Environment

Prepared for:
Washington Gas Company
Springfield, VA

Prepared by:
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Beltsville, MD
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October 2015

Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan Washington Gas East Station Site

Final

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List of Acronyms

ANS	Academy of Natural Science
ARAR	Applicable or Relevant and Appropriate Requirement
AWTA	Anacostia Watershed Toxics Alliance
BAZ	Biologically Active Zone
BERA	Baseline Ecological Risk Assessment
BTV	Background Threshold Value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIP	Community Involvement Plan
CLP	Contract Laboratory Program
cm	Centimeter
COPC	Constituent of Potential Concern
COPEC	Constituent of Potential Ecological Concern
CSM	Conceptual Site Model
CSO	Combined Sewer Overflow
DARRP	Damage Assessment, Remediation, and Restoration Program
District	District of Columbia
DDOE	District Department of the Environment
DNAPL	Dense Non-Aqueous Phase Liquid
DQI	Data Quality Indicator
DQO	Data Quality Objective
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ESV	NPS Ecological Screening Values
FID	Flame Ionization Detector

ft.	Feet
FS	Feasibility Study
FSP	Field Sampling Plan
GAC	Granular Activated Carbon
GIS	Geographic Information System
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
HPT	Hydraulic Profiling Tool
HQ	Hazard Quotient
ICIAP	Institutional Controls Implementation and Assurance Plan
IDW	Investigation Derived Waste
LNAPL	Light Non-Aqueous Phase Liquid
MCL	Maximum Contaminant Level
MG	Manufactured Gas
mi	Mile
MLLW	Mean Lower Low Water
MWCOG	Metropolitan Washington Council of Governments
NAPL	Non-Aqueous Phase Liquid
NELAP	National Environmental Laboratory Accreditation Program
NCP	National Contingency Plan
NOAA	National Oceanographic and Atmospheric Administration
NPS	National Park Service
OU1	Operable Unit 1
OU2	Operable Unit 2
PAH	Polynuclear Aromatic Hydrocarbon

PCB	Polychlorinated Biphenyl
PID	Photoionization Detector
POP	Project Operations Plan
PRG	Preliminary Remediation Goal
ppm	Part per million
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RG	Remedial Goal
RI	Remedial Investigation
River	Anacostia River
ROD	Record of Decision
RSL	USEPA Region 9 Regional Screening Level
RSP	Residual Saturation Point
SAP	Sampling and Analysis Plan
Sec	Second
SEDA	Sediment Erosion and Deposition Assessment
SEM/AVS	Simultaneously Extracted Metals/Acid-Volatile Sulfide
Site	Washington Gas East Station Site
SLERA	Screening-Level Ecological Risk Assessment
SMP	Site Management Plan
SOW	Statement of Work
SPME	Solid-Phase Microextraction
SSO	Storm Sewer Outfall

SVOC	Semi Volatile Organic Compound
TCL	Target Compound List
TCZ	Target Capture Zone
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbon
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U. S. Geological Survey
VOC	Volatile Organic Compound
WG	Washington Gas Light Company

1.0 Introduction

This Work Plan presents a program to perform a Remedial Investigation (RI) and Feasibility Study (FS) for Operable Unit 2 (OU2) for the Washington Gas East Station Site located in southeast District of Columbia (District). This work is being performed under a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Consent Decree between Washington Gas Light Company (WG), the United States, and the District entered by the U.S. District Court for the District of Columbia on September 26, 2012. The Consent Decree also addresses Operable Unit 1 (OU1) which is defined as surface soils and subsurface soils on the District property and U.S. Army Corps of Engineers (USACE) property located between the WG East Station Property and the Anacostia River (River). Consent Decree activities for OU1 are not included in this OU2 RI/FS Work Plan. Pursuant to the Consent Decree, WG will conduct the OU2 RI/FS work subject to the oversight and approval of the U.S. Department of the Interior National Park Service (NPS), in consultation with the District.

This Work Plan only pertains to actions that WG is required to take related to an RI/FS for OU2 of the Site. OU2 is defined in Section IV of the CD as: "groundwater, surface water, and sediments of the Anacostia River where hazardous substances released at or from the Washington Gas East Station Property have come to be located."

The RI/FS will be performed in accordance with the CD requirements, which incorporate NPS's 2006 Record of Decision (ROD) (NPS, 2006), as Appendix A and the Statement of Work (SOW), dated December 2011 (Revised August 2012), as Appendix B. The SOW defines specific response activities and obligations that will guide the preparation of this Work Plan and the execution of the work as described herein. Pursuant to the CD, WG will conduct the OU2 RI/FS work pursuant to, and in compliance with, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and its implementing regulations, and subject to the oversight and approval of the National Park Service (NPS), in consultation with the District.

The work described in this Work Plan is consistent with the requirements of various U. S. Environmental Protection Agency (USEPA) guidance documents including but not limited to: *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988) and *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005a). A more complete listing of the applicable USEPA guidance documents is included in Section 7, which provides the references cited in this Work Plan.

1.1 Site Background

The general Site location is shown on Figure 1, and includes the 11.4-acre WG East Station Property, which includes the former Manufactured Gas (MG) plant, an adjacent 4.2-acre public property located between the WG East Station Property and the River (referred to in this document as the government property), and the River adjacent to the government property. In 2008, certain portions of the government property were transferred from the United States to the District pursuant to federal legislation; however, USACE plans to continue operating the River debris removal facility on the government property in the future (Figure 1-1). In this document, the 0.35 acre USACE-managed United States property is referred to as the USACE property.

The WG East Station Property is the location of a former MG facility that operated from 1888 to 1948. From 1946 to 1948, WG converted its distribution system entirely to natural gas, eliminating its need for manufactured gas. From 1948 until January 1983, the plant was operated only for peaking purposes or once a year on a trial-run basis to check equipment. The plant was closed in 1983 and largely demolished between 1983 and 1986. The MG-related aboveground oil storage tanks on the portion of the Site north of Water Street SE were removed in 1997. The area north of Water Street Southeast is currently occupied by two large office buildings with their associated parking lots, a two-story building used for WG office space and the treatment system for the groundwater pump and treat system, and a closed facility previously used for fueling vehicles with compressed natural gas.

The government property, which is the main focus of this RI/FS, is located south of Water Street SE, between the WG East Station Property and the River. The government property is filled land that was reclaimed from the River and adjacent wetlands and marshes. Historical maps show that filling of this area began in 1797. Filling of the area was completed shortly after a seawall was constructed along the shore of the River. The seawall was installed to allow filling of the wetlands along the River in 1914. Historical reports show that byproducts of the MG operations were occasionally placed as fill on the Site, including residual products from the cleaning of coke filter beds, tar that was mixed with solid waste, and wood chips contaminated with absorbed tar and complex cyanides. The thickness of the fill has been observed between 1 foot (ft.) and 13 ft. below existing grade, with an average of approximately 8 ft. of fill above the underlying natural silt layer. Leakage of oil from underground pipelines on the WG property and the adjoining property to the east are also potential sources of petroleum contamination on the Site. The fill also reportedly includes dredge spoils placed in this area from a dredge and fill operation under direction of the USACE, and demolition debris, rocks, and sand from other sources.

The River in the vicinity of the Site is described in Section 3.3.1. The RI investigation will be divided into two parts: 1) landside, which will include all RI activities performed on the terrestrial government property; and 2) in-river, which will include all RI activities performed in the River.

1.2 RI/FS Objectives

As stated in the SOW, “the purpose of the OU2 RI/FS is to determine the nature and extent of Site contamination in the groundwater that discharges to the Anacostia River and the nature and extent of Site contamination in surface water and sediments in the Anacostia River.” The OU2 RI/FS will have the following objectives:

- Collect data of sufficient quality and quantity to enable the assessment of risk to human and ecological receptors from Site contamination;
- Identify and assess applicable or relevant and appropriate requirements (ARARs) for the Site;
- Identify and evaluate a reasonable array of remedial alternatives, including the No Action alternative, to address unacceptable risks and ARARs;
- Identify and evaluate remedial alternatives with respect to the nine criteria in the NCP [National Contingency Plan]; and
- Identify a preferred remedial action for OU2.

The SOW also stated: “The OU2 RI/FS will incorporate, as appropriate, and add to relevant data from the 1999 East Station RI/FS and data subsequently collected at the Site. More specifically, for the purpose of determining Site contamination impacts to the River surface water and sediments,

additional data are required to determine the nature and extent of Site contamination vertically and horizontally in the vicinity along the seawall northeast of existing monitoring well MW-5, to the southwest of the 12th Street sewer outfall, the area between these two locations, and north of MW-18 approximately between MW-18 and MW-10."

To achieve these objectives, according to the SOW, the OU2 RI/FS shall include the following:

- Installing and monitoring additional groundwater monitoring wells and monitoring select existing wells to the extent needed to address data gaps in areas not sufficiently addressed previously to determine whether Site contamination in groundwater or present as non-aqueous phase liquid (NAPL) are discharging to the River in the vicinity of the seawall at concentrations that exceed appropriate screening levels. Consistent with CERCLA and the NCP, WG will perform human health and ecological risk assessments, as well as ARARs analysis, to enable NPS to establish Preliminary Remediation Goals (PRGs) to be further evaluated in the FS;
- Delineating the extent of NAPL, and its resulting dissolved contamination, and dissolved contamination in groundwater vertically and horizontally in the vicinity of the seawall and potentially upgradient of the seawall to the extent needed for the FS. More specifically, for the purpose of determining the impacts of Site contamination to the River surface water and sediments, additional data are required to determine the nature and extent of Site contamination in groundwater vertically and horizontally in the vicinity along the seawall northeast of existing monitoring well MW-5, to the southwest of the 12th Street sewer outfall, the area between these two locations, and north of MW-18 approximately between MW-18 and MW-10 (Note: Figure 1-1 of this Work Plan shows these areas). NAPL delineation may require continuous coring and in-situ analysis for the presence of NAPL;
- Determining Site contamination NAPL source areas that may result in Site contamination migration to the River at concentrations above Remediation Goals (to be determined by NPS through the RI/FS process), including source areas above the water table and below the OU1 remedial soil removal depths on the government property;
- Determining the presence of potential preferential pathways for Site contamination NAPL and dissolved contaminant transport into the River (e.g., by implementing additional borings with particular emphasis on the sand and gravel unit's interface with the Arundel Clay; the existence of preferential silt or sand pathways in the Arundel Clay and overlying silt will be evaluated; mass flux and mass discharge calculations will be reevaluated following the additional delineation steps, which will quantify the relative contaminant mass discharge from defined hydrogeologic units contributing mass to the River);
- Evaluating existing available and summarizing relevant sediment data related to the Site in one report to be used to identify data gaps;
- Performing a bathymetric survey and selecting representative background sampling locations;
- Delineating the area and depth of Site contamination in sediments;
- Fingerprinting/forensic analysis of polynuclear aromatic hydrocarbons (PAHs) present in groundwater and in sediment samples, and other methods that may be used to aid in distinguishing between Site contamination and contamination from other potential sources;
- Performing a benthic organism study suitable for performance of an ecological risk assessment;

- Collecting sediment samples to sufficient depths to evaluate the connection, or lack thereof, between Site contamination signature PAHs and River PAHs from upgradient, non-site-related sources, if evidence from the terrestrial Site investigation indicates contaminant migration from the vicinity of the seawall to the River;
- Performing pore water and/or soil analyses of riverbed core samples to evaluate the potential for Site contamination migration (including contaminated groundwater and NAPL) into the River for purposes of the RI/FS, if warranted by other supporting data;
- Completing sediment stability analysis in the vicinity of the Site;
- Submitting preparatory documents as described in Section 4 in the Consent Decree SOW; and
- Developing and evaluating remedial alternatives following the requirements of 40 CFR Section 300.430 of the NCP.

1.3 Work Plan Organization

This Work Plan is divided into the following seven sections:

- **Section 1** provides an introduction to the OU2 RI/FS Work Plan. It provides an overview of the Site background, the objectives of the RI/FS, and the regulatory agencies involved in the RI/FS process.
- **Section 2** provides a description of the physical characteristics of the Site, the history of WG operations at the Site, and a summary of previous investigations.
- **Section 3** provides a detailed evaluation of existing environmental data that have been used to develop a conceptual site model (CSM) for the Site based on the existing data reviewed in the preparation of this Work Plan. The CSM considers the following media that will be studied in this RI/FS: groundwater and NAPL that have the potential to migrate into the River; sediments within the River; and River surface water. The CSM will be updated as information is collected during the RI/FS and will form the basis for risk assessments and the establishment of PRGs for the Site.
- **Section 4** describes the data quality objectives (DQOs) for the RI/FS based on the CSMs described in Section 3 along with data gaps to be addressed by the RI/FS. This section also describes the work that will be performed to address these data gaps.
- **Section 5** provides a description of the tasks that will be implemented during the RI/FS.
- **Section 6** includes the schedule for implementation of the OU2 RI/FS.
- **Section 7** includes the references cited in the OU2 RI/FS Work Plan and relevant guidance documents identified at the time of the preparation of this Work Plan.

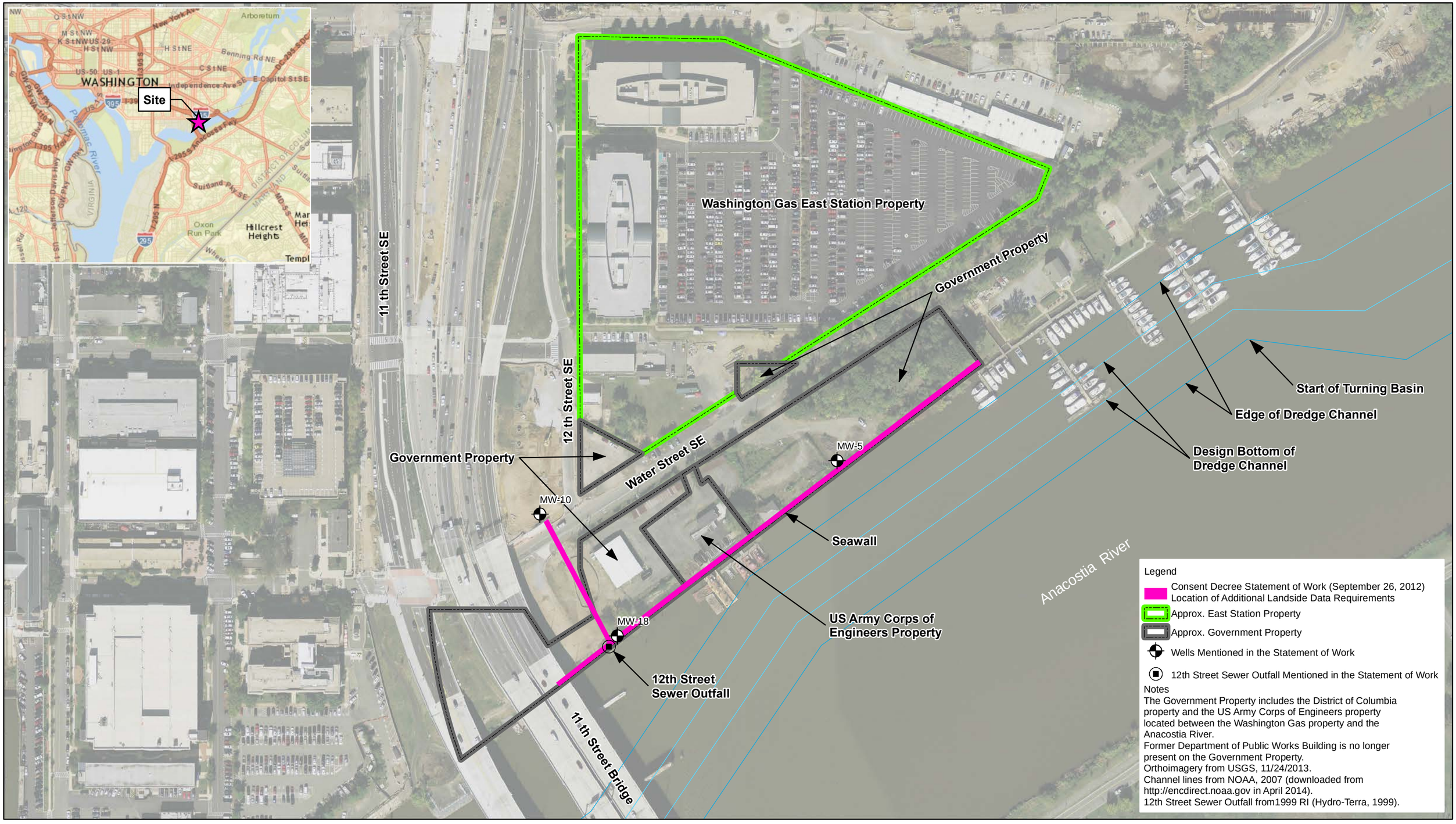

Figure 1-1 Property Locations
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

0 90 180 Feet

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2.0 Physical Setting and Previous Investigations

This section presents background information related to the current understanding of the physical setting of the Site, the Site history, and existing information on previous Site investigations and remedial actions. This section focuses on the media of concern for the OU2 RI/FS: surface water and sediment in the River and groundwater/NAPL that has a potential to migrate to the River and impact surface water or sediment. Soils are included in OU1 and are not included in this RI/FS Work Plan.

2.1 Physical Characteristics of the Site

This section includes a description of the physical characteristics of the Site and surrounding area. These descriptions are based on both published regional information and site-specific information.

2.1.1 Physical Setting

The Site is located adjacent to the River in southeast Washington, D.C. An aerial photograph showing the general location of the Site and the surrounding area is shown in Figure 2-1 and a U. S. Geological Survey (USGS) topographic map of the area is shown in Figure 2-2. Figure 1-1 presents a current Site plan showing the property limits of the WG East Station Property, and property limits of the District and USACE-managed properties (jointly referred to as the government property) which are located between the WG East Station Property and the River. A seawall forms the bank of the River in the area of the Site, with the exception of approximately 70 feet (ft.) of shoreline adjacent to the Site in the area of the former 11th Street bridge abutment and a 3 ft. section at the USACE-managed property.

The Site is located in an urban area. Current development on the WG East Station Property consists of multistory office buildings and parking lots, with additional similar future development planned. WG understands that the strip of land currently owned by the District between WG East Station Property and the River will have a future recreational use and will be included in the District's Anacostia Waterfront Initiative. The USACE property is mostly paved with an office and dock space for access to the River. As part of the OU1 work plan prepared under the Consent Decree, WG will develop an Institutional Controls Implementation and Assurance Plan (ICIAP) that identifies and provides procedures for implementing, maintaining, monitoring, and reporting on the institutional controls for the government property.

The seawall was installed by the USACE beginning about 1914 (Hydro-Terra, 1999). The seawall is reportedly constructed of squared stones placed on a concrete sill, which was placed on timber piles driven into the River sediments (Hydro-Terra, 1989). This type of construction, called "pile grillage" generally consisted of "piles, spaced three feet apart, ten feet outside the bulkhead line" (NPS, 1985).

2.2 Previous Investigations

This section identifies the previous investigations performed at the Site and in the River.

2.2.1 Site Investigations

Following closure of the WG plant in 1983, a number of environmental studies were conducted, culminating in a RI/FS completed in 1999 (Hydro-Terra, 1999). The investigations included soil and

groundwater sampling on the WG East Station Property and adjacent government property, and sampling of adjacent River sediments and surface water. Table 2-1 provides a list of the investigations conducted at the Site associated with the former MG Plant. This table also provides a brief summary of the scope of each investigation. Hydrogeologic information and analytical data obtained from these investigations have been incorporated into the CSM presented in Section 3.

Following the 1999 RI/FS, WG prepared the East Station Decision Document specifying a remedy which was accepted by USEPA. This decision document did not differentiate between the WG East Station Property and the adjacent government property, but it acknowledged that the NPS would be issuing a separate ROD for the property that was owned at the time by the United States (i.e., the government property). The OU2 RI/FS is being conducted under what was referred to in the decision document as the NPS ROD (note that the work is being performed under a subsequent Consent Decree). The decision document presented the following selected remedy:

- Eliminate human exposure to surface soil by covering exposed soil, during development, with either one foot of clean soil stabilized with vegetation or impervious structures;
- Manage the risk to site development workers, current and future utility-maintenance workers, and future onsite office workers by applying institutional controls that minimize exposure;
- Protect River biota from excessive influx of chemicals by continuing to pump and treat groundwater that otherwise would enter the River and by continuing to extract DNAPL from wells in areas where it accumulates above residual concentrations and in areas where it may enter the River; and
- Undertake or participate in additional environmental studies that might influence future remedial action at the Site and in the River.

Coal tar recovery efforts at the Site were initiated in 1976 and are ongoing. Recovery efforts consist of the following activities: 1) operation of a pump and treat system, which includes a subsurface interceptor trench connected to a recovery well, recovery wells, and a groundwater treatment system; and 2) manual recovery of non-aqueous phase liquids (NAPL) from monitoring and recovery wells where they accumulate (see Section 2.3).

2.2.2 Anacostia River Investigations

Formal environmental investigations have been conducted to evaluate the surface water and the sediments in the River adjacent to the WG East Station Property. Table 2-2 provides a list of the sediment investigations conducted in close proximity to the WG East Station Property, a summary of the scope of each investigation and the relevance of the information collected during each investigation to the OU-2 RI/FS. These investigations are summarized in the report *A Summary of Findings, Sediment Studies in the Anacostia River Vicinity of the East Station Study Area*, 2005; prepared by Hydro-Terra, Inc. in 2006. This report is included in this Work Plan in Appendix A.

In addition to these studies conducted proximal to the Site, a number of studies have been completed within the larger River system. The Anacostia River watershed has received significant attention over the recent past and numerous localized and watershed-wide water quality and sediment quality studies have been undertaken. These studies, along with the NOAA Damage Assessment, Remediation, and Restoration Program (DARRP) Anacostia River database, were reviewed to assist in understanding the prevailing historical background sediment and water quality conditions and to provide context for development of the CSM. Available technical papers, reports, and databases that

were reviewed are listed in Table 2-2. These River system study reports are also included in Appendix A.

Based upon these extensive studies, it has been demonstrated that polychlorinated biphenyls (PCBs), PAHs, metals, and to a lesser degree volatile organic compounds (VOCs) are found in sediment samples collected throughout the River, upstream and downstream of the Site. The sources of these contaminants of potential concern (COPCs) have been attributed to industrial discharges, urban runoff and stormwater, and combined sewer outfalls (CSOs). The Site has been identified in some of these studies (e.g., NOAA, 2009; AWTA, 2002) as a potential contributing source to some of the contaminants, including PAHs, observed in River sediments. These studies did not identify the Site as a potential contributing source of PCBs.

Figure 2-3 is a summary of the studies that are included in the NOAA DARRP database. This database is updated periodically and the current database includes data for studies conducted between 1980 through 2011. The figure shows the locations of sediment samples by study. This figure also depicts the location of the WG East Station Site, the locations of the other large landside investigations being conducted along the River (Kenilworth Park Landfill, Pepco Benning Road, Poplar Point, Washington Navy Yard, and SE Federal Center) and the approximate locations of CSOs and storm sewer outfalls (SSOs).

Figure 2-4 presents the total PAH concentrations in surficial sediment for the samples included in the NOAA DARRP database. While PAHs are not the only COPCs at the WG East Station Site, they are common contaminants of concern at typical MG sites and NOAA and AWTA have suggested that the East Station Site may be a source of PAHs in the River sediments. As depicted in this figure, a majority of the surficial sediment total PAH concentrations over most of the River is in the 2.0 to 35.4 parts per millions (ppm) range. There is a very low percentage of samples with concentrations above (included some samples adjacent to the WG East Station Site) or below this range.

In addition to the limited sampling of River sediments previously conducted by WG, the Anacostia River watershed has received increased attention, and as a result, numerous local and watershed-wide water quality and sediment quality studies have been undertaken. NOAA compiled a database of these studies including sediment quality data from 37 studies conducted within the Anacostia River watershed. WG has participated in these watershed-wide initiatives through membership in the USEPA-sponsored Anacostia Watershed Toxics Alliance (AWTA).

In addition to these studies, in February 2014 the District Department of Energy and Environment (DOEE; formerly named the District Department of the Environment) issued for public comment a draft Anacostia River Sediment Project Remedial Investigation Work Plan and a draft Community Involvement Plan (CIP) for the Anacostia River Study Area. The purpose of this study is to determine the nature and extent of contaminated environmental media in the River, reduce overall costs for a natural resource damage assessment (NRDA) and RI field characterization by coordinating the NRDA and RI characterization sampling efforts to the extent practicable at this stage of the investigation, and assess potential risks to human health and the environment. The public comment period for these documents closed on March 7, 2014. At the time this work plan was prepared this study was in progress.

2.3 Groundwater Remedies

Since 1976 groundwater remedies have been implemented at the Site to capture groundwater and to recover mobile NAPL. The following remedial activities have been implemented at the Site. The locations of these remedies are shown on Figures 2-5 (fill unit) and 2-6 (sand and gravel unit).

- In 1976, a trench well was installed in the fill unit to capture groundwater flowing towards the River.
- In 1993, the groundwater pump and treat system was expanded by installing two shallow recovery wells (RW-1 and RW-2) in the fill unit and one recovery well (RW-3) in the sand and gravel unit. The current groundwater treatment facility was added at the same time.
- In 1996, direct extraction of accumulated NAPL from monitoring wells began. Collected NAPL is transferred to a bulk holding tank in the treatment facility prior to disposal off site. A summary of the NAPL volume collected under this program is included in Table 2-3. The total volume of NAPL collected from the monitoring wells between 1996 and December 2014 is 7,175 gallons.
- In 2003, two additional extraction wells in the fill unit (RW-4S and RW-7S) were connected to the groundwater pump and treat system to expand the capture zone.
- In 2010, the pump and treat system was upgraded to improve treatment efficiency. During the five-year period from 2006 to 2010, an average of approximately 19,450 gallons of groundwater was extracted from six wells (RW-1, RW-2, RW-3, RW-4S, RW-7S and trench well) daily and treated (AECOM, 2011). During this time, a total of 2,115 gallons of NAPL, or an average of 423 gallons per year, was recovered by the treatment system. Following the 2010 upgrade and a change in maintenance procedures to clean out the sedimentation tank more frequently, the average annual NAPL recovery rate increased from approximately 423 gallons per year (2006-2010) to 2,353 gallons per year (2011-2014).
- A total of 20,863 gallons of NAPL, including 13,688 gallons which were recovered from the treatment system and 7,175.49 gallons recovered by manually pumping the monitoring and recovery wells in the field have been recovered from the Site. This total does not include NAPL removed from the treatment system prior to 2001 when WG started to record NAPL removed from the treatment system.

The current arrangement of the groundwater treatment system consists of the following:

- Sedimentation tank to remove both light non-aqueous phase liquids (LNAPL) and DNAPL;
- Oil/water separator to further remove LNAPL and DNAPL;
- Sedimentation tank where coagulant is added to remove fine sediment/turbidity;
- Two parallel bag filters to remove remaining solid material;
- Organo-clay and granular activated carbon adsorption (GAC) unit to remove oil and grease;
- GAC unit to remove VOCs and Semi Volatile Organic Compound (SVOCs); and
- Totalizing flow meter to track discharge volumes.

In April 2011, WG prepared a document entitled “Five Year Review of Remedial Action” (AECOM, 2011) and submitted it to the District and USEPA Region III. The purpose of the review was to evaluate the implementation and performance of the environmental remedies required by the East

Station Decision Document in order to determine if the set of remedies is protective of human health and the environment. The five-year review document provides a comprehensive review of the implementation and current performance of the required environmental remedies implemented at the Site. The results of this review, as relevant, were considered during the preparation of the OU2 RI/FS Work Plan, but did not supersede the requirements of the Consent Decree and SOW.

Table 2-1
Previous Landside Environmental Investigations
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Investigation Summary Document	Summary of Investigation Scope
Hydro-Terra, Inc. 1983. Preliminary Investigation of Possible Subsurface Contamination, East Station, Washington Gas Light Company. 1983.	Investigation of the presence, nature, and extent of ground water contamination with the objective of determining the presence of constituents of concern, characterizing the hydrogeologic system, assessing the potential off-site migration of constituents of concern, identifying possible sources of contamination, and defining additional work to further the investigation. This investigation included evaluation of the significance of lenticular seams of sand in the Arundel Clay.
Hydro-Terra, Inc. 1989. Contamination & Land Use Study, Phase II, East Station Property. June, 1989.	Investigation to evaluate the area and extend of groundwater contamination including installation of 15 groundwater monitoring wells.
GeoTrans, Inc. 1991. East Station – Phase III Study Groundwater Recovery System. August, 1991.	Investigation to design a groundwater recovery system including seven well installations.
Ecology and Environment, Inc. 1995. Site Inspection, National Capital Parks - East Station Site, S.E. Washington, DC	Investigation to expand upon the results of the preliminary assessment, further assess the potential threat to human health and the environment, and further evaluate likely sources of contamination. The investigation included the collection of eight surface soil, seven subsurface soil, six sediment, and one groundwater sample.
Hydro-Terra, Inc. 1996.Tar Contamination Mapping and Recovery-Well Siting at East Station. September 20, 1996.	Investigation with the objectives of identifying locations of areas of highest tar concentration within the fill layer and the evaluation of the hydrogeologic features influencing the migration of tar and included the installation of 11 piezometers.
Hydro-Terra, Inc. 1999. Additional Remedial Investigation and Feasibility Study (Phase IV). March 25, 1999.	Investigation to fill data gaps from Phase I,II, & III, including an ecological risk assessment, a new human health risk assessment, detailed description of the hydrogeologic setting, documentation of land use, and additional information on chemical sources and pathways. Expanded scope included evaluation of source and extent of oil discovered during the investigation and an evaluation of effectiveness of pump and treat system. Feasibility study was completed and remedies were recommended for five operating units including groundwater, DNAPL, surface soil, subsurface soil, and sediment.

Table 2-1
Previous Landside Environmental Investigations
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Investigation Summary Document	Summary of Investigation Scope
Hydro-Terra, Inc. 2001. Report of Well Installation and Plan for Extracting Ground Water on National Park Service-East Property. March 13, 2001.	Investigation to define and implement additional remedial measures, which included identifying measures required to expand capture of groundwater in fill migrating towards the River, installing extraction/monitoring wells, and evaluating if native silt is a pathway to the river.
Hydro-Terra, Inc. 2002. Assessment to Health Risk to Utility and Landscape Workers on National Park Service Property South of East Station in Washington, D.C. March 25, 2002.	Supplemented the risk assessment performed as part of RI/FS to include utility maintenance worker exposure specific to the NPS property and an evaluation of health effects to landscape workers. Additional soil sampling was performed on the NPS property and risk levels were recalculated using the additional soil data.
Hydro-Terra, Inc. 2003. Additional Measures Taken to Capture Remaining Shallow Ground Water Flowing to the Anacostia River from the East Station Study Area. January 9, 2003.	Summarizes the implementation of the plan (above) to capture the remaining shallow ground water flowing to the Anacostia River.
Hydro-Terra, Inc. 2003. Three-Year Review and Evaluation of Ground-water Pumping and Treatment and Other Remedial Actions on the East Station Site. July, 2003.	The review found the groundwater remedy to be effective in protecting human health and the environment and did not contain any recommendations.
Hydro-Terra, Inc. 2005. Five-Year Review of Remedial Actions at East Station Site in Washington, DC. 2005.	Five-year remedy effectiveness review was conducted.
Washington Gas Company. 2007. Second Three-Year Review and Evaluation of Ground Water Pumping and Treatment at the East Station Site. March, 2007.	Evaluates the pump and treat system from July 2003 to December 2006 including field work to evaluate the effectiveness of the ground water pumping program, whether ground water can move vertically through the silt unit near the sea wall to the clay beneath, confirm the existence of the clay unit in the area of the seawall, assess whether the clay is a conduit for contaminants to move towards the river, and confirm the depression in the silt unit.
AECOM, 2011. Second Five-Year Review of Remedial Action. April, 2011.	Evaluates the implementation and performance of the groundwater pumping program, capture zone, groundwater quality monitoring, groundwater infiltration monitoring, and sediment sampling. Remedy was found to be in compliance with the Decision Document and protective of human health and the environment.

Table 2-2
Previous Anacostia River Investigations Near the Washington Gas East Station Site
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Investigation Summary Document	Summary of Investigation Scope	Relevance of Report to Site	Will Data from Report Be Used to Assess Background Concentrations?
Near the Washington Gas East Station Site			
Hydro-Terra, Inc. 1989. Contamination & Land Use Study. Phase II. Volumes I and II	Twelve sediment locations, including one upstream and two downstream, from a depth of 1.5 ft of were sampled in 1988 and analyzed for Priority Pollutant base/neutrals and acids. Three samples were analyzed for BTEX. River water samples were collected at the sediment locations. A benthic macroinvertebrate study was also conducted. PAHs were detected at all sediment sample locations. No PAHs or volatile organic compounds (VOCs) were detected in the water samples. The benthic study indicated the presence of poorly oxygenated water and high organic loading.	Investigation was conducted at WG East Station and is directly relevant to the Site.	No. Samples were collected from immediate vicinity of the government property and are not representative of background conditions.
D.K. Velinsky, et al. 1992. Sediment Contamination Studies of the Potomac and Anacostia Rivers around the District of Columbia. Final Report	Surface sediment samples were taken at six locations and analyzed for various organic compounds and trace metals. Samples were collected upstream and downstream of the Site. None of the samples were collected in front of the Site. PAHs detected at all locations. Metals concentrations were highest downstream of Site.	Investigation includes six samples collected from Anacostia River including locations near, but not part of, the government property. Downstream samples provide general information about concentrations of PAHs and trace metals in the River.	One sample collected a short distance downstream of the John Phillip Sousa Bridge will be evaluated for consideration in the background dataset.

Table 2-2
Previous Anacostia River Investigations Near the Washington Gas East Station Site
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Investigation Summary Document	Summary of Investigation Scope	Relevance of Report to Site	Will Data from Report Be Used to Assess Background Concentrations?
Versar, Inc. 1993. An Assessment of Potential Residual Effects of the January 1992 Oil Spill in the Anacostia River	To study the effects of a spill of No. 4 fuel oil a short distance upstream of the Site, 15 shallow sediment samples were collected and analyzed for total petroleum hydrocarbons (TPH), PAHs, pesticides, polychlorinated biphenyls (PCBs), three metals (cadmium, lead, and mercury), and other parameters. Nine of the samples were collected from the spill area and two each from three reference areas. PAHs were detected in the samples, however, statistically, no significant difference was found in the PAH concentrations and metals concentrations between the spill area and the Site.	The spill investigated was located immediately upstream of the government property. Data collected to support investigation include analysis of PAH fingerprint in sediment samples near the government property. These data may be integrated into the forensics evaluation.	One study reference area located upstream of the government property may be evaluated for consideration in the background dataset.
Ecology and Environment, Inc. 1995. Site Inspection, National Capital Parks - East Station Site, S.E. Washington, DC	Five sediment locations in the vicinity of the Site (and of Hydro-Terra's locations sampled in 1988) were sampled and analyzed for total organic carbon (TOC), VOCs, semivolatile organic compounds (SVOCs) (acids & base/neutrals), pesticides, and metals. Three locations were adjacent to the Site and two were upstream. The study indicated that a comparison of the 1988 and 1995 PAH data sets suggested a possible improvement in sediment quality between 1988 and 1995.	Investigation was conducted at WG East Station and is directly relevant to the Site.	Majority of samples were collected from immediate vicinity of the government property and are not representative of background conditions. Two samples were analyzed for use as background stations, and one located more than 0.25 miles upstream. This sample will be evaluated for use in the background dataset.

Table 2-2
Previous Anacostia River Investigations Near the Washington Gas East Station Site
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Investigation Summary Document	Summary of Investigation Scope	Relevance of Report to Site	Will Data from Report Be Used to Assess Background Concentrations?
Hydro-Terra, Inc. 1999. Additional Remedial Investigation and Feasibility Study (Phase IV), East Station. Washington, D.C, Volumes 1 and 2	Shallow sediment samples from seven locations were collected at a sampling depth was 18 inches. The sediment samples were analyzed for TAL metals, TCL VOCs and SVOCs, and cyanide. Relatively low concentrations of volatile organic compounds (BTEX) were detected in three of the four sediment samples obtained opposite the Site. The average concentration of PAHs observed in sediment samples opposite the Site is lower than the average obtained during the 1988 investigation, but higher than the average concentration of the samples collected by Ecology and Environment in 1995.	Primarily the landside RI, data were collected from the River to support the WG East Station RI.	Yes. A subset of samples was analyzed for use as background stations. These samples will be evaluated for use in the background dataset.
Louisiana State University 2002. Sediment Capping Research Study	Extensive sediment sampling was performed in an area of the river approximately 300 by 400 feet in size downstream of the Site. In addition, an upstream sediment sample near the USACE dock was collected and analyzed for TAL metals and TCL VOCs and SVOCs. The metal concentrations were similar to results obtained during the 1998 Hydro-Terra investigation. PAHs in the upstream sample were lower than during the 1998 investigation. No BTEX was detected.	The capping study included an area near the government property where PAHs were a concern. The data are directly relevant to the RI.	One location is referenced as upstream, but the exact location is not known. This station will be reviewed to determine applicability for inclusion in the background dataset.

Table 2-2
Previous Anacostia River Investigations Near the Washington Gas East Station Site
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Investigation Summary Document	Summary of Investigation Scope	Relevance of Report to Site	Will Data from Report Be Used to Assess Background Concentrations?
Gascoyne Laboratories (samples collected by) 2002. Sediment Sampling Results from the Removal of ST Services' Pier	Sediment samples were collected for VOCs and SVOCs. Four grab samples were collected prior to pier removal, and three samples (depth not reported) were collected probably during pier removal. Water samples were also collected. PAHs were detected in the samples. No BTEX compounds were detected above the method detection limits.	Investigation was conducted at WG East Station and is directly relevant to the Site.	No. Samples collected do not represent background.
Gascoyne Laboratories (samples collected by) 2003 Sediment Sampling Results from the Removal of WG's Two Piers	Thirty-nine sediment samples were collected and analyzed for VOCs and SVOCs, metals, gasoline-range organics, diesel-range organics, TPH, and percent moisture. Samples were taken from 0-6 inches and 7-18 inches. The metal analyses indicate that barium, copper, and lead concentrations in the sediment were lower overall than detected in the 1998 Hydro-Terra samples. Of the BTEX family compounds, only ethylbenzene was detected above the detection limits in three samples. The results showed that PAH concentrations diminished with depth.	Investigation was conducted at WG East Station and is directly relevant to the Site.	No. Samples collected do not represent background.
Anacostia River			
NOAA DARRP	Compilation of sediment concentrations and toxicity information from 37 databases.	Will be evaluated for background dataset.	Will be evaluated for background dataset.

Table 2-2
Previous Anacostia River Investigations Near the Washington Gas East Station Site
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Investigation Summary Document	Summary of Investigation Scope	Relevance of Report to Site	Will Data from Report Be Used to Assess Background Concentrations?
Anacostia Watershed Toxics Alliance and Anacostia Watershed Restoration Commission. A Toxic Chemical Management Strategy for the Anacostia River	Presents a holistic approach and projected costs for managing the toxic condition of the Anacostia River including control of on-going sources or toxics and remediation of past releases.	As a member of AWTA, Washington Gas and Light has contributed to the development of the management plan.	No. There are no data collected to support this document.
Horne Engineering Services, Inc. 2003. Revised Draft Site Characterization Report for Comparative Validation of Innovative "Active Capping" Technologies Anacostia River, Washington DC	Sediment samples were collected and analyzed from the Anacostia River for a broad range of physical, chemical and biological information to establish an environmental baseline for the proposed capping areas and to obtain sufficient sediment geotechnical data for cap placement and design.	The study focused on two areas in the Anacostia River. The second area is located near the Washington Gas East Station Site.	No. There are no background data from this study.
D.K. Velinsky, et al. 2011. Historical Contamination of the Anacostia River	Six sediment cores were collected in the downstream section of the tidal Anacostia River to determine current sediment contaminant levels and determine a historical perspective of the sediment changes in contamination using ^{137}Cs and ^{210}Pb dating.	Samples were collected immediately downstream of the government property near the Washington Navy Yard. These data support the overall CSM of OU2.	No. Samples were collected downstream of the government property.
CH2M Hill. 2009. Approach for Developing Background Sediment Concentrations Using Existing Data Sets	Presents approach for determining background concentrations of COPCs in sediment for comparison to results from the Lower Anacostia River Washington Navy Yard Operable Unit (OU) 2.	Washington Navy Yard is located immediately downstream of the Site. The approach and interpretation of Riverwide concerns is directly relevant to the Site.	The approach used in this Appendix will be considered in the assessment of background, but there are no new data presented.

Table 2-2
Previous Anacostia River Investigations Near the Washington Gas East Station Site
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Investigation Summary Document	Summary of Investigation Scope	Relevance of Report to Site	Will Data from Report Be Used to Assess Background Concentrations?
A.E. Pinkney, et al. 2001. Tumor Prevalence and Biomarkers of Exposure and Response in Brown Bullhead (*Ameiurus nebulosus*) from the Tidal Potomac River, USA, Watershed	Bullheads were sampled in 1997 from the Anacostia River, Neabsco Creek, and Quantico Embayment to investigate the prevalence of skin and liver tumors. The Tuckahoe River served as a reference.	Pinkney relates PAHs to tumors in brown bullhead from the Anacostia River. These data are important to the ecological risk assessment.	Sediment concentration data will not be used, but the tumor prevalence from different parts of the watershed may be included in the BERA.
A.E. Pinkney, et al. 2004. Tumor Prevalence and Biomarkers of Exposure and Response in Brown Bullhead (*Ameiurus nebulosus*) from the Anacostia River, Washington, DC and Tuckahoe River, Maryland, USA	Bullheads were sampled in the fall of 2000 and 2001 in the Anacostia River to investigate the prevalence of skin and liver tumors. The Tuckahoe River served as a reference.	Pinkney relates PAHs to tumors in brown bullhead from locations upstream and downstream of the Site. These data are important to the ecological risk assessment.	Sediment concentration data will not be used, but the difference in tumor prevalence from different sides of the Site may be included in the BERA.
H.L. Phelps. 2005. Identification of PCB, PAH and Chlordane Source Areas in the Anacostia River Watershed	Asiatic clams were translocated from the healthy Potomac to sites in the Anacostia River watershed were assessed for bioaccumulation after two weeks. Bioaccumulation results were used to find the clean upstream reaches of the most highly contaminated first-order tributaries of the Anacostia Watershed.	Clam deployment locations included near, upstream of and downstream of the Site. Concentrations of PAH from clams in the lower Anacostia River were higher than reference conditions.	No. Sediment data were not collected as part of the study.
B.L. McGee, et al. 2009. Using the Sediment Quality Triad to Characterize Baseline Conditions in the Anacostia River	Sediment chemistry, benthic community structure, and sediment toxicity were measured at 20 stations in the tidal portion of the Anacostia River from Bladensburg, MD to Washington, DC. The measurements were used to establish a baseline of conditions to evaluate the effects of management actions.	Three stations from the study were located near the Site. Several other stations were located upstream.	The data from this study will be evaluated for use in the background dataset.

Table 2-2
Previous Anacostia River Investigations Near the Washington Gas East Station Site
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Investigation Summary Document	Summary of Investigation Scope	Relevance of Report to Site	Will Data from Report Be Used to Assess Background Concentrations?
X. Lu, et al. 2006. Bioavailability of Polycyclic Aromatic Hydrocarbons in Field-Contaminated Anacostia River Sediment	Sediment–water partitioning behavior and bioavailability of five polycyclic aromatic hydrocarbons were measured in field-contaminated sediment collected from moderately polluted regions of the Anacostia River.	The exact locations of the sampling stations are not indicated by the author, but PAHs are a known COPC/COPEC at the Site, and data related to the sorption to River sediments are important to understanding the fate and transport of PAHs.	No. Locations are not clearly identified.
Syracuse Research Corporation, et al. 2000. Interpretive Summary of Existing Data Relevant to Potential Contaminants of Concern within the Anacostia River Watershed	Presents a preliminary conceptual site model of the tidal Anacostia River and associated chemical hazards, screening-level human health and ecological risk assessments, and data gaps.	Provides context of the Site to the Anacostia River as a system.	No.
NOAA. 2009. White Paper on PCB and PAH Contaminated Sediment in the Anacostia River S. Hahn. 2009. Anacostia River White Paper AWTA Presentation	Geospatial analysis was used to identify and map sediment hotspots in the Anacostia River. Risk reduction associated with hot spot capping was evaluated.	Paper and associated presentation provide an overall review of PAH and PCB concentrations in sediment in the Anacostia River, putting the concentrations at the Site in perspective.	The data used in this paper were obtained from DARRP, which will be the primary source of the background dataset.
A.E. Pinkney. 2009. Analysis of Contaminant Concentrations in Fish Tissue Collected from the Waters of the District of Columbia	Presents newly collected and historic fish tissue burden of contaminants from the Anacostia and Potomac Rivers and compares the concentrations temporally and against tissue standards.	Provides context of tissue burden of range of contaminants	No sediment data in the study.

Table 2-2
Previous Anacostia River Investigations Near the Washington Gas East Station Site
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Investigation Summary Document	Summary of Investigation Scope	Relevance of Report to Site	Will Data from Report Be Used to Assess Background Concentrations?
Tetra Tech, Inc. 2014. Draft Remedial Investigation Work Plan Anacostia River Sediment Project, Washington, DC	Serves as the primary planning document governing characterization of river surface water, biota, and sediments (including the potential effects of groundwater seepage) for the purpose of completing the RI in the Anacostia River. Addresses the environmental media characterization requirements associated with preparing a NaturalResources Damage Assessment (NRDA) for the river. Proposes bathymetric survey work, 134 surface sediment samples for nature and extent characterization (42 of the locations will also be used for benthic invertebrate characterization), 83 sediment cores up to 10 feet to characterize the sediment profile, poor water sampling at 19 locations, surface water samples from 14 near shore locations, and fish tissue sampling at 42 locations.	The characterization of Riverwide surface water, biota, and sediments is directly relevant to the Site.	If available, data collected to support this program will be reviewed for use in the background dataset.
A.E. Pinkney, et al. 2013. Temporal and Spatial Patterns in Tumor Prevalence in Brown Bullhead (Ameiurus nebulosus) in the Tidal Potomac River Watershed	Compared tumor prevalence in Anacostia River bullheads collected in 2009, 2010, and 2011 with those from 1996, 2000, and 2001. Compared tumor prevalence at various locations within the Potomac River watershed. Analyzed the 1992-2011 Chesapeake Bay bullhead tumor database to identify reference locations and covariates.	Pinkney relates PAHs to tumors in brown bullhead from the Anacostia River. These data are important to the ecological risk assessment.	Sediment concentration data will not be used, but the tumor prevalence from different parts of the watershed may be included in the BERA.

Table 2-3
NAPL Recovery from 1996 to 2014
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Well	NAPL Recovery from 1996 to 2014 (Gallons)																			Total
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
MW11	0	1.5	10	25.25	22	11	9	6.2	2.75	0.4	0	0	0	0	0	0	0	0	0	**88.1**
MW13	0	2	2	0.65	4.85	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	**9.6**
MW15	0	0	6.5	1.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**8.45**
MW18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
MW19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
MW20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
MW21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
MW22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
MW23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
MW24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
MW26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
MW27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
MW28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
MW29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
MW-6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
MW-8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
P6S	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	**0.1**
RW4S	0	0	1	0.35	0.1	1.6	0.25	22	7.8	2.95	2.25	2.1	2	2	0	1	2	2	3.5	**52.9**
RW5S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
RW6S	0	394.7	355.3	261.75	287.5	273.25	244.75	218.5	158.7	153.25	115	141	126.25	85.5	41.5	49	50.25	56	51	**3063.2**
RW7S	0	0	3.5	0	0	8.3	25.5	254.75	365.05	366.5	315	278	243.75	99.5	111.5	50	86	29	59.54	**2295.89**
TRW-1	0	0	0	0	0	0	0	7.6	0	4.25	1	1.1	0	0	0	0	0	4.5	13	**31.45**
WGL02S	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	**0.1**
WGLO1S	18	21.5	11.5	5.85	4.1	6	5.5	7.45	7	2.8	5.75	4.5	3.5	2.5	0.5	0.5	1.5	1	0	**109.45**
WGLO2D	62	103.8	132.2	110.75	127.75	88.25	56.25	92.25	53.5	33.5	63	54	53.5	43	22.5	30.5	46.5	64	55.5	**1292.75**
WGLO3S	30.5	19.8	21.7	6.5	6.25	9.35	8.25	15.5	13.3	7.1	5	4.5	4	2.5	2	3.5	4	3.5	4.5	**171.75**
P11S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	6.5	**8**
MW-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.5	17	**29.5**
MW-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	5.25	**14.25**
Total	**110.5**	**543.3**	**543.7**	**413.05**	**452.55**	**397.85**	**349.5**	**624.45**	**608.1**	**570.75**	**507**	**485.2**	**433**	**235**	**178**	**134.5**	**191.75**	**181.5**	**215.79**	**7175.49**

Treatment System	NAPL Recovery from 1996 to 2014 (Gallons)																			Total
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
Sed. Tank	0	0	0	0	0	381.5	365	500	465	450	498	452	450	410	305	2974.5	1577	1560	3300	**13688**
Total	**110.5**	**543.3**	**543.7**	**413.05**	**452.55**	**779.35**	**714.5**	**1124.45**	**1073.1**	**1020.75**	**1005**	**937.2**	**883**	**645**	**483**	**3109**	**1768.75**	**1741.5**	**3515.79**	**20863.5**

Figure 2-1 Site and Vicinity
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Notes
Orthoimagery from Bing Maps Aerial, 2010.
Channel lines from NOAA, 2007 (downloaded from http://encdirect.noaa.gov in April 2014).

0 1,000 2,000 Feet

AECOM

\\Uswtf1fp001\JOBS\Indl_Service\Project Files\Washington Gas MGP\GIS\MXD\RI_FS_Work_Plan\MXD\Fig_2_1_Site_and_Vicinity.mxd

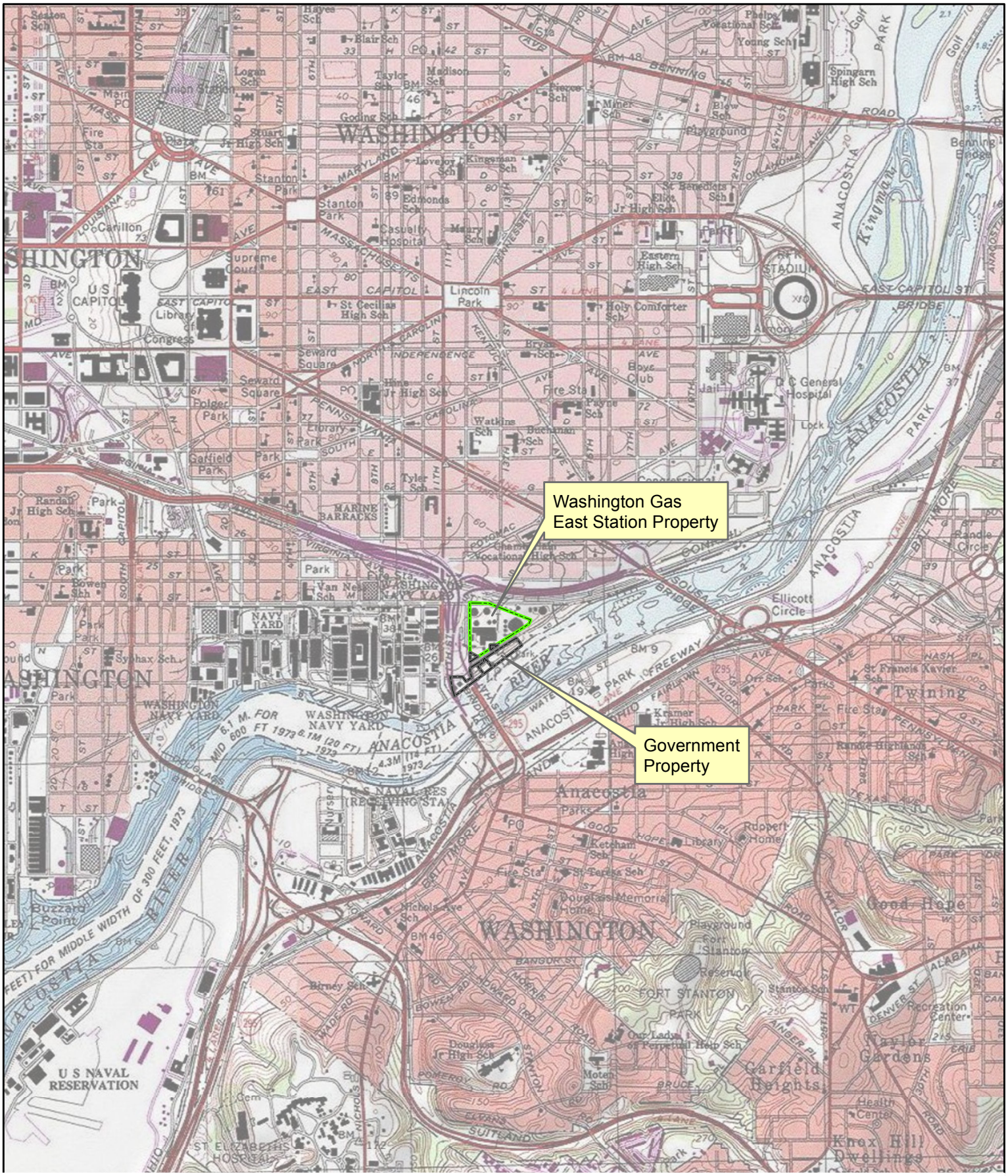

Figure 2-2 Topographic Map
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Note
Topographic Map from 2013 National Geographic Society, i-cubed.

