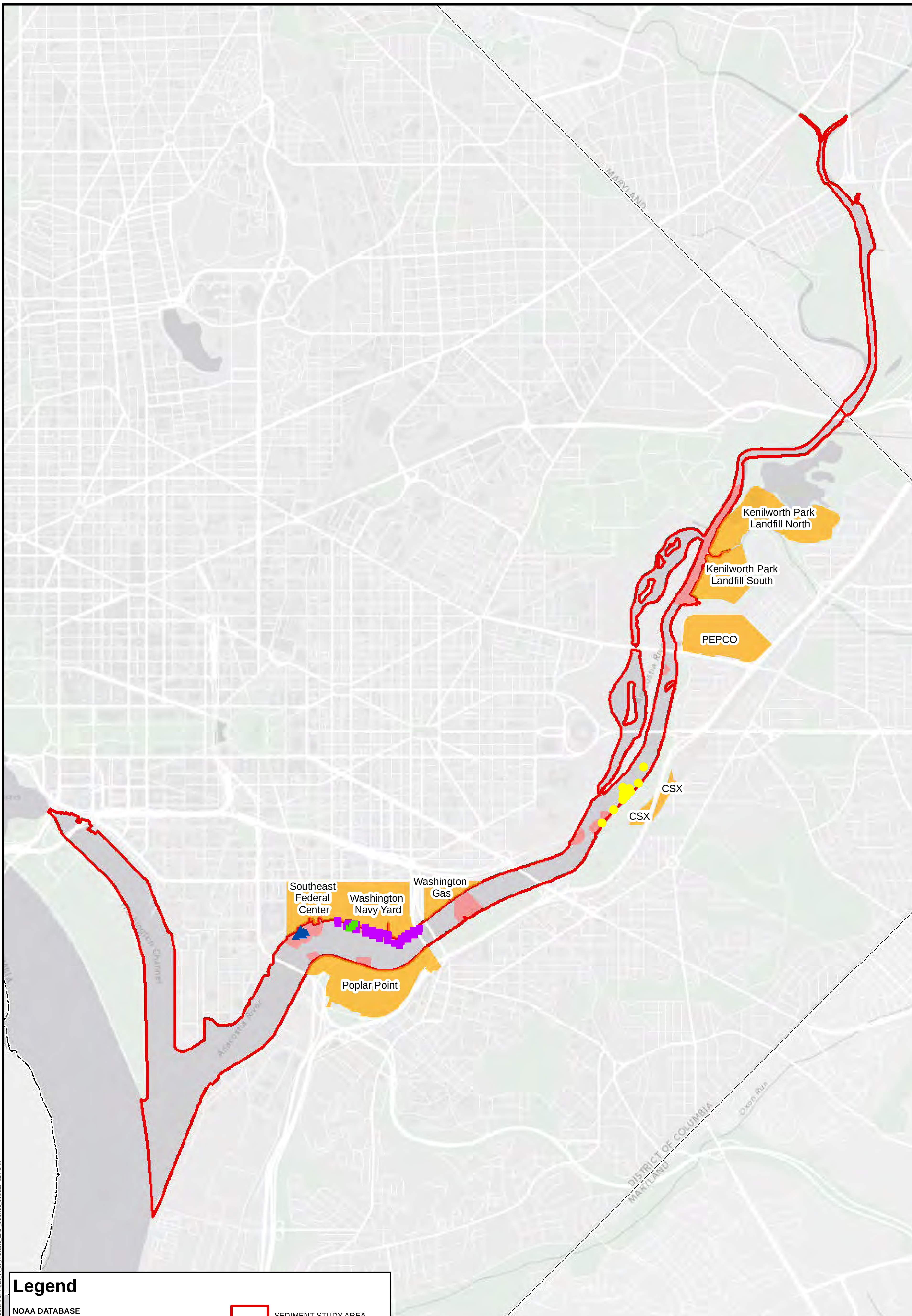


SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012, DCGIS, 2012, NOAA, 2013, AND DEPARTMENT OF THE NAVY, 2013.

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.15
SUMMARY ANALYTICAL RESULTS FOR
ZINC IN SURFACE SEDIMENT

TETRA TECH



Legend

NOAA DATABASE

- ▲ 2003 Active Capping Site Char Rpt (8)

NIRIS DATABASE

- 2002 WA Navy Yard Pier No. 5 (16)
- 2006, 2009 Washington Navy Yard Sed/Tiss (70)

CSX DATABASE

- 2011 CSX Sediment Study (38)

- SEDIMENT STUDY AREA
- WASHINGTON DC BOUNDARY
- CLEANUP SITE BOUNDARY
- AWTA AOC

DRAFT

N W E S

0 1,500 3,000 Feet

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 4.16
PREVIOUS SUBSURFACE SEDIMENT
SAMPLING LOCATIONS

TETRA TECH

SOURCE: MODIFIED FROM CH2MHILL, 2011, GEOSYNTEC, 2012,
DCGIS, 2012, AND DEPARTMENT OF THE NAVY, 2013.

Date Saved: 9/25/2013 4:32:06 PM User: joel.peters Path: S:\CADD\S\2592\mxd\WorkPlan\Figure_04_16_Anacostia_11x17_SOURCE_SUBSEDIMENT.mxd

5.0 REMEDIAL INVESTIGATION

The RI will address the goals outlined in **Table 4.1**. Additional sampling is necessary to validate previous sampling, identify potential sources of COCs in the environmental media, allocate contamination to specific sources where possible, and evaluate the potential for risk to human health and the environment. Additional data is also required to support the NRDA process and provide information needed to assess remedial options in a FS. The sampling approach for sediment, fish tissue, and benthic invertebrate data gaps will be dynamic in that the sampling performed will be tailored to the conditions observed in the field. A set of implementation plans including a FSP, QAPP, Health and Safety plan will be developed to detail the sampling and analytical methods and quality control criteria and procedures that will be used.

The RI will consist of the collection of samples from surface sediment, subsurface sediment, surface sediment pore water, surface water, and fish tissue. In addition, samples will be collected to characterize benthic invertebrate conditions. **Table 5.1** (below) summarizes the number of samples planned for each environmental medium and indicates the report section in which sampling activities for each medium are discussed.

Table 5.1
Summary of Planned Sampling Activities for the RI

ENVIRONMENTAL MEDIUM	NUMBER OF PLANNED SAMPLES	SECTION
Surface Sediment	134	5.1.2
Subsurface Sediment	249	5.1.2
Surface Sediment Pore Water	19	5.1.3
Benthic Invertebrate Characterization	42	5.1.4 and 5.1.5
Surface Water	14	5.2
Fish Tissue	46	5.3

5.1 Sediment Characterization

Building upon historical databases, the RI sampling program is designed to gather the majority of the remaining data needed for the RI and risk assessments, as well as initiate some NRDA data collection. The overall RI objectives that the sediment sampling efforts will support include:

- Identify and evaluate direct and indirect, known and unknown sources of significant contamination,
- Define the horizontal and vertical extent of contamination in surface and subsurface sediment,

- Identify surface and buried sources of contamination that pose a potential risk to human health or the environment,
- Assess what sources can be controlled by early actions such as the removal of an unanticipated contaminant hot spot that presents an immediate threat to human health or the environment,
- Update the watershed sediment/surface water model, and
- Collect data to understand contaminant fate and transport in the river system to adequately support remediation decisions.

The following types of data will be collected during sediment sampling:

- Surface sediment chemistry to characterize the nature and extent of contamination, evaluate potential contaminant sourcing processes, support the ecological risk assessment (ERA) and the human health risk assessment (HHRA), and support the planned FS,
- Sediment bioassays to support the assessment of benthic risks for the ERA,
- Subsurface sediment chemistry and physical data to characterize the nature and extent of contamination, and
- Surface and subsurface sediment physical data to augment the available sediment chemistry data and support the planned FS.

Sediment sample locations are shown on **Figure 5.1**. The analyses planned at each location along with overall sampling objective (RI, NRDA, or both), summary of rationale, and location description are shown on **Table 5.2**.

5.1.1 Bathymetric Survey

A bathymetric and utility survey will be conducted in those areas where recent bathymetric information is not available. If only limited survey information is available, a complete survey of the project area may be more cost effective than combining a number of previously conducted surveys of limited extent. The bathymetric survey will provide a basis for understanding the depth of the water column and the configuration of the river bottom and will be used to prepare a contour map of the top of the sediment surface in and around the investigation areas. The surveying systems that will be used include a multibeam echo sounder for the deeper water areas and a multichannel sweep system to efficiently survey areas with shallower water. The presence of buried utilities observed during the survey and global positioning system (GPS) benchmarked locations of these utilities will be noted on a base map of the area. The survey will be completed prior to sediment sampling.

5.1.2 Physical and Chemical Sediment Sampling

Sediment samples will be collected from the sediment surface at approximately 134 locations within the project area to laterally characterize the nature and extent of contamination. Sample locations are shown in **Figure 5.1**. The surface sediment sample interval is defined as 0 to 0.5 foot below the sediment surface. The sampling locations shown on **Figure 5.1** may be adjusted based on the bathymetric survey results and associated analyses of the data generated by this survey. In addition, samples in close proximity to utilities will be relocated as necessary to ensure that sample collection can proceed safely.

Surface grab samples will be collected using a petite Ponar dredge sampler from the top 0.5 foot of sediment at each sampling location to characterize the surface sediments, to validate previous sample results, to fill existing data gaps, and to characterize the sediments near MS4 and CSS outfalls as appropriate. If obstructions such as boulders or debris are encountered at a specific station, the location of the station may be changed to collect sediment samples as required.

Nearshore surface sediment samples will be collected within areas where fishing or nearshore recreation is documented or observed, including Kingman and Heritage Islands Recreational Areas, Bladensburg Waterfront Park, and Anacostia Park. The purpose of these sample locations is to evaluate the potential risk to anglers or other recreationalists who may be exposed to nearshore sediment during low tides. Fourteen samples are anticipated; however, sample numbers and locations may be adjusted based on field observations of human activity.

During this phase of work, the surface sediment samples will be logged for visual and physical observations. A portion of the sample will be placed in a pan, inspected for sediment type, color, odor, obvious signs of biota and other notable features, and then returned to the river. The remainder of the sample will then be prepared for shipment to the laboratory.

Field personnel will record field observations of the physical characteristics of the sediment encountered at each sampling station and also important observations regarding the physical characteristics of the study area.

Deep sediment core samples will be collected from 83 stations (Figure 5.1) at depths up to 10 feet below the sediment surface to characterize the sediment profile at each location. Based on field screening, up to three sediment horizons will be selected from each core for sampling. Field screening will consist of visual inspection of the core samples for indications of potential contamination including abnormal discoloration or odors, elevated photoionization detector (PID) readings, or other indications suggesting the presence of contamination. The 10 foot depth is based on historical subsurface sampling (Velinsky et al. 2011). If field screening at a given sampling point indicates the potential that contamination extends to depths greater than

10 feet, sampling will continue to greater depths to the extent that the field sampling equipment will permit. Some locations may not achieve 10 feet because of shallow sediment depth or the presence of an obstruction to drilling. Locations that show significant contamination at depth may be evaluated further in a follow-up sampling phase. The sediment cores will be collected using a vessel equipped to advance a 2-4 inch diameter Vibracore™ sampler (or equivalent) to the target depth below the sediment surface, or to refusal, whichever is encountered first.

Field personnel will record field observations of the subsurface sampling event to include:

- Sample station designation
- Location coordinates recorded with a GPS unit
- Water surface elevation
- Depth to sediment
- Depth core was advanced
- Depth of sediment recovered
- Sediment core logging for sediment stratigraphy

All sediment samples will be submitted for the following physical and chemical analyses:

- Grain size by sieve and hydrometer
- Total organic carbon
- Priority Pollutant List

Several specialized analyses will be conducted on a subset (20%) of the sediment samples:

- PCB congeners
- Dioxins and furans
- Acid-volatile sulfide/simultaneously extracted metals (AVS/SEM)
- Moisture content/percent solids
- Bulk density
- Atterberg Limits

It is estimated that up to 249 discrete interval subsurface sediment samples will be collected for laboratory analysis. The locations of the specialized analyses will be determined by site specific conditions within the project area, such as likely contaminant sources or fluvial geomorphological features. The specific locations will be outlined in the FSP.

5.1.3 Sediment Pore Water Sampling

Pore water within the sediment will be sampled at 19 locations (**Figure 5.2**) to a depth of 0-0.5 feet below the sediment surface. Sample locations were selected to provide spatial coverage of all reaches of the river within the Study Area. Within each reach of the river, sample locations were biased toward outfalls and areas were elevated PAH concentrations in surface sediment were previously identified. Pore water collection locations will be co-located at selected surface sediment locations as noted in **Table 5.3**. Sample locations will be recorded with a GPS unit.

All pore water samples will be collected ex situ via laboratory-based extraction and submitted for the following chemical analyses:

- Total organic carbon
- Dissolved organic carbon
- Priority Pollutant List (If a limited sample volume is available for a given sample, the parameter list will be prioritized and reduced accordingly as will be detailed in the FSP.)

5.1.4 Sediment Sampling for Benthic Invertebrate Toxicity Tests

Benthic invertebrate characterization sampling will be conducted at 42 of the 134 surface sampling locations. The benthic invertebrate sampling locations are listed in **Table 5.3** and shown in **Figure 5.2**. Surface sediment will be collected for toxicity testing at half or more of the benthic invertebrate sampling locations; benthic invertebrates will be collected where available at the remaining locations. Benthic invertebrate sampling will only be conducted if these organisms are present in sufficient numbers, as determined through field judgment. If insufficient benthic invertebrates are present at any given sampling location, sampling for toxicity testing will be conducted. Sample points were selected to achieve three goals simultaneously: (1) general spatial coverage of all reaches of the river; (2) biased to include inlets, outfalls, and bridges; and (3) biased toward shallower waters away from people, closer to vegetated habitat where animals might be more likely to forage at low tide.

Surficial sediment samples will be collected for lab-based toxicity testing using either the amphipod (*Hyalella azteca*) or midge (*Chironomus dilutus*) or both. Direct toxicity tests provide a measure of survival and growth of invertebrates that are in direct contact with sediment. Results will provide both direct and indirect evidence of potential impact to support the ERA and NRDA: (1) The extent of direct toxicity to organisms exposed to surficial sediment is a measure of injury to the aquatic ecosystem and a line of evidence in the ERA; and (2) the potential adverse effect on the availability of typical invertebrate species in the aquatic food web, which is an indirect measure of injury to high trophic level predators, including humans. For example, if benthic invertebrate prey sources are in decline because of toxic effects of sediments, then birds and mammals that prey on the invertebrates may experience adverse effects such as increased foraging effort, decreased nutrition, or other indirect effects.

5.1.5 Sampling for Benthic and Epibenthic Invertebrates

Organisms may not only experience direct toxic effects of sediment contaminants, but may also accumulate contaminants in their tissues. Tissue concentrations of field-collected organisms serve dual purposes as indicators of direct exposure and uptake by benthic invertebrates, and as measures of potential transfer of contaminants from the sediment to other organisms in the aquatic ecosystem. Tissue concentrations in organisms collected from the Anacostia River will be used in both the ERA and the NRDA.

