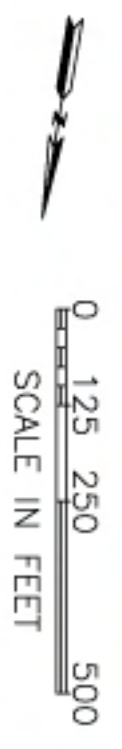


- LEGEND:**
- PROPERTY BOUNDARY
 - BENNING ROAD FACILITY PROPERTY BOUNDARY
 - PROPOSED INVESTIGATION AREA
 - ▲ PROPOSED SEDIMENT SAMPLE LOCATION
 - ▲ PROPOSED WETLAND SEDIMENT SAMPLE LOCATION



AECOM

Benning Road Facility RI/FS Project
3400 Benning Rd., NE
Washington, DC 20019

DATE: 07/10/2012 DRAWN BY: LAD CHECKED BY: RD

Sediment Sample Locations

FIGURE 11

Figure 12
Benning Road RI/FS Project Timeline
Pepco Benning Road Site
3400 Benning Road, NE, Washington DC
(As of July 2012)

Action Number	Action/Event	Duration (days)	Total Timeline from Work Plan Approval (days)	Notes
1	Approval of RI/FS WP (including HSP, FSP, QAPP, and CSM) by DDOE	0	0	
2	Obtain Permits (NPS, USACE, DCRA/DDOE)	30	30	Concurrent with Action Item 3
3	Begin RI Field Work	30	30	Per CD, not more than 30 days after the final RI/FS WP approval
4	Complete RI Field Work	120	150	
5	Pepco's Submission of Draft RI Report	120	270	Not more than 120 days after completion of RI field work
6	Pepco's Submission of Draft FS Report	180	330	Not more than 180 days after completion of RI field work (or 120 days after approval of treatability study report, if required)

Notes:

1. Bold faced-entries indicate activities that will trigger request for public comment.
2. Dates are subject to change as project planning and implementation progresses. This document will be updated periodically as necessary.
3. RI Field Work duration does not include any delays due to weather, additional work plan approvals and permits.

Acronyms:

CD - Consent Decree
CSM - Conceptual Site Model
FS - Feasibility Study
FSP - Field Sampling Plan

HSP - Health and Safety Plan
QAPP - Quality Assurance Project Plan
RI - Remedial Investigation
WP - Work Plan



Tables

Table 1
Historical Removal Actions and Investigations
Benning Road Facility RI/FS Project
3400 Benning Road, NE
Washington, DC 20019

Date	Incident / Investigation	Location	Activities
May-85	PCB Cleanup: Underground pipe leaked waste transformer oil containing PCBs.	Underground pipe leading from Kenilworth Transformer Shop (Current Building 56)	Removal of aboveground storage tank, associated piping, and excavation of PCB-contaminated material >5 ppm (approximately 288 cu ft)
Sep-88	PCB Cleanup: Soil contamination detected under concrete pad used to prepare off-line PCB capacitor banks for disposal in area formerly used to store used electrical equipment.	Parking lot located in the northeast portion of facility.	Removal of approximately 2500 cu ft (389 tons) of PCB-contaminated material (>5 ppm), including concrete slab.
1989-91	UST Removals: A total of 6 USTs were removed/closed in place during this period	550-gal #4 (south of bulk tank #1) 4,000-gal diesel (fuel island) 15K-gal #2 (est of Units 13 and 14) 2,000-gal used oil (Fleet Main.) 250-gal #4 10K-gal Diesel (Fuel Island)	All UST removals were inspected and approved for closure by the District.
Mar-91	PCB Cleanup: PCB capacitor leaked approximately 8 pounds onto concrete surface and seeped through expansion joints.	Concrete covered area located between Buildings 42 and 61	Approximately 126 cu ft PCB contaminated soil (>25 ppm PCBs) were removed and backfilled. Concrete replaced.
Apr-95	PCB Cleanup: PCB containing caulk and joint filler located inside cooling tower structures were found to be impacting the cooling tower concrete basins, sludge and water inside the basins, and soil adjacent to the basin's wall expansion joints. Pre-cleanup sediment sampling results from cooling tower blowdown discharge location upstream of Outfall 013 indicated no PCBs above 1 ppm.	Unit 15 and 16 cooling tower basins and surrounding soil	Approximately 185 cu ft of soil (>1-3 ppm) PCB was excavated. Old joint filler and caulk were removed and the expansion joints and basin were double washed and rinsed. The basin was encapsulated with concrete sealant after all rinse water was removed.
Sep-96 to Mar-97	Intake Dredging: Dredging of Station Intake for creation of wetlands	Generating station intake and points up- and downstream	Intake area in the Anacostia River was dredged and the dredge spoils were used to construct wetlands. Pre- and post-dredge sediment samples exhibited total PCBs of 119-934 ppb.
Apr-97	USEPA Multi-media Inspection: NPDES, RCRA and TSCA compliance inspection conducted by USEPA.	Entire facility	No compliance problems noted. PCBs at 0.25-3.13 ppm detected in residue samples from storm sewers inlets and outfalls. Elevated concentrations of heavy metals were also detected.
Dec-99	Phase I Environmental Site Assessment: conducted by PHI in anticipation of property transaction.	Entire facility	Recognized environmental concerns noted oil staining at two #4 and #2 fuel oil recirculation ASTs located east of the generating station. No concrete bottom noted in the containment areas.
Nov-03	Salvage Yard Investigation: Soil investigation was completed in area formerly used for storing used electrical equipment.	Salvage yard located west of Buildings 75 and 88	Approximately 296 cu ft of PCB contaminated material (>1 ppm) was removed from the site. TPH-DRO was detected, but were below DCDOH requirements upon final excavation.
Jun-09	USEPA Site Inspection: Site Inspection conducted during 2008 to determine further actions under CERCLA.	Former sludge dewatering area and the Anacostia River water and sediments	Metals, PAHs and PCBs were detected in the former sludge dewatering area and in Anacostia River sediments at concentrations exceeding the screening levels. USEPA links the historical discharges at the site to contamination found in river sediments.
Jan-10	Phase I ESA: conducted in connection with substation expansion.	18.5-acre area in the eastern and southern portions of the site that will be impacted by the substation expansion.	Conclusions noted potential for petroleum, metals and PCB impacts of subsurface soils and recommended sampling to develop proper health and safety and soils management procedures during construction.

**Table 2
Target Areas
Benning Road Road Facility RI/FS Project
3400 Benning Road, NE
Washington, DC 20019**

TA #	Name	Location	Comments	Target Constituents
1	Former Sludge Dewatering Area	Between Building 65 and Cooling Towers	Area exists in the former coal yard and was used as a decanting area for boiler fireside wash down for river sediment sludge from the clarifiers. In September 2008, TetraTech completed sampling to a depth of 1 ft bgs as part of a Site Inspection for USEPA. (USEPA, 2009; referred to as "USEPA SI Report")	PAHs, PCBs,metals
2	Benning Fueling Island	Located east of Building # 32	A 20,000 gallon gasoline UST and a 20,000 gallon diesel UST currently hold fuel for fleet vehicles at the Benning Fueling Island. These tanks are provided with leak detection monitoring systems. According to the 1999 URS Phase I ESA, there have been no tank tightness failures. A 4,000 gallon diesel UST was removed in this area in 1991. Soil was found to be impacted and was removed according to a letter submitted by Pepco to DC DDOE. A 10,000 gallon diesel UST was removed in June 1991 with soil impact identified in the excavation. The impacted soil was reportedly excavated and the cases were closed with the District approval. (URS, 1999)	TPH-GRO/DRO
3	Former 15,000 Gallon Number 2 Fuel Oil UST	East of Generating Station building near units 13 and 14.	The UST was removed in 1989 and confirmatory samples showed TPH levels in excess of 100 mg/kg. A 20 ft by 20 ft area was excavated to 15 ft bgs where groundwater was encountered. An oil sheen was noted on the water table and the oil/water mixture was pumped out to the plant oil/water separator. The excavation was backfilled and a recovery well installed to recover any residual oil. DC DDOE considered this case closed in a February 1992 letter. (URS, 1999)	TPH - DRO
4	2003 Salvage Yard Investigation	Salvage yard located west of Buildings # 75 and # 88	Soil investigation and soil removal were completed in area formerly used for storing used electrical equipment. Jacques Whitford Company completed soil sampling down to a maximum depth of 5 feet. (Jacques Whitford Company, 2003)	Metals, TPH-GRO/DRO,PCBs
5	1995 Cleanup Area	Unit 15 and 16 cooling tower basins and surrounding soil	PCB containing caulk and joint filler located inside cooling tower structures were found to be impacting the cooling tower concrete basins, sludge and water inside the basins, and soil adjacent to the basin's wall expansion joints. Pre-cleanup sediment sampling results from cooling tower blowdown discharge location upstream of Outfall 013 indicated no PCBs above 1 ppm.(Pepco, 1995)	TPH, PCBs
6	1991 Cleanup Area	Between Buildings # 41 and # 61	PCB capacitor leaked approximately 8 pounds onto concrete surface and seeped through expansion joints.1991 report stated that there were multiple excavations and that PCB concentrations were not detected. (Pepco, 1991)	TPH, PCBs
7	1988 Parking Lot Cleanup Area	Parking lot located in the eastern portion of facility.	Soil contamination detected under concrete pad used to prepare off-line PCB capacitor banks for disposal in area formerly used to store used electrical equipment. The concrete pad was demolished and disposed followed by removal of soil to a depth of 12 inches below grade. The cleanup was performed and 19 truckloads of PCB impacted materials were disposed of at a Waste Management facility located in Model City, New York. (Pepco, 1988)	TPH,PCBs
8	1985 Excavation Area	Underground pipe leading from Kenilworth Transformer Shop (Current Building # 56)	Underground pipe leaked waste transformer oil containing PCBs. (Pepco, 1985)	TPH, PCBs
9	Green Tag Storage Area	Storage Building #66	Building utilized for temporary storage of drums containing sludge removed from manholes while they await analysis for PCB content. An area located outside and in front of building 66 is used to store empty transformer casings that were previously identified as non-PCB. At the time of the EPA inspection, all of the casings were marked with a green tag that indicated they were less than 50 mg/kg PCB. (USEPA, 1997).	TPH, PCBs
10	Red Tag Storage Area	South of Building # 68 (PCB Storage Building)	The area is concrete and used for storage of empty transformer casings which had previously been identified with red tags as PCB contaminated (50 to 499 mg/kg). The casings are stored in this area until they are shipped off site for recycling. The EPA inspector noted no indications of spills or leaks in the area around the casings. (USEPA, 1997)	TPH, PCBs
11	Building #68 (PCB Building)	Building #68	Building used for storage of PCBs and hazardous waste in drums. The floor is concrete with a continuous concrete curb one foot high providing containment for 22,443 gallons. There were no leaks observed by the EPA inspector on or around the containers. Additionally, no staining was observed by the EPA inspector in Building 68. (USEPA, 1997)	PAHs, PCBs, TPH-GRO/DRO, metals
12	Building #57	Building #57	Building houses two 10,000 gallon holding tanks for accumulating waste oil. All waste oil with a PCB concentration of less than 49 mg/kg is pumped to these tanks. Both tanks are located in a large concrete vault inside of the building. These tanks are reportedly inspected daily by Pepco personnel. Currently, accumulated oil is taken to a permitted off-site facility for disposal/recycling. In the past, oil was transported to Pepco's Morgantown Generating plant to be burned in their boilers. At the time of the EPA inspection, oil stains were observed on the outside of tank 1 and on the concrete floor in the vault area. A concrete sump located in the back corner of the vault area was also observed to be full of oil. The loading area is located on the ground level of the building just above the storage tank area. The loading area slopes downward from the front and drains back into the tanks via a drain. No cracks were observed in the concrete loading ramp. (USEPA, 1997)	TPH-DRO, PCBs

**Table 2
Target Areas
Benning Road Road Facility RI/FS Project
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TA #	Name	Location	Comments	Target Constituents
13	Bulk Storage ASTs and Loading Rack	East of the Generating Station Building	3 AST's located within dikes and on a clay floor with initial construction dates ranging from 1942 to 1968. Tank capacities range from 618,000 gallons to 1,984,000 gallons. In 1995 a HDPE liner covered with flowable fill was installed on the top of the clay floor. The tanks were upgraded with new steel bottoms in 1997 and 1999. TPH GRO and/or DRO was identified in soil samples collected in this area in January 2012 in connection with the proposed demolition of the tanks. (AECOM, 2012). As of writing of this work plan, AST#1 was emptied and AST #2 is being pumped down with AST #3 to follow. Once the remaining #4 fuel oil contents are emptied, the tanks will be cleaned and demolished.	TPH-GRO/DRO
14	Former Railroad Switchyard	Adjacent to southern property boundary and east of Building # 32.	According to the URS Phase I ESA dated December 1999, four transformers likely existed in this area. Soil staining was observed by URS during Site reconnaissance. PCBs were not reported by URS in two oil samples collected by Pepco from each of the transformers that remained. Additionally, a soil sample was collected by Pepco prior to demolition activities in the switchyard and no PCBs were reported. URS could not confirm the location or rationale for the soil sample collected by Pepco. (URS, 1999)	TPH-DRO, PCBs
15	Generating Station Transformers	West of the Generating Station	According to the URS Phase I ESA dated December 1999, approximately 22 transformers with a total capacity of approximately 64,000 gallons were present in the vicinity of the Generating Station Building. Nineteen of these transformers were located on the exterior of the west side of the Generating Station. Pepco's 1993 SPCC-ERP indicates all large power transformers are surrounded by a concrete berm or pit capable of containing all the oil. In addition, the SPCC-ERP indicates some of the smaller service station transformers do not have containment pits or berms. No spills were reported in this area by URS (URS, 1999). All transformers, except for two service transformers, were de-energized and drained to remove oil. Some transformer skeletons remain in place. The two service transformers are still in service for providing electricity to the plant building.	TPH-DRO, PCBs
16	Print Shop	Southern portion of Building # 32	According to the URS Phase I ESA dated December 1999, the Print Shop stored small quantities (<5 gallons) of various solvents and chemicals. URS could not confirm how long the Print Shop had been in operation. URS reported that Pepco replaced hazardous products with non-hazardous substitutes as they became available. URS did not identify any floor drains in the print shop area. The facility had a silver recovery unit, which extracts silver from used developing chemicals. After the silver was extracted, the remaining non-hazardous fluids were discharged into the sanitary sewer with the approval of the POTW. Print Shop was dismantled and removed. Print Shop operations were relocated or contracted out. An inspection of the print shop area is needed to determine if any other subsurface pathways (expansion joints, compromised concrete, etc) are present. Following this inspection, an evaluation can be made to determine if intrusive activities are necessary.	Metals, VOCs
17	Storm Drain System	Across the site	Based on a review of the USEPA 2009 SI Report, all process water generated on the Site is discharged into the main storm drain that extends across the Site from the southeast corner to the northwest. This pipe discharges through the main outfall (#013) leaving the facility into a pipe that goes under Anacostia Avenue and drains into the Anacostia River. According to the USEPA SI report, there have been no NPDES violations. However, sediment sampling in the discharge location closest to the former Sludge Dewatering Area is needed to evaluate potential for discharge of contaminants to the Anacostia River. A review of the First Quarter 2012 Discharge Monitoring Reports (DMR) indicates excursions of copper, zinc and iron, and no excursions of PCBs. Pepco is implementing a Total Maximum Daily Load (TMDL) Implementation Plan approved by the USEPA to identify and reduce the sources of metals in the storm water discharges from the facility. Pepco also analyzes for PCB congeners as required by the NPDES permit, for monitoring purposes only.	Metals, PCBs, PAHs
18	Kenilworth Fueling Island	Approximately 105 feet west of Building # 56	The refueling area includes one out of service 20,000-gallon gasoline UST. The tank was taken out of service in February 2012 and is scheduled for removal in August 2012. In July 2012 Pepco made notification to DDOE for removal of this UST. A leaking UST case was reported in this area resulting from a leaking pressurized pipe associated with the UST. In 1996, a remediation system was installed to recover free product and the case was closed by DDOE in September 1997.	TPH-GRO

Table 2
Target Areas
Benning Road Road Facility RI/FS Project
3400 Benning Road, NE
Washington, DC 20019

Notes:

TA - Target Areas
ft bgs - feet below ground surface
UST - underground storage tank
LUST - leaking underground storage tank
mg/kg - milligrams per kilogram
TPH - Total Petroleum Hydrocarbons
GRO - gasoline range organics
DRO - diesel range organics
PCBs - polychlorinated biphenyl s
TSS - total suspended solids
ft - feet
mg/L - milligrams/liter
TA correspond to locations depicted on Figure 5
HDPE - high density polyethylene liner
ASTs - Aboveground Storage Tanks
SPCC-ERP - Spill Prevention Control and Countermeasures - Emergency Response Plan
PPE - Probable Point of Entry
µg/kg - micrograms per kilogram
µg/L - micrograms per Liter
COPC - Contaminant of Potential Concern
NPDES - National Pollutant Discharge Elimination System
PAHs - Polycyclic aromatic hydrocarbons
SI - Site Inspection
USEPA - United States Environmental Protection Agency
DDOE - District Department of the Environment

Table 3
Landside Data Quality Objectives
Benning Road Facility
3400 Benning Road, N.E.
Washington, DC

DQO Step	Site-Specific Information
Step 1: State the Problems	Based on limited sediment sampling, PCBs, PAHs, and metals were detected at elevated levels in the Anacostia River in the vicinity of the Benning Road facility (the Site). Additional environmental assessment including soil and groundwater sampling is necessary at the Site to characterize environmental conditions, refine the CSM and to determine whether past or current conditions at the Site have caused or contributed to contamination of the river. This data is also needed to evaluate the potential for risk to human health and evaluate potential remedial alternatives.
Step 2: Identify the Decisions	<ol style="list-style-type: none"> 1) Has the nature and extent of soil and groundwater contamination been adequately delineated? 2) Are potential target chemical concentrations detected in soil, groundwater or storm drain impacting the river currently or in the past? 3) Is the site-specific hydrogeology and volumetric flux of groundwater to the Anacostia River well understood in the context of the CSM? 4) Is the storm drain system and associated discharge to the Anacostia River at various outfalls well understood in the context of the CSM? 5) Are the target chemical concentrations in soil and groundwater at the Site greater than background concentrations? 6) Are the target chemical concentrations in soil or groundwater present at levels that indicate the potential for risk to human health or the environment?
Step 3: Identify Inputs to the Decision	<p>The key inputs for making the required decisions are briefly summarized as follows:</p> <ol style="list-style-type: none"> 1) Historical hydrogeological information, geotechnical information, analytical data and Site use/operations documentation. 2) Potential surface soil impacts will be evaluated by collecting 20 surface soil samples for PID and XRF instrument field screening. 3) Potential current or historic discharges from the storm drain system will be evaluated by sampling 5 sediment/residue and 5 water samples. Forensic analysis will be performed on up to 2 samples. 4) Five (5) HSA geotechnical soil borings and ERI will be performed to verify existing data and better characterize Site lithology and potential impacts, respectively. 5) 40 DPT soil borings with XRF field instrument screening and TPH/PCB aroclor analysis using on-site mobile laboratory will be performed to evaluate potential subsurface impacts. Discrete groundwater sampling at DPT locations will be performed to evaluate potential groundwater impacts. 6) HSA-installed monitoring wells, groundwater sampling, and aquifer testing will be performed following site-wide assessment to evaluate potential groundwater impacts and Site-specific hydrogeology. 7) A comprehensive analysis for VOCs, SVOCs, Metals, PCBs, Pesticides, Dioxin, and Furans will be performed selectively in the various media sampled to evaluate for these potential impacts.