0 1,000 2,000 Feet

AECOM

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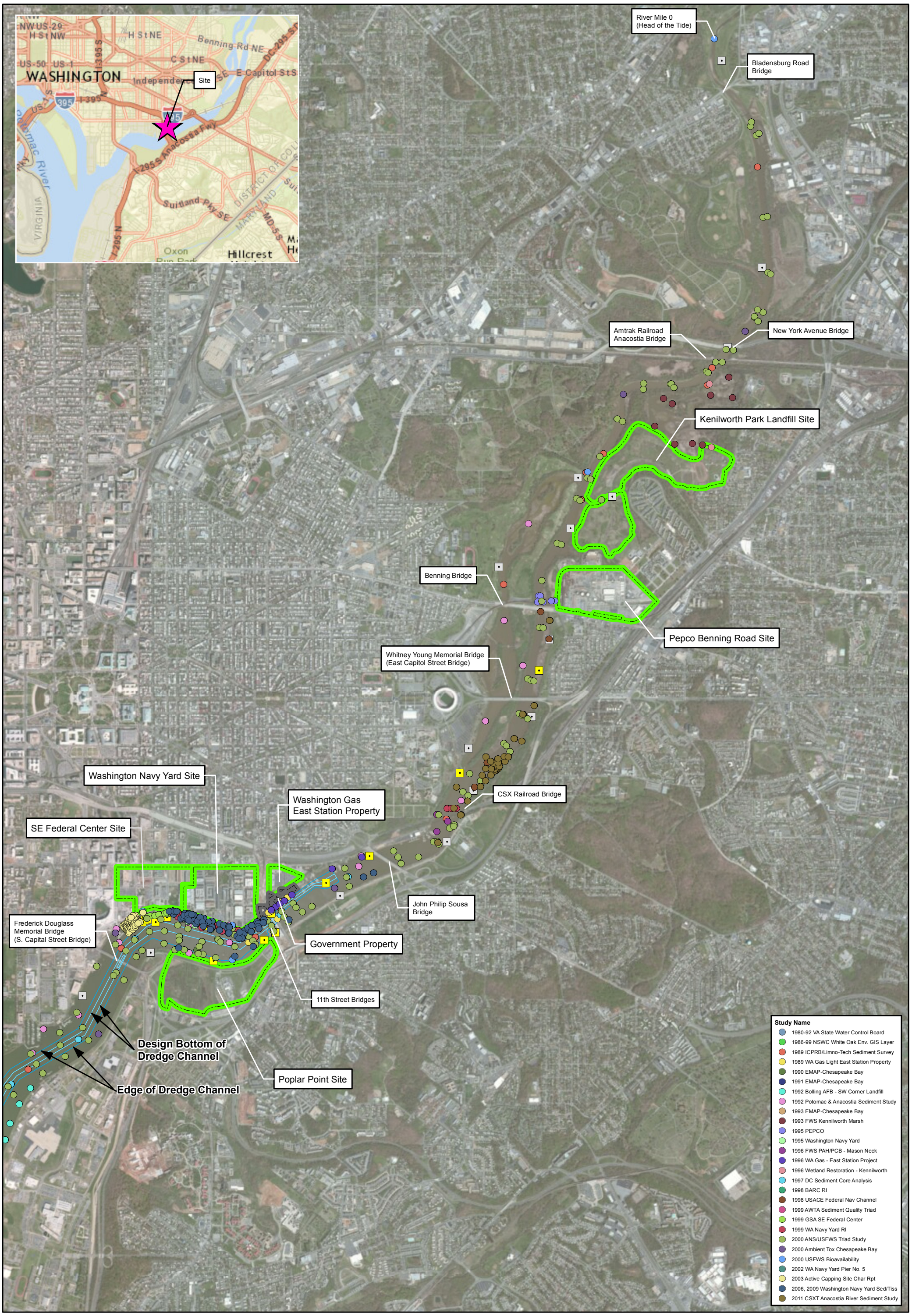


Figure 2-3
Anacostia River Sediment Sample Locations by Study
Operable Unit 2 - Remedial Investigation
and Feasibility Study Work Plan
Washington Gas East Station Site

Legend
CSOs*
Storm Sewer Outfalls*

* Locations approximate based on information from WNY Background Evaluation

Notes
Satellite and aerial imagery from Esri and other contributers (downloaded from http://www.esri.com/data/basemaps in March 2015).
Channel lines from NOAA, 2007 (downloaded from http://encdirect.noaa.gov/ in April 2014).

AECOM

0 0.25 0.5 1 Miles

Path: \\Uswtf1fp001\JOBS\Indl_Service\Project Files\Washington Gas MGP\GIS\MXD\RI_FS_Work_Plan\MXD\Fig_2_3_Sediment_Sample_Loc_Study.mxd

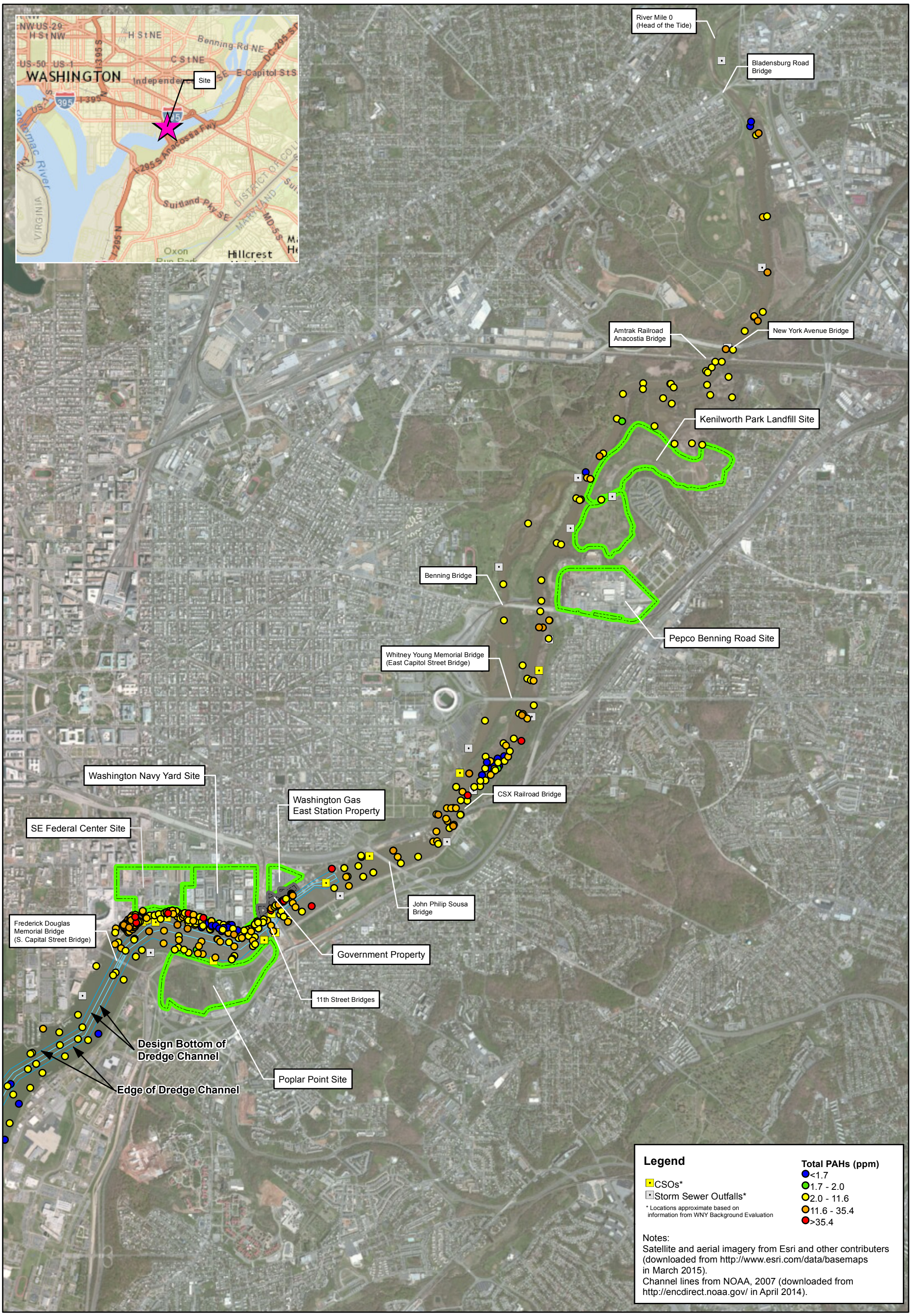


Figure 2-4
Anacostia River Surficial Sediment PAH Data
Operable Unit 2 - Remedial Investigation
and Feasibility Study Work Plan
Washington Gas East Station Site

Surficial sediment data included on this figure has been collected from the following studies:

1. *1989 ICPRB/ Limno-Tech Sediment Survey*
2. *1992 Potomac & Anacostia Sediment Study*
3. *1995 Washington Navy Yard*
4. *1996 WA Gas - East Station Project*
5. *1997 DC Sediment Core Analysis*
6. *1999 WA Navy Yard RI*
7. *2000 Ambient Tox Chesapeake Bay*
8. *2000 ANS/ USFWS Triad Study*
9. 2000 USFWS Bioavailability
10. 2006/09 Washington Navy Yard
11. 2002/3 Gascoyne Lab
12. 1995 Ecology & Environment
13. 1989 Hydro-Terra
14. 1999 Hydro-Terra
15. 1990, 1991, 1993 EMAP
16. 2011 CSXT Anacostia River Sediment Study

N

0 0.25 0.5 1 Miles

AECOM

Path: \\Uswtf1fp001\JOBS\Indl_Service\Project Files\Washington Gas MGP\GIS\MXD\RI_FS_Work_Plan\MXD\Fig_2_4_Surficial_Sediment_PAH_Data.mxd

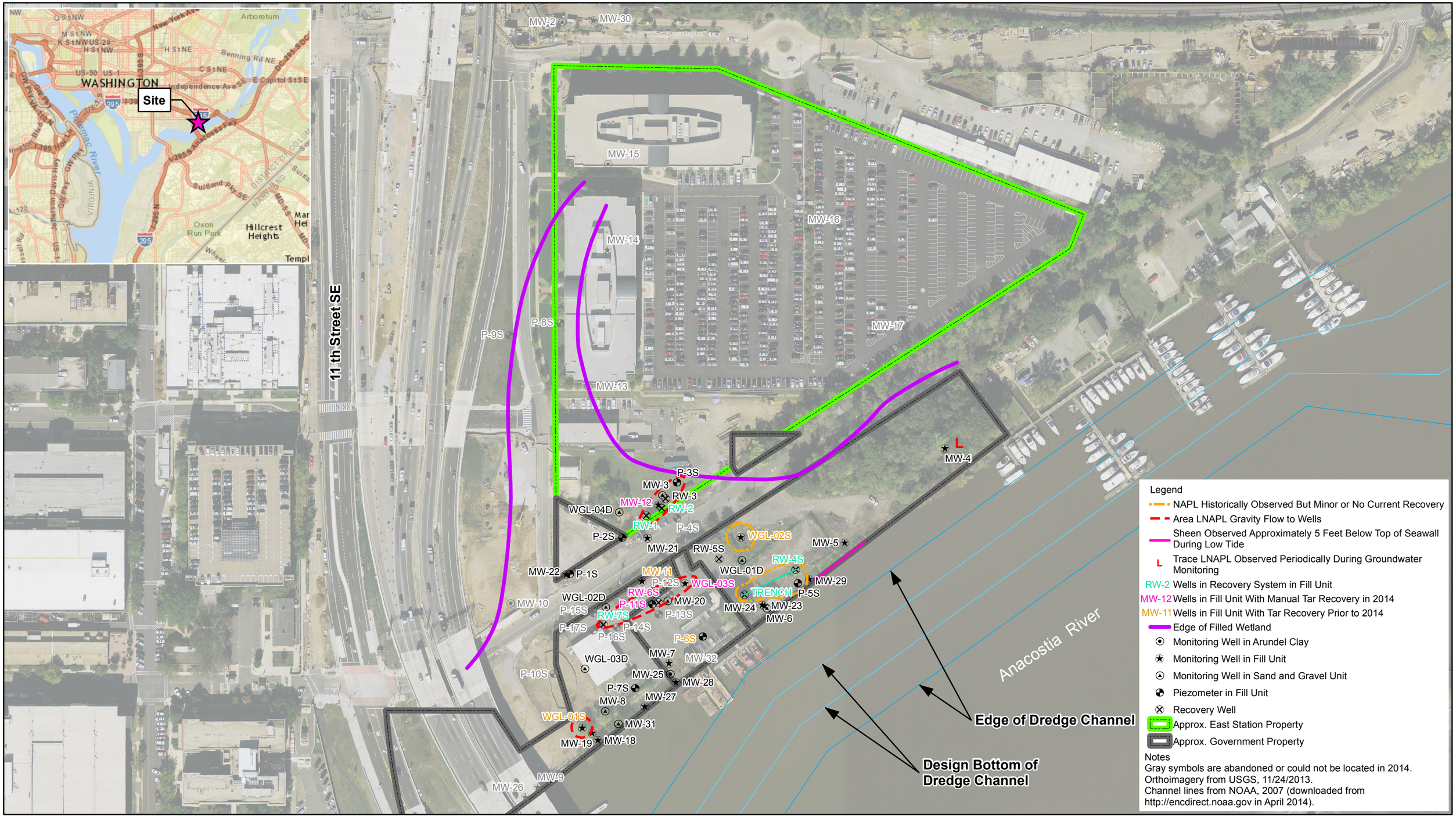


Figure 2-5
Area of NAPL and Location of Recovery Wells in Fill Unit
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Path: \\Uswtf1fp001\JOBS\Indl_Service\Project Files\Washington Gas MGP\GIS\MXD\RI_FS_Work_Plan\MXD\Fig_2_5_Filled_Wetlands_NAPL.mxd

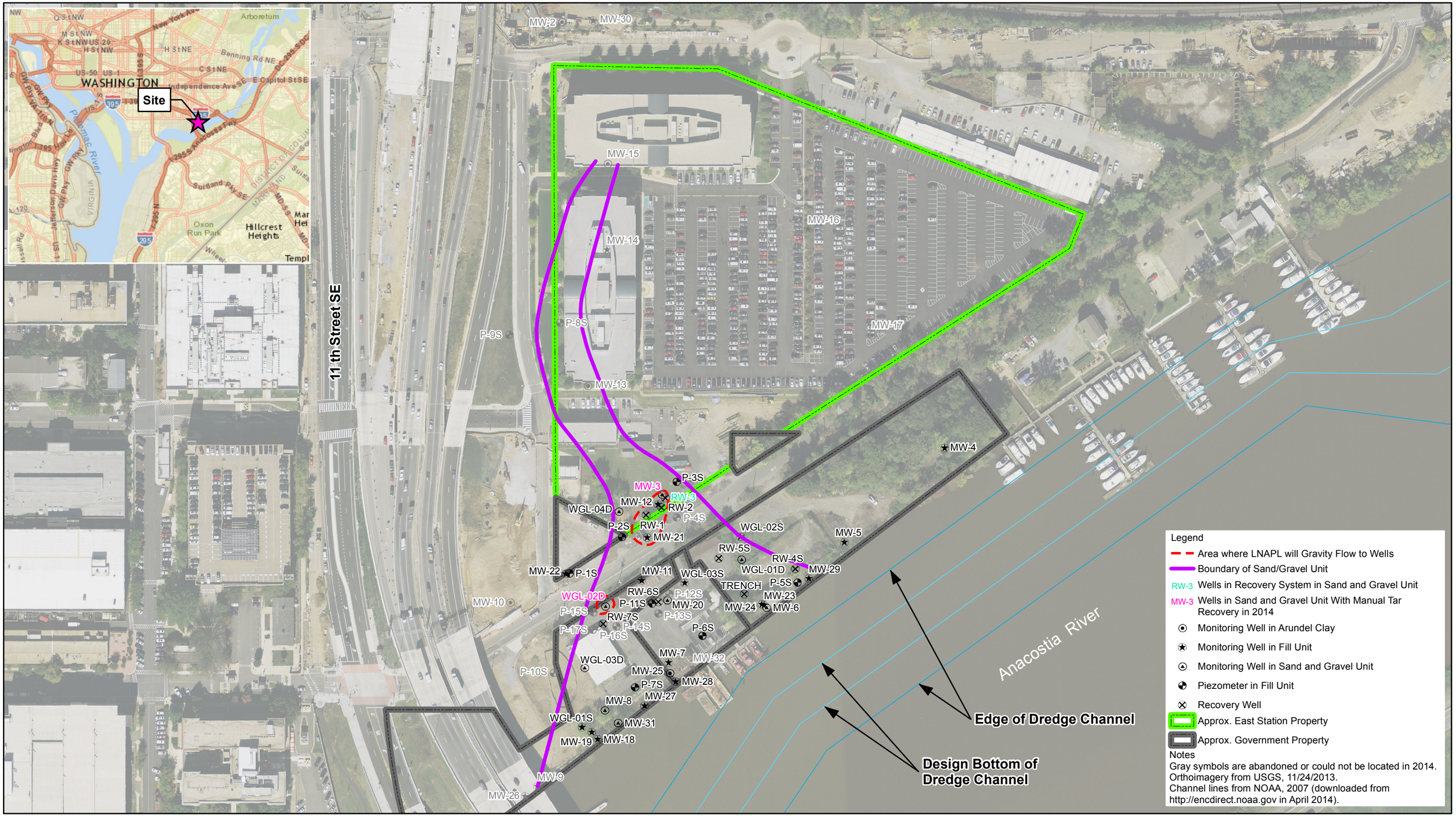


Figure 2-6
Area of NAPL and Location of Recovery Wells in Sand and Gravel Unit
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

0 100 200 Feet

AECOM

Path: \\Uswtf1fp001\JOBS\Indl_Service\Project Files\Washington Gas MGP\GIS\MXD\RI_FS_Work_Plan\MXD\Fig_2_6_Sand_Gravel_NAPL.mxd

3.0 Conceptual Site Model

The OU2 RI/FS Work Plan CSM presents an evaluation of the available Site data and River sediment and surface water data. The data evaluation discussed in this section was used to identify data gaps to be addressed in the RI/FS. The CSM describes the potential migration and exposure pathways and the preliminary assessment of human health and environmental impacts as they relate to OU2. This CSM, along with the OU2 RI/FS goals and objectives, has been used to identify data gaps and establish DQOs. These DQOs serve as the basis for identification of the RI/FS work elements necessary to achieve the RI/FS goals and objectives, as presented in Section 4. The CSM is used to direct the RI and the evaluation of existing data with respect to the following principal study questions, which are based on the goals of the OU2 RI/FS identified in the Consent Decree:

- *Principal Study Question 1*: What is the nature and extent of Site-related contaminants in groundwater adjacent to the seawall and in River sediments and surface water?
- *Principal Study Question 2:* What is the mass flux/discharge of Site-related contaminants in groundwater/NAPL to the River?
- *Principal Study Question 3:* Are Site-related contaminant concentrations in sediment and surface water posing an unacceptable risk to human receptors, under current or future exposure conditions, as a result of historical operations of the MG facility at the Site; and what are the potential current and future risks to ecological receptors associated with exposure to Site-related contaminants in River sediment, pore water, and surface water?

A CSM can be used as a framework to better understand and present observed and measured conditions and dynamics of a complex site. It is based on the current understanding of Site conditions, and includes such factors as potential contaminant source(s), geology and hydrogeology, nature and extent of contaminant in environmental media, fate and transport characteristics, and pathways to potential receptors. In this Work Plan, the CSM includes details regarding the Site use history, environmental setting, impacted groundwater conditions, and potential contaminant migration pathways. The CSM also incorporates River conditions including sediment quality, river flow hydraulics, and sediment transport mechanisms. An understanding of the relationship between the landside conditions and conditions within the River is critically important to understanding the Site and is a key component of this CSM. The CSM is a living document and will ultimately be revised to incorporate more current and comprehensive data generated during the RI/FS studies.

Figure 3-1 presents a CSM schematic for the WG Site showing potential migration and exposure pathways and receptors. The following sub-sections identify the potentially Site-related contaminants and pathways for migration from the Site to the River, summarize the currently available information for the River, and present the ecological and human health CSMs.

3.1 East Station Site Manufactured Gas Plant Contaminants of Potential Concern

The following four bullets identify the COPCs to be considered in the RI/FS. Additional details regarding these COPCs are provided below these summary bullets:

- The OU2 RI/FS is intended to identify and address contaminants in the River due to WG's former MG operations at the East Station Site. The SOW states that "the OU2 RI will delineate Site contamination in OU2, including PAHs, coal-tar related VOCs, and cyanide."
- Based on the SOW requirements, as well as review of extensive soil, sediment, and groundwater data collected historically from the Site, the following specific contaminants have been identified as COPCs for the OU2 RI: 17 PAHs, 4 VOCs (benzene, toluene, ethylbenzene, and xylenes [BTEX]), cyanide, Resource Conservation and Recovery Act (RCRA) metals, and 4 phenolic compounds.
- In addition to these contaminants required by the SOW, WG will conduct sampling for Polychlorinated Biphenyls (PCBs) to confirm that they are not present at the Site. WG has submitted a position paper to NPS, for inclusion in the administrative record, which includes a summary of the PCB sampling previously performed at the Site and in the River. Based on this historical data, WG concluded that East Station is not a source of PCBs, however, because there are sufficient data gaps that preclude dismissing PCBs as Site-related COPCs, PCB sampling is included in this work plan, in conformance with the requirements in the Consent Decree and CERCLA. PCB Aroclors will be sampled in NAPL accumulating in existing monitoring and recovery wells and in NAPL saturated soils. In addition, groundwater grab samples will be analyzed for PCB Aroclors. If the results of these NAPL and groundwater grab samples show that the Site is a potential source of PCBs, PCB congeners will be included in the analysis of other media (i.e., groundwater and sediment).
- Additionally, based on limited and infrequent historical detections in groundwater, the NPS has included methyl-tert butyl ether (MTBE) as a contaminant in groundwater to be used as a conservative tracer to demonstrate groundwater pathways to the River. A summary of the MTBE sampling previously performed at the Site has been presented to the NPS by WG in a separate document for inclusion in the administrative record. WG has concluded that based on the limited and infrequent historical detections and the generally ubiquitous presence of MTBE in urban environments, MTBE is not a good tracer for East Station. However, because MTBE appears to be comingled with MG-related contaminants in the five wells where it has been detected, in conformance with the NPS requirement and CERCLA, MTBE will be included in the landside groundwater samples and, if present in landside groundwater, MTBE will also be included in the in-river samples.

The classes of contaminants referenced in the SOW include the following specific contaminants, which are identified as COPCs for the OU2 RI:

PAHs	Coal-tar Related VOCs	Cyanide
Acenaphthene	Benzene	Total
Acenaphthylene	Ethylbenzene	Free/Physiologically Available
Anthracene	Toluene	
Benz(a)anthracene	Total Xylenes	
Benzo(a)pyrene		
Benzo(b)fluoranthene		
Benzo(g,h,i)perylene		
Benzo(k)fluoranthene		
Chrysene		
Dibenz(a,h)anthracene		
Fluoranthene		
Fluorene		
Indeno(1,2,3-cd)pyrene		
Naphthalene		
Phenanthrene		
Pyrene		
2-Methylnapththalene		

In addition to the above-referenced contaminants, COPCs for the OU2 RI include RCRA metals and phenolics. The eight RCRA metals are currently being analyzed in the twice-a-year groundwater sampling program. Both phenolics and PAHs are SVOCs that are typically present at MG sites (Hayes, et. al, 1996). RCRA metals and phenolics that are considered the OU2 COPCs include the following specific contaminants:

RCRA Metals	Phenolics
Arsenic	Phenol
Barium	2-Methylphenol
Cadmium	4-Methylphenol
Chromium	2,4-Dimethylphenol
Lead	
Mercury	
Selenium	
Silver	

As stated above, in conformance with the NPS additional requirements, the following contaminants are included in the OU2 RI.

- PCBs - Aroclors (landside NAPL from monitoring and recovery wells, NAPL saturated soils, and grab groundwater samples); and Congeners (in other media if detected in landside NAPL).
- MTBE – in landside groundwater; other media if detected in landside groundwater.

3.2 Potential Groundwater and NAPL Migration to River

The following four bullets identify the primary components of the CSM related to the potential migration of impacted groundwater and NAPL to the River; additional supporting details are provided below the bullets:

- MG-related contaminants can potentially migrate to the River via dissolved-phase groundwater transport, as a NAPL (if mobile), and as dissolved-phase in groundwater contacting mobile or immobile NAPL.
- The Site hydrogeology (e.g., tidal effects, low permeability geology, possible sea wall interference to shallow groundwater flow) and the existing groundwater/NAPL pumping and extraction system may sufficiently limit contaminant migration from the landside portion of the Site to the River. However, the relatively more permeable shallow surficial fill and the deeper sand and gravel units could also provide contaminant migration pathways for dissolved contaminants and coal tar NAPL to the River. In addition, it is possible that the presence of sandy lenses within the silt unit and the Arundel Clay, as well as excavations for on-Site structures and Site-related pits or sumps, may also contribute to contaminant transport to the River.
- NAPL recovery continues at the Site through the pump and treat system and by manual pumping of monitoring wells where it accumulates. Mobile and recoverable NAPL, therefore, is still present in portions of the Site, but in other areas NAPL recovery has declined or stopped indicating that mobile NAPL is either no longer present or that well and/or hydrogeologic conditions prevent the migration of NAPL to these wells.
- Available data suggest that the pump and treat system is capturing some contaminated groundwater from identified significant NAPL source areas preventing some, but not all, contaminated groundwater migration to the River under all tidal conditions. However, the nature and extent of contaminated groundwater and NAPL source areas on the government property bordering and upgradient of the River are not completely defined; therefore, the area of groundwater capture to prevent migration to the River is unknown.
  - The RI Report (Hydro-Terra, 1999) concluded that at high tide (both under pumping and non-pumping conditions) groundwater in the fill unit did not flow towards the River. At low tide, the RI Report (Hydro-Terra, 1999) concluded that groundwater in the fill unit flowed towards the River under non pumping conditions and that some, but not all, contaminated groundwater from identified significant NAPL source areas in the fill unit was captured under pumping conditions.
  - The RI Report (Hydro-Terra, 1999) also concluded that at high tide (both under pumping and non-pumping conditions) groundwater in the sand and gravel unit did not flow towards the River. At low tide, the RI concluded that the groundwater in the sand and gravel unit flowed towards the River.
  - During initiation of OU1 remediation efforts in January 2015, sheens were observed on the surface of the River at several locations between MW-4 and MW-5 along the seawall boundary of the Site, emanating from the seawall before and after low tide events. These sheens appear to provide evidence of shallow NAPL migration from the Site.

The primary focus of the OU2 RI/FS is the River. However, to evaluate potential risks in the River and remedies to address these potential risks, one of the requirements of the Consent Decree must be achieved first, which is to determine the nature and extent of Site contaminants in groundwater/NAPL

that discharge to the River under both static (non-pumping) and pumping conditions. Therefore, the OU2 RI/FS will evaluate the potential for on-going and future migration of contaminants in groundwater and NAPL from the landside portion of the Site into the River. The CSM describing potential groundwater and NAPL migration from the Site to the River was developed by integrating data collected during numerous past studies (see Section 2.2), land use and development history, the Site environmental setting, and the history of Site conditions.

MG-related contaminants can potentially migrate to the River via dissolved-phase groundwater transport, and as a NAPL (if mobile). The cross-section along the seawall in Figure 3-2 provides a depiction of the geologic and groundwater system through which any potential contaminant migration from the Site to the River would have to take place. Therefore, this geology cross-section was used as the basis for presenting the CSM for potential groundwater/NAPL transport to the River. Groundwater analytical data (Figure 3-3) and observations of the presence or absence of NAPL (Figure 3-4) have been added to this geologic cross section and are discussed in this section. To further support the CSM presented in this section, the pertinent information referenced above has been incorporated into four cross-sections oriented perpendicular to the River (Figures 3-5 through 3-8). Additionally, map views of this data are presented to facilitate review (Figures 3-9 and 3-10).

For contaminants to migrate to the River, they have to be present in the subsurface near and upgradient of the River, and there has to be a complete migration pathway for them to reach the River. The following discussion presents the CSM in terms of these aspects: presence/concentrations of MG contaminants, pathways for migration, and potential quantification of migration (mass flux to the River). The potential migration of dissolved-phase contaminants and NAPL is discussed separately, as their mechanisms of migration are different.

3.2.1 Geology

The Site is located in the Atlantic Coastal Plain physiographic province and within the former floodplain of the River.

During the course of previous environmental investigations at the Site, geologic data have been collected from numerous test pits, borings, and monitoring well installations. Figure 3-11 shows the locations of these sampling points. The available boring logs and the well construction information are presented in Appendix B. As the borings were advanced, soils were sampled using a variety of drilling and sampling techniques. The geologic logs from these borings and test pits do not always provide complete supporting information (e.g., samples were not collected continuously or sample recovery was not complete). Although minor gaps exist in these logs, they still provide valuable geologic information for the Site.

The geologic data obtained during these investigations were summarized in the RI Report (Hydro-Terra, 1999) and are incorporated in this Work Plan on maps and geologic cross-sections. The geologic data presented in the RI Report have been reviewed and in some places new data presentations have been prepared for this Work Plan. These geologic data are incorporated into the discussion of the stratigraphic units below. Figure 3-12 shows the locations of the cross-sections included in this Work Plan. With the exception of one cross-section that extends across the River (Figure 3-13), the geologic data presented are from landside investigations; geologic data are not available for other portions of the River adjacent to the Site. Figure 3-13 combines two cross-sections from the RI Report (Hydro-Terra, 1999): cross-section 1999 RI A-1999 RI C from the RI Report (which presents geologic information for the western end of the Site, perpendicular to the River), and a cross-

section that extends across the River, also included in the RI Report (which was developed from geotechnical borings for the previous 11th Street Bridge).

Figures 3-14 through 3-16 are cross-sections originally presented in the RI Report (Hydro-Terra, 1999). The cross-section on Figure 3-14 is oriented approximately perpendicular to the River and parallel to 12th Street. This cross-section shows the geology in the western portion of the Site. Figures 3-15 and 3-16 are oriented parallel to the River. The cross-section on Figure 3-15 is located approximately 600 ft. from the River and shows the geology for the northern portion of the WG East Station Site. The cross-section on Figure 3-16 is located approximately 300 ft. from the River, approximately along the southern WG property boundary on Water Street Southeast. This cross-section depicts the geology along the government property's northern Site boundary.

Three additional cross-sections (Figures 3-2, 3-17, and 3-18) have been prepared specifically for this Work Plan. Figure 3-2 (cross-section K-M) presents a cross-section parallel to the River on the government properties. This cross-section was prepared following a review of all available boring logs and test pit logs in the area of the cross-section. The cross-section on Figure 3-17 (labeled 1999 RI G-L) is oriented perpendicular to the River in the western portion of the Site. This cross-section shows the currently available geologic data in the area of additional landside investigation identified in the SOW in the area of MW-10 to MW-18. The cross-section on Figure 3-18 (labeled 1999 RI F-M) is oriented perpendicular to the River and is located in the eastern portion of the Site.

The Site is underlain by four primary stratigraphic units, as described in the RI Report (Hydro-Terra, 1999):

- Fill Unit: The uppermost (surficial) stratum at the Site is composed of mixed fill material deposited above the historical riverbed and associated riparian environments (marsh, mudflats and wetlands) behind the seawall. The fill reportedly includes cinder/ash and dredge spoils placed in this area as a dredge and fill operation under direction of the USACE, wastes, including cinder, ash, "coke breeze" (fine ash), and "purifier sponge" (wood chips and iron oxide) from the WG East Station Site, and demolition debris, rocks, and sand from other sources (Hydro-Terra, 1989). Cinder, ash, and coke breeze are typical fills generated at MG sites and where present may contain leachable metals (Hayes et. al., 1996). Purifier sponge may have blue staining from ferrocyanides (Hayes, et. al,. 1996). The fill ranges from approximately 10 to 25 ft. in thickness. Along the seawall, the fill ranges in thickness from about 7 to 13 ft. as shown on the cross-section in Figure 3-2. The fill is thickest where it was placed into a former tributary to the River (stream bed) that ran along the current location of 12th Street (see Figures 3-2, 3-15 and 3-16). The fill material does not extend beneath the River (see Figure 3-13). Figure 3-19 shows the extent of the filled wetland (marsh, mudflats and wetlands) at the Site as shown in the RI Report (Hydro-Terra, 1999). In upland areas outside of the historical River, the associated riparian environments and the former tributary to the River, fill is also present and is underlain by the Arundel Clay.
- Silt Unit: Beneath the fill in the historical River, historical River margin, and the former inlet of the River is a layer of natural silt, which was formerly the bed of the River and its surrounding margin (see Figures 3-13, 3-14, and 3-18). The silt unit ranges from 0 to approximately 30 ft. in thickness and is thickest near the River and in the former inlet upgradient of the River as shown in Figure 3-16. The silt unit thins to the north where it pinches out against underlying formations with distance from the River as shown on the cross-section on Figure 3-18.

Excavations for on-site foundations for the former MG structures may have created holes in the silt unit, forming preferential pathways for the migration of contaminants into the underlying formations.[1] The silt extends from the Site beneath the River, and forms the bed of the River, up to 18 feet thick below the River channel dredge depth, as shown on the cross-section in Figure 3-13. Sand lenses or sandy zones have been observed within the silt unit. Previous investigations have shown that the sand lenses generally exist and are more common near the top or bottom of the silt unit (Figure 3-2).

- Sand and Gravel Unit: Beneath portions of the Site and continuously under the River, the silt unit is underlain by a Pleistocene age sand and gravel unit that ranges in thickness from approximately 0 to 10 ft. beneath the Site and up to 15 ft. beneath the River (see Figure 3-13). The RI report (Hydro-Terra, 1999) states that this sand and gravel unit "occupies the center of the former drainage way eroded into the deeper Arundel Clay" as shown in Figure 3-16. With the exception of the area within the former inlet of the River and underneath the River, the sand and gravel unit appears to be of limited extent, but apparently continuous under and in closer proximity to the River, thinning and becoming less common in the upland zones of the Site, as shown on the cross-sections in Figures 3-13, 3-14, and 3-16. Similar to the fill unit, the sand and gravel unit is also thicker within the former inlet of the River (former stream bed) trending along 12th Street and along the River. Figure 3-20 is a map showing the extent of the sand and gravel unit at the Site. Included on this figure are the thickness of the sand and gravel unit at each boring location and isopleths of the sand and gravel unit thickness. This figure is based on information provided in the RI Report (Hydro-Terra, 1999), but has been modified slightly based on the review of the Site data in preparation of this Work Plan. As shown on Figure 3-20, the extent of the sand and gravel unit is not defined along the River to the southwest beyond the area of the bridges or to the southeast.
- Arundel Clay: The fourth unit is the Arundel Clay, which is present beneath the entire Site and the River. The Arundel Clay is low permeability over-consolidated clay and extends to thicknesses of greater than 100 ft. in this area (Hydro-Terra, 1999). Where boreholes have penetrated into the clay, sand lenses or sandy zones within the clay have been observed in the upper portions of the Arundel Clay as shown in Figures 3-4, 3-6, and 3-8.

Beneath these four stratigraphic units is the Patuxent formation, which lies beneath the Arundel Clay at depths greater than 100 ft. The Patuxent formation is typically composed of medium- to coarse-grained, feldspathic and quartzose sands and gravels interbedded with layers of red, mottled, and gray clay (MGS, 2014). Investigations at the Site have not advanced borings through the Arundel Clay to the Patuxent formation.

3.2.2 Hydrogeology

The majority of groundwater flow (transport volume) occurs in three primary water-bearing units beneath the Site:

[1] The RI Report states, "North of the existing office/treatment building, where the original gas-plant structures were built, the silt is believed to have been removed to create a more stable foundation for the original gas-plant structures, as evidenced on cross-section A-C. It is also probable that along the higher reach of the former stream along 12th Street the silt was not present in the channel, and, instead, the sand/gravel unit was exposed" (Hydro-Terra, 1999.)

- Fill Unit: The water table is located within the surface fill unit at the government property. The depth to groundwater in monitoring wells completed in this unit typically ranges from 2 to 10 ft. below land surface. A lower permeability silt unit lies below the fill unit, where present. Where the silt unit is not present the lower permeability Arundel Clay lies below the fill unit. Based on water level measurements collected for the RI Report, under non-pumping conditions, the groundwater gradient in the fill unit is toward the River, generally concordant with surface topography (Hydro-Terra, 1999). However, the presence of the groundwater interceptor trench, pumping wells, and the seawall affect the shallow groundwater flow gradient over a large portion of the Site, and some portion of the groundwater is hydraulically contained on site. As constructed, the seawall may partially restrict the hydraulic connection between the Site and the River, but the extent is unknown[2].

  The RI included groundwater flow evaluations conducted under pumping and non-pumping conditions and at high and low tides (Hydro-Terra, 1999). The RI Report concluded from these evaluations that at high tide (both under pumping and non-pumping conditions) groundwater in the fill unit did not flow to the River. At low tide, the RI Report concluded that groundwater in the fill unit discharged to the River under non-pumping conditions and that some, but not all, groundwater in the fill unit was captured under pumping conditions.

  In addition to the RI evaluation of groundwater flow evaluations, during the 2014 biannual groundwater monitoring events, water levels were measured in all available on-site wells within a two hour window of the high or low tide. Water levels were measured at high tide during the spring monitoring round and at low tide during the fall monitoring round. A groundwater contour map for the fill unit for the fall monitoring events is included as Figure 3-21. Figure 3-21 shows that at low tide water flows from the River towards the Site and operating recovery wells west of MW-6. East of MW-6, water flows from the Site towards the River. The pump in RW-7S was not operational during the groundwater elevation measurements, so these groundwater contours may not reflect the full extent of capture at low tide under normal operating conditions.

  The RI Report also presented hydraulic conductivities calculated from slug tests of 14 wells (MW-4, MW-5, MW-7, MW-9, MW-11, MW-12, MW-14, WGL-01S, WGL-02S, WGL-03S, RW-4S, RW-5S, RW-6S and RW-7S.) The horizontal hydraulic conductivities ranged from 1 to 530 ft./day, with an average of 73 ft./day and a median of 17 ft./day. The RI Report attributed the variability in hydraulic conductivity to the heterogeneity of the fill unit.

  The water table in the fill unit measured in April 2014 and November 2014 is shown on the geologic cross-sections presented as Figures 3-2, 3-17 and 3-18. The April 2014 water level measurements were collected around high tide and, therefore, represent a high tide condition. The November 2014 water level measurements were collected around low tide and, therefore, represent a low tide condition. The water level measurements during these high and low tide monitoring events are presented in Table 3-1. This table also includes the screen interval for each well. Water level measurements collected from March 2012 through November 2014 are included in Appendix B.

- Sand and Gravel Unit: In addition to the fill unit, the sand and gravel unit underlies portions of the government property. At the government property, the sand and gravel unit is present beneath the silt unit resulting in confined conditions. In areas where the silt unit confines the

[2] As shown by tidal survey conducted by Hydro-Terra, Inc., and summarized in Tar Contamination Mapping and Recovery-Well Siting at East Station, Washington D.C. (Hydro-Terra, Inc., 1996).

sand and gravel unit, dissolved contaminants in the fill unit are less likely to migrate to the sand and gravel unit. The RI Report (Hydro-Terra, 1999) stated there were confining groundwater flow conditions after measuring water level fluctuations during a tidal cycle and reviewing water level elevations collected during routine groundwater sampling rounds. The RI Report (Hydro-Terra, 1999) presents the results of tidal surveys where water levels were measured in the River and in sand and gravel unit wells. The RI report concluded that water level fluctuations of "as much as two feet in response to tidal fluctuations of up to three feet" were observed in the sand and gravel unit wells in comparison to less than one foot or no fluctuations in fill unit wells. This statement was based on two tidal surveys, one conducted by Hydro-Terra and summarized in the 1989 Contamination & Land Use Study, Phase II report. The survey measured water levels in three sand and gravel unit wells, including two on the government property (MW-6 and MW-8), both located in close proximity to the River and one well, MW-3, located north of Water Street Southeast. The second tidal survey was conducted by GeoTrans, Inc. and summarized in the 1991 East Station – Phase III Study Groundwater Recover System, Design and Results of Related Site Investigations. This tidal survey consisted of continuous monitoring of government property wells in the fill unit (WGL-01S) and in the sand and gravel unit (WGL-03D). These changes in water levels reflect the pressure impact of the change in River elevation associated with the tidal change.

Similar to groundwater in the fill unit, under natural flow conditions, groundwater gradient in the sand and gravel unit was toward the River during low tide (Hydro-Terra, 1999). The 1999 RI included groundwater flow evaluations conducted under pumping and non-pumping conditions and at high and low tides (Hydro-Terra, 1999). The 1999 RI Report concluded from these evaluations that at high tide (both under pumping and non-pumping conditions) groundwater in the sand and gravel unit did not flow towards the River. At low tide, the RI Report concluded that the gradient in the sand and gravel unit was towards the River under non-pumping conditions, but that the gradient was reversed and groundwater was captured under pumping conditions.

In addition to the RI evaluation of groundwater flow evaluations, during the 2014 biannual groundwater monitoring events, water levels were measured in all available on-site wells within a two hour window of high or low tide. Water levels were measured at high tide during the spring monitoring round and at low tide during the fall monitoring round. A groundwater contour map for the sand and gravel unit for the fall 2014 monitoring event is included as Figure 3-22. This figure shows that at low tide water flows from the River towards the Site. However, the groundwater gradient is at an oblique angle in the southwestern corner of the Site without sand and gravel wells located further to the west, indicating that some flow could be to the River.

The RI presented hydraulic conductivities calculated from slug tests of eight wells (MW-3, MW-6, MW-8, MW-15, MW-20, WGL-01D, WGL-02D, and WGL-03D) screened partially in the sand and gravel unit. The hydraulic conductivities ranged from 1.2 to 141 ft./day, with an average of 29 ft./day and a median of 10 ft./day.

The groundwater elevation for each well screened in the sand and gravel unit, measured in April 2014 and November 2014, is labeled on the geologic cross-sections presented as Figures 3-2 and 3-17. The April 2014 water level measurements were collected around high tide and, therefore, represent a high tide condition. The November 2014 water level measurements were collected around low tide and, therefore, represent a low tide condition. The shallow fill unit water table surface is also shown on these two figures for both the April and November 2014 water level measurement events. The water level measurements during these high and low tide monitoring events are presented in Table 3-1. This table also

includes the screened interval for each well. Water level measurements collected from March 2012 through November 2014 are included in Appendix B.

- Patuxent Aquifer: The Patuxent Aquifer is the shallowest aquifer beneath the Site with sufficient yield to provide potable water for public use. This confined aquifer lies beneath the Arundel Clay (aquitard) at depths greater than 100 ft. The Patuxent Aquifer has an upward hydraulic gradient in this area, with a potentiometric surface within or above the Arundel Clay (NPS, 2006). There are no known drinking water wells within a four-mile radius of the Site, and the District does not permit the construction of potable wells in this area (NPS, 2006).

The two other units at the Site, the silt unit and Arundel Clay, are both aquitards and yield little groundwater to wells because they appear to have low hydraulic conductivities. However, sand lenses within the silt unit and in the top of the Arundel Clay have been identified and may be water-bearing contaminant transport pathways. Although the presence and extent of these sand lenses within these lower permeability units have been evaluated in previous investigations, this matter requires further evaluation. The RI Report (Hydro-Terra, 1999) provides the following information on the hydraulic properties of the silt unit and Arundel Clay:

Silt Unit

- Laboratory tests of two silt samples to determine their Unified Soil Classifications classified both samples as low plasticity inorganic silt (ML) (Hydro-Terra, 1999).
- A laboratory test of coarser textured sediment from the silt unit to determine its Unified Soil Classification classified this sample as silty sand (SM) (Hydro-Terra, 1999).
- Laboratory standing-head hydraulic conductivity tests of two Shelby tube samples of the silt provided measurements of 2.9×10^{-7} and 3.8×10^{-7} centimeters (cm)/second (sec) or 0.00082 and 0.0011 ft./day (Hydro-Terra, 1999). These hydraulic conductivities are indicative of a relatively impermeable unit, which will limit the migration of dissolved contaminants through this unit.

These hydraulic conductivity results and laboratory tests along with the geologic logs show that the silt unit may restrict dissolved and NAPL contaminant migration between the fill unit and the sand and gravel unit; however, they also show the potential for dissolved transport connections through more permeable heterogeneities. Regardless, DNAPL exists in the sand and gravel unit, which raises uncertainties about the uniform presence and/or the relative impermeability of the silt unit to DNAPL migration.

Arundel Clay

- Laboratory tests of four Arundel Clay samples were conducted to determine Unified Soil Classifications. One sample was classified as medium to high plasticity inorganic clay (CH), two samples were classified as low plasticity inorganic clay (CL), and one sample was classified as low plasticity inorganic silt (ML). The ML sample was from a zone described on boring logs as a clayey sand or sandy clay (Hydro-Terra, 1999).
- Slug testing of an Arundel sandy-clay or clayey-sand zone yielded hydraulic conductivities of 7.49×10^{-5} and 2.03×10^{-4} cm/sec or 0.21 and 0.58 ft./d (Hydro-Terra, 1999). Two laboratory in-situ falling-head tests were run on samples collected from the intervals where the slug tests were performed and each produced a hydraulic conductivity of 2.0×10^{-6} cm/sec or 0.0057 ft./day (Hydro-Terra, 1999).

- Standing-head tests were also run in the laboratory on two additional samples of the Arundel sandy clay and yielded estimates of 4.5 x 10^{-7} and 3.0 x 10^{-5} cm/sec or 0.0013 ft./day and 0.085 ft./day (Hydro-Terra, 1999).
- The more prevalent plastic clay encountered in the unit was not tested (Hydro-Terra, 1999).
- In 1980, Mueser, Rutledge, Johnson & DeSimone (MRJ&D) conducted a long-term pumping test in a well screened in a sand/gravel and a sandy zone in the underlying Arundel Clay (described as a clay sand) on the Navy Yard near 10th Street and determined that the overlying silt unit restricts direct recharge from the River to this sand/gravel zone. An earlier test by the firm in 1974 produced the same conclusion. The pumping tests were performed as part of a geotechnical investigation of possible subway crossings of the River (Hydro-Terra, 1999). Although this pumping was not performed at the Site and, therefore, may not reflect Site conditions, it is a long-term pumping test, which provides better hydrologic information than slug tests or laboratory tests, and it was conducted of a sandy zone within the Arundel Clay similar to those present at the Site.

These geologic observations, unit thickness, and hydraulic testing results demonstrate that the Arundel Clay functions as an aquitard to groundwater flow and dissolved contaminant migration to and from the Patuxent Aquifer . However, these hydraulic testing results have not evaluated if sand lenses within the Arundel Clay are potential contaminant migration pathways to the River.

3.2.3 Dissolved Phase Contaminants

MG-related contaminants that are dissolved in groundwater will migrate downgradient through preferential pathways with relatively higher permeabilities. Along these preferential migration pathways, dissolved contaminant mass will diffuse into relatively lower-permeability soils. The primary water-bearing or most permeable geologic units at the Site where dissolved phase contaminants have been detected in monitoring wells are the fill unit and the sand and gravel unit. In addition, there are sand seams in the silt unit and Arundel Clay confining unit and, more commonly, along the geologic gradational contacts with the fill unit and sand and gravel unit that could also provide pathways for contaminant migration and areas where contaminant mass may accumulate through diffusion. The following discussion summarizes the dissolved groundwater data by geologic unit. There are no monitoring wells screened solely in the silt unit, Arundel Clay, or within the gradational sand contacts along the fill/silt contact or the sand and gravel contact with the silt unit and Arundel Clay, so dissolved data for these units are not further described below.

3.2.3.1 Fill Unit Groundwater

This section discusses the available groundwater analytical data in the fill unit and the extent of groundwater capture from the pump and treat system operating in the fill unit.

<u>Extent of Fill Unit</u>

As described in Section 3.2.1, the fill unit is present along the seawall and in the inlet of the River (former stream bed) that formerly ran along 12th Street. The fill unit, which is bounded by the seawall, does not extend beneath the River. The fill unit is present at thicknesses of less than 10 feet everywhere on the government property. Figure 3-19 shows the extent of the thickest portions of the fill unit at the Site within the former River inlet described previously.

Fill Unit Groundwater Flow and Capture

Under non-pumping conditions, groundwater presumably migrates in the fill unit and sand lenses along the gradational contact with the lower silt unit through and possibly under the seawall and discharges to the River. Migration under the seawall is presumably less likely because the seawall extends approximately 2 to 4 ft. into the lower silt unit, which would restrict downward vertical flow from the fill unit relative to more permeable horizontal flow pathways through the fill unit and the seawall. Groundwater migration through the seawall is presumably more likely given it is largely constructed of stone below the water table. However, the impact of the fill placed behind the seawall on the permeability of the seawall (e.g., lower permeability material filling in the spaces between the seawall stone) is currently not known. It is also not known if under non-pumping conditions and relatively high river water elevation conditions, e.g., during spring flood, groundwater would flow towards the River or flow would be from the River to the Site.

The purpose of the existing groundwater remediation system is to reverse the natural gradient such that contaminated groundwater in the fill unit no longer flows to the River. The effectiveness of the existing remediation system in preventing groundwater discharge to the River has been previously evaluated (e.g., RI Report and three- and five-year review reports). The RI Report indicated that groundwater flow to the River in the fill unit was likely at low tide under non-pumping conditions and that some, but not all contaminated groundwater in the fill unit was captured under pumping conditions. Similarly the Second Three-Year Review and Groundwater Pumping and Treatment Report (WG, 2007) indicated that capture was achieved under pumping conditions at low tide over most of the Site where NAPL has been observed and to within 100 to 200 ft. (depending on location) of the seawall.

The actual contaminated groundwater area requiring capture and hydraulic containment is unknown. Therefore, the most recent five-year review (AECOM, 2011) recommended that the capture area of the groundwater recovery system be re-evaluated. This re-evaluation should include an evaluation of a larger quantity and distribution of groundwater elevation data (vertical and horizontal) and surface water level data, current withdrawal rates, recharge conditions from precipitation, and the influence of tidal fluctuations through a tidal effects evaluation than is currently available. This re-evaluation is a data gap for the OU2 RI.

During the OU1 remediation excavation oily sheens on the River surface were observed along the seawall, between MW-4 and MW-5, before and after low tide events when River water levels were typically low in winter. The sheens were observed when the River surface was approximately 5 ft. below the top of the seawall, which is similar to the water table elevation in the fill unit. Based on these sheen observations, it is possible that one or more of the following conditions apply: 1) NAPL is migrating from the fill unit through the seawall to the River during low tide; 2) the groundwater capture area does not extend to the seawall or capture all contaminant discharge to the River; and 3) the upper portion of the seawall is not impermeable to NAPL migration from the government property to the River.

Fill Unit Groundwater Analytical Data

Current Groundwater Analytical Data. Table 3-2 presents the most recent (November 2014) groundwater data collected at the Site for monitoring wells screened in the fill unit. Historical groundwater data are presented below in the following subsection. The November 2014 groundwater samples are collected as part of the routine biannual groundwater sampling program. The wells included for sampling are located along the perimeter of the Site and generally, but not exclusively,

near the seawall. Some perimeter wells are not included in the groundwater sampling program because they are located in close proximity to other monitoring wells which are screened within the same geologic unit. The laboratory detection limits for the 2013 and 2014 sampling were established to meet, to the extent practical, appropriate human health and ecological benchmarks. The formal establishment of appropriate benchmarks and associated laboratory detection limits for the OU2 RI will be included in the Quality Assurance Project Plan (QAPP).

Samples from the groundwater monitoring wells are being analyzed for target compound list (TCL) VOCs, TCL SVOCs, RCRA metals (dissolved) and total cyanide (dissolved). The most mobile of these parameters and/or the ones most likely to contribute to risk are benzene, naphthalene, and cyanide. These parameters are the most likely to migrate via the dissolved-phase groundwater pathway.

Figure 3-3 presents the identical cross-section as Figure 3-2 with available analytical results from the most recent groundwater sampling round added for benzene and naphthalene. In general, concentrations of these parameters based on the November 2014 sampling event are relatively low in groundwater along the seawall (concentrations less than 10 µg/l, except for MW-5 which had a benzene concentration of 120 µg/l). Information about total PAHs (sum of 17 PAHs) and cyanide is also included on the cross-section.

Historical Groundwater Analytical Data. Figure 3-9 is a map view of the Site presenting the concentrations of benzene, naphthalene, cyanide, and total PAHs for all monitoring wells in the fill unit where the information is available. This figure presents the most current analytical data, along with the most recent year that the data were collected. The wells that are not included in the routine biannual groundwater sampling program have not been recently sampled, and most of these wells were last sampled in 1996 or 2001. As indicated in Figure 3-9, the analytical data collected from monitoring well locations adjacent to the seawall are significantly lower than concentrations of these contaminants near the center of the government property. These lower concentrations could suggest that some, but not all, groundwater in the fill unit is captured by the pump and treat system, or that concentrations are declining over time.

Figures 3-23 a-o present groundwater concentration plots (benzene, naphthalene, cyanide, and total PAHs) for available data collected between 1988 and 2014 for the nine fill unit wells included in the biannual groundwater monitoring and for five additional wells on the government property. These plots indicate that the fill unit wells have both a high number of detects and non-detects for these four contaminants. Where there are sufficient data to visually evaluate if trends are evident, the trends are not evident or are variable. The other wells and analytes have too many non-detects to evaluate trends. A statistical analysis of these data has not been performed.

The central portion of the cross-section on Figure 3-3 is the area where NAPL was observed prior to implementation of the groundwater remediation system; therefore, it is the area targeted by the remediation activities. Six wells are regularly monitored along the seawall in this area (MW-18, MW-23, MW-27, MW-28, MW-29, and P6-S). Concentrations of benzene, PAHs, and cyanide are typically low (in comparison to Maximum Contaminant Level (MCLs) for benzene and cyanide or the USEPA Region 9 Regional Screening Level (RSL) for PAHs) or not detected at three of these wells (MW-18, MW-27, and MW-28). The highest concentrations are present at P6-S; in April 2014, benzene was detected at 86 µg/l, total PAHs were 150 µg/l, and cyanide was present at 1,200 µg/l. Note, MCLs and RSLs are used in this discussion to place the analytical data into perspective, not to imply that these screening levels are appropriate for comparison to the groundwater data.

3.2.3.2 Sand and Gravel Unit

This section discusses the available groundwater analytical data in the sand and gravel unit and the extent of groundwater capture from the pump and treatment system operating in the sand and gravel unit.

Extent of Sand and Gravel Unit

As described in Section 3.2.1, the sand and gravel unit is present in the center of the former drainage way eroded into the deeper Arundel Clay along what is now 12th Street. The sand and gravel unit extent is unknown, although it is typically present near the River. Historical geotechnical boring logs for the former 11th Street Bridge indicate that the sand and gravel unit extends from the landside beneath the River. The sand and gravel unit is generally confined by the overlying silt unit, but there are places where the overlying silt unit is not present and in these locations the sand and gravel unit is not confined.

Sand and Gravel Unit Groundwater Flow and Capture

Under static (non-pumping) conditions in the sand and gravel unit, the horizontal hydraulic gradient and the vertical component of the gradient are presumably variable, both away from (at high tide) and towards (at low tide) the River. However, how far inland high tide may affect the sand and gravel gradient is unknown. To reach the River, groundwater in the sand and gravel unit must migrate through the overlying silt confining unit. The low permeability of the silt unit, as shown by laboratory tests summarized in the 1999 RI (Hydro-Terra, 1999), suggests that migration through this unit could be a slow process; however the degree of interconnection through sand lenses at the top of the sand and gravel unit and the bottom of the fill unit is unknown.