Collecting benthic and epibenthic invertebrates in the field from specific locations is more difficult than collecting sediment because organisms may not be distributed as expected. The purpose of analyzing field-collected organisms is to measure concentrations of contaminants that might actually be transferred to predators at the site. Although laboratory-based bioaccumulation tests on collected sediments may be simpler to conduct, the results are difficult to link to the actual transfer of contaminants from sediment to invertebrates in the river. Laboratory bioaccumulation tests measures uptake by a clean organism under controlled laboratory conditions for a fixed period of time. In contrast, tissue concentrations in field-collected organisms represent lifetime exposure under environmentally variable conditions.

Invertebrate samples will be collected opportunistically at approximately half of the locations listed in **Table 5.3** and shown in **Figure 5.2**. During collection of surface sediment samples, the availability of invertebrate tissue will be qualitatively evaluated and a decision made whether adequate volume of invertebrate tissue can be obtained.

Both laboratory- and field-based measures of bioaccumulation are valuable indicators of bioavailability of chemicals. These tests provide distinct types of information about the potential transfer of chemicals from sediment to organisms. Taken together, the combined measures of bioaccumulation provide data to support both the ERA and the NRDA.

Field-collected tissue samples are the most direct measure of actual ingestion exposure to higher trophic level predators. For example, fish, birds, and mammals are exposed to whatever chemicals are in the bodies of the benthic organisms they eat. Whenever possible, field-collected tissue concentrations will be used in food chain models to represent dietary exposure to chemicals. However, field-collected tissue samples are limited by two factors: (1) the confounding of multiple sources of contaminants to the benthic organism and (2) the absence of benthic organisms in some locations.

Tissue concentrations of benthic organisms collected from the field represent exposure not only to sediment but also to surface water and prey items. Therefore, interpretation of bioavailability of chemicals in sediment is somewhat confounded by field-collected tissue samples. These limitations are addressed by exposing organisms to sediment samples under controlled laboratory conditions to isolate the bioaccumulation of chemicals solely from sediment sources.

Field-collected tissues may not be available in all sediment locations. Some existing reports indicate that portions of the Anacostia River may have few benthic invertebrates (whether naturally or as a result of contamination). One way to predict the potential for bioaccumulation from sediments in areas where benthic organisms are too scarce to support tissue collection is to exposure test organisms to the sediments in the laboratory. We will analyze potential bioaccumulation in locations where benthic invertebrate abundance is too low to support tissue collection by conducting laboratory bioaccumulation tests.

The field and laboratory bioaccumulation data provide separate and complementary measures of potential exposure of organisms to contaminants in sediment. It would be inappropriate to assume exposure of higher trophic level predators at locations where no benthic organisms occur because no predation can occur where no prey live. The laboratory bioaccumulation and toxicity tests can support evaluation of the cause of scarce benthic invertebrate populations in certain areas. In summary, laboratory and field data will be integrated in the ERA and NRDA to support rational, defensible conclusions about complete exposure pathways leading to injury and risk.

5.2 Surface Water Sampling

Nearshore surface water samples will be collected from within 1 foot of the surface within areas where fishing or nearshore recreation is documented or observed, including Kingman and Heritage Islands Recreational Areas, Bladensburg Waterfront Park, Anacostia Park, and the Haines Point waterfront bordering Washington Channel. Sampling locations are shown on **Figure 5.3**. The surface water samples will be collocated with the 14 nearshore sediment samples described in **Section 5.1.2**. above. The purpose of these sample locations is to evaluate the potential risk to anglers or other recreationalists who may be exposed to nearshore surface water while fishing, boating, swimming, or participating in other activities on the river. A minimum of 14 samples are anticipated; however, the number of samples and sample locations may be adjusted based on field observations of actual or potential human activity. Sample locations are shown in **Figure 5.3**. Sample locations will be recorded with a GPS unit.

All surface water samples will be submitted for the following chemical analyses:

- Field parameters (pH, temperature, specific conductivity, oxidation/reduction potential, dissolved oxygen)
- Total organic carbon
- Priority Pollutant List
- Dioxin-like PCB congeners
- Dioxins and furans

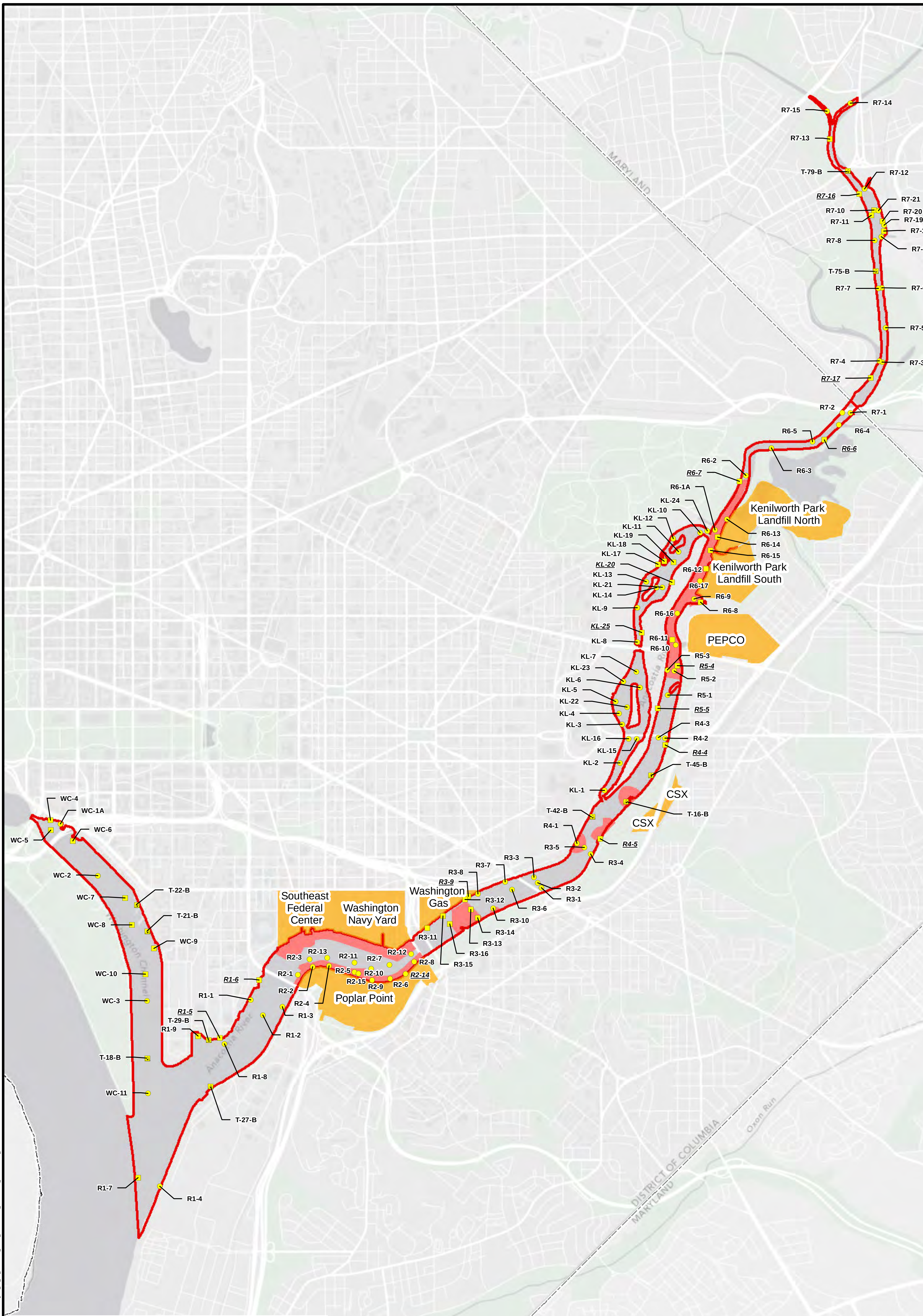
5.3 Fish Tissue Sampling and Analysis

Fish tissue concentrations provide evidence that fish were exposed to contaminated surface water, sediment, or prey items. Because fish move around, fish samples do not provide a definitive link to a particular location, but they do provide an overview of injury and risk within the aquatic environment. Fish tissue samples will also be used in the HHRA. Fish tissue sampling will be conducted at 42 locations. Sample locations are shown on **Figure 5.3**. Analysis at each location is shown on **Table 5.4**.

At each fish sampling locations, one to three types of fish samples will be collected (based on availability). Ideally, fish from three feeding guilds (forage fish, mid-level predator, and top predator) will be collected. However, existing data suggest that top predators (such as catfish and largemouth bass) are absent from some reaches of the river. Forage fish include herring, banded killifish, and topminnows. Mid-level predators are represented by various species of sunfish, including bluegill and pumpkinseed.

Forage fish samples will be used in two ways: to support injury determination and risk to these species directly, and to provide estimates of food chain transfer to piscivorous birds and mammals (such as the green heron, cormorant, otter, and raccoon). (See **Section 7.0** for discussion of typical birds and mammals in the Anacostia River.) Samples of mid- and top-level predator fish will be used in the same ways as forage fish, as well as in the HHRA . When available, larger fish samples (of the size an angler might be reasonably expected to catch and consume) will be filleted and only the muscle analyzed. These samples will be used in the HHRA to estimate contaminant ingestion by recreational anglers and their families

Fish sampling locations were selected to provide spatial coverage of all reaches of the river within the Study Area. Within each reach of the river, sample locations were biased toward outfalls (where contaminants are expected). Sampling will also occur where the presence of contaminants is generally unknown such as inlets areas with known fishing piers, and backwater areas. Sample collection locations may be shifted in the field to accommodate logistical requirements of the selected sample collection methods. Details will be provided in the FSP.



Date Saved: 10/23/2013 10:34:05 AM User: joel.peters Path: S:\CADD\S\2592\mxd\WorkPlan\Figure_05_01_Anacostia_11x17_PROPOSED_SAMPLING_LOCATIONS_SEDIMENT.mxd

Legend

- PROPOSED SHALLOW SEDIMENT SAMPLE
- PROPOSED SHALLOW/DEEP SEDIMENT SAMPLE
- BENTHIC TISSUE SAMPLING LOCATION
- CLEANUP SITE BOUNDARY
- SEDIMENT STUDY AREA
- AWTA AOC
- WASHINGTON DC BOUNDARY

R1-5 Italics underlined sample name indicates sample is for human health-pedestrian access to riverbank.

SOURCE: MODIFIED FROM CH2MHILL, 2011, AND DCGIS, 2012.

DRAFT

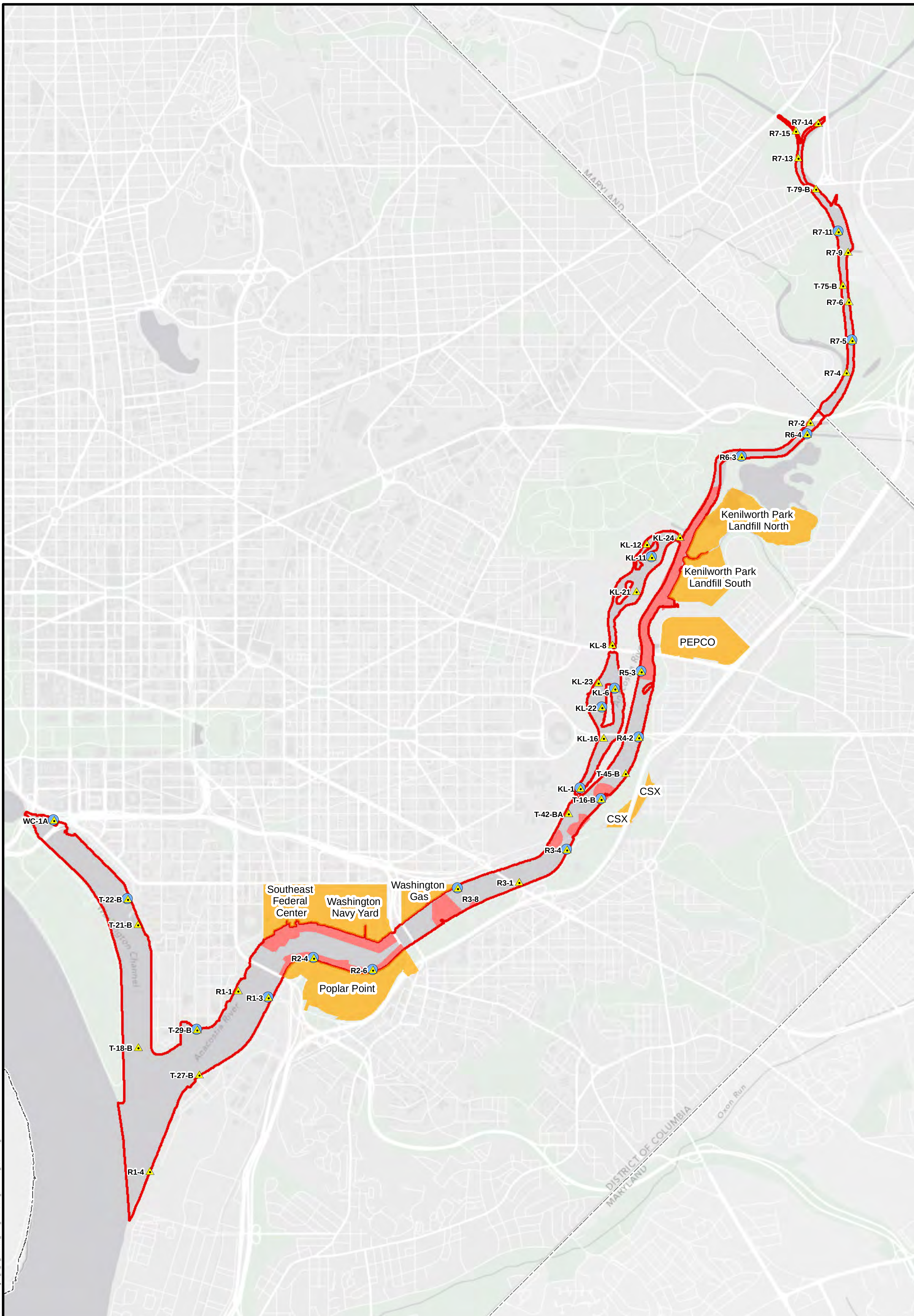
N W E S

0 1,500 3,000 Feet

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 5.1
PROPOSED SEDIMENT SAMPLING LOCATIONS

TETRA TECH



Legend

- BENTHIC TISSUE SAMPLING LOCATION
- PORE WATER SAMPLING LOCATION
- PRP BOUNDARY
- SEDIMENT STUDY AREA
- WASHINGTON DC BOUNDARY
- AWTA AOC