Table 3
Landside Data Quality Objectives
Benning Road Facility
3400 Benning Road, N.E.
Washington, DC

DQO Step	Site-Specific Information
Step 4: Define the Study Boundaries	<p>The Landside investigation includes Target Areas identified within the 77-acre Site (i.e. Benning Road Facility located at 3400 Benning Road, Northeast in Washington, DC). The Site is bordered by a DC Solid Waste Transfer Station to the north, Kenilworth Maintenance Yard (owned by the National Park Service, NPS) to the northwest, the Anacostia Avenue and Anacostia River to the west, Benning Road to the south and residential areas to the east and south (across Benning Road).</p>
Step 5: Develop a Decision Rule	<ol style="list-style-type: none"> 1) Historical information will be reviewed to identify potential sources of target chemicals and contamination at the Site. Past or current sources at the Site will then be evaluated using ERI followed by confirmatory soil and groundwater samples at target zones to delineate potential zones of impact and identify any continuing sources of contamination. 2) An evaluation will be performed which compares the analytical results to background to see if the concentrations are consistent with background concentrations. Should concentrations be less than or consistent with background concentrations, then this suggests no unacceptable risk attributable to the Site. 3) If the groundwater and soil concentrations of target chemicals are at or below the conservative human health screening values, then the potential source area will be recommended for no further evaluation. 4) If the soil or groundwater concentrations are above the screening values at a potential source area, the Site data will be further evaluated, including a fate and transport analysis of the target chemicals to characterize the potential impacts to the river.
Step 6: Specify Tolerable Limits of Decision Errors	<p>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, and the comparability of the data to existing data will be evaluated.</p> <p>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 have been established at a level at least three times less than the action limit whenever technically feasible. In general, statistical analysis will not be used to determine decision error tolerance limits. Generally each sample will be used to make a decision.</p>

Table 3
Landside Data Quality Objectives
Benning Road Facility
3400 Benning Road, N.E.
Washington, DC

DQO Step	Site-Specific Information
Step 7: Optimize the Design	The sampling design incorporates a progressive elimination approach using screening parameters to help focus the sampling and analysis for target chemical concentrations over the Site. The variability of data will have an effect on the sampling design. If necessary, the sample frequency and the analytical procedures may undergo changes to optimize the design. The design options, such as sample collection design, sample size and analytical procedures will be evaluated based on cost and ability to meet the DQOs.

Table 4
Waterside Data Quality Objectives
Benning Road Facility
3400 Benning Road, N.E.
Washington, DC

DQO Step	Site-Specific Information
Step 1: State the Problems	Based on limited sediment sampling, PCBs, PAHs, and metals were detected at elevated levels in the Anacostia River in the vicinity of the Benning Road facility (the Site). Additional sediment and surface water sampling is necessary to identify potential Site-related, near-Site and far-Site sources of COPCs in sediment and surface water and evaluate the potential for risk to human health and the environment.
Step 2: Identify the Decisions	<ol style="list-style-type: none"> 1) Has the nature and extent of sediment contamination been adequately delineated? 2) Are the target chemical concentrations in surface sediments adjacent to the Site greater than upstream from the Site? 3) Are the target chemical concentrations in sub-surface sediments adjacent to the Site greater than upstream from the Site? 4) Are the target chemical concentrations in surface water adjacent to the Site greater than upstream from the Site? 5) Are detected concentrations in surface water or sediment present at levels that indicate the potential for risk to human health or the environment? 6) Is sedimentation in the portion of the Anacostia River in Study Area well understood in the context of the CSM? 7) Are the target chemical concentrations in sediment or surface water present at levels that indicate the potential for risk to human health or the environment?
Step 3: Identify Inputs to the Decision	<p>The key inputs for making the required decisions are briefly summarized as follows:</p> <ol style="list-style-type: none"> 1) PCBs and PAHs within the Anacostia River will be evaluated by sampling surface water and sediment (surface and sub-surface) from within the Waterside Investigation Area and background locations for laboratory analysis. 2) Inorganics within the Anacostia River will be evaluated by sampling surface water and surface sediment from within the Waterside Investigation Area and background locations for laboratory analysis of inorganics, hardness (water only), grain size (sediment only), TOC (sediment only), and SEM/AVS (sediment only). 3) VOCs, SVOCs, Pesticides, Dioxins, and Furans within the Anacostia River will be evaluated by sampling a sub-set of surface water and sediment (surface) samples from within the Waterside Investigation Area and background locations for laboratory analysis. 4) A sub-set of sediment samples will be collected and submitted for forensic laboratory analysis of PCBs and PAHs to differentiate between Site-related, near-Site and far-Site sources of COPCs.
Step 4: Define the Study Boundaries	The Benning Road facility is located at 3400 Benning Road, Northeast in Washington, DC. The Waterside investigation will primarily address sediment conditions within an area of the Anacostia River approximately 10 to 15 acres in size including approximately 2,500 linear feet to the south (approximately 700 feet south of the Benning Road Bridge) and 1,000 linear feet to the north of the Site's main storm water outfall area.

Table 4
Waterside Data Quality Objectives
Benning Road Facility
3400 Benning Road, N.E.
Washington, DC

DQO Step	Site-Specific Information
Step 5: Develop a Decision Rule	<p>1) A benchmark comparison will be conducted to determine whether the sediment and surface water concentrations of organic and inorganic constituents adjacent to the site are above human health and ecological benchmarks, indicating the potential for risk.</p> <ul style="list-style-type: none"> a. If the benchmark comparison indicates that adjacent concentrations are below human health and/or ecological benchmarks, then this suggests no unacceptable risk attributable to the site. b. If the benchmark comparison indicates that adjacent concentrations are above human health and/or ecological benchmarks, then additional investigation may be necessary. <p>If the constituent concentrations are less than the sediment quality benchmarks, then those contaminants are not expected to contribute to total site risk. If the contaminant concentrations are greater than the sediment quality benchmarks, then further evaluation may be required.</p> <p>2) A statistical evaluation will be conducted to determine whether the sediment and surface water concentrations of organic and inorganic constituents adjacent to the site are consistent with upstream conditions.</p> <ul style="list-style-type: none"> a. If the statistical evaluation indicates that adjacent concentrations are less than or consistent with upstream concentrations, then this suggests no unacceptable risk attributable to the site. b. If the statistical evaluation indicates that adjacent concentrations are greater than upstream concentrations, then additional investigation may be necessary.
Step 6: Specify Tolerable Limits of Decision Errors	<p>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, and the comparability of the data to existing data will be evaluated.</p> <p>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 have been established at a level at least three times less than the action limit whenever technically feasible. In general, statistical analysis will not be used to determine decision error tolerance limits. Generally each sample will be used to make a decision.</p>

Table 4
Waterside Data Quality Objectives
Benning Road Facility
3400 Benning Road, N.E.
Washington, DC

DQO Step	Site-Specific Information
Step 7: Optimize the Design	<p data-bbox="639 338 1435 485">The sampling design incorporates a progressive elimination approach utilizing screening parameters to help focus the sampling and analysis and characterize any hotspots in the sediment areas. PCB aroclors analysis, using an on-site mobile laboratory, on all sediment samples will be used for screening purposes.</p> <p data-bbox="639 527 1435 663">The variability of data will have an effect on the sampling design. If necessary, the sample frequency and the analytical procedures may undergo changes to optimize the design. The design options, such as sample collection design, sample size and analytical procedures will be evaluated based on cost and ability to meet the DQOs.</p>

**Table 5: Landside Data Collection Program
Benning Road Facility RI/FS Project
3400 Benning Rd, N.E.**

Data Type	Data Use	Approximate Quantity	Methods
Surface Soil Samples (Phase I)			
Chemical analysis	Evaluation of surface soil quality	25 locations	TPH (8015), VOC (8260), PCB (8082), Metals, EPA 16 PAHs (8270)
		Up to 10 locations	VOCs (8260), SVOCs (8270), Pesticides, and Dioxins/furans
Forensic analysis	Evaluation of PCB and PAH origin and contribution	Up to 5 locations	PCB 680 Homologs and/or PCB 1668 Congeners, PAH fingerprinting
Storm Drain System (leading to Outfall 013) Sampling (Phase I)			
Water	Surface water discharge pathway	5 locations	PCBs (8082), PCB (608), EPA 16 PAHs (8270), dissolved and total Metals, VOCs (8260), TPH (8015), Pesticides
Sediment	Surface water discharge pathway	5 locations	PCBs (8082), PCB (608), EPA 16 PAHs (8270), Metals, VOCs (8260), TPH (8015), Pesticides
Forensic samples	PCB and PAH origin, site reference, surface water pathway	Up to 2 locations	PCB 680 Homologs, PCB 1668 B Congeners, PAH fingerprinting, dioxins/furans
Surface Geophysics (Phase I)			
Electrical Resistive Imaging (ERI)	Evaluation of subsurface geology, obstructions, NAPL plumes and optimization of soil boring and monitoring well placement	Up to 8 transects of 300-500 ft long	Geo Trax™ Survey
Soil Borings to 100 ft below grade (Phase I)			
Lithology	Subsurface geology	Continuous	Visual identification
PID Reading	Screening for VOCs	Continuous	Field methods
Geotechnical	Subsurface geology	25 samples (5 locations, and up to 5 samples per location)	ASTM Grain size and Atterberg limits
Geotechnical	Subsurface geology	10 Shelby tubes (5 locations and two samples per boring)	ASTM Permeability
Subsurface Soil and Groundwater Samples (Phase II)			
Direct Push (Geoprobe™) Borings to 5 ft below groundwater	Subsurface geology, identification of free phase oils	40 locations	Visual identification
VOC Vapor Screen	Rapid characterization, flexibility to field adjust sampling grid	Continuous	Photoionization Detector (PID) field instrument
Metals screen	Subsurface soil quality, rapid characterization, flexibility to field adjust sampling grid	120 samples (three depths at 40 locations)	X-Ray Fluorescence (XRF) field instrument
Soil chemical	Rapid characterization, flexibility to field adjust sampling grid	120 samples (three depths at 40 locations)	Mobile lab TPH (8015) and PCBs (8082)
Soil chemical	Metals confirmation/correlation	24 samples (20% of 120)	Metals (fixed lab)
Soil chemical	Evaluation of subsurface soil quality	Up to 40 samples	VOCs (8260), PAHs (8270)
Soil chemical	Evaluation of subsurface soil quality	Up to 10 samples	Pesticides, SVOC (8270), dioxins/furans
Groundwater chemical	Evaluation of groundwater quality	40 locations	Mobile lab TPH (8015) and PCBs (8082)
Groundwater chemical	Evaluation of groundwater quality	40 locations	VOCs (8260), EPA 16 PAHs (8270), total and dissolved metals

**Table 5: Landside Data Collection Program
Benning Road Facility RI/FS Project
3400 Benning Rd, N.E.**

Groundwater chemical	Evaluation of groundwater quality	Up to 10 samples	Pesticides, SVOC (8270), dioxins/furans
Forensic analysis	Evaluation of PCB and PAH origin and contribution	Up to 5 soil/groundwater samples	PCB 680 Homologs, PCB 1668 Congeners, PAH fingerprinting
Monitoring Wells to the top of Arundel Clay (Phase III) *			
GW elevation monitoring	Determine depth to groundwater and groundwater gradient	TBD	Gauging
Aquifer testing	Evaluation of aquifer characteristics	TBD	Slug Testing
Chemical analysis	Evaluation of groundwater quality	TBD	VOC (8260), PCB (8082), dissolved and total Metals, EPA 16 PAHs (8270), SVOC (8270), pesticides
Chemical analysis	Evaluation of groundwater quality	TBD	Pesticides, dioxins/furans
Forensic analysis	Evaluation of PCB and PAH origin and contribution	TBD	PCB 680 Homologs and/or PCB 1668 Congeners, PAH fingerprinting
Civil Surveying			
Horizontal and vertical surveys	To locate all sampling points	All locations sampled in Phases I, II and III	GPS surveys

* Number and location of monitoring wells to be determined following evaluation of results from Phase I and Phase II.

**Table 6: Waterside Data Collection Program
Benning Road Facility RI/FS Project
3400 Benning Rd, N.E.**

Data Type	Data Use	Approximate Quantity	Methods
River Bottom Surveys (Phase I)			
Bathymetric survey	Understanding of depth of the water column and configuration of river bottom	Investigation area and background locations	USACE Hydrographic survey methods (Differential Geographic Positioning System, DGPS)
Utility Survey	Confirm utilities and other underwater obstructions	Investigation area and background locations	Side scan sonar
Surface Water Samples (Phase II)			
General chemistry	Evaluation of surface water quality near sediment-water interface	20 locations (10 transects + up to 10 background)	Field methods for measuring temperature, pH, turbidity, dissolved oxygen and conductivity
Chemical analysis	Surface water impacts	20 locations (10 transects + up to 10 background)	PCBs (8082), EPA 16 PAHs (8270), and Total and dissolved phase Metals (including hardness)
		Up to 10 locations	VOCs (8260), SVOCs (8270), Pesticides, and Dioxins/furans
Surface Sediment Samples (Phase II)			
Chemical analysis	Evaluation of surface sediment quality and background surface sediment quality	55 samples (45 near the site + up to 10 background)	PCBs (8082), Metals, EPA 16 PAHs (8270), AVS/SEM
		Up to 20 samples	VOCs (8260), SVOC (8270), Pesticides, and Dioxins/furans
Sediment characteristics	Evaluation of surface sediment quality and background surface sediment quality	55 samples (45 near the site + up to 10 background)	Total Organic Carbon (TOC), ASTM grain size
Forensic analysis	Evaluation of PCB and PAH origin and contribution	Up to 8 samples	PCB 680 Homologs and/or PCB 1668 Congeners, PAH fingerprinting
Subsurface Sediment Samples (phase II)			
Vibracore Borings (8 to 10 ft deep depending on refusal)	Sediment physical characteristics	55 samples (45 near the site + up to 10 background)	Visual identification
Chemical analysis	Evaluation of subsurface sediment quality and background surface sediment quality	165 samples (3 depths at 55 locations)	PCB (8082) and PAH16 (8270)
Forensic analysis	Evaluation of PCB and PAH origin and contribution	Up to 7 samples	PCB 680 Homologs and/or PCB 1668 Congeners, PAH fingerprinting
Geotech	Evaluation of subsurface sediment physical characteristics	Up to 20 samples	ASTM Grain size and TOC

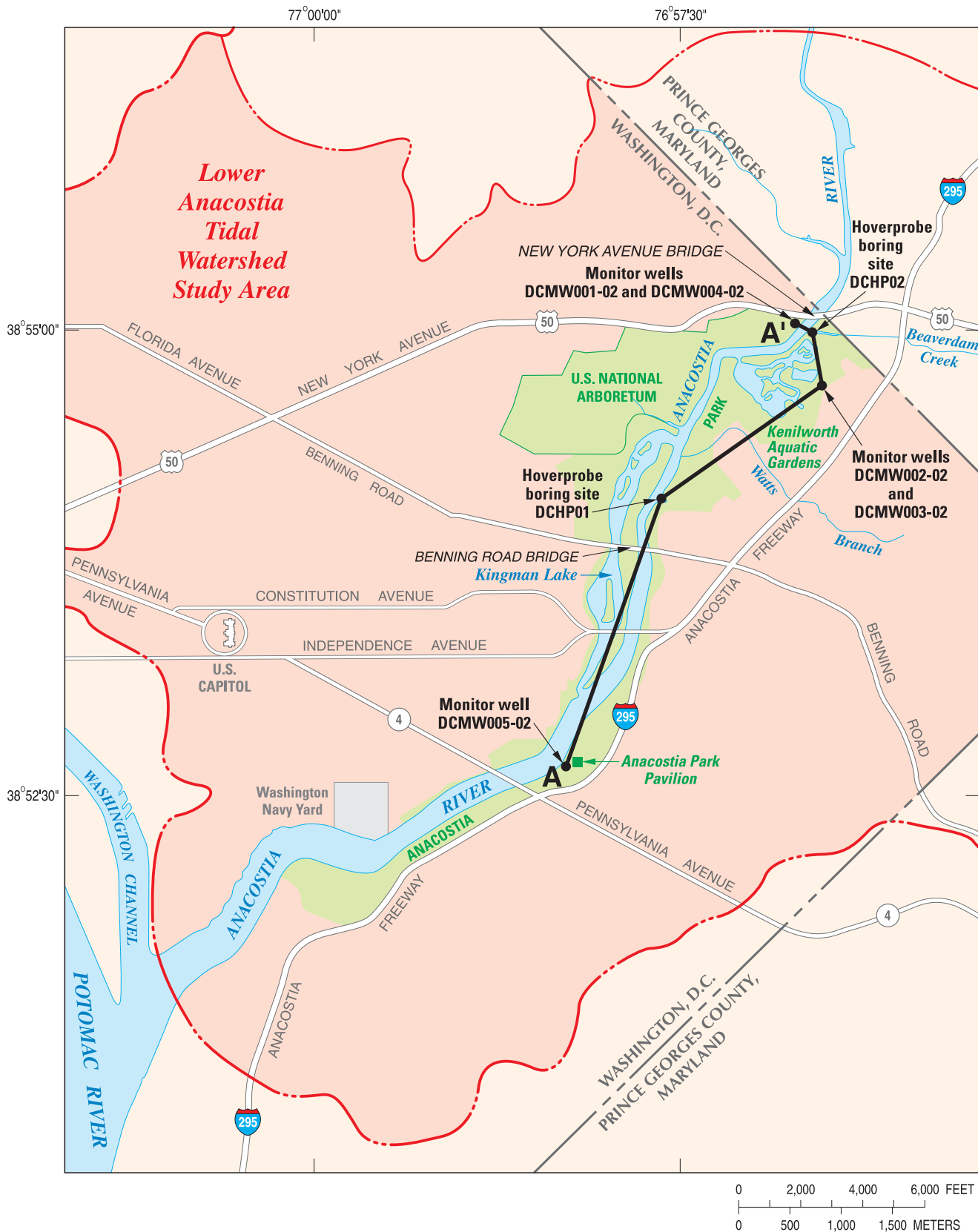
Table 7
Project Team
Benning Road Facility RI/FS Project
3400 Benning Road, NE
Washington, DC 20019

Title	Name	Telephone Number	Email
Pepco Project Manager	Fariba Mahvi	(202) 331-6641 (office); (202) 345-7647 (mobile)	fmahvi@pepco.com
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	RI Landside: George Sauer, P.G.	(703) 706-0514 (office); (703) 609-5068 (mobile)	George.Sauer@aecom.com
	FS: Ravi Damera, P.E.	(703) 706-0514 (office); (703) 609-5068 (mobile)	ravi.damera@aecom.com
AECOM Technical Reviewer	Brendan McGuinness	(703) 706-0505 (office)	Brendan.McGuinness@aecom.com
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AECOM Analytical Task Manager	Robert Kennedy	(978) 905-2269 (office)	robert.kennedy@aecom.com
AECOM Health and Safety	Sean Liddy	(410) 869-6164 (mobile)	Sean.Liddy@aecom.com
Field Team Leader	Scott Beatson	(240) 565-6511 (office); (410) 200-5944 (mobile)	scott.beatson@aecom.com
	Sean Crouch (Alternate)	(240) 565-6517 (office); (443) 878-0551 (mobile)	sean.crouch@aecom.com
Data Manager	To be determined	To be determined	To be determined
Subcontractors	To be determined	To be determined	To be determined



Appendix A

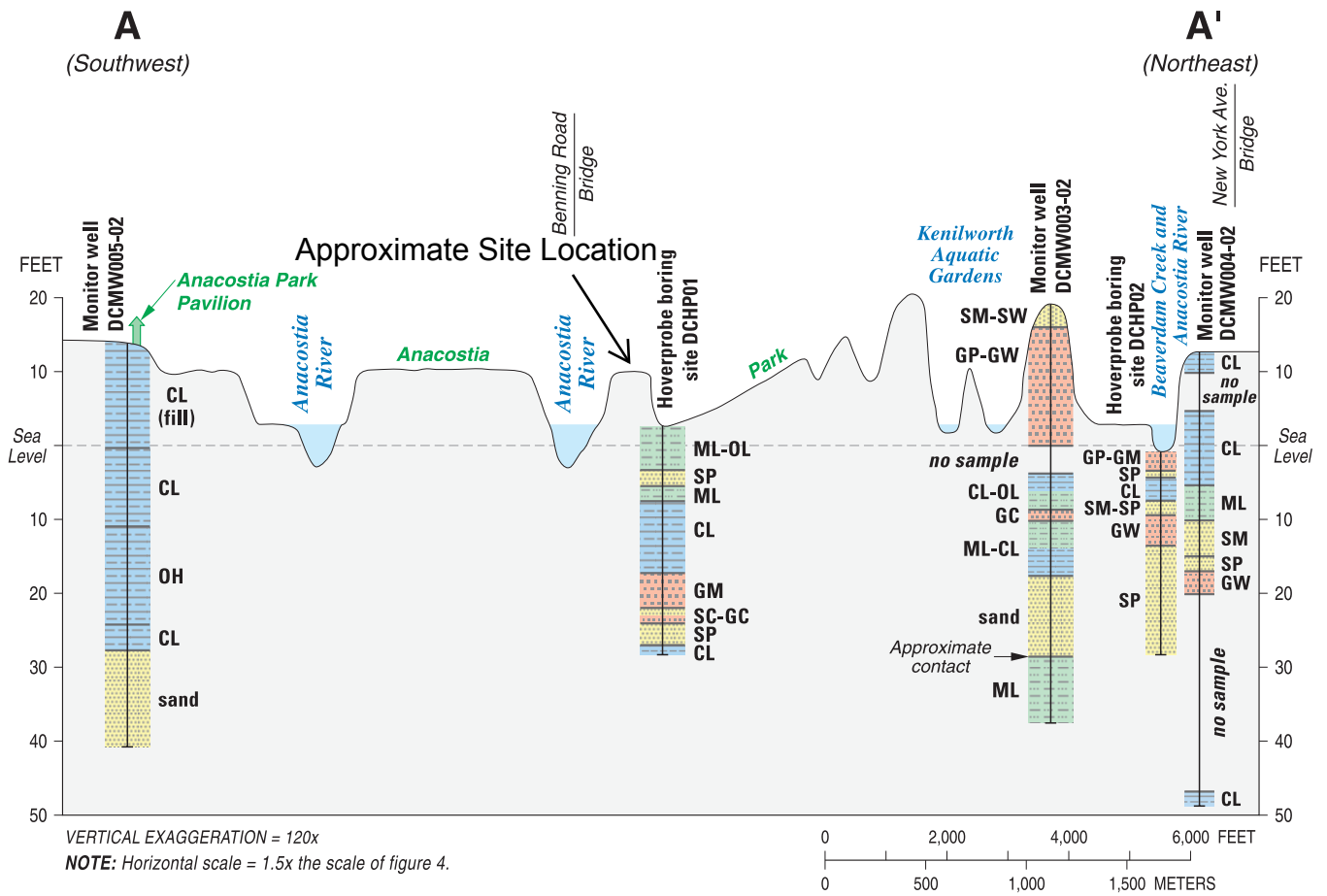
USGS Lithologic Section along the Anacostia River



EXPLANATION

- DCHP01** ● LOCATION OF MONITOR WELLS AND HOVERPROBE BORING SITES AND IDENTIFICATION NUMBER
- A—A'** TRACE OF LITHOLOGIC SECTION

Figure 4. Location of monitor wells, hoverprobe boring sites, and trace of lithologic section A-A' along the Anacostia River, Washington, D.C., July 2002.