The presence and potential interconnectivity of more permeable sand lenses within the silt unit and Arundel Clay have not been fully evaluated at the Site. If sand lenses are present and interconnected, they could provide potential pathways for preferential groundwater flow. Information regarding the presence/absence of more permeable sand lenses within the silt unit is an OU2 RI data gap.

Groundwater is currently being pumped from the sand and gravel unit to contain the migration of MG-related contaminants. The single pumping well (RW-3) appears to be effective at capturing and controlling groundwater in the sand and gravel unit (AECOM, 2011), although the area of capture is unknown.

The RI Report included groundwater flow evaluations conducted under pumping and non-pumping conditions and at high and low tides (Hydro-Terra, 1999). The Second Three-Year Review and Evaluation of Groundwater Pumping and Treating (Washington Gas, 2007) included groundwater flow evaluations under pumping conditions at low tide. The RI Report indicated that groundwater flow toward the River in the sand and gravel unit was only likely at low tide under non-pumping conditions. The Second Three-Year Review and Evaluation of Groundwater Pumping and Treating concluded that nearly all of the groundwater is captured within the sand and gravel unit except in the area of MW-31. However, the actual area of groundwater capture in the sand and gravel unit is unknown.

Sand and Gravel Unit Groundwater Analytical Data

Current Groundwater Analytical Data. Table 3-3 presents the most recent (November 2014) groundwater data collected at the Site for monitoring wells screened in the sand and gravel unit.

These groundwater samples are collected as part of the routine biannual groundwater sampling program. One of these wells (MW-20) is screened just in the sand and gravel unit and five of these wells (WGL-01D, WGL-03D, MW-6, MW-25, and MW-31) are screened in the sand and gravel unit, the Arundel Clay, and/or the silt unit. These wells are located on the government property both in the interior and along the seawall. The laboratory detection limits for the 2013 and 2014 sampling were established to meet, to the extent practical, appropriate human health and ecological benchmarks. The formal establishment of appropriate benchmarks and associated laboratory detection limits for the OU2 RI will be included in the QAPP. The groundwater monitoring wells are analyzed for TCL VOCs, TCL SVOCs, RCRA metals (dissolved) and total cyanide (dissolved).

Figure 3-3 presents the identical cross-section as Figure 3-2, but includes benzene and naphthalene results from the most recent groundwater sampling round from three locations in the sand and gravel unit. Based on the November 2014 sampling at all three locations, benzene and naphthalene were not detected in groundwater along the seawall. Information about total PAHs (sum of 17 PAHs) and cyanide is also included on the cross-section. These contaminants were also present at relatively low levels, particularly in comparison to fill unit wells located in the general area of the seawall. However, the 10 to 20-foot well screen lengths at these three locations also include groundwater from sand seams in the silt unit above and the Arundel Clay below the sand and gravel unit. Therefore, the impacts of these sand seams on the groundwater sample collected, either by dilution or contribution of contaminants, is not known.

Figure 3-5 presents this same information on a cross-section perpendicular to the River located at the western side of the Site. As shown on this cross-section, both benzene and naphthalene were not detected above their MCLs in the two sand and gravel unit groundwater monitoring wells sampled in November 2014 that are located along this cross-section. However, 0.78 J ppb of benzene was detected in well WGL-03D, which has a 20-foot well screen, half of which is within the silt unit. The impacts of sand seams in the silt unit on the groundwater sample collected, either by dilution or contribution of contaminants, is not known.

Historical Groundwater Analytical Data. Figure 3-10 presents a plan view of the Site presenting the concentration of benzene, naphthalene, cyanide, and total PAHs for all monitoring wells in the sand and gravel unit where data were available. This figure presents the most current analytical data, along with the year that the data were collected. The wells that are not included in the routine biannual groundwater sampling program have not been recently sampled, and most of these wells were last sampled in 1996 or 2001. As indicated in this figure, and in comparison to the fill unit analytical data shown in Figure 3-9, the analytical data for the contaminants presented are generally lower in the sand and gravel unit wells than in the fill unit wells. Additionally, similar to the fill unit wells, the concentrations of contaminants in the wells located along the seawall are lower than wells near the interior of the government property.

Figures 3-24 a-h present groundwater concentration plots for the six sand and gravel unit wells included in the biannual groundwater monitoring and two additional wells. The analytical data presented are for the period of record and include analytical data, as available, from 1988 to 2014. The contaminants plotted are benzene, naphthalene, cyanide, and total PAHs. As these graphs show, the sand and gravel unit wells all have a high number of non-detects for these four contaminants.

As depicted in the cross-sections in Figures 3-3 and 3-5, there are five wells screened across the confined sand and gravel unit (note that two wells are on both cross-sections), and four of these are regularly sampled (MW-6, MW-25, MW-31, and WGL-03D). Data from these wells typically indicate

minimal current impacts from MG impacts. Benzene and cyanide are typically, but not always, not detected in these wells. Low levels of PAHs in comparison to RSLs are occasionally detected in some samples (nondetect in November 2014 excluding WGL-03D, at which the maximum November 2014 detection was 30 µg/l). This monitoring well was transposed into the cross-section oriented perpendicular to the River to provide deeper geological information than was available with wells located on the cross-section. This well is located farther northeast than the other wells along the section and is located closer to the NAPL recovery system where more impact from NAPL would be expected.

3.2.3.3 Mass Flux/Discharge to the River

For MG-related contaminants to migrate from the Site to the River, MG-related contaminants in groundwater need to be present adjacent to the seawall and, with the exception of DNAPL, there needs to be a hydraulic gradient that could potentially cause groundwater flow towards the River (potential NAPL transport is discussed later in Section 3.2.4). To assess potential impacts to the River, it is important to quantify the mass discharge of contaminants that could reach the River. Mass discharge is estimated based on the sum of all mass flux estimates from all contaminated groundwater flow from all geologic units from cross-sections perpendicular to the groundwater gradient into the River.

The flux of contaminants through the primary water-bearing units (i.e., the fill unit and the sand and gravel unit) was initially estimated in the RI Report (Hydro-Terra, 1999). The RI Report estimated that the flux of organics (sum of VOCs and SVOCs) and inorganics (including naturally occurring organics) from the fill unit are 162 grams (0.36 pounds) per day and15 grams (0.03 pounds) per day, respectively. The RI Report also estimated that the flux of organics and inorganics from the sand and gravel unit are 0.8 grams (0.0017 pounds) per day and 1.1 grams (0.0023 pounds) per day, respectively. However, conditions have changed significantly since that time. The development of the Maritime Plaza has reduced the amount of recharge to the ground and, therefore, has possibly reduced the amount of groundwater flow. Interpretation of the data indicates that the Plaza construction has resulted in a reduction in the average amount of water that is pumped and treated at the Site. The extent of impacts may not be completely delineated, e.g., in the west (between MW-10 and MW-18) where less geologic and groundwater data is available. The extent of impacts is a data gap and will be further evaluated in OU2 RI/FS.

In addition to the primary water-bearing units, less extensive layers or zones of sand have been identified in some areas within the confining units (silt unit and Arundel Clay) along the seawall. These smaller sand lenses may provide potential preferential pathways for localized migration from the Site towards the River. The presence of impacts in these zones has generally not been characterized by previous studies. These zones may permit transport of a small volume of groundwater relative to the primary water-bearing units. However, if contaminant concentrations are relatively high, there is potential for this pathway to be important in the calculation of the mass discharge of contaminants to the River. The presence and significance of these zones of sand and/or possible contaminant migration within the silt and clay units is a data gap and will be further evaluated in the OU2 RI/FS.

3.2.4 NAPL

Free phase liquid detected in soils and groundwater on the Site includes coal tar DNAPL and smaller volumes of floating LNAPL. These NAPLs may be present in soil as immobile NAPL that may stain the fill or soil, or as mobile, free flowing liquid, which may flow into a monitoring or recovery well, and may migrate within the subsurface. In terms of potential migration towards the River, only mobile

NAPL has the potential to migrate as NAPL; however, immobile NAPL can provide a long-term source of dissolved contaminants to groundwater.

As described below, historical monitoring suggests that the locations of DNAPL are relatively stable and not moving southward towards the River from the areas of accumulation, and LNAPL is not found on-Site in significant quantities. However, the full extent of LNAPL or DNAPL, mobile or immobile, has not been defined, and recent discoveries of sheens along the seawall near low tide suggest mobile NAPL exists along the seawall boundary.

Figure 3-4 presents the identical cross-section as Figure 3-2, with available information about where indicators of NAPL were identified during drilling of soil borings and wells. Figures 3-6 and 3-8 provide the same information for two cross-sections located perpendicular to the River. The indicators of NAPL include observations of tar, oil, and/or sheen on the surface of the soil. Such observations were noted at many of the drilled locations. These observations provide an understanding of where NAPL may have once been and where resulting dissolved contaminant migration may be occurring, but they may not be appropriate for assessing the current potential for NAPL migration towards the River. Many of the borings were installed more than two decades ago, and thus the observations may not represent current conditions following various remedial activities. However, residual (non-mobile) NAPL can be very persistent and remain in the soil for long periods of time continuing to create downgradient dissolved contamination. Thus, the information from historical soil borings does not provide complete information about the current presence and mobility of NAPL that has the potential to migrate towards the River.

Figures 2-5 (fill unit) and 2-6 (sand and gravel unit) depict the primary areas where mobile NAPL is known to be currently present at the Site. These figures also depict the locations of the recovery wells included in the pump and treat system, the wells where WG performs manual DNAPL removal, where DNAPL removal has occurred in the past, but is no longer occurring (i.e., DNAPL is no longer flowing into the wells), and where NAPL was observed as sheens during past groundwater sampling rounds. As depicted in these figures, the following three primary areas of mobile NAPL coal tar are known at the Site:

- Vicinity of RW-1 and RW-2, fill unit;
- Vicinity of RW-7S, RW-6S, fill unit, WGL-02D, sand and gravel unit; and
- Vicinity of WGL-01S, fill unit.

None of these areas are located along the seawall and, therefore, these areas are not shown in cross-section in Figure 3-4; WGL-01S is located near the seawall, but DNAPL has not been detected in two wells (MW-18 and MW-19) located between WGL-01S and the seawall.

In summary, DNAPL has collected in wells installed in areas of mobile DNAPL and accumulated DNAPL is extracted from these wells with total fluid recovery pumps or manually. The 2006 NPS ROD requires continued removal of DNAPL that appears in monitoring or recovery wells. Historical monitoring in approximately 46 wells suggests that the locations of DNAPL are relatively stable and not moving southward towards the River from the areas of accumulation.

LNAPL is not found on the Site in significant quantities but is commonly observed as sheens in select Site monitoring wells (MW-4 and P-6S) (see Figure 3-5). During the April 2014 water level measurement round, an LNAPL sheen was only observed in MW-4 which is located on the government property. This well is located approximately 400 ft. from the nearest NAPL recovery well

(RW-4S). The November 2014 groundwater sample from MW-4 contained no detectable concentrations of naphthalene or benzene. Although not associated with NAPL, a potential MG-related contaminant cyanide was detected at 0.31 µg/l in November 2014. The LNAPL observed in MW-4 has not been sampled. When observed, LNAPL is commonly observed at the Site as sheens and no chemical analysis of the LNAPL has previously been performed.

As shown on the cross-section in Figure 3-4, there were observations of immobile NAPL (referred to as stains and sheens in boring logs) on soil in many of the borings and wells drilled near the seawall. Of the wells shown on this cross-section, ten existing wells (P-6S, P-7S, MW-4, MW-5, MW-7, MW-18, MW-22, MW-23, MW-28 and MW-29) are screened across a zone where NAPL was observed in the boring logs. NAPL has accumulated in only two of these wells (P-6S and MW-4). These observations suggest either that much of mobile NAPL has been removed by the pump and treat system and that NAPL, if still present in the soil column, is immobile and unlikely to reach the River, or that well construction (i.e., well screen slot size, filter sand type, or screened interval) is inhibiting NAPL flow into the well. During the OU1 remediation excavation, observations of sheens along the seawall near low tide suggest mobile NAPL exists along the seawall boundary in the area between MW-4 and MW-5. In addition, immobile NAPL along the seawall represent potential continued sources of dissolved contamination to the River.

Table 2-3 presents a summary of NAPL recovery from monitoring wells at the Site from 1996 to 2014. This table summarizes information regarding all NAPL collected at the Site, both through the pump and treat system and from manual bailing. Prior to 1996, NAPL recovery was not recorded. From 1996 to 2014 approximately 20,900 gallons of NAPL have been recovered. Given that the majority of the NAPL on-Site is DNAPL, it is assumed that the majority of the NAPL recovered is DNAPL.

Comprehensive rounds of well gauging were conducted in April and November 2014, which included measuring water and LNAPL levels in all accessible wells. The water level data is presented in Table 3-1. During these events, the only well along the seawall where LNAPL was observed was MW-4 (both well gauging rounds), which is within 50 ft. of the seawall. Only a sheen was observed in this well during these gauging rounds.

The mechanism for migration of NAPL is different than for groundwater. Whereas groundwater flow directions are based on hydraulic gradients, NAPL migration is driven primary by gravity and capillary pressure, although hydraulic gradients can drive low-density coal tar DNAPL, particularly in gravels. Both LNAPL and DNAPL migrate vertically downward until they reach a condition that restricts further vertical migration. For LNAPL, this is typically the water table surface. LNAPL then migrates along the water table surface, so its direction of migration is the direction of the slope of that surface. Where groundwater is being pumped by the recovery system, the groundwater drawdown will cause LNAPL to move towards the pumping wells within the capture zone. Outside the capture zone of the pumping system, LNAPL will migrate in the direction of the water table's hydraulic gradient. This migration will continue until a point of discharge is reached (at the Site, this point of discharge would be the River) or until all of the LNAPL is adhered to soil grains. As discussed previously, apparent NAPL migration was observed during the OU1 remediation excavation as sheens along the seawall around low tide.

If released to the subsurface in sufficient quantities, DNAPL can migrate vertically downward through the water table until it reaches a geologic unit with lower permeability or until all the DNAPL is dissolved into the less permeable unit and/or adhered to soil grains. At the Site, the top of the silt unit is believed to form a relatively lower permeability layer. Once it reaches the silt unit, if not before, the DNAPL that does not diffuse into or adhere to the silt may migrate down the slope of that surface. Figure 3-25 is a contour map of the top of the silt unit. This contour map indicates that along much of

the seawall, the slope of the silt is inwards towards the Site and not outwards towards the River, which creates a “stratigraphic trap”. On the northeastern end of the Site north of MW-5, available information is more limited, but the top of the silt unit appears to slope to the northeast towards the River and away from the Trench Well and other recovery wells. In the vicinity of RW-4S and WGL-01S, if mobile DNAPL is present, there is the potential for migration towards the River due to the slope of the top of the silt unit in this area. However, there is no information that suggests there may be mobile DNAPL present in this area of the Site. As shown on Figure 3-25, the silt surface topography along the seawall in areas to the northeast beyond well MW-4 and to the southwest beyond well MW-26 is not defined.

DNAPL has also been observed in the confined sand and gravel unit. The DNAPL presumably entered the sand and gravel unit in the northwestern part of the Site where excavations for on-site foundations for MG structures may have created holes in the confining silt unit, or through discontinuities in the overlying silt, as discussed elsewhere in this document. DNAPL has not been observed in wells in the sand and gravel unit near the seawall, nor were there any observations indicating NAPL along the seawall in the sand and gravel unit during drilling of these wells. The closest NAPL is observed in wells in the sand and gravel unit is MW-20, which is located approximately 140 feet from the seawall.

3.2.5 Summary

Figure 3-1 summarizes the elements of the Site CSM. The hydrogeology of the Site controls part, but not all, of the contaminant migration from the landside portion of the Site to the River. The relatively more permeable surficial fill and the sand and gravel units may provide the more obvious migration pathways for dissolved contaminants and coal tar NAPL; however, sandy lenses within the silt unit and the Arundel Clay may also contribute to contaminant transport and long-term sources of dissolved mass to the River despite these units being characterized as aquitards overall. Excavations for on-Site foundations for MG structures may have created holes in the silt unit where coal tar residuals have apparently been able to migrate into the lower sand and gravel unit. Conversely, the silt unit acts as a “cap” over the sand and gravel unit in most areas of the Site, apparently impeding the entry of coal tar contaminants into the lower units. The Arundel Clay is assumed to serve as the impermeable base of the Site hydrogeology, not allowing further downward vertical migration. The seawall also may be an important boundary condition relative to groundwater and contaminant flow into the River. However, recent observations of sheens along the seawall around low tide indicate that NAPL is migrating through the seawall into the River. It is also possible that localized contaminant migration pathways such as sand lenses or NAPL migration exists through these apparent impediments that have not been considered in previous investigations.

3.2.6 Groundwater Data Gaps

The OU2 RI will characterize contaminant mass transport from the landside portion of the Site to the River. Conditions upgradient of the groundwater to surface water discharge boundary further away from the River than the seawall are important for the OU2 RI/FS to the extent that they inform the understanding of how the localized geology, hydrogeology, and river dynamics impact contaminant transport to the River. Therefore, the purpose of further evaluation of the groundwater system is to determine the impacts of Site contamination to the River surface water and sediments.

Contaminants that historically migrated from the Site to the River will be assessed as part of the OU2 RI/FS. The landside investigation addresses potential current and future migration from the Site to the River. On the landside, MG contamination may exist as NAPL and/or dissolved mass in the groundwater system which has the potential to migrate to and reach the River at levels that contribute

to unacceptable risks in the River. The previous section presented the current understanding of the CSM regarding potential migration from the Site to the River. The OU2 RI/FS objectives and the CSM serve as the basis for identifying what additional information is needed to be able to assess potential risks.

As stated in the SOW, additional information on the vertical and horizontal extent of contamination (dissolved and/or NAPL) is needed in the following areas (see Figure 1-1):

- Along the seawall northeast of MW-5;
- Along the seawall southwest of the 12th Street sewer outfall;
- Along the seawall between MW-5 and the 12th Street sewer outfall; and
- North of MW-18 (between MW-18 and MW-10).

To estimate the potential for contaminant transport towards and into the River (mass flux/discharge), it is necessary to understand the nature and extent of dissolved and NAPL impacts, the nature of the hydraulic connection between the River and the groundwater system, and impact of River water level changes on fill unit groundwater quality. The following types of information are needed:

- Hydraulic gradients in groundwater flow zones and relative to the River, including consideration of the gradients created by the groundwater pump and treat system, and the tidal fluctuations in both the River and groundwater, and including synoptic time-series piezometric head measurements in the fill, silt, sand seams in the silt, sand and gravel, and sand seams in the Arundel Clay;
- Hydraulic conductivities, especially where elevated contaminant concentrations are present in groundwater upgradient from the River; and including fill, silt, sand seams in the silt, sand and gravel, and sand seams in the Arundel Clay; and
- Other indicators of hydraulic connection and contaminant transport from the Site to the River, such as groundwater chemistry, velocity measurements/estimates, and extent of NAPL.

Sand lenses or discontinuities within and bordering the confining units (silt unit, Arundel Clay) could be acting as zones of preferential migration and zones for accumulation of diffused contaminant mass. Although this possibility has been evaluated in previous investigations, further evaluation is required by the SOW. Therefore, the presence of these lenses, impacts within the lenses, and the potential for migration within the lenses will be further evaluated in the OU2 RI/FS.

3.3 Anacostia River

The following bullets identify the primary components of the CSM related to the conditions within the River; additional details are provided below the bullets:

- Historical sediment sampling adjacent to the Site indicates that PAHs are present in sediments near the seawall. PAHs are also present throughout the River from a variety of urban sources. The historical Site investigations indicate that detected individual PAH concentrations in the sediments near the Site are variable (ranging from several ppm to in excess of 100 ppm, and diminish with depth. The highest PAH concentrations were found in samples collected during the removal of two WG piers in 2003 (these piers were formerly used for loading coal tar onto vessels). PAHs adjacent to the Site and throughout the river are

routinely found at concentrations in excess of sediment screening values (USEPA Region 3 sediment screening values were used for this comparison).

- The nature and extent of Site-related impacts is not currently defined.
- It is unknown whether or not conditions in the River pose a potential risk to human health or the environment from OU2 related COPCs.
- The River is in an urban watershed with multiple sources of COPCs. The extensive studies of the River that have been conducted have demonstrated that PCBs, PAHs, metal, and (to a lesser degree) VOCs are found in sediment samples collected throughout the River, upstream and downstream of the Site. The sources of these COPCs have been attributed to industrial discharges, urban runoff and stormwater, and CSOs.

One of the requirements of the OU2 RI/FS is to assess the potential for risk associated with exposure to Site-related contaminants in River sediments and surface water. The CSM for the River was developed by integrating the data collected during the past studies near the Site and the regional studies of the River. Summarizing the available River data and identifying data gaps is also a required work item in the SOW.

The Site has been cited in certain of these studies as a potential contributing source to some of the contaminants, including PAHs, observed in River sediments. PCBs are not typical MG contaminants and NOAA (2009) and AWTA (2002) did not identify the Site as a potential contributing source of PCBs. Therefore, unless present in NAPL or NAPL-saturated soil samples collected during the landside investigation, PCBs are not included as COPCs for the WG East Station Site. Based on the results of these studies, PAHs, other SVOCs, select inorganic contaminants, cyanide, and VOCs are considered sediment COPCs at the Site, but may also be present in the River due to sources other than the Site.

In evaluating the potential risk associated with exposure to the COPCs related to the Site, other sources of these contaminants must also be evaluated. Many of the COPCs, particularly PAHs and metals, are found in typical urban runoff and in stormwater, and in CSO discharges. Distinguishing the contribution from urban anthropogenic sources from the potential contribution from the Site is one of the goals for the OU2 RI/FS, and fingerprinting or similar analytical evaluations are required in the SOW.

3.3.1 Anacostia River System

The Anacostia River watershed encompasses an area of approximately 176 square miles (mi^2) within the District of Columbia and Maryland, and lies within two physiographic provinces, the Piedmont Plateau and the Coastal Plain. The River begins in Bladensburg, Maryland, at the confluence of its two major tributaries, the Northwest Branch and the Northeast Branch, and flows a distance of approximately 8.4 miles (mi) before it discharges into the Potomac River in the District (Sullivan and Brown, 1988). The majority of the watershed is urban. Geographic Information System (GIS) layers developed by the Metropolitan Washington Council of Governments (MWCOG) indicate that land use in the watershed is approximately 43% residential, 11% industrial/commercial, 27% forest or wetlands, and the remainder of the watershed is agricultural, institutional, water and other miscellaneous uses. The MWCOG GIS data also indicate that 22.5% of the watershed area is covered by impervious surfaces (MWCOG, 1997).

The River is a freshwater estuary, with tidal influences extending upstream into the Northeast and the Northwest Branches. The variation in the River's water surface elevation over a tidal cycle is

approximately 3 ft. (Hydro-Terra, 1999). The width of the River varies from approximately 197 ft. in some upstream reaches to approximately 1,640 ft. near the confluence with the Potomac River, and average channel depths vary from about 5.2 ft. near Bladensburg to about 20.3 ft. just downstream of the South Capitol Street Bridge, approximately 5,000 ft. downstream of the Site. During base flow conditions, measured flow velocities during the tidal cycle have been in the range of 0 to 1 ft./ sec (Katz et al., 2001).

In the general area of the Site, the tidal estuary is fresh water with a river width of approximately 800 ft., an approximately 3-ft. tidal cycle, and water depths ranging from approximately 3.6 ft. to 5.0 ft. below Mean Lower Low Water (MLLW). The River adjacent to the Site is part of the USACE Washington Harbor operation and maintenance project which addresses sedimentation of the River and maintains the condition of the River suitable for navigation. The River portion of this maintenance project extends from the confluence with the Potomac River to approximately 1,500 ft. upstream of the Site. The location of the dredged channel is shown on the property map on Figure 1-1. The channel is shown as four lines on this figure: the edge of the channel (outer two lines) and edge of the design bottom dredge elevation (middle two lines). The maintenance project includes a 400-square foot (ft^2) turning basin upstream of the Site and authorized channel dimensions adjacent to the Site of 200 ft. wide and 24 ft. deep (USACE, 2007). The USACE fact sheet (USACE, 2007) reports that the channel was last dredged in 1985 and the last channel condition survey was conducted in 2011. The results of the condition survey show that river depth outside, but adjacent to the channel at the former 11th Street Bridge ranged from 7 to 11 feet. The NOAA charts (NOAA, 2007) also show that the minimum channel depth along the entire length of the channel is approximately 5 ft. Therefore, it appears that the channel depth adjacent to the Site is likely around 10 ft. USACE mapping shows that the channel is located as close as approximately 55 linear feet from the seawall within 100 ft. (50 to 75 ft.) of the seawall at the Site (NOAA, 2007).

With European settlement, the forested Anacostia River watershed was progressively cleared for agricultural use, which increased the sediment loading to the River. During the industrial revolution in the nineteenth century, urbanization and associated loss of forested and wetland areas further increased the sediment loading to the River. Sedimentation occurring in the channel is discussed further in Section 3.3.4. Industrialization also resulted in industrial waste discharges, nonpoint source discharges, and CSO discharges to the River (MWCOG, 2009). Although efforts have been and continue to be underway to reduce the sources of these discharges to the River, these discharges continue today and are likely to continue into the foreseeable future.

3.3.2 Sediment Chemistry Data

The CSM for the River adjacent to the Site was developed using the findings of historical sediment studies, current understanding of the hydrodynamic systems as well as the ERA conducted by Hydro-Terra (1999). Much of the sediment data available adjacent to the Site and in the area of the Site are surface sediment data with little subsurface sampling conducted.

<u>Sediments in Vicinity of WG East Station Site</u>

From 1988 through 2005, at least eight sediment sampling events were conducted in River sediments in the vicinity of the Site (Hydro-Terra, 2005). The Hydro-Terra 2005 summaries of these investigations are included in Appendix A of this RI/FS Work Plan. WG did not conduct all of these studies, the sampling methods and analytical methodologies vary from study to study, and the studies span a period of nearly two decades. The summary provided in Appendix A does not include the Washington Navy Yard OU2 Investigation completed while this Work Plan was being prepared. The

data will be reviewed and considered as part of the Technical Memorandum written after the landside investigation in preparation for the in-river investigation.

These investigations indicate that detected individual PAH concentrations in the sediments near the government property are variable but range from a low of 4 to 5 ppm to a high of well in excess of 100 ppm. The highest PAH concentrations were generally found in samples collected during the removal of two WG piers in 2003 (one pier was used for unloading coal and loading coal tar onto vessels; the other pier was used to support water intake pipes for the former East Station pump house). Individual PAH concentrations of 20 to 60 ppm are common. Sample depths vary and generally are shallow, typically 0 to 6 inches below the sediment surface. The sampling program for removal of the two WG piers also collected samples from 7 to 18 inches below the sediment surface.

BTEX was sampled at some sediment sample locations. When sampled, BTEX was either not detected or was detected at low concentrations (individual contaminants ranging up to1.6 ppm). Similar to the PAH samples, sample depths were generally shallow (0 to 6 inches below the sediment surface).

Some sediment locations were also sampled for total cyanide. When sampled, cyanide was either not detected or was detected at concentrations up to 48.8 ppm. These sediment samples were also collected from 0 to 6 inches below the sediment surface.

Sediments within One Mile of WG East Station Site

To expand the view of sediment concentrations and to present a localized summary of PAH concentrations, the results of sediment sampling contained in the NOAA DARRP Anacostia River database within 1 mi of the government property (both upstream and downstream) were reviewed. Fifteen studies were identified and the interpretation of the more localized existing sediment quality data for PAHs is summarized below. These investigations indicate that the total PAH concentrations in the sediments within one mi of the government property are variable but range from a low of non-detect (detection limits are not included in the database for some studies, particularly older studies) to a high of 211 ppm. A majority of the sampling locations contained less than 70 ppm total PAHs. These data, which are presented as a concentration map in Figure 3-26, indicate that the concentrations of PAHs in sediment within one mi of the government property are generally similar to those in the immediate vicinity of the government property, with the possible exception of eight sediment samples collected close to the seawall adjacent to the government property. These eight samples appear to have elevated total PAH concentrations relative to those nearer the middle of the River.

3.3.3 Sediment Toxicity Data

Site-specific sediment toxicity sampling and analysis for sediments adjacent to the Site has not been conducted. Additionally, data needed to support the sediment toxicity tests, such as pore water analysis for PAHs and Simultaneously Extracted Metals/Acid-Volatile Sulfide (SEM/AVS) sampling, has not yet been performed. Sediment toxicity data and supporting data, therefore, represent a data gap.

3.3.4 Sedimentation Rates

Sedimentation has been a problem to navigation in the tidal River since colonial times (Scatena, 1987). Estimated average annual sediment discharge into the tidal embayment of the River was 134,420 tons in 1963 and 137,600 tons in 1981 (Scatena, 1987). Because of the low flow velocities in

the tidal portion of the River, the majority of sediment entering the tidal embayment is thought to settle and remain in the tidal River, rather than being discharged to the Potomac River.

Based on a variety of methods, including analyses of historical bathymetry records, dredging records, and pollen profiles of sediment bed core samples, Scatena (1987) estimated sedimentation rates in the range of 0.5 to 3.6 inches/year. Velinsky et al. (2011) estimated sedimentation rates in the range of 1.1 to 2.8 inches/year based on contaminant profiling and radioisotope sampling. Velinsky's study was conducted immediately downstream of the Site.

A federal navigation channel is present in the River adjacent to the Site. In 1902, Congress authorized dredging of the River. The authorized dredge area extends from the confluence of the River with the Potomac River to just upriver of the government property. This channel has an authorized project depth of 24 ft. below MLLW. According to the USACE records, the channel was last dredged in 1985 and the last channel condition survey was conducted in 2012 (NOAA, 2013). The results of the condition survey show that river depth outside, but adjacent to the channel at the former 11th Street Bridge ranged from 7 to 11 feet. The NOAA charts (NOAA, 2007) also show that the minimum channel depth along the entire length of the channel is approximately 5 ft. Therefore, it appears that the channel depth adjacent to the Site is likely around 10 ft. USACE mapping shows that the channel is located as close as approximately 55 linear feet from the seawall at the Site (NOAA, 2007).

3.3.5 Surface Water Concentration Data

Surface water sampling of the River has not been conducted as extensively as sediment sampling and the NOAA DARRP database does not include surface water data. Some of the other environmental sites along the River may have collected surface water samples, but if collected, this data is not readily available.

Surface water samples were collected adjacent to the Site and upgradient of the Site during the RI Report (Hydro-Terra, 1999). Surface water samples were collected at ten locations on outgoing tides. These samples were analyzed for TAL metals, TCL, VOCs, SVOCs, and total cyanide. No VOCs, SVOCs, or cyanide were detected in the surface water samples. Iron was detected above USEPA fresh water quality criteria at two locations: one next to the Site and one upstream of the Site. Lead was also above the USEPA fresh water criteria at locations adjacent to the Site and at one upstream of the Site.

3.3.6 Beneath the River Groundwater Data

Groundwater samples have not been collected from the water-bearing units present beneath the River. If the OU2 RI demonstrates that landside groundwater is discharging to the River through water-bearing units beneath the River, the nature and extent of contamination within these units is a data gap.

3.3.7 Anacostia River Data Gaps

There is uncertainty associated with sediment COPCs originating from the Site, due to potential contributions from other sources, the nature of the tidal River system, and sediment deposition. After a review of Site-related documents, the following types of information are needed to reduce these uncertainties:

- The horizontal and vertical extent of COPC-contaminated sediment proximate to the Site requires further delineation.
- No data regarding the nature and extent of COPC-contaminated groundwater from beneath the River proximate to the Site have been collected.
- No sediment toxicity testing data are available to evaluate potential toxicity associated with exposure to surficial sediments.
- No data regarding SEM/AVS, surficial sediment pore water, sediment total organic carbon (TOC), pH, and other similar data used to evaluate bioavailability of COPCs have been reviewed for this Work Plan, although the 2011 Washington Navy Yard OU2 Investigation, completed while this Work Plan was being prepared, included relevant analyses.
- The source(s) of COPCs in sediments proximate to the Site have not been adequately determined.

3.4 Ecological Conceptual Site Model

The CSM for the Ecological Risk Assessment (ERA) is focused on the surface water and sediments of the River adjacent to the Site. The CSM is provided in detail in Appendix C, which includes the work plan for the ERA. The ERA CSM describes the origin (sources) of COPCs, as well as potential transport pathways, exposure pathways, and receptors. The CSM is developed as part of the ERA Problem Formulation, and will be updated as more data become available through the implementation of OU2 RI/FS activities.

3.5 Human Health Conceptual Site Model

The Human Health CSM provides the basis for the development of the HHRA. The HHRA CSM is provided in detail in Appendix D, which includes the work plan for the HHRA. The HHRA will evaluate potential risks to human receptors (recreational receptors and workers) in the River. The plan of study includes data collection to address data gaps related to evaluation of potential exposure and risk (e.g., sediment sampling, in the context of the urban River).

Table 3-1
Well Construction Information and 2014 Groundwater Gauging Information
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Well Construction Information						April 2014 (HIGH TIDE)		November 2014 (LOW TIDE)	
Well	Measuring Point Elevation (ft AMSL) (a)	Total Well Depth (ft bgs)	Screened Interval (ft bgs)	Screened Inteval (ft AMSL)	Screened Within	Depth to Water (ft)	Groundwater Elevation (ft AMSL)	Depth to Water (ft)	Groundwater Elevation (ft AMSL)
MW-3	17.68	61	52-61	-34.32 to -43.32	Sand and Gravel	19.2	-1.52	NM	NM
MW-4	8.85	16	5-13	3.85 to -4.15	Fill	7.91	0.94	8.35	0.50
MW-5	4.07	8	3-8	1.07 to -3.93	Fill	2.98	1.09	3.62	0.45
MW-6	3.84	54	34-54	-30.16 to -50.16	Sand and Gravel	3.33	0.51	3.41	0.43
MW-7	5.88	13	5-13	0.88 to -7.12	Fill	5.78	0.1	6.05	-0.17
MW-8	6.96	55	45-55	-38.04 to -48.04	Sand and Gravel	NM	NM	NM	NM
MW-11	14.99	14	4-14	10.99 to 0.99	Fill	14.84	0.15	15.33	-0.34
MW-12	16.76	25	13-25	3.76 to -8.24	Fill	NM	NM	NM	NM
MW-18	4.7	14	4-9	0.7 to -4.3	Fill	4.88	-0.18	4.57	0.13
MW-19	5.34	10	5-8	0.34 to -2.66	Fill	5.16	0.18	5.26	0.08
MW-20	6.73	62.5	47-57	-40.27 to -50.27	Sand and Gravel	7.51	-0.78	20.82	-14.09
MW-21	14.45	32	22-27	-7.55 to -12.55	Fill	12.05	2.4	13.18	1.27
MW-22	14.57	29	19-24	-4.43 to -9.43	Fill	NM	NM	13.44	1.13
MW-23	3.47	16	9.5-11	-6.03 to -7.53	Fill	2.65	0.82	5.39	-1.92
MW-24	3.61	8.5	3.5-6	0.11 to -2.39	Fill	2.47	1.14	3.40	0.21
MW-25	4.68	74	44-64	-39.32 to -59.32	Clay	5.41	-0.73	5.46	-0.78
MW-27	4.03	13	3-13	1.03 to -8.97	Fill	4.46	-0.43	4.16	-0.13
MW-28	4.15	13	3-8	1.15 to -3.85	Fill	4.65	-0.5	4.26	-0.11
MW-29	4.17	9	4-9	0.17 to -4.83	Fill	2.17	2	3.30	0.87
MW-31	4.73	66	46-56	-41.27 to -51.27	Sand and Gravel	5.49	-0.76	5.57	-0.84
P-1S	13.96	24	19-24	-5.04 to -10.04	Fill	NM	NM	12.83	1.13
P-2S	13.87	20	15-20	-1.13 to -6.13	Fill	NM	NM	12.64	1.23
P-3S	19.3	15	10-15	9.3 to 4.3	Fill	14.52	4.78	12.70	6.60
P-5S	4.47	9	4-9	0.47 to -4.53	Fill	2.11	2.36	3.65	0.82
P-6S	4.11	10	5-10	-0.89 to -5.89	Fill	4.05	0.06	4.35	-0.24
P-7S	6.71	13	8-13	-1.29 to -6.29	Fill	6.61	0.1	6.97	-0.26
P-11S	6.71	16	11-16	-4.29 to -9.29	Fill	6.69	0.02	NM	NM
RW-1	12.02	Unknown	Unknown	Unknown	Fill	NM	NM	15.90	NM
RW-2	11.77	Unknown	Unknown	Unknown	Fill	NM	NM	13.00	NM
RW-3	12.12	Unknown	Unknown	Unknown	Sand and Gravel	NM	NM	14.00	NM
RW-4S	6.17	18.5	8.5-13.5	-2.33 to -7.33	Fill	4.89	1.28	6.10	0.07
RW-5S	7.22	22	6.5-16.5	0.72 to -9.28	Fill	4.66	2.56	5.91	1.31
RW-6S	7.12	22	6.5-16.5	0.62 to -9.38	Fill	NM	NM	7.62	NM
RW-7S	7.55	16.5	11-21	-3.45 to -13.45	Fill	NM	NM	8.00	NM
WGL-01D	7.43	56	35-55	-27.57 to -47.57	Sand and Gravel	7.68	-0.25	7.50	-0.07
WGL-01S	6.94	19	4-19	2.94 to -12.06	Fill	7.19	-0.25	7.28	-0.34
WGL-02D	9.31	60	40-60	-30.69 to -50.69	Sand and Gravel	10.2	-0.89	13.26	-3.95
WGL-02S	12.77	24	9-24	3.77 to -11.23	Fill	9.48	3.29	11.46	1.31
WGL-03D	10.75	55	35-55	-24.25 to -44.25	Sand and Gravel	11.51	-0.76	11.65	-0.90
WGL-03S	9.33	28	13-28	-3.67 to -18.67	Fill	9.35	-0.02	10.10	-0.77
WGL-04D	17.19	59	39-59	-21.81 to -41.81	Sand and Gravel	16.5	0.69	17.41	-0.22

Notes:
(a) Measuring point elevation taken from Table 1, Second Three-Year Review and Evaluation of Ground Water Pumping and Treatment at the East Station Site, March 2007. Measuring point elevations will be resurveyed as part of the OU2 RI/FS field effort.
AMSL - Above mean sea level.
bgs - Below ground surface.
ft - Feet.
NM - Not Measured.
Washington Naval Yard (tidesandcurrents.noaa.gov)
- April 16, 2014 high tide 3.42 ft. at 09:39 am
- November 17, 2014 low tide 0.3 ft. at 10:18 am

Table 3-2
Summary of Detected Contaminants in November 2014 Groundwater Samples in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

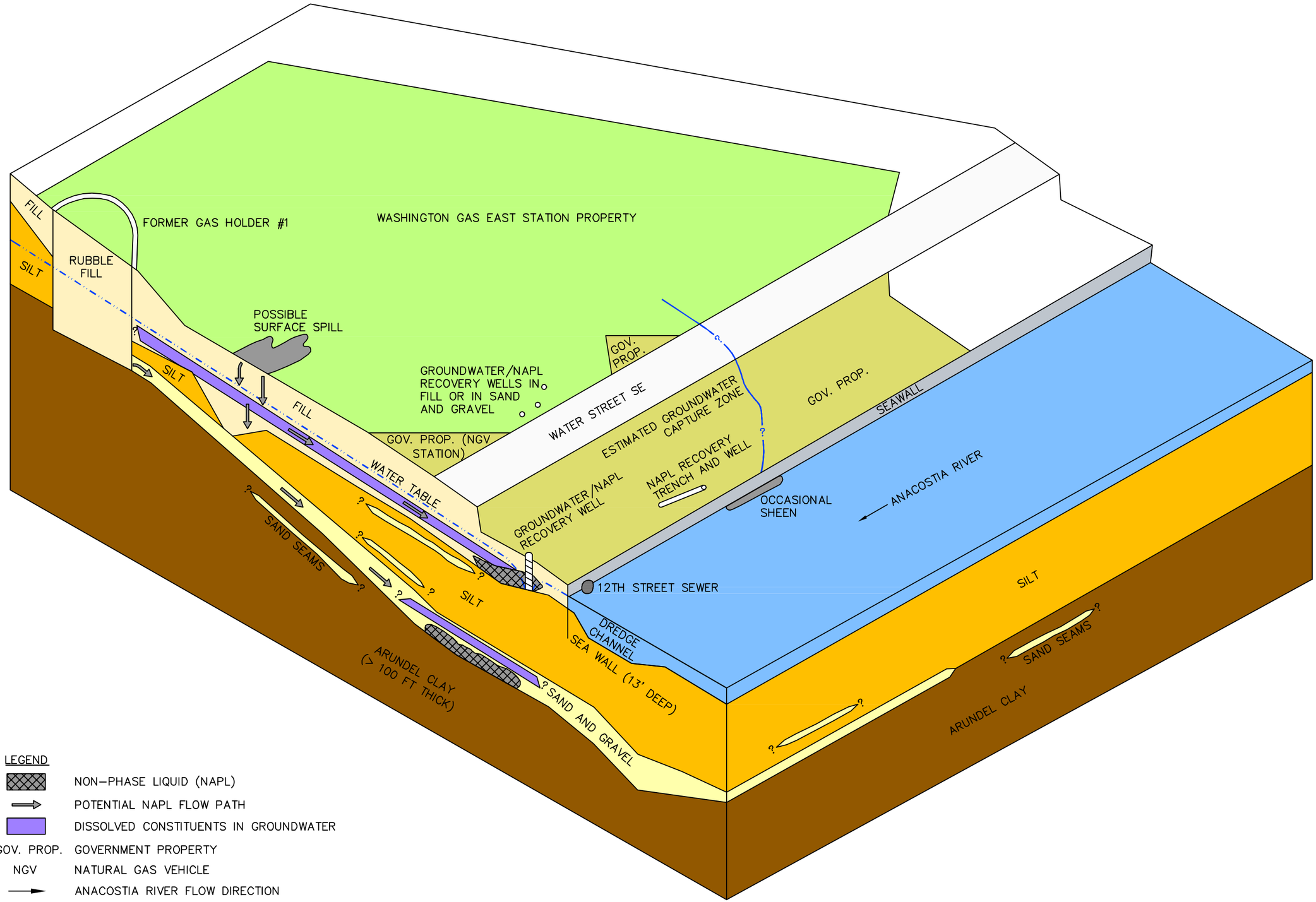
	Sample Designation	MW-4	MW-5	MW-18	MW-23	MW-27	MW-28	MW-29	MW-29	P-6S	WGL-02S
	Sample Date	11/19/2014	11/18/2014	11/18/2014	11/20/2014	11/19/2014	11/19/2014	11/19/2014	11/19/2014	11/18/2014	11/19/2014
	Units								Duplicate		
INORGANICS											
ARSENIC	ug/l	**0.78 J**	**0.71 J**	**1.1 J**	**9**	**0.84 J**	**1.3 J**	**2.8 J**	**2.9 J**	**3.2 J**	**2.1 J**
BARIUM	ug/l	**350 B**	**190 B**	**110 B**	**170 B**	**56 B**	**82 B**	**56 B**	**54 B**	**340 B**	**95 B**
CADMIUM	ug/l	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**0.065 J**	< 1.0
CHROMIUM	ug/l	**0.80 J**	**1.3 J**	**0.46 J**	**0.90 J**	**0.21 J**	**0.36 J**	**1.2 J**	**1.2 J**	**1.4 J**	**8.4**
LEAD	ug/l	< 1.0	< 1.0	**2.5 B**	< 1.0	**0.27 JB**	**0.14 JB**	< 1.0	< 1.0	< 1.0	**4.1 B**
SELENIUM	ug/l	**0.43 J**	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	**0.29 J**	**0.50 J**
CYANIDE	mg/l	**0.31**	**0.34**	**0.034**	**0.22**	**0.0048 J**	**0.029**	**0.29**	**0.33**	**1.2**	**2.1**
VOLATILES											
1,2,4-TRIMETHYLBENZENE	ug/l	< 1.0	**8.7**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 5.0	< 1.0
1,3,5-TRIMETHYLBENZENE	ug/l	< 1.0	**8.9**	< 1.0	**0.86 J**	< 1.0	**1.7**	**1.2**	**1.1**	< 5.0	< 1.0
2-CHLOROTOLUENE	ug/l	< 1.0	< 6.7	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.2 J**	< 1.0
ACETONE	ug/l	< 10	< 67	< 10	< 10	< 10	< 10	**3.6 J**	< 10	< 50	< 10
BENZENE	ug/l	< 1.0	**120**	< 1.0	**1.7**	< 1.0	**1.2**	**2.4**	**2.4**	**86**	**9.5**
CARBON DISULFIDE	ug/l	**0.70 J**	< 6.7	< 1.0	< 1.0	< 1.0	< 1.0	**0.31 J**	**0.32 J**	< 5.0	< 1.0
CYCLOHEXANE	ug/l	**0.37 J**	**2.9 J**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 5.0	< 1.0
CYMENE	ug/l	< 1.0	< 6.7	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**2.2 J**	< 1.0
ETHYLBENZENE	ug/l	< 1.0	**32**	< 1.0	< 1.0	< 1.0	**0.48 J**	**0.84 J**	**0.92 J**	**7.1**	**1.3**
ISOPROPYLBENZENE	ug/l	**3.8**	**19**	< 1.0	**3.2**	< 1.0	**1.3**	**0.40 J**	**0.39 J**	**33**	**0.87 J**
METHYL TERT-BUTYL ETHER (MTBE)	ug/l	**0.39 J**	< 6.7	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 5.0	< 1.0
METHYLCYCLOHEXANE	ug/l	< 1.0	**3.7 J**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 5.0	< 1.0
N-BUTYLBENZENE	ug/l	< 1.0	< 6.7	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**2.9 J**	< 1.0
N-PROPYLBENZENE	ug/l	< 1.0	**12**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**7.6**	< 1.0
S-BUTYLBENZENE	ug/l	**0.69 J**	< 6.7	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 5.0	< 1.0
TOLUENE	ug/l	< 1.0	< 6.7	< 1.0	**0.29 J**	< 1.0	< 1.0	< 1.0	< 1.0	**3.2 J**	**0.22 J**
TOTAL XYLENES	ug/l	< 2.0	**8.7 J**	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	**5.3 J**	**0.44 J**
SEMIVOLATILES											
2-METHYLNAPHTHALENE	ug/l	< 0.38	**0.64**	< 0.20	< 0.19	< 0.19	< 0.19	< 0.19	< 0.19	**18**	< 0.19
ACENAPHTHENE	ug/l	**42**	**43**	**1.1**	**39**	**1.4**	**5.4**	**1.4**	**1.3**	**50**	**2.5**
ACENAPHTHYLENE	ug/l	< 0.38	**1.7**	< 0.20	< 0.19	< 0.19	< 0.19	< 0.19	< 0.19	**2.8**	**0.46**
ACETOPHENONE	ug/l	< 1.9	< 1.9	< 1.0	**0.41 J**	< 0.95	**0.44 J**	**0.52 J**	**0.54 J**	**2.1**	< 0.95
ANTHRACENE	ug/l	**2.3**	**2.7**	< 0.20	**1.5**	< 0.19	**0.26**	**0.37**	< 0.19	**7.7**	**0.21**
BENZO[A]ANTHRACENE	ug/l	< 0.38	**0.22 J**	< 0.20	< 0.19	< 0.19	< 0.19	< 0.19	< 0.19	**0.34 J**	< 0.19
BENZO[A]PYRENE	ug/l	< 0.38	< 0.38	< 0.20	< 0.19	< 0.19	< 0.19	< 0.19	< 0.19	< 0.38	**0.2**
BIS(2-ETHYLHEXYL)PHTHALATE	ug/l	< 9.5	< 9.5	**3.4 J**	< 4.8	< 4.8	< 4.8	< 4.8	< 4.8	**3.3 J**	< 4.8
CAPROLACTAM	ug/l	< 9.5	< 9.5	**4.0 JB**	**1.2 JB**	**0.54 JB**	**0.51 JB**	< 4.8	< 4.8	< 9.5	< 4.8
CARBAZOLE	ug/l	< 1.9	**9.8**	< 1.0	< 0.96	< 0.95	< 0.95	< 0.96	< 0.96	< 1.9	**0.36 J**
CHRYSENE	ug/l	< 0.38	**0.21 J**	< 0.20	< 0.19	< 0.19	< 0.19	< 0.19	< 0.19	**0.22 J**	< 0.19
DIBENZOFURAN	ug/l	< 1.9	**4.4**	< 1.0	**0.43 J**	< 0.95	**0.20 J**	< 0.96	< 0.96	**3.5**	**0.23 J**
FLUORANTHENE	ug/l	**2.6**	**2.2**	< 0.20	**0.69**	**0.15 J**	**0.23**	**0.55**	**0.4**	**2.5**	**0.33**
FLUORENE	ug/l	**18**	**26**	< 0.20	**9.4**	**0.18 J**	**3.5**	**1**	**0.96**	**31**	**0.95**
NAPHTHALENE	ug/l	< 0.38	**5.6**	< 0.20	**0.21**	< 0.19	**0.42**	< 0.19	< 0.19	**3.7**	**0.51**
PHENANTHRENE	ug/l	< 0.38	**31**	< 0.20	**0.96**	< 0.19	**0.11 J**	< 0.19	< 0.19	**33**	< 0.19
PYRENE	ug/l	**3.4**	**2.9**	**0.22**	**0.84**	**0.24**	**0.34**	**1.1**	**0.79**	**3.5**	**0.65**
TOTAL PAHs	ug/l	**68**	**120**	**1.3**	**53**	**2**	**10**	**4.4**	**3.5**	**150**	**5.8**

Notes:
B = compound found in blank and sample
J = result between method detection limit and quantitation limit and is estimated
< indicates non-detect
Compounds not detected in at least one sample are not shown on table

Table 3-3
Summary of Detected Contaminants in November 2014 Groundwater Samples in Sand and Gravel
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

	Sample Designation	MW-6	MW-20	MW-25	MW-31	WGL-01D	WGL-03D
	Sample Date	11/19/2014	11/18/2014	11/20/2014	11/18/2014	11/18/2014	11/19/2014
	Units						
INORGANICS							
ARSENIC	ug/l	**1.6 J**	**0.58 J**	**9.3**	**0.84 J**	**0.71 J**	**2.6 J**
BARIUM	ug/l	**540 B**	**200 B**	**240 B**	**220 B**	**410 B**	**210 B**
CADMIUM	ug/l	< 1.0	**0.26 J**	< 1.0	< 1.0	**0.12 J**	**0.15 J**
CHROMIUM	ug/l	**0.42 J**	**0.80 J**	**0.62 J**	**0.37 J**	**0.42 J**	**0.32 J**
LEAD	ug/l	< 1.0	**0.16 JB**	< 1.0	< 1.0	< 1.0	**0.13 JB**
SELENIUM	ug/l	< 5.0	**0.34 J**	< 5.0	< 5.0	< 5.0	< 5.0
CYANIDE	mg/l	**0.0037 J**	< 0.010	< 0.010	**0.0024 J**	**0.0037 J**	**0.0021 J**
VOLATILES							
ACETONE	ug/l	< 10	< 10	< 10	< 10	< 10	**4.7 J**
BENZENE	ug/l	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**0.78 J**
CYCLOHEXANE	ug/l	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**0.74 J**
ISOPROPYLBENZENE	ug/l	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**6.1**
METHYL TERT-BUTYL ETHER (MTBE)	ug/l	**7.0**	**0.44 J**	< 1.0	< 1.0	**3.5**	< 1.0
METHYLCYCLOHEXANE	ug/l	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.1**
N-PROPYLBENZENE	ug/l	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**0.55 J**
TOTAL XYLENES	ug/l	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	**0.82 J**
SEMIVOLATILES							
ACENAPHTHENE	ug/l	**7.2**	**0.59**	**4.6**	**3.4**	**1.8**	**20**
ANTHRACENE	ug/l	< 0.19	< 0.19	< 0.19	< 0.19	< 0.19	**0.21**
BENZO[A]ANTHRACENE	ug/l	< 0.19	< 0.19	< 0.19	< 0.19	< 0.19	**0.58**
BENZO[A]PYRENE	ug/l	< 0.19	< 0.19	< 0.19	< 0.19	< 0.19	**0.42**
BENZO[B]FLUORANTHENE	ug/l	< 0.19	< 0.19	< 0.19	< 0.19	< 0.19	**0.44**
BENZO[K]FLUORANTHENE	ug/l	< 0.19	< 0.19	< 0.19	< 0.19	< 0.19	**0.25**
BIS(2-ETHYLHEXYL)PHTHALATE	ug/l	< 4.8	**3.8 J**	< 4.8	**3.4 J**	**3.0 J**	< 5.1
CAPROLACTAM	ug/l	< 4.8	**1.6 JB**	**0.38 JB**	**1.3 JB**	**0.99 JB**	< 5.1
CHRYSENE	ug/l	< 0.19	< 0.19	< 0.19	< 0.19	< 0.19	**0.50**
FLUORANTHENE	ug/l	**0.13 J**	< 0.19	< 0.19	< 0.19	< 0.19	**0.54**
FLUORENE	ug/l	**0.53**	< 0.19	< 0.19	< 0.19	< 0.19	**3.1**
PHENANTHRENE	ug/l	**1.1**	< 0.19	**0.40**	< 0.19	< 0.19	**3.2**
PYRENE	ug/l	**0.18 J**	< 0.19	< 0.19	< 0.19	< 0.19	**1.2**
TOTAL PAHs	ug/l	**9.1**	**0.59**	**5**	**3.4**	**1.8**	**30**

Notes:
B = compound found in blank and sample
J = result between method detection limit and quantitation limit and is estimated
< indicates non-detect
Compounds not detected in at least one sample are not shown on table



AECOM

Figure: 3-1

CONCEPTUAL SITE MODEL
OPERABLE UNIT 2 - REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.3 Date: 2015-03-31

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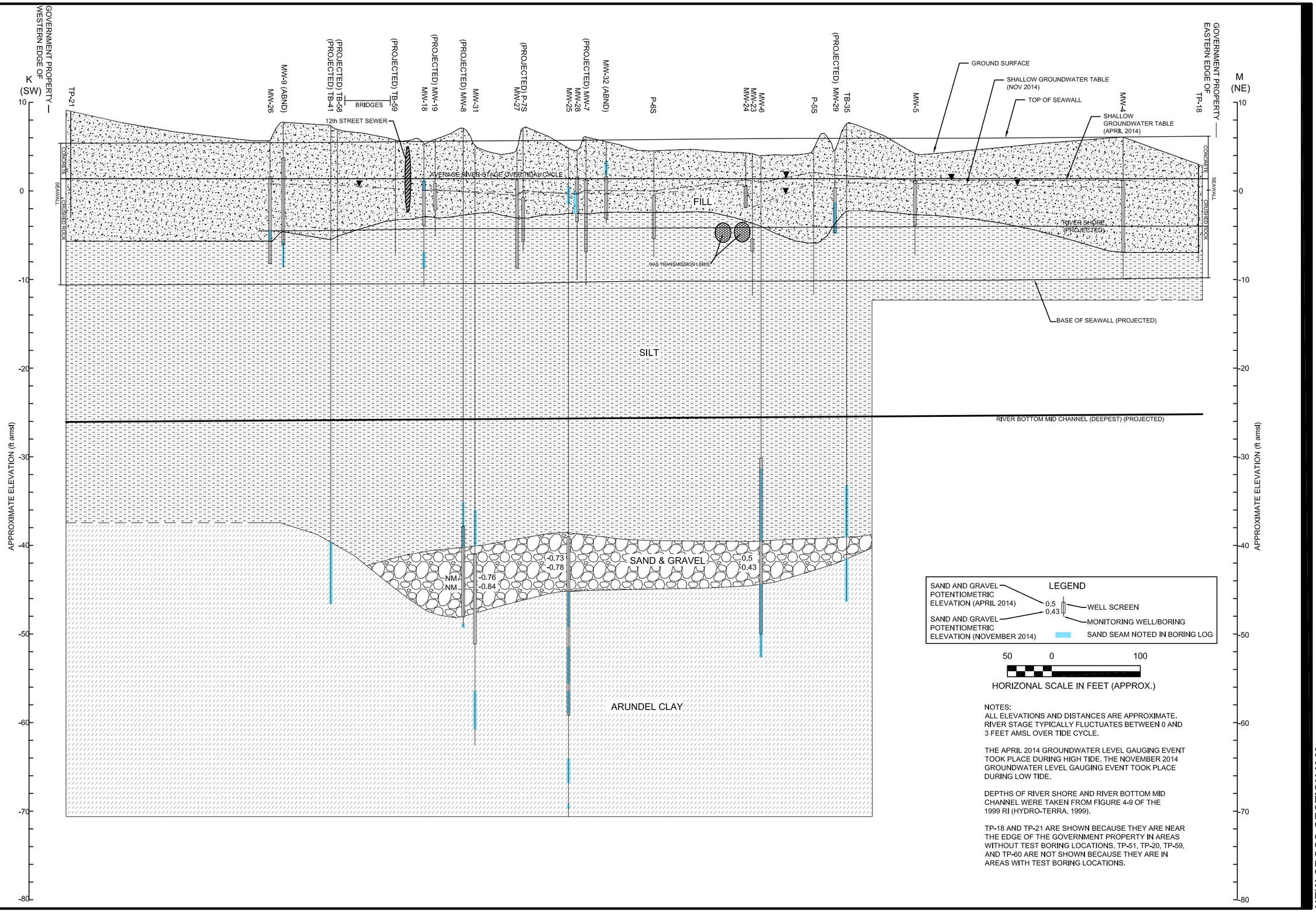

NOTES:
ALL ELEVATIONS AND DISTANCES ARE APPROXIMATE. RIVER STAGE TYPICALLY FLUCTUATES BETWEEN 0 AND 3 FEET AMSL OVER TIDE CYCLE.