DRAFT

N W E S

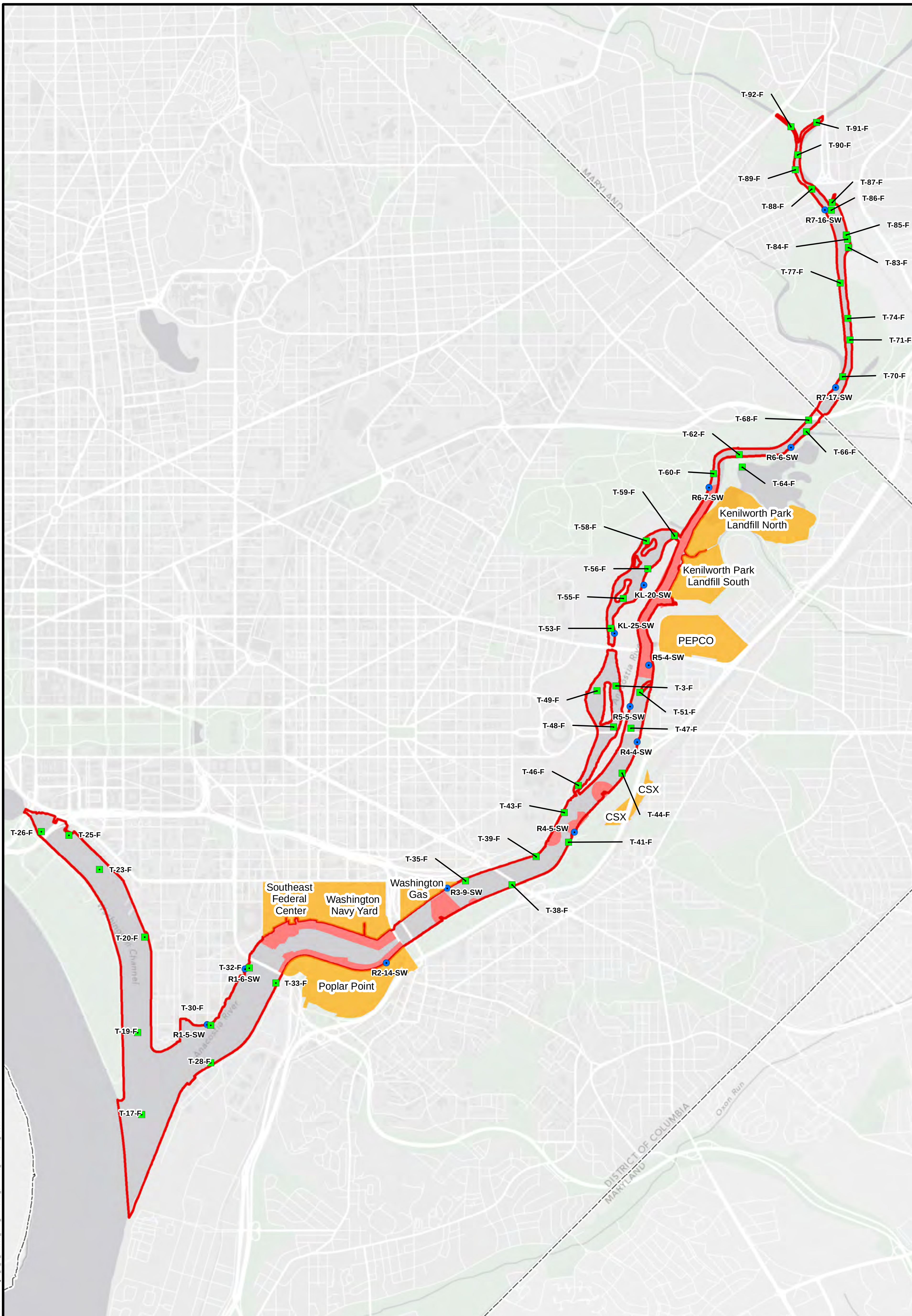
0 1,500 3,000 Feet

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 5.2
PROPOSED BENTHIC INVERTEBRATE EVALUATION AND PORE WATER SAMPLING LOCATIONS IN SURFACE SEDIMENT

TETRA TECH

SOURCE: MODIFIED FROM CH2MHILL, 2011, AND DCGIS, 2012.



Legend

FISH TISSUE SAMPLING LOCATION	SEDIMENT STUDY AREA
SURFACE WATER SAMPLING LOCATION	AWTA AOC
	PRP BOUNDARY
	WASHINGTON DC BOUNDARY

DRAFT

N S W E

0 1,500 3,000 Feet

ANACOSTIA RIVER SEDIMENTS
REMEDIAL INVESTIGATION WORKPLAN

FIGURE 5.3
PROPOSED FISH TISSUE AND SURFACE WATER SAMPLING LOCATIONS

TETRA TECH

SOURCE: MODIFIED FROM CH2MHILL, 2011, AND DCGIS, 2012.

TABLE 5.2
Proposed Sediment Sampling Locations and Rationale, Page 1 of 5

Location	Reach	Characterization Objective [2]	Analyses [3,4]	Pore Water	Deep Sediment	Rationale	Proximate to Existing Sample	Location
WC-1A	Washington Channel	RI/NRDA	PP, BI	X	X	Outfall	N	Outfall F-477-703 North of I-395 Bridge
WC-2		RI	PP		X	Spatial Coverage	N	Center of Washington Channel, midway between WC-1 and existing sample point
WC-3		RI	PP		X	Spatial Coverage	N	Center of Washington Channel, midway between two existing sample points
WC-4		RI	PP			Spatial Coverage	N	Outfall F-290-057 North of I-395 Bridge
WC-5		RI	PP			Spatial Coverage	N	Mid-channel offshore from WC-4 and WC-1A
WC-6		RI	PP			Spatial Coverage	N	Mid-channel offshore from Outfall F-518-460
WC-7		RI	PP			Spatial Coverage	N	Mid-channel offshore from marina and Outfall F-892-361
WC-8		RI	PP			Spatial Coverage	N	Mid-channel offshore from Outfalls F-969-934 & F-018-809
WC-9		RI	PP			Outfall	N	Outfall F-073-094
WC-10		RI	PP			Spatial Coverage	N	Center of Washington Channel, midway between two existing sample points
WC-11		RI	PP		X	Spatial Coverage	N	Mouth of Washington Channel
T-22-B		NRDA	PP, BI	X		Spatial Coverage	N	Adjacent to marina dock
T-21-B		NRDA	PP, BI			Spatial Coverage	N	Adjacent to marina dock
T-18-B		NRDA	PP, BI			Spatial Coverage	N	Center channel upstream from mouth of Washington Channel
R1-1	South Capitol Street Bridge to Mouth of River	RI/NRDA	PP, BI		X	Outfall	N	West bank near F-093-544 coverage of unsampled portion of channel
R1-2		RI	PP		X	Spatial Coverage	N	Center channel, coverage of unsampled portion of channel
R1-3		RI/NRDA	PP, BI	X	X	Spatial Coverage	N	East bank near NPDES004, coverage of unsampled portion of channel
R1-4		RI/NRDA	PP, BI		X	Outfall	N	Adjacent to Outfall F-128-495
R1-5		RI	PP			Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)
R1-6		RI	PP			Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)
T-29-B		NRDA	PP, BI	X		Spatial Coverage	N	Near south bank, just upstream from confluence with Washington Channel
T-27-B		NRDA	PP, BI			Outfall	N	North band at Outfall F-937-544
R1-7		RI	PP			Verification	Y	HPAH hotspot at mouth of Anacostia River
R1-8		RI	PP		X	Verificaton	Y	HPAH hotspot southeast of R1-5
R1-9		RI	PP			Spatial Coverage	N	Fort McNair Marina
R2-1	11th Street Bridge to South Capitol Street Bridge	RI	PP		X	Verification	Y	Overlap with year 2000 data point; east shoreline at Poplar Point
R2-2		RI	PP		X	Spatial Coverage	N	East shoreline at Poplar Point
R2-3		RI	PP		X	Spatial Coverage	N	Center channel, offshore from R2-2

TABLE 5.2
Proposed Sediment Sampling Locations and Rationale, Page 2 of 5

Location	Reach	Characterization Objective [2]	Analyses [3,4]	Pore Water	Deep Sediment	Rationale	Proximate to Existing Sample	Location
R2-4	11th Street Bridge to South Capitol Street Bridge	RI/NRDA	PP, BI	X	X	Outfall	Y	East shoreline at Poplar Point, at Sewer Outfall F-897-104
R2-5		RI	PP		X	Outfall, Verification	Y	East shoreline at Poplar Point, overlap with year 2000 point, adjacent to F-417-217
R2-6		RI/NRDA	PP, BI	X	X	Outfall	N	Adjacent to NPDES 005
R2-7		RI	PP		X	Verification	Y	Center channel adjacent to year 2000 point
R2-8		RI	PP		X	Outfall	N	Adjacent to NPDES 006
R2-9		RI	PP		X	Outfall	N	Adjacent to F-008-706
R2-10		RI	PP		X	Spatial Coverage	N	Center channel from R2-9
R2-11		RI	PP		X	Verification	Y	Center channel from R2-05 and adjacent to year 2000 point
R2-12		RI	PP		X	Spatial Coverage	N	Center channel from R2-8
R2-13		RI	PP		X	Spatial Coverage	N	Center channel from R2-4
R2-14		RI	PP		X	Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)
R2-15		RI	PP		X	Outfall, Verification	Y	Outfall F-417-217; overlap with year 2000 sampling point
R3-1	CSX Bridge to 11th Street Bridge	RI/NRDA	PP, BI		X	Verification	Y	Transect near Pennsylvania Ave. Bridge near year 2000 point
R3-2		RI	PP		X	Verification	Y	Transect near Pennsylvania Ave. Bridge near year 2000 point
R3-3		RI	PP		X	Verification	Y	Transect near Pennsylvania Ave. Bridge near year 2000 point
R3-4		RI/NRDA	PP, BI	X	X	Verification, Outfall	Y	Transect near CSX Bridge near year 2000 point; near Fort Davis tributary (F-238-290)
R3-5		RI	PP		X	Verification	Y	Transect near CSX Bridge near year 2000 point
R3-6		RI	PP		X	Spatial Coverage	N	Center channel from R3-7
R3-7		RI	PP		X	Outfall	N	Adjacent to NPDES 018
R3-8		RI/NRDA	PP, BI	X	X	Outfall	N	Adjacent to F-405-220
R3-9		RI	PP			Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)
R3-10		RI	PP		X	Verification, Outfall	Y	Outfall F-124-260 and a HPAH hotspot
R3-11		RI	PP			Spatial Coverage	N	Nearshore, southwest corner of Washington Gas
R3-12		RI	PP			Spatial Coverage	N	Nearshore off of Washington Gas
R3-13		RI	PP			Spatial Coverage	N	Mid channel forming transect with R3-12
R3-14		RI	PP			Spatial Coverage	N	Near shoreline opposite from Washington Gas, forming transect with R3-12
R3-15		RI	PP			Spatial Coverage	N	Nearshore off of Washington Gas
R3-16		RI	PP			Spatial Coverage	N	Mid channel forming transect with R3-15

TABLE 5.2
Proposed Sediment Sampling Locations and Rationale, Page 3 of 5

Location	Reach	Characterization Objective [2]	Analyses [3,4]	Pore Water	Deep Sediment	Rationale	Proximate to Existing Sample	Location
R4-1	East Capitol Street Bridge to CSX Bridge	RI	PP		X	Verification	Y	Transect near CSX Bridge near year 2000 point
R4-2		RI/NRDA	PP, BI	X	X	Verification, Outfall	Y	Transect near East Capitol St. Bridge; near Chaplin tributary (F-903-371) and 2000 point
R4-3		RI	PP		X	Spatial Coverage	N	Transect near East Capitol St. Bridge
R4-4		RI	PP			Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)
R4-5		RI	PP			Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)
T-42-BA		NRDA	PP, BI			Verfication	Y	HPAH hotspot downstream from Kingman Lake confluence
T-16-B		NRDA	PP, BI	X		Spatial Coverage	N	West shore adjacent to East Capitol Street Bridge
T-45-B		NRDA	PP, BI			Spatial Coverage	N	East bank north of Fort Dupont Creek Outfall
R5-1	Benning Road Bridge to East Capitol Street Bridge	RI	PP		X	Outfall	N	Adjacent to F-090-064
R5-2		RI	PP		X	Verification	Y	Transect downstream from year 2000 transect
R5-3		RI/NRDA	PP, BI	X	X	Verification	Y	Transect downstream from year 2000 transect
R5-4		RI	PP			Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)
R5-5		RI	PP			Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)
R6-1A	Amtrak Bridge to Benning Road Bridge	RI	PP		X	Verification, Outfall	Y	Mouth of Hickey Run near existing elevated year 2000 point
R6-2		RI	PP		X	Spatial Coverage	N	Center channel to augment existing year 2000 points
R6-3		RI/NRDA	PP, BI	X	X	Spatial Coverage	N	Center channel to augment existing year 2000 points
R6-4		RI/NRDA	PP, BI	X	X	Verification, Outfall	Y	Confluence with Lower Beaverdam Creek
R6-5		RI	PP		X	Spatial Coverage	N	Center channel between year 2000 transects
R6-6		RI	PP			Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)
R6-7		RI	PP			Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)
R6-8		RI	PP			Spatial Coverage	N	Mouth of outfall at northwest boundary of the Pepco site
R6-9		RI	PP		X	Spatial Coverage	N	At mouth of inlet for outfall at northwest boundary of the Pepco site
R6-10		RI	PP		X	Spatial Coverage	N	At mouth of inlet for outfall at southwest boundary of the Pepco site
R6-11		RI	PP			Spatial Coverage	Y	Center channel off of Pepco site; near ANS 2000 sample (concentration 1119 ug/kg)
R6-12		RI	PP			Spatial Coverage	N	Nearshore sediment bar off of Kenilworth Park South Landfill
R6-13		RI	PP		X	Spatial Coverage	N	Nearshore off of Kenilworth Park North Landfill