EXPLANATION

- DCHP01**
 | MONITOR WELL OR HOVERPROBE BORING
 | SITE AND IDENTIFICATION NUMBER
- STRATIGRAPHIC CONTACT

UNIFIED SOIL CLASSIFICATION SYSTEM		
SYMBOL AND MAJOR DIVISION	LETTER	DESCRIPTION
GRAVEL	GP	Poorly graded gravel
	GW	Well graded gravel
	GM	Silty gravel
	GC	Clayey gravel
SAND	SP	Poorly graded sand
	SW	Well graded sand
	SM	Silty sand
	SC	Clayey sand
SILT	ML	Inorganic silt, very fine sand, and clayey silt
	OL	Organic silt and organic clayey silt
CLAY	CL	Inorganic clay, silty clay, and sandy clay
	OH	Organic clay

Figure 7. Lithologic section A-A' along the Anacostia River, Washington, D.C.



Appendix B

Anacostia River Watershed Maps

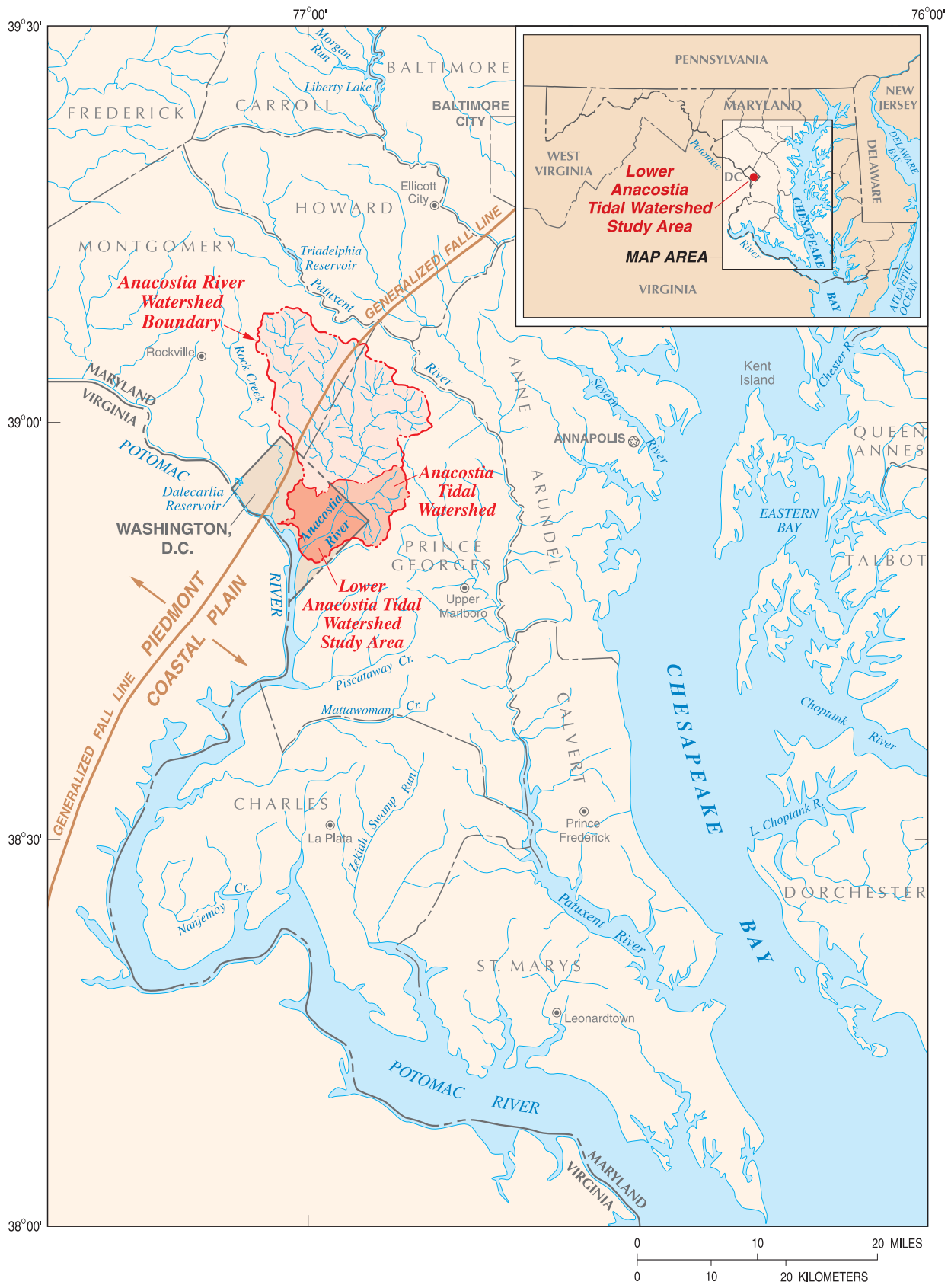
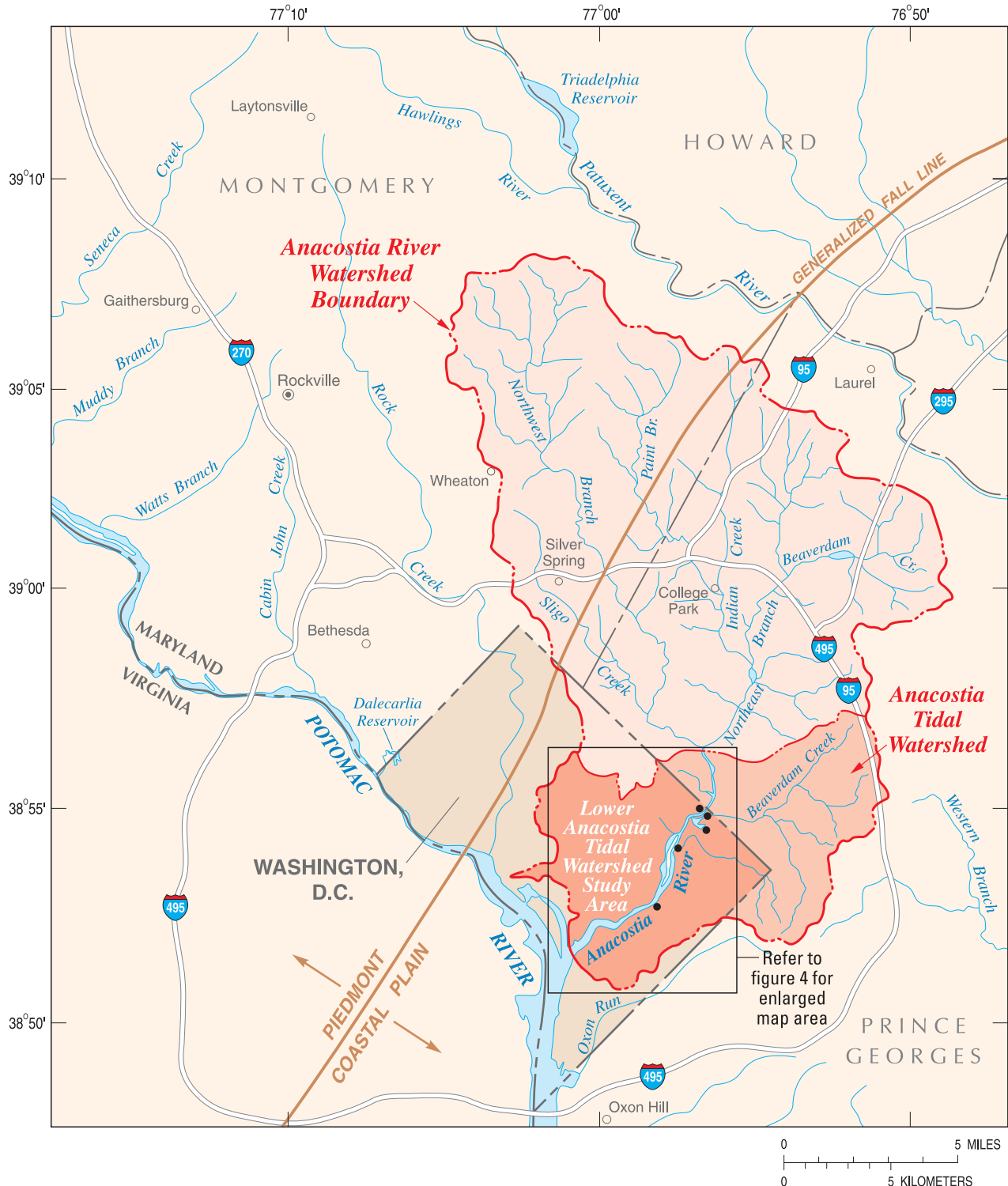


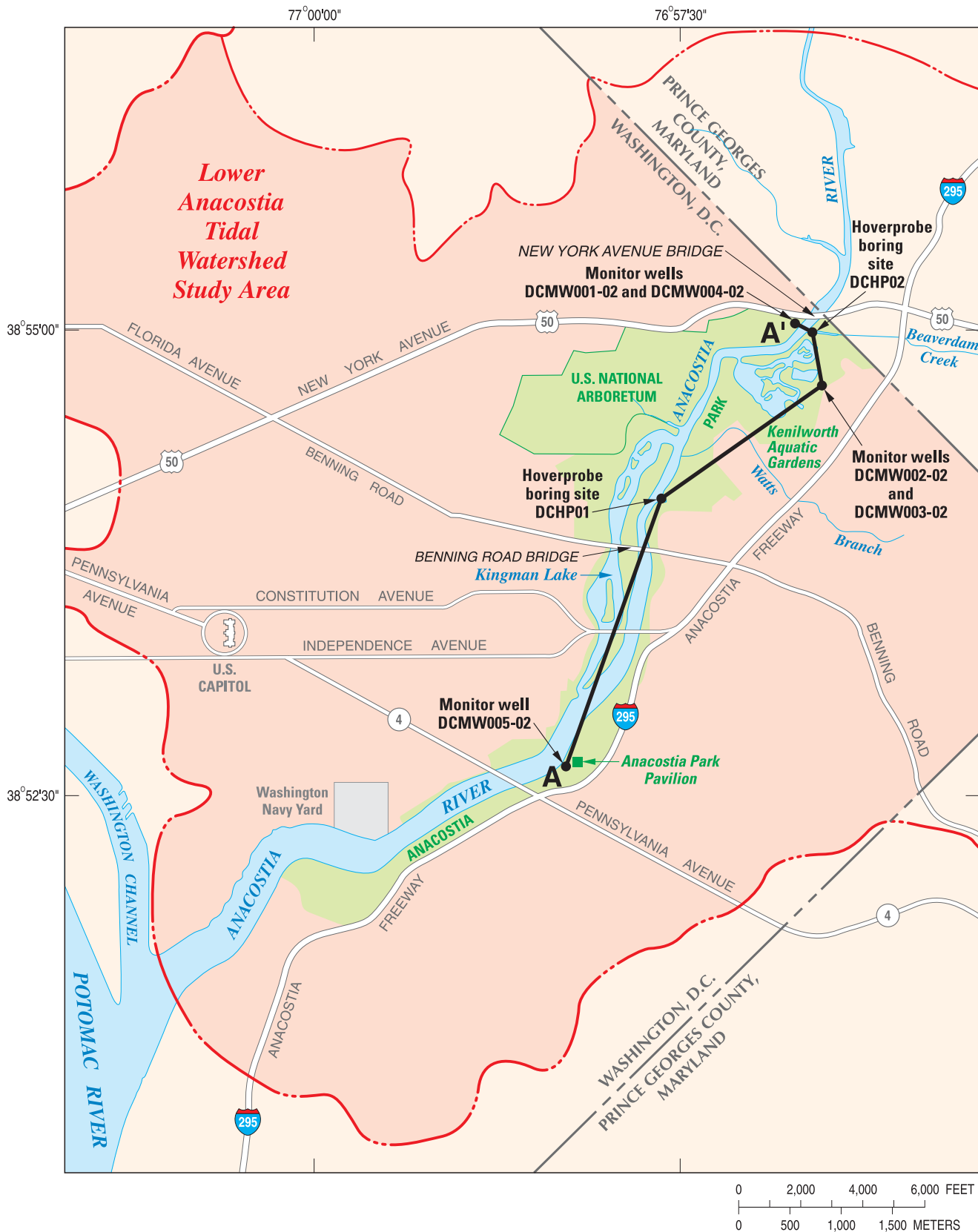
Figure 1a. Location of the Anacostia River watershed and the lower Anacostia tidal watershed study area in Washington, D.C.



EXPLANATION

- LOCATION OF MONITOR WELLS AND HOVERPROBE BORING SITES
(Refer to figure 4 for site locations and identification numbers.)

Figure 1b. Detailed view of the Anacostia River watershed, the lower Anacostia tidal watershed study area in Washington, D.C., and location of monitor wells and hoverprobe boring sites.

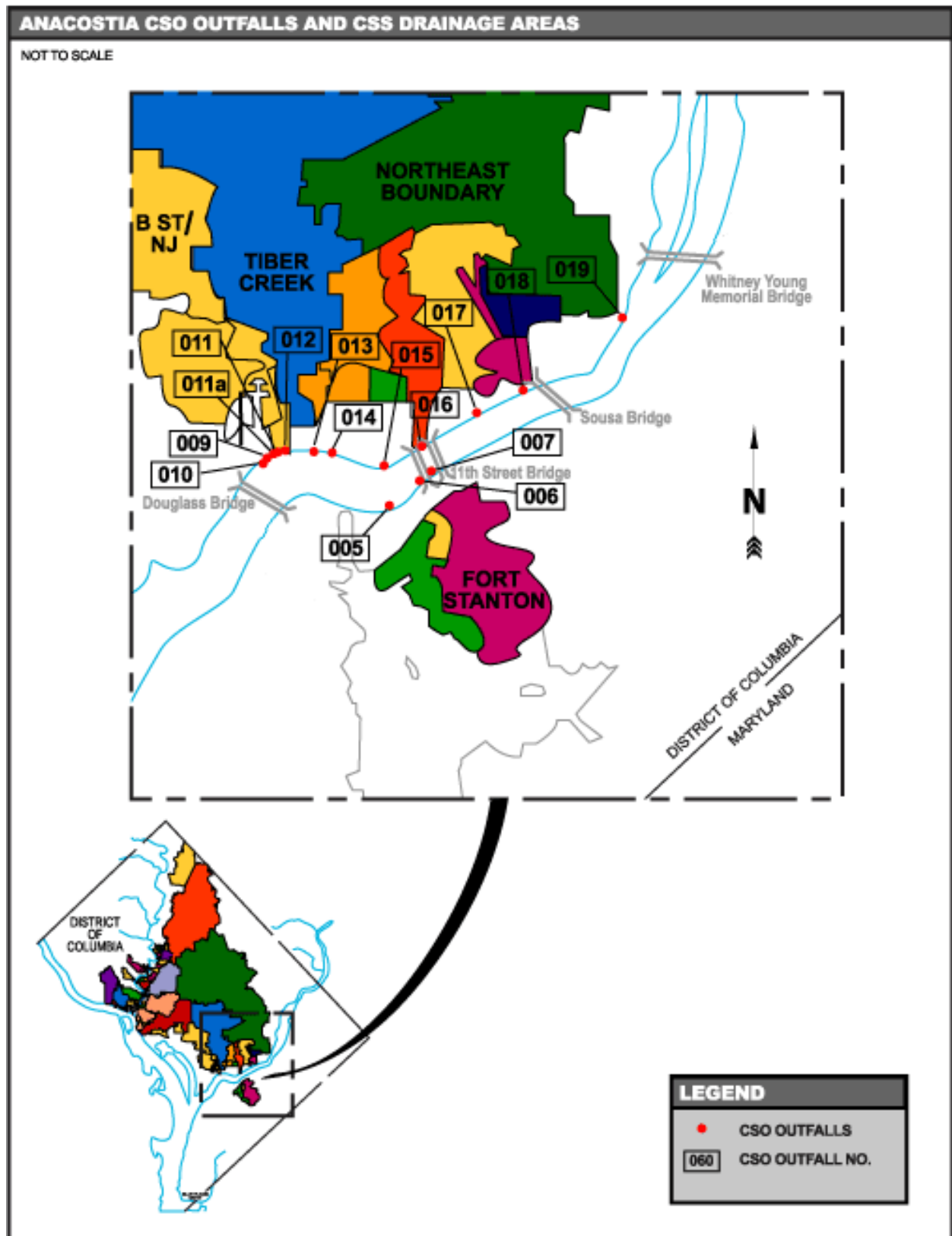


EXPLANATION

- DCHP01** ● LOCATION OF MONITOR WELLS AND HOVERPROBE BORING SITES AND IDENTIFICATION NUMBER
- A—A'** TRACE OF LITHOLOGIC SECTION

Figure 4. Location of monitor wells, hoverprobe boring sites, and trace of lithologic section A-A' along the Anacostia River, Washington, D.C., July 2002.