THE APRIL 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING HIGH TIDE. THE NOVEMBER 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING LOW TIDE.

DEPTHS OF RIVER SHORE AND RIVER BOTTOM MID CHANNEL WERE TAKEN FROM FIGURE 4-9 OF THE 1999 RI (HYDRO-TERRA, 1999).

TP-18 AND TP-21 ARE SHOWN BECAUSE THEY ARE NEAR THE EDGE OF THE GOVERNMENT PROPERTY IN AREAS WITHOUT TEST BORING LOCATIONS. TP-51, TP-20, TP-59, AND TP-60 ARE NOT SHOWN BECAUSE THEY ARE IN AREAS WITH TEST BORING LOCATIONS.

NEW CROSS-SECTION K-M
PARALLEL TO THE ANACOSTIA RIVER
OPERABLE UNIT 2 - REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.8 Date: 2015-03-31

AECOM

Figure: 3-2

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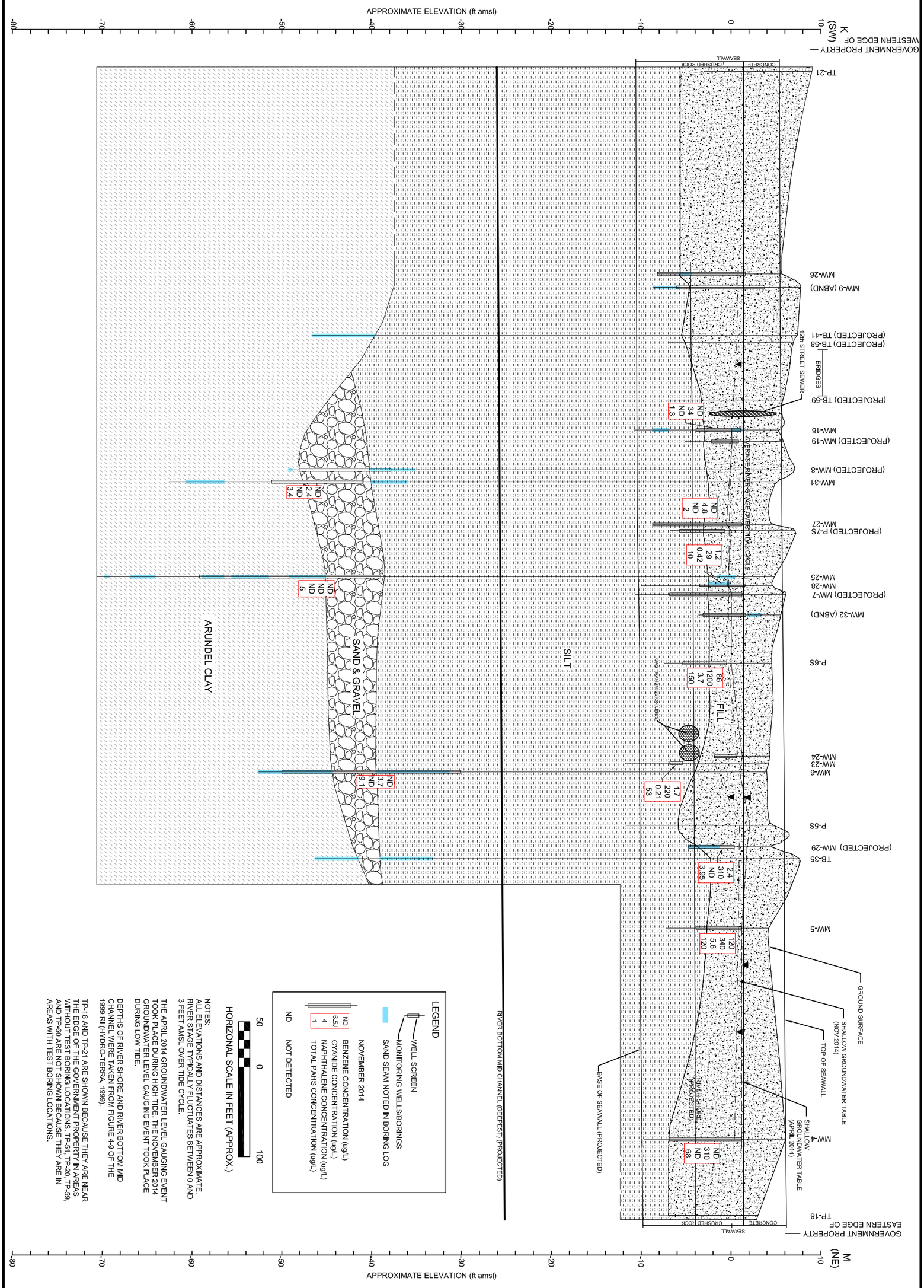
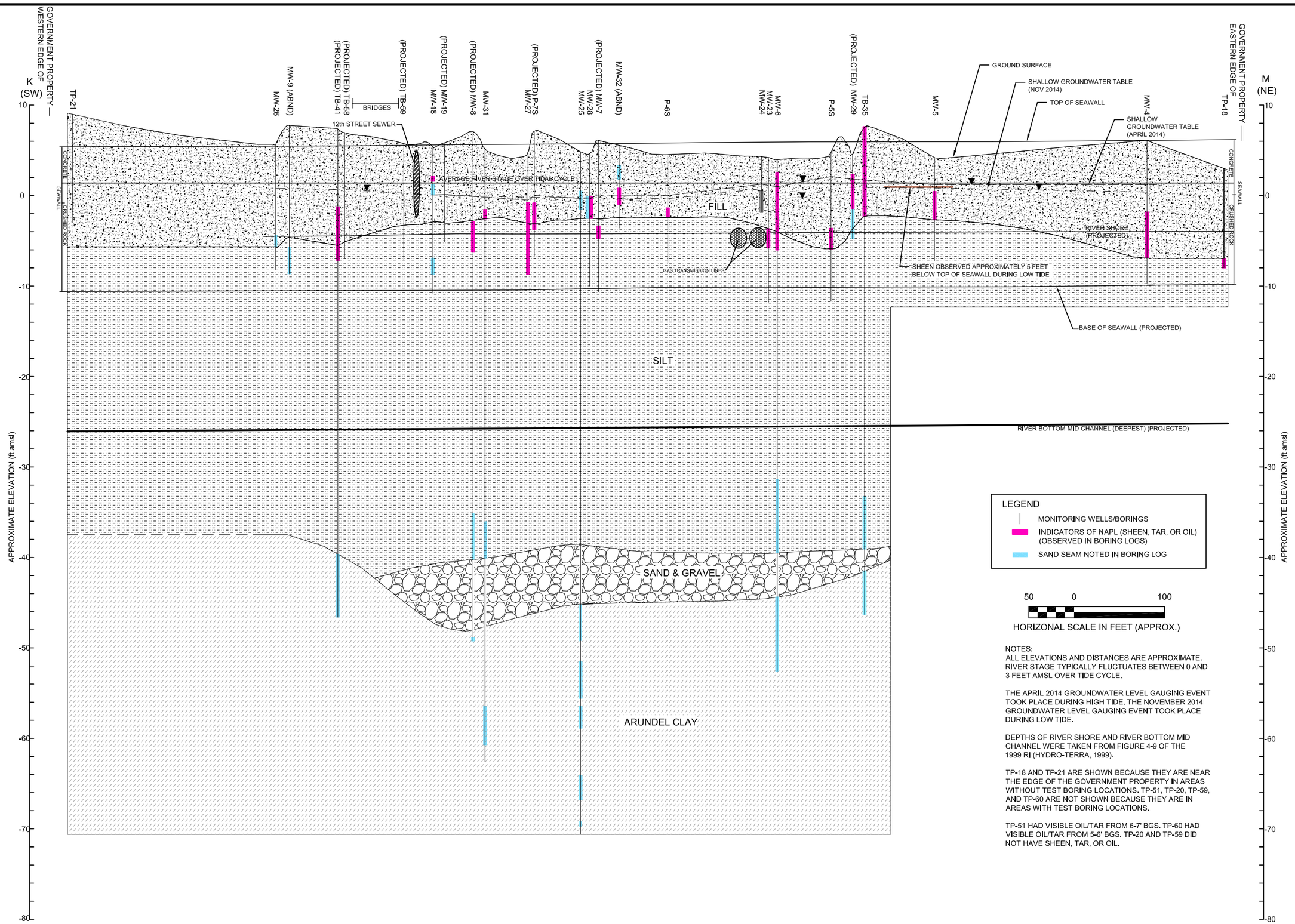


CONCENTRATIONS OF BENZENE, NAPHTHALENE, TOTAL PAHs, AND CYANIDE IN NOVEMBER 2014 IN GROUNDWATER ALONG THE ANACOSTIA RIVER - NEW CROSS-SECTION K-M

OPERABLE UNIT 2 - REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.8 Date: 2015-03-31

AECOM

Figure: 3-3



LEGEND

- MONITORING WELLS/BORINGS
- INDICATORS OF NAPL (SHEEN, TAR, OR OIL) (OBSERVED IN BORING LOGS)
- SAND SEAM NOTED IN BORING LOG

50 0 100

HORIZONAL SCALE IN FEET (APPROX.)

NOTES:
ALL ELEVATIONS AND DISTANCES ARE APPROXIMATE. RIVER STAGE TYPICALLY FLUCTUATES BETWEEN 0 AND 3 FEET AMSL OVER TIDE CYCLE.

THE APRIL 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING HIGH TIDE. THE NOVEMBER 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING LOW TIDE.

DEPTHS OF RIVER SHORE AND RIVER BOTTOM MID CHANNEL WERE TAKEN FROM FIGURE 4-9 OF THE 1999 RI (HYDRO-TERRA, 1999).

TP-18 AND TP-21 ARE SHOWN BECAUSE THEY ARE NEAR THE EDGE OF THE GOVERNMENT PROPERTY IN AREAS WITHOUT TEST BORING LOCATIONS. TP-51, TP-20, TP-59, AND TP-60 ARE NOT SHOWN BECAUSE THEY ARE IN AREAS WITH TEST BORING LOCATIONS.

TP-51 HAD VISIBLE OIL/TAR FROM 6-7' BGS. TP-60 HAD VISIBLE OIL/TAR FROM 5-6' BGS. TP-20 AND TP-59 DID NOT HAVE SHEEN, TAR, OR OIL.

AECOM

Figure: 3-4

INDICATORS OF NAPL IN BORING LOGS
ALONG THE ANACOSTIA RIVER - NEW CROSS-SECTION K-M
OPERABLE UNIT 2 - REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.8 Date: 2015-03-31

Project Management Initials: Designer: Checked: Approved: ANSI B 11" x 17"

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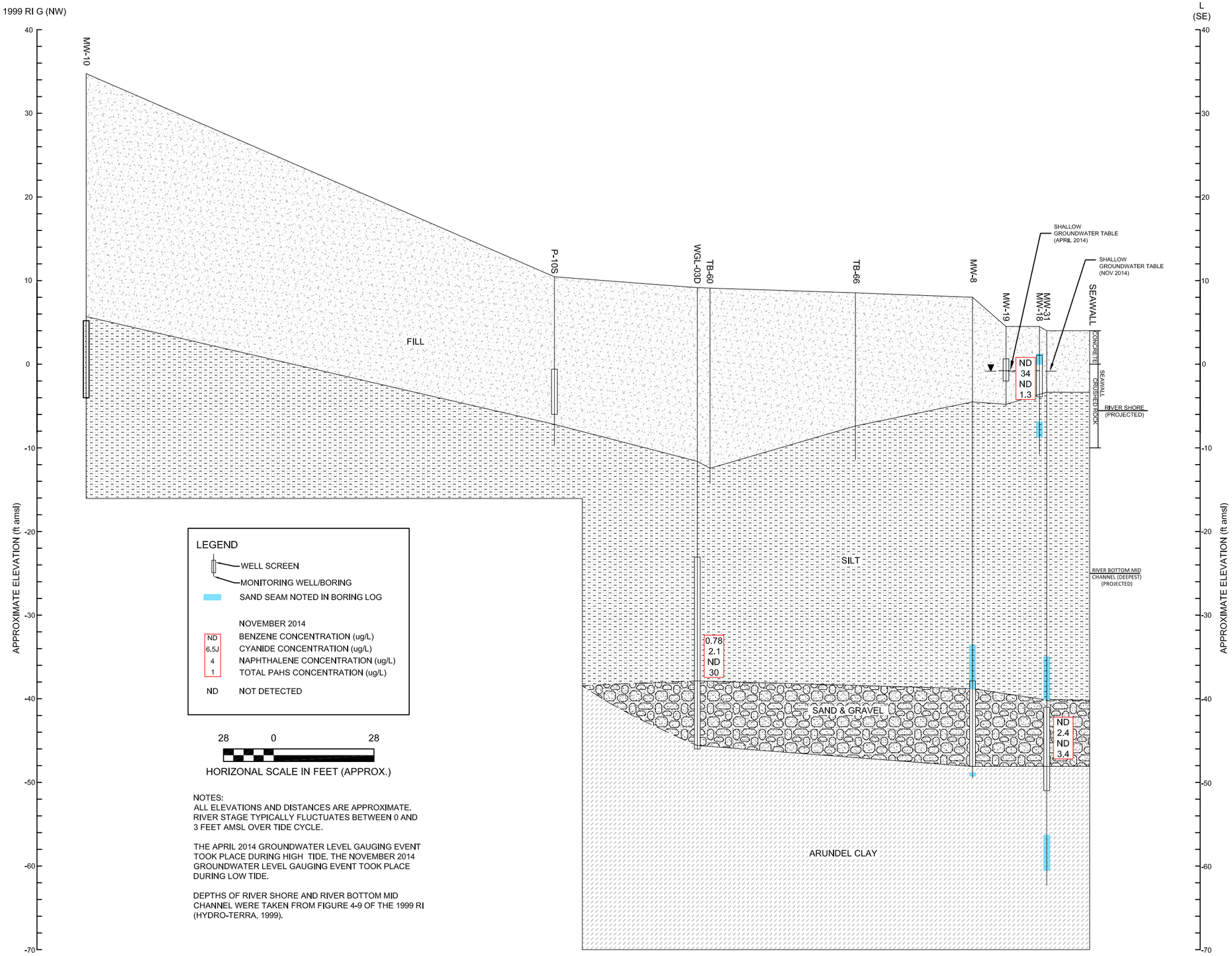

NOTES:
ALL ELEVATIONS AND DISTANCES ARE APPROXIMATE. RIVER STAGE TYPICALLY FLUCTUATES BETWEEN 0 AND 3 FEET AMSL OVER TIDE CYCLE.

THE APRIL 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING HIGH TIDE. THE NOVEMBER 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING LOW TIDE.

DEPTHS OF RIVER SHORE AND RIVER BOTTOM MID CHANNEL WERE TAKEN FROM FIGURE 4-9 OF THE 1999 RI (HYDRO-TERRA, 1999).

AECOM

Figure: 3-5

CONCENTRATIONS OF BENZENE, NAPHTHALENE, TOTAL PAHs, AND CYANIDE IN NOVEMBER 2014 IN GROUNDWATER - NEW CROSS-SECTION 1999 RI G - L

OPERABLE UNIT 2 - REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.8 Date: 2015-03-31

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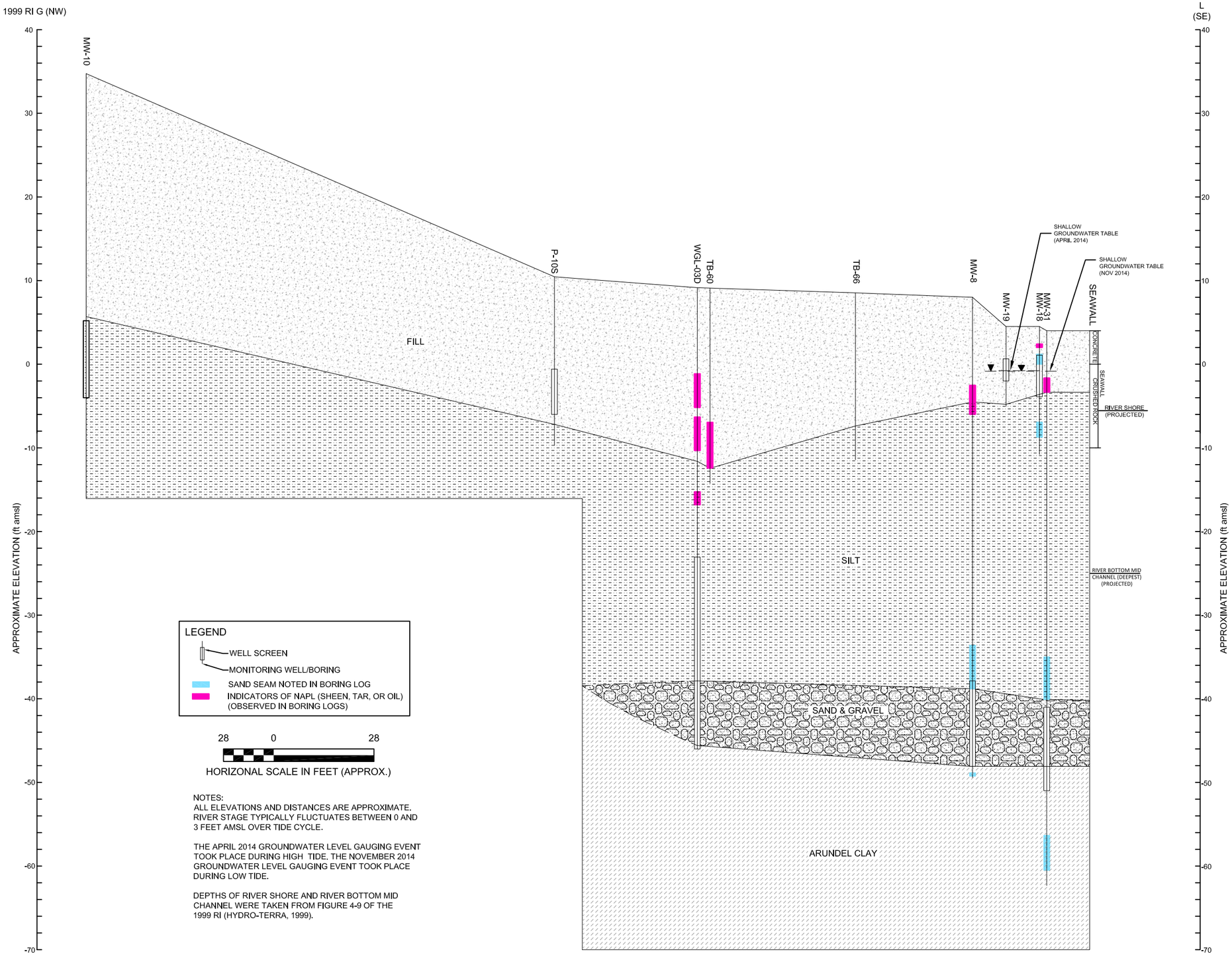

LEGEND

- WELL SCREEN
- MONITORING WELL/BORING
- SAND SEAM NOTED IN BORING LOG
- INDICATORS OF NAPL (SHEEN, TAR, OR OIL) (OBSERVED IN BORING LOGS)

28 0 28

HORIZONAL SCALE IN FEET (APPROX.)

NOTES:
ALL ELEVATIONS AND DISTANCES ARE APPROXIMATE. RIVER STAGE TYPICALLY FLUCTUATES BETWEEN 0 AND 3 FEET AMSL OVER TIDE CYCLE.

THE APRIL 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING HIGH TIDE. THE NOVEMBER 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING LOW TIDE.

DEPTHS OF RIVER SHORE AND RIVER BOTTOM MID CHANNEL WERE TAKEN FROM FIGURE 4-9 OF THE 1999 RI (HYDRO-TERRA, 1999).

AECOM

Figure: 3-6

INDICATORS OF NAPL IN BORING LOGS
NEW CROSS-SECTION 1999 RI G - L
OPERABLE UNIT 2 - REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.8 Date: 2015-03-31

Project Management Initials: Designer:____ Checked:____ Approved:____ ANSI B 11" x 17"

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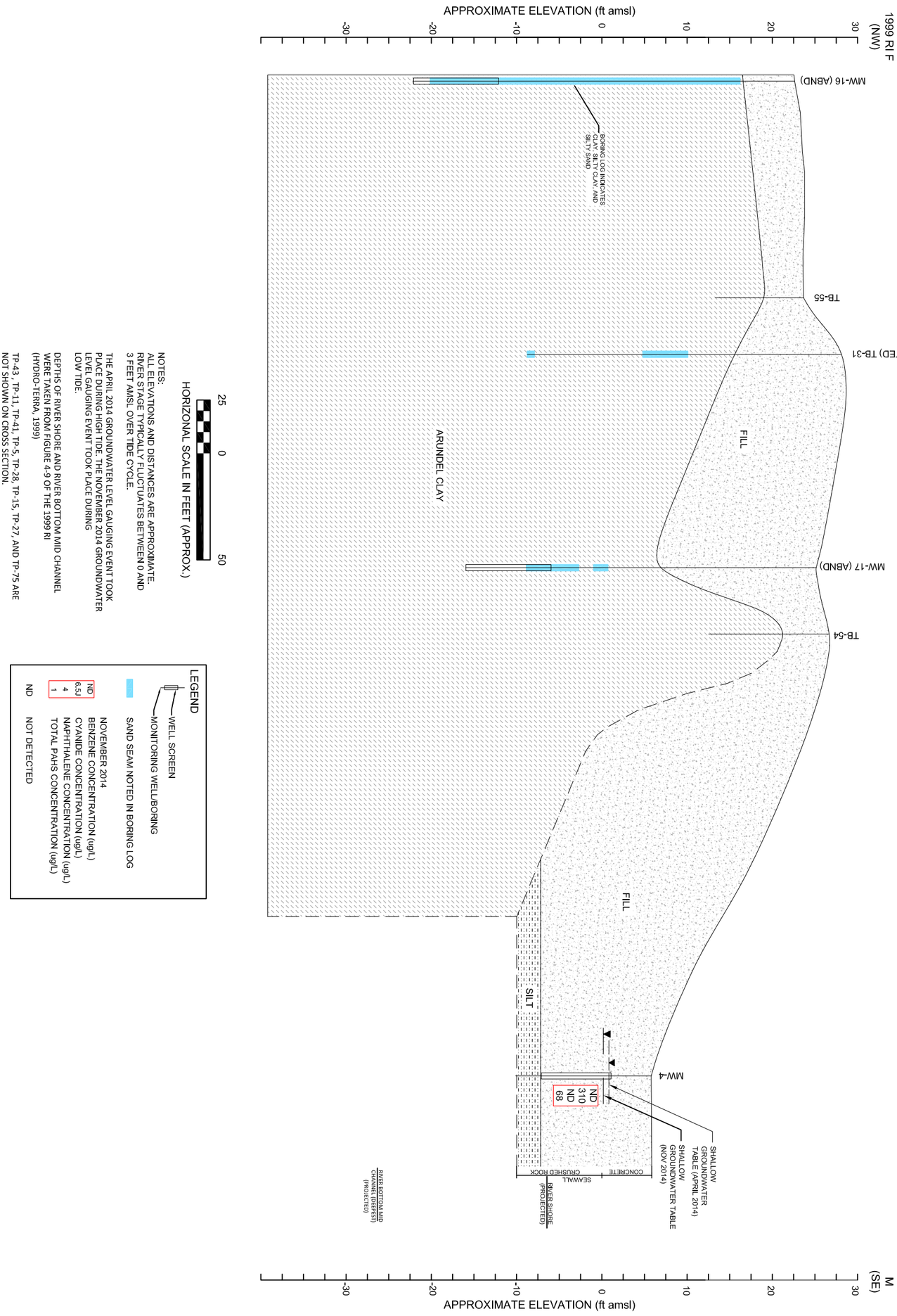

CONCENTRATIONS OF BENZENE, NAPHTHALENE, TOTAL PAHs, AND CYANIDE IN NOVEMBER 2014 IN GROUNDWATER - NEW CROSS-SECTION 1999 RI F - M

OPERABLE UNIT 2 - REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.8 Date: 2015-03-31

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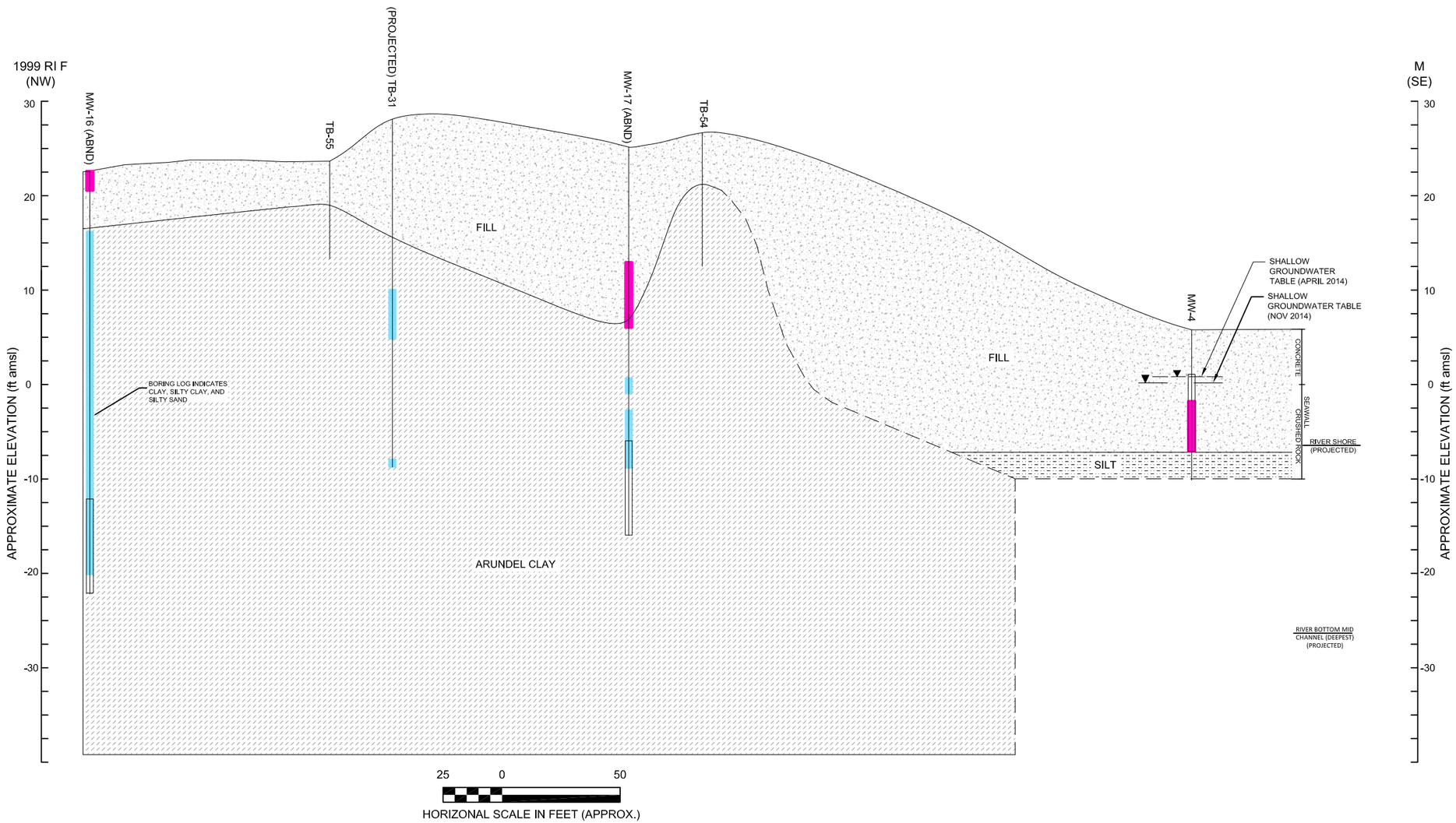
Figure: 3-7



NOTES:
ALL ELEVATIONS AND DISTANCES ARE APPROXIMATE.
RIVER STAGE TYPICALLY FLUCTUATES BETWEEN 0 AND 3 FEET AMSL OVER TIDE CYCLE.

THE APRIL 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING HIGH TIDE. THE NOVEMBER 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING LOW TIDE.

DEPTHS OF RIVER SHORE AND RIVER BOTTOM MID CHANNEL WERE TAKEN FROM FIGURE 4-9 OF THE 1999 RI (HYDRO-TERRA, 1999).

TP-43 , TP-11, TP-41, TP-5, TP-28, TP-15, TP-27, AND TP-75 ARE NOT SHOWN ON CROSS SECTION.

TP-27 HAD VISIBLE OIL 8-9' BGS. TP-28 HAD HARD TAR 0-1' BGS. TP-43, TP-11, TP-41, TP-5, TP-15, AND TP-75 DID NOT HAVE SHEEN, TAR, OR OIL.

LEGEND
- WELL SCREEN
- MONITORING WELL/BORING
- INDICATORS OF NAPL (SHEEN, TAR, OR OIL) (OBSERVED IN BORING LOGS)
- SAND SEAM NOTED IN BORING LOG

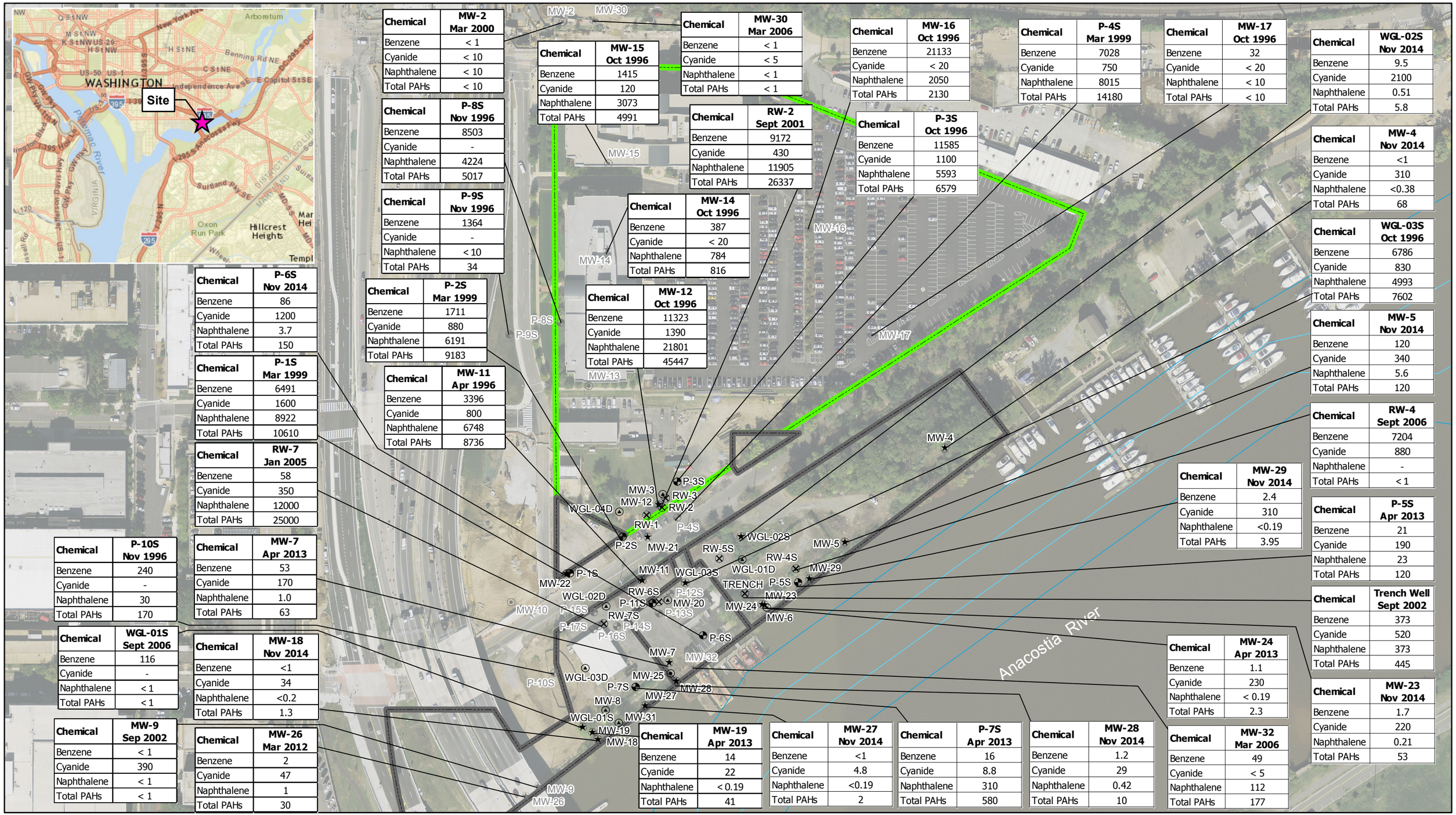
AECOM

Figure: 3-8

INDICATORS OF NAPL IN BORING LOGS
NEW CROSS-SECTION 1999 RI F - M
OPERABLE UNIT 2 - REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.8 Date: 2015-03-31

Last saved by: BOURDEAUJ(2015-04-23) Last Plotted: 2015-04-23
Filename: \\USWTF1FP001\OBSINDL_SERVICE\PROJECT FILES\WASHINGTON GAS MGP\GIS\MXD\RI_FS_WORK_PLAN\MXD\CROSS_SECTIONS.DWG

Project Management Initials: Designer:____ Checked:____ Approved:____ ANSI B 11" x 17"



Chemical	MW-2 Mar 2000
Benzene	< 1
Cyanide	< 10
Naphthalene	< 10
Total PAHs	< 10

Chemical	MW-15 Oct 1996
Benzene	1415
Cyanide	120
Naphthalene	3073
Total PAHs	4991

Chemical	MW-30 Mar 2006
Benzene	< 1
Cyanide	< 5
Naphthalene	< 1
Total PAHs	< 1

Chemical	MW-16 Oct 1996
Benzene	21133
Cyanide	< 20
Naphthalene	2050
Total PAHs	2130

Chemical	P-4S Mar 1999
Benzene	7028
Cyanide	750
Naphthalene	8015
Total PAHs	14180

Chemical	MW-17 Oct 1996
Benzene	32
Cyanide	< 20
Naphthalene	< 10
Total PAHs	< 10

Chemical	WGL-02S Nov 2014
Benzene	9.5
Cyanide	2100
Naphthalene	0.51
Total PAHs	5.8

Chemical	P-8S Nov 1996
Benzene	8503
Cyanide	-
Naphthalene	4224
Total PAHs	5017

Chemical	RW-2 Sept 2001
Benzene	9172
Cyanide	430
Naphthalene	11905
Total PAHs	26337

Chemical	P-3S Oct 1996
Benzene	11585
Cyanide	1100
Naphthalene	5593
Total PAHs	6579

Chemical	MW-4 Nov 2014
Benzene	<1
Cyanide	310
Naphthalene	<0.38
Total PAHs	68

Chemical	P-9S Nov 1996
Benzene	1364
Cyanide	-
Naphthalene	< 10
Total PAHs	34

Chemical	MW-14 Oct 1996
Benzene	387
Cyanide	< 20
Naphthalene	784
Total PAHs	816

Chemical	WGL-03S Oct 1996
Benzene	6786
Cyanide	830
Naphthalene	4993
Total PAHs	7602

Chemical	P-6S Nov 2014
Benzene	86
Cyanide	1200
Naphthalene	3.7
Total PAHs	150

Chemical	P-2S Mar 1999
Benzene	1711
Cyanide	880
Naphthalene	6191
Total PAHs	9183

Chemical	MW-12 Oct 1996
Benzene	11323
Cyanide	1390
Naphthalene	21801
Total PAHs	45447

Chemical	MW-5 Nov 2014
Benzene	120
Cyanide	340
Naphthalene	5.6
Total PAHs	120

Chemical	P-1S Mar 1999
Benzene	6491
Cyanide	1600
Naphthalene	8922
Total PAHs	10610

Chemical	MW-11 Apr 1996
Benzene	3396
Cyanide	800
Naphthalene	6748
Total PAHs	8736

Chemical	RW-4 Sept 2006
Benzene	7204
Cyanide	880
Naphthalene	-
Total PAHs	< 1

Chemical	RW-7 Jan 2005
Benzene	58
Cyanide	350
Naphthalene	12000
Total PAHs	25000

Chemical	MW-29 Nov 2014
Benzene	2.4
Cyanide	310
Naphthalene	<0.19
Total PAHs	3.95

Chemical	P-5S Apr 2013
Benzene	21
Cyanide	190
Naphthalene	23
Total PAHs	120

Chemical	P-10S Nov 1996
Benzene	240
Cyanide	-
Naphthalene	30
Total PAHs	170

Chemical	MW-7 Apr 2013
Benzene	53
Cyanide	170
Naphthalene	1.0
Total PAHs	63

Chemical	Trench Well Sept 2002
Benzene	373
Cyanide	520
Naphthalene	373
Total PAHs	445

Chemical	WGL-01S Sept 2006
Benzene	116
Cyanide	-
Naphthalene	< 1
Total PAHs	< 1

Chemical	MW-18 Nov 2014
Benzene	<1
Cyanide	34
Naphthalene	<0.2
Total PAHs	1.3

Chemical	MW-24 Apr 2013
Benzene	1.1
Cyanide	230
Naphthalene	< 0.19
Total PAHs	2.3

Chemical	MW-23 Nov 2014
Benzene	1.7
Cyanide	220
Naphthalene	0.21
Total PAHs	53

Chemical	MW-9 Sep 2002
Benzene	< 1
Cyanide	390
Naphthalene	< 1
Total PAHs	< 1

Chemical	MW-26 Mar 2012
Benzene	2
Cyanide	47
Naphthalene	1
Total PAHs	30

Chemical	MW-19 Apr 2013
Benzene	14
Cyanide	22
Naphthalene	< 0.19
Total PAHs	41

Chemical	MW-27 Nov 2014
Benzene	<1
Cyanide	4.8
Naphthalene	<0.19
Total PAHs	2

Chemical	P-7S Apr 2013
Benzene	16
Cyanide	8.8
Naphthalene	310
Total PAHs	580

Chemical	MW-28 Nov 2014
Benzene	1.2
Cyanide	29
Naphthalene	0.42
Total PAHs	10

Chemical	MW-32 Mar 2006
Benzene	49
Cyanide	< 5
Naphthalene	112
Total PAHs	177

0 100 200 Feet

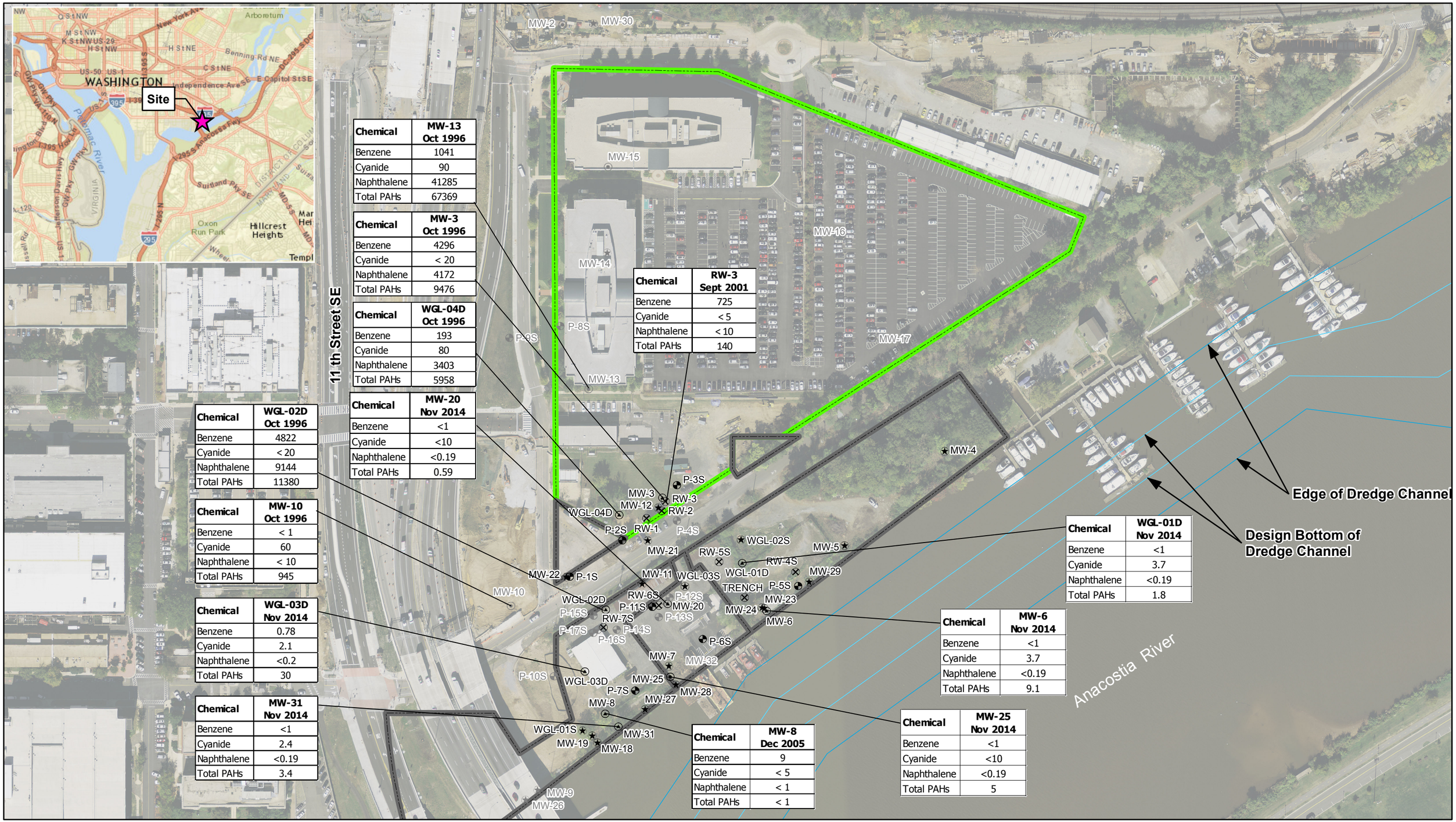
Legend
- Monitoring Well in Arundel Clay
- Monitoring Well in Fill Unit
- Monitoring Well in Sand and Gravel Unit
- Piezometer in Fill Unit
- Recovery Well
- Approx. East Station Property
- Approx. Government Property

Notes
Gray symbols are abandoned or could not be located in 2014.
All units (ug/L)
< - Compounds not detected above the detection limit.
Orthoimagery from USGS, 11/24/2013.
Channel lines from NOAA, 2007 (downloaded from http://encdirect.noaa.gov in April 2014).

AECOM

Figure 3-9
Most Recent Analytical Results in Wells Screened in Fill
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Path: \\Uswtf1fp001\JOBS\Indl_Service\Project Files\Washington Gas MGP\GIS\MXD\RI_FS_Work_Plan\MXD\Fig_3_9_Most_Recent_Analy_Results_Fill.mxd



Chemical	MW-13 Oct 1996
Benzene	1041
Cyanide	90
Naphthalene	41285
Total PAHs	67369

Chemical	MW-3 Oct 1996
Benzene	4296
Cyanide	< 20
Naphthalene	4172
Total PAHs	9476

Chemical	WGL-04D Oct 1996
Benzene	193
Cyanide	80
Naphthalene	3403
Total PAHs	5958

Chemical	RW-3 Sept 2001
Benzene	725
Cyanide	< 5
Naphthalene	< 10
Total PAHs	140

Chemical	MW-20 Nov 2014
Benzene	<1
Cyanide	<10
Naphthalene	<0.19
Total PAHs	0.59

Chemical	WGL-02D Oct 1996
Benzene	4822
Cyanide	< 20
Naphthalene	9144
Total PAHs	11380

Chemical	MW-10 Oct 1996
Benzene	< 1
Cyanide	60
Naphthalene	< 10
Total PAHs	945

Chemical	WGL-03D Nov 2014
Benzene	0.78
Cyanide	2.1
Naphthalene	<0.2
Total PAHs	30

Chemical	MW-31 Nov 2014
Benzene	<1
Cyanide	2.4
Naphthalene	<0.19
Total PAHs	3.4

Chemical	WGL-01D Nov 2014
Benzene	<1
Cyanide	3.7
Naphthalene	<0.19
Total PAHs	1.8

Chemical	MW-6 Nov 2014
Benzene	<1
Cyanide	3.7
Naphthalene	<0.19
Total PAHs	9.1

Chemical	MW-8 Dec 2005
Benzene	9
Cyanide	< 5
Naphthalene	< 1
Total PAHs	< 1

Chemical	MW-25 Nov 2014
Benzene	<1
Cyanide	<10
Naphthalene	<0.19
Total PAHs	5

Figure 3-10
Most Recent Analytical Results in Wells Screened in Sand and Gravel
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Path: \\Uswtf1fp001\JOBS\Indl_Service\Project Files\Washington Gas MGP\GIS\MXD\RI_FS_Work_Plan\MXD\Fig_3_10_Most_Recent_Analy_Results_Sand_Gravel.mxd

Legend
- Monitoring Well in Arundel Clay
- Monitoring Well in Fill Unit
- Monitoring Well in Sand and Gravel Unit
- Piezometer in Fill Unit
- Recovery Well
- Approx. East Station Property
- Approx. Government Property

0 100 200 Feet

Notes
Gray symbols are abandoned or could not be located in 2014.
All units (ug/L)
< - Compounds not detected above the detection limit.
Orthoimagery from USGS, 11/24/2013.
Channel lines from NOAA, 2007 (downloaded from http://encdirect.noaa.gov in April 2014).