TABLE 5.2
Proposed Sediment Sampling Locations and Rationale, Page 4 of 5

Location	Reach	Characterization Objective [2]	Analyses [3,4]	Pore Water	Deep Sediment	Rationale	Proximate to Existing Sample	Location
R6-14	Amtrak Bridge to Benning Road Bridge	RI	PP			Spatial Coverage	N	Nearshore off of Kenilworth Park North Landfill
R6-15		RI	PP			Spatial Coverage	Y	Bar at mouth of Watts Branch; near ANS 2000 sample (concentration 599 ug/kg)
R6-16		RI	PP		X	Spatial Coverage	N	Mid-channel off of Pepco site
R6-17		RI	PP		X	Spatial Coverage	N	Mid-channel off of Kenilworth Park South Landfill
R7-1	Upper tidal limit to Amtrak Bridge	RI	PP		X	Verification	Y	Transect at New York Ave. Bridge near existing year 2000 point
R7-2		RI/NRDA	PP, BI		X	Verification	Y	Transect at New York Ave. Bridge near existing year 2000 point
R7-3		RI	PP		X	Spatial Coverage	N	Transect near confluence with Dueling Creek
R7-4		RI/NRDA	PP, BI		X	Spatial Coverage	N	Transect near confluence with Dueling Creek
R7-5		RI/NRDA	PP, BI	X	X	Spatial Coverage	N	Center channel downstream from unnamed wetland tributary
R7-6		RI/NRDA	PP, BI		X	Verification	Y	Near year 2000 transect
R7-7		RI	PP		X	Verification	Y	Near year 2000 transect
R7-8		RI	PP		X	Verification	Y	Located near year 2000 point; transect with R7-9
R7-9		RI/NRDA	PP, BI		X	Outfall	N	Confluence with unnamed tributary
R7-10		RI	PP			Verification	Y	Center channel sediment bar; near year 2000 transect
R7-11		RI/NRDA	PP, BI	X		Verification	Y	Center channel sediment bar; near year 2000 transect
R7-12		RI	PP		X	Outfall	N	Confluence with unnamed tributary
R7-13		RI/NRDA	PP, BI			Spatial Coverage	N	Center channel sediment bar
R7-14		RI/NRDA	PP, BI		X	Verification	Y	Upstream on Northeast Branch near year 2000 point
R7-15		RI/NRDA	PP, BI		X	Spatial Coverage	N	Upstream on Northwest Branch
R7-16		RI	PP			Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)
R7-17		RI	PP			Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)
T-75-B		NRDA	PP, BI			Spatial Coverage	N	West bank midway between R7-7 and R7-8
T-79-B		NRDA	PP, BI			Spatial Coverage	N	Adjacent to Bladensburg Road Bridge
R7-18		RI	PP			Spatial Coverage	N	Adjacent to pier structure at Bladensburg marina
R7-19		RI	PP		X	Spatial Coverage	N	Adjacent to shoreline at Bladensburg marina
R7-20		RI	PP			Spatial Coverage	N	Adjacent to shoreline at Bladensburg marina
R7-21		RI	PP		X	Spatial Coverage	N	On shore side of mid-channel bar just north of Bladensburg marina

TABLE 5.2
Proposed Sediment Sampling Locations and Rationale, Page 5 of 5

Location	Reach	Characterization Objective [2]	Analyses [3,4]	Pore Water	Deep Sediment	Rationale	Proximate to Existing Sample	Location
KL-1	Kingman Lake	RI/NRDA	PP, BI	X	X	Spatial Coverage	N	Downstream near mouth of Kingman Lake
KL-2		RI	PP		X	Spatial Coverage	N	Broad channel between Kingman Lake mouth and East Capitol Street
KL-3		RI	PP		X	Outfall	N	Downstream from F-284-041
KL-4		RI	PP		X	Outfall	N	Downstream from unnamed outfall on west bank
KL-5		RI	PP		X	Outfall	N	Downstream from F-611-365
KL-6		RI/NRDA	PP, BI	X	X	Spatial Coverage	N	East channel north of East Capitol Street and south of Benning Road
KL-7		RI	PP		X	Spatial Coverage	N	Main channel south of Benning Road
KL-8		RI/NRDA	PP, BI		X	Outfall	N	Downstream from F-567-976
KL-9		RI	PP		X	Outfall	N	Downstream from F-052-384
KL-10		RI	PP		X	Spatial Coverage	N	Upstream mouth of Kingman Lake
KL-11		RI/NRDA	PP, BI	X	X	Spatial Coverage	N	Channel in northern silted-in portion of Kingman Lake
KL-12		RI/NRDA	PP, BI		X	Spatial Coverage	N	Channel in northern silted-in portion of Kingman Lake
KL-13		RI	PP		X	Spatial Coverage	N	Channel in northern silted-in portion of Kingman Lake
KL-14		RI	PP		X	Spatial Coverage	N	Channel in northern silted-in portion of Kingman Lake
KL-15		RI	PP		X	Spatial Coverage	N	Transect along East Capitol St. Bridge
KL-16		RI/NRDA	PP, BI		X	Spatial Coverage	N	Transect along East Capitol St. Bridge
KL-17		RI	PP			Spatial Coverage	N	West bank near golf course
KL-18		RI	PP			Spatial Coverage	N	Island east of KL-17
KL-19		RI	PP			Spatial Coverage	N	Island east of KL-18
KL- 20		RI	PP			Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)
KL-21		RI/NRDA	PP, BI		X	Spatial Coverage	N	Mud flat east of KL-14
KL-22		RI/NRDA	PP, BI	X	X	Spatial Coverage	N	Mud flat north of East Capitol St. Bridge
KL-23		RI/NRDA	PP, BI		X	Spatial Coverage	N	West bank mud flat north of KL-22
KL-24		RI/NRDA	PP, BI		X	Spatial Coverage	N	Mudflat adjacent to upstream mouth of Kingman Lake
KL-25		RI	PP			Spatial Coverage	N	Characterization for human health (pedestrian access to riverbank)

Notes:

1. Samples prefixed by "T-," as well as all samples with flagged "BI" for analyses, will be used for benthic tissue evaluations (see Note 4) and will also be analyzed as discussed in Note 3.
2. Characterization Objective: RI - Remedial Investigation (including ecological and human health risk assessments); NRDA - Natural Resources Damage Assessment
3. Analyses: PP - EPA Priority Pollutant List; BI - Benthic Invertebrate sampling will be performed; at 20 percent of the samples (locations to be determined by criteria defined in the FSP), specialty analyses to be defined in the FSP) will be performed including PCB congeners, PCDDs/PCDFs, AVS/SEM, moisture content/percent solids, bulk density, and Atterberg limits
4. At "BI" locations, surface sediment samples will be analyzed for chemical constituents *and* designated as either a toxicity or tissue location. The goal is to designate half the BI stations as tissue locations and the other half as toxicity testing stations; actual locations will be determined in the field. Where adequate benthic invertebrate tissue is available, as indicated by visual observation of the grab sample, additional sediment will be collected and sieved for benthic invertebrates to be subjected to tissue analysis for bioaccumulative constituents. Where the initial sediment grab sample contains few or no benthic organisms, conditions will be noted but no additional effort to obtain benthic invertebrates will be made. Locations that do not yield adequate benthic invertebrates for tissue analysis will be subjected to laboratory toxicity testing using benthic invertebrates. Test methods will follow ASTM E1706 - 05(2010): Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates. BI tissue samples will be analyzed for metals, total Aroclors, total chlordane, total DDTs, dieldrin, heptachlor epoxide, and total polycyclic aromatic hydrocarbons (PAHs).

TABLE 5.3

Proposed Benthic Invertebrate and Porewater Sampling Locations, Page 1 of 2

Location	Reach	Characterization Objective [2]	Analyses [3,4]	Pore Water[5]	Location
WC-1A	Washington Channel	RI/NRDA	PP, BI	X	Outfall F-477-703 North of I-395 Bridge
T-22-B		NRDA	PP, BI	X	Adjacent to marina dock
T-21-B		NRDA	PP, BI		Adjacent to marina dock
T-18-B		NRDA	PP, BI		Center channel upstream from mouth of Washington Channel
R1-1	South Capitol Street Bridge to Mouth of River	RI/NRDA	PP, BI		West bank near F-093-544 coverage of unsampled portion of channel
R1-3		RI/NRDA	PP, BI	X	East bank near NPDES004, coverage of unsampled portion of channel
R1-4		RI/NRDA	PP, BI		Adjacent to Outfall F-128-495
T-29-B		NRDA	PP, BI	X	Near south bank, just upstream from confluence with Washington Channel
T-27-B		NRDA	PP, BI		North band at Outfall F-937-544
R2-4	11th Street Bridge to South Capitol Street	RI/NRDA	PP, BI	X	East shoreline at Poplar Point, at Sewer Outfall F-897-104
R2-6		RI/NRDA	PP, BI	X	Adjacent to NPDES 005
R3-1	CSX Bridge to 11th Street Bridge	RI/NRDA	PP, BI		Transect near Pennsylvania Ave. Bridge near year 2000 point
R3-4		RI/NRDA	PP, BI	X	Transect near CSX Bridge near year 2000 point; near Fort Davis tributary (F-238-290)
R3-8		RI/NRDA	PP, BI	X	Adjacent to F-405-220
R4-2	East Capitol Street Bridge to CSX Bridge	RI/NRDA	PP, BI	X	Transect near East Capitol St. Bridge; near Chaplin tributary (F-903-371) and 2000 point
T-42-BA		NRDA	PP, BI		HPAH hotspot downstream from Kingman Lake confluence
T-16-B		NRDA	PP, BI	X	West shore adjacent to East Capitol Street Bridge
T-45-B		NRDA	PP, BI		East bank north of Fort Dupont Creek Outfall
R5-3	Benning Road Bridge to East Capitol Street Bridge	RI/NRDA	PP, BI	X	Transect downstream from year 2000 transect
R6-3	AMTRAK Bridge to Benning Road	RI/NRDA	PP, BI	X	Center channel to augment existing year 2000 points
R6-4		RI/NRDA	PP, BI	X	Confluence with Lower Beaverdam Creek
R7-2	Upper tidal limit to Amtrak Bridge	RI/NRDA	PP, BI		Transect at New York Ave. Bridge near existing year 2000 point
R7-4		RI/NRDA	PP, BI		Transect near confluence with Dueling Creek
R7-5		RI/NRDA	PP, BI	X	Center channel downstream from unnamed wetland tributary
R7-6		RI/NRDA	PP, BI		Near year 2000 transect
R7-9		RI/NRDA	PP, BI		Confluence with unnamed tributary

TABLE 5.3

Proposed Benthic Invertebrate and Porewater Sampling Locations, Page 2 of 2

Location	Reach	Characterization Objective [2]	Analyses [3,4]	Pore Water[5]	Location
R7-11	Upper tidal limit to Amtrak Bridge	RI/NRDA	PP, BI	X	Center channel sediment bar; near year 2000 transect
R7-13		RI/NRDA	PP, BI		Center channel sediment bar
R7-14		RI/NRDA	PP, BI		Upstream on Northeast Branch near year 2000 point
R7-15		RI/NRDA	PP, BI		Upstream on Northwest Branch
T-75-B		NRDA	PP, BI		West bank midway between R7-7 and R7-8
T-79-B		NRDA	PP, BI		Adjacent to Bladensburg Road Bridge
KL-1	Kingman Lake	RI/NRDA	PP, BI	X	Downstream near mouth of Kingman Lake
KL-6		RI/NRDA	PP, BI	X	East channel north of East Capitol Street and south of Benning Road
KL-8		RI/NRDA	PP, BI		Downstream from F-567-976
KL-11		RI/NRDA	PP, BI	X	Channel in northern silted-in portion of Kingman Lake
KL-12		RI/NRDA	PP, BI		Channel in northern silted-in portion of Kingman Lake
KL-16		RI/NRDA	PP, BI		Transect along East Capitol St. Bridge
KL-21		RI/NRDA	PP, BI		Mud flat east of KL-14
KL-22		RI/NRDA	PP, BI	X	Mud flat north of East Capitol St. Bridge
KL-23		RI/NRDA	PP, BI		West bank mud flat north of KL-22
KL-24		RI/NRDA	PP, BI		Mudflat adjacent to upstream mouth of Kingman Lake

Notes:

1. Samples prefixed by "T-" will be subjected to benthic tissue evaluations (see Note 4) and will also be analyzed as discussed in Note 3.
2. Characterization Objective: RI - Remedial Investigation (including ecological and human health risk assessments); NRDA - Natural Resources Damage Assessment
3. Surface sediment will be collected for analysis of priority pollutants (PP) at all benthic invertebrate (BI) sample locations, in addition 20% of the surface sediment locations will be analyzed for additional specialty analyses (see Table 5-1) including PCB congeners, PCDDs/PCDFs, AVS/SEM, moisture content/percent solids, bulk density, and Atterberg limits
4. Surface sediment samples will be analyzed for chemical constituents *and* designated as either a toxicity or tissue location. Benthic invertebrates will be collected for tissue analysis at approximately half the BI locations and sediment will be collected for toxicity testing stations at the other BI locations. Actual locations will be determined in the field. Where adequate benthic invertebrate tissue is available, as indicated by visual observation of the grab sample, additional sediment will be collected and sieved for benthic invertebrates for tissue analysis for bioaccumulative constituents. Where the initial sediment grab sample contains few or no benthic organisms, conditions will be noted but no additional effort to obtain benthic invertebrates will be made. Additional sediment will be collected for toxicity testing using benthic invertebrates at locations that do not yield adequate benthic invertebrates for tissue analysis. Toxicity test methods will follow ASTM E1706 - 05(2010): Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates. BI tissue samples will be analyzed for priority pollutants, pesticides, and polycyclic aromatic hydrocarbons (PAHs).
5. Pore water will be collected at select BI locations distributed across the reaches. Pore water will be extracted in the lab and analyzed for SVOCs, metals, pesticides, total cyanide, dioxins and furans, PCB aroclors, TOC, DOC, and pH

TABLE 5.4
Proposed Fish Tissue and Surface Water Sampling Locations and Rationale, Page 1 of 5

Location	Medium	Reach	Characterization Objective [1,9]	Chemical/ Ecological Analyses[2,3,4]	Ecological Risk Assessment Rationale[6,8]	Human Health Risk Assessment Rationale[5,6,7,8]	Location
T-26-F	Tissue	Washington Channel	HHRA/ERA/NRDA	See Notes 2 and 3	ERA samples collected opportunistically at this location	Contaminants may be elevated, and fish may congregate near bridge; pier provides angling access	Between Francis Case and 14th Street Bridges
T-25-F	Tissue	Washington Channel	HHRA/ERA/NRDA	See Notes 2 and 3	ERA samples collected opportunistically at this location	Spatial coverage; angling opportunity	Near boat slips on east bank
T-23-F	Tissue	Washington Channel	HHRA/ERA/NRDA	See Notes 2 and 3	ERA samples collected opportunistically at this location	Spatial coverage; angling opportunity	Near boat slips on east bank
T-20-F	Tissue	Washington Channel	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage	Spatial coverage	East bank Washington Channel near Titanic Memorial
T-19-F	Tissue	Washington Channel	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage	Spatial coverage	Center of Washington Channel near the National War College
T-33-F	Tissue	South Capitol Street Bridge to Mouth of River	HHRA/ERA/NRDA	See Notes 2 and 3	Contaminants may be elevated, and fish may congregate near bridge	Contaminants may be elevated, and fish may congregate near bridge	Below 11th Street Bridge, east bank at pier
T-32-F	Tissue	South Capitol Street Bridge to Mouth of River	HHRA/ERA/NRDA	See Notes 2 and 3	Contaminants may be elevated, and fish may congregate near bridge	Contaminants may be elevated, and fish may congregate near bridge	Below 11th Street Bridge, west bank at pier
T-30-F	Tissue	South Capitol Street Bridge to Mouth of River	HHRA/ERA/NRDA	See Notes 2 and 3	ERA samples collected opportunistically at this location	Potential angling opportunity	West bank at pier
T-28-F	Tissue	South Capitol Street Bridge to Mouth of River	HHRA/ERA/NRDA	See Notes 2 and 3	ERA samples collected opportunistically at this location	Potential angling opportunity	East bank at pier
T-17-F	Tissue	South Capitol Street Bridge to Mouth of River	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage	Spatial coverage	At confluence with Potomac
R1-5-SW	Surface water	South Capitol Street Bridge to Mouth of River	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample R1-5
R1-6-SW	Surface water	South Capitol Street Bridge to Mouth of River	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample R1-6
R2-14-SW	Surface water	11th Street Bridge to South Capitol Street Bridge	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample R2-14
T-38-F	Tissue	CSX Bridge to 11th Street Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Contaminants may be elevated, and fish may congregate near bridge	Contaminants may be elevated, and fish may congregate near bridge	Below Pennsylvania Avenue Bridge, east bank