Appendix B: CSO Outfalls and Drainage Areas

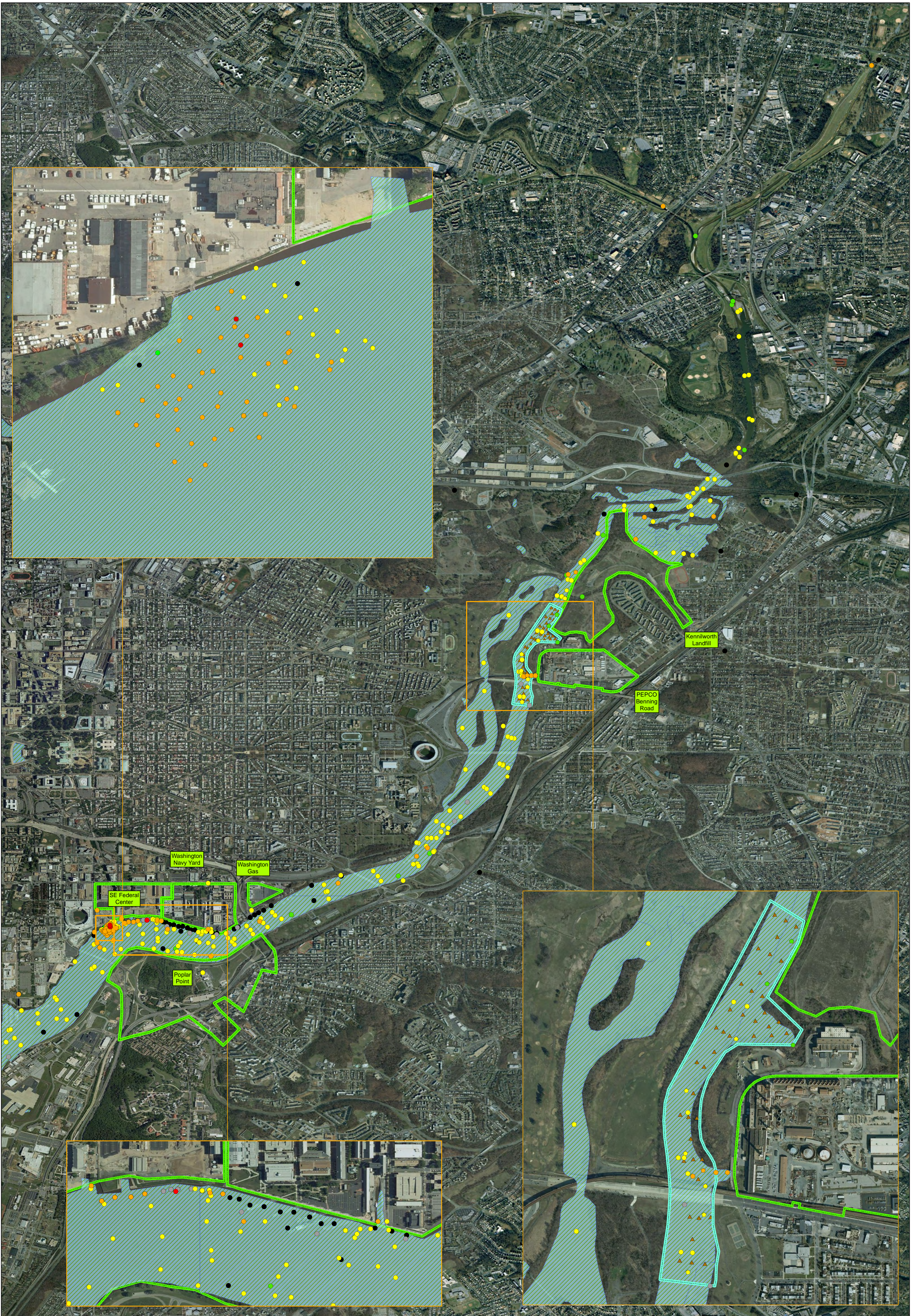


Source: http://www.dcwasa.com/wastewater_collection/css/default.cfm



Appendix C

Existing Anacostia River Chemical Data based on NOAA Database



Total PCBs Concentrations in the Anacostia River Surficial Sediment
Benning Road Facility RI/FS Project
3400 Benning Rd., NE
Washington, DC 20019

0 0.5 1 2 Miles

Data presented has been queried from the NOAA Query Manager Database and may include data from the following studies:
 1980-92 VA State Water Control Board
 1981-82 MD DEP Water Monitoring Data
 1986-99 NSWC White Oak Env. GIS Layer
 1989 ICP/RB/Limo-Tech Sediment Survey
 1990 EMAP - Chesapeake Bay
 1991 EMAP - Chesapeake Bay
 1992 Potomac & Anacostia Sediment Study
 1993 EMAP - Chesapeake Bay
 1993 FWS Kennilworth Marsh
 1995 PEPCO
 1995 Washington Navy Yard
 1996 PWS PAH/PCB - Mason Neck
 1996 WA Gas - East Station Project
 1996 Wetland Restoration - Kennilworth
 1998 BARC RI
 1998 USACE Federal Nav Channel
 1999 AVTA Sediment Quality Triad
 1999 GSA SE Federal Center
 1999 WA Navy Yard RI
 2000 ANS Sediment Study
 2000 Ambient Tox Chesapeake Bay
 2000 USFWS Bioavailability
 2003 Active Capping Site Char Rpt
 2009 Final Site Inspection Report

Total PCBs (ppb)
 ● <59.8
 ● 59.8 - 676
 ● 676 - 5000
 ● 5000 - 100000+
 ● Non-Detect
 ● No Record

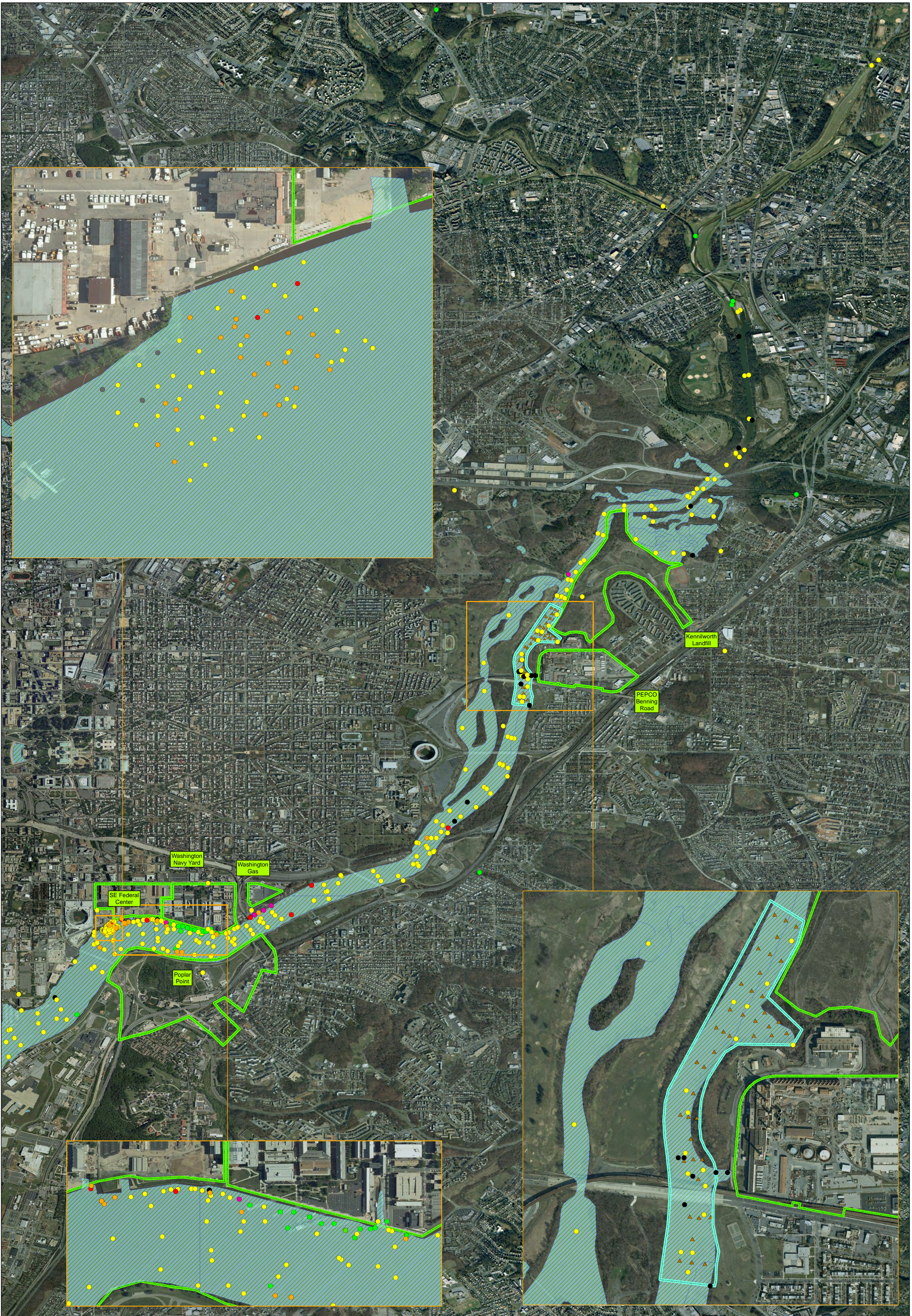
From 2009 SI Report
 ● <59.8
 ● 59.8 - 676
 ● 676 - 5000
 ● 5000 - 10000

▲ Proposed Sampling Location
 [Green Outline] Property Boundaries
 [Blue Outline] Proposed Study Area
 [Blue Hatched] Riverine Boundary

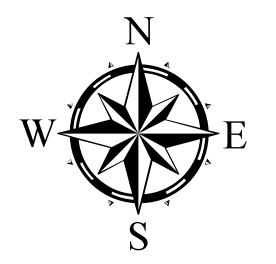
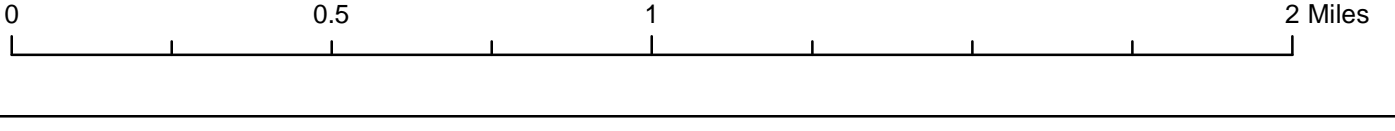
Note: Totals from 2009 SI Report are sums of Aroclors 1254 and 1260



Figure 1



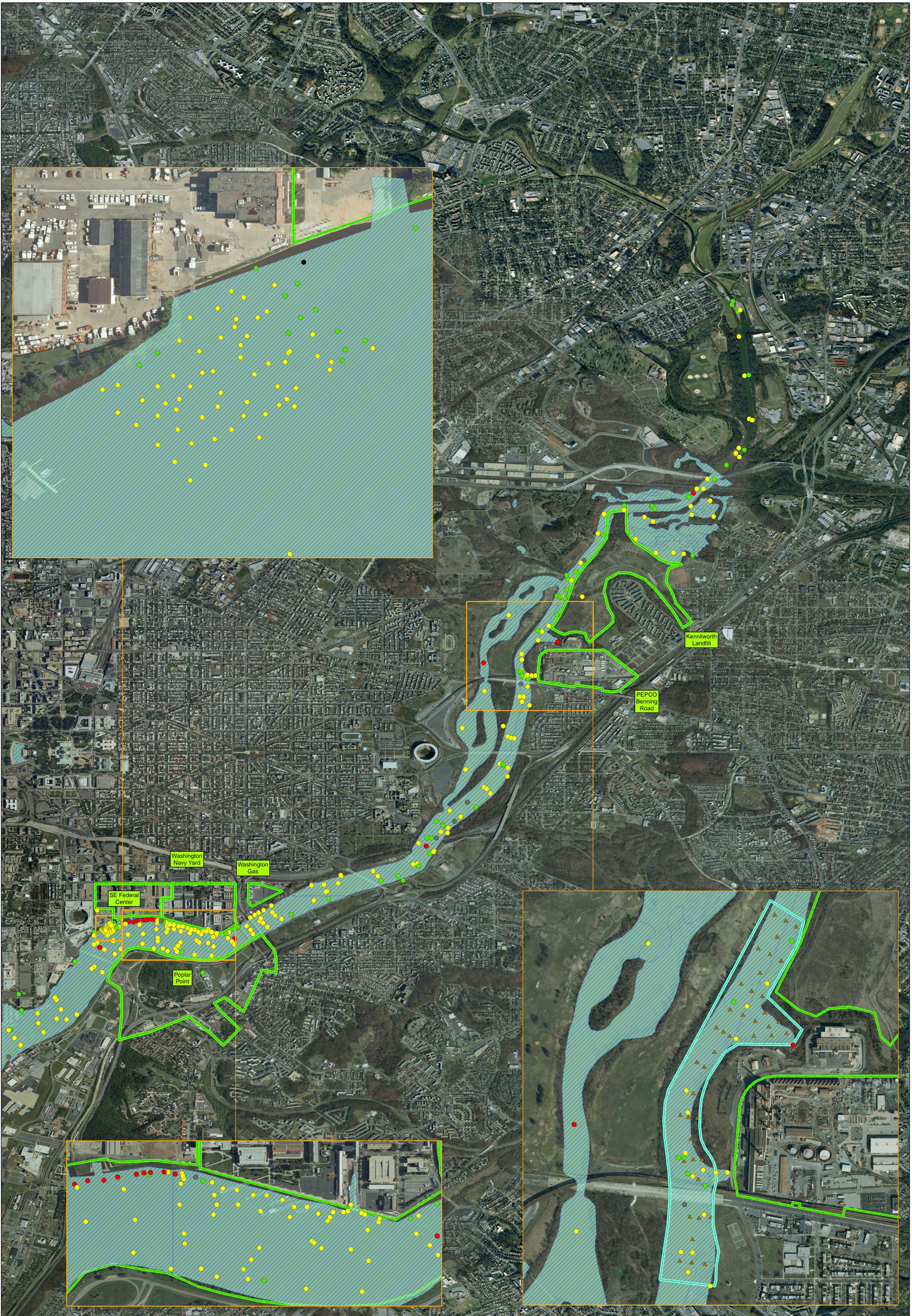
Total PAH Concentrations in the Anacostia River Surficial Sediment
Benning Road Facility RI/FS Project
3400 Benning Rd., NE
Washington, DC 20019



- Data presented has been queried from the NOAA Query Manager Database and may include data from the following studies:
- 1980-92 VA State Water Control Board
 - 1981-82 MD DEP Water Monitoring Data
 - 1986-99 NSWC White Oak Env. GIS Layer
 - 1989 ICP/RB/Limo-Tech Sediment Survey
 - 1990 EMAP - Chesapeake Bay
 - 1991 EMAP - Chesapeake Bay
 - 1992 Potomac & Anacostia Sediment Study
 - 1993 EMAP - Chesapeake Bay
 - 1993 FWS Kennilworth Marsh
 - 1995 PEPSCO
 - 1995 Washington Navy Yard
 - 1996 PWS PAH/PCB - Mason Neck
 - 1996 WA Gas - East Station Project
 - 1996 Wetlands Restoration - Kennilworth
 - 1998 BARC RI
 - 1998 USACE Federal Nav Channel
 - 1999 AVTA Sediment Quality Triad
 - 1999 GSA SE Federal Center
 - 1999 WA Navy Yard RI
 - 2000 ANS Sediment Study
 - 2000 Ambient Tox Chesapeake Bay
 - 2000 USFWS Bioavailability
 - 2003 Active Capping Site Char Rpt
 - 2009 Final Site Investigation Report
- PAH values (ppm)**
- <1.61
 - 1.61 - 22.8
 - 22.8 - 50.0
 - 50.0 - 100.0
 - 100 +
 - Non-Detect
 - No Record
- ▲ Proposed Sampling Location
 Proposed Study Area
 Property Boundaries
 Riverine Boundary

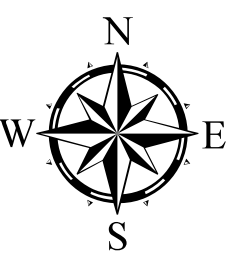


Figure 2



**Total Cadmium Concentrations in the Anacostia River Surficial Sediment
Benning Road Facility RI/FS Project
3400 Benning Rd., NE
Washington, DC 20019**

0 0.5 1 2 Miles

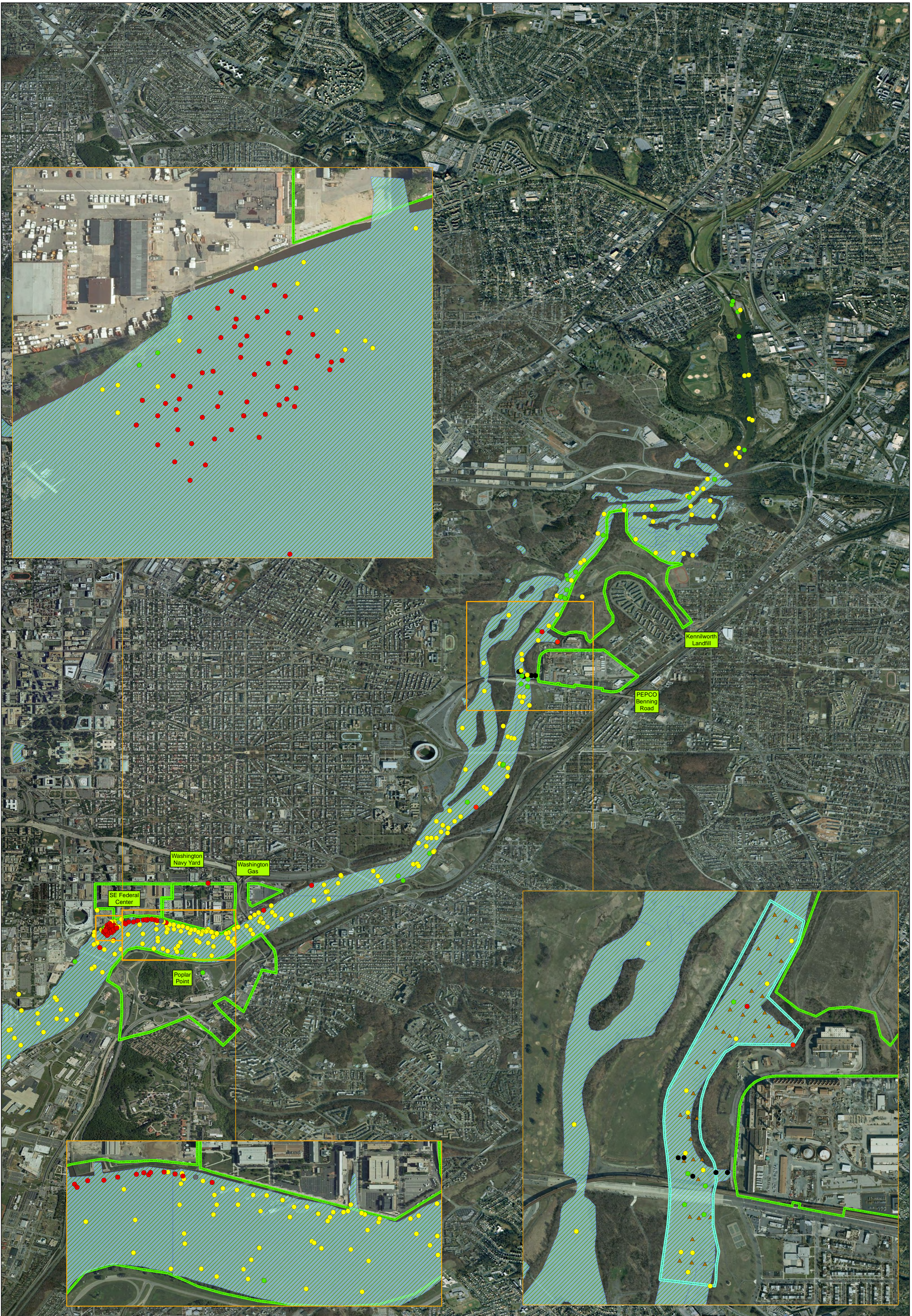


Data presented has been queried from the NOAA Query Manager Database and may include data from the following studies:
 1980-92 VA State Water Control Board
 1981-82 MD DEP Water Monitoring Data
 1986-99 NSWC White Oak Env. GIS Layer
 1989 ICP/B/Limnol-Tech Sediment Survey
 1990 EMAP - Chesapeake Bay
 1991 EMAP - Chesapeake Bay
 1992 Bolling AFB - SW Corner
 1992 Potomac & Anacostia Sediment Study
 1993 EMAP - Chesapeake Bay
 1993 FWS Kennilworth Marsh
 1995 PEPCO
 1995 Washington Navy Yard
 1996 PWS PAH/PCB - Mason Neck
 1996 WA Gas - East Station Project
 1996 Wetlands Restoration - Kennilworth
 1998 BARC RI
 1998 USACE Federal Nav Channel
 1999 AWTA Sediment Quality Triad
 1999 GSA SE Federal Center
 1999 WA Navy Yard RI
 2000 ANS Sediment Study
 2000 Ambient Tox Chesapeake Bay
 2000 LUSTWS Bioavailability
 2003 Active Clipping Site Char Rpt
 2009 Final Site Inspection Report

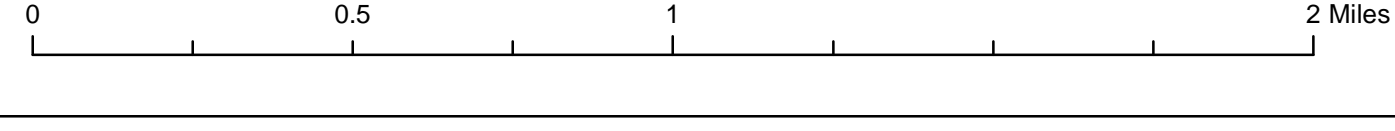
- Total Cadmium (mg/kg)**
- <0.99
 - 0.99 - 4.98
 - 4.98+
 - Non-Detect
 - No Record
 - ▲ Proposed Sampling Location
 - Proposed Study Area
 - Property Boundaries
 - Riverine Boundary



Figure 3



Total Copper Concentrations in the Anacostia River Surficial Sediment
Benning Road Facility RI/FS Project
3400 Benning Rd., NE
Washington, DC 20019