AECOM

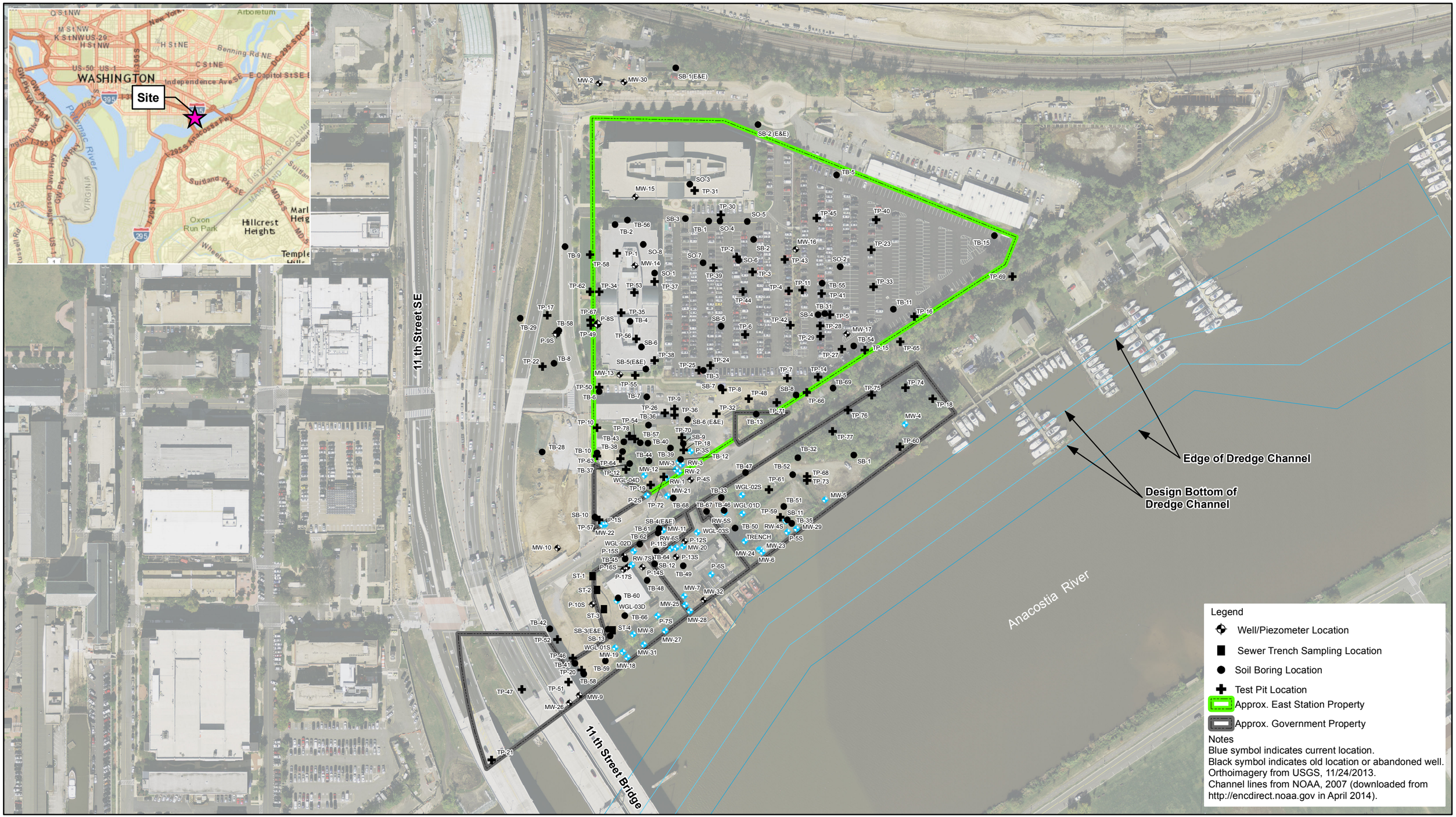


Figure 3-11 Previous Environmental Investigation Sampling Locations
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

0 80 160 Feet

AECOM

\\Uswtf1fp001\JOBS\Indl_Service\Project Files\Washington Gas MGP\GIS\MXD\RI_FS_Work_Plan\MXD\Fig_3_11_Previous_Environ_Sampling_Loc.mxd

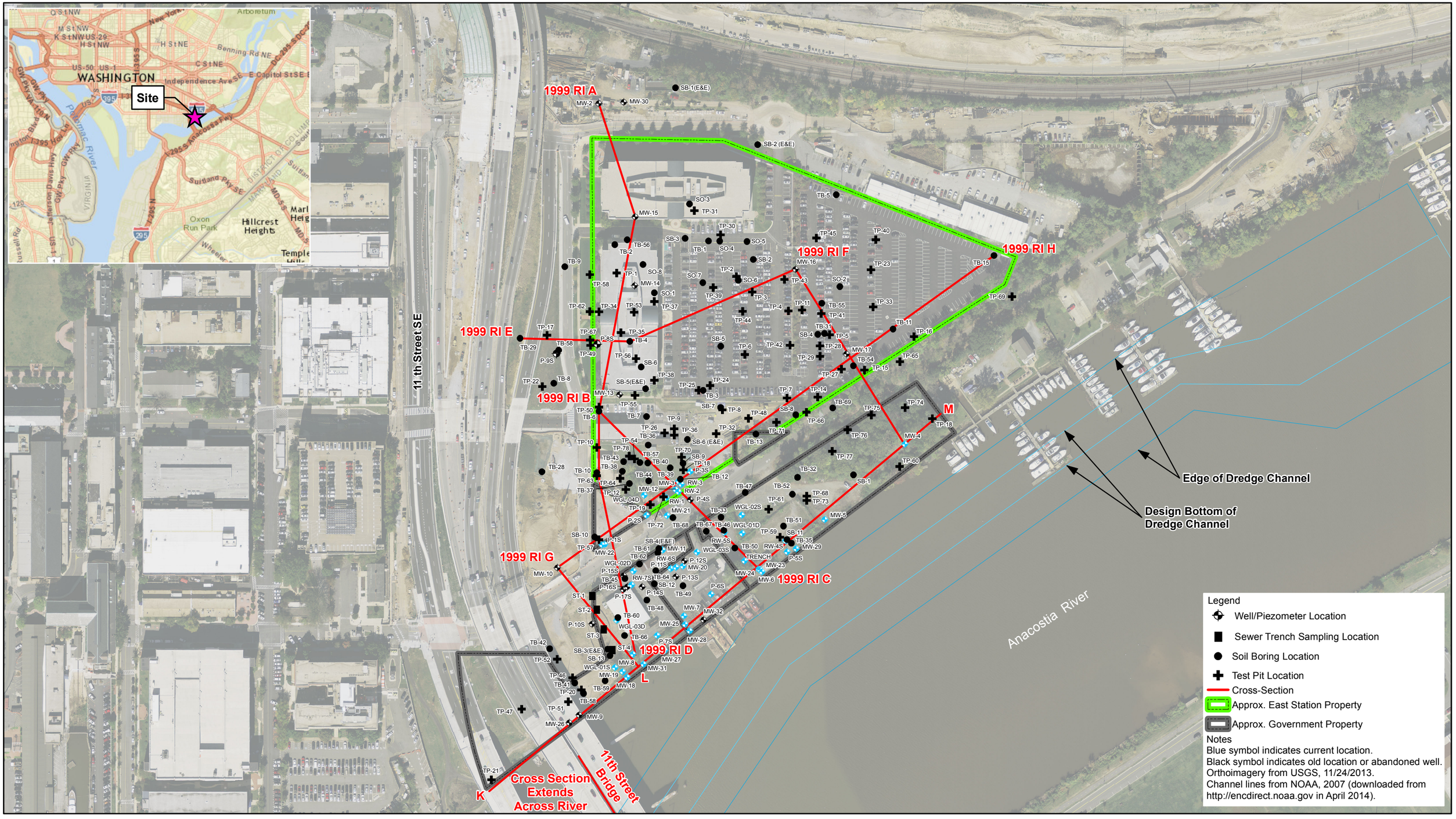


Figure 3-12 Cross-Section Locations
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

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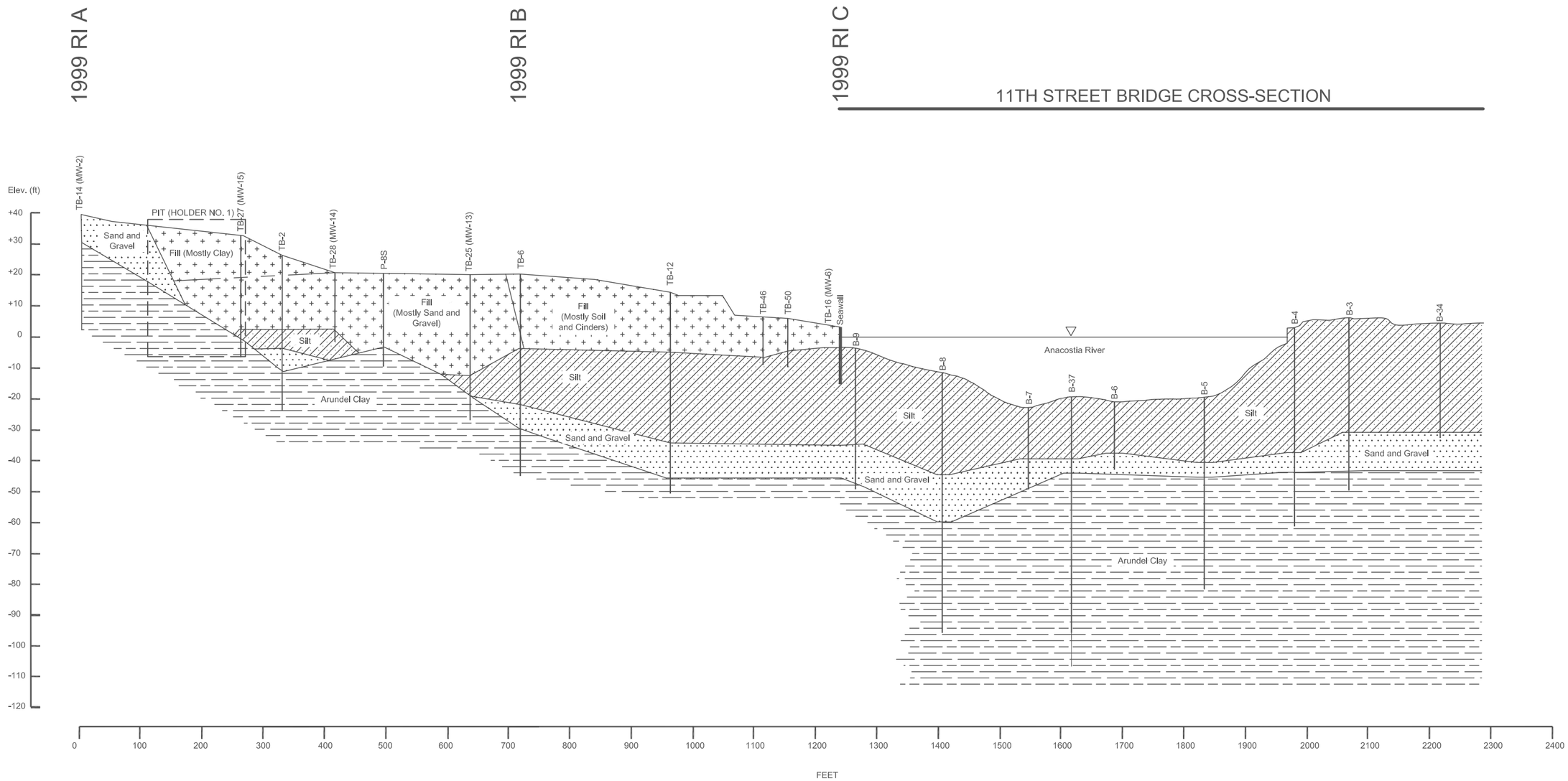


SOURCE: 1999 RI (HYDRO-TERRA, INC. 1999).

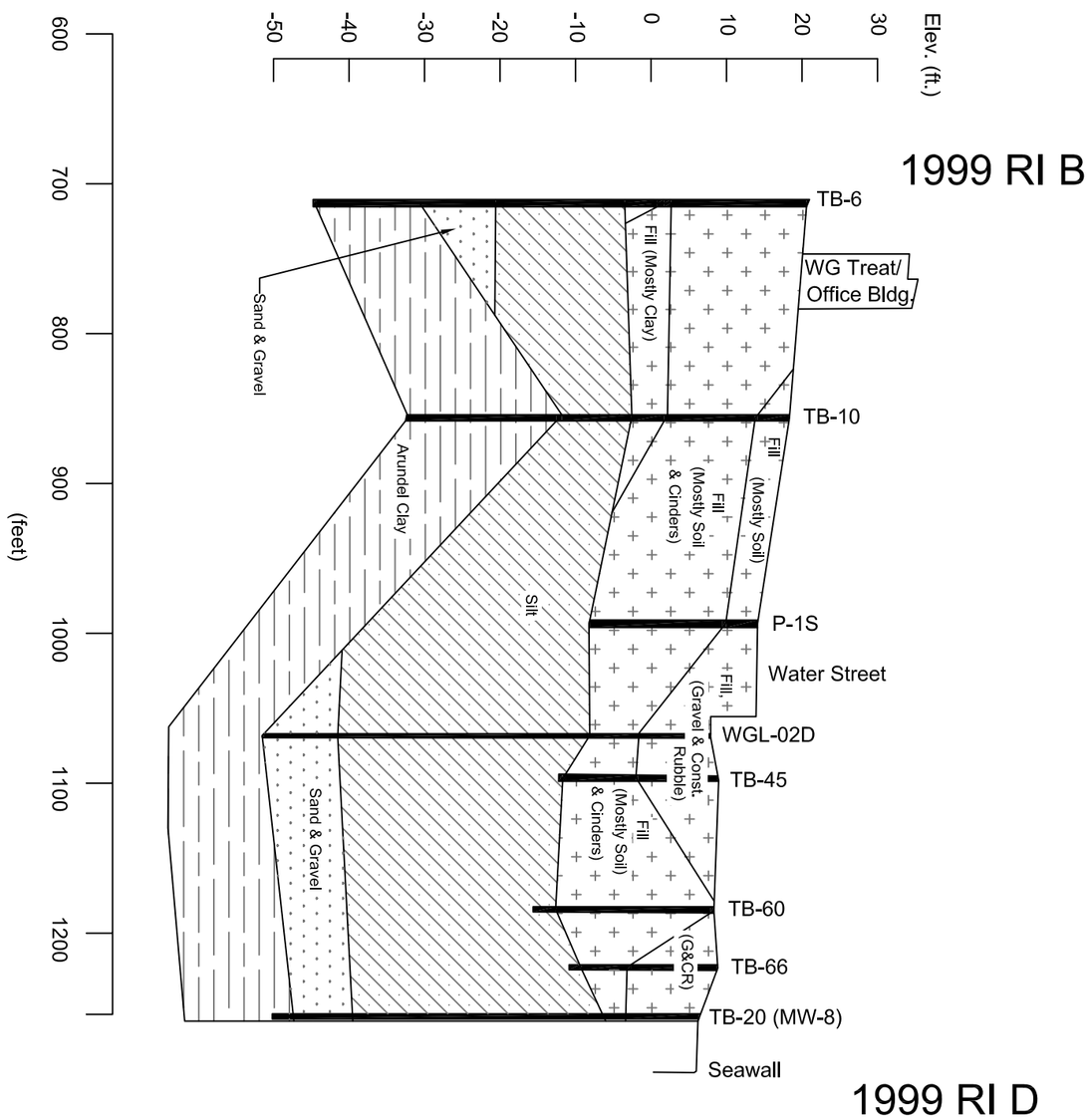
NOTE: CROSS SECTION WAS NOT MODIFIED TO INCLUDE LOCATIONS COMPLETED SINCE THE 1999 RI.

AECOM

Figure: 3-13

1999 RI CROSS-SECTION A-C AND 11TH STREET BRIDGE
OPERABLE UNIT 2 - REMEDIAL INVESTIGATION AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.8 Date: 2015-03-31

Last saved by: BOURDEAUJ(2015-04-23) Last Plotted: 2015-04-23
Filename: \\USWTF1FP001\JOBS\INDL SERVICE\PROJECT FILES\WASHINGTON GAS MGP\GIS\MXD\RI FS WORK PLAN\MXD\FIG 3 13 CROSS SECTION AC.DWG
Project Management Initials: Designer:____ Checked:____ Approved:____ ANSI B 11" x 17"



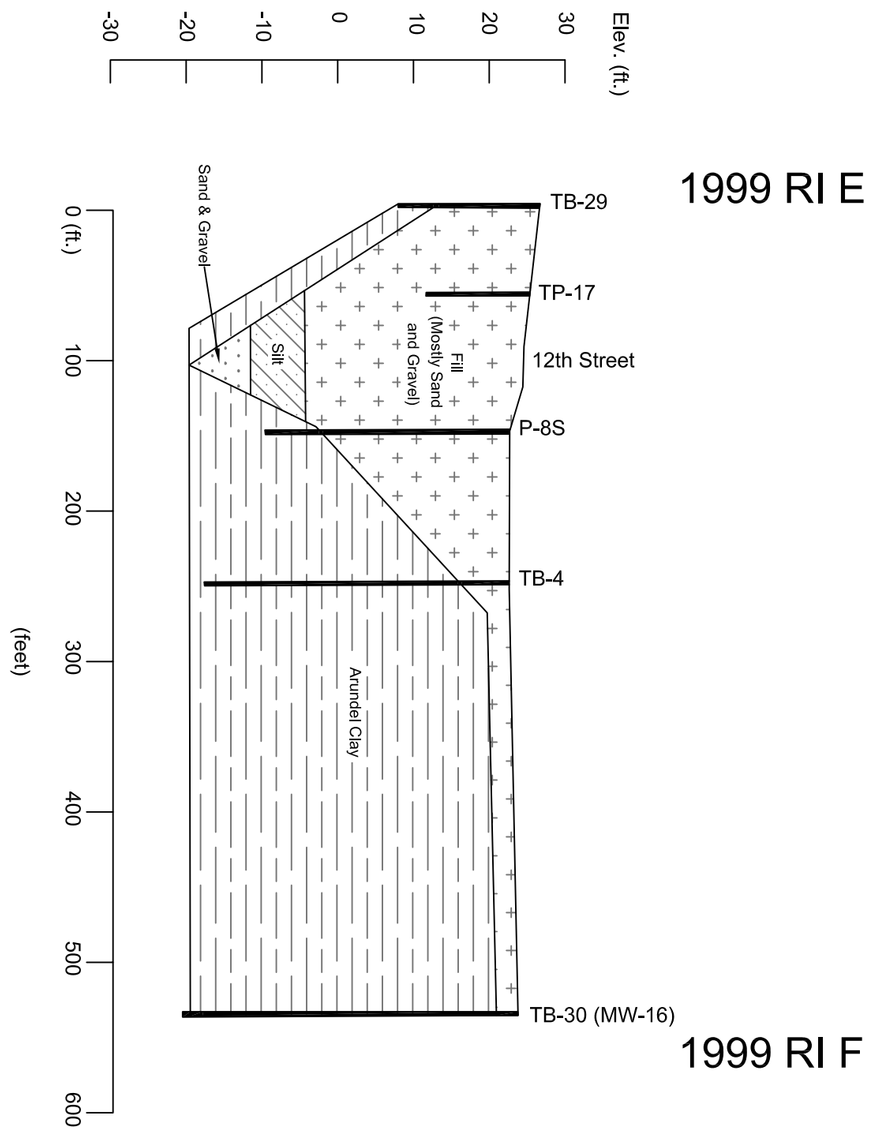
SOURCE: 1999 RI (HYDRO-TERRA, 1999).

NOTE: CROSS SECTION WAS NOT MODIFIED TO INCLUDE LOCATIONS COMPLETED SINCE THE 1999 RI.

1999 RI CROSS-SECTION B-D
OPERABLE UNIT 2 - REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.8 Date: 2015-04-07

AECOM

Figure: 3-14



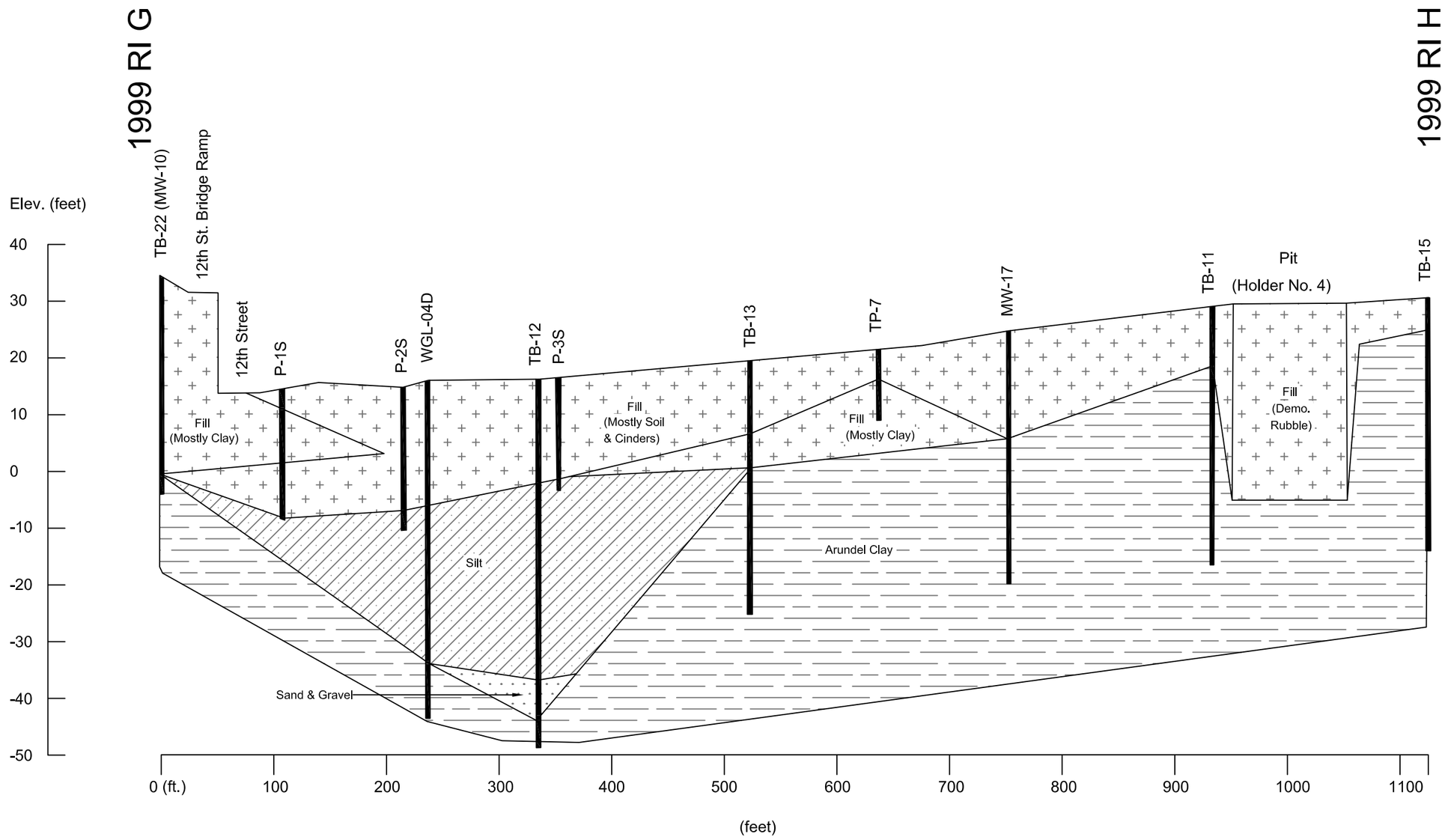
SOURCE: 1999 RI (HYDRO-TERRA, 1999).

NOTE: CROSS SECTION WAS NOT MODIFIED TO INCLUDE LOCATIONS COMPLETED SINCE THE 1999 RI.
THE GEOLOGY BELOW TP-17 IS SHOWN AS INTERPRETED IN THE 1999 RI.

1999 RI CROSS-SECTION E-F
OPERABLE UNIT 2 - REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.8 Date: 2015-04-07

AECOM

Figure: 3-15



SOURCE: 1999 RI (HYDRO-TERRA,1999).

NOTE: CROSS SECTION WAS NOT MODIFIED TO INCLUDE LOCATIONS COMPLETED SINCE THE 1999 RI.
THE GEOLOGY BELOW TB-12 AND WGL-04D IS SHOWN AS INTERPRETED IN THE 1999 RI.

AECOM

Figure: 3-16

1999 RI CROSS-SECTION G-H
OPERABLE UNIT 2 - REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.8 Date: 2015-04-07

Last saved by: BOURDEAUJ(2015-04-23) Last Plotted: 2015-04-23
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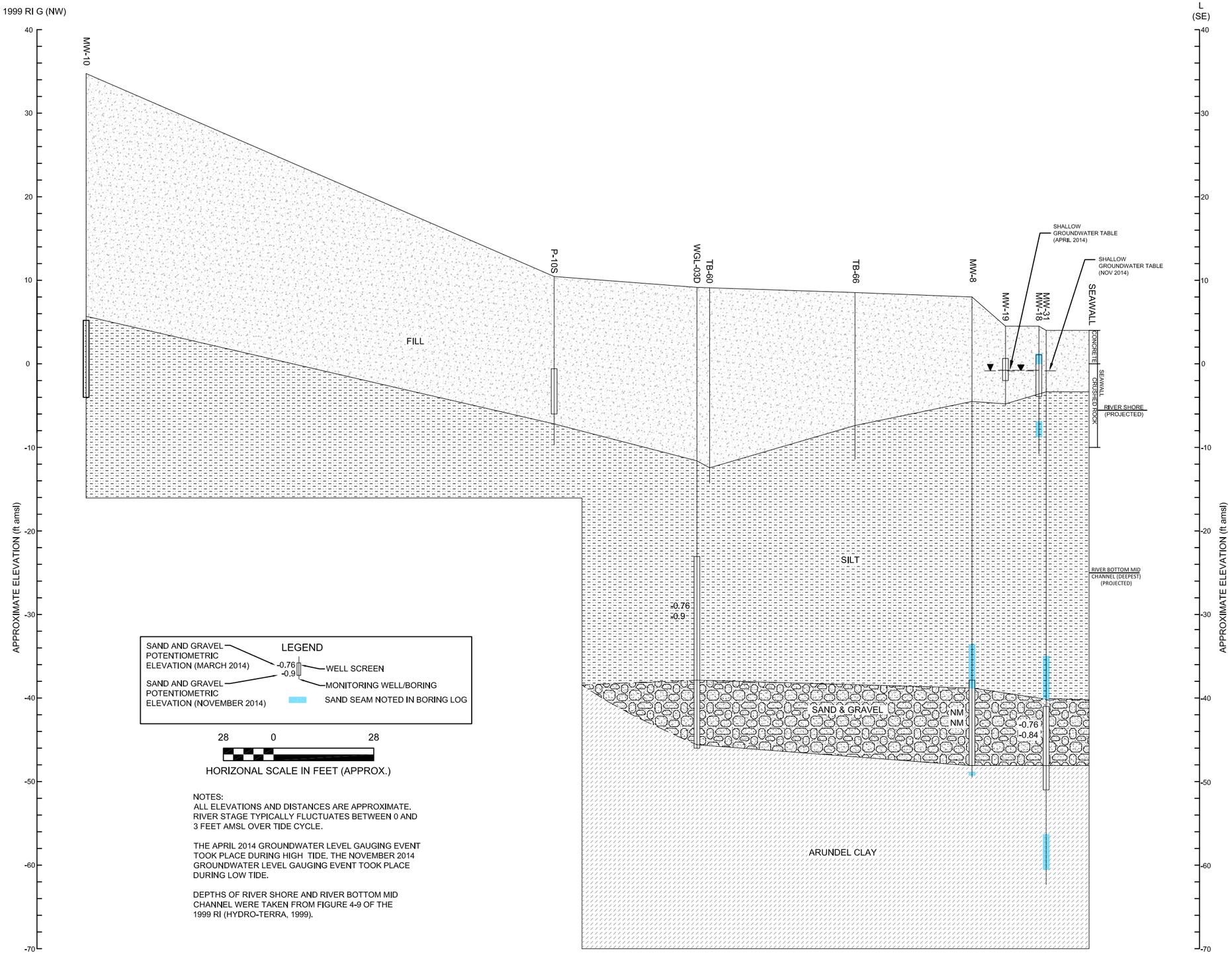
Project Management Initials: Designer:____ Checked:____ Approved:____ ANSI B 11" x 17"



NOTES:
ALL ELEVATIONS AND DISTANCES ARE APPROXIMATE.
RIVER STAGE TYPICALLY FLUCTUATES BETWEEN 0 AND 3 FEET AMSL OVER TIDE CYCLE.

THE APRIL 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING HIGH TIDE. THE NOVEMBER 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING LOW TIDE.

DEPTHS OF RIVER SHORE AND RIVER BOTTOM MID CHANNEL WERE TAKEN FROM FIGURE 4-9 OF THE 1999 RI (HYDRO-TERRA, 1999).

AECOM

Figure: 3-17

NEW CROSS-SECTION 1999 RI G - L
PERPENDICULAR TO THE ANACOSTIA RIVER
OPERABLE UNIT 2 - REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.8Date: 2015-03-31

Project Management Initials: Designer:____ Checked:____ Approved:____ ANSI B 11" x 17"

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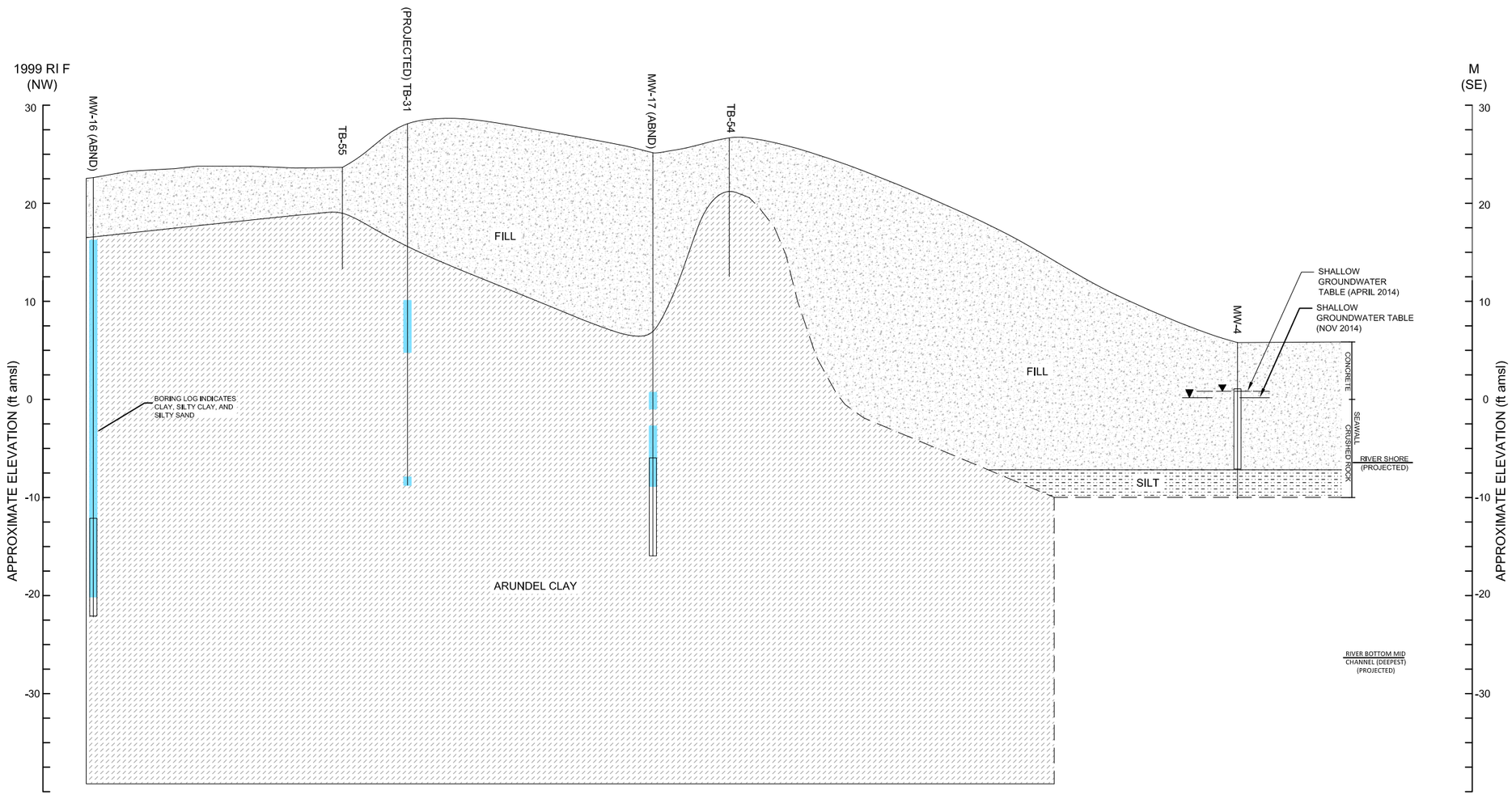

25 0 50

HORIZONAL SCALE IN FEET (APPROX.)

NOTES:
ALL ELEVATIONS AND DISTANCES ARE APPROXIMATE.
RIVER STAGE TYPICALLY FLUCTUATES BETWEEN 0 AND 3 FEET AMSL OVER TIDE CYCLE.

THE APRIL 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING HIGH TIDE. THE NOVEMBER 2014 GROUNDWATER LEVEL GAUGING EVENT TOOK PLACE DURING LOW TIDE.

DEPTHS OF RIVER SHORE AND RIVER BOTTOM MID CHANNEL WERE TAKEN FROM FIGURE 4-9 OF THE 1999 RI (HYDRO-TERRA, 1999).

TP-43 , TP-11, TP-41, TP-5, TP-28, TP-15, TP-27, AND TP-75 ARE NOT SHOWN ON CROSS SECTION.

LEGEND
- WELL SCREEN
- MONITORING WELL/BORING
- SAND SEAM NOTED IN BORING LOG

AECOM

Figure: 3-18

NEW CROSS-SECTION 1999 RI F - M
PERPENDICULAR TO THE ANACOSTIA RIVER
OPERABLE UNIT 2 - REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
WASHINGTON GAS EAST STATION SITE
Project No.: 60274556.8 Date: 2015-03-31

Last saved by: BOURDEAUJ(2015-04-23) Last Plotted: 2015-04-23
Filename: \\USWTF1P001\OBSINDL_SERVICE\PROJECT FILES\WASHINGTON GAS MGP\GIS\MXD\RI_FS_WORK_PLAN\MXD\CROSS_SECTIONS.DWG

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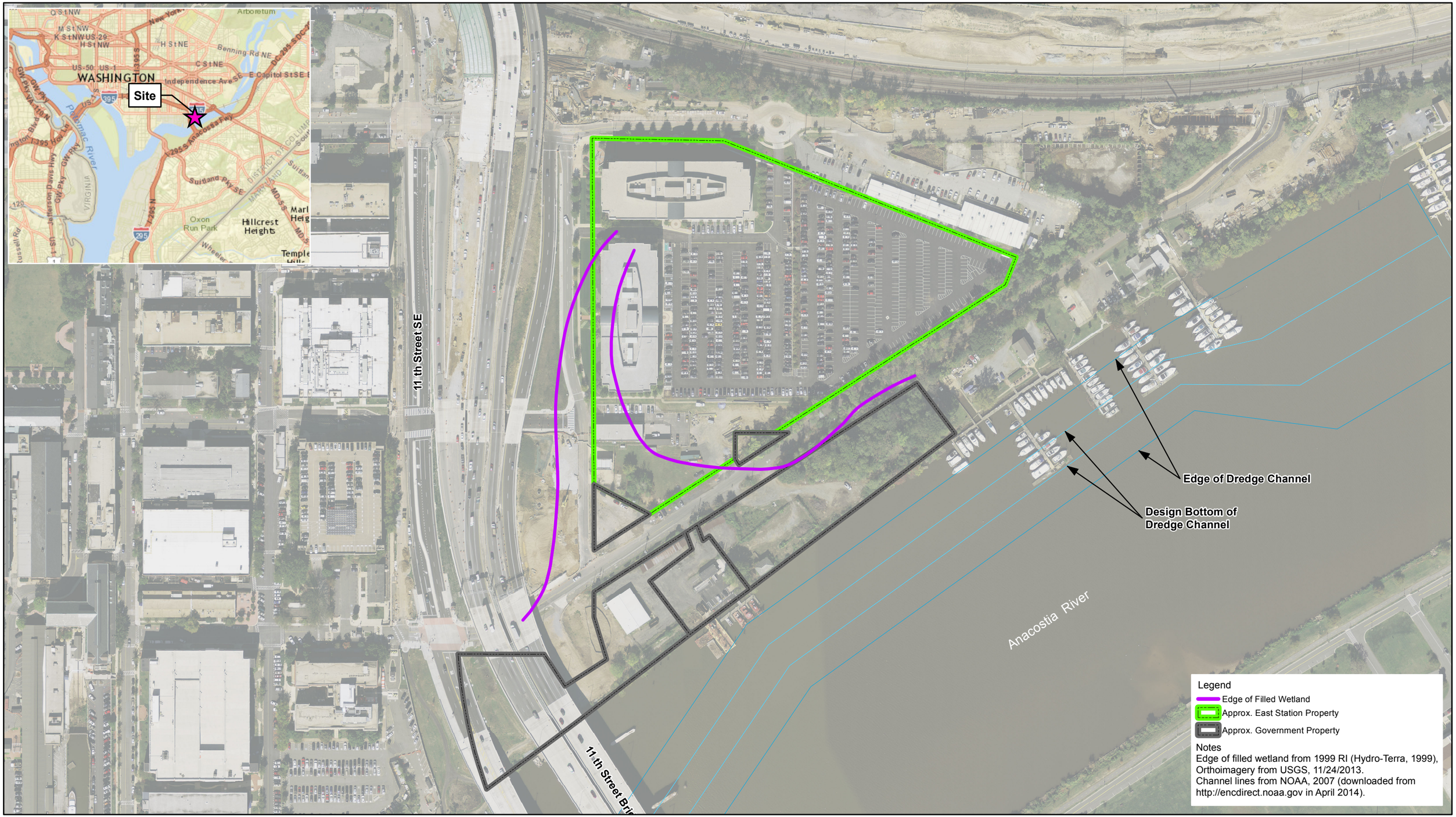

Figure 3-19 Area of Filled Wetland
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

0 80 160 Feet

AECOM

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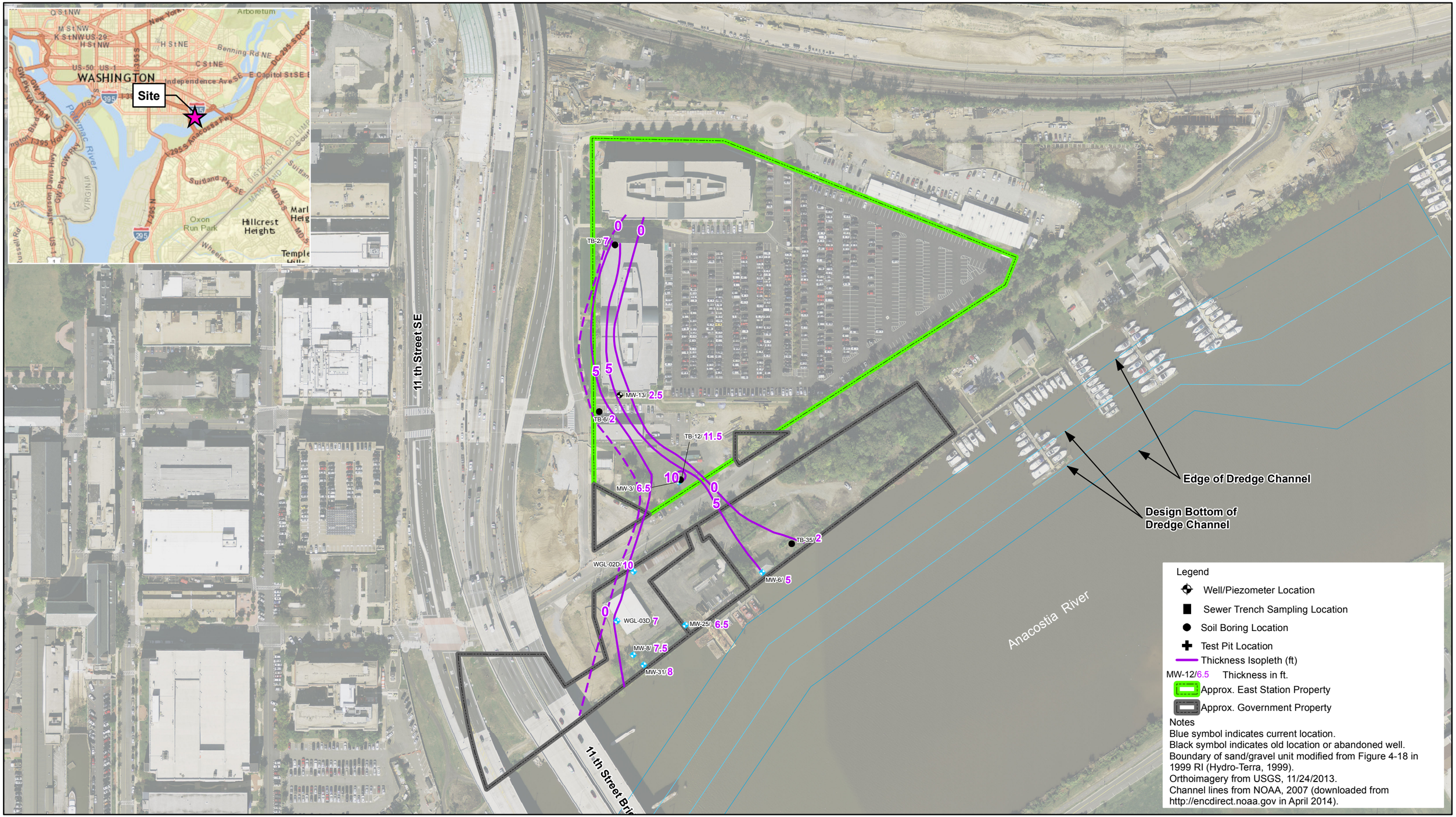

Figure 3-20 Sand and Gravel Thickness
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

0 100 200 Feet

AECOM

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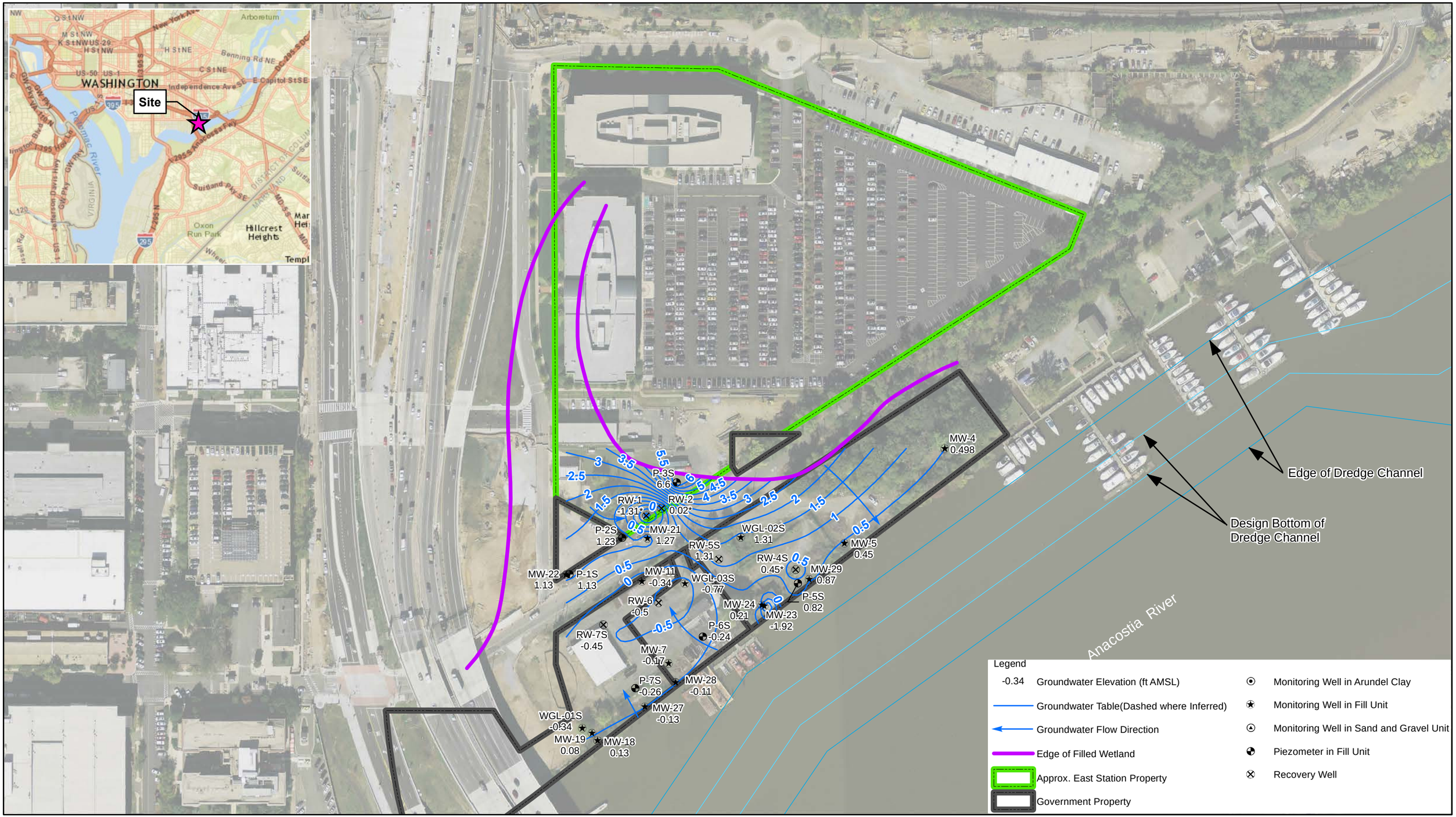


Figure 3-21
Contour Map of Groundwater Table in Fill at Low Tide - Fall 2014
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Path: P:\Jobs\Indl_Service\Project Files\Washington Gas MGP\GIS\MXD\RI_FS_Work_Plan\MXD\Fig_3_21_Contour_Map_of_Groundwater_20150521.mxd

*Recovery wells are never 100 percent efficient and therefore measured water levels do not reflect the water level in the adjacent aquifer. To estimate the water level in the aquifer adjacent to a recovery well, the water level in a recovery well was averaged with the water level in the monitoring well closest to the recovery well. This averaged water level elevation was used at the recovery well for contouring.

RW-7S was not operating at the time of water level measurements.

Orthoimagery from USGS, 11/24/2013.
Channel lines from NOAA, 2007
(downloaded from
http://encdirect.noaa.gov in April 2014).

0 100 200 Feet

N

AECOM

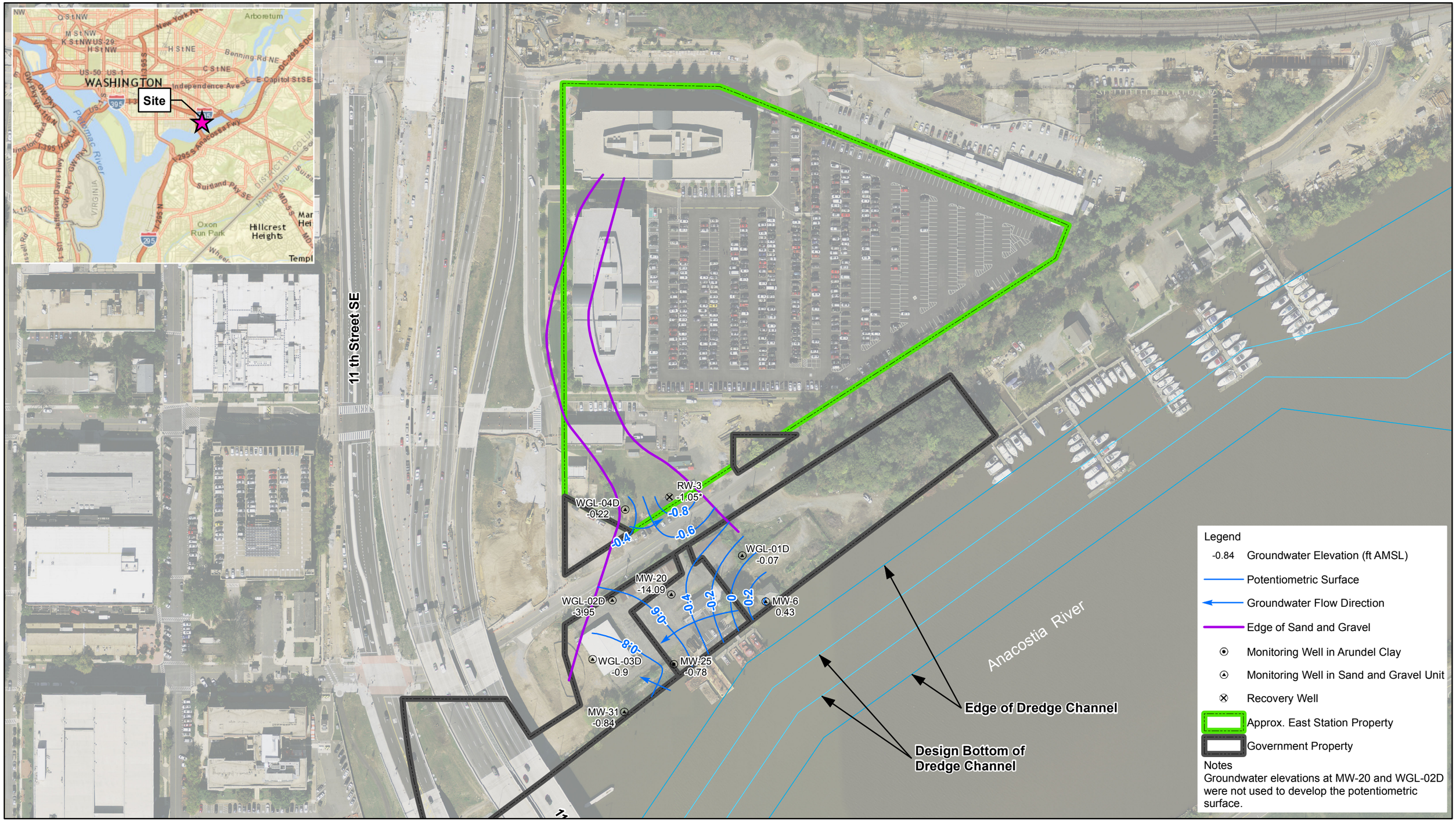


Figure 3-22
Contour Map of Potentiometric Surface in Sand and Gravel Unit at Low Tide - Fall 2014
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

*Recovery wells are never 100 percent efficient and therefore measured water levels do not reflect the water level in the adjacent aquifer. To estimate the water level in the aquifer adjacent to the recovery well, the water level in the recovery well was averaged with the water level in the monitoring well closest to the recovery well. This averaged water level elevation was used at the recovery well for contouring.

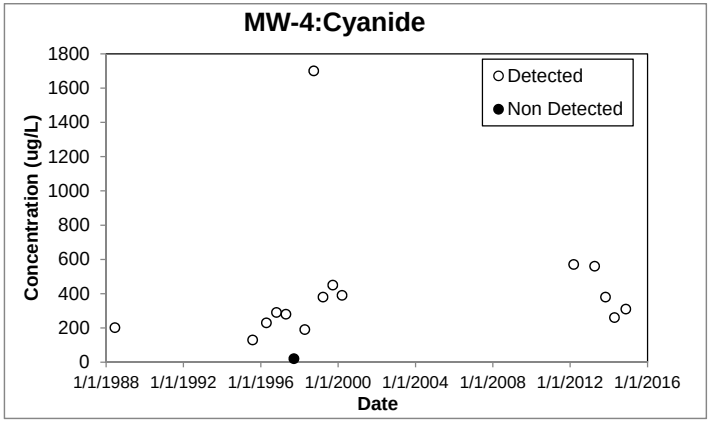
Orthoimagery from USGS, 11/24/2013.
Channel lines from NOAA, 2007 (downloaded from http://encdirect.noaa.gov in April 2014).

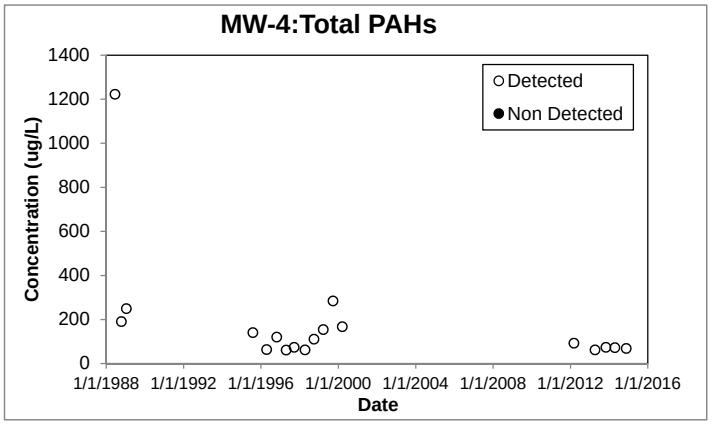
0 80 160 Feet

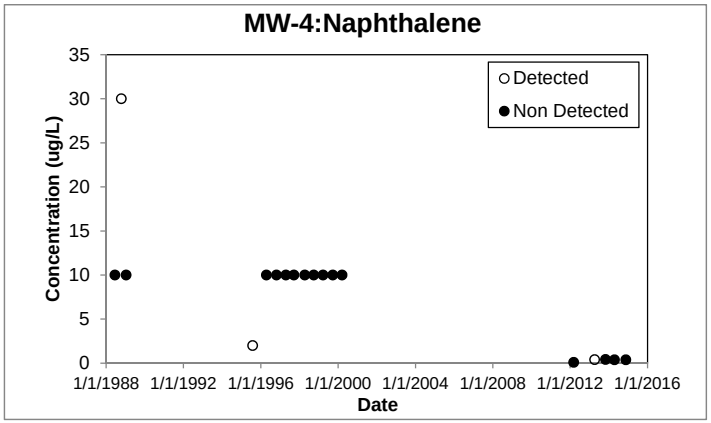
AECOM

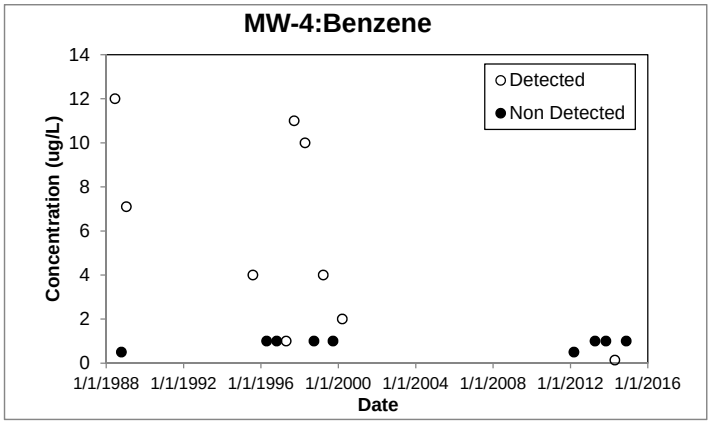
Path: P:\Jobs\Indl_Service\Project Files\Washington Gas MGP\GIS\MXD\RI_FS_Work_Plan\MXD\Fig_3_22_Potentiometric_Surface.mxd

Figure 3-23a
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



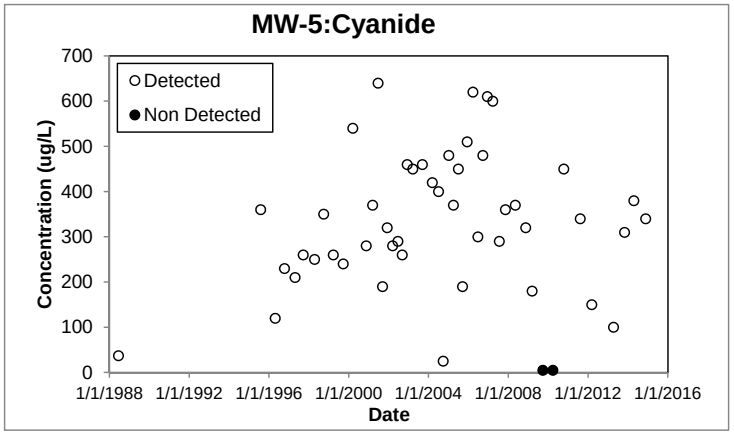


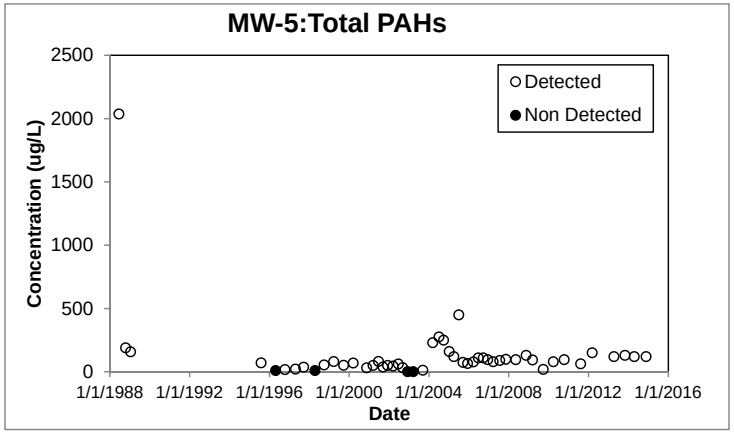


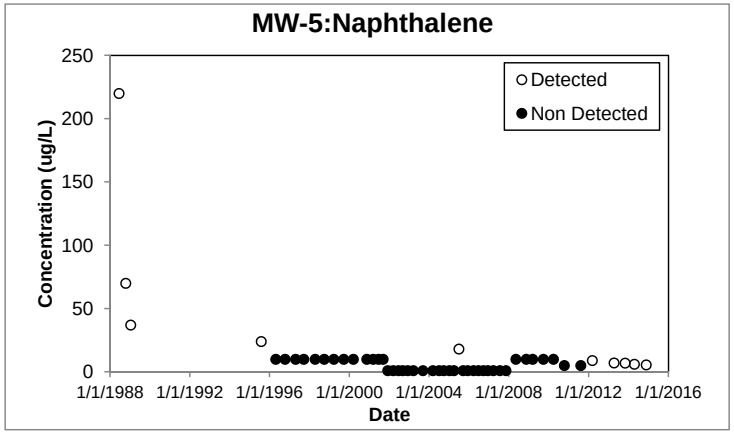


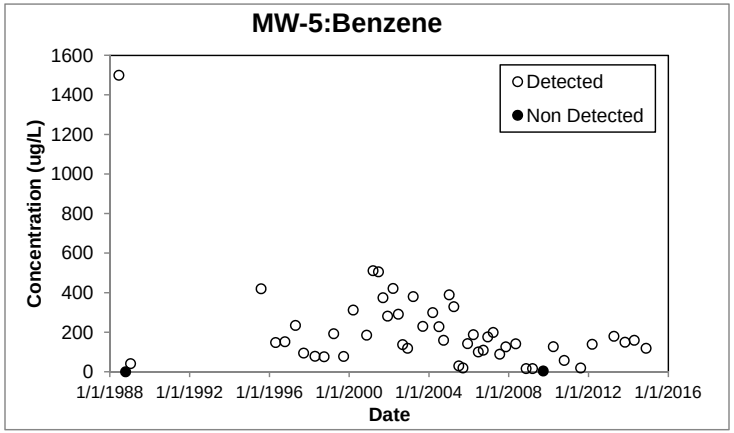
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 5/19/1988.
MTBE was detected in April 2013, October 2013, and November 2014.