TABLE 5.4
Proposed Fish Tissue and Surface Water Sampling Locations and Rationale, Page 2 of 5

Location	Medium	Reach	Characterization Objective [1,9]	Chemical/ Ecological Analyses[2,3,4]	Ecological Risk Assessment Rationale[6,8]	Human Health Risk Assessment Rationale[5,6,7,8]	Location
T-35-F	Tissue	CSX Bridge to 11th Street Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	ERA samples collected opportunistically at this location	Contaminants may be elevated, and fish may congregate near boat slips; potential angling opportunity	Boat slips on west bank below Pennsylvania Avenue Bridge
R3-9-SW	Surface water	CSX Bridge to 11th Street Bridge	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample R3-9
T-39-F	Tissue	East Capitol Street Bridge to CSX Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	ERA samples collected opportunistically at this location	Contaminants may be elevated, and fish may congregate near boat slips; potential angling opportunity	Boat slips on west bank
T-44-F	Tissue	East Capitol Street Bridge to CSX Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage	Spatial coverage	Main stem east bank
T-43-F	Tissue	East Capitol Street Bridge to CSX Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage	Spatial coverage	Main stem west bank
T-41-F	Tissue	East Capitol Street Bridge to CSX Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	ERA samples collected opportunistically at this location	Contaminants may be elevated, and fish may congregate near bridge; known angling location	Below railroad bridge; fishing pier on east bank
R4-4-SW	Surface water	East Capitol Street Bridge to CSX Bridge	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample R4-4
R4-5-SW	Surface water	East Capitol Street Bridge to CSX Bridge	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample R4-5
T-51-F	Tissue	Benning Road Bridge to East Capitol Street Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage	Spatial coverage	Adjacent to F-090-064
T-47-F	Tissue	Benning Road Bridge to East Capitol Street Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Contaminants may be elevated, and fish may congregate near bridge	Contaminants may be elevated, and fish may congregate near bridge	Near Whitney Street Memorial Bridge; main stem
R5-4-SW	Surface water	Benning Road Bridge to East Capitol Street Bridge	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample R5-4
R5-5-SW	Surface water	Benning Road Bridge to East Capitol Street Bridge	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample R5-5
T-66-F	Tissue	Amtrak Bridge to Benning Road Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Contaminants may be elevated, and fish may congregate near RR bridge; shallow tributary drains into river on east bank	Contaminants may be elevated and fish may congregate near railroad bridge	Downstream of the railroad bridge; on east bank at mouth of tributary
T-64-F	Tissue	Amtrak Bridge to Benning Road Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Foraging area for green heron and other birds; likely fish nursery area and crayfish habitat	HHRA samples will be collected opportunistically	In channels within within mudflats on east bank (below Kenilworth Gardens)

TABLE 5.4

Proposed Fish Tissue and Surface Water Sampling Locations and Rationale, Page 3 of 5

Location	Medium	Reach	Characterization Objective [1,9]	Chemical/ Ecological Analyses[2,3,4]	Ecological Risk Assessment Rationale[6,8]	Human Health Risk Assessment Rationale[5,6,7,8]	Location
T-62-F	Tissue	Amtrak Bridge to Benning Road Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Foraging area for green heron and other birds; likely fish nursery area and crayfish habitat	Spatial coverage	In main channel at entrance to mudflats (below Kenilworth Gardens)
R6-6-SW	Surface water	Amtrak Bridge to Benning Road Bridge	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample R6-6
R6-7-SW	Surface water	Amtrak Bridge to Benning Road Bridge	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample R6-7
T-60-F	Tissue	Amtrak Bridge to Benning Road Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage	Spatial coverage	Upstream from Kenilworth Park Landfill and confluence of Hickey Run
T-92-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage	Foot path leads to water	Near Anacostia Tributary Trail (ATT) bridge
T-91-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage	Foot path leads to water	Upstream on Northeast Branch, below Baltimore Avenue Bridge
T-90-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage	Trail leads to shore where sandbar is accessible to wading and fishing	Sandbar accessible from ATT
T-89-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Narrow channel west of sandbar may provide refuge for fish away from main channel	Narrow channel west of sandbar may provide refuge for fish away from main channel	Shoreline channel next to sandbar accessible from ATT
T-88-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage	Foot path leads to water; contaminants may be elevated, and fish may congregate near bridge	Near Bladensburg Bridge
T-87-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Shallow area of apparent sediment deposition may be attractive to forage fish and their predators	Large fish are not expected here; HHRA samples will be collected opportunistically	Shallow narrow inlet on east bank near ATT bridge
T-86-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	ERA samples collected opportunistically at this location	Foot path leads to water; accessible to anglers	East bank south of ATT bridge; in deeper channel
T-85-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	ERA samples collected opportunistically at this location	Public pier popular with anglers	Piers associated with Bladensburg Waterfront Park
T-84-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	ERA samples collected opportunistically at this location	Public pier popular with anglers	Piers associated with Bladensburg Waterfront Park

TABLE 5.4
Proposed Fish Tissue and Surface Water Sampling Locations and Rationale, Page 4 of 5

Location	Medium	Reach	Characterization Objective [1,9]	Chemical/ Ecological Analyses[2,3,4]	Ecological Risk Assessment Rationale[6,8]	Human Health Risk Assessment Rationale[5,6,7,8]	Location
T-83-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	ERA samples collected opportunistically at this location	Public pier popular with anglers	Piers associated with Bladensburg Waterfront Park
T-77-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage	Spatial coverage	Open channel
T-74-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Tidal channels within marsh may be attractive to forage fish and their predators	HHRA samples will be collected opportunistically	Near mouth of the tidal channels providing access to marsh on east bank
T-71-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Tidal channels within marsh may be attractive to forage fish and their predators	HHRA samples will be collected opportunistically	Near mouth of the tidal channels providing access to marsh on east bank
T-70-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	The tributary appears very shallow at low tide, good habitat for forage fish (and crayfish) and their vertebrate predators	Small tributary may provide fish habitat outside of main stem of the river.	On west bank, downstream of small tributary with pier
T-68-F	Tissue	Upper tidal limit to Amtrak Bridge	HHRA/ERA/NRDA	See Notes 2 and 3	Contaminants may be elevated, and fish may congregate near bridge	Contaminants may be elevated, and fish may congregate near bridge	Downstream of Route 50 bridge; on west bank
R7-16-SW	Surface water	Upper Tidal Limit to Amtrak Bridge	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample R7-16
R7-17-SW	Surface water	Upper Tidal Limit to Amtrak Bridge	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample R7-17
T-59-F	Tissue	Kingman Lake	HHRA/ERA/NRDA	See Notes 2 and 3	Shallow area off the main channel may suppoer forage fish and crayfish and their predators	Popular recreational area; angling may occur in deeper areas	North entrance to Kingman Channel
T-58-F	Tissue	Kingman Lake	HHRA/ERA/NRDA	See Notes 2 and 3	Forage area for numerous birds, including osprey	HHRA samples will be collected opportunistically	West backwater of Kingman Lake
T-56-F	Tissue	Kingman Lake	HHRA/ERA/NRDA	See Notes 2 and 3	Forage area for numerous birds, including osprey	HHRA samples will be collected opportunistically	West backwater of Kingman Lake
T-55-F	Tissue	Kingman Lake	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage in side channel	HHRA samples will be collected opportunistically	West backwater of Kingman Lake
T-53-F	Tissue	Kingman Lake	HHRA/ERA/NRDA	See Notes 2 and 3	Spatial coverage in side channel	HHRA samples will be collected opportunistically	North of Benning Road bridge
T-49-F	Tissue	Kingman Lake	HHRA/ERA/NRDA	See Notes 2 and 3	Quiet backwater may provide good foraging habitat for birds and mammals	HHRA samples will be collected opportunistically	Western tidal slough in Kingman Lake area
T-48-F	Tissue	Kingman Lake	HHRA/ERA/NRDA	See Notes 2 and 3	Contaminants may be elevated, and fish may congregate near bridge	Contaminants may be elevated, and fish may congregate near bridge	Near Whitney Street Memorial Bridge, Kingman Lake

TABLE 5.4
Proposed Fish Tissue and Surface Water Sampling Locations and Rationale, Page 5 of 5

Location	Medium	Reach	Characterization Objective [1,9]	Chemical/ Ecological Analyses[2,3,4]	Ecological Risk Assessment Rationale[6,8]	Human Health Risk Assessment Rationale[5,6,7,8]	Location
T-46-F	Tissue	Kingman Lake	HHRA/ERA/NRDA	See Notes 2 and 3	Quieter side channel may provide habitat for fishes	Spatial coverage	Ingress/egress to Kingman Lake from main Anacostia River
T-3-F	Tissue	Kingman Lake	HHRA/ERA/NRDA	See Notes 2 and 3	ERA samples collected opportunistically at this location	Location of recreational angling opportunities	At pier in Kingman Lake
KL-20-SW	Surface water	Kingman Lake	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample KL-20
KL-25-SW	Surface water	Kingman Lake	HHRA	See Note 4	-	Potential human recreational exposure	Colocated with surface sediment sample KL-25

Notes:

1. Characterization Objective: ERA - Ecological Risk Assessment; HHRA - Human Health Risk Assessment; NRDA - Natural Resource Damage Risk Assessment. Where all three objectives are listed, the HHRA objective will be met opportunistically, based on the availability of suitable fish.
2. ERA fish samples will be analyzed for metals, total aroclors, total chlordane, total DDTs, dieldrin, heptachlor epoxide, and total polycyclic aromatic hydrocarbons (PAHs).
3. HHRA fish samples will be analyzed for Target Analyte List (TAL) metals, dioxin-like polychlorinated biphenyl (PCB) congeners, Aroclors, total chlordane, total DDTs,dieldrin, heptachlor epoxide, and total PAHs.
4. Surface water samples (referenced in Section 5.2) will be collected at the 14 nearshore sediment sampling locations for HHRA exposure (see Figure 5-2) and analyzed for TAL metals (and mercury), semi-volatile organic compounds (including PAHs), and pesticides and PCBs (including PCB congeners).
5. Targeted fish species for HHRA include all fishes typically caught and consumed by recreational anglers. Anticipated species include bottom feeders (carp and catfish) and mid-water foragers (largemouth bass, sunfish, and eel).
6. Where sample sizes are adequate, larger individual fish that exceed the allowable catch size will be designated as "HHRA" samples and prepared accordingly. Smaller individuals of the same species will be designated "ERA" samples and prepared accordingly. Species that are not typically consumed by humans will be designated "ERA" regardless of size.
7. All fish collected for HHRA will be filleted. Skin will be removed or left on as appropriate to the species, representing the typical way the species is prepared for consumption. Carcasses will be analyzed separately and combined with the fillets in the HHRA as appropriate for various receptor groups.
8. Sample collection methods differ for the two type of assessment, but also overlap. The larger fish typically caught for human consumption may be collected using electroshocking equipment, collected from anglers, or caught by trot line, hoop net, or angling. Smaller specimens suitable for ecological risk assessment may be incidentally collected using these methods. In addition, forage fishes targeted in the ecological risk assessment may be collected using seines, minnow traps, or cast nets. Crayfish caught during fish sampling will also be analyzed as forage (for birds and mammals). Any large fish caught using these methods will be designated HHRA samples and processed accordingly.
9. All HHRA and ERA samples will be appropriate for inclusion in the NRDA dataset at a later date.

6.0 DATA EVALUATION AND REPORTING

This section describes the processes used to ensure the analytical data generated during the field effort are verified, validated, and documented. This section also addresses the synthesis of these data into the project database, the tasks to identify and document potential remaining data gaps and associated reporting, and the objectives moving forward for updating and revising the watershed model.

6.1 Data Evaluation

Field sampling will be conducted in accordance with the FSP (to be prepared) which will address the required numbers, types, and locations of samples and the required types of field and laboratory analyses needed to achieve the project DQOs. The FSP will also indicate the procedures to be used to document sample collection including the chain of custody (CC) and laboratory analyses request documents. CCs and other field documentation will be reviewed on a daily basis to ensure accuracy and completeness. Any discrepancies will be resolved before samples are delivered to the laboratory.

Detailed DQOs will be defined along with quality control criteria and limits in a Quality Assurance Project Plan (QAPP) to be developed. Sampling and analytical methods will be selected to meet the project DQOs and quality control criteria. Analytical data collected during this investigation will be verified and validated in accordance with USEPA Region 3 protocols (validation protocols). Validation will be performed at an acceptance level sufficient for risk assessment Level 4. Data verification is the process of evaluating the completeness, correctness, and conformance and compliance of a specific data set against method and procedural requirements. Data validation is an analyte- and sample-specific process to determine the analytical quality of a data set. Data quality flags as assigned by the analytical laboratory will be independently reviewed against the validation protocols. Individual values may be flagged as non-detect, detected and qualified (e.g., biased high, biased low, estimated, etc.), or rejected. An analysis result flagged as rejected cannot be used.

Following validation, the data will be incorporated into the project database. An initial goal will be to compare the surface sediment sampling results from the current event with the results from the ANS 2000 sampling event. The results of this comparison will verify usability of the ANS 2000 data for use in assessing the nature and extent of contamination and other project objectives.

6.2 RI Data Report

The data from the current sampling will be spatially evaluated to identify any potential remaining data gaps and to quantify zones of elevated concentrations. An RI Data Report will be prepared that will discuss project objectives, field data collection procedures, and analytical methods and summarize the data collection results. The Data Report will also include a discussion of data validation conducted in accordance with the approved QAPP. The report will also document the management and disposal of investigation-derived wastes. Data tables will be used to denote locations where screening criteria are exceeded.

The data report will include:

- A summary of field activities and methods, including a discussion of any discrepancies with the sampling and analysis plan and the effect of such changes upon data usability.
- Rules for data reduction and use.
- Tabulated chemical, physical, and biological data.
- A sample identification matrix that relates sample identification numbers to sample locations.
- Maps showing actual sample locations.
- Field logs.
- Laboratory data sheets.

Lastly, the report will provide conclusions and recommendations regarding potential remaining data gap closure and associated strategies for moving forward to the RI Summary Report.

6.3 RI Summary Report

An RI Summary Report will be prepared that synthesizes the results of all investigations conducted during the RI. All data will be reported in tabular form, and various map overlays and other plots will be used to present the information. The pertinent features of the RI report will be a description of the investigations conducted, discussion of the nature and extent of contamination identified, characterization of potential migration pathways, evaluation of contaminant fate and transport, and incorporation of the baseline human health and ecological risk assessments. The RI portion of the report outline will follow the EPA guidance.