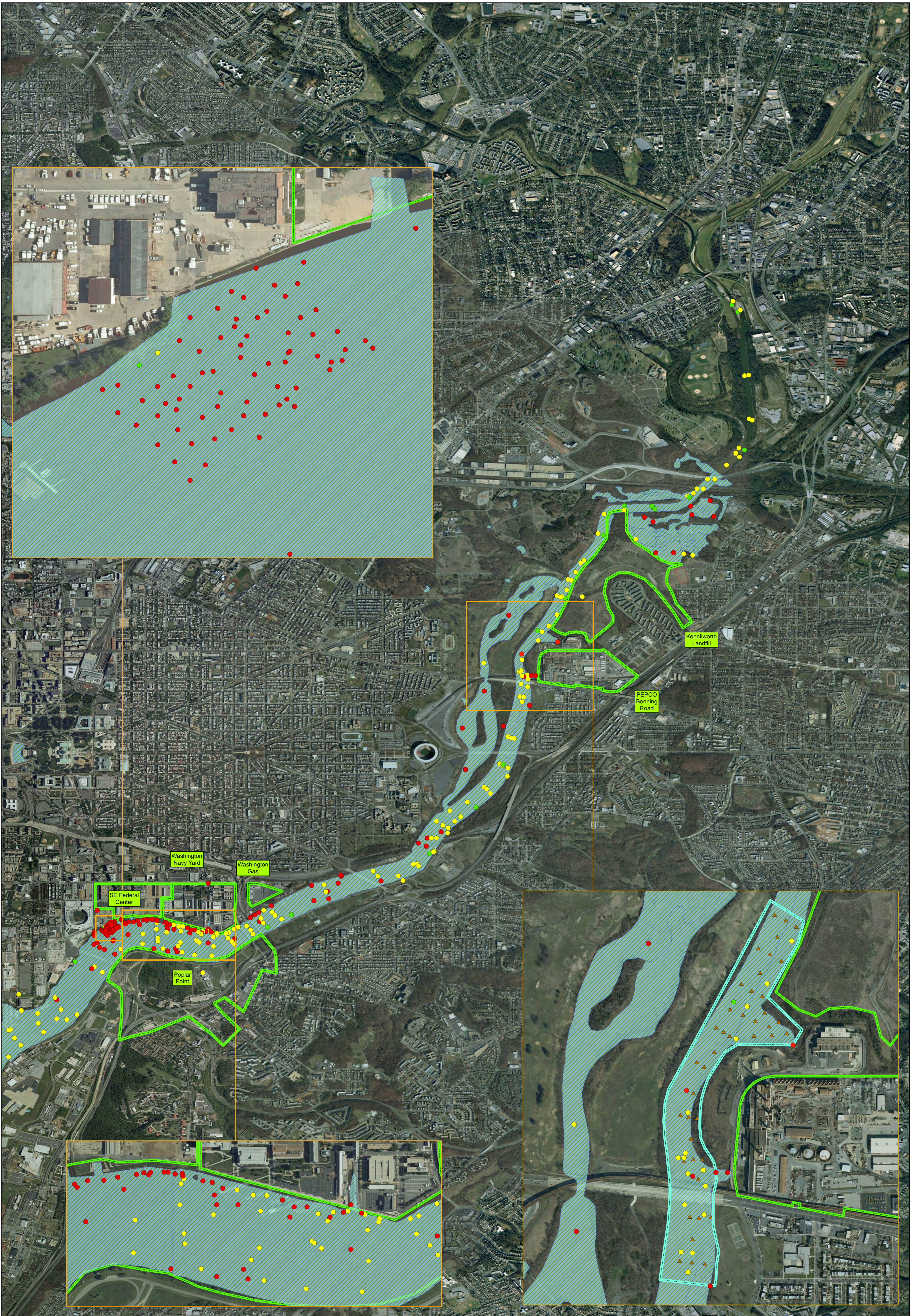
Data presented has been queried from the NOAA Query Manager Database and may include data from the following studies:

- 1980-92 VA State Water Control Board
- 1981-82 MD DEP Water Monitoring Data
- 1986-99 NSWC White Oak Env. GIS Layer
- 1989 ICPRB/Linco-Tech Sediment Survey
- 1990 EMAP - Chesapeake Bay
- 1991 EMAP - Chesapeake Bay
- 1992 Potomac & Anacostia Sediment Study
- 1993 EMAP - Chesapeake Bay
- 1993 FWS Kennilworth Marsh
- 1995 PEPSCO
- 1995 Washington Navy Yard
- 1996 PWS PAH/PCB - Mason Neck
- 1996 WA Gas - East Station Project
- 1996 Wetland Restoration - Kennilworth
- 1997 DC Sediment Core Analysis
- 1998 BARC RI
- 1998 USACE Federal Nav Channel
- 1999 AWTIA Sediment Quality Triad
- 1999 WA Navy Yard RI
- 2000 ANS Sediment Study
- 2000 Ambient Tox Chesapeake Bay
- 2000 USFWS Bioavailability
- 2003 Active Capping Site Char Rpt
- 2009 Final Site Inspection Report

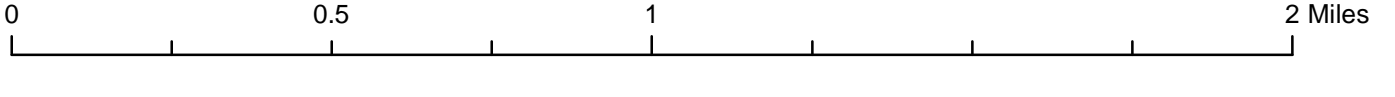
- Total Copper (mg/kg)**
- <31.6
 - 31.6 - 149.0
 - 149.0+
 - Non-Detect
 - No Record
- Proposed Sampling Location**
- ▲
- Proposed Study Area**
- (hatched)
- Property Boundaries**
- (green outline)
- Riverine Boundary**
- (blue outline)



Figure 4



**Total Lead Concentrations in the Anacostia River Surficial Sediment
Benning Road Facility R/FS Project
3400 Benning Rd., NE
Washington, DC 20019**

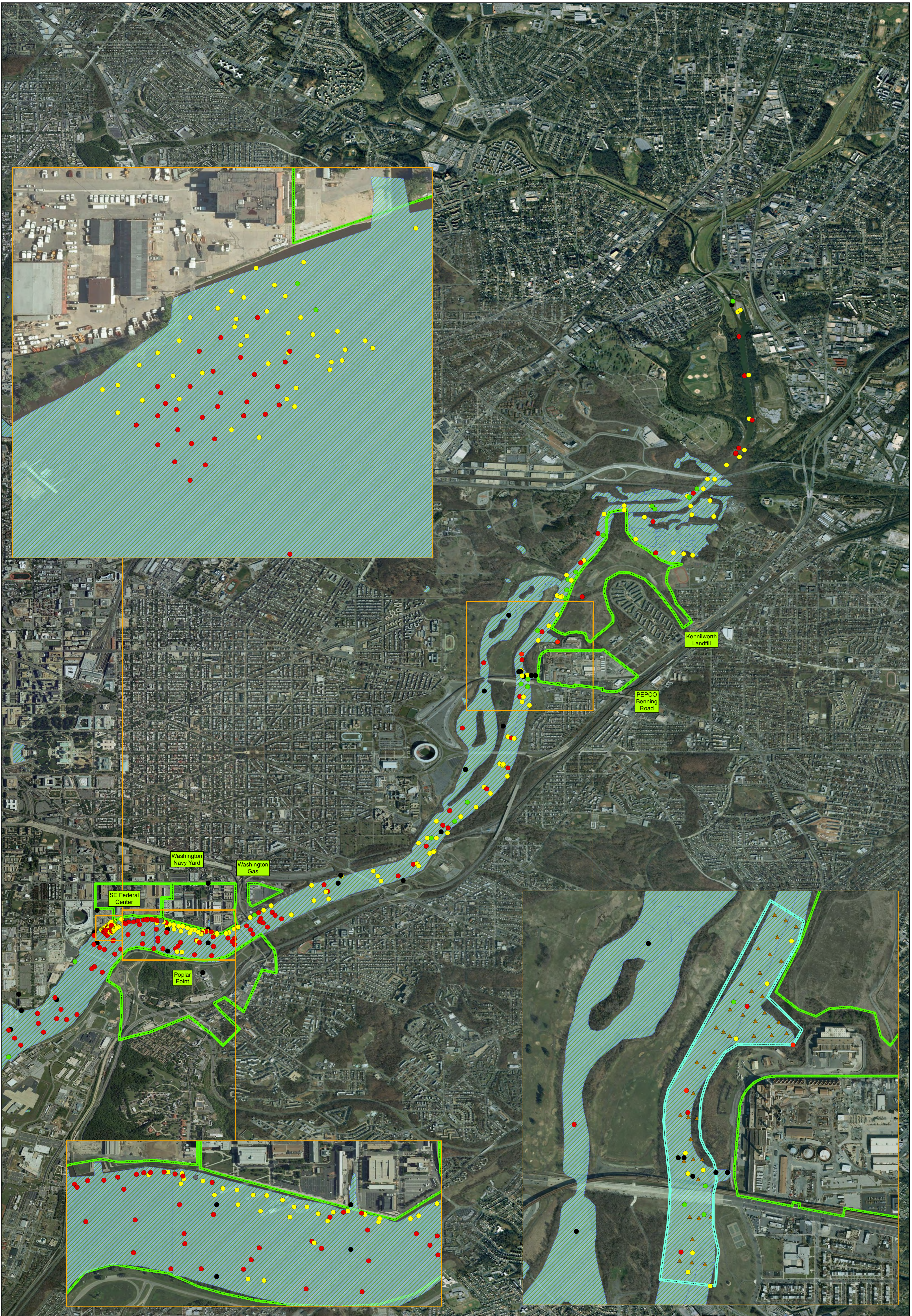


Data presented has been queried from the NOAA Query Manager Database and may include data from the following studies:
 1980-92 VA State Water Control Board
 1981-82 MD DEP Water Monitoring Data
 1986-98 NSWC White Oak Env. GIS Layer
 1989 ICP/RB/Limo-Tech Sediment Survey
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 1992 Potomac & Anacostia Sediment Study
 1993 EMAP - Chesapeake Bay
 1993 FWS Kennilworth Marsh
 1995 PEPCO
 1995 Washington Navy Yard
 1996 PWS PAH/PCB - Mason Neck
 1996 WA Gas - East Station Project
 1996 Wetland Restoration - Kennilworth
 1998 BARC RI
 1998 USACE Federal Nav Channel
 1999 AVTA Sediment Quality Triad
 1999 GSA SE Federal Center
 1999 WA Navy Yard RI
 2000 ANS Sediment Study
 2000 Ambient Tox Chesapeake Bay
 2000 USFWS Bioavailability
 2003 Active Clipping Site Char Rpt
 2009 Final Site Inspection Report

- Total Lead (mg/kg)**
- <35.8
 - 35.8 - 128.0
 - 128.0+
 - Non-Detect
 - No Record
- ▲ Proposed Sampling Location
 □ Proposed Study Area
 □ Property Boundaries
 □ Riverine Boundary



Figure 5



Total Nickel Concentrations in the Anacostia River Surficial Sediment
Benning Road Facility RI/FS Project
3400 Benning Rd., NE
Washington, DC 20019

0 0.5 1 2 Miles

Data presented has been queried from the NOAA Query Manager Database and may include data from the following studies:
 1980-92 VA State Water Control Board
 1981-82 MD DEP Water Monitoring Data
 1986-99 NSWC White Oak Env. GIS Layer
 1989 ICP/B/Limnol-Tech Sediment Survey
 1990 EMAP - Chesapeake Bay
 1991 EMAP - Chesapeake Bay
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 1995 PEPSCO
 1995 Washington Navy Yard
 1996 PWS PAH/PCB - Mason Neck
 1996 WA Gas - East Station Project
 1996 Wetlands Restoration - Kennilworth
 1998 BARC RI
 1998 USACE Federal Nav Channel
 1999 AVTA Sediment Quality Triad
 1999 GSA SE Federal Center
 1999 WA Navy Yard RI
 2000 ANS Sediment Study
 2000 Ambient Tox Chesapeake Bay
 2000 LUSTWS Bioavailability
 2003 Active Clipping Site Char Rpt
 2009 Final Site Inspection Report

- Total Nickel (mg/kg)**
- <22.7
 - 22.7 - 48.6
 - 48.6+
 - Non-Detect
 - No Record
- ▲ Proposed Sampling Location
- ▭ Proposed Study Area
- ▭ Property Boundaries
- ▨ Riverine Boundary

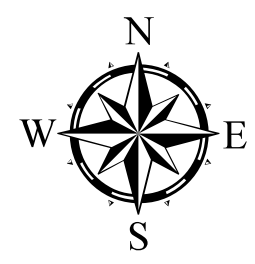
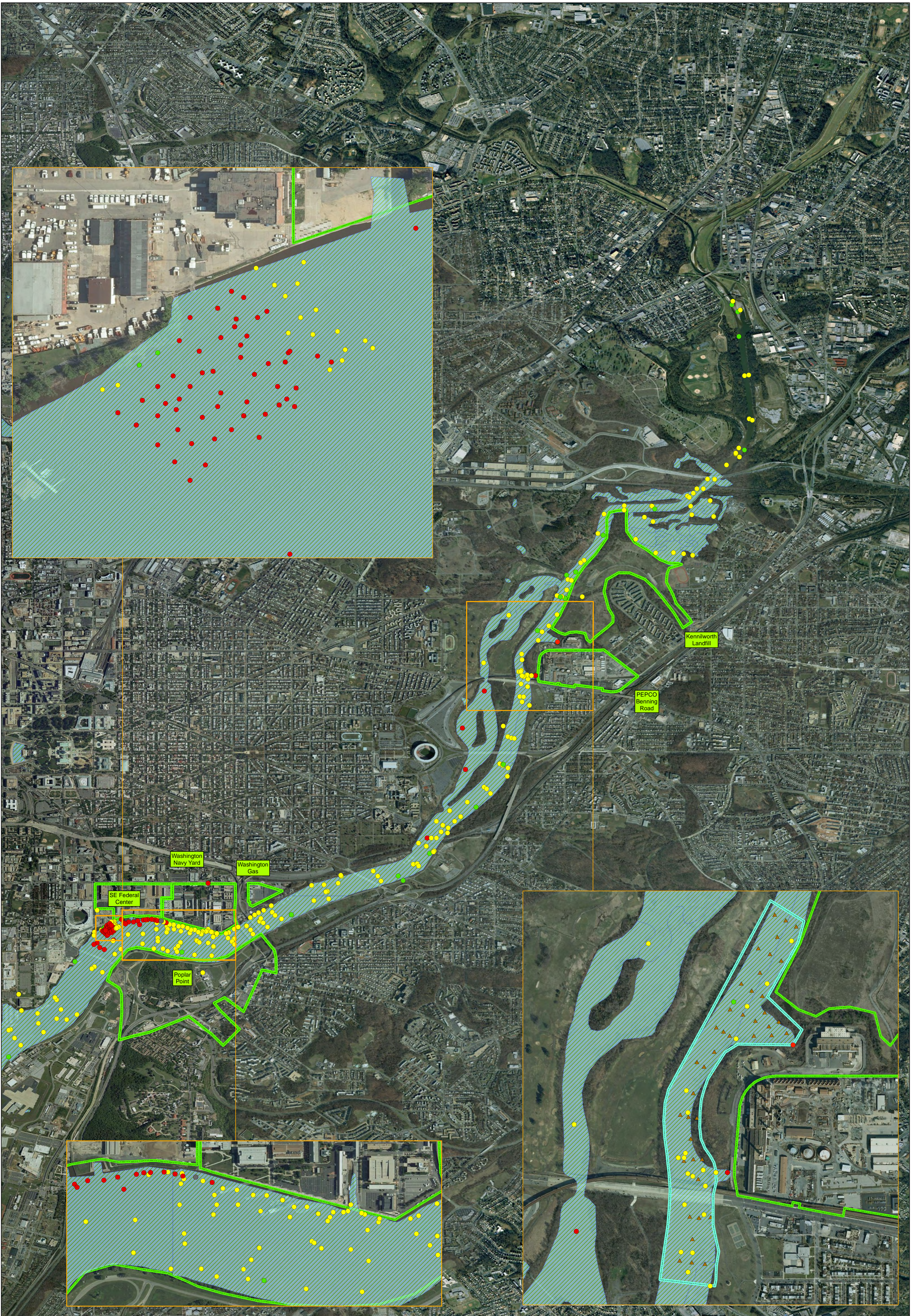
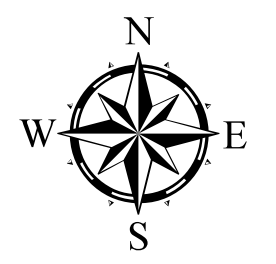
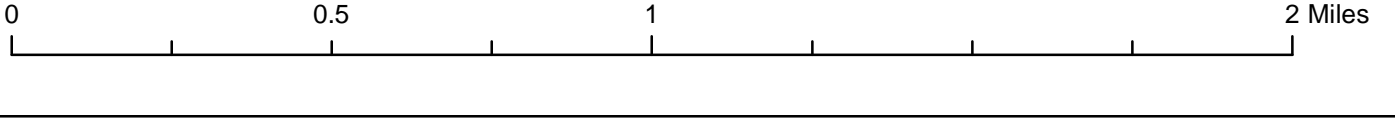


Figure 6



Total Zinc Concentrations in the Anacostia River Surficial Sediment
Benning Road Facility RI/FS Project
3400 Benning Rd., NE
Washington, DC 20019



Data presented has been queried from the NOAA Query Manager Database and may include data from the following studies:

- 1980-92 VA State Water Control Board
- 1981-82 MD DEP Water Monitoring Data
- 1986-99 NSWC White Oak Env. GIS Layer
- 1989 ICPRB/Linco-Tech Sediment Survey
- 1990 EMAP - Chesapeake Bay
- 1991 EMAP - Chesapeake Bay
- 1992 Potomac & Anacostia Sediment Study
- 1993 EMAP - Chesapeake Bay
- 1993 FWS Kennilworth Marsh
- 1995 PEPSCO
- 1995 Washington Navy Yard
- 1996 PWS PAH/PCB - Mason Neck
- 1996 WA Gas - East Station Project
- 1996 Wetland Restoration - Kennilworth
- 1987 DC Sediment Core Analysis
- 1998 BARC RI
- 1998 USACE Federal Nav Channel
- 1999 AFTA Sediment Quality Triad
- 1999 GSA SE Federal Center
- 1999 WA Navy Yard RI
- 2000 ANS Sediment Study
- 2000 Ambient Tox Chesapeake Bay
- 2000 USFWS Bioavailability
- 2003 Active Capping Site Char Rpt
- 2009 Final Site Inspection Report

- Total Zinc (mg/kg)**
- <121.0
 - 121.0 - 459.0
 - 459.0+
 - Non-Detect
 - No Record
 - ▲ Proposed Sampling Location
 - Property Boundaries
 - ▨ WetlandPly
 - ▭ Proposed Study Area



Figure 7



Appendix D

Human Health Risk Assessment Work Plan

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1 Introduction

This baseline human health risk assessment (HHRA) work plan has been prepared to present methodology that will be used to evaluate potential human health risks at the Benning Road facility (the Site) and a segment of the Anacostia River adjacent to the Site. Together, the Site and the adjacent segment of the River are referred to herein as the “Study Area”. The results of the baseline HHRA will be used to help inform the need for any additional evaluation and/or remedial action within the Study Area.

The 77-acre Site is bordered by a DC Solid Waste Transfer Station to the north, Kenilworth Maintenance Yard (owned by the National Park Service, NPS) to the northwest, the Anacostia River to the west, Benning Road to the south and residential areas to the east and south (across Benning Rd.). The general Site location is shown in **Figure 1** of the RI/FS Work Plan. Most of the Site is comprised of the Benning Service Center, which involves activities related to construction, operation and maintenance of Pepco’s electric power transmission and distribution system serving the Washington, D.C., area. The Service Center accommodates more than 700 Pepco employees responsible for maintenance and construction of Pepco’s electric transmission and distribution system; system engineering; vehicle fleet maintenance and refueling; and central warehousing for materials, supplies and equipment. The Site houses three active electrical substations that support Pepco’s distribution network. The Site is also the location of the Benning Road Power Plant, which is scheduled to be shut down in 2012. The majority of the Site is covered by impervious material such as asphalt or concrete. Active construction/staging areas that are not covered in impervious material are covered in gravel. Public access to the Site is restricted by perimeter fences and two guarded entrances that are manned 24 hours a day and seven days a week.

Based on the limited access and tight security, and the presence of pavement and/or soil cover across the vast majority of the facility where current or historical operations took place, there is very little potential for individuals to trespass onto the Site and come into contact with impacted surface soils. The presence of pavement and soil cover also limits the potential for on-site workers to come into contact with surface soils. The facility’s operating procedures and administrative controls prevent or manage potential exposure to impacted subsurface soils by workers who may perform excavation activities on-site. Groundwater is not used as a source of drinking water; drinking water in the area is provided by a remote municipal source (DC Water). In short, potential direct contact exposure pathways for on-site impacted soils and/or groundwater now or in the foreseeable future are concluded to be incomplete or effectively controlled through administrative measures.