Figure 3-23b
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



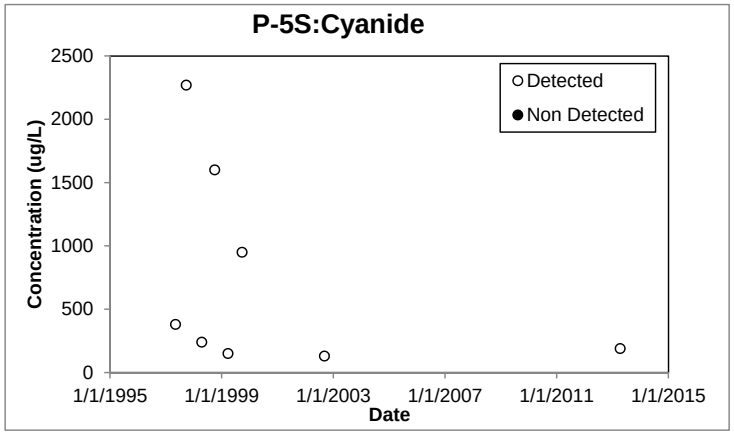


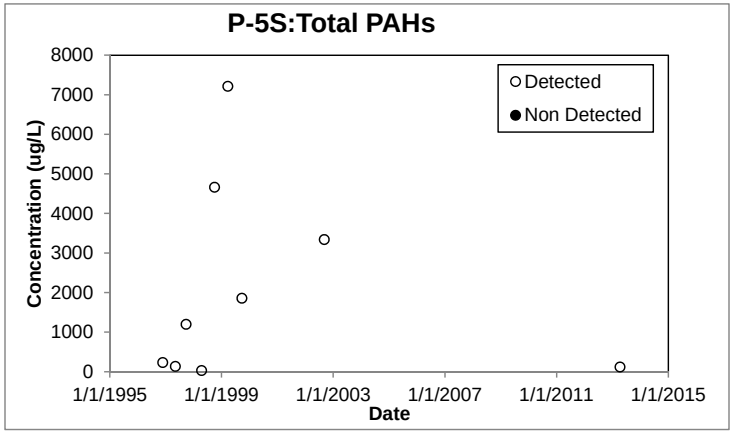


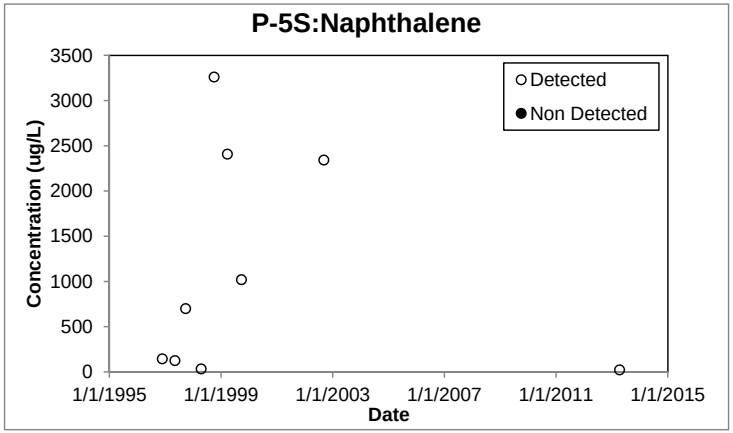


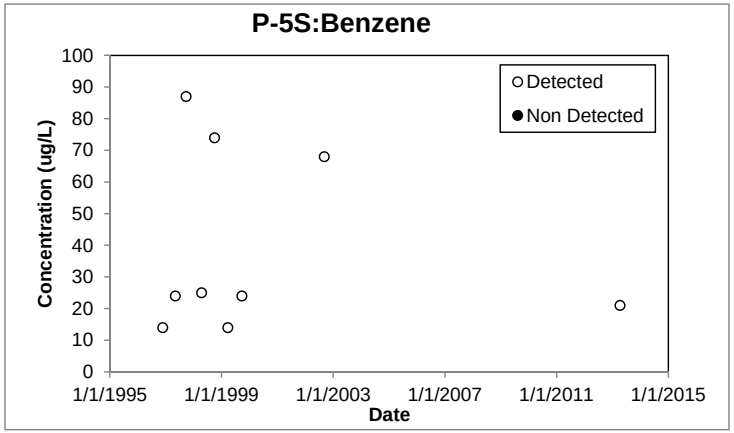
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 6/7/1988.

Figure 3-23c
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



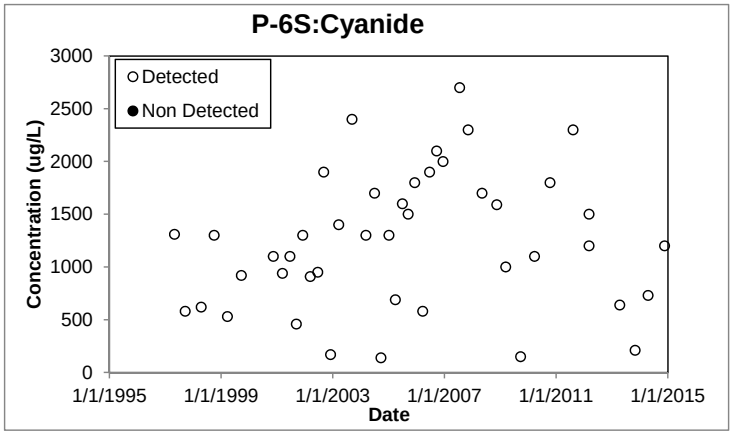


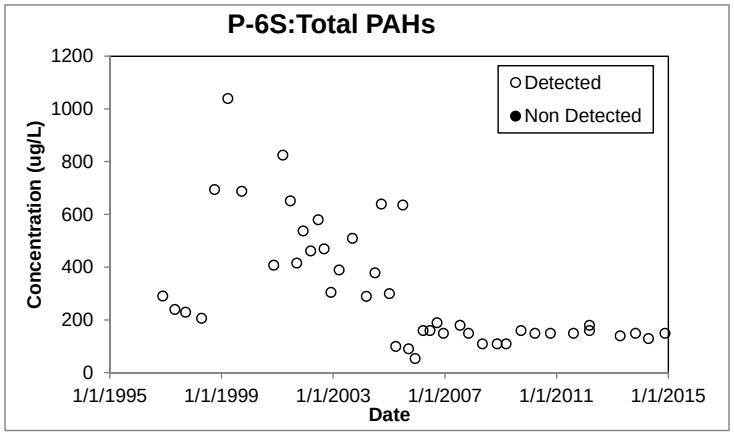


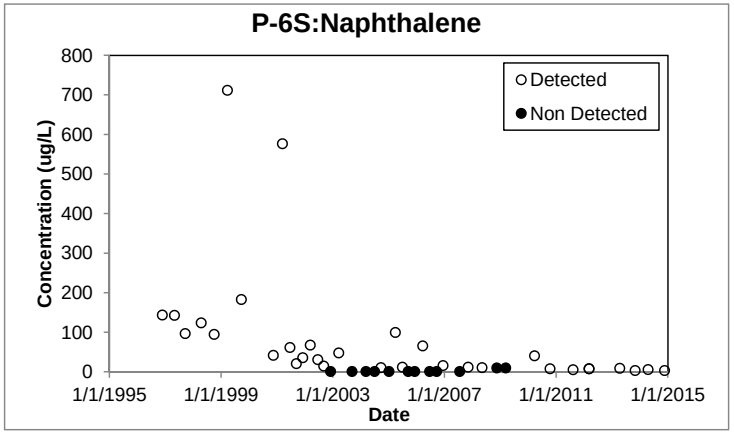


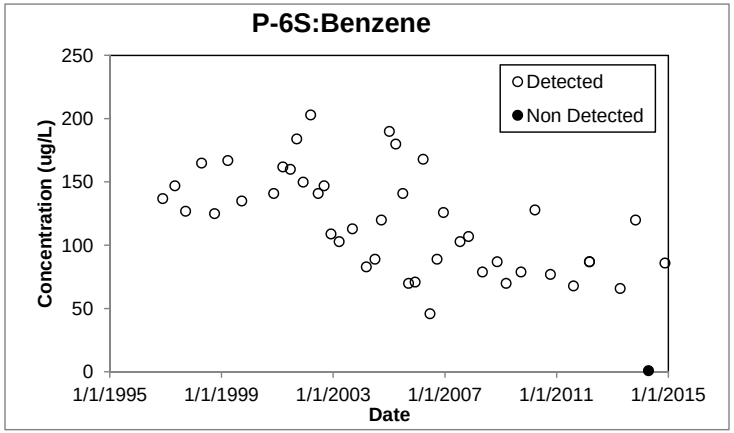
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 5/1/1996.

Figure 3-23d
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



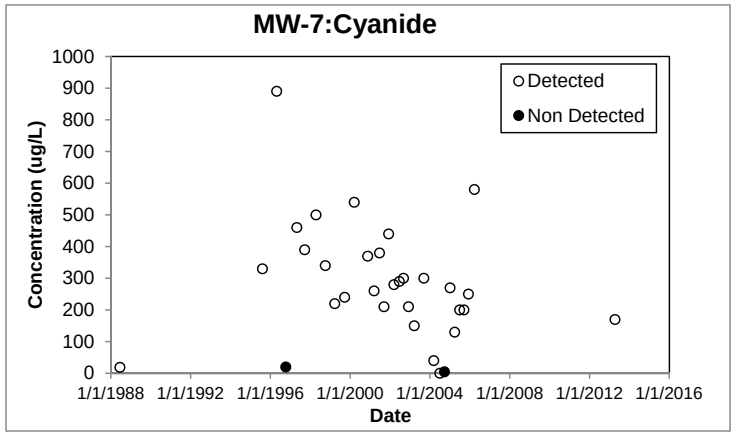


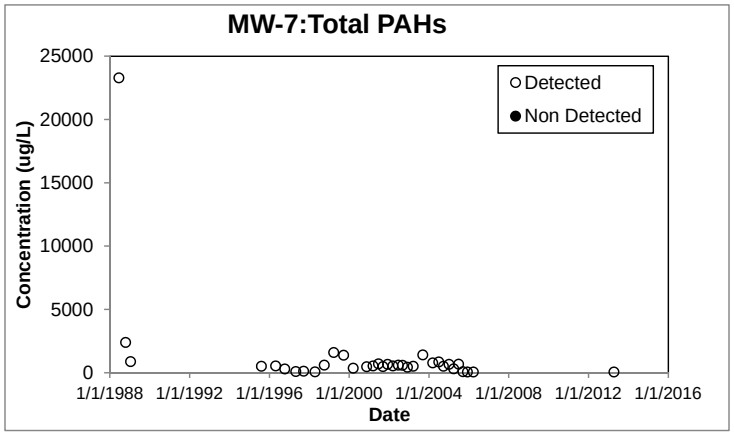


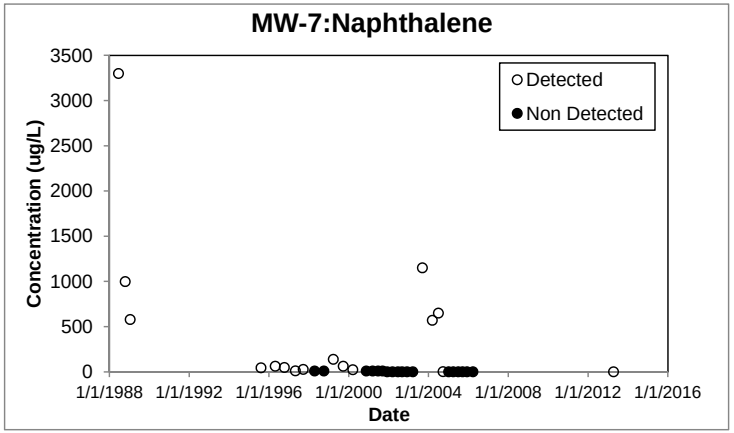


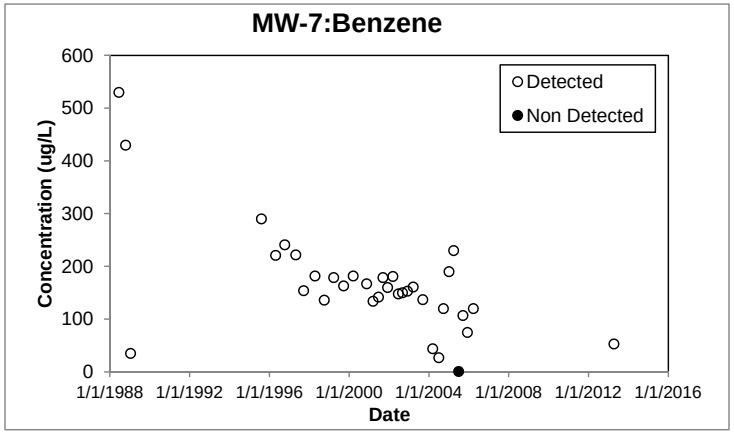
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 4/23/1996.

Figure 3-23e
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



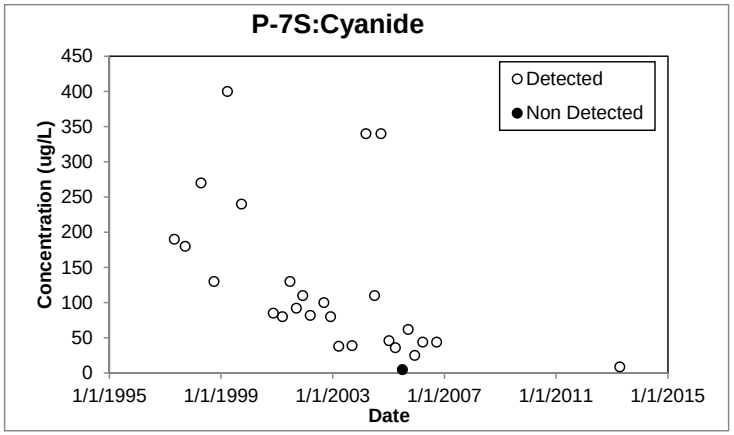


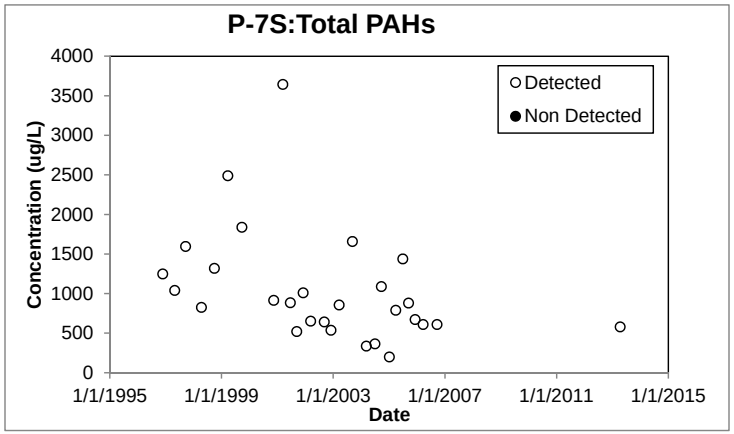


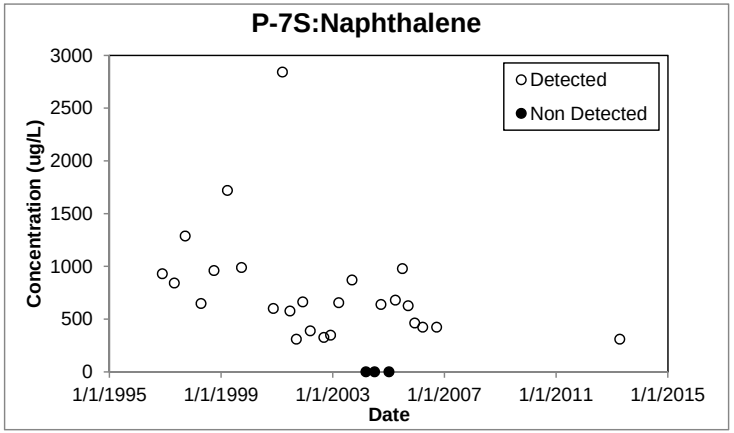


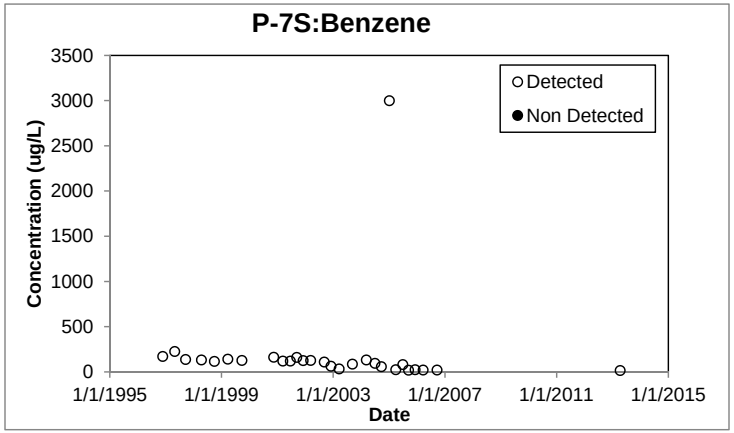
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 5/17/1988.

Figure 3-23f
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



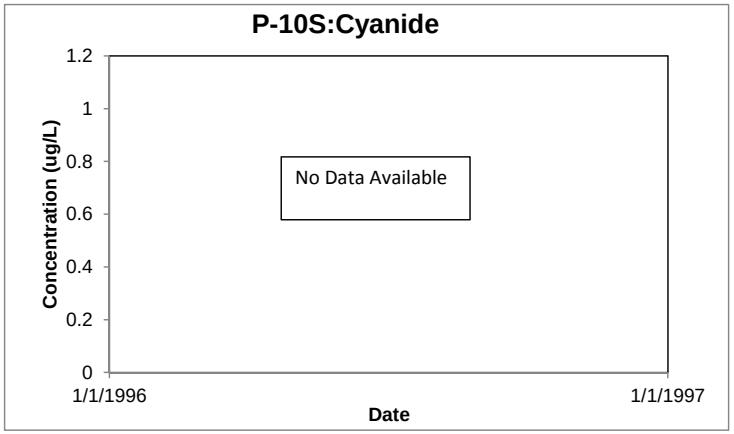


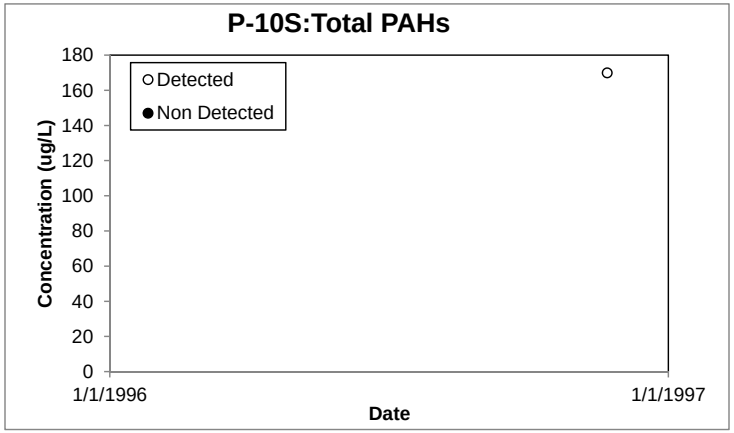


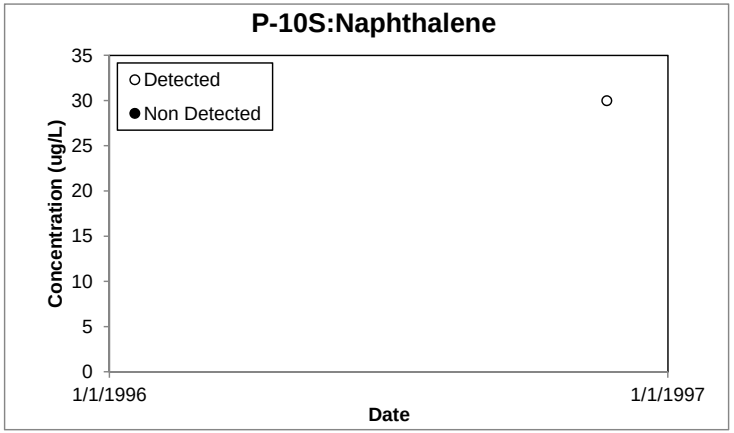


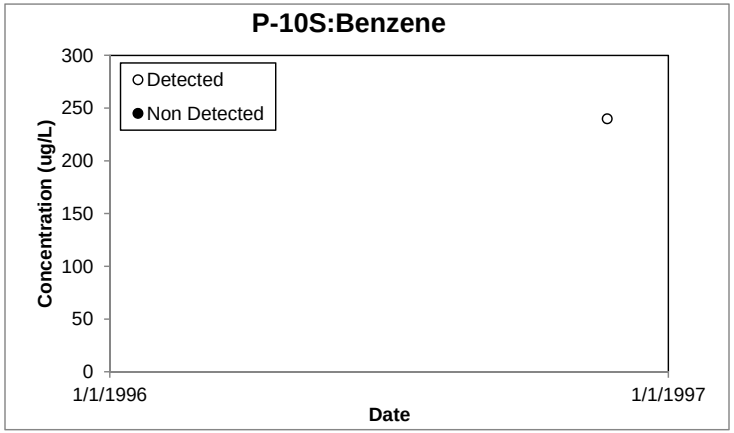
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 4/23/1996.

Figure 3-23g
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



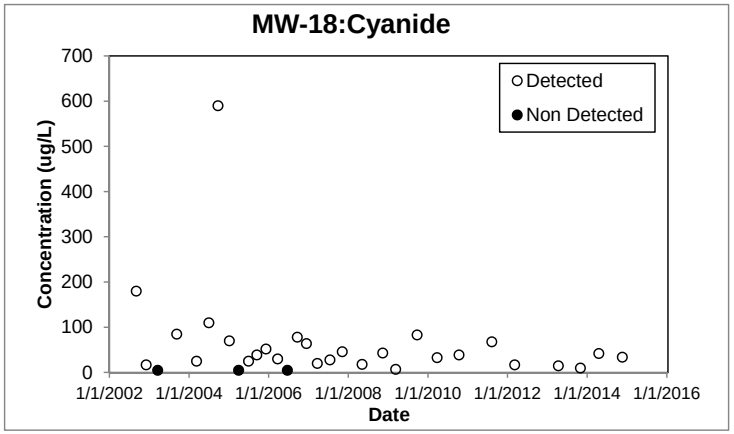


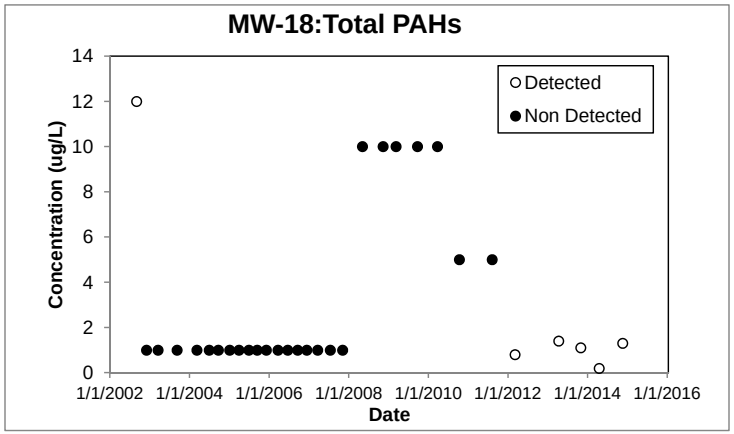


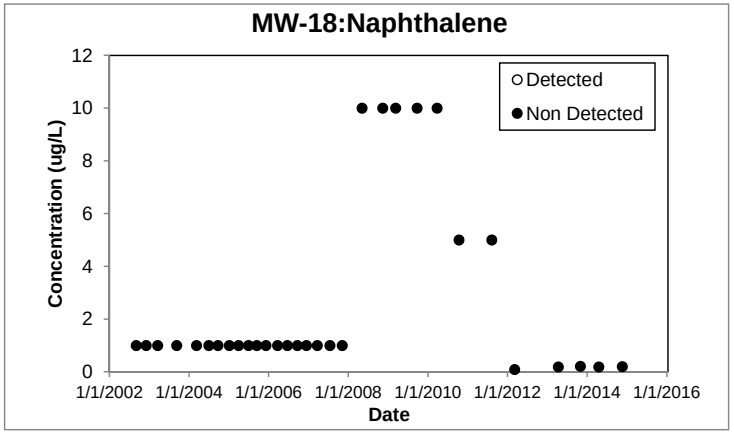


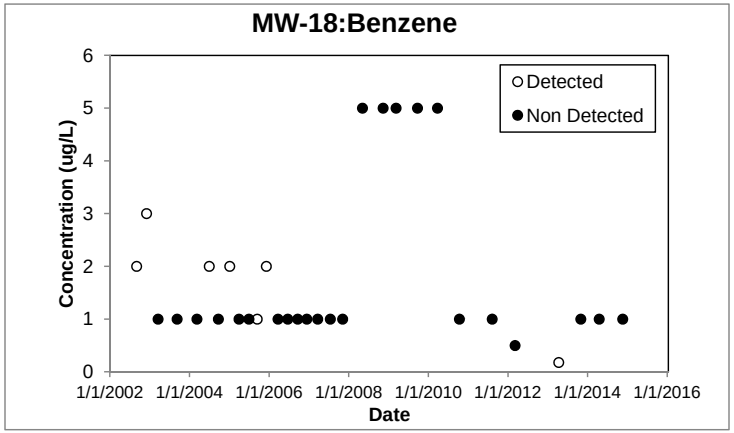
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 4/17/1996.

Figure 3-23h
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



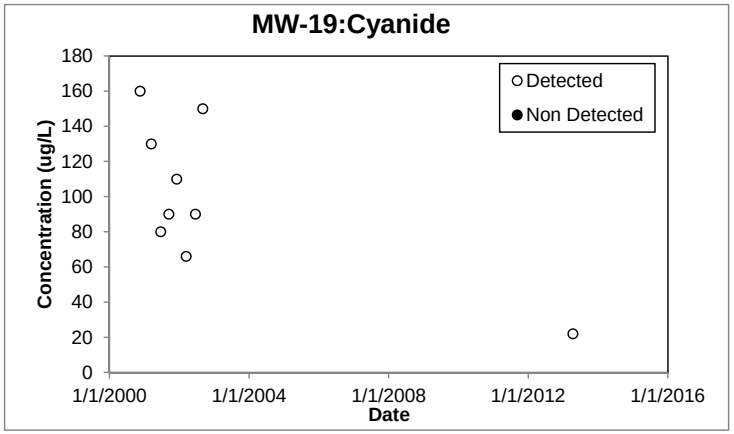


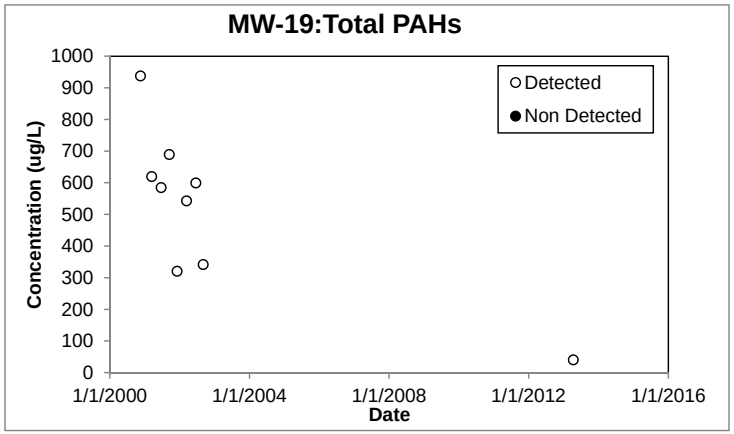


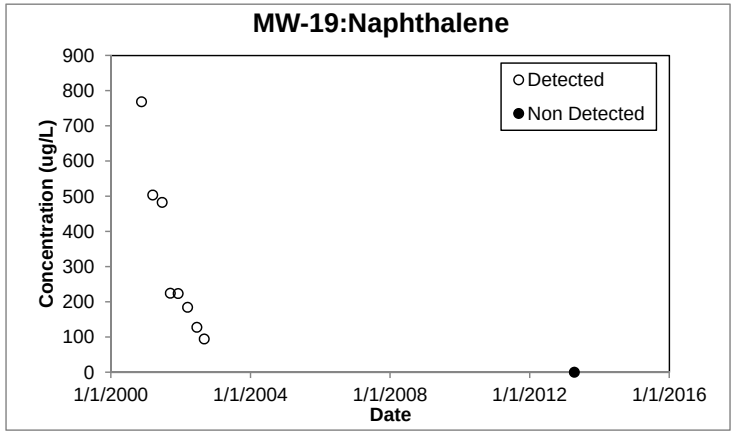


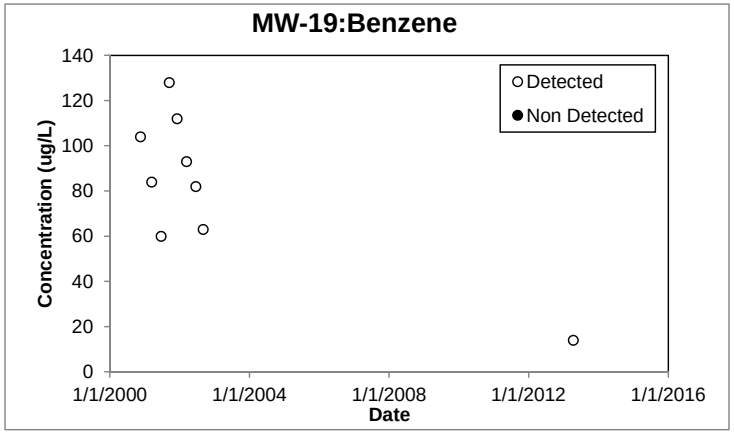
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 9/26/2000.

Figure 3-23i
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



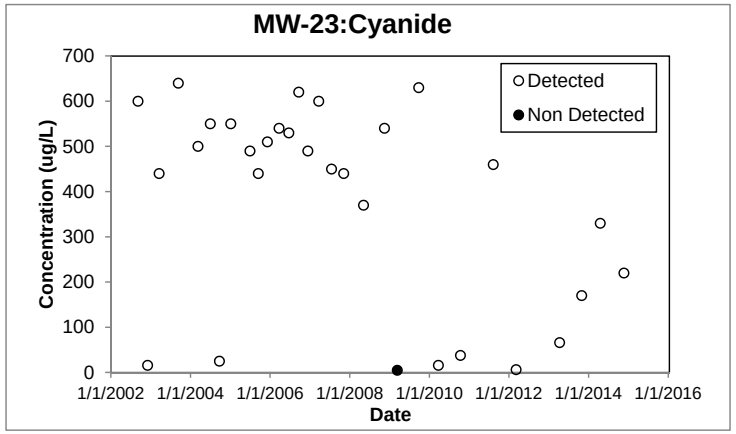


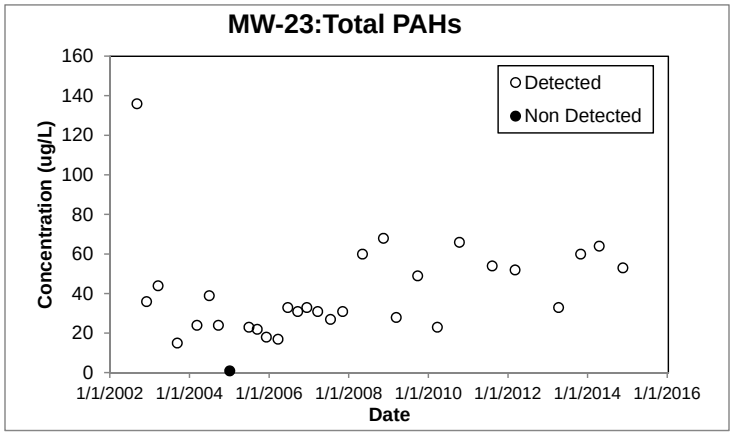


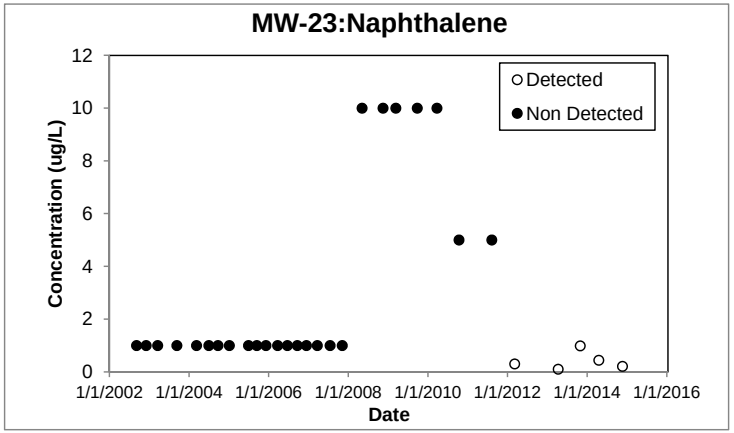


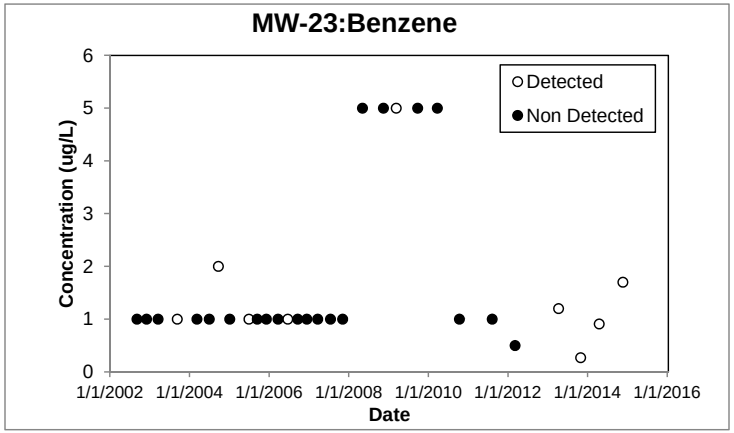
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 9/27/2000.

Figure 3-23j
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



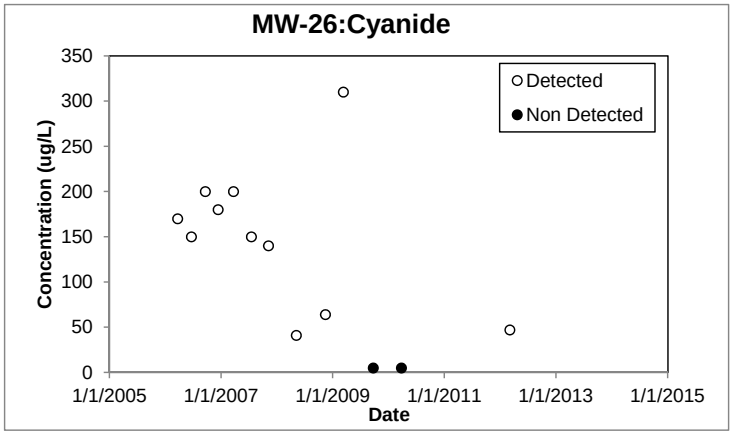


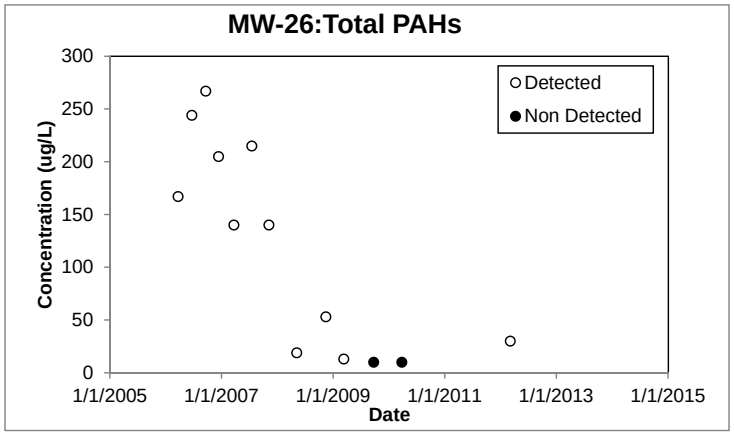


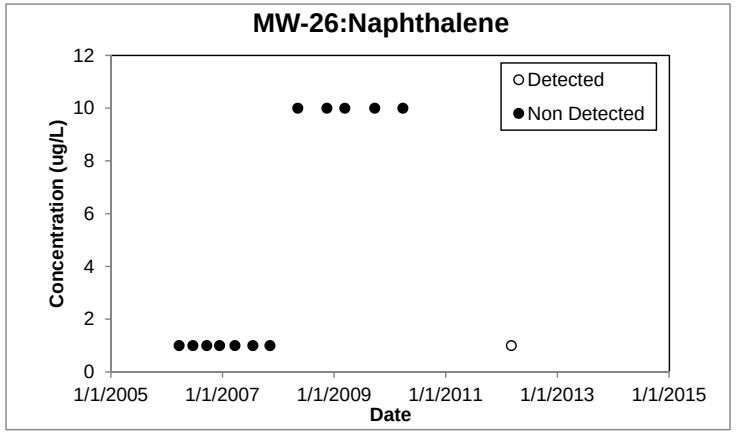


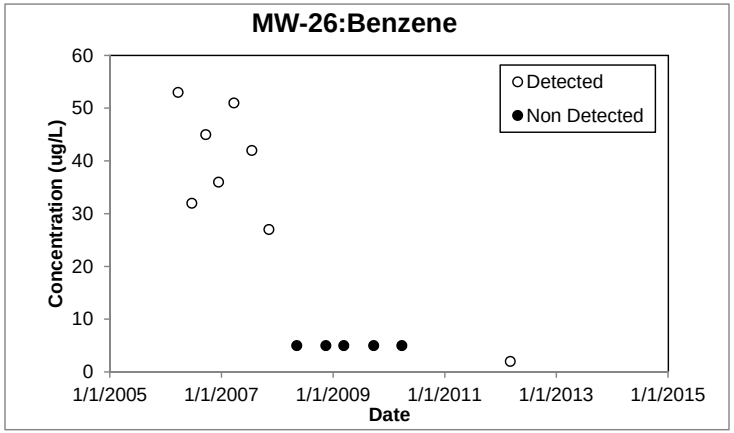
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 9/27/2000.

Figure 3-23k
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



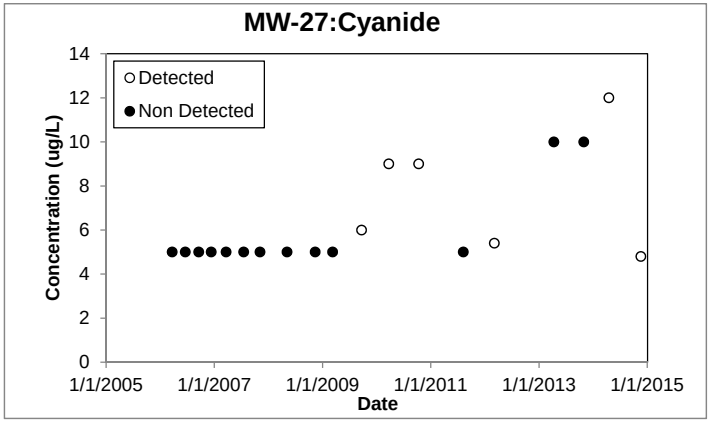


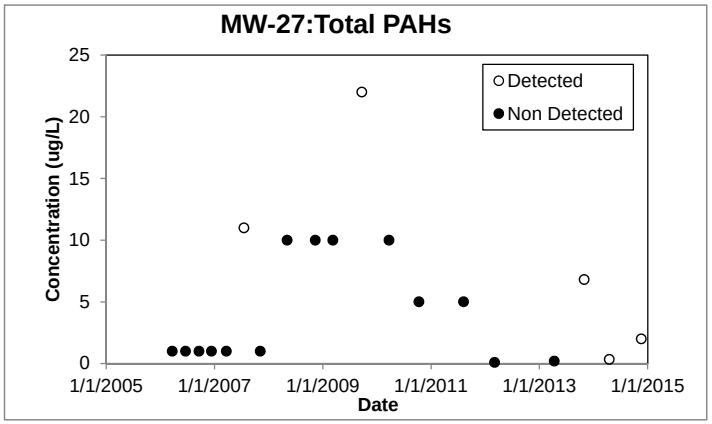


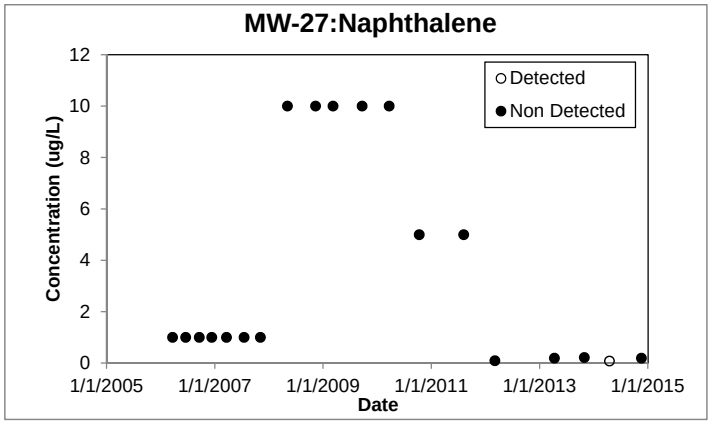


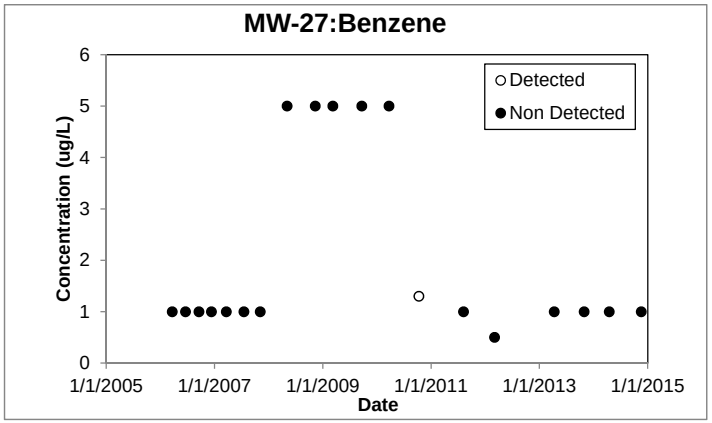
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 3/8/2006.

Figure 3-23l
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



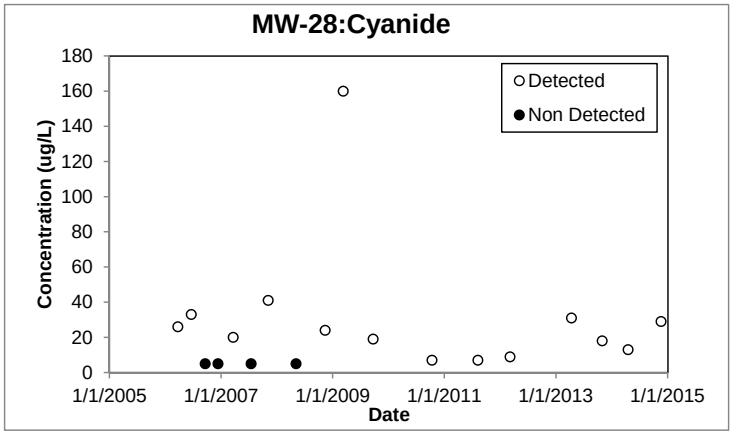


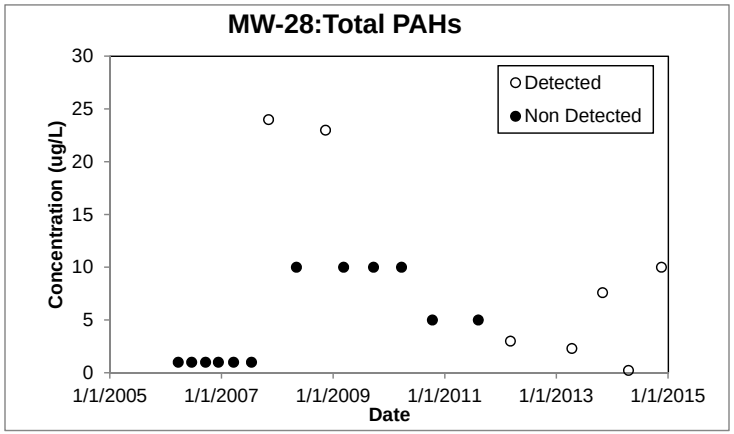


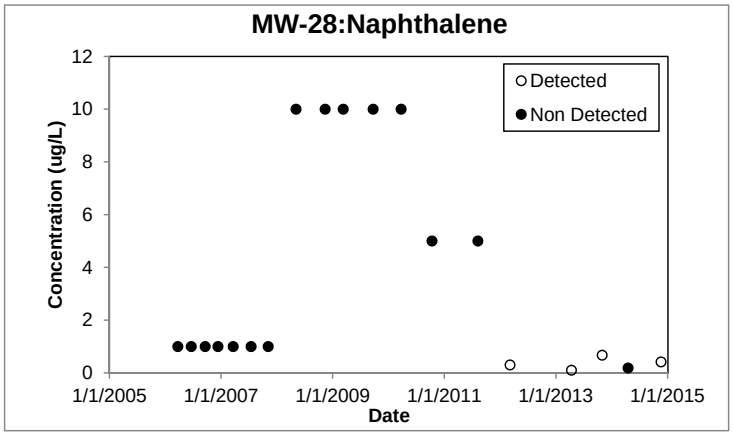


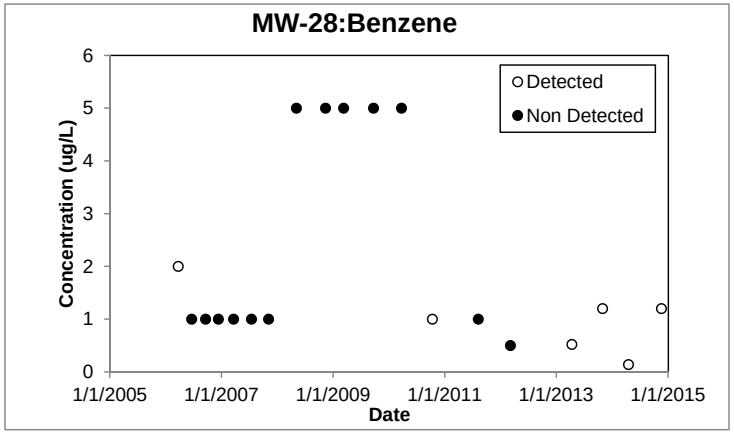
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 3/9/2006.
MTBE was detected in October 2010, March 2012, and April 2014.

Figure 3-23m
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



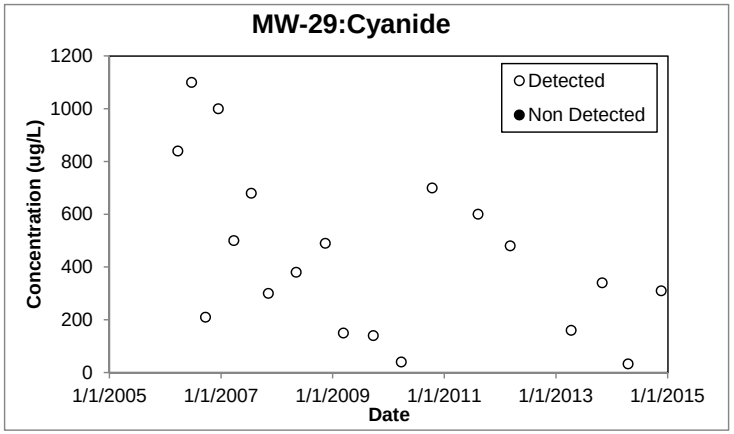


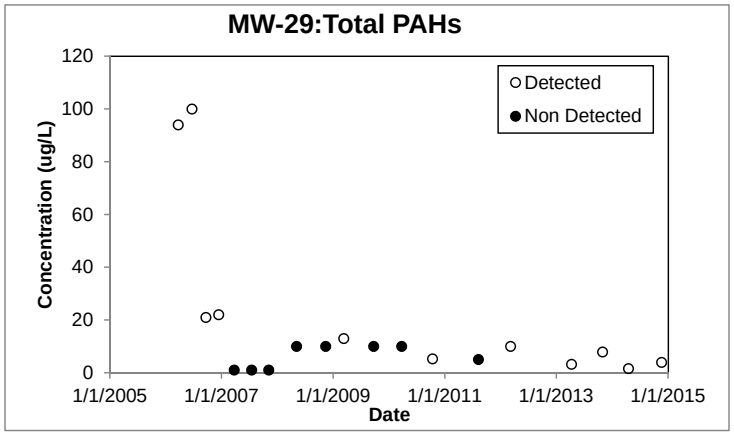


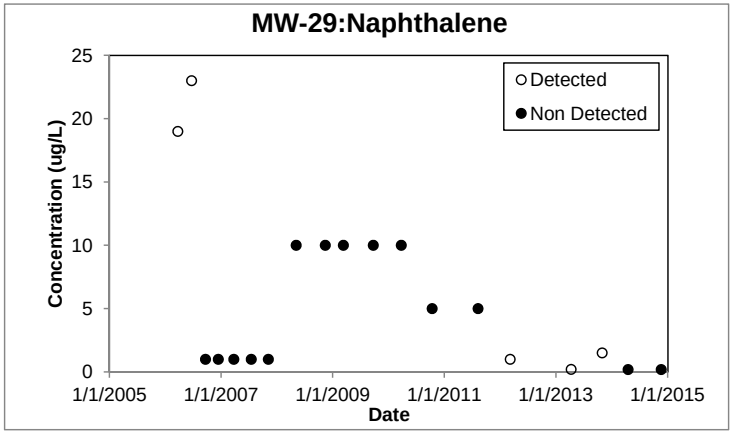


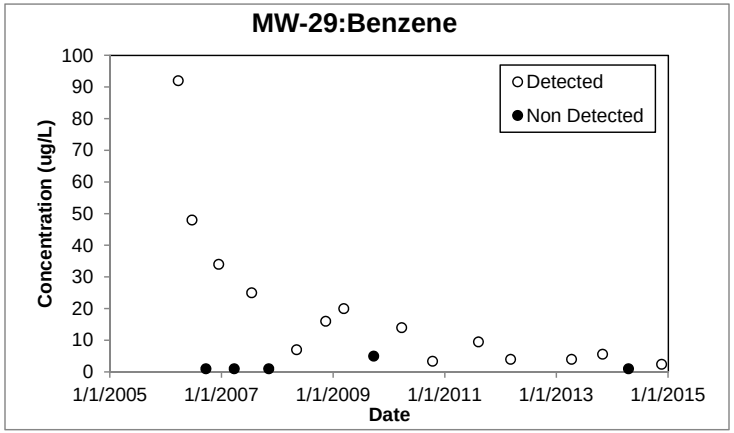
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 3/9/2006.

Figure 3-23n
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



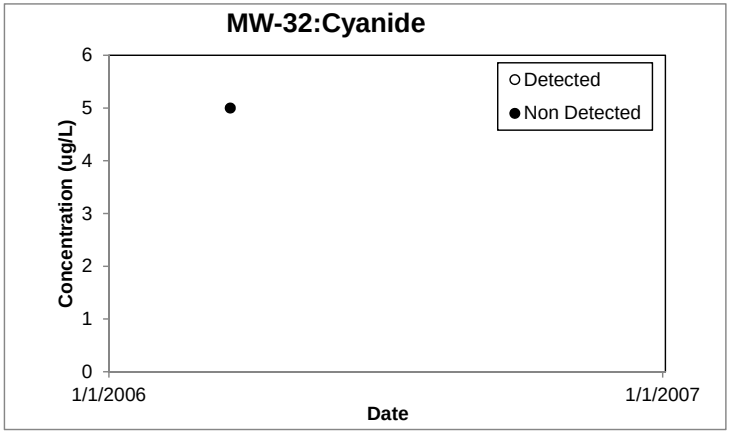


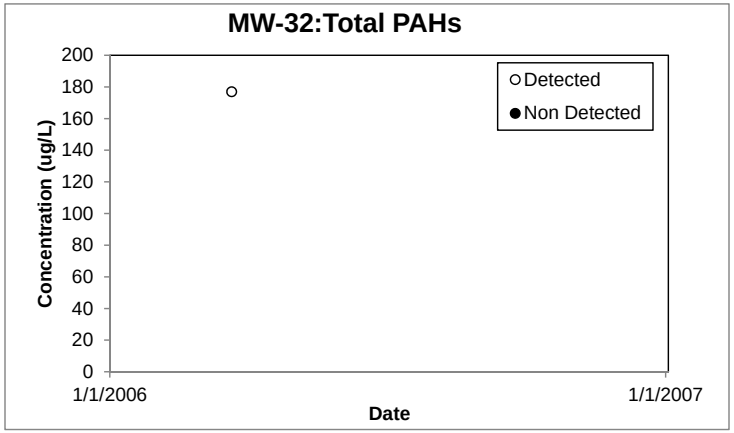


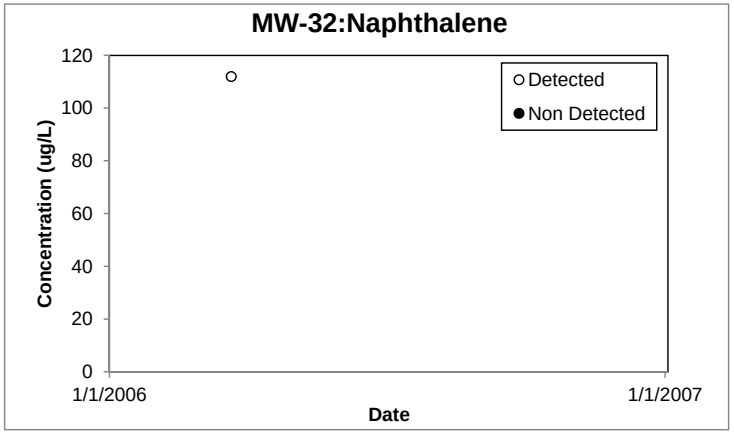


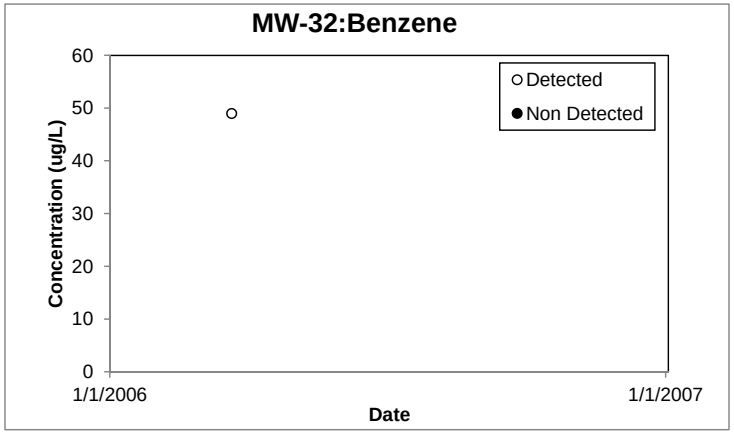
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 3/9/2006.