The RI Summary Report will include a summary of the historic data along with the data collected under this work plan. The RI Summary Report will include updates to the conceptual site model, the TAM/WASP model and current findings for the six specific sites. The RI summary report will define the nature and extent of the contamination in the River, identify hot spots, summarize the sources of contamination and source control, and provide an evaluation of contaminant fate and transport including the results from the update of the TAM/WASP model.

The RI will evaluate the risk implications of potential exposure to subsurface sediments. This discussion will be based on the results of the baseline ERA and HHRA (and data used in these assessments) and subsurface sediment chemistry data.

The major topics of the RI will include:

- Environmental setting and previous investigations;
- Nature and extent of contamination;
- Contamination sources, pathways, and source control;
- Fate and transport of sediment and sediment-associated chemicals;
- Summaries of the risks identified in the baseline ERA and the HHRA

Ecological risk assessment and human health risk assessment summary reports will be prepared as attachments to the RI report, or as separate reports. These reports will summarize the findings for the ecological and human health risks from contaminants in the sediments, surface water, pore water and biota in the river. More information on the ecological and human health risk assessments are presented in **Sections 7 and 8** of this work plan.

6.4 Watershed Model Update and Revision

Once verification and validation of the RI data are complete, the data can be used to support efforts to update and revise the TAM/WASP model. As discussed in Behm and others (2003), the calibration process can include adjusting chemical load inputs (contributions from CSS outfalls, MS4 outfalls, tributaries, groundwater seepage, etc.), sediment/water partitioning coefficients, and other fate and transport parameters to achieve the best possible match between predicted water column, fish tissue, and sediment concentrations and observed concentrations. In addition, updating the watershed model may involve computer code modifications to allow treatment of a greater range of system processes (e.g., emulsification, photo-oxidation, biodegradation, etc.) that can be important in accessing the fate and transport of sediment contaminants. Alternatively, other computer modeling approaches may potentially be considered to augment the TAM/WASP model should the addition of these processes be deemed necessary by watershed stakeholders.

7.0 ECOLOGICAL RISK ASSESSMENT

The primary objective of the ecological risk assessment (ERA) is to determine whether site contaminants pose a current or potential risk to ecological receptors in the absence of remediation. The ERA will be used to determine whether remediation is necessary at the site, provide justification for performing remedial action, and determine what exposure pathways must be remediated. The areas to be addressed in the ERA include the Anacostia River (bank-to-bank) sediments, surface water, and related biota within the study area. Areas within the six environmental sites (**Section 1.4** and **Figure 1.1**) are excluded from the ERA because other entities are responsible for characterization and assessment at those sites. On **Figure 1.1**, the excluded areas are denoted as “AWTA AOC” or “NEW AOC.” As part of the RI, the ERA will be based on data collected during the RI field activities and other data available from other reliable sources, including historic data and data from the six environmental sites that are found to be usable based on the project DQOs.

This technical approach was based on both site specific and programmatic information, including the following: review of field investigations conducted on the Anacostia River; a review of supporting data on the river ecosystem; EPA guidance on ERAs; and knowledge of and experience with best practices in ERAs.

The physical characteristics and known environmental condition of the tidal Anacostia River are described in **Section 2.0**. The ecological conceptual site model (CSM) is presented in **Section 3.2**. Together, these discussions provide a context for the technical approach. General approaches to the screening-level ERA (SLERA) and baseline ERA (BERA) are presented below.

7.1 Screening Level Ecological Risk Assessment (SLERA)

The SLERA will be conducted consistent with EPA ERA guidance for Superfund sites (EPA 1997a), discussions with DDOE staff, and applicable DDOE guidance. Two steps are involved in conducting a SLERA: (1) problem formulation and (2) screening level exposure estimate and risk calculation. Upon completion of Steps 1 and 2, the site must be evaluated for one of the three possible decisions summarized below.

1. There is enough information to conclude that potential ecological risks are very low or nonexistent and therefore no further action is warranted at the site on the basis of ecological risk.
2. The information is not adequate to make a decision at this point, and the ERA process will proceed to a BERA.
3. The information indicates a potential for adverse ecological effects, and a focused BERA is warranted.

The following sections discuss problem formulation and screening-level exposure estimates and risk calculations for the SLERA.

7.1.1 Problem Formulation

The objective of the problem formulation step is to collect sufficient information concerning the Anacostia River Site to develop a CSM. The preliminary CSM, introduced in **Section 3.2**, includes a fate and transport diagram (**Figure 3.1**) that traces movements of contaminants through the ecosystem and identifies potential exposure pathways and receptors. One of the major goals of the CSM is to identify complete exposure pathways and receptors at potential risk.

7.1.1.1 Habitat Assessment

The purpose of the habitat assessment is to gather data necessary to identify potential ecological receptors and to support the development of a conceptual site model. The assessment will summarize existing information on habitat within the study area from other studies and the published literature. It will include the identification of the state and federal threatened and endangered species likely to be present at the study site.

7.1.1.2 Assessment Endpoints

Assessment endpoints for a screening level assessment are focused on adverse effects on all potential ecological receptors. Key receptor groups associated with the Anacostia River include benthic invertebrates, fish, and semi-aquatic avian and mammalian receptors that may be exposed to contaminants in sediment, water, and food items in the river. Typical species and exposure pathways for ecological receptors in the Anacostia River are discussed in **Section 3.2.2** (Conceptual Site Model). Fate and transport mechanisms, ecotoxicological properties, habitats, and receptors at the site all influenced the selection of the assessment endpoints. The survival, growth, and reproduction of key organisms are considered ecological values to be protected. The general ecological management goal that will guide selection of assessment endpoints is summarized below:

- Ensure adequate protection of ecological systems within the impacted areas of the Anacostia River by protecting them from the deleterious effects of acute and chronic exposures to site-related constituents of concern (COC).

The specific assessment endpoints for the SLERA are summarized below:

- Ensure adequate protection of the aquatic communities in the Anacostia River by protecting them from the deleterious effects of acute and chronic exposures to site-related COCs in sediment, surface water, and prey.
- Ensure adequate protection of the aquatic-dependent avian and mammalian populations along the shoreline of the Anacostia River by protecting them from the

deleterious effects of acute and chronic exposures due to uptake of site-related COCs in sediment, surface water, and prey.

- Ensure adequate protection of threatened and endangered species and species of special concern and their habitats in the Anacostia River by protecting them from the deleterious direct and indirect effects of acute and chronic exposures to site-related COCs.

"Adequate protection" generally is defined as protection of the growth, reproduction, and survival of local populations of typical species that are not listed under the Endangered Species Act (ESA). That is, the focus is on ensuring the sustainability of the local population rather than on protection of every individual in the population. Risk to federal- and state-identified threatened and endangered species will be evaluated in the ERA at the level of the individual, as required by the ESA.

7.1.2 Measurement Endpoint

Measurement endpoints were selected to represent the species or communities of the Anacostia River ecosystem that can be directly evaluated. A measurement endpoint is "a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint and is a measure of biological effects (such as mortality, reproduction, or growth)" (EPA 1997a). It is anticipated that receptors will be exposed to COCs primarily through direct contact with and ingestion of sediment, surface water, and food items. Measurement endpoints in a SLERA are generally numeric criteria that can be used to support decisions about the potential for unacceptable risk. Several potential sources were reviewed to identify appropriate ecological screening values (ESV) for use as measurement endpoints for the SLERA.

7.1.2.1 Sediment

Potential risk to aquatic invertebrates and fish will be evaluated by comparing the concentrations of chemicals in sediment with toxicity benchmarks for aquatic organisms. No federal or state standards have been developed for chemicals in sediment. The chemical concentrations in sediments from the Anacostia River will be compared with the EPA Region 3 Freshwater Sediment Screening Benchmarks (**Table 2.5**) and available regional background concentrations.

7.1.2.2 Surface Water

Potential risk to aquatic invertebrates and fish will be evaluated by comparing the concentrations of chemicals in surface water with toxicity benchmarks for aquatic organisms. Measurement endpoints for aquatic invertebrates and fish exposed to surface water in the Anacostia River will be the District's aquatic life water quality standards (DC 2010).

Potential risk to aquatic receptors is indicated by surface water concentrations that exceed the water quality standards for chronic exposures (DC 2010). Chemicals with no District standards will be evaluated using EPA's national water quality standards. When constituent-specific criteria are not provided by either of these sources, the EPA Region 3 Freshwater Screening Benchmarks (EPA 2013b) will be used. Constituents for which no aquatic life criteria are available from any of the sources identified above will be carried forward into the BERA, as applicable, for further risk evaluation.

7.1.2.3 Food Chain Model

For birds and mammals, reproductive or physiological effects will be evaluated using toxicity reference values (TRV) derived from the toxicological literature. Daily ingested doses will be estimated based on chemical concentrations in sediment, surface water and prey in the river and information on natural history for avian and mammalian receptors. Sediment and surface water direct toxicity criteria do not take into account the potential exposure of birds and mammals to chemicals within their food taken from the Anacostia River. The measurement endpoint for birds and mammals will be a daily ingested dose of chemicals calculated using a food chain model (FCM). Dose estimates will then be compared with TRVs to assess potential risk, as described below.

The FCM assumes exposure to COCs primarily through ingestion of contaminated environmental sediment surface water, and prey. Exposure models estimate the mass of a COPEC internalized daily by a receptor per kilogram of body weight per day (the daily COPEC dose). Estimates of exposure generally are based on knowledge of the spatial and temporal distribution of both COCs and receptors, and on specific natural and life history characteristics that influence exposure to COCs. Results for surface sediment samples will be used in FCMs to estimate doses to avian and mammalian receptors.

Daily doses will be estimated for each COC and representative receptor when adequate data are available and these models are appropriate. Dose estimates will then be compared with a high and low TRV to estimate the potential adverse biological effects on the receptor. No observed adverse effect level (NOAEL) and lowest observed adverse effect level (LOAEL) TRVs will be used as low and high benchmarks, respectively, to evaluate potential risks to birds and mammals. The NOAEL TRV will represent the highest dose at which no adverse effects are expected to occur (*de minimis* risk). A receptor could potentially receive a daily dose that exceeds the NOAEL TRV and still not experience an adverse effect; thus, NOAEL TRVs are conservative and have the potential to over-estimate risk. The LOAEL TRV represents the lowest dose at which adverse effects have been detected. While typically less conservative than NOAEL TRVs, LOAEL TRVs are generally more representative of a natural toxicological response with meaningful ecological ramifications. The risk to each representative species will be characterized using a hazard quotient (HQ) approach based on this comparison.

The total exposure from ingestion for each receptor of concern will be calculated as the sum of the dietary exposure estimates. The following generic equation will be adapted for each representative receptor:

$$Dose_{total} = \frac{([IR_{prey} \times C_{prey}] + [IR_{sed} \times C_{sed}] + [IR_{sw} \times C_{sw}]) \times SUF}{BW}$$

where

$Dose_{total}$	=	Estimated dose from ingestion (mg/kg-day)
IR_{prey}	=	Ingestion rate of prey (kg/day)
C_{prey}	=	Concentration in DW of COC in prey (mg/kg)
IR_{sed}	=	Ingestion rate of sediment (kg/day)
C_{sed}	=	Concentration in DW of COC in sediment (mg/kg)
IR_{sw}	=	Ingestion rate of surface water (L/day)
C_{sw}	=	Concentration of COC in surface water (mg/L)
SUF	=	Site use factor (unitless)
BW	=	Adult body weight (kg)

The risk estimates developed in the SLERA will ensure that the assessment does not indicate little or no risk when a risk actually exists. Therefore, conservative assumptions will be used in this analysis in the absence of site- or species-specific data, such as maximum concentrations, site use factors of unity, and other conservative assumptions. Ecological receptors were selected based on species distributions reported in the literature (AWTA 2002; NPS 2010). Exposure will be assessed within the context of the following linear food chains to evaluate potential ecological effects on secondary consumer birds and mammals:

- Surface Water and Sediment → Benthos and Aquatic Life → Mink
- Surface Water and Sediment → Benthos and Aquatic Life → Green Heron

Site-specific prey data may not be available for use in the dose calculation described above. Therefore, bioaccumulation models will be used to estimate the concentrations of COCs in prey tissue based on the concentrations of COCs in sediment. Sediment-to-biota bioaccumulation models for benthic invertebrates and fish may be used, either as simple bioaccumulation factors (BAF) that can be multiplied by the concentration in the sediment or as regression models that incorporate the concentration in sediment to estimate the COC concentration in prey.

Updated ecological sediment screening level BAFs and regressions will be used whenever available. Additional regression models and simple BAFs (Bechtel-Jacobs Company, LLC 1998; Sample and Arenal 1999; Sample, Opresko, and Suter 1996; Baes, Sharp, Sjoreen, and Shor 1984; EPA 2005) will be chosen if no regression is available. A regression model will be applied only if the model is significant (the slope differs significantly [$p < 0.05$] from 0) and the coefficient of determination (R^2) is greater than or equal to 0.6. If these criteria are not met, another regression model or BAF will be selected to estimate bioaccumulation.

7.1.3 SLERA Exposure Estimates and Risk Calculations

The maximum concentration is considered a conservative estimate of the exposure point concentration (EPC) in the SLERA. In general, an estimate of exposure is compared with a relevant toxicologically-based screening value to yield an HQ representing potential risk, as shown in the equation below:

$$HQ = \frac{EPC}{ESV} \text{ or } \frac{Dose}{TRV}$$

An HQ threshold value of 1.0 will be used to identify COCs. Generally, the greater the HQ, the greater the likelihood of an effect. Although probabilities cannot be specified based on a point-estimate approach, an HQ of less than 1.0 is generally regarded as indicating a low probability of adverse ecological effects. A constituent with an HQ greater than 1.0 is present at levels above its threshold concentration but may or may not pose actual risk.

7.1.4 SLERA Summary and Conclusions

One of the final objectives of the SLERA is to identify potential ecological risks that should be further characterized and refined in the BERA. EPA guidance has identified this as a risk management decision point. The SLERA will present a summary of the procedures used, the potential risks identified, and a discussion of the uncertainties associated with the results. Based on the results of the SLERA and the uncertainties, a risk management recommendation will be provided on whether a BERA is needed to support a final risk management decision. In the BERA, exposure assumptions are refined to reflect more realistic field conditions. Additional data may be collected in the BERA to measure field conditions that affect exposure, effects, and related risks.

7.2 Baseline Ecological Risk Assessment (BERA)

A BERA, if recommended at the conclusion of the SLERA, would be consistent with EPA's ERA guidance for Superfund sites (EPA 1997a), as discussed below. The three principal phases of a BERA are problem formulation, study design and implementation, and risk characterization.

7.2.1 Problem Formulation – Refinement

The objective of the BERA problem formulation is to establish the risk assessment goals and focus, characterize potential ecological effects, update the CSM, refine exposure pathways, and establish the assessment endpoints.

As an initial step in BERA problem formulation, COCs identified during the SLERA will be re-evaluated to focus the BERA on COCs most likely to drive a remedial action. COCs that pose a negligible risk based on low magnitude (HQ near 1.0), low frequency of detection (less than 5 percent), or minimal difference from background may be eliminated from further consideration in the BERA.