Any on-site impacts are not expected to pose a threat to human health via air migration to off-site receptors. General site conditions, including the presence of impervious or gravel surfaces across most of the site, are expected to prevent or limit the generation of soil-derived fugitive dust emissions. Exposure via inhalation of soil-derived fugitive dust by off-site receptors is typically negligible, particularly if the surface soil is covered and downwind receptors are not located at the fence line (USEPA, 2002e; 1991c). The USEPA's Site Inspection report also concludes that the soil-to-offsite air migration pathway is insignificant: "contamination detected on the site does not pose a significant threat to the air migration pathway" (USEPA, 2009). Based on these considerations, the off-site air migration pathway is not significant enough to evaluate further in the HHRA.

USEPA has noted that contaminant migration via stormwater flows (both overland and through storm drains) and groundwater discharges to the Anacostia River may be of concern; the RI will collect data to determine/confirm these potential migration pathways.

The completed or potentially completed exposure pathways are reflected in the preliminary Conceptual Site Model (CSM) described in Section 3 of the RI/FS Work Plan, and illustrated on **Figure 9** of the Work Plan. The HHRA will evaluate all of the completed or potentially completed exposure pathways after any refinements to the CSM based on the findings of the RI work.

The baseline HHRA will be conducted in accordance with applicable USEPA guidance including, but not limited to, the following:

- Risk Assessment Guidance for Superfund (RAGS): Volume 1 - Human Health Evaluation Manual (Part A) (USEPA, 1989a);
- Human Health Evaluation Manual Supplemental Guidance; Standard Default Exposure Factors (USEPA, 1991a);
- Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. OSWER 9655.0-30. April, 1991. (USEPA, 1991b);
- Guidance for Data Usability in Risk Assessment (Part A) (USEPA, 1992a);
- Guidelines for Exposure Assessment (USEPA, 1992b);
- Guidance Manual for the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children. Publication 9285.7-15-1. February 1994 (USEPA, 1994), and associated, clarifying, Short Sheets on IEUBK Model inputs, including, but not limited to, OSWER 9285.7-32 through 34, as listed on the OSWER lead internet site at www.epa.gov/superfund/programs/lead/prods.htm;
- Land Use in the CERCLA Remedy Selection Process (USEPA, 1995);

- Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil (USEPA, 1996);
- Exposure Factors Handbook (EFH) (USEPA, 2011);
- Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (USEPA 2002a);
- Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children. Windows version©. (USEPA, 2002b);
- Human Health Toxicity Values in Superfund Risk Assessments, OSWER Directive 9285.7-53 (USEPA 2003);
- RAGs: Volume I. Human Health Evaluation Manual. Part E, Supplemental Guidance for Dermal Risk Assessment (USEPA, 2004);
- Guidelines for Carcinogen Risk Assessment (USEPA, 2005a);
- Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005b);
- Child-Specific Exposure Factors Handbook (USEPA 2008);
- ProUCL Version 4.1.01 (or the most currently available version, available from <http://www.epa.gov/osp/hstl/tsc/software.htm>, Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations; and
- USEPA Regional Screening Levels (USEPA, 2012a,b).

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

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

The HHRA work plan is organized into the following sections:

- Data Evaluation and Hazard Identification – Section 2 presents the methods to be used in the data evaluation and hazard identification, including selection of chemicals of potential concern (COPCs) that will be evaluated quantitatively in the risk assessment;

- Dose-Response Assessment – Section 3 presents a discussion of the dose-response assessment process. The dose-response assessment evaluates the relationship between the magnitude of exposure (dose) and the potential for occurrence of specific health effects (response) for each COPC. Both potential carcinogenic and non-carcinogenic effects will be considered. The most current USEPA-verified dose-response values will be used when available;
- Exposure Assessment - Section 4 presents a discussion of the exposure assessment process. The purpose of the exposure assessment is to provide a quantitative estimate of the magnitude and frequency of potential exposure to COPCs by a receptor. Potentially exposed individuals, and the pathways through which those individuals may be exposed to COPCs are identified based on the physical characteristics of the Study Area, as well as the current and reasonably foreseeable future uses of the Site and surrounding area. The extent of a receptor's exposure is estimated by constructing exposure scenarios that describe the potential pathways of exposure to COPCs and the activities and behaviors of individuals that might lead to contact with COPCs in the environment;
- Risk Characterization – Section 5 presents a discussion of the risk characterization process and uncertainties associated with the risk assessment process. Risk characterization combines the results of the exposure assessment and the toxicity assessment to derive site-specific estimates of potentially carcinogenic and non-carcinogenic risks resulting from both current and reasonably foreseeable future potential human exposures to COPCs. The results of the risk characterization will be used to identify constituents of concern (COCs), which are the subset of those COPCs whose risks result in an exceedance of the target risk range of 10^{-6} to 10^{-4} for potential carcinogens and a target Hazard Index of 1 for non-carcinogens (that act on the same target organ) (USEPA, 1990; 1991b);
- Uncertainty Evaluation - Within any of the steps of the risk assessment process described above, assumptions must be made due to a lack of absolute scientific knowledge. Some of the assumptions are supported by considerable scientific evidence, while others have less support. The assumptions that introduce the greatest amount of uncertainty in this risk evaluation will be discussed in the Risk Characterization section of the HHRA report; and
- Summary and Conclusions - Section 6 discusses the summary and conclusions section of the baseline HHRA report.

2 Data Evaluation and Hazard Identification

Analytical data collected in support of the RI will be compiled and tabulated in a database for statistical analysis. The steps used to summarize the data for use in identifying COPCs are discussed here. The additional steps used to summarize the data for identifying exposure point concentrations (EPCs) are presented in Section 4.

Data for samples and their duplicates will be averaged before summary statistics are calculated, such that a sample and its duplicate are treated as one sample for calculation of summary statistics (including maximum detection and frequency of detection) (USEPA, 1989a). Where both the sample and the duplicate are not detected, the resulting values used in the statistics will be the average of the sample-specific quantitation limits (SSQLs). Where both the sample and the duplicate are detected, the resulting values will be the average of the detected results. Where one of the pair is reported as not detected and the other is detected, the detected concentration will be used.

Summary statistic tables will include the following statistics:

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

COPC Selection

The compiled data will be compared to appropriate screening levels to identify COPCs for inclusion in the quantitative risk assessment. The COPC selection process will be conducted on a site-wide basis. Chemicals that are detected at least once in a medium will be sequentially screened as detailed below. The COPC screening steps are as follows:

1. *Identify chemicals that are essential nutrients.* Chemicals identified as essential nutrients (i.e., calcium, iron, magnesium, sodium and potassium) will not be included as COPCs (USEPA, 1989a).
2. *Evaluate frequency of detection.* For data sets with at least 20 samples, a chemical detected in 5% or fewer of the samples will not be retained as a COPC (USEPA, 1989a) provided samples with detected concentrations do not indicate the presence of potential hot spots.
3. *Compare maximum concentrations to health risk-based screening levels.* A chemical with a site-wide maximum detected concentration above its screening level will be retained as a COPC.
 - *Sediment/Wetland soils.* USEPA Regional Screening Levels (RSLs, USEPA, 2012a) for residential soil will be used to select COPCs in sediment and/or wetland soils adjacent to the river. Because residential soil RSLs are overly conservative for the selection of COPCs for river sediment/wetland soil with which humans may come into contact only occasionally, the residential soil RSLs for carcinogens will be multiplied by ten, which is equivalent to a 10^{-5} cancer risk level. The residential soil RSLs for non-carcinogens are set at a hazard quotient of 1, and will not be modified for COPC selection.
 - *Surface water.* USEPA RSLs for tap water will be used to select COPCs in surface water. Because tap water RSLs are overly conservative for the selection of COPCs for occasional exposures to surface water (e.g., recreational), the tap water RSLs will be modified consistent with sediment (carcinogens will be multiplied by ten, non-carcinogens will be used as is).
 - *Fish tissue.* Recent fish tissue data available from other studies will be evaluated in conjunction with the USEPA Region 3 Risk Based Screening Levels for fish (USEPA, 2012b) and will be used to select COPCs in fish tissue.
 - *Groundwater-to-surface water discharge.* Default and/or site-specific dilution factors will be applied to groundwater data from nearshore monitoring wells to estimate surface water concentrations at the point of discharge to the river. Concentrations above surface water screening values may be considered indicative of a potential for human health risks and may warrant further evaluation through Site-specific modeling efforts.

Tables documenting the COPC selection process for each medium will be presented in the baseline HHRA report, with the rationale for inclusion or elimination clearly stated. To the extent that sufficient background data are available, COPCs that appear to be influenced by regional urban background concentrations will be flagged in the screening process for further consideration in the risk characterization (USEPA 2002c,d).

Dose-Response Assessment

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

The USEPA's guidance for sources of human health dose-response values in risk assessment will be followed in selecting dose-response values (USEPA, 2003). Sources of published dose-response values that may be used in the HHRA include USEPA's Integrated Risk Information System (IRIS) (USEPA, 2012c) and the USEPA National Center for Environmental Assessment (NCEA) in Cincinnati, Ohio. In accordance with USEPA (2003), when dose-response values are not available from those sources, other sources of information may include California Environmental Protection Agency (CalEPA), the Agency for Toxic Substances and Disease Registry (ATSDR), and the Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997).

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

Dose-response values are available for oral and inhalation exposures. Oral dose-response values will be used to evaluate dermal exposures using appropriate adjustment factors from USEPA (2004). Inhalation dose-response values are not expected to be relevant or complete exposure pathways for the Site. For carcinogens presumed to act via a mutagenic mode of action, dose-response values are generally based on the linearized multistage model, which assumes that cancer risks are linear in the low-dose region (USEPA 2005b,c). Consistent with the Cancer Guidelines and Supplemental Guidance for Assessing Susceptibility for Early-Life Exposure to Carcinogens (USEPA 2005c), the application of age-dependent adjustment factors for chemicals with a mutagenic mode of action will be used in the calculation of risk from specific chemicals, such as PAHs. The potential contribution to lifetime risk from early life exposures to PAHs and associated chemicals with mutagenic modes of action will be discussed in the risk characterization and uncertainty sections of the report.

In the event that polychlorinated biphenyls (PCBs), dioxins and furans (PCDDs/PCDFs), mercury, and/or lead are identified as COPCs, the following approaches will be used to assess these compounds in the HHRA.

Polychlorinated Biphenyls

Risks from potential exposures to PCBs will be calculated using the most current guidance available from USEPA. Current USEPA guidance provided in IRIS (USEPA, 2012c) provides three tiers of cancer slope factors (CSFs) for evaluating potential carcinogenic effects of total PCBs (sum of congeners or Aroclors): 1) high risk and persistence, 2) low risk and persistence, and 3) lowest risk and persistence. The choice of slope factor for use depends on the medium of exposure and PCB chlorine content (USEPA, 2012). Total PCB concentrations will be calculated by summing individual detected congener concentrations (or detected Aroclors if congener data are not available). Non-cancer risks from potential exposures to total PCBs will be calculated using an appropriate RfD for a PCB mixture (based on Aroclor 1016 or Aroclor 1254).

Dioxins and Furans (PCDDs/PCDFs)

Because dioxins and furans occur in complex mixtures, the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), by far the most extensively studied of the group, is used as a reference for the other members of this family of chlorinated compounds. Based on their ability to bind to the Ah receptor, seven dioxin and 10 furan congeners are assumed to have a mechanism of toxicity similar to that of 2,3,7,8- TCDD. Toxic equivalency factors (TEFs) have been developed by WHO (Van den Berg, et al., 2006) to equate the toxicity of each dioxin-like congener to that of 2,3,7,8-TCDD. TEFs have been identified for 17 dioxins and furans, ranging from 0.0003 to 1, as shown in Table 1. In December 2010, USEPA published guidance that adopts the 2005 WHO mammalian TEFs for HHRA, but does not address specific risk assessment applications of TEFs (USEPA, 2010c).

Table 1: Toxic Equivalency Factors (TEFs) for Dioxin-Like Compounds

Compound	WHO 2005 TEF
<i>Chlorinated dibenzo-p-dioxins</i>	
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003
<i>Chlorinated dibenzofurans</i>	
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3

Compound	WHO 2005 TEF
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.0003

Source: USEPA, 2010c.

By multiplying the concentration of each dioxin-like congener in an environmental sample by its TEF, and summing the results, a toxic equivalent concentration (TEQ) can be calculated for that sample; alternatively the TEF can be applied to the TCDD oral CSF to derive congener-specific CSFs. The California EPA Toxicity Criteria Database lists an oral CSF of $1.3E+05$ (mg/kg-day)⁻¹ for TCDD (CA EPA, 2009). This is the CSF used by USEPA to derive the most recent (May 2012) cancer Regional Screening Level (RSL) for TCDD (USEPA, 2012a). For evaluating potential noncarcinogenic effects of dioxin, USEPA's oral reference dose of $7.0E-10$ mg/kg-day will be used (USEPA, 2012c). The implications of using the dioxin RfD will be discussed in the uncertainty analysis, including issues associated with background exposures. The background daily TEQ intake for an adult is estimated to be on the order of $6E-10$ mg/kg-day, mostly from food (Lorber et al., 2009).

Mercury

Mercury is considered by USEPA to be a noncarcinogen (USEPA, 2012c). Reference doses are available for a number of forms of mercury, including elemental mercury, mercuric chloride, and methyl mercury. The RfD for mercuric chloride will be used to evaluate the total mercury data, and the RfD for methyl mercury will be used to evaluate the methyl mercury data. Mercury in sediment is most likely to exist in the salt form; therefore, the RfD for mercuric chloride is appropriate. The site-specific data on the fraction of methyl mercury comprising total mercury in sediment and fish tissue will be considered in determining appropriate mercury dose-response values.

Lead

Potential risks from lead are not assessed using the RfD or CSF approach (USEPA, 2012c). Therefore, lead in sediment or surface water will be evaluated using available pharmacokinetic models, as appropriate (e.g., Integrated Exposure Uptake Biokinetic (IEUBK) Model and Adult Lead Model (ALM) [<http://www.epa.gov/superfund/lead/products>]).

3 Exposure Assessment

The purpose of the exposure assessment is to estimate the magnitude and frequency of potential human exposure to the COPCs retained for quantitative evaluation in the baseline HHRA. The first step in the exposure assessment process is the characterization of the setting of the Study Area. Current and reasonably foreseeable potential future uses and potential receptor populations (i.e., those who may contact the impacted environmental media of interest) are then identified. Potential exposure scenarios appropriate to current and reasonably foreseeable potential future uses and receptors are then developed. Those potential exposure pathways for which COPCs are identified and are judged to be complete will be evaluated quantitatively in the baseline risk assessment. Reasonable maximum exposure (RME) assumptions, and central tendency exposure (CTE) assumptions based on appropriate USEPA guidance will be employed in the quantitative risk assessment. The RME provides an estimate of the upper range of exposure in a population (the 90th percentile or greater of expected exposure) expected to occur under both current and future land use conditions, and is based on a combination of the upper-bound and central estimates of exposure parameters. It is not appropriate to set all RME exposure factor inputs to upper-percentile values, inasmuch as the resulting exposure estimates may exceed RMEs for the population of interest (USEPA 2004). The intent of the RME is to estimate a conservative exposure case that is above the average case but still within the range of possible exposures (USEPA 1989a, 1992b). The CTE uses average exposure parameters to calculate the average exposure of an individual. Both RME and CTE analyses will be presented for each exposure scenario.

Consistent with USEPA's guidance, the exposure assessment will rely on site-specific approaches and assumptions to the extent possible. Use of default or surrogate assumptions as a basis for remedial decision-making is inconsistent with USEPA guidance documents, which stress the importance of using data that represent the characteristics of the local population(s) and site (USEPA 1989a, b, 1998, 2000a, 2011a). Due to the site-specific nature of exposure assumptions for the fish ingestion pathway, site-specific data will be used to the extent possible. Since site-specific data gathering is ongoing, specific exposure parameter values are not provided in this document, but will be presented in a separate Technical Memorandum for discussion with the regulatory agencies. Relevant USEPA sources of exposure information, including the updated Exposure Factors Handbook (USEPA 2011a) and Child-Specific Exposure Factors Handbook (USEPA, 2008), will also be used in the identification of appropriate RME and CTE exposure assumptions for the HHRA.

Identification of Potential Exposure Scenarios

Exposure scenarios are developed on the basis of the HHRA CSM summarized in Section 3 of the RI/FS Work Plan. The following potentially complete exposure scenarios are identified as warranting evaluation in the baseline HHRA:

Worker

It is assumed that an adult worker may be exposed to COPCs via direct contact (incidental ingestion and dermal contact) with surface sediment and surface water while working along the banks of the Anacostia River adjacent to the Site.

Recreational Receptor

It is assumed that recreational receptors may be exposed to COPCs via direct contact (incidental ingestion and dermal contact) with surface sediment and surface water while wading or swimming in the Anacostia River. The age of the recreational receptor most likely to visit the river is assumed to be an older child/teenager. An adult accompanied by a young child is also assumed to occasionally visit the river.

Recreational Angler

Despite the presence of an advisory warning against the consumption of certain species of fish from the Anacostia and Potomac Rivers, it is assumed that a recreational angler visits the Anacostia River to fish and consumes his/her catch. It is assumed that the recreational angler may be exposed to COPCs via 1) direct contact (incidental ingestion and dermal contact) with sediment and surface water, and 2) ingestion of fish. The ages of the recreational angler is assumed to be an adult and older child. It is assumed that the adult angler brings home fish that may be consumed by a young child.

Quantification of Potential Exposures

To estimate the potential risk to human health that may be posed by exposures to COPCs, it is first necessary to estimate the potential exposure dose of each COPC. The exposure dose is estimated for each constituent via each exposure pathway by which a receptor is assumed to be exposed. Exposure dose equations combine the estimates of constituent concentration in the environmental medium of interest with assumptions regarding the type and magnitude of each receptor's potential exposure to provide a numerical estimate of the exposure dose. The exposure dose is defined as the amount of COPC taken into the receptor and is expressed in units of milligrams of COPC per kilogram of body weight per day (mg/kg-day).

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

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

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

3.1 Estimating Potential Exposures to COPCs in Sediment

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

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

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

where:

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

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

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

where:

ADD	=	Average Daily Dose (mg/kg-day)
CS	=	Sediment/Soil Concentration (mg/kg sediment)
SA	=	Exposed Skin Surface Area (cm ² /day)
AF	=	Sediment/Soil to Skin Adherence Factor (mg sediment/cm ²)
FI	=	Fraction Contacted from Potentially Impacted Source (unitless)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (year)
DAF	=	Dermal Absorption Fraction (constituent-specific) (unitless)
CF	=	Unit Conversion Factor (kg sediment/soil/10 ⁶ mg sediment)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days)

3.2 Estimating Potential Exposures to COPCs in Fish Tissue

The equation used to estimate a receptor's potential exposure via fish consumption is:

Average Daily Dose (Lifetime and Chronic) Following Fish Consumption (mg/kg-day):

$$ADD = \frac{CF \times IR \times FI \times (1 - Loss) \times AAF \times EF \times ED}{AT \times BW}$$

where:

ADD	=	Average Daily Dose (mg/kg-day)
CF	=	Concentration in Fish Tissue (mg/kg)
IR	=	Ingestion Rate (kg/day)
FI	=	Fraction ingested from Source
Loss	=	Preparation/cooking loss (unitless)
AAF _o	=	Oral Absorption Adjustment Factor (constituent-specific)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)

AT = Averaging Time (days)
 BW = Body Weight (kg)

3.3 Estimating Potential Exposures to COPCs in Surface Water

Chronic Daily Intake Following Ingestion of Surface Water (mg/kg-day):

$$CDI = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

where:

CDI = Chronic Daily Intake (mg/kg-day)
 CW = Water concentration (mg/L)
 IR = Water ingestion rate (L/day)
 EF = Exposure frequency (days/year)
 ED = Exposure duration (year)
 BW = Body weight (kg)
 AT = Averaging time (days)

The equation used to estimate a receptor's potential exposure via dermal contact with surface water is as follows.

$$CDI = \frac{DA_{event} \times EV \times EF \times ED \times SA}{BW \times AT}$$

where:

CDI = Chronic Daily Intake (dermally absorbed dose) (mg/kg-day)
 DA_{event} = Absorbed Dose per Event (mg/cm²-event)
 SA = Surface Area (cm²)
 EV = Event Frequency (events/day)
 EF = Exposure Frequency (days/year)
 ED = Exposure Duration (years)
 BW = Body Weight (kg)
 AT = Averaging Time (years)

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

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

where:

DA_{event}	=	Absorbed Dose per Event ($\text{mg}/\text{cm}^2\text{-event}$)
CW	=	Concentration in Water (mg/L)
PC	=	Permeability Constant (cm/hr)
ET	=	Exposure Time (hr/event)
CF	=	Conversion factor ($\text{L}/1000 \text{ cm}^3$)

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

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

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

where:

DA_{event}	=	Absorbed Dose per Event ($\text{mg}/\text{cm}^2\text{-event}$)
FA	=	Fraction Absorbed water (dimensionless)
PC	=	Permeability Constant (cm/hour)
CW	=	Concentration in Water (mg/L)
T	=	Lag Time per event (hr/event)
ET	=	Exposure Time (hr/event)
t^*	=	Time to Steady State (hr) = $2.4T$
B	=	Dimensionless ratio of the PC of a chemical through the stratum corneum relative to its permeability constant across the viable epidermis
CF	=	Conversion Factor ($\text{L}/1000 \text{ cm}^3$)

Parameters for Water Dermal Dose Calculation

The estimation of exposure doses resulting from incidental dermal contact with surface water requires the use of a dermal permeability constant (PC) in units of centimeters per hour (cm/hr). This method assumes that the behavior

of constituents dissolved in water is described by Fick's Law. In Fick's Law, the steady-state flux of the solute across the skin ($\text{mg}/\text{cm}^2/\text{hr}$) equals the permeability constant ($\text{PC cm}/\text{hr}$) multiplied by the concentration difference of the solute across the membrane (mg/cm^3). This approach is discussed by USEPA (USEPA, 1989a; 2004).