Figure 3-23o
Concentration vs. Time Plots for Wells Screened in Fill
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



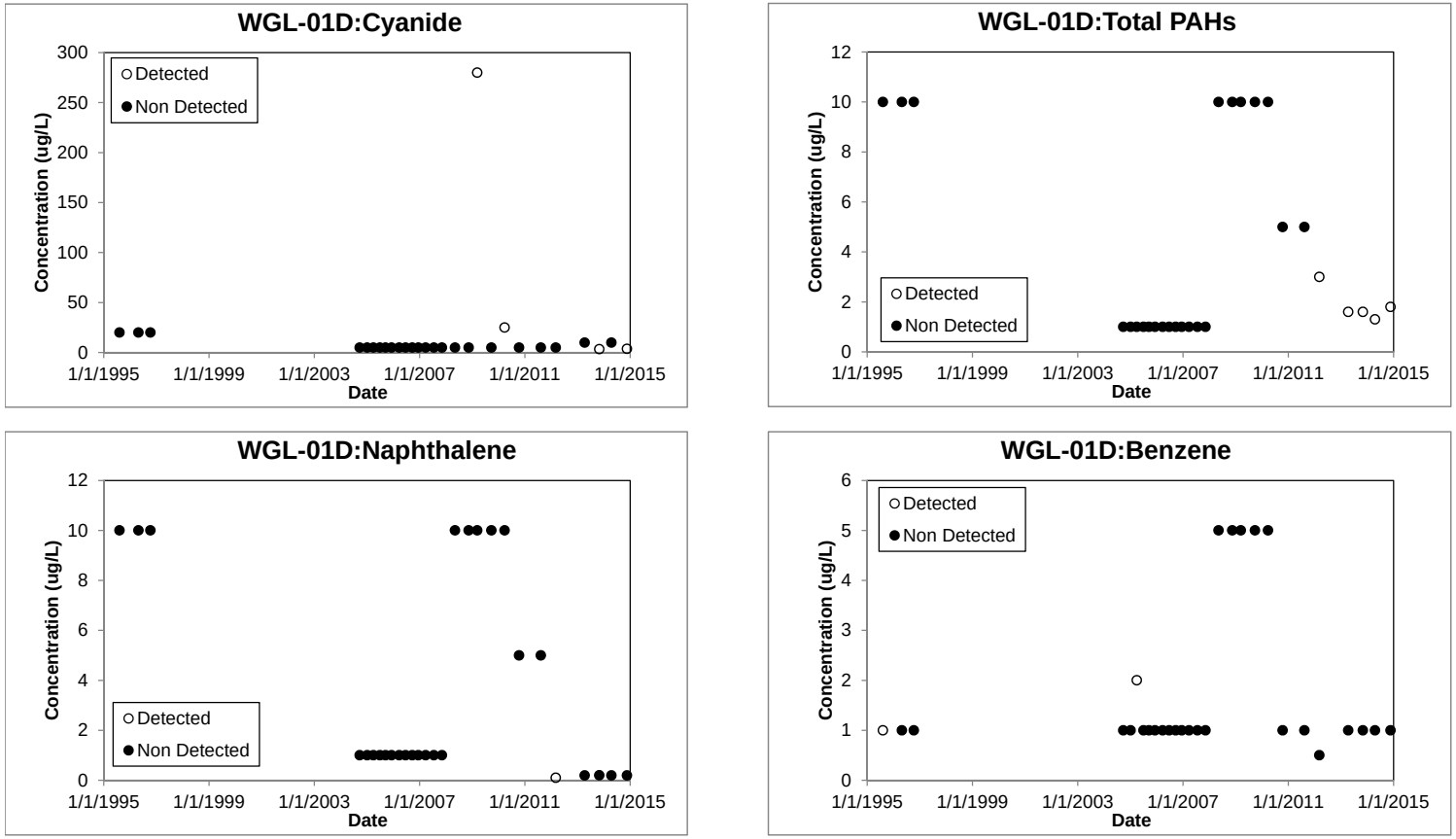






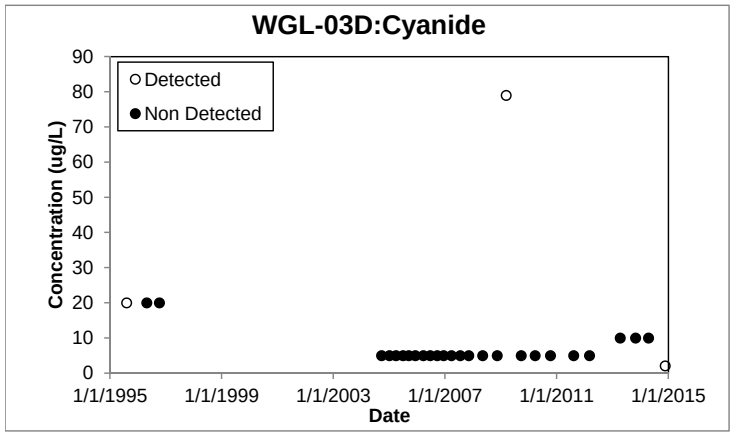
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 3/9/2006.

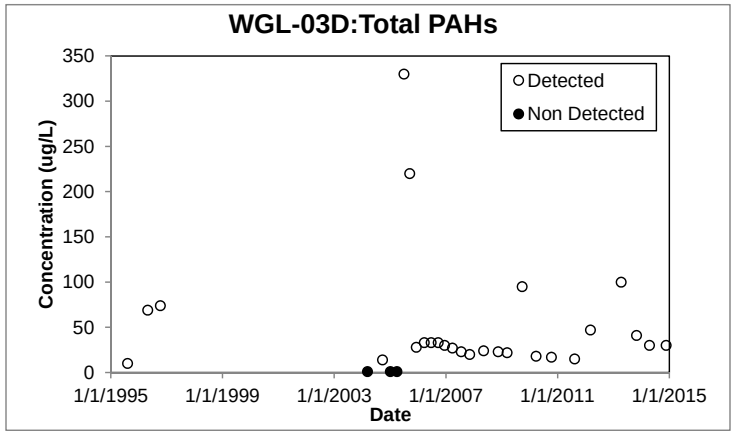
Figure 3-24a
Concentration vs. Time Plots for Wells Screened in Sand and Gravel
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

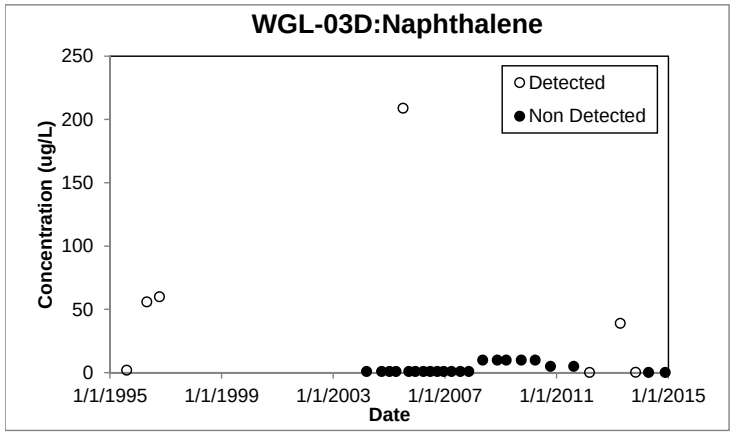


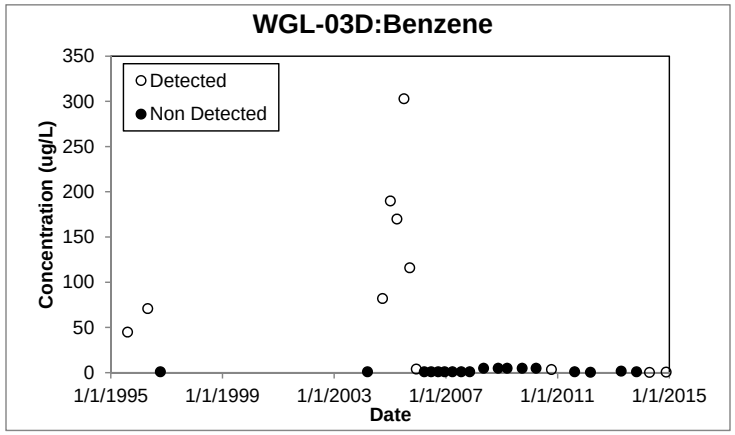
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 3/29/1991.
MTBE was detected in this well in March 2012, April 2013, October 2013, April 2014, and November 2014.

Figure 3-24b
Concentration vs. Time Plots for Wells Screened in Sand and Gravel
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



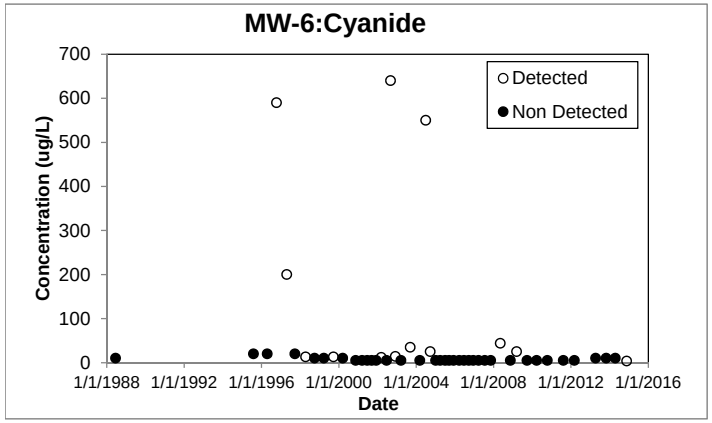


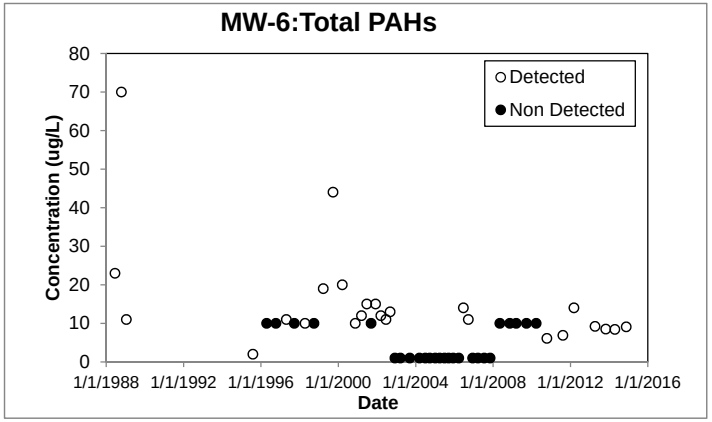


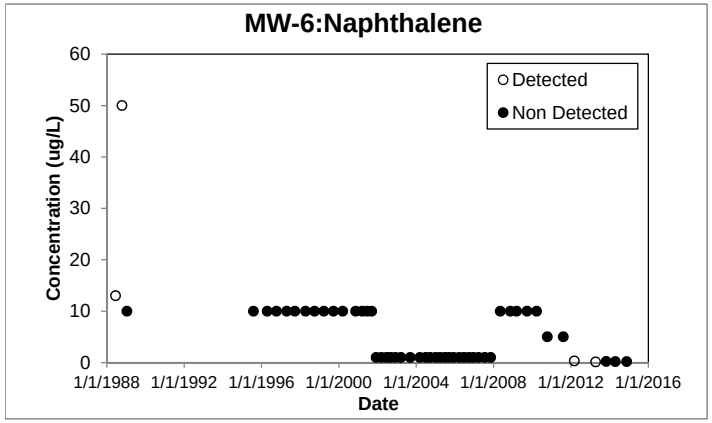


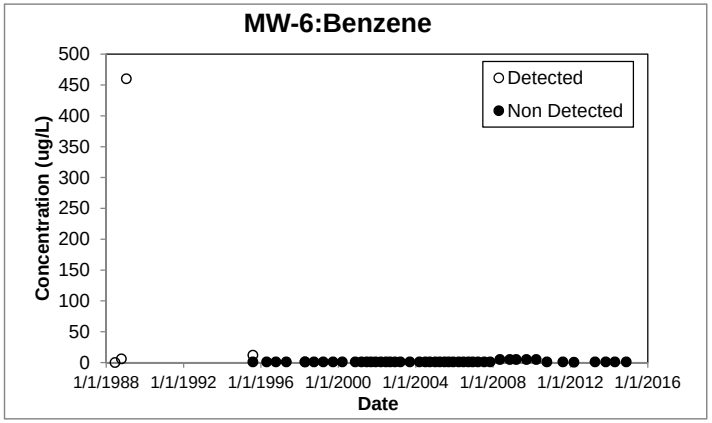
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 5/16/1991.

Figure 3-24c
Concentration vs. Time Plots for Wells Screened in Sand and Gravel
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



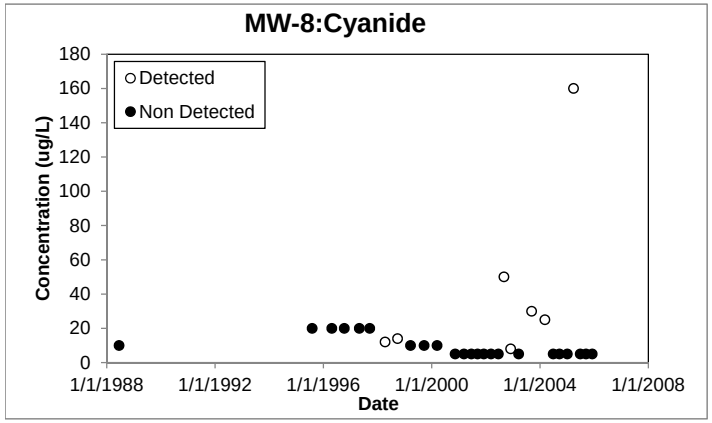


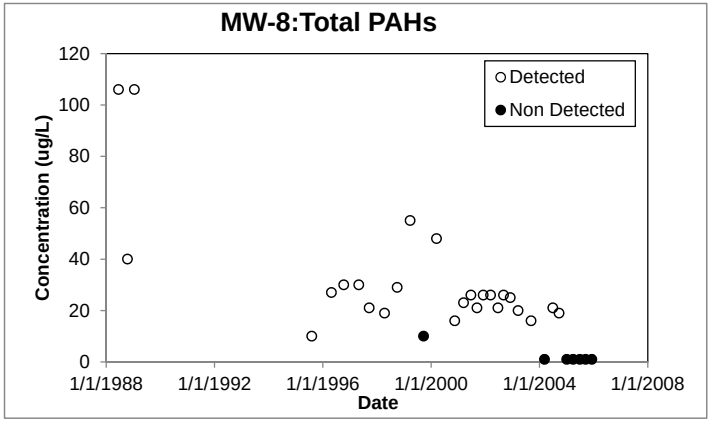


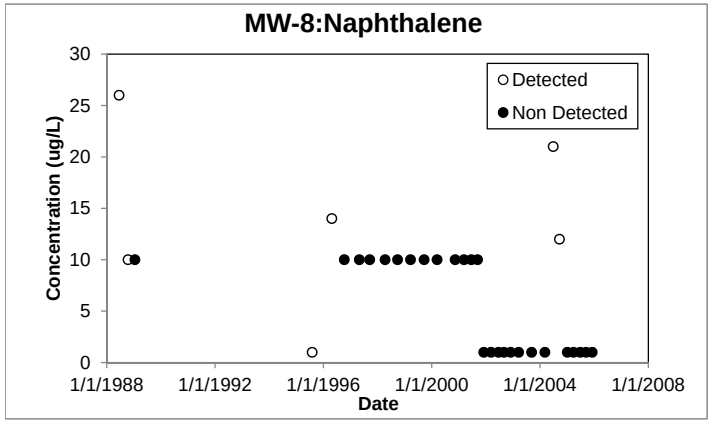


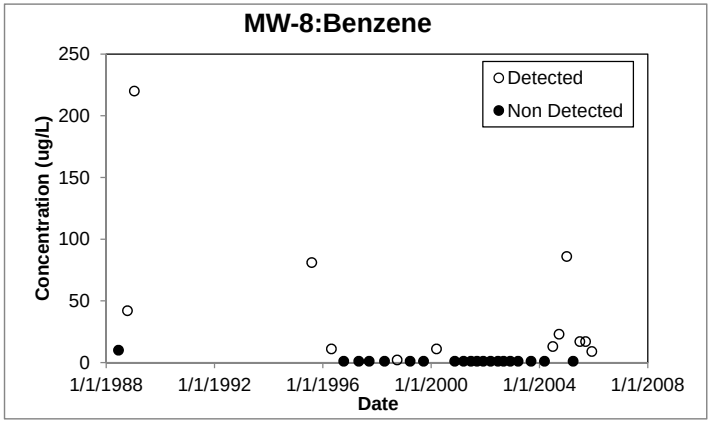
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 5/26/1988.
MTBE was detected in this well in October 2010, August 2011, March 2012, April 2013, October 2013, April 2014, and November 2014.

Figure 3-24d
Concentration vs. Time Plots for Wells Screened in Sand and Gravel
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



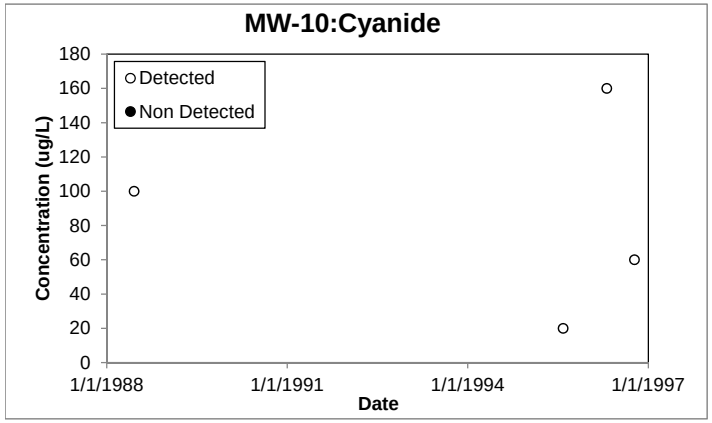


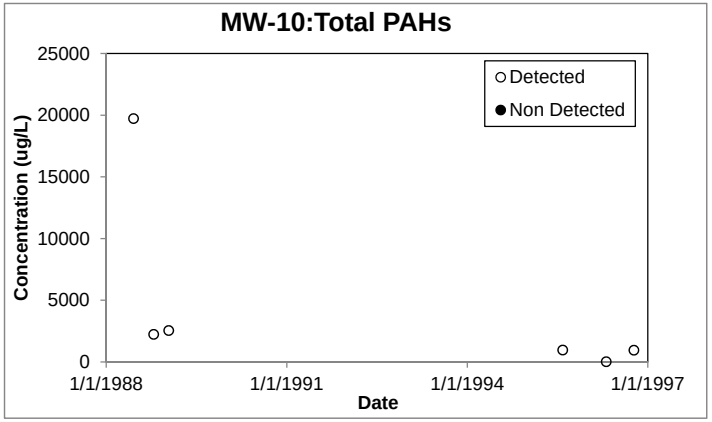


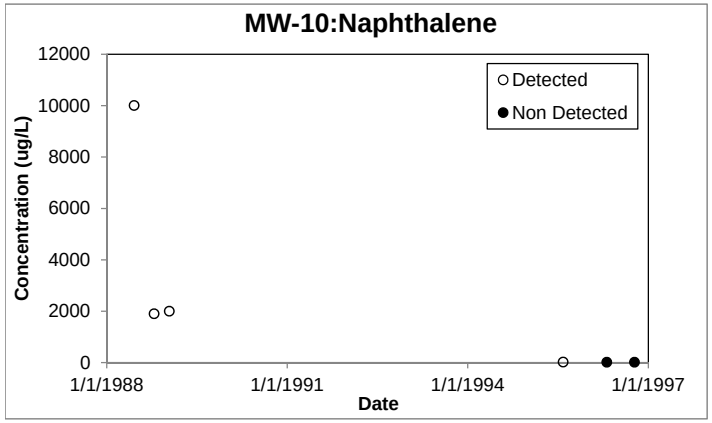


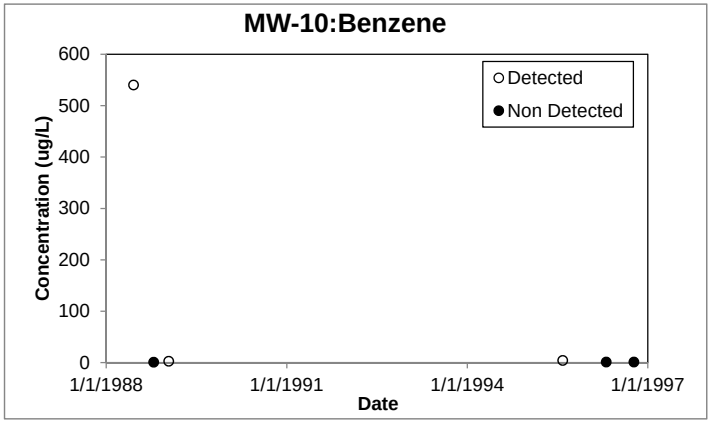
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 6/2/1988.

Figure 3-24e
Concentration vs. Time Plots for Wells Screened in Sand and Gravel
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



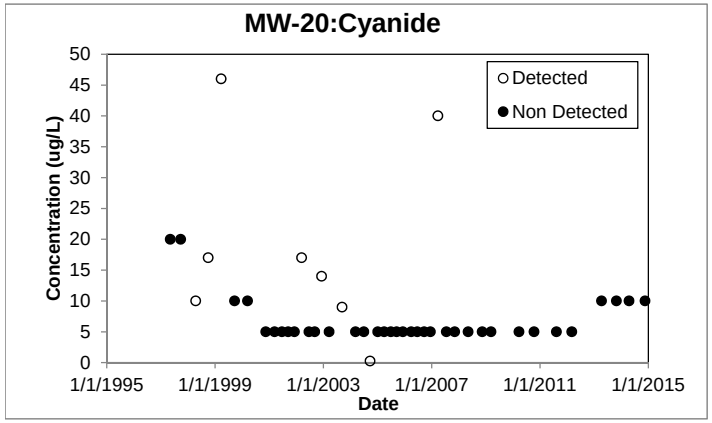


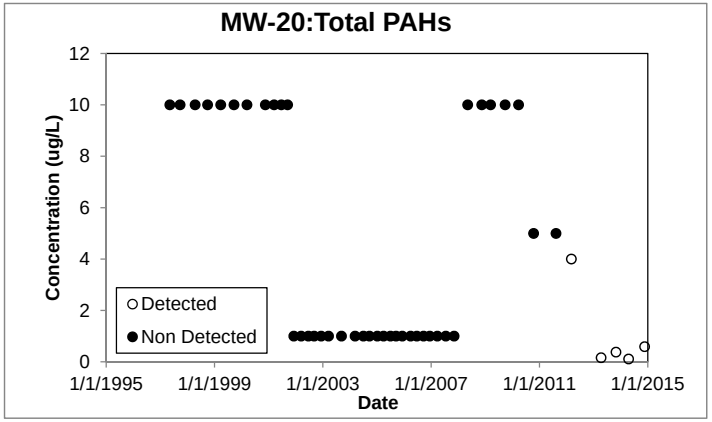


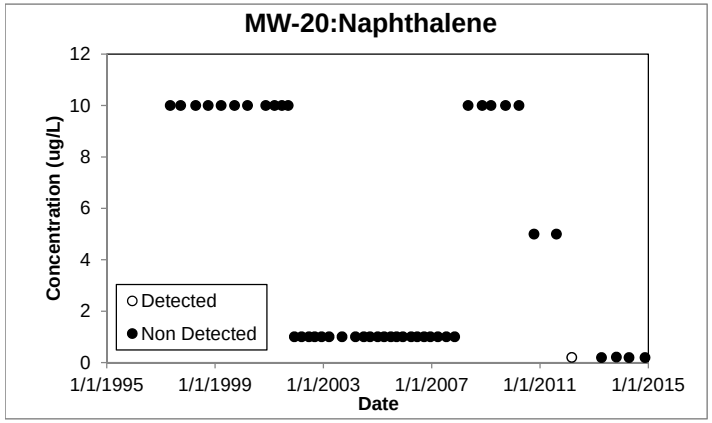


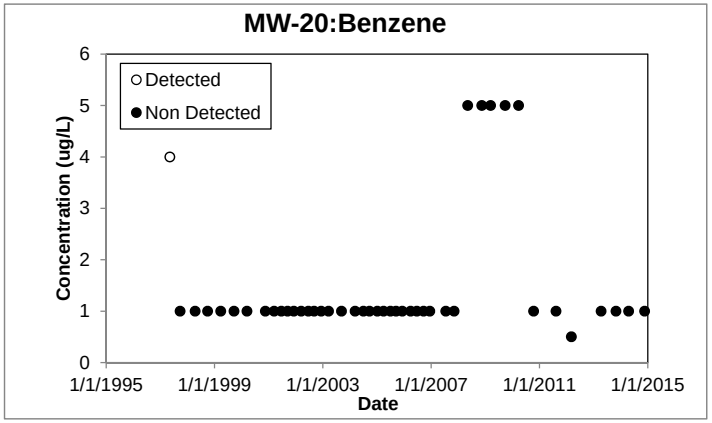
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 5/19/1988.

Figure 3-24f
Concentration vs. Time Plots for Wells Screened in Sand and Gravel
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



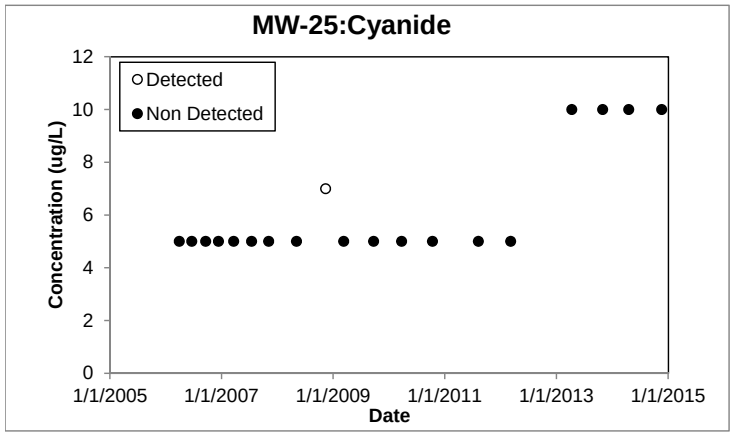


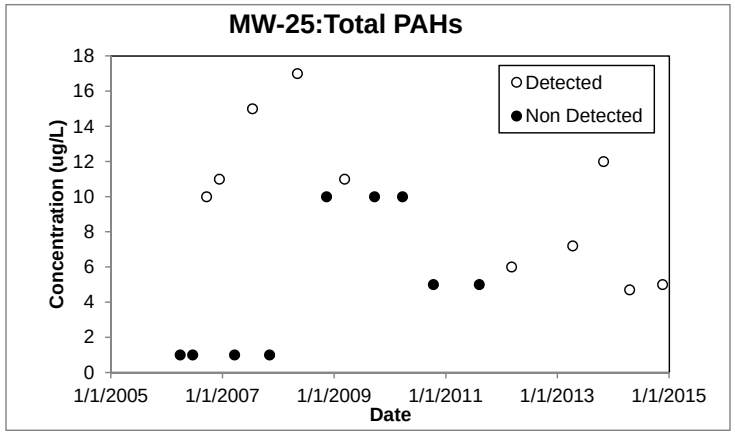


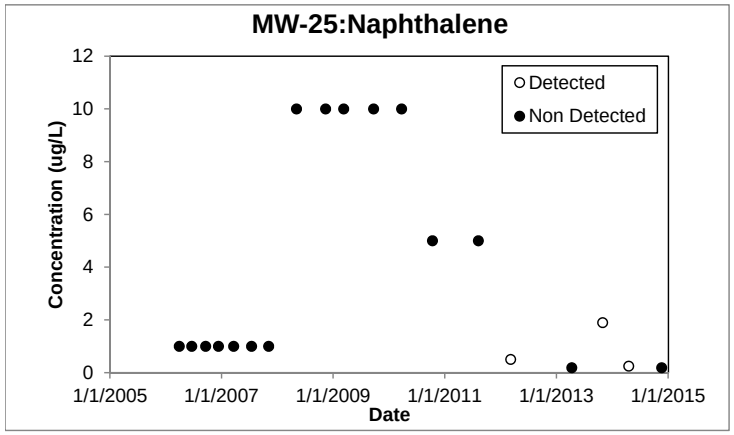


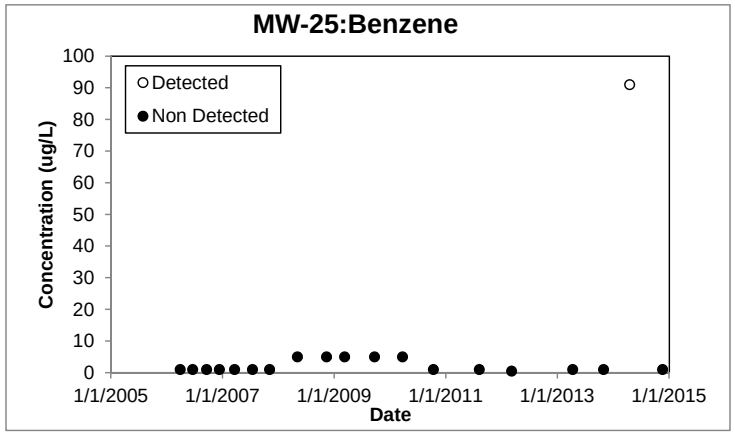
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 12/16/1996.
MTBE was detected in this well in November 2014.

Figure 3-24g
Concentration vs. Time Plots for Wells Screened in Sand and Gravel
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



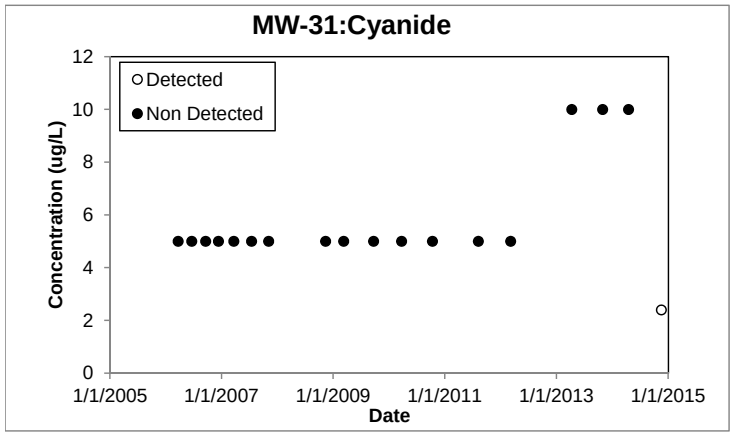


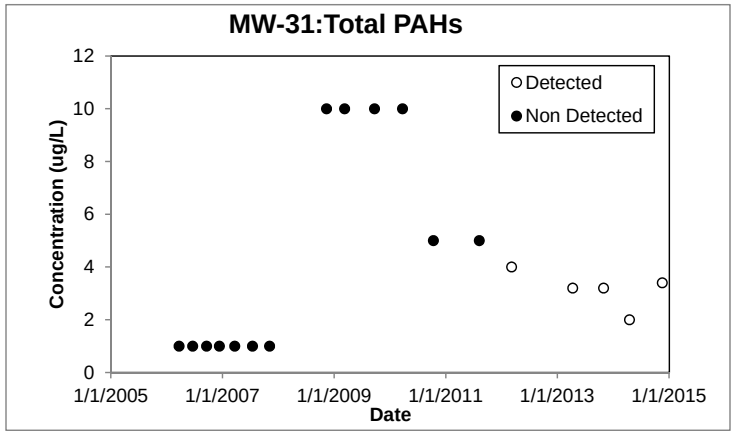


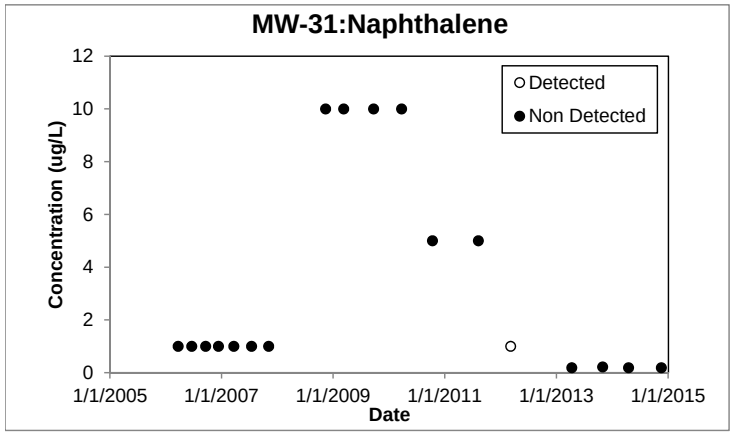


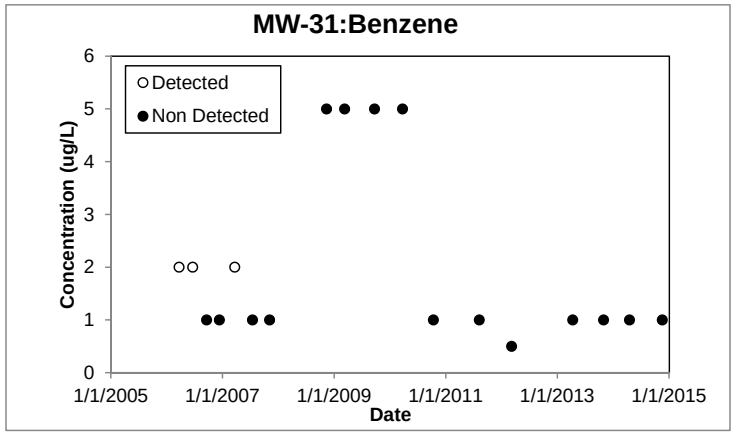
Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 3/16/2006.

Figure 3-24h
Concentration vs. Time Plots for Wells Screened in Sand and Gravel
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site









Note:
Non detect concentrations are shown at the detection limit for cyanide, naphthalene, and benzene.
Total PAHs represents the sum of detected concentrations of 17 PAHs for data collected after 1989.
Total PAHs represents the sum of detected concentrations of 16 PAHs for data collected before 1989.
If all PAHs were non detect, the highest individual detection limit is used.
Duplicate sample concentrations are shown as the average.
Since March 2012 cyanide samples have been field filtered. Prior data are assumed to represent total cyanide.
Well installed 3/14/2006.

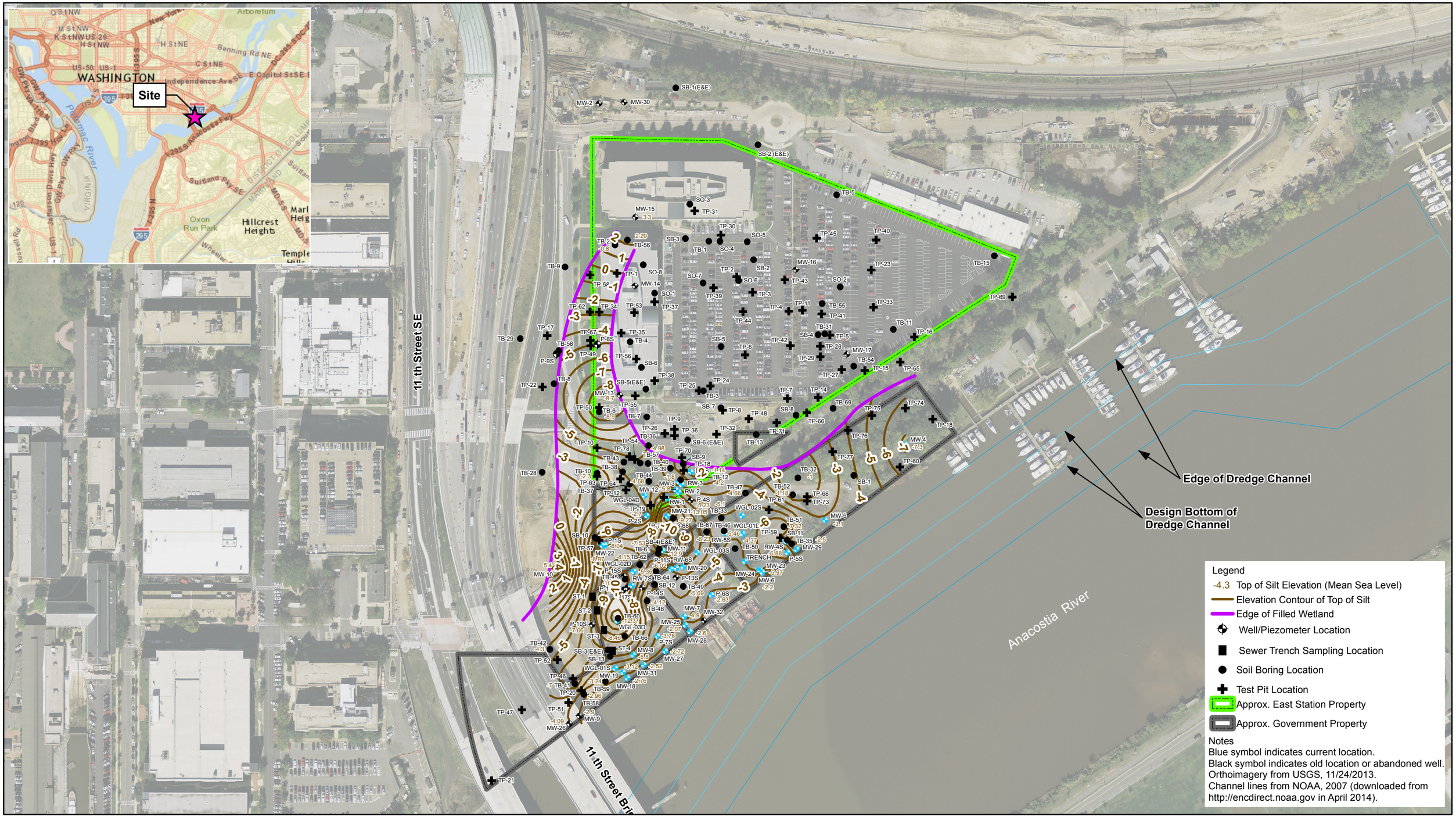


Figure 3-25 Elevation Contour of Top of Silt
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

0 100 200 Feet

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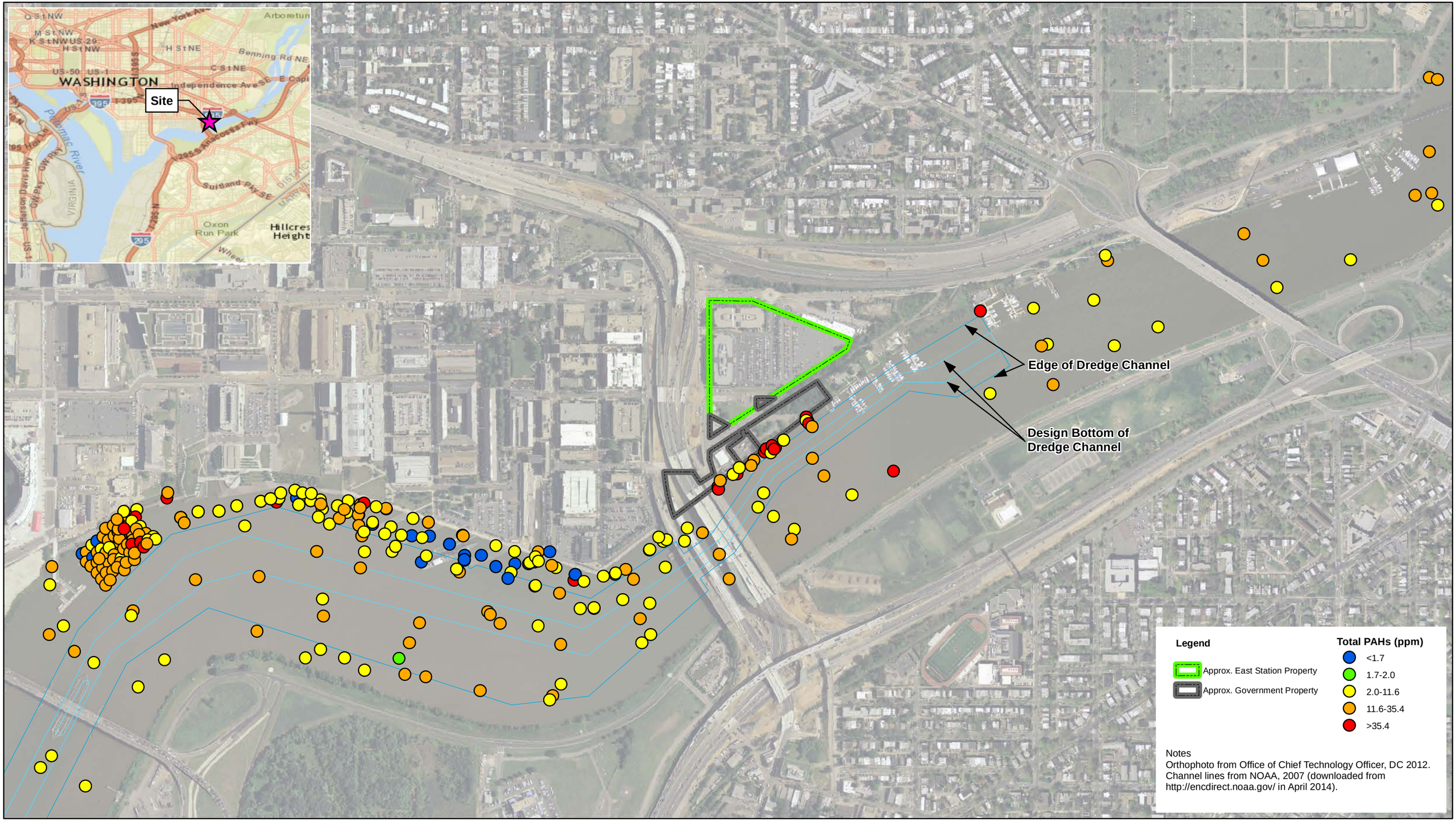

Figure 3-26 Anacostia River Surficial Sediment PAH Data Within One Mile of Washington Gas East Station Site Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan Washington Gas East Station Site

Surficial sediment data included on this figure has been collected from the following studies:

1. *1989 ICPRB/ Limno-Tech Sediment Survey*
2. *1992 Potomac & Anacostia Sediment Study*
3. *1995 Washington Navy Yard*
4. *1996 WA Gas - East Station Project*
5. *1997 DC Sediment Core Analysis*
6. *1999 WA Navy Yard RI*
7. *2000 Ambient Tox Chesapeake Bay*
8. *2000 ANS/ USFWS Triad Study*
9. *2000 USFWS Bioavailability*
10. *2006/09 Washington Navy Yard*
11. *2002/3 Gascoyne Lab*
12. *1995 Ecology & Environment*
13. *1989 Hydro-Terra*
14. *1999 Hydro-Terra*
15. *1990, 1991, 1993 EMAP*

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4.0 Work Plan Rationale

This section describes the OU2 RI/FS activities that will be performed to satisfy data needs based on the DQOs established for this RI/FS.

4.1 Data Quality Objectives

The DQO process is a systematic planning tool derived from the scientific method (USEPA, 2006). It is designed to clarify the objectives of data collection and maximize efficiency during the data collection process.

DQOs are qualitative and quantitative statements which clarify the objectives of the project, define the procedures to be used to gather data, and identify the error tolerance appropriate for the use of each data type. There are seven steps in the DQO process; the output of each step influences the choices of the next step. The DQO process is also iterative; output from one step may lead to reconsideration of previous steps; and complex projects such as the OU2 RI/FS may require that the DQO process follow an adaptive management approach and be used repeatedly as the project progresses and decisions require a sharper focus.

The DQO process followed for the OU2 RI will be refined in the QAPP to be prepared for the WG East Station RI/FS. The outcome of the DQO process for the OU2 RI/FS is presented in Table 4-1. As shown in Table 4-1, three principal study questions were developed during the DQO process:

- Principal Study Question 1: What is the nature and extent of Site-related contaminants in groundwater adjacent to the seawall and in River sediments and surface water?
- Principal Study Question 2: What is the mass flux/discharge of Site-related contaminants in groundwater/NAPL to the River?
- Principal Study Question 3: Are Site-related contaminant concentrations in sediment and surface water posing an unacceptable risk to human receptors, under current or future exposure conditions, as a result of historical operations of the MG facility at the Site; and what are the potential current and future risks to ecological receptors associated with exposure to Site-related contaminants in River sediment, pore water, and surface water?

Table 4-1 Data Quality Objective Development

DQO Step	Description
Step 1. State the Problem (Why is this investigation being performed?)	The groundwater beneath the government property is contaminated by contacting the wastes on the WG Site or by contacting the wastes migrating from the WG Site onto the government property or by contact with the wastes deposited directly onto the government property itself. The groundwater could potentially impact the River. Sediments in the River are contaminated with material that may be attributed to the Site. Some of the coal tar waste is present at sufficient volumes and density, and of low enough viscosity, to form DNAPL accumulations that are migrating within the government property to some of the pumping and monitoring wells in both the fill and the sand and gravel layer. The extent of groundwater capture and the nature and extent of site-related contaminants are uncertain at the boundary between the government property and the River.
Principal Study Question #1 (Q1)	
Q1, Step 2. Principal Study Question (What question does the investigation need to answer)?	What is the nature and extent of Site-related contaminants in groundwater that discharges to the River, adjacent to the seawall and in River sediments and surface water?

Q1, Step 3. Information Inputs (What data do we need to answer the Principal Study Question?)	<u>Landside:</u>
	• Nature (current concentrations) and extent of Site-related NAPL and its resulting dissolved contaminants in groundwater at the seawall, and at all downgradient landside groundwater discharge boundaries to the River.
	  • Site-related contaminants include 17 PAHs, 4 VOCs (BTEX); cyanide; RCRA metals; and 4 phenolic compounds. Groundwater samples will also be analyzed for MTBE and NAPL samples (accumulating in monitoring and recovery wells and of NAPL saturated soils) will also be analyzed for PCBs.
	  • Fingerprinting and forensics of all PAHs in NAPL detected during the investigation or known to exist in monitoring wells at the government property to characterize Site-related contaminants.
	<u>In-river:</u>
	• Hydrographic survey (including bathymetry and utility surveys) to confirm the current river bottom configuration including the configuration of the authorized dredge channel located adjacent to the Site. In addition to the landside investigation data, these data will be used to select sampling locations representative of potential Site-related contamination and historical background conditions.
	• Beneath the River, nature and extent of contaminated groundwater data (specifically presence/absence of Site-related NAPL and dissolved concentrations of Site-related contaminants)
	• Sediment data (specifically presence/absence of NAPL and concentrations of Site-related contaminants)
	  • Site-related contaminants include 4 VOCs (BTEX); cyanide; RCRA

Table 4-1 Data Quality Objective Development

DQO Step	Description
	metals; and 4 phenolic compounds. MTBE and PCBs will be analyzed for in sediments if present in landside groundwater (MTBE) or NAPL/NAPL-saturated soil (PCB) samples. The full list of Site-related contaminants will be analyzed in all in-river samples unless there are compelling reasons to change the analyte list based on the landside RI results. • The 40+ PAHs (extended PAH fingerprint list and aliphatic hydrocarbon fingerprint list) by flame ionization detector (FID) will be analyzed in all sediment samples. • Surface water data. • 17 PAHs, 4 VOCs (BTEX); cyanide; RCRA metals; and 4 phenolic compounds, and potentially PCBs. The full list of Site-related contaminants will be analyzed in all in-river samples unless there are compelling reasons to change the analyte list based on the landside RI results. • Hardness, pH, conductivity, sodium, calcium, magnesium, potassium, chloride, sulfate, bicarbonate, and total dissolved solids. • A historical background data set will be compiled from the NOAA DARRP database of COPC concentrations, and will be supplemented with data collected from approximately three reference stations. High quality data representative of Site-related COPCs in surface water and sediment are needed for ARAR comparisons.
Q1, Step 4. Define Study Boundaries (Specific details regarding sample composition; spatial and temporal)	As defined in the Consent Decree: "Operable Unit 2 or OU2 shall mean groundwater, surface water, and sediments of the Anacostia River where hazardous substances released at or from the Washington Gas East Station Property have come to be located." <u>Landside:</u> • Horizontal boundary: One transect parallel to the seawall along the full length of the government property, and one transect perpendicular to the seawall near the southeastern government property boundary. • Vertical boundary: 10 ft. into, but not through, the Arundel Clay; total depths are estimated to range from 30 ft. below land surface in the north to 55 ft. below land surface in the south. • Temporal boundaries: • Groundwater samples will be collected three times (one during hydraulic profiling and two from monitoring wells). One monitoring well sampling round will occur in the spring. Sampling times will be informed by the tidal survey. • NAPL-saturated soil samples will be collected during drilling. • NAPL samples from existing wells will be collected during the first drilling mobilization. NAPL samples from new wells will be collected immediately after installation.

Table 4-1 Data Quality Objective Development

DQO Step	Description

	• Soil samples will be collected regularly during drilling and core logging for screening with a photoionization detector (PID).
	
	<u>In-river:</u>
	• Horizontal boundary:
	  • Site-related: An area of the River adjacent to the seawall, approximately 1,000 ft. in length adjacent to the government property and extending approximately 100 feet into the River. This area may be expanded or contracted based on the results of the landside investigation or based on the results of the beneath the River groundwater investigation. Specific sampling locations will be selected following, and partially based on, a hydrographic survey and review of results from the landside investigation including drive point profiling and monitoring well installation and sampling analysis.
	  • Background conditions data set: Sediment samples obtained historically from locations a minimum of 0.25 mi (beyond the potential title flux of sediments upstream) up to a maximum of 2 mi upstream of the Site, excluding any samples that were collected at environmental or hazardous waste sites
	  • Reference locations: In-river samples will be collected at approximately three reference locations believed to be upstream of the Site. Locations will be chosen after the historical background conditions data set is compiled.
	• Vertical boundary:
	  • Sediment samples:
	  • Sub-surficial depth: Between 0.5 ft. and 10 ft. below the sediment surface unless a greater sampling depth is appropriate based on the landside and/or sediment investigation results.
	  • Beneath the river groundwater samples: 5 ft. and 10 ft. beneath the sediment-surface water interface.
	  • Surface water samples: surface water within 1-2 ft. of the river bottom.
	• Temporal boundaries:
	  • In-river sediment, beneath the river groundwater, and surface water samples will be collected once, after the landside investigation is complete. This sampling will be performed between 1 March and 30 April.

Q1, Step 5. Analytic Approach/ Decision Rules (How will the data answer the question or what additional data will be collected?)	The data will be used to determine the areal and vertical extent of Site-related contaminants below the government property and in the River. Fingerprinting will be the primary mechanism to characterize the nature of contaminants in the River as Site-related or unrelated. The background data set will be considered complete if there is sufficient data to perform forensic comparisons to fingerprinting samples collected near the government property. If the River investigations do not delineate the nature and extent of Site-related contaminants in sediments and surface water

Table 4-1 Data Quality Objective Development

DQO Step	Description
	adjacent to the Site, additional investigation may be warranted. The investigation may proceed farther upstream or downstream if the landside investigation indicates the potential for Site-related contamination, and to the limits of visual Site-related NAPL in sediment. The investigation may also extend farther out from the landside into the River if the landside investigation, and/or if the beneath the River groundwater investigation, discovers that Site-related contaminants in groundwater are discharging to River sediments beyond the authorized dredge channel. Samples will be collected at greater depths if the nature and extent of Site-related contaminants is not satisfactorily characterized following initial sampling.
Q1, Step 6. Specify Decision Error Limits	Site data will be evaluated relative to background conditions using ProUCL software or other appropriate statistical methods; outliers will be analyzed in accordance with ProUCL guidance or other appropriate guidance. Analytical data will be considered acceptable if they meet the appropriate data validation criteria presented in the QAPP.
Q1, Step 7. Optimize the Study Design	Sections 4.2 and 4.3 provide specific information on the study designs for groundwater/NAPL, River surface water, and River sediment.
Principal Study Question #2 (Q2)	
Q2, Step 2. Principal Study Question (What question does the investigation need to answer?)	What is the mass flux/discharge of Site-related contaminants in groundwater/NAPL to the River?

Q2, Step 3. Information Inputs (What data do we need to answer the Principal Study Question?)	<u>Landside:</u>
	• Hydraulic conductivities in all units, including fill, silt, clay, sand and gravel, and sand lenses
	  • Complete cores of geologic data to identify zones of relative high conductivity that may be transporting contaminants, including sand lenses or transition zones in the silt layer and in the Arundel Clay
	  • Relative hydraulic conductivity vertical profile data collected along the seawall between monitoring wells
	  • Paired wells to evaluate vertical gradients between units
	  • Slug tests to evaluate horizontal hydraulic conductivity within a unit
	• Groundwater data (specifically presence/absence of Site-related contaminants and concentration of Site-related contaminants) in all water-bearing units, including fill, silt, clay, sand and gravel, and sand lenses
	  • Site-related contaminants include 17 PAHs, 4 VOCs (BTEX); cyanide; RCRA metals; and 4 phenolic compounds
	  • PCBs, if present in NAPL/NAPL-saturated soils
	  • Geochemical parameters (pH, dissolved oxygen, etc.…)
	• NAPL (both LNAPL and DNAPL) data (specifically presence/absence of Site-related NAPL)
	  • Physical properties of observed NAPL to evaluate mobility

Table 4-1 Data Quality Objective Development

DQO Step	Description
	• Chemical properties (including fingerprinting) of mobile NAPL in existing wells and newly encountered NAPL in soil • LNAPL and DNAPL vertical and lateral extent, source areas • Variation in mass flux and mass discharge • Time-series, relatively continuous piezometric head data in all relevant units at various depths along the River relative to River water levels to determine horizontal and vertical hydraulic gradient directions and magnitude. • Area of groundwater capture distinguished from the area of transport to the River and its horizontal gradient. <u>In-river:</u> • Geologic data (particularly presence/absence of sand lenses in silt layer and in the Arundel Clay) to identify zones of relative high conductivity • Grain size analysis • River sediment data to evaluate contaminant transport • Concentrations of Site-related contaminants as determined by landside groundwater sampling • TOC and pH • Beneath the river groundwater data to evaluate vertical gradients within the sediments • NAPL (both LNAPL and DNAPL) data • Physical properties of observed NAPL to evaluate mobility including density and viscosity at various temperatures • Chemical properties (including fingerprinting) of NAPL in sediments and groundwater • LNAPL and DNAPL vertical and lateral extent • River bottom configuration to evaluate potential discharge areas • Bathymetry survey including the authorized dredge channel adjacent to the Site • Utility survey
Q2, Step 4. Define Study Boundaries (Specific details regarding sample composition; spatial and temporal)	<u>Landside:</u> • Horizontal boundary: • Two transects on the government property: 1) along the seawall, approximately 900 ft. in length; and 2) in the area between MW-10 and MW-18, approximately 300 ft. in length and the horizontal extent of Site-related contaminants. • Pressure transducer data loggers will be installed at the following six wells for the tidal study: four nested wells near the seawall (one in each geologic unit [fill, silt, sand and gravel, and Arundel Clay]), one fill unit well located inland from the seawall and one sand and gravel unit well located inland from the seawall. • Vertical boundary: 10 ft. into, but not through, the Arundel Clay; total depths are estimated to range from 30 ft. below

Table 4-1 Data Quality Objective Development

DQO Step	Description

	land surface in the north to 55 ft. below land surface in the south.
	• Temporal boundaries:
	  • A tidal survey will be performed to determine when the maximum hydraulic gradient to the River occurs relative to the tidal cycle. The tidal survey will be performed by installing pressure transducer data loggers in six wells and one River location for six months; water levels in all wells will be gauged twice per month at the time of maximum hydraulic gradient to the River, plus or minus 1.5 hours (assumed to be low tide).
	  • Landside NAPL samples will be collected once from soil borings and monitoring wells.
	<u>In-river:</u>
	• Horizontal boundary:
	  • Sample locations are described in DQO step Q1, step 4.
	  • Beneath the river groundwater level measurements will be obtained at all in-river groundwater sampling locations (see Q1, step 4).
	  • Three surface water level monitoring stations will be established along the seawall; a pressure transducer data logger will be installed at one of these locations for the tidal study.
	• Vertical boundary: 10 ft. below the sediment surface, unless the landside RI results indicate that the depth should be revised, or the in-river RI results indicate a greater depth is necessary.
	• Temporal boundaries: The River location pressure transducer will be maintained in place during the in-River portion of the RI. Beneath the river groundwater level measurements will be collected during in-river groundwater sampling and compared to the pressure transducer readings.