Tetra Tech will review the recent toxicity literature for the COCs included in the BERA to identify whether there are more relevant TRVs based on the NOAELs and LOAELs for site-specific receptors. The toxicity mechanism and function (acute or chronic) for each TRV also will be identified. The goal is to identify TRVs that are more appropriate for the species and exposure pathways expected at the site.

Potentially complete exposure pathways identified in the SLERA CSM will be refined based on site-specific conditions. The fate and transport of each COC significantly affects potential exposure and effects at the site.

To complete the CSM for the BERA, measurement and assessment endpoints will be reviewed and modified as needed. Available literature will be reviewed to refine assumptions on distribution and abundance of species; conservation status; and natural history of key species (such as foraging behavior, habitat use, home range, and other site-specific information). Potential or known presence of federal- and state-identified threatened and endangered species will be evaluated.

The BERA endpoints will focus on specific exposure pathways for a variety of receptors. In the riverine habitats of the Anacostia River, these endpoints may include the following:

- Function and viability of the aquatic community (benthic invertebrates and fish)
- Function and viability of omnivorous mammals along the shoreline (represented by the mink)
- Function and viability of carnivorous birds along the shoreline (represented by the green heron)

Omnivorous and carnivorous birds and mammals are important consumers at the site and play a role in structuring the riverine community. Adverse effects on these top predators would be undesirable because the loss of top predators generally leads to disruption of lower trophic levels.

7.2.2 Measurement Endpoints and Study Design

The measurement endpoints identified during the SLERA will be re-evaluated to ensure they are appropriate for the BERA and modified as needed.

The next step in the BERA will be to prepare a study design to clearly identify the lines of evidence and the measurement endpoints needed to evaluate risk to assessment endpoints. The following sections discuss the aquatic habitat study design and the FCM.

7.2.2.1 Sediment

Under the SLERA the measurement endpoints were based on conservative sediment criteria and guidelines. These endpoints will be reviewed and modified if appropriate. However, if the conservative guidelines are retained, rather than compare the maximum sediment concentration with a toxicity benchmark, the full range of sediment exposure concentrations will be evaluated using probabilistic statistics.

Laboratory bioassays will provide a measure of direct toxicity to standardized test organisms under controlled exposure conditions. Bioassay results will be compared with both laboratory control samples and reference samples (if available).

7.2.2.2 Surface Water

The same measurement endpoints for surface water used in the SLERA will be used in the BERA.

Estimated doses may be refined to reflect more realistic exposure scenarios in the Anacostia River. For example, site use factors and ingestion rates may be modified to represent a more typical exposure rather than the maximum exposure scenario for receptors that are not protected under the ESA.

7.2.2.3 Prey Tissue

The FCM used in the SLERA is based on maximum sediment and water concentrations and modeled tissue concentrations to estimate doses. To make the FCM more site specific and realistic, tissues of organisms from the Anacostia River will be analyzed for target chemicals. Where available, benthic invertebrates, such as crayfish and clams, will be collected. Fishes of a species and size likely to be eaten by birds and mammals will also be analyzed (See **Section 5.3**) It is anticipated that both pelagic and demersal fish species (such as killifish, sunfish, herring, and catfish) will be collected.

Collocated sediment and tissue samples can be analyzed to derive site-specific biota-sediment accumulation factors (BSAFs) for use in the BERA. If field-collected tissue samples are unavailable, it may be necessary to collect site-specific sediments for bioaccumulation testing in the laboratory to derive estimates of BSAFs.

7.2.2.4 Bioassays

Laboratory bioassays provide an independent line of evidence in the BERA. As mentioned above, such direct toxicity tests can provide a better understanding of the toxicity associated with sediment from a specific area than a simple review of sediment chemistry. However, bioassays are not always definitive, as the toxic effects are not always well correlated with the sediment chemistry. Bioassay results will be evaluated as one line of evidence contributing to the risk characterization.

7.2.3 Risk Characterization

Risk characterization focuses on the causal relationship between exposure and effects. The characterization will incorporate what is known about potential exposure pathways to representative receptors in the Anacostia River with evidence of chemical concentrations in sediment, water, and biota. Risk characterization consists of two parts: (1) risk estimation and (2) risk description.

Risk estimation is a quantitative process in which exposure concentrations are compared with effect levels appropriate to the receptor and medium being evaluated. The resulting HQs are numerical estimates of risk, given the assumptions stated elsewhere in the BERA. Risk estimates are calculated for individual chemicals and receptors, and do not take into account multiple exposures or indirect effects. For some receptors, more than one risk estimate will be calculated based on different exposure or effect assumptions. For example, risk estimates can be calculated for surface water concentrations using both acute and chronic effect levels. For sediment, risk estimates can be prepared for samples at discrete depths. The particular assumptions that prevail for each type of risk estimate will be explained in the BERA.

Risk description is a more qualitative evaluation of the numerical risk estimates and other factors that influence the realization of risk for each receptor. In the risk description, chemicals of greatest concern, or “risk drivers,” are identified based on the magnitude of the risk estimate and the confidence level in the exposure assessment. Risk to federal- and state-identified threatened and endangered species will be discussed at the level of the individual, as required by the ESA.

7.2.4 Uncertainty Analysis

It is critical that the risk managers understand the uncertainties associated with the risk estimates provided in the BERA. The uncertainty analysis will discuss a variety of topics including the limitations of the sampling data, use of toxicity benchmarks, food chain modeling, bioaccumulation data, bioavailability, site use factors, body weight and ingestion rates, development of TRVs, individual and population variations, and risk characterization.

7.2.5 BERA Summary and Conclusions

Overall risks to the selected ecological receptors will be presented using a weight-of-evidence approach. This approach considers the various COCs present, the uncertainties associated with the data collection methods, toxicity data, and risk estimation methods. It will also evaluate the laboratory and field data and the consistency between them, and the impact of the data on the estimated risks. Presentation of the estimated risks based on both NOAEL and LOAEL TRVs will provide risk managers with an understanding of the potential range of risks for the ecological receptors and will allow them to develop site-specific remediation goals.

8.0 HUMAN HEALTH RISK ASSESSMENT

The primary objective of the human health risk assessment (HHRA) is to determine whether site contaminants pose a current or potential risk to human health in the absence of remediation. The HHRA will be used to determine whether remediation is necessary at the site, provide justification for performing remedial action, and determine what exposure pathways must be remediated. The areas to be addressed in the risk assessment include the Anacostia River (bank-to-bank) sediments, surface water, and related biota within the study area. The anticipated significant exposure pathways that will be considered are ingestion of contaminated fish tissue and surface water and direct contact with contaminated surface water and sediment. As noted in **Section 1.4**, the assessment of risks to human health resulting from exposure to potential contaminants in the soil on Kingman and Heritage Islands is outside of the scope of this investigation.

Tetra Tech will conduct HHRA activities consistent with EPA and District of Columbia (District) guidance. The primary guidance documents to be used in preparing the HHRA are listed below. This list is not comprehensive, and other EPA and District guidance documents, as well as documents prepared by other organizations, will be used as appropriate.

1. EPA. 1989. Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual (Part A)." Interim Final. Office of Emergency and Remedial Response (OERR). Washington, D.C. EPA 540-1-89-002. December.

2. EPA. 1991. "RAGS, Volume I: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors." Interim Final. Office of Solid Waste and Emergency Response (OSWER) Directive 9285.6-03. March 25.

3. EPA. 1992b. "Guidance for Data Usability in Risk Assessment (Part A) Final." OERR. Publication 9285.7-09A. April.

4. EPA. 1997b. "Exposure Factors Handbook." Volumes I through III. Office of Research and Development. EPA 600-P-95-002Fa, -Fb, and -Fc. August.

5. EPA. 2001. RAGS, Volume 1 – Human Health Evaluation Manual Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments. Final. Office of Superfund Remediation and Technology Innovation. Publication 9285.7-47. December.

6. EPA. 2002a. "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites." OSWER 9285.6-10. December.

7. EPA. 2003. "Human Health Toxicity Values in Superfund Risk Assessments." OSWER Directive 9285.7-53. December.

8. EPA. 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. OSWER. EPA 540-R-99-005. July.

9. EPA. 2005. "Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens." Risk Assessment Forum. EPA 630-R-03-003F. March.

10. EPA. 2010. "ProUCL Version 4.1 User Guide." Draft. ORD. EPA 600-R-07-041. May.

11. EPA. 2011. "Exposure Factors Handbook: 2011 Edition." Office of Research and Development (ORD). EPA 600-R-090-052F. September12.

12. EPA. 2013c. "User's Guide for Regional Screening Levels (May 2013)."

13. EPA. 2013d. "Regional Screening Level (RSL) Fish Ingestion Table, (May 2013)."

As described in EPA's RAGS, the risk assessment will be conducted in four basic steps: (1) data evaluation and identification of constituents of concern (COC), (2) exposure assessment, (3) toxicity assessment, and (4) risk and hazard characterization. In addition, the HHRA will include a discussion and evaluation of significant sources of uncertainties in the risk assessment process as applied at the Anacostia Site. Each of these risk assessment elements is summarized below.

8.1 Data Evaluation and Identification of COCs

The HHRA will be based primarily on available medium-specific analytical results associated with remedial investigation (RI) activities. These RI results will be as supplemented by historical analytical results collected by other individuals and organizations at sites adjacent to or near the Anacostia Site; contaminants from these other sites may have contributed to contamination present at the Anacostia Site. In these investigations numerous sediment, surface water, pore water, biota, and other samples have been or will be collected.

The cumulative analytical results will be evaluated in accordance with EPA's Guidance for Data Usability in Risk Assessment (Part A) Final (EPA 1992a) to determine whether the data may be used in a quantitative risk assessment. The evaluation process will be documented as part of HHRA activities.

Medium-specific COCs will be selected following the process described in EPA's RAGS. The first step is to identify all chemicals positively detected in at least one sample, including (1) chemicals with no data qualifiers and (2) chemicals with data qualifiers indicating known identities but estimated concentrations (for example, J-qualified data). As discussed in RAGS, this initial list of chemicals may be reduced based on the following factors:

- Evaluation of detection frequency (chemicals detected in less than 5 percent of samples and not potentially site-related will not be retained as COCs),
- Evaluation of essential nutrients, and
- Use of a concentration-toxicity screen (the more conservative [lower] of chemical-, receptor-, and medium-specific levels among EPA Regional Screening Levels [RSL] [EPA 2013b], EPA fish ingestion RSLs [EPA 2013d], maximum contaminant levels [MCL] [EPA 2012], federal and state water quality criteria [EPA 2013a], and other medium-specific levels as appropriate).

After consideration of these factors, those chemicals with maximum detected concentrations exceeding screening levels or for which screening levels are not available will be retained as medium-specific COCs. To ensure that elevated detection limits (DL) do not result in inappropriate exclusion of chemicals from further evaluation, one-half of the maximum detected DL of a constituent not detected in a given medium will be compared to the appropriate screening level. The results of these comparisons may result in inclusion of a non-detected chemical as a COC or discussion of the potential impact of excluding such a chemical as part of the uncertainty discussion.

As described in EPA's RAGS, background screening was a secondary step in the COC selection process (EPA 1989). However, consistent with EPA's evolving stance regarding the use of background in risk assessments (EPA 2002b), based on more recent EPA guidance, background screening will not be considered in the selection of COCs for the Anacostia site (EPA 2002b). The primary contaminants associated with the Anacostia site include polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), dioxins and furans, pesticides, and metals. Concentrations of COCs in upstream medium-specific samples will be qualitatively compared to site-specific concentrations to provide context for and inform the interpretation of HHRA results by risk managers.

8.2 Exposure Assessment

The exposure assessment presents the methods used to estimate the types and magnitudes of potential human exposure to COCs in various media. EPA's RAGS defines exposure as human contact with a chemical or physical agent. The exposure assessment consists of three fundamental steps: (1) exposure setting characterization (including characterizing the site and potential receptors), (2) exposure pathway identification through a conceptual site model (CSM), and (3) exposure quantification. Each of these steps is briefly discussed below.

8.2.1 Exposure Setting Characterization

The exposure setting consists of the physical setting (including natural and man-made features), land uses, and the populations living near the site. This information forms the foundation for selecting potential receptors, exposure pathways, and exposure parameters (for example, how often a receptor may visit the site). The environmental setting of the Anacostia River is described in **Section 2.0** of this WP.

8.2.2 Exposure Pathway Identification

Exposure pathways to be considered in the HHRA will be identified through a human health CSM. The CSM links potential or actual contaminant releases to potential human exposures. Specifically, the CSM identifies (1) potential contaminant sources and mechanisms of release, (2) potential receptors and exposure pathways, and (3) exposure scenarios. **Figure 3.1** presents the generalized CSM for the Anacostia site. This generalized CSM will be updated to reflect specific conditions, receptors, pathways, etc. which are identified as relevant and important to the HHRA. The human health CSM will be included as part of the draft HHRA.

Consistent with EPA's RAGS, the Anacostia Site HHRA will consider only complete (or potentially complete) exposure pathways. As described in RAGS, an exposure pathway generally consists of four elements: a source and mechanism of chemical release, (2) a retention or transport medium (or media in cases involving media transfer of chemicals), (3) a point of potential human contact with the contaminated medium, and (4) an exposure route (for example, ingestion). Based on an initial review, the primary human health receptors are persons engaged in recreational activities. Additionally, workers engaged in construction and utility installation/repair activities may be exposed to site-related contamination if the activities are located immediately adjacent to or extend into the river. A preliminary list of potential human receptors for consideration in the HHRA is presented below:

- Recreational receptors – this group of receptors includes persons (adult, youth, and child) engaged in recreational activities (including fishing, swimming, boating, and hiking) in or along the Anacostia River in the study area. It is important to remember that the HHRA (and the RI in general) is focused on the area within the river from bank to bank; that is, the HHRA will not be evaluating potential exposure to contaminated soil and sediment outside the banks. Also, recreational receptors include friends and relatives of persons who catch fish and other biota (such as clams or crayfish) from the Anacostia River who may be exposed through ingestion of contaminated biota tissue only.
- Subsistence Receptors – this group of receptors includes persons (adult, youth, and child) who rely on fish from the Anacostia River for the majority of their protein. Reports in the public media indicate that as many as 17,000 individuals may be considered

subsistence fishers that rely on the Anacostia River (Anacostia Watershed Society 2012). According to EPA, concern about fish and shellfish safety is higher for subsistence anglers, as they exhibit some of the highest consumption rates (http://cfpub.epa.gov/eroe/index.cfm?fuseaction=list.listBySubTopic&ch=47&s=287).

- Construction and Utility Workers – this group of receptors (adults only) includes persons engaged in construction and utility installation/repair activities that requires exposure to sediment and surface water within the banks of the Anacostia River in the study area.

All receptors are assumed to be exposed under both current and future land use conditions. In fact, for the purposes of the draft HHRA, current and future land use conditions for the Anacostia site are expected to be similar in the sense that activities that currently occur in and along the river (for example, swimming, boating, and fishing) are expected to also take place in the future. However, the frequency and locations at which these activities occur is expected to increase in the future. For example, various developments are already planned along the river.