The PC values will be derived from USEPA (2004) Exhibit B-3. For the COPCs lacking PCs in the USEPA guidance, PCs will be calculated using the USEPA algorithms. In addition to PCs, several other parameters are necessary to calculate dermal dose from exposure to organic compounds in water. These parameters will also be obtained from USEPA (2004), Exhibit B-3, and include the ratio of the permeability coefficient of a chemical through the stratum corneum relative to its permeability coefficient across the viable epidermis (B , dimensionless), lag time (T , hours/event), and time to steady state (t^* , hours). Parameters for constituents not available from USEPA (2004) will be calculated. Note that the spreadsheets that accompany RAGS Part E (USEPA, 2004) (available on USEPA's website <http://www.epa.gov/oerrpage/superfund/programs/risk/ragse/>) will be used to obtain the parameters, as the printed version often shows 0.0 for small values.

3.4 Constituent-Specific Parameters

The dermal and oral absorption and preparation/cooking loss parameters identified in the equations presented above are chemical-specific, and are described below.

Dermal Absorption Fractions

The dermal absorption fraction (DAF) accounts for lower absorption through the skin. USEPA chemical-specific DAFs will be used where available (USEPA, 2004). DAFs are available for PCBs and some of the inorganic COPCs. For the inorganics lacking DAFs in USEPA (2004), the default value of 0.001 (0.1%) for inorganic chemicals recommended by USEPA Region 4 (2000b), or other appropriate default DAFs, will be used.

Oral Absorption Adjustment Factors

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

$$\text{AAF} = \frac{\text{(fraction absorbed in humans for the environmental exposure)}}{\text{(fraction absorbed in the dose - response study)}}$$

The use of an AAF allows the risk assessor to make appropriate adjustments if the efficiency of absorption between environmental exposure and experimental exposure is known or expected to differ because of physiological effects and/or matrix or vehicle effects. When the dose-response curve is based on administered dose data, and if it is estimated that the fraction absorbed from the site-specific exposure is the same as the fraction absorbed in the laboratory study, then the AAF is 1. In the absence of detailed toxicological information on every constituent, it has been common practice for risk assessors to use a default oral AAF value of 1. However, use of AAFs in standard risk assessment calculations can provide more accurate and more realistic estimates of potential human health risk. Representative and appropriate AAFs based on available toxicological data will be developed to the extent practicable. The derivation of any non-default oral AAFs used in the HHRA will be provided in an appendix to the HHRA report. In the absence of appropriate data, a default AAF of 1 will be used.

Preparation/Cooking Loss

Preparation and cooking procedures can modify the amount of COPC ingested by fish consumers (USEPA, 2000a). Numerous studies have demonstrated the loss of chemicals such as PCBs from fish tissues during preparation and cooking (e.g., Bayen et al. 2005, Hori et al., 2005, Zabik et al. 1994, 1995a, 1995b, 1996, Moya 1998, Skea et al 1979), many of which are summarized in USEPA 2000a. Incorporating a modification factor to account for preparation and cooking loss requires information on methods used to prepare and cook the angler's catch, and the extent to which the COPC concentrations measured in the tissue types analyzed are likely to decrease based on these cooking methods. Cooking loss factors have been included in the angler scenarios for several large sediment site HHRAs, including the Housatonic River (Weston, 2005), Lower Fox River (RETEC, 2002), and Kalamazoo River (CDM, 2003). Preparation/cooking loss factors representative of site-specific conditions will be included in the baseline HHRA provided the supporting data needed are available, as described below.

Available data on catch preparation and cooking practices, as well as tissue type, will be summarized for species relevant to the Anacostia River. In addition, the available literature will be reviewed to identify studies that provide data on species, preparation and cooking methods, and chemical groups relevant to the Site. Data from these studies will be summarized, including observed ranges and means of cooking loss estimates. Based on this information, preparation/cooking loss estimates will be developed for use in the HHRA.

3.5 Calculation of Exposure Point Concentrations

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

The exposure point concentration (EPC) will be defined as the 95% upper confidence level (UCL) (USEPA 2002a) for the RME scenario. UCLs will be calculated using USEPA's ProUCL Version 4.1.01 (USEPA, 2011b, 2010a,b). The UCL recommended by ProUCL will be used unless determined to be inappropriate based on a statistical review, or if it exceeds the maximum detected concentration (USEPA 1989a). The maximum will be used where the UCL exceeds the maximum, and the uncertainty associated with the corresponding risk estimates will be discussed in the uncertainty section of the HHRA.

Mean or median concentrations will be used to represent the CTE scenario EPCs (use of the mean where data follow a normal distribution, and the median where no distribution is discernible).

For sediment, data from samples collected near the shore, where the potential for direct contact is greatest, will be used to estimate EPCs for the sediment exposure pathways. The need to segment the river into separate exposure areas for the baseline HHRA will be evaluated once RI data collection is complete.

For fish, available data will be used where possible to estimate EPCs. Relevant and appropriate data from existing studies will be considered for use in developing site-specific tissue EPCs. If adequate fish tissue data are not available, it may be necessary to predict tissue concentrations from surface water and/or sediment data using bioaccumulation modeling. The basis for any modeled fish tissue concentrations will be documented in the HHRA.

4 Risk Characterization

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

4.1 Carcinogenic Risk Characterization

The purpose of carcinogenic risk characterization is to estimate the upper-bound likelihood, over and above the background cancer rate, that a receptor will develop cancer in his or her lifetime as a result of exposure to a constituent in an environmental medium. This likelihood is a function of the dose of a constituent (described in the Exposure Assessment) and the CSF (described in the Dose-Response Assessment) for that constituent. The American Cancer Society (ACS) estimates that the lifetime probability of contracting cancer in the U.S. is 1 in 2 for men and 1 in 3 for women (ACS, 2012). The Excess Lifetime Cancer Risk (ELCR) associated with estimated exposures at a site is the likelihood, over and above the background cancer rate, that an individual will develop cancer in his or her lifetime due to those site exposures. The cancer risk is expressed as a probability (e.g., 10^{-6} , or one in one million). An ELCR of 10^{-6} indicates that an individual would have a 1 in one million chance of developing cancer in addition to the 1 in 2 or 1 in 3 background chance estimated by the ACS. The relationship between the ELCR and the estimated LADD of a constituent may be expressed as:

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

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

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

The product of the CSF and the LADD is unitless, and provides an upper-bound estimate of the potential carcinogenic risk associated with a receptor's exposure to a constituent or an exposure pathway for each receptor. Current USEPA risk assessment guidelines assume that cancer risks are additive or cumulative. Pathway- and area-specific risks are summed to estimate the total potential cancer risk for each receptor. A summary of the total cancer risks for each receptor group will be presented in this section of the HHRA.

USEPA has established target risk levels under the National Contingency Plan (NCP) (USEPA, 1990). Target risk levels refer to levels of cancer risk or hazard indices that are deemed acceptable by the USEPA or other regulatory agencies. These are levels below which the potential for adverse effects to humans are assumed to be negligible or inconsequential. The NCP establishes a target cancer risk range of 10^{-6} to 10^{-4} and a target hazard index of less than or equal to one (USEPA, 1990). The USEPA subsequently clarified that, "Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4} , and the non-carcinogenic hazard quotient is less than 1, action generally is not warranted, unless there are adverse environmental impacts" (USEPA, 1991b).

Thus, potential risks will be compared to the USEPA range of 10^{-6} to 10^{-4} . COPCs that cause exceedance of the risk range will be identified as COCs.

4.2 Non-carcinogenic Risk Characterization

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

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

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

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

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

Using the results of the RME and CTE risk calculations, chemicals of concern (COCs) will be identified, which are those COPCs that cause exceedance of the non-cancer target HI of 1 per target organ.

4.3 Risk Characterization for Lead

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

4.4 Risk Assessment Refinement

The baseline HHRA will be conducted using reasonable but conservative exposure and dose-response assumptions, and will follow a deterministic (i.e., point estimate) approach. The risk estimates may be further refined by using, for example: site-specific bioavailability factors, site-specific exposure data, or probabilistic (or Monte Carlo) analysis. The potential contribution of background conditions will also be considered in the evaluation of risk assessment results. Use of such refinements, such as a probabilistic risk assessment, will allow the potential risks to be put in perspective and will provide information that the risk manager may use to more accurately characterize risks on a location-specific basis and to communicate the nature of the risks. The need for refinements to the risk assessment process will be explored pending the outcome of the initial deterministic risk assessment.

4.5 Uncertainty Analysis

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

There are many potential sources of uncertainty in the risk assessment process; some are more important than others. The major areas of uncertainty include: the quality of the analytical data, assumptions about the frequency, duration, and magnitude of exposure, the receptors identified, and the availability and accuracy of dose-response data. The uncertainties will be discussed qualitatively, including steps taken to compensate for uncertainty, and the impact on the risk assessment results.

5 Summary and Conclusions

The summary and conclusions of the baseline HHRA will be summarized. The receptor/exposure scenarios that result in unacceptable risks, if any, will be identified, and constituents of concern (COCs) will be presented.

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Appendix E

**Ecological Risk
Assessment Work Plan**

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Table 1: Exposure Parameters for Wildlife Receptors

1 Introduction

The results of the waterside field investigation will be used to evaluate the potential for ecological risks associated with exposure to environmental media within or along the Anacostia River adjacent to the Site. The ecological risk assessment (ERA) will be conducted according to the general tiered approach and methodology provided by the USEPA *Ecological Risk Assessment Guidance for Superfund (ERAGS): Process for Designing and Conducting Ecological Risk Assessment, Interim Final* (USEPA, 1997), *Guidelines for Ecological Risk Assessment* (USEPA, 1998), and *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (USEPA, 2001).

Each successive tier of ERA requires more detailed and quantitative data analysis and interpretation. Conducting assessments in a tiered, step-wise manner allows the risk assessor and risk manager to maximize the use of available information and sampling data, while providing the opportunity to reduce the uncertainties inherent in the ERA process through the use of focused supplemental data collection to fill key data gaps identified in the previous tier of the assessment, as necessary.

In accordance with the USEPA guidance and process documents, the principal components of the ERA will include:

- **Problem Formulation:** In this phase, the objectives of the ERA are defined, and a plan for characterizing and analyzing risks is determined. Available information regarding stressors and specific sites is integrated. Products generated through problem formulation include assessment endpoints and CSMs;
- **Risk Analysis:** During the risk analysis phase of work, data are evaluated to characterize potential ecological exposures and effects; and
- **Risk Characterization:** During risk characterization, exposure and stressor response profiles are integrated through risk estimation. Risk characterization also includes a summary of uncertainties, strengths, and weaknesses associated with the risk assessment.

These three components are conceptually sequential. However, the risk assessment process is frequently iterative, and new information brought forth during the risk characterization phase, for instance, may lead to a review of the problem formulation phase, or additional data collection and analysis. This work plan describes the general approach for each of these ERA components, as follows:

- Section 2 describes the Problem Formulation, which includes a summary of the Field Reconnaissance Site Visit, and the identification of ecological receptors and exposure pathways for the development of the assessment endpoints and the CSM;
- Section 3 describes the Risk Analysis, which includes a summary on data treatment, and the plan for risk analyses of warm water fish, benthic invertebrates, and vertebrate wildlife; and,
- Section 4 describes the Risk Characterization, which includes a discussion of how the results of the environmental risk analysis will be analyzed and interpreted and how uncertainty of the analysis will be evaluated.

The results of the ERA will be used to help inform the need for any additional evaluation and/or remedial action at the Site, and the Natural Resource Damage Assessment (NRDA).

2 Problem Formulation

Problem Formulation provides the framework for the ERA and serves to define the risk assessment objectives and the geographic area to be considered and identify the ecological receptors, exposure pathways and endpoints to be evaluated.

The risk assessment objective for this ERA is to evaluate whether or not populations of ecological receptors are potentially at risk due to exposure to Site-related chemical stressors within the Waterside Investigation Area. As indicated in **Figure 2** of the RI/FS Work Plan, the Waterside Investigation Area encompasses approximately 10 to 15 acres of the Anacostia River and associated wetlands including approximately 1,500 linear feet to the south (approximately 1,000 ft south of the Benning Road Bridge) and 1,000 linear feet to the north of the Site's main storm water outfall area.

2.1 Field Reconnaissance

Pepco will conduct a site reconnaissance to develop a better understanding of the Study Area and surrounding conditions. Observations made during the Study Area reconnaissance will include a detailed evaluation of the habitat present within the Waterside Investigation Area. These observations will be critical for the identification of appropriate sampling locations and techniques, as well as the identification of target ecological receptors for the evaluation in the ERA.

In addition, available biological data for the Anacostia River in the vicinity of the Study Area will be reviewed to develop an understanding of the overall conditions. The United States Fish and Wildlife Service (USFWS), District Department of the Environment (DDOE), and National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service will be contacted to determine if any federally listed species or other sensitive receptors exist at or in the vicinity of the Study Area. This information will further support the selection of target ecological receptors and the identification of appropriate sampling locations and methodology.

2.2 Selection of Specific Receptors and Exposure Pathways

Potential ecological receptors occurring within the Study Area and potentially complete ecological exposure pathways will be evaluated. Each exposure pathway includes a potential source of COPC, an environmental medium, and a potential exposure route. In accordance with agency guidance, incomplete routes of exposure will not be evaluated in the ERA. This approach is used to focus the risk evaluation on exposure pathways that are

considered to be potentially complete and for which there are adequate data pertaining to the receptors, exposure, and toxicity for completion of the risk analysis.

Exposure pathways for several groups of ecological receptors have been identified as potentially relevant. The available data suggest surface water, sediment, and fish tissue are the primary media of potential ecological concern within the Anacostia River. Potentially complete exposure pathways were determined to exist for fish, benthic macroinvertebrates, and piscivorous wildlife. Based on the available data and the CSM described in Section 3 of the RI/FS Work Plan, the ecological exposure pathways to be evaluated in the ERA include:

- Direct contact with surface water and sediment by warmwater fish;
- Direct contact with sediment by benthic macroinvertebrates; and
- Ingestion of contaminated prey items and abiotic media (i.e., surface water, sediment, and/or hydric soil) by selected vertebrate wildlife receptors (i.e., fish, piscivorous birds and mammals).

2.3 Selection of Biological Endpoints

Ecologically-based assessment endpoints and measures of effect were designed to evaluate potential ecotoxicological effects associated with exposure to identified COPC. According to USEPA (1998), assessment endpoints are formal expressions of the actual environmental value to be protected. They usually describe potential adverse effects to long-term persistence, abundance, or production of populations of key species or key habitats. Typically, assessment endpoints and receptors are selected for their potential exposure, ecological significance, economic importance, and/or societal relevance.

Because assessment endpoints often cannot be measured directly, a set of surrogate endpoints (measures of effect) are generally selected for ecological risk assessment that relate to the assessment endpoints and have measurable attributes (e.g., comparison of media concentrations to screening levels, results of food web models) (USEPA, 1997, 1998). These measures of effect provide a quantitative metric for evaluating potential effects of constituents on the ecosystem components potentially at risk. Since each measurement endpoint has intrinsic and extrinsic strengths and limitations, several measurement endpoints will be used to evaluate each assessment endpoint. Several of the endpoints considered below are based upon tissue residue data. For fish and other prey items, available data from published sources will be used where possible to estimate fish tissue residue concentrations in the Anacostia River. If adequate fish tissue data are not available, it may be necessary to predict tissue concentrations from surface water and/or sediment data using bioaccumulation modeling. The basis for any modeled fish tissue concentrations will be documented in the ERA.

The assessment endpoints and measures of effect selected for the ERA are:

- **Assessment Endpoint 1** – Protection and maintenance of fish communities in aquatic habitats within the Anacostia River typical of comparable upstream aquatic habitats with similar morphology, hydrology, and urban setting.
 - Measure of Effect 1a – Comparison of surface water concentrations to surface water screening values. Concentrations above the screening values are considered indicative of a potential for ecological risks.
 - Measure of Effect 1b – Comparison of groundwater concentrations collected from Nearshore monitoring wells to surface water screening values. Default and/or site-specific dilution factors will be applied to Nearshore monitoring well groundwater data to estimate surface water concentrations at the point of discharge to the river. Concentrations above the screening values may be considered indicative of a potential for ecological risks and may warrant further evaluation through Site-specific modeling efforts.
 - Measure of Effect 1c – Comparison of fish tissue COPC burdens to available critical body residue (CBR) thresholds and background tissue concentrations. In the absence of local fish tissue concentrations, levels of bioaccumulative COPCs in whole body fish tissue may be estimated using uptake factors.
- **Assessment Endpoint 2** – Protection and maintenance of freshwater benthic invertebrate populations in aquatic habitats within the Anacostia River typical of comparable aquatic habitats with similar morphology, hydrology, and urban setting.
 - Measure of Effect 2a – Comparison of sediment concentrations to low effect sediment screening values. Concentrations above the screening values are considered indicative of a potential for ecological risks.
 - Measure of Effect 2b – Characterization of bioavailability potential in sediment based on SEM and AVS relationships. SEM/AVS ratios greater than 1 in a sediment sample will be considered an indicator of potential bioavailability for divalent cationic metals. The SEM and AVS difference (SEM-AVS) and the influence of sediment organic carbon content will also be considered in this evaluation.
- **Assessment Endpoint 3** – Protection and maintenance of a piscivorous vertebrate wildlife community in aquatic and wetland habitats within the Anacostia River typical of comparable aquatic habitats with similar morphology, hydrology, and urban setting.
 - Measure of Effect 3a – Comparison of calculated potential daily exposure for avian and mammalian receptors from exposure to bioaccumulative COPCs in abiotic media (surface water, sediment,

and/or hydric soil) and ingestion of contaminated prey items to constituent-specific toxicity reference values (TRVs). Estimated doses above the TRVs are considered indicative of a potential for ecological risks.

2.4 Conceptual Site Model (CSM)

The end product of the problem formulation step is the development/refinement of the CSM. The CSM helps to describe the COPC origin, fate, transport, exposure pathways, and receptors of concern. A detailed description of the current preliminary CSM is found in Section 3 of the RI/FS Work Plan. The data collected to support the ERA will be used to further refine the CSM. The CSM will also consider the context of the Study Area within the anthropogenically impacted Anacostia River watershed. For instance, available Site data will be reviewed relative to readily available background data, sediment and surface water concentrations. Background concentrations of COPCs provide valuable insight into what toxic chemicals may be entering the Anacostia River from other sources and will be considered in the risk analysis. Collection of Site-specific background data and/or evaluation of background or reference condition data from other ongoing projects on the Anacostia River (e.g., Kenilworth Landfill, Poplar Point, and Washington Navy Yard) will be used to determine the background conditions.

3 Risk Analysis

The risk analysis phase of the ERA is based on the CSM developed in problem formulation. Risk analysis includes both the characterization of potential ecological exposure and effects. The ecological exposure assessment involves the identification of potential exposure pathways and an evaluation of the magnitude of exposure of identified ecological receptors. The ecological effects assessment describes the potential adverse effects associated with the identified COPC to ecological receptors and reflects the type of assessment endpoints selected. The data and methods that will be used to identify and characterize ecological exposure and effects are described in the following subsections.

3.1 Data Treatment

Exposure point concentrations (EPCs) will be estimated within each Site medium for each COPC in order to evaluate the selected ecological exposure pathways and receptors. These EPCs represent the range of media concentrations that ecological receptors may encounter. Average and maximum EPCs will be considered in the food chain evaluation and in the comparison of historic and recently collected concentration data against benchmarks. The maximum EPC will be the upper confidence limit (UCL) on the arithmetic mean, or the maximum when UCLs cannot be calculated due to data limitations (i.e., number of samples or number of detected results).

All analytical data (previous and future) will be compiled and tabulated in a database for statistical analysis. Data for samples and their duplicates will be averaged before summary statistics are calculated, such that a sample and its duplicate will be treated as one sample for calculation of summary statistics (including maximum detection and frequency of detection). Where both the sample and the duplicate are not detected, the resulting values are the average of the sample-specific quantitation limits (SSQLs). Where both the sample and the duplicate are detected, the resulting values are the average of the detected results. Where one of the pair is reported as not detected and the other is detected, the detected concentration is used.

USEPA's ProUCL Version 4.1.01 software (USEPA, 2011) will be used to calculate UCLs on the arithmetic mean and arithmetic means according to USEPA guidance (USEPA, 2002), using ProUCL and the Kaplan-Meier method where non-detects are present (using SSQLs and appropriate substitution methods), and simple arithmetic means of detected concentrations for datasets with no non-detects. The ProUCL recommended UCL (i.e., 95%, 97.5%, 99%) will be used as the selected UCL. Based on information presented in the ProUCL guidance (USEPA, 2010a,b) regarding minimum sample size and frequency of detection, UCLs and Kaplan-Meier means will be calculated

where at least 10 samples and at least six detected results are available. While ProUCL version 4.1.01 recommends a minimum of 10 samples with six detected values in order to calculate reliable UCLs, the guidance recognizes that this may not always be possible due to resource or other restraints, and allows the user best professional judgment when determining the validity of the calculations.

The following summary statistics will be calculated:

- Frequency of Detection (FOD): The frequency of detection is reported as the number of samples reported as detected for a specific constituent and the total number of samples analyzed. The total number of samples reflects the averaging of duplicates discussed above;
- Maximum Detected Concentration: This is the maximum detected concentration for each constituent/area/medium combination, after duplicates have been averaged;
- Minimum Detected Concentration: This is the minimum detected concentration for each constituent/area/medium combination, after duplicates have been averaged;
- Mean Detected Concentration: This is the arithmetic mean concentration for each constituent/area/medium combination, after duplicates have been averaged, based on detected results only;
- Kaplan Meier Method Mean: When non-detects are present in the dataset, the mean concentrations will be derived by the program using appropriate SSQL substitution methods (USEPA, 2010a,b);
- UCL: The UCL recommended by ProUCL version 4.00.02. If more than one UCL is recommended by the program (i.e., 95%, 97.5%, 99%), the higher UCL will be selected;
- Maximum EPC: The lower of the selected UCL and the maximum detected concentration will be selected; and
- Average EPC: Arithmetic mean for datasets with no non-detects; Kaplan-Meier mean for datasets with non-detects. When the Kaplan-Meier mean cannot be calculated due to an insufficient number of detects, then the arithmetic mean of the detected results will be selected.

3.2 Warmwater Fish Community Risk Analysis

Fish may potentially be exposed to COPCs from direct contact with surface water and sediment and ingestion of sediment and contaminated food items. Studies conducted by the USFWS (Pinkney, et, al, 2002) found that brown bullhead catfish (*Ameiurus nebulosus*) collected from the Anacostia River in Washington, DC had high rates of both liver and skin tumors and that PAHs appear to play a role in tumor formation. As described in Section 2.3 above, three measures of effect will be used to evaluate the assessment endpoint developed for the warmwater fish community in the Waterside Investigation Area.

Potential risks to fish from COPC exposure in surface water will be evaluated through comparisons of site surface water and groundwater data with literature-derived toxicity thresholds. Surface water data will be collected in the vicinity of the Site and groundwater data from monitoring wells along the shoreline will be used to estimate surface water concentrations at the point of discharge to the river (e.g. default and/or site-specific dilution factors will be applied the the groundwater concentrations to represent surface water concentrations). The following surface water screening level sources will be used to evaluate exposure to surface water:

- DDOE Water Quality Standards (WQS) for the protection of freshwater aquatic life (DDOE, 2006);
- USEPA Region 3 Freshwater Screening Benchmarks (USEPA, 2006a); and
- Literature-based toxicological benchmarks (Suter & Tsao, 1996 and Buchman, 2008).

Potential risks to fish from COPC exposure via ingestion of sediment and contaminated food items will be evaluated through an assessment of fish tissue body burdens. Fish tissue data from recent studies will be evaluated for potential inclusion in the RI (e.g., studies such as Pinkney et al., 2001; Maryland Department of the Environment [MDE], 2012) will be reviewed to identify samples collected in the vicinity of the Site). Several different species have been collected from within the Potomac River (e.g., bluegill, carp, channel catfish, largemouth bass, American eel, bullhead, pumpkinhead sunfish, white sucker) and at least some tissue residue samples have been analyzed for PCBs, PAHs, metals, and pesticides (not all samples were analyzed for all parameters). For fish and other prey items, relevant and appropriate available data from published sources will be used where possible to estimate EPCs. If adequate fish tissue data are not available, it may be necessary to predict tissue concentrations from surface water and/or sediment data using bioaccumulation modeling. The basis for any modeled fish tissue concentrations will be documented in the ERA.

In order to evaluate the potential impact to the fish community due to exposure to COPCs in the Anacostia River within the Waterside Investigation Area, effects ranges for body burdens will be compiled from the literature and will represent tissue concentrations resulting from actual exposures that could potentially result in adverse biological effects. Values will be derived based on no observed adverse effects levels (NOAELs) and lowest observed adverse effects levels (LOAELs). NOAELs indicate a body residue concentration at which no adverse effects were observed and LOAELs indicate a body residue concentration at which adverse effects may begin to be observed. COPCs in fish tissue will be compared against the selected Critical Body Residue (CBRs).

3.3 Benthic Macroinvertebrate Community Risk Analysis

Benthic organisms (e.g., those living in sediment) may potentially be exposed to COPCs from direct contact with sediment. As described in Section 2.3 above, two measures of effect will be used to evaluate the assessment endpoint developed for the benthic macroinvertebrate community in the Waterside Investigation Area.

Potential risks to benthic macroinvertebrates from COPC exposure in sediment will be evaluated through comparisons of site data with the literature-derived toxicity thresholds. Sediment analytical chemistry analysis results will be compared to available low effect and probable effect sediment quality guidelines selected using a hierarchy of the following sources:

- Freshwater sediment values presented by the National Oceanic and Atmospheric Administration (NOAA) in Screening Quick Reference Tables (SQUIRT)(Buchman, 2008);
- USEPA Region 3 Freshwater Sediment Screening Benchmarks (USEPA, 2006b);
- USEPA Region 5 Ecological Screening Levels for sediment (USEPA, 2003); and
- Ontario Ministry of the Environment (OMOE) Provincial Sediment Quality Guidelines (Persaud et al., 1993)

To account for the potential for divalent metals bioavailability to be limited within the Study Area, SEM, AVS, and TOC will be measured in sediments collected as part of the proposed field effort. USEPA (2005) guidance on metals bioavailability evaluates possible binding of metals by both AVS and organic matter. Therefore, data collected as part of the proposed field program will be evaluated on a sample-by-sample basis using the following scale to evaluate whether or not the organic carbon binding phase (represented as fraction organic carbon or f_{oc}), in conjunction with the AVS, is affecting the bioavailability of divalent metals in sediments:

- If the $(\sum SEM - AVS)/f_{oc}$ excess exceeds 3000 $\mu\text{mol}/\text{goc}$, the sediments are presumed to be "likely to be toxic";
- If the $(\sum SEM - AVS)/f_{oc}$ excess is between 130 and 3,000 $\mu\text{mol}/\text{goc}$, predictions of effects are uncertain; and
- If the $(\sum SEM - AVS)/f_{oc}$ excess is less than 130 $\mu\text{mol}/\text{goc}$, the sediments are presumed to "not likely" be toxic.

3.4 Vertebrate Wildlife Community Risk Analysis

Potential exposure routes for wildlife receptors include potential direct or indirect ingestion of surface water, sediment, and ingestion of food items containing COPCs. To evaluate potential wildlife exposure, representative wildlife species will be selected for evaluation in food chain models that estimate exposures to wildlife species

respective to their position in the food chain. The following subsections present representative species, exposure parameters, COPC concentrations in prey items, calculation of potential doses, and evaluation of effects for vertebrate wildlife receptors.

3.4.1 Representative Species

As described in Section 5.4, the Waterside Investigation Area includes riverine aquatic habitat and wetland habitat. These areas may offer habitat resources for a variety of vertebrate wildlife species. However, due to the steep elevation change between the upland and the river, there is a general lack of wading habitat along most of the shoreline adjacent to the Site (i.e., the river becomes deep very quickly). Therefore, the evaluation of potential risks to wildlife will focus on the wetland area adjacent to the Site.

Since constituents may biomagnify through the food web, representative vertebrate wildlife species from multiple trophic levels will be evaluated. Carnivores and piscivores represent the top of the food chain and are potentially exposed to the higher levels of bioaccumulated analytes. Therefore, potential piscivorous wildlife receptors, great blue heron and raccoon, will be evaluated in food web models for the Waterside Investigation Area.

3.4.2 Estimation of Exposure

Wildlife species may potentially be exposed to COPCs in sediment and surface water through the incidental ingestion and food chain exposure pathways. Exposure assumptions (e.g., body weights, food and water ingestion rates, relative consumption of food items, foraging range, exposure duration, etc.) for the selected wildlife species, great blue heron and raccoon, will be obtained from the USEPA's Wildlife Exposure Factors Handbook (USEPA, 1993) and are provided in **Table 1**. Allometric equations (Nagy, 2001 and Calder and Braun, 1983) will be used to estimate food and water ingestion rates, respectively.

Food item concentrations will be modeled from measured concentrations in surface soil, sediment, and surface water. Calculation of food item concentrations is discussed below.

Wildlife exposure parameters and concentrations of COPC sediment, and surface water, and food items will be used to estimate the potential ingested doses to which wildlife receptors might be exposed at the site. Calculation of these ingested doses is discussed below.

3.4.3 Food Item Tissue Concentrations

Prey items for wildlife species (great blue heron and raccoon) evaluated in the food web exposure models will include freshwater fish, and if appropriate, represented by tissue concentrations from available studies (e.g., Pinkney et al., 2001; MDE, 2012). In the absence of site-specific tissue data, tissue concentrations may be estimated using literature-derived uptake factors. The primary source of uptake factors will be the uptake factors and regression equations recommended by USEPA in development of Eco-SSLs (USEPA, 2007b). In the absence of Eco-SSL-based values, other literature sources will be reviewed for relevant uptake factors.

3.4.4 Calculation of Potential Doses

To estimate potential dietary exposure, a total daily dose (TDD) will be estimated for each species. The TDD calculation considers the following factors: concentrations of the COPC in the food items that the species would consume, estimated amounts of abiotic media (e.g., sediment) that it would incidentally ingest, the relative amount of different food items in its diet, body weight, exposure duration (ED), species-specific area use factors (AUFs), and food ingestion rates. The ED represents the portion of the year that the receptor is exposed to the site (e.g., may be modified by migration). An AUF is defined as the ratio of the area of organisms' home range to the available habitat area within the site.

The following generalized equation will be used to evaluate the TDD from each source (i.e., food or prey item, drinking water, incidental ingestion):

$$\text{TDD} = \frac{(\text{Tissue or Media Concentration} \times \text{Ingestion Rate} \times \text{ED} \times \text{AUF})}{\text{Body Weight}}$$

This generalized equation will be modified for each representative species using the species-specific exposure parameters. The ERA will be conducted using conservative exposure and dose-response assumptions. The risk estimates may be further refined by using, for example: additional location-specific exposure data or location-specific bioavailability factors. Use of such refinements will allow the potential for risks to be put in perspective and will provide information that the risk manager may use to more accurately characterize risks on a location-specific basis and to communicate the nature of the risks.

3.4.5 Estimation of Effects

Toxicity reference values (TRVs) can be defined as the daily dose of a constituent that is considered protective of wildlife (mammals and birds) populations or individuals. The dose is expressed in milligram per kilogram body weight per day ($\text{mg}/\text{kg}_{\text{bw}}/\text{day}$) and can be based on either a NOAEL or a LOAEL.

TRVs incorporated into the quantitative evaluation of potential ecological risks to wildlife will be obtained primarily from two sources: the current USEPA Ecological Soil Screening Level (Eco-SSL) documents (available at www.epa.gov/ecotox/ecossl/) and Oak Ridge National Laboratory's (ORNL) publication *Toxicological Benchmarks for Wildlife: 1996 Revision* (Sample et al., 1996). When TRVs are not available in these documents, the literature will be reviewed for relevant data and TRVs derived using the methodology of ORNL (Sample et al., 1996).

USEPA guidance (USEPA, 1997) specifies that it is preferred that TRVs represent a NOAEL for chronic exposure to site-related constituents. Should a NOAEL not be available, USEPA guidance allows the use of the lowest exposure level shown to produce adverse effects (i.e., the LOAEL) in the development of TRVs. Both upper and lower bound TRVs (LOAEL-based TRVs and NOAEL-based TRVs, respectively) will be developed for this assessment in order to estimate a range of potential risks to mammalian and avian receptors. The NOAEL-based TRVs represent non-hazardous exposure levels for the wildlife species evaluated, while the LOAEL-based TRVs represent potential exposure levels at which adverse effects may become evident.

NOAEL-based TRVs will preferably be based on chronic NOAELs, with an emphasis on studies that measured effects on survival, reproduction, and growth endpoints applicable to the protection of wildlife populations. The following steps will be followed to select LOAEL-based TRVs:

- If a LOAEL is reported for the study used to derive the NOAEL-based TRV, that LOAEL value will be selected as the LOAEL-based TRV;
- In the case where the geometric mean of several NOAELs for growth and reproductive endpoints was used as the NOAEL-based TRV (i.e., EcoSSL-based TRVs), the geometric mean of the LOAELs for growth and reproduction will be calculated and selected as the LOAEL-based TRV;
- For EcoSSL-based TRVs, when the NOAEL-based TRV was based on a single NOAEL and no corresponding LOAEL is available, the upper-bound LOAEL for growth and reproduction will be used; and

- For TRVs derived from other sources, when there was no paired LOAEL, a factor of 4 will be applied to the NOAEL-based TRV to estimate a LOAEL-based TRV.

If no toxicity information is available for a COPC, and it is not possible to identify TRVs, potential risks associated with the estimated exposure for the respective COPC will not be quantitatively evaluated and the absence of toxicity information will be discussed as part of the uncertainty evaluation.

4 Risk Characterization

The results of the environmental risk analysis will be analyzed and interpreted to determine the likelihood of adverse environmental effects, and to determine whether a conclusion of no significant risk can be reached for each assessment endpoint evaluated. The ecological risk characterization will summarize the results of the risk analysis phase of work and will provide interpretation of the ecologically significant findings. Aspects of ecological significance that will be considered to help place the sites into a broader ecological context include the nature and magnitude of effects, the spatial and temporal patterns of effects, results of the background/reference site analyses, and the potential for recovery once a stressor has been removed.

Background data will be collected for many of the endpoints, including sediment and surface water concentrations. These background concentrations of COPCs provide valuable insight into what toxic chemicals may be entering the Anacostia River from other sources and will be considered in the risk analysis. In addition, the background data that will be collected as described in the RI/FS Work Plan, background or reference condition data from other ongoing projects on the Anacostia River may be considered (e.g., Kenilworth Landfill, Poplar Point, and Washington Navy Yard Remedial Investigation Reports will be reviewed and as appropriate, background data from these reports will be considered in the Benning Road RI).

The documentation of the risk characterization will include a summary of assumptions, uncertainties (both generic and site-specific), strengths and weaknesses of the analysis phase of work, and justification of conclusions regarding the ecological significance of the estimated (i.e., risk of harm) or actual (i.e., evidence of harm) risks.

The estimation of ecological risks involves a number of assumptions. A primary component of any risk assessment is an estimate or discussion of the uncertainty associated with these assumptions. The ERA for the Site will include examination of uncertainty related to the site-specific risk evaluations, and an analysis of the uncertainties which potentially affect all sites.

All discussions of uncertainty will include examination and review of several aspects of the ERA including, but not limited to, sampling, data quality, study design, selection of indicator species, estimates of exposure, and selection of ecological benchmarks and screening values. The uncertainty section of the ERA will identify limitations and assumptions and relate them to the potential effects these uncertainties may have on the overall conclusions of the ERA.

The major sources of uncertainty in a risk assessment include the potential for errors in assumptions, analyses, and in making measurements. Another source of uncertainty lies in the variability inherent in the components of the ecosystem being evaluated.

Although it is not practical to account for all sources of uncertainty, it is important to identify and address the major elements of uncertainty in the risk evaluation and assessment. Some uncertainties bias the results of the risk assessment towards excessive risk, while others bias towards no significant risk. Once identified, the uncertainties will be classified by this bias, and the overall effects on the risk assessment will be reflected in the conclusions.

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Table 1. Exposure Parameters for Wildlife Receptors

Receptor Species	Body Weight (kg)	Assumed Diet		Food Ingestion Rate (kg _{dw} /day)	Food Ingestion Rate (kg _{ww} /day)	Fraction Sediment in Diet (%) Amount as kg _{dw} /day	Water Intake Rate (kg/day)	Home Range (ha)	Exposure Duration (unitless)
		Units	Fish						
Piscivores									
Great Blue Heron (<i>Ardea herodias</i>)	2.336 (a)	% kg _{ww} /day	95% 0.5521 (b)	0.1453 (c)	0.5521 (d)	5% 0.0073 (e)	0.1042 (f)	4.5 (g)	0.67 (h)
Omnivores									
Raccoon (<i>Procyon lotor</i>)	5.7 (a)	% kg _{ww} /day	91% 0.5510 (b)	0.1520 (c)	0.5510 (d)	9.4% 0.0143 (e)	0.4742 (f)	156 (g)	1 (h)

General Notes:

Food ingestion rates are wet weight for food items and dry weight for sediment/soil ingestion. As needed, rate may be converted.

Ingested diet and ingested abiotic media (i.e., soil or sediment) total 100% of dietary ingestion.

See individual organism notes for source, units, and conversion.

Moisture content of food items assumed to be as follows: 75% for Fish (USEPA, 1993).

BW - Body Weight.

FIR - Food Ingestion Rate.

WIR - Water Ingestion Rate (1 L of water has weight of 1 kg).

COPC - Constituent of Potential Concern.

ha - hectare.

ww - Wet Weight.

dw - Dry Weight.

USEPA - United States Environmental Protection Agency.

Footnotes for individual species parameters and assumptions presented on next pages.

Notes for Great Blue Heron (*Ardea herodias*):

(a) Average body weight of adult male and female herons (USEPA, 1993).

(b) Diet assumed to be exclusively fish.

(c) Food ingestion rate calculated using algorithm for carnivorous birds developed by Nagy, 2001 [FIR (g_{dw}/day) = 0.849*BW^{0.663}].

(d) Dry weight food ingestion rate converted to wet weight food ingestion rate:

$$FIR_{ww} = \text{Sum} \{[(\text{Proportion of food}_i \text{ in diet}) \times (FIR_{dw})] / (1 - \text{moisture content}_i)\}$$

(e) Assumption for wading bird based on best professional judgement.

(f) Water ingestion rate calculated using algorithm for all birds developed by Calder and Braun, 1983 [WIR (kg/day) = 0.059*BW^{0.67}].

(g) Average feeding territory size based on studies conducted in freshwater marsh and estuary in Oregon (USEPA, 1993).

(h) Great blue heron assumed to be migratory and present for 8 months of the year (March to October; USEPA, 1993).

Table 1. Exposure Parameters for Wildlife Receptors

Notes for Raccoon (*Procyon lotor*):

- (a) Average body weight of adult male and female raccoons in Illinois, Missouri, and Alabama studies (USEPA, 1993).
- (b) Diet assumed to be exclusively fish.
- (c) Food ingestion rate calculated using algorithm for omnivorous mammals developed by Nagy, 2001 [FIR (g_{dw}/day) = 0.432*BW^{0.678}].
- (d) Dry weight food ingestion rate converted to wet weight food ingestion rate:
$$\text{FIR}_{\text{ww}} = \text{Sum} \{[(\text{Proportion of food, in diet}) \times (\text{FIR}_{\text{dw}})] / (1 - \text{moisture content}_i)\}$$
- (e) Value for raccoon soil consumption (Table 4-4; USEPA, 1993).
- (f) Water ingestion rate calculated using algorithm for all mammals developed by Calder and Braun, 1983 [WIR (kg/day) = 0.099*BW^{0.90}].
- (g) Mean of home ranges from Michigan study (USEPA, 1993).
- (h) Raccoon assumed to be present and actively foraging year-round.



Appendix F

RI Report Outline

Appendix F

Remedial Investigation Report Outline

Executive Summary

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- 7.1. Summary
- 7.2. Conclusions

Appendices