The primary exposure scenarios expected at the site involve exposures to chemicals in sediment, surface water, and biota. Potential exposure scenarios include the following:

- Direct contact (incidental ingestion of and dermal contact with) chemicals in sediment and surface water. Potential human exposure to sediment by recreational receptors is assumed to be limited to shallow depths as encountered while receptors are engaged in expected recreational activities in and along the river such as swimming, boating, and fishing. The risk assessment will assess potential exposure to sediment 0 to 6 inches deep, but will acknowledge the potential for limited contact to somewhat deeper sediment (up to about 12 inches deep).Construction and utility workers may be exposed to deeper sediments.
- Ingestion of chemicals in biotic tissue (assumed to be primarily fish tissue, but may also include other species such as clams). For the purposes of the draft HHRA, most human receptors are assumed to consume only fillets and not the whole fish (EPA 1997c 1998). It should be noted that, in effort to collect a representative sample, the fillets will be collected with the skin on. However, some subsistence anglers may ingest other portions of the fish or the whole fish. Prior to sample collection, a determination will be made whether population characteristics of subsistence fishers on the Anacostia River are likely to consume the whole fish. This determination is expected to be accomplished as part of the Community Involvement Plan and potentially interviews with local anglers as part of the field effort. Analytical protocols will be developed accordingly.

8.2.3 Exposure Quantification

Receptor-specific exposures will be quantified using standard exposure dose equations that consider a variety of parameters including medium-specific COC concentration (referred to as the exposure point concentration [EPC]), contact rate, the frequency and duration of exposure, and receptor-specific body weight. Consistent with EPA guidance, exposures will be quantified under both reasonable maximum exposure (RME) conditions (the maximum exposure reasonably assumed to occur) and central tendency exposure (CTE) conditions (the typical or average exposure).

Exposure parameters are based on standard default values or recommendations (not available for all receptors) as modified based on site-specific conditions.

For most receptors, medium-specific EPCs will be selected as the lesser of the 95 percent upper confidence limit (UCL) of the mean and the maximum detected concentration at each exposure point. The 95 UCL will be calculated using EPA's Pro UCL, Version 4.1 (EPA 2010). EPCs for construction workers will be based on maximum detected concentrations at each exposure point.

In addition to quantifying exposures based on direct medium measurements, the Anacostia Site HHRA may also conduct modeling to fill data gaps. As necessary, based on the identification of volatile COCs, modeling will be conducted to evaluate the migration of VOCs into the air inside construction trenches. Such modeling will be evaluated using a methodology developed by the Virginia Department of Environmental Quality (VDEQ) as part of its "Voluntary Remediation Program Risk Assessment Guidance" (VDEQ 2013).

EPA-derived algorithms will be used to calculate chronic daily intakes for each exposure route. The generic equations for calculating chemical intake are provided below (EPA 1989, 2009a):

$$\text{I (oral or dermal)} = \frac{C \times CR \times EF \times ED}{BW \times AT}$$

$$\text{I (inhalation)} = \frac{C \times ET \times EF \times ED}{AT}$$

Where:

I = Intake: the amount of chemical at the exchange boundary from oral or dermal exposure (milligrams per kilogram [mg/kg]-day for oral and dermal exposure; milligrams per cubic meter [mg/m^3] for inhalation exposure)

C = Chemical concentration within the exposure medium: the EPC (for example, mg/kg for soil)

CR = Contact rate: the amount of contaminated medium contacted orally or dermally per unit of time or event; may be the ingestion rate or dermal contact rate (for example, milligrams per day [mg/day] for the ingestion rate of soil). The contact rate is not applicable to inhalation exposures.

ET = Exposure time: number of hours of exposure (hours per day [hr/day]); exposure time is applicable only to inhalation exposures.

EF = Exposure frequency: how often the exposure occurs (days per year)

ED = Exposure duration: the number of years a receptor comes in contact with the contaminated medium (years)

BW = Body weight: the average body weight of the receptor over the exposure period (kilograms); applicable only to oral and dermal exposures

AT = Averaging time: the period over which exposure is averaged (days for oral and dermal exposures; hours for inhalation exposures).

For carcinogens, the averaging time is 25,550 days (oral and dermal exposures) and 613,200 hours (inhalation exposures) on the basis of a lifetime exposure of 70 years, which represents the average life expectancy.

For noncarcinogens, the averaging time is the exposure duration expressed in days (ED x 365 days/year) for oral and dermal exposures and in hours (ED x 365 days/year x 24 hr/day) for inhalation exposures.

Pathway-specific variations of the generic equations above will be used to calculate intakes of COCs. The proposed receptor-specific exposure parameters used in variations of these equations will be presented in tabular format.

Also, EPA guidance regarding evaluation of risk from early-life exposure to carcinogens recommends a different approach to estimating chemical intake for carcinogenic chemicals with a mutagenic mode of action (EPA 2005). This guidance will be incorporated and used to modify the above equations consistent with EPA’s RSL User’s Guide (EPA 2013c).

8.3 Toxicity Assessment

The toxicity assessment identifies the toxicity factors that will be used to quantify potential adverse effects (including both carcinogenic and noncarcinogenic effects) on human health associated with potential exposure to site-specific COCs. COC-specific toxicity factors will be identified from EPA’s RSL tables (EPA 2013b), which list toxicity values selected in accordance with EPA’s revised recommended toxicity value hierarchy (EPA 2003), summarized below.

- Tier 1 – EPA’s Integrated Risk Information System (IRIS) (EPA 2013e)

- Tier 2 – EPA's provisional peer-reviewed toxicity values (PPRTV)
- Tier 3 – Other EPA and non-EPA sources of toxicity information, including, but not limited to, (1) the California Environmental Protection Agency (CalEPA) toxicity values, (2) the Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (MRL), and EPA's Health Effects Assessment Summary Tables (HEAST).

Chronic noncarcinogenic toxicity factors will be used for all receptors, with one exception. Because construction workers typically are expected to be exposed at a single site for a period of time less than 7 years (often 1 year or less), subchronic toxicity factors will be used for construction workers.

8.4 Risk Characterization

Risk characterization combines the exposure estimates calculated in the exposure assessment with the toxicity factors identified in the toxicity assessment to calculate COC-, exposure pathway-, and receptor-specific carcinogenic risks (risks) and noncarcinogenic hazards (hazards). Risks and hazards will be calculated following standardized methods described in EPA's RAGS (EPA 1989) and summarized below.

8.4.1 Characterization of Cancer Risk

Risks associated with exposure to chemicals classified as carcinogens are estimated as the incremental probability that an individual will develop cancer over a lifetime as a direct result of an exposure (EPA 1989). The estimated risk is expressed as a unitless probability.

Three steps are used in estimating cancer risks for chemicals classified as carcinogens. First, the chemical intake is multiplied by the chemical-specific slope factor (SF) (oral and dermal exposure) or the chemical-specific inhalation unit risk (IUR) (inhalation exposure) to derive a cancer risk estimate for a single chemical and pathway. The calculation is based on the following relationship:

- Chemical-Specific Cancer Risk (oral or dermal) = Intake (mg/kg-day) x SF $(mg/kg\text{-}day)^{-1}$
- Chemical-Specific Cancer Risk (inhalation) = Intake (milligrams per cubic meter [mg/m^3]) x 10^3 (micrograms [µg]/milligram [mg]) x IUR (micrograms per cubic meter [$\mu g/m^3$])$^{-1}$

Second, the individual chemical cancer risks are assumed additive to estimate the cancer risk associated with exposure to multiple carcinogens for a single exposure pathway, as follows:

- Pathway-Specific Cancer Risk = ∑ Chemical-Specific Cancer Risk

Third, pathway-specific risks are summed to estimate the total cancer risk for each receptor.

8.4.2 Hazard

The potential for exposure that may result in adverse health effects other than cancer is evaluated by comparing the intake with a reference dose (RfD) (oral and dermal exposure) and with a reference concentration (RfC) (inhalation exposure) of each chemical not classified as a carcinogen, and of each carcinogen known to cause adverse health effects other than cancer. When calculated for a single chemical, the comparison yields a ratio termed the hazard quotient (HQ):

$$\text{HQ (oral or dermal)} = \frac{\text{Intake (mg/kg-day)}}{\text{RfD (mg/kg-day)}}$$

$$\text{HQ (inhalation)} = \frac{\text{Intake (mg/m}^3\text{)}}{\text{RfC (mg/m}^3\text{)}}$$

The HQs for all chemicals are summed to evaluate the potential for adverse health effects other than cancer from concurrent exposures to multiple chemicals, yielding a hazard index (HI) as follows:

$$\text{HI} = \sum \text{HQ}$$

Pathway-specific HIs are then summed to estimate a total HI for each receptor. An HI less than 1 indicates that adverse noncancer health effects are not expected. If the total HI exceeds 1, further evaluation in the form of a segregation of the HI via a target organ analysis may be performed to assess whether the noncancer HIs are a concern (EPA 1989). Target organ HIs greater than 1 may indicate a potential adverse effect. However, a target organ analysis will not be conducted in cases where the total HI exceeds 1 and the HQ for an individual COC also exceeds 1 because the HQ results for the individual COC already indicate that concern may be warranted.

8.4.3 Lead

Consistent with the sources of screening values to be used in the HHRA (see **Section 8.1**), potential risks from exposure to lead in sediment by child, youth, and adult recreational receptors and adult construction and utility workers will be characterized by comparing the average concentration of lead in sediment at each exposure area to the EPA RSLs (EPA 2013b). Specifically, risks to recreational receptors will be characterized by initially comparing the average lead concentration in sediment to the residential soil RSL of 400 mg/kg, which was calculated using the Integrated Exposure Uptake Biokinetic (IEUBK) model and default assumptions (EPA 2009b). Similarly, potential risks from exposure to lead in sediment by adult construction and utility workers will initially be screened by comparing average lead concentrations in sediment to the industrial soil RSL of 800 mg/kg, which was calculated using the Adult Lead Model (ALM) (EPA 2009c, d). As necessary, average lead concentrations in sediment will be compared to receptor-specific screening levels calculated using the most recent version of EPA's IEUBK model and the ALM (2009b, 2009c).

8.5 Uncertainty Assessment

The risks and hazards calculated as part of the Anacostia Site HHRA are subject to various degrees of uncertainty from a variety of sources associated with all the major phases of the HHRA process. The uncertainty assessment will identify and discuss the nature of the uncertainty (including direction [overestimation or underestimation] and magnitude) associated with the most significant sources of site-specific uncertainty (including particular assumptions and data limitations).

9.0 NATURAL RESOURCE DAMAGE ASSESSMENT PROCESS

This section provides a brief summary of the Natural Resource Damage Assessment (NRDA) process and how, for the Anacostia contaminated sediments project, the NRDA process relates to the RI. A principal goal of the RI is to collect the necessary data to support a NRDA. As described in **Section 1.2** and **1.3**, the objectives of the NRDA are to identify the spatial and temporal extent of injuries to natural resources. The RI will collect data to describe the area of injured natural resources, the duration of injury, and the likely restoration efforts necessary to restore resources to a fishable and swimmable condition. The NRDA relies in part on data collected during the RI, but is a separate line of inquiry. A focused work plan will describe the analytical steps required to develop the NRDA. The NRDA is expected to include the following general tasks:

Task 1: Information Review – Tetra Tech will review available existing reports and data, as well as data collected during the RI. Existing data and reports include data on potential impacts to natural resources in or associated with the tidal Anacostia River. Natural resources include, but are not limited to, surface water, groundwater, wetlands, sediments, benthic invertebrates, finfish, shellfish, amphibians, reptiles, mammals, which have social, recreational, or economic value to various public user groups. Available environmental data will be reviewed to identify baseline conditions and evaluate potential injuries within the Anacostia River. Data gaps will also be identified.

Task 2: Prepare Streamlined Pre-Assessment Screen – Tetra Tech will prepare a streamlined pre-assessment screen to determine whether an injury has occurred and to describe any exposure pathways. The conceptual site models in the ecological and human health risk assessments, as well as existing reports, will provide a basis for the determination of complete exposure pathways.

Task 3: Preliminary Injury Determination – Tetra Tech will prepare a preliminary injury determination using existing data and data collected during the RI/FS, including per se injury based on fish consumption advisories and violations of water quality criteria and other potential injuries to natural resources. Data gaps will also be identified.

Task 4: Pathway Determination Study/Additional Data Collection – If data gaps are identified, a separate work plan will be prepared for the additional data necessary to quantify the injuries and determine damages. Additional data may include other organisms necessary to support a food web analysis as part of the pathway determination study. Tetra Tech will also evaluate the need for a separate human use survey, if existing data are inadequate.

Task 5: Prepare Natural Resource Damage Assessment Plan – A NRDA plan will identify how the potential damages will be evaluated. This task may include facilitation of public meetings as warranted, preparation of fact sheets on key resources, and preparation of a responsiveness summary.

Task 6: Prepare Natural Resource Damage Assessment Report – The NRDA report will include injury determination, quantification, and damage determination. The value associated with the loss of use of the parks and other recreational facilities by the public will be included in the assessment. The extent of injury will be estimated using documented techniques, such as the commonly used Habitat Equivalency Analysis (HEA). HEA is based on a natural resource service-to-service approach to damage assessment.

Task 7: Prepare Post-Assessment Report – Tetra Tech will conduct a post-assessment, including evaluation of restoration alternatives. This task may include solicitation of restoration alternatives from stakeholders and facilitation of public meetings.

10.0 SCHEDULE

This section provides a summary of the schedule for the Anacostia River contaminated sediments project through the completion of the RI. **Table 10.1** lists the major milestones for the project and the due dates relative to the sequence of tasks.

TABLE 10.1
SUMMARY OF DELIVERABLES FOR RI/FS ON THE ANACOSTIA RIVER

TASK	DUE DATE or DURATION*
Draft Remedial Investigation Work Plan Submitted for Public Review and Comment	November 25, 2013
Draft Community Involvement Work Plan Submitted for Public Review and Comment	November 25, 2013
Public Comment Period for Draft Remedial Investigation Work Plan and Community Relations Plan Completed	December 30, 2013
Final Remedial Investigation Work Plan Completed	January 30, 2014
Draft Site Plans (FSP/QAPP/HASP) Submitted for Public Review and Comment	January 30, 2014
Public Comment Period for Draft Site Plans (FSP/QAPP/HASP) Completed	February 15, 2014
Final Site Plans (FSP/QAPP/HASP)	60 days after receipt of comments on the Draft Site Plans
Remedial Field Investigation	To be initiated within 180 days of approval of the final Work Plan and Site Plans (weather and season permitting)**
Remedial Investigation Data Report	60 days after receipt of laboratory analyses results from the field investigation
Draft Remedial Investigation Report	90 days after approval of the RI Data Report
Final Remedial Investigation Report	45 days after receipt of comments on the Draft RI Report

* Schedule assumes comments received can be addressed in the allotted time.

** Assumes that requisite environmental permits can be obtained within the 180 day timeframe.

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