Q2, Step 5. Analytic Approach/ Decision Rules (How will the data answer the question or what additional data will be collected?)	The data will be used to calculate the mass discharge, which is the total contaminant mass (including NAPL and the mass dissolved in groundwater) that discharges into the River from hazardous substances released at or from the WG Site (Site-related contaminants) per unit time. Mass discharge is the sum of all mass flux measures across an entire plume (ITRC, 2010); mass flux is a measure of the contaminant mass that migrates or fluxes through a cross sectional area orthogonal to the mean groundwater gradient per unit time, for defined hydrogeologic units contributing mass to the River. Mass flux is calculated using the hydraulic conductivity, hydraulic gradient (which may vary in response to tides), and concentration for a hydrogeologic unit. If the landside and in-river investigations do not adequately delineate the mass discharge of Site-related contaminants in groundwater at the seawall to the River, additional investigation maybe warranted to obtain additional inputs or refine existing inputs for mass flux calculations.

Table 4-1 Data Quality Objective Development

DQO Step	Description
Q2, Step 6. Specify Decision Error Limits	According to mass flux guidance (ITRC, 2010), "the greatest sources of error and uncertainty in mass flux or mass discharge estimates include estimates of hydraulic conductivity (K) and contaminant concentrations." To minimize these errors, direct push permeability readings and grab groundwater samples will be combined with constructed monitoring wells screened in one hydrogeologic unit per well. In addition, potential hydraulic gradient errors will be minimized by calculating gradients over the entire tidal cycle and distinguishing the capture area from the area where transport is to the River. Analytical data will be considered acceptable if they meet the appropriate data validation criteria presented in the QAPP.
Q2, Step 7. Optimize the Study Design	Sections 4.2 and 4.3 provide specific information on the study designs for groundwater/NAPL and River sediment, respectively, that will address each of the DQOs.
Principal Study Question #3 (Q3)	
Q3, Step 2. Principal Study Question (What question does the investigation need to answer?)	Are Site-related contaminant concentrations in sediment and surface water posing an unacceptable risk to human receptors, under current or future exposure conditions, as a result of historical operations of the MG facility at the Site; and what are the potential current and future risks to ecological receptors associated with exposure to Site-related contaminants in River sediment, pore water, and surface water?
Q3, Step 3. Information Inputs (What data do we need to answer the decision question?)	For benthic invertebrates: • Surficial sediment samples from the Site are needed to conduct benthic invertebrate toxicity testing and to compare sediment concentrations of contaminants of potential ecological concern (COPECs) to toxicity benchmarks. • SEM/AVS analysis and measurements of TOC in Site sediment samples to determine the bioavailable fraction of metals. • Pore water concentrations of PAHs for input into the sediment narcosis model to evaluate PAH bioavailability. • Surficial sediment pore water concentrations of COPECs are needed to compare to water-based toxicity benchmarks. • Benthic invertebrate community information will be needed to evaluate potential impacts on density and diversity. For fish: • Surface water and surficial sediment pore water samples are needed for input into the fish tissue narcosis model and to compare concentrations of COPECs to surface water toxicity benchmarks. For aquatic invertebrates: • Surface water samples are needed to compare concentrations of COPECs to surface water toxicity benchmarks. A human health CSM has been prepared (provided as Appendix D) using existing data, and will be revised using data collected in the RI. The human

Table 4-1 Data Quality Objective Development

DQO Step	Description
	health risk assessment (HHRA) will be completed using the CSM. • Surficial sediment and surface water samples from the Site are needed to quantify human exposures and risks from COPCs under current Site conditions. • Subsurface sediment samples are needed to compare COPC concentrations to surficial sediment concentrations in order to determine potential future risks from exposure to sediments that are deeper than the current exposure depth. A sediment stability analysis will be completed to determine if assumptions about exposure depths are reasonable. A background concentration data set will be compiled for all media specified above and reference location community samples are needed for comparison to Site data.
Q3, Step 4. Define Study Boundaries (Specific details regarding sample composition; spatial and temporal)	<u>Landside:</u> No risk assessment-related sampling will be performed on the landside. <u>In-river:</u> • Horizontal boundary: Sediment and surface water sampling locations will be the same as those discussed in DQO Q1 and Q2, step 4. • Vertical boundary: Samples will be collected as described in DQO Q1, step 4, in addition to the following risk-based samples: Vertical boundary: Surficial sediment will be collected from the sediment interval of 0 to 0.5 ft. This sample depth limit is considered adequate for HHRA purposes unless the sediment stability analysis and dredging plans indicate that deeper exposure depths could be reasonably expected. This depth is also equivalent to the assumed biologically active zone (BAZ), but this will be verified by visually evaluating sediment cores for indications of bioactivity. Temporal boundaries: All in-river sediment, pore water, and surface water, and benthic invertebrate community samples will be collected once. This sampling will be performed between 1 March and 30 April.
Q3, Step 5. Analytic Approach/ Decision Rules (How will the data answer the question or what additional data will be collected?)	Sediment and surface water data will be compared to risk-based screening levels to identify human health COPCs. These COPCs will be retained for further evaluation as part of the risk characterization. The HHRA will estimate potential exposures for each receptor group and quantify cancer risks and noncarcinogenic Hazard Quotients (HQs). Samples collected from reference locations will be used to estimate the level of risk attributable to the Site. Sediment, surface water, and sediment pore water data will be analyzed for the COPECs by USEPA or equivalent methods for the baseline ecological risk assessment (BERA). Results of these analyses will be compared to toxicity benchmarks to calculate HQs. Toxicity testing results and community data will be used as additional lines of evidence in the BERA. Samples collected from reference locations will be used to estimate the level of risk attributable to the Site.

Table 4-1 Data Quality Objective Development

DQO Step	Description
Q3, Step 6. Specify Decision Error Limits	Analytical data will be considered acceptable if they meet the appropriate data validation criteria presented in the QAPP. For the HHRA, the decision error limits are +/- 100% of the mean, or are 5% for false negative errors and 20% for false positive errors. Decision error limits are not applicable to many of the lines of evidence that will be used to evaluate risks to ecological receptors (e.g., chemical data used to derive sample-specific hazard quotients, invertebrate population data used to develop qualitative impact rankings). However, decision error limits can be applied in terms of the sediment toxicity testing. In particular, as the number of replicates per treatment increases, so does the power to detect a 20% response relative to the control mean or reference mean. USEPA (2000) will be used as a guide for determining the minimum number of replicates per treatment such that a response can be reliably detected, if present.
Q3, Step 7. Optimize the Study Design	Sections 4.2 and 4.3, and Appendices C and D provide specific information on the study designs for groundwater/NAPL and River sediment.

The RI will be conducted to collect the various types of data (listed below) necessary to fully assess potential risks in the River associated with the Site. The RI will be conducted in several steps with subsequent work dependent on the results of previous work.

4.2 Landside Remedial Investigation

To address the principal study questions stated above, the following field activities will be performed during the landside RI:

- Advance soil borings to collect continuous geologic information and observations of contamination such as NAPL from the ground surface into the top of the Arundel Clay, and collect soil samples with NAPL or obvious contamination for contaminant analysis;
- Perform groundwater profiling to collect estimates of permeability and to collect groundwater samples from the ground surface into the top of the Arundel Clay;
- Install monitoring wells and collect groundwater samples from new and existing monitoring wells;
- Make observations of NAPL (both LNAPL and DNAPL) and collect NAPL-saturated soil samples for analysis where observed;
- Measure aquifer properties including hydraulic conductivities and unit thickness in all geologic units; including fill, silt, clay, sand and gravel, and sand seams within the silt unit and the Arundel Clay;
- Collect time-series, piezometric head data in all relevant geologic units; and
- Estimate the potential for contaminant transport towards and into the River (mass flux/discharge).

The following sections describe the activities that will be performed during the RI field program. For each activity, the purpose is presented along with a description of known or potential existing data, an assessment of the data gaps, and a summary of the work to be performed to close the data gaps.

4.2.1 Geologic Information

Purpose: To calculate the flux of Site-related contaminants to the River, geologic data are needed along a 900 ft. transect on the government property adjacent to the seawall and in an area approximately 300 ft. in length located approximately perpendicular to the seawall between wells MW-10 and MW-18. Geologic information is specifically needed to characterize water-bearing units and to determine the presence or absence of sand lenses in the silt unit and in the Arundel Clay and, if present, whether these lenses provide a flow path to the River. The geologic data along with the groundwater quality data and hydrogeologic data will be used to identify flow paths to the River and to calculate the flux of Site-related contaminants.

Existing Data Review: Borings have been advanced, test pits excavated, and monitoring wells installed over the course of environmental investigations at the Site. Geologic logs were prepared for most of these activities and are available in summary reports and are also presented in these summary reports in cross-section, top of geologic unit map, and aerial extent map. Interpretations based on these data are presented in Section 3.2.1 and related figures; boring logs are included in Appendix B.

Data Gaps: Review of these geologic logs indicates that data gaps exist in the coverage of a portion of the Site along the seawall and in the area between MW-10 and MW-18. Laterally, there is a high density of data in the central and western portions of the Site along the seawall where NAPL has been observed and where NAPL recovery is occurring. Data are more sparse in the eastern portion of the Site adjacent to the seawall and between MW-10 and MW-18. Vertically, there is a high density of data in the fill unit and sand and gravel unit data and less data in the silt unit and Arundel Clay. Many of the borings were not extended into the Arundel Clay, so there are less data in the Arundel Clay than in other geologic units.

Summary of Work to Close Data Gaps: High-density geologic data will be collected by advancing borings along the length of the seawall and in the area between MW-10 and MW-18. Figure 4-1 shows the proposed locations of these borings. Boring locations may be adjusted in the field based on the field conditions including the presence of utilities. If NAPL is observed during advancement of these borings, samples of NAPL-saturated soil will be collected for analysis. If sand lenses or transition zones are identified in the silt unit or Arundel Clay, these areas will be considered for grab groundwater samples during the next field phase of groundwater profiling.

Based on the results of these borings (i.e., presence or absence of sand lenses in the silt unit or Arundel Clay or presence of NAPL in the silt unit or Arundel Clay) additional borings may be advanced between the initial borings. The additional borings, if required, will be advanced during the same field program as the initial borings. The decision to advance additional borings will be a field decision proposed by WG and implemented after review and acceptance by the NPS.

The procedures for advancing borings are presented in Section 5.4.1.

4.2.2 Profiling and Grab Groundwater Samples

Purpose: In addition to the geologic data needs described in Section 4.2.1, to calculate the flux of Site-related contaminants to the River, relative hydraulic conductivity data and contaminant

concentrations in groundwater are needed along the two transects. Relative hydraulic conductivity data is needed to identify the presence of preferential groundwater flow paths and to provide estimates of the relative hydraulic conductivity of each of these flow paths. Contaminant concentration data is needed along with the hydraulic conductivity data to identify the presence/absence of Site-related contaminants and concentration of Site-related contaminants in all water-bearing units including fill, silt, sand and gravel, clay and sand lenses. These data will be used to identify locations and screen intervals for monitoring wells to be installed (see Section 4.2.3) along the same transects and at various depths. These monitoring wells will be used to confirm the hydraulic conductivity data with slug tests (see Section 4.2.5) and to confirm the contaminant concentration data with groundwater sampling (see Section 4.2.3).

Existing Data Review: Borings have been advanced, monitoring wells installed, and slug tests and laboratory permeability tests performed over the course of environmental investigations at the Site. The hydraulic conductivities obtained from the slug tests and laboratory permeability tests have been summarized in the 1999 RI Report (Hydro-Terra, 1999) and in Section 3.2.2 of this work plan. Contaminant concentration data is summarized in maps of the most recent sampling results by geologic unit (i.e., fill unit and sand and gravel unit) in Figures 3-9 and 3-10 and as trend graphs for select wells in Figures 3-23 and 3-24.

Data Gaps: Review of these hydraulic conductivity and analytical data indicates that data gaps exist in the coverage along the two transects. Although hydraulic conductivity data and contaminant concentration data is available for the most likely preferential flow paths, i.e., the fill unit and sand and gravely unit, data is not available for sand lenses that may be present in the silt unit and at the top of the Arundel Clay. Data for these sand lenses is needed for the calculation of contaminant mass flux. Additionally hydraulic conductivity data and contaminant concentration data at a greater density are also needed in the fill unit and sand and gravel unit to refine the flux estimate for these units.

Summary of Work to Close Data Gaps: High-density relative hydraulic conductivity vertical profile data and grab groundwater samples will be collected along the length of the seawall and in the area between MW-10 and MW-18. Groundwater grab samples will be analyzed for all contaminants identified in Section 3.1. The locations for the collection of this vertical profile data and grab groundwater samples will be selected following the completion of the geologic borings described above. If NAPL is observed during advancement of these borings, samples of NAPL-saturated soil will be collected for analysis. If sand lenses or transition zones are identified in the silt unit or Arundel Clay during vertical hydraulic profiling, these areas will be identified for grab groundwater sampling.

Based on the results of the vertical profiling and grab groundwater samples, additional profiling and sampling may be conducted between the initial locations. The additional locations, if required, may be advanced during the same field program or during a separate mobilization. The decision to perform additional profiling and to collect additional grab groundwater samples will be proposed by WG and implemented after review and acceptance by the NPS.

The procedures for performing profiling and collecting grab groundwater samples are presented in Section 5.4.2.

4.2.3 Monitoring Well Installation and Landside Groundwater Sampling

Purpose: The purpose of monitoring well installation and groundwater sampling is to collect data that cannot be obtained from the geologic borings and grab groundwater samples. Examples of these types of data include the chemistry and mobility of NAPL (if found), representative water quality data

from properly constructed wells, hydraulic head data, relative hydraulic heads between units, and aquifer permeability testing.

Existing Data Review: Sixty-three monitoring wells and piezometers have been installed at the Site. Forty-one of these wells and piezometers are believed to still exist. WG currently conducts biannual sampling of 14 wells at the Site on District property. These samples are analyzed for TCL VOCs, TCL SVOCs, filtered RCRA metals, and filtered cyanide.

Groundwater sampling for PCBs at the government property has been limited to one sample from one monitoring well. Two samples of influent groundwater and NAPL were also collected at the WG treatment system. All results were below laboratory reporting limits for PCBs.

Data Gaps: The objective of the collection of the geologic information as described in Section 4.2.1 is to determine the presence or absence of sand lenses or transition zones in the silt unit and in the Arundel Clay and, if present, determine if these sand lenses provide a potential contaminant flow path to the River. An additional objective is to determine the presence or absence of NAPL in all geologic units including the sand lenses, if present, in the silt unit and Arundel Clay. This information along with analytical data and hydraulic properties will allow for the calculation of flux of Site-related contaminants to the River. A data gap exists if sand lenses that have not been previously characterized are found in the silt unit or Arundel Clay, and if these sand lenses contain significant contaminant mass. Wells will need to be installed in these lenses to obtain the necessary information to calculate mass flux/discharge. Additionally, monitoring wells may also need to be installed in the fill unit or sand and gravel unit if data gaps are identified during the boring program.

Although not previously identified as COPCs there is insufficient historical groundwater PCB data to determine whether or not they should be included as COPCs. Additional sampling is required to reduce uncertainty and verify the CSM interpretation that Site-related PCBs have not impacted groundwater or River sediments.

Summary of Work to Close Data Gaps: Based on the findings of the geologic investigations the locations of the monitoring wells will be proposed in a technical memorandum. Wells will be proposed at a select number of the following types of locations:

- In locations where the geologic boring data indicate NAPL may be present, to be able to confirm these findings, to collect NAPL samples for physical and chemical testing, and to assess its vertical and lateral extent and mobility;
- In zones most likely to be transporting contaminants from groundwater towards the River to sufficiently delineate the vertical and horizontal extent of contaminants in all units transporting contaminants;
- In several locations where there is low potential for flux, to confirm the geologic boring information and to fully delineate the edges of the vertical and horizontal extent of contaminants;
- Co-located to provide nested wells in each of the hydrologic units, and sand lenses if necessary based on the geologic borings; and
- At specific locations listed in the Consent Decree (e.g., northeast of MW-5, southwest of MW-18, etc.).

It is not necessary to install wells at every possible location with a high potential for flow towards the River; the quantitative data from a smaller number of wells will be used in combination with the geologic boring, hydraulic profiling, and grab groundwater samples along the seawall to quantify flux, including areas where additional wells have not been placed. The number of wells to be proposed will be identified following review of the results of the geologic investigation and detailed in a technical memorandum, described above. It is estimated that up to a total of 25 new monitoring wells are expected to be installed, with wells at more than one depth in some locations. Following the review of the groundwater sampling analytical results and hydraulic information gathering, the need for additional well locations and/or multiple wells at one location (i.e., at numerous depths) will be evaluated. If additional wells are required, a technical memorandum will be prepared detailing the purpose and locations of the proposed additional wells.

Groundwater and Surface Water Sampling. Groundwater sampling data will be used to identify where Site-specific contaminants are present and potentially migrating towards the River. Groundwater samples will be collected from wells located along the length of the seawall and in the area between MW-10 and MW-18. The remaining wells on government property are not currently considered for sampling as part of the RI because they are not located adjacent to the seawall or the transect perpendicular to the River (MW-11, P-11S, WGL-02S, and WGL-03S), are NAPL recovery wells (RW-1, RW-2, RW-3, RW-4S, RW-5S, RW-6S, RW-7S), or are located near and screened in the same formation (although sometimes at different depths) as other wells (MW-24 - located adjacent to MW-23 and both screened in the fill unit; P-5S – located near MW-29 and both screened in the fill unit; and P-7S – located near MW-27 and both are screened in the fill unit.) Thus sampling them would not contribute to meeting the objectives of the RI. The locations of the existing wells to be included for groundwater sampling are shown on Figure 4-1. The need to sample additional existing monitoring wells will be re-evaluated following the boring and profiling program and data generated from that effort before installing monitoring wells.

Surface water samples will be collected from the River concurrently with the groundwater samples for use in the tidal survey to allow comparison of general chemical parameters (i.e., hardness, pH, conductivity, sodium, calcium, magnesium, potassium, chloride, sulfate, bicarbonate, and total dissolved solids) between groundwater and surface water as another line of evidence of the tidal interaction between surface water and groundwater. Surface water samples will be collected at three locations to be established (locations will be marked so that sampling will occur at the same locations each sampling round) along the seawall: one at either end of the government property and one in the approximate middle of the government property. These locations will be positioned adjacent to existing monitoring wells (MW-4, MW-6/MW-23, and MW-18) and are shown on Figure 4-1.

Groundwater and surface water sampling will be conducted at a minimum of two occasions to assess seasonal variability, with the first sampling event occurring at least two months after the tidal survey is initiated and initial results evaluated, and one event occurring in the spring. Tidal studies during the RI (Hydro-Terra, 1999) showed that the NAPL recovery system captured groundwater at a portion of the Site (i.e., no groundwater gradient towards the River) at high tide, but that there was some gradient towards the River at low tide. Groundwater samples will be collected when the maximum hydraulic gradient to the river occurs, plus or minus 1.5 hours (likely at low tide, but the maximum hydraulic gradient relative to the tidal cycle will be determined by a tidal survey).

Groundwater samples will be analyzed for all contaminants identified in Section 3.1, including COPCs, and MTBE (PCBs will only be collected if PCBs are present in NAPL or grab groundwater samples). . These COPCs will be used to support the groundwater contaminant delineation, the estimation of contaminant flux to the River, and the risk assessments. Groundwater and surface will be also be

analyzed for the general parameters listed above. The general chemical parameters will be used to aid in evaluating potential hydraulic connections between the different geologic units, and between Site groundwater and the River. Groundwater and surface water sampling procedures are presented in Section 5.4.4.

4.2.4 NAPL Observations and Analysis

Purpose: The purpose of documenting and analyzing NAPL (both LNAPL and DNAPL) is to determine the presence/absence of NAPL in the various formations beneath the Site, to determine if the NAPL is mobile and has the potential to migrate to the River, and to determine the chemical characteristics of the NAPL.

Existing Data Review: Observations on the presence/absence of NAPL have been recorded on boring and test pit logs and on groundwater sampling logs and fluid level measurements records. These data have been presented and summarized in the RI Report (Hydro-Terra, 1999) and in the 2011 Five-Year Review Report (AECOM, 2011). The RI Report (Hydro-Terra, 1999) included an evaluation of NAPL mobility and the potential for NAPL to migrate to the River based on data available at the time of the report. Additionally, NAPL recovery operations are conducted at the Site by the pump and treat system from recovery wells and through manual NAPL recovery from monitoring and recovery wells in which it accumulates.

MG-related NAPL contains various contaminants that can affect the mobility of PCBs. To date, no NAPL samples have been analyzed for PCBs. As directed by the NPS, NAPL samples from existing monitoring and recovery wells and of NAPL saturated soils will be sampled for PCB Aroclors to confirm that PCBs are not present at the Site. If PCBs are detected in the NAPL, PCB congeners will be added to other media sampled.

Data Gaps: The presence/absence of NAPL has been recorded for most geologic units at the Site. Some of the NAPL is mobile, as it continues to be actively recovered from wells. It is also likely that some of the NAPL present is immobile. Part of the RI is to identify NAPL that is mobile and may be migrating towards the River. In addition, recent analysis of the NAPL mobility has not been performed and is a data gap.

The lack of PCB data potentially associated with NAPL and questions regarding the potential presence of PCBs on the government property and East Station are data gaps. As directed by the NPS, NAPL samples from existing monitoring and recovery wells and of NAPL-saturated soils will be sampled for PCB Aroclors to confirm that PCBs are not present at the Site

Summary of Work to Close Data Gaps: During drilling, soil and NAPL samples will be collected at all intervals where NAPL is observed (if any) to evaluate the mobility and the chemical composition of the NAPL. Representative samples of each type of NAPL found at the Site will be submitted for analysis. Recommendations for samples to submit for analysis will be proposed by WG. NAPL samples will be submitted after review and acceptance by the NPS. These results will support a weight-of-evidence approach for evaluating NAPL mobility.

During the first drilling mobilization for geologic logging, NAPL will be collected from existing monitoring wells on the government property for fingerprinting and mobility analysis. The list of fingerprinting compounds includes 40+ PAHs (extended PAH fingerprint list and aliphatic hydrocarbon fingerprint list)and high resolution hydrocarbon fingerprint analysis (TPH) to create references for

fingerprinting and forensic samples. NAPL that accumulates in new monitoring wells will be collected for similar analyses following installation.

Because PCBs were not previously identified as COPCs, initial samples (i.e., NAPL-saturated soils encountered during the first drilling mobilization for geologic logging, and accumulated NAPL in existing monitoring wells and recovery wells at the East Station and government property) will be screened for PCBs using PCB Aroclor analysis. If PCB Aroclors are present in the initial NAPL, samples or NAPL-saturated soils samples, all NAPL encountered during drilling to install new monitoring wells and all NAPL that accumulates in new wells will be analyzed for the 209 PCB congeners for direct comparison to groundwater Congener detections. As directed by the NPS, NAPL samples from existing monitoring and recovery wells where it accumulates and of NAPL saturated soils will be sampled for PCB Aroclors to confirm that PCBs are not present at the Site. As stated in other sections, groundwater and sediment sampling for PCB Congeners may also be required.

NAPL sampling details are presented in Sections 5.4.1, 5.4.3, and 5.4.4.

4.2.5 Aquifer Properties

Purpose: To calculate the mass flux/discharge of Site-related contaminants to the River, aquifer properties (hydraulic conductivities and unit thickness) are required for all geologic units impacted by Site-related contaminants; including fill unit, sand and gravel unit, and sand seams within the silt unit and the Arundel Clay. Piezometric data, as described in Section 4.2.6 and Site-related contaminant data, as described in Sections 4.2.2 and 4.2.3, are also required to calculate the mass flux/discharge of Site-related contaminants to the River.

Existing Data Review: Hydraulic conductivity data have been calculated for existing wells, many of which are screened in two or more geologic units. These conductivity data are presented in the RI Report (Hydro-Terra, 1999). The hydraulic conductivity values were determined primarily by slug testing. Samples of sandy Arundel Clay (three samples) and organic silt (two samples) were also analyzed by laboratory standing-head permeability tests of Shelby tubes. Geologic unit thickness data is available from boring logs and Site geologic cross-sections.

Data Gaps: Some aquifer property data is available for most of the Site, and for some individual geologic units. As borings are advanced during the landside RI, sand lenses or transition zones in the silt unit and Arundel Clay may be identified where additional aquifer property data is required. Additionally, if new monitoring wells are installed in the other geologic units at the Site, collection of additional aquifer property data may be beneficial.

Summary of Work to Close Data Gaps: Existing information on permeability (because the laboratory tested with water, this value equates to hydraulic conductivity) from the RI Report (Hydro-Terra, 1999) and any more recent information from the operation of the pump and treat system will be supplemented with information from hydraulic profiling, testing in the new monitoring wells, and the tidal survey (see Section 4.2.6). Groundwater level response to the tidal fluctuation in the River will be used to develop quantitative estimates of permeability. These estimates will be made using standard published analytical equations (e.g., Jacob, 1950; Ferris, 1963). Slug testing will be conducted in all of the new wells to develop quantitative estimates of hydraulic conductivity.

Information on unit thicknesses will be obtained from the previous RI Report (1999) and geologic logging at new locations. Hydraulic profiling procedures are described in Section 5.4.2. Slug testing procedures are described in Section 5.4.4.

4.2.6 Piezometric Data

Purpose: Piezometric data, including hydraulic gradients within and between units, and between units and the River are required along with aquifer property data (see Section 4.2.5) and groundwater concentration data (see Sections 4.2.2 and 4.2.3) to estimate the flux of Site-related contaminants to the River. Time-series piezometric head data in the River and all relevant geologic units are required to evaluate the impacts of tidal fluctuations on groundwater gradients and the resulting impact on the flux of Site-related contaminants. Additionally, piezometric data are needed to confirm the impacts and area of capture of the pump and treat system in operation at the Site.

Existing Data Review: Piezometric data have been collected during various investigations of the Site over time and are summarized in the RI Report (Hydro-Terra, 1999), in the 2002 modifications to the pump and treat system (Hydro-Terra, 2003), in the three and five-year pump and treat system review reports (Hydro-Terra, 1999), and in the biannual groundwater monitoring reports. These data provide information on hydraulic gradients within and between units, the impact of tidal fluctuations on groundwater flow, and the area of capture of the groundwater pump and treat systems.

Data Gaps: Current and comprehensive piezometric data, including data collected over time and over tidal cycles is required for all geologic units and the River. Additionally, if sand lenses or transition zones are identified in the silt unit and Arundel Clay, piezometric data for these sand lenses is required.

Summary of Work to Close Data Gaps: The following piezometric data will be collected to fill data gaps.

Water Level Monitoring: Water levels in all wells and the three surface water River stations will be gauged on a twice per month basis over a six-month period. Water levels in wells and in the River will be used to interpret hydraulic gradients, capture zones and, along with permeability data, the potential for migration of Site groundwater toward the River. Water level monitoring procedures are described in Section 5.4.4

Tidal Evaluation: During the same six month period, continuous water level monitoring will be performed at seven locations, and the manual measurements will be compared to the continuously collected data. Continuous water level monitoring procedures are described in Section 5.4.4.

4.2.7 Mass Flux/Discharge Estimates

Purpose: One of the objectives of the landside RI is to calculate the mass flux/discharge of site-related contaminants into the River, including dissolved contaminants and NAPL flow if any, that may contribute to unacceptable risks within the River.

Existing Data Review: The RI Report (Hydro-Terra, 1999) calculated the mass flux/discharge to the River using the existing geologic, hydrogeologic, chemistry and NAPL presence/absence and mobility data available at the time.

Data Gaps: The previous mass flux estimates are outdated because concentrations in many wells have decreased since the 1999 RI and other potential areas of contamination were not considered. In addition, the groundwater capture areas may not be sufficiently accurate for use in the mass flux/discharge estimates. If sand lenses and/or transition zones are present in the silt unit and/or the Arundel Clay, information is not available to determine whether contaminants are present in the lenses and, if so, to calculate the mass flux to the River for these units. Additionally, there are

portions of the Site where the spacing between wells is large, resulting in data gaps in these areas. In summary, existing hydraulic conductivity, gradient, and concentration data is not of sufficient resolution and accuracy to provide an accurate representation of Site mass flux and mass discharge.

Summary of Work to Close Data Gaps: The geologic, hydrogeologic, and chemistry information collected during the landside RI along with historical data will be used to calculate the mass of contaminants, including dissolved contaminants in groundwater and NAPL, if any, migrating across two transects from Site groundwater towards the River. This evaluation will include both horizontal and vertical (between geologic units) flow rate analysis. The potential for NAPL flow to the River will also be evaluated using NAPL and soil physical characteristics. The influence and effectiveness of the pump and treat system, contaminant extent, and where and when (on the tidal cycle) groundwater discharges may be taking place, will all be considered. In addition to Site-specific data, regional information on water balances and recharge/discharge rates will also be considered.

The geologic information obtained from the borings (e.g., presence/absence of sand lenses or coarser zones and sand lens thickness) will be used to support the mass flux calculations. Instead of relying only on data from wells, the conditions between wells will be incorporated into the mass flux calculations based on observations from the borings and groundwater profiling. In this way, remedial actions, if needed, can be focused on specific areas or units that are transporting the greatest contaminant mass, rather than being spread across the entire seawall frontage and the full depth of the upper geologic units. The mass flux technical memorandum is described below.

Technical Memorandum: A technical memorandum will be prepared at the end of the landside remedial investigation to summarize the mass flux/discharge calculations. The results of the mass flux/discharge calculations will be used to inform the in-river studies. The in-river sampling program presented in the following section may be adjusted based on the mass flux/discharge estimates. For example, if significant mass flux is shown to occur in a particular area along the seawall, the location of sediment samples may be adjusted to provide sampling of the River sediments adjacent to this area. Additionally the mass flux estimates may be used to modify the beneath the River groundwater sampling program.

4.3 In-River Remedial Investigation

The OU2 RI/FS Work Plan objectives for the in-river RI are to determine the nature and extent of Site-related sediment contaminants, to quantify potential risk to human health and ecological receptors, and to distinguish what portion of risk is attributed to the Site versus upstream sources. To meet these objectives the following field activities will be performed during the in-river remedial investigation:

- Perform a hydrographic survey (including bathymetric and utility surveys) in the River adjacent to the Site;
- Collect surficial and sub-surficial sediment samples in the River adjacent to the Site;
- Collect surficial sediment samples for benthic toxicity testing and pore water sampling;
- Advance sampling probes to collect beneath the River groundwater samples in the River adjacent to the Site;
- Review existing NOAA DARRP sediment database for suitability for use as a background data set;
- Collect sediment samples for fingerprint/forensic analysis;

- Perform a sediment stability analysis; and
- Collect surface water samples in the River adjacent to the Site.

The in-river RI will be conducted following the completion the landside RI and will focus on evaluating the nature and extent of sediment contamination, as well as the potential for groundwater discharge to impact sediment and surface water and to pose a potential risk to human and ecological receptors. The following sections describe the activities that will be performed during the RI field program. For each activity, the purpose is presented along with a description of known or potential existing data, an assessment of the data gaps, and a summary of the work to be performed to close the data gaps.

4.3.1 Hydrographic Survey

Purpose: The hydrographic surveys will include bathymetric and utility surveys. The purpose of the bathymetric survey is to provide River bottom sediment contours, including the immediate vicinity of the USACE river debris removal facility which is in active use, and in the dredge channel. This survey will also be used to assist with the sediment stability analysis. A utility survey will also be performed. The purpose of the utility survey is to identify utilities in the sediments so that they can be avoided during beneath the River groundwater sampling and sediment sampling.

Existing Data Review: The most recent publicly-available hydrographic surveys of the River were conducted by the USACE in 1997, downstream of the Site (adjacent to the Washington Navy Yard) in 2011, and river-wide during the DOEE Anacostia River Sediment Project in 2013 (TetraTech 2014).

Data Gaps: Current hydrographic survey data is a data gap.

Summary of Work to Close Data Gaps: A hydrographic survey, including bathymetry and utility locations, will be performed along the length of the government property and to the center of the River, as described in Section 5.4.6. The bathymetric survey will provide information on sediment bottom contours. The utility survey will identify and confirm the location of utilities in the area of the Site. The proposed River sampling described below may be adjusted based on the results of these surveys. Changes will be proposed to and acknowledged in writing by NPS prior to implementation. The hydrographic survey data will also be used in the sediment stability analysis.

4.3.2 Sediment Sampling

Purpose: The purpose of the sediment sampling is to delineate the nature and extent of Site-related contaminants vertically and horizontally in the area of the seawall along the government property.

Existing Data Review: Extensive sediment sampling has been conducted of the River over many years. Sediment sampling has also been conducted in the area of the seawall (Hydro-Terra, 1999). This data has been summarized in the River CSM in Section 3.3.

Data Gaps: Delineation of the nature and extent of Site-related contaminants in the area adjacent to the seawall along the Site is a data gap. Additionally, bioavailability of Site-related contaminants, which require toxicity testing and SVM/AVS testing, is a data gap. A macroinvertebrate community survey is required to understand the general conditions of the benthic community in the area of the Site compared to reference stations.

Summary of Work to Close Data Gaps: Sediment sampling will be conducted adjacent to the Site; and into the federally maintained navigation channel, which when dredged to authorization depth is

the deepest point in the River adjacent to the Site. The federally maintained navigation channel was last dredged in 1985 to a depth of 24 ft. The previous bathymetric surveys of the River adjacent to the Site indicate that the River depth in the dredged channel adjacent to the Site appears to be around 10 ft. The bathymetry survey described in Section 4.3.1 will provide the current depth of this dredge channel in the area of the Site. Sediments within the channel, therefore, are likely derived from upstream sources, however it is recognized that these sediments may have been impacted by Site-related contaminants since their deposition.

Sampling will be performed along the length of the government property (approximately 1,000 ft.), as access (e.g., presence of docks and utilities) permits, and to approximately 100 ft. from the shore and into the dredge channel. Sampling is proposed within this area in an approximately 100-ft. grid pattern (see Figure 4-2), which yields approximately 22 sample locations. Twenty-two samples are anticipated to be sufficient to support statistical evaluations of data, including comparisons of near-Site surficial sediment data to background data.

If the landside investigation indicates the potential for flux of contaminated groundwater or NAPL to the River the sampling locations may be modified to target identified discharge areas along the seawall or expanded to incorporate potential discharge further from the shore into the River. Additionally, if visual evidence of MG contamination (e.g., NAPL) is observed in the sediment samples, the proposed sampling program will be expanded to delineate the limits of these visual impacts. Sediment samples will also be collected at three reference locations (see Figure 4-3) to support the ERA activities (as discussed elsewhere in this Work Plan, existing surficial sediment data from historical studies of the River will be used to support the comparisons to reference samples).

Modifications to sample locations will not be implemented until submitted to and acknowledged in writing by NPS.

The proposed sediment sampling and analysis is described in Section 5.4.7.

4.3.3 In-River Groundwater Sampling and Water Level Monitoring

Purpose: In this work plan, water in sub-surficial sediments beneath the River is referred to as “groundwater beneath the River”. Interstitial water in the BAZ of surficial sediments, assumed from 0 to 0.5 ft. (to be verified during the RI), is referred to as “surficial sediment pore water.” The purpose of the beneath the River groundwater sampling is to evaluate if groundwater containing Site-related contaminants is migrating from the Site through River subsurface sediments to River surface water and if it is, what is the contaminant mass discharge to surface water.

Existing Data Review: Samples of groundwater beneath the River have not been previously collected at the Site.

Data Gaps: Analytical data and water level elevation data for groundwater beneath the River is a data gap.

Summary of Work to Close Data Gaps: This groundwater beneath the River sampling program will be informed by the results of the landside remedial investigation and the sediment sampling. Following completion of the landside remedial investigation, the technical memorandum described above will be prepared to summarize the results of the landside investigation and propose any modifications to the following work for NPS review and approval. Modifications may include sample locations, depths, and analytes. Additionally, a technical memorandum will be prepared following the

sediment sampling and will propose any modifications to the following work for NPS review and approval. Modifications may include sample locations and depths.

Groundwater samples and groundwater level data (measurement of the groundwater level within the groundwater sampling probe at the depth of groundwater sampling) will be collected at 10 locations beneath the River in the 1,000 ft. long area adjacent to the government property and in transects (paired locations) from the seawall into the dredge channel, as well as at approximately three background/reference locations. Background/reference location (see Section 4.3.5 for a discussion of background/reference stations) sampling for groundwater beneath the river is essential in order to differentiate Site groundwater contaminants, from legacy river-wide contaminated sediments that are present in the sub-surface. Figure 4-2 shows the proposed locations of the samples adjacent to the Site, and Figure 4-3 shows the proposed locations of reference samples. Groundwater sampling is described in Section 5.4.7.

4.3.4 Toxicity Testing and Surficial Sediment Pore Water Analysis

Purpose: The purpose of the benthic toxicity testing and pore water analysis is to evaluate the potential effects of Site-related contaminants in surficial sediment on ecological receptors, in the context of acceptable risk levels and background conditions in this urban River. Pore water analysis for site-related contaminants will be performed on the locations where laboratory toxicity testing is conducted.

Existing Data Review: Benthic toxicity testing and pore water sampling have not been conducted in sediments immediately adjacent to the Site, but have been conducted in support of the Washington Navy Yard RI (CH2M-Hill, 2014) and the USFWS River-wide study (McGee et al., 2009). A benthic survey has been conducted in the sediment immediately adjacent to the Site (Hydro-Terra, 1989).

Data Gaps: Benthic toxicity data and pore water sampling data are not available for sediments adjacent to the Site and are a data gap. Pore water samples are required to support the bioavailability analysis, as documented in the ERA Work Plan (Appendix C). Decisions regarding potential risk cannot be made with bulk sediment data alone, but rather with considerations for Site-specific bioavailability.

Summary of Work to Close Data Gaps: Pore water samples will be extracted from 10 to 13 surficial sediment samples. The same sediment samples will be submitted for toxicity testing. The results of surficial sediment sampling for total contaminant concentrations will be used to select which subset of surficial samples will be analyzed for risk-related analysis.

4.3.5 Background Condition Evaluation

Purpose: The purpose of the background evaluation is to distinguish site conditions from naturally occurring and anthropogenic background conditions. Developing an understanding of background conditions is critical because the CERCLA program generally, “does not clean up to concentrations below natural or anthropogenic background levels” (USEPA, 2002). The USEPA (2002) defines “background” as contaminants or locations that are not influenced by releases from a site, and is usually described as naturally occurring or anthropogenic (i.e., “natural and human-made substances present in the environment as a result of human activities [not specifically related to the CERCLA release in question] [USEPA, 2002]). The USEPA (2005a) Sediment Remediation Guidance emphasizes that in riverine systems there are cases where area-wide contamination may pose risks, particularly from anthropogenic sources.

Existing Data Review: A number of studies have been conducted in the River over the past few decades. Some of these efforts have been directly related to contaminated sites while others have been conducted to study the overall condition of the River. Several of the studies conducted for contaminated sites included sampling background and reference locations. These data have been compiled into a significant analytical database of River sediment data (i.e., the NOAA DARRP database), including information regarding PAHs, inorganic, and other organic contaminants in the River.

Data Gaps: A significant body of River surficial sediment analytical data currently exists for the majority of the Site-related contaminants. These data need to be evaluated for suitability for use as the naturally occurring and anthropogenic background condition for the Site.

Summary of Work to Close Data Gaps: The RI program will include an evaluation of background concentrations of COPCs from naturally occurring and anthropogenic sources for risk assessment and to evaluate the nature and extent of Site-related contamination, as described in Section 5.4.5.

4.3.6 Fingerprint/Forensic Analysis

Purpose: The purpose of the fingerprint/forensic analysis is to attempt to distinguish between potential Site-related sources of COPCs and other sources, including urban background sources to the River.

Existing Data Review: Some of the data needed for fingerprint/forensic analysis has been collected from the sediments within the River, but data collected specifically for this purpose has not been collected adjacent to the government property.

Data Gaps: Analytical data for fingerprint/forensic analysis is a data gap.

Summary of Work to Close Data Gaps: In addition to the PAH analyte list presented in Section 5.2.1 that will be used for all sediment samples, all samples from the locations adjacent to the government property and the reference locations will be submitted for high resolution hydrocarbon fingerprint (TPH) analysis using high-resolution gas chromatography equipped with a FID. In addition, NAPL samples will be collected and analyzed as described in Section 4.2.4. Fingerprint/forensic analysis is detailed in Section 5.4.7, and data interpretation methods are described in Section 5.4.8.

4.3.7 Sediment Stability Analysis

Purpose: The purpose of the sediment stability analysis to evaluate if sediments adjacent to the Site are stable, accumulating, or eroding. This information will support the HHRA and ERA (i.e., will help determine if subsurface sediments should be considered in the uncertainty evaluation in these risk assessments) and will support the feasibility study in the remedy evaluation (e.g., sediment stability analysis will inform dredging, capping, and monitored natural recovery evaluations).

Existing Data Review: Several sources of sediment data are available to support the evaluation of sediment stability. Bathymetry data is available from the DOEE and USACE for several years. Comparison of bottom contours between years will allow evaluation of sedimentation or erosion rates. Additionally, one or more studies have been performed that estimate a timeline profile of the sediments with depth. Initial review of the USACE bathymetry data and the sediment timeline profiles indicated that the Site and surrounding area is an area of the River where sediment is accumulating. This accumulation is most evident in the sediment infilling of the dredge channel located adjacent to the Site.

Data Gaps: Sufficient sediment data are available to perform a sediment stability analysis for the sediments adjacent to the Site.

Summary of Work to Close Data Gaps: The existing sediment and surface water data will be evaluated to support a weight-of-evidence approach for evaluating the sediment stability adjacent to the Site. The types of data that will be evaluated include, but are not limited to, bathymetry data including historical DOEE and USACE surveys, and the bathymetry survey that will be performed as part of this work plan, timeline profiles of sediments from sediment studies in the area, grain size analyses from sediment studies in the area and from analyses performed as part of this work plan, and surface water flow rates from a gauging station on the River. It is possible that this initial sediment stability analysis will identify additional data gaps, which may need to be filled in the future.

4.3.8 Surface Water Sampling

Purpose: The purpose of surface water sampling is to evaluate the potential impacts of Site-related COPCs on River surface water associated with groundwater/NAPL discharge as a potential migration pathway to the River.

Existing Data Review: Surface water data has been collected from the River, including ten samples collected adjacent to the seawall (Hydro-Terra, 1999) and during a subsequent groundwater monitoring event.

Data Gaps: Surface water data adjacent to the Site are available; however, current surface water data is not available, resulting in a data gap.

Summary of Work to Close Data Gaps: Surface water samples will be collected at ten stations adjacent to the Site and at three background locations. The Site-related surface water samples will be collected at ten of the same locations as, and immediately before, the beneath the River groundwater samples. The three background sampling locations will be co-located with the three sediment reference stations shown on Figure 4-2 (proposed locations, to be verified during the background condition evaluation discussed in Section 4.3.5). Surface water sampling is described in Section 5.4.7.

Figure 4-1 Location of Landside Data Collection
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

0 90 180 Feet

AECOM

Path: P:\Jobs\Indl_Service\Project Files\Washington Gas MGP\GIS\MXD\RI_FS_Work_Plan\MXD\Fig_4-1_LocationofLandSideDataCollection.mxd

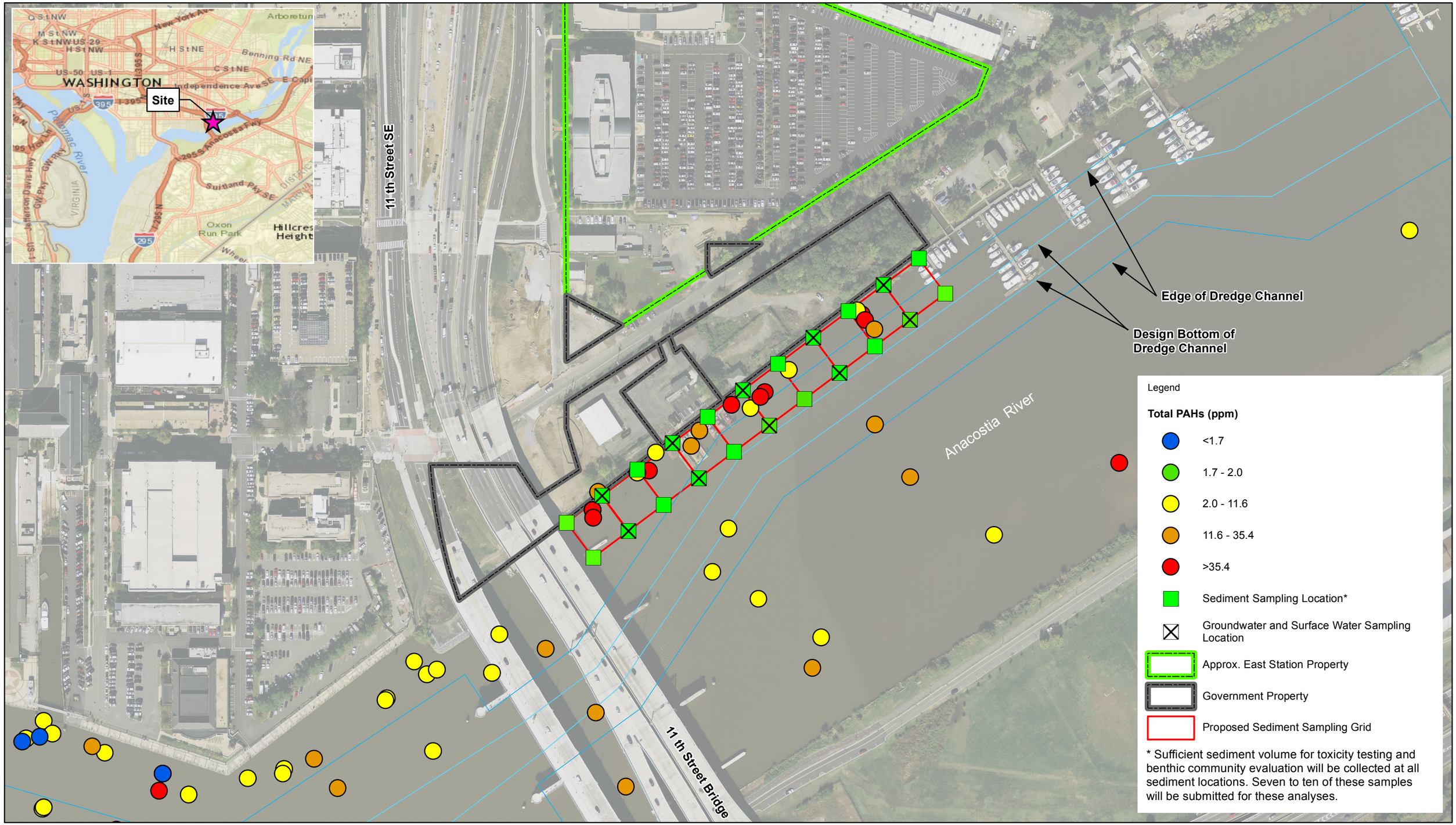

Figure 4-2
Location of In-River Data Collection and Surficial Sediment PAH Data
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Path: \\uschl1fp001\Data\Projects\Jobs\Indl_Service\Project Files\Washington Gas MGP\GIS\MXD\Fig_4_2_edit.mxd

Note
Sample locations will be adjusted based on accessibility and the presence of utilities.

Orthoimagery from USGS, 11/24/2013.
Channel lines from NOAA, 2007 (downloaded from http://encdirect.noaa.gov in April 2014).

0 100 200 400 Feet

AECOM

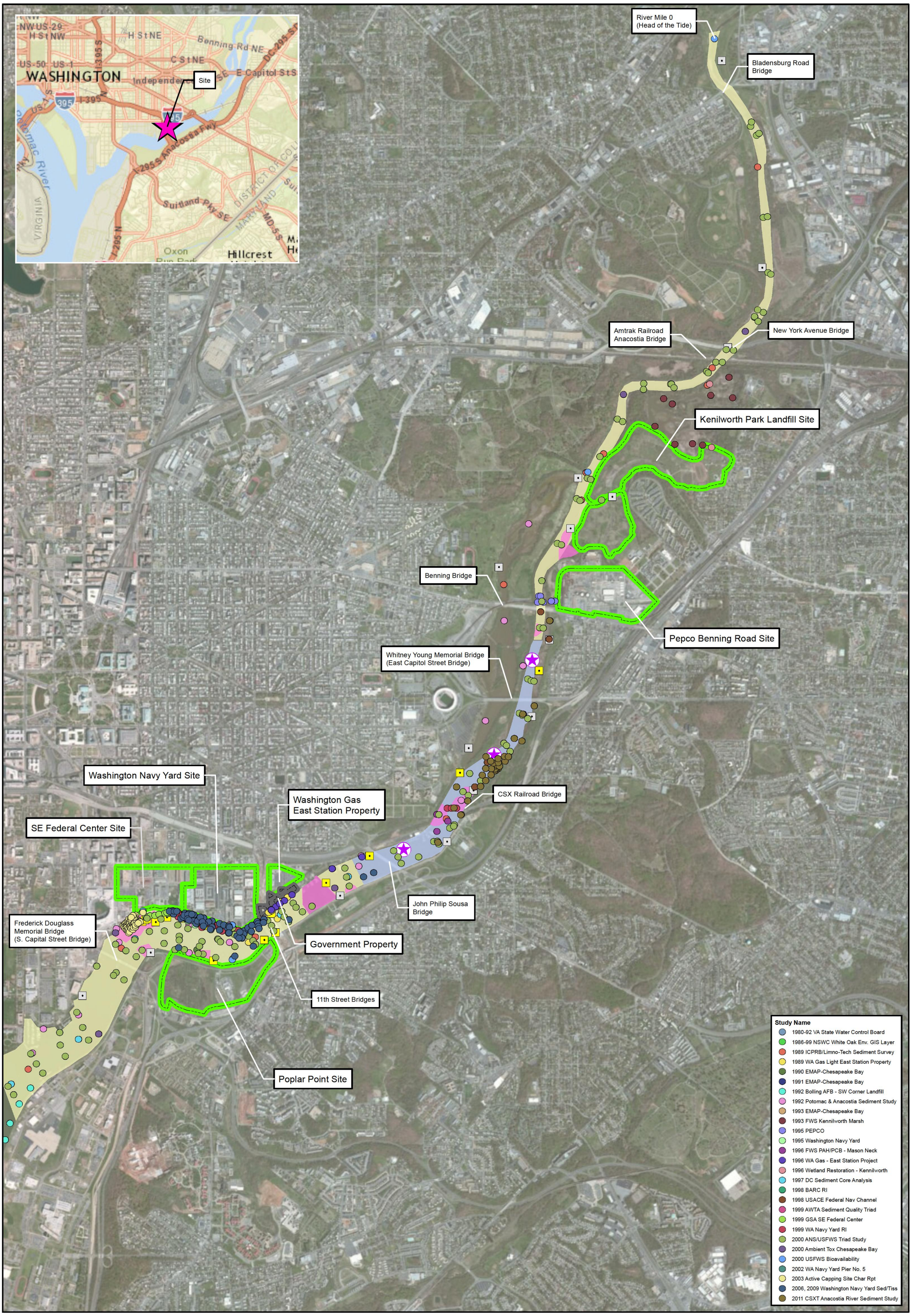

Figure 4-3
Anacostia River Sediment Sample Locations And Proposed Reference Locations
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

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

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

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

0 0.25 0.5 1 Miles

AECOM

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5.0 RI/FS Tasks

The tasks to be performed during the OU2 RI/FS are described in this section. These descriptions provide an overview of the activities to be performed to complete each task. For the RI field investigations these task descriptions also provide a summary of when each task will be performed in relation to the other OU2 RI/FS tasks.

5.1 Project Planning

The project planning task includes the tasks that are performed after the Consent Decree is issued to prepare for the RI field investigation. The following tasks have or will be conducted as part of the project planning task.

Kick off Meeting: A kick off meeting was held at the Site on November 14, 2012 with the NPS, the District, and WG and its consultants in attendance. WG's approach to implementing the OU2 RI/FS was discussed.

Collection and Evaluation of Existing Dat: Existing Site data, including regional data on sediment quality in the River were compiled. Data relevant to the OU2 RI/FS are summarized in this RI/FS Work Plan.

RI/FS Work Plan: The RI/FS Work Plan, this document, was prepared. In the preparation of this document CSMs were developed to answer the principal study questions, and DQOs were identified along with data needs to address these DQOs.

Project Operation Plan: The Project Operation Plan (POP) including the Site Management Plan (SMP), the Health and Safety Plan (HASP), and the Sampling and Analysis Plan (SAP), which includes the QAPP and the Field Sampling Plan (FSP), will be prepared following discussion of and understanding on the work plan elements and scope of work between the NPS, DOEE, and WG. The POP will be prepared and submitted to the NPS and District in accordance with the schedule in the Consent Decree. The SAP will provide the details of field tasks identified in this RI/FS Work Plan.

5.2 General Remedial Investigation Items

The RI will be conducted in accordance with the approved POP. This section describes the process for the RI at the Site.

5.2.1 RI Analytes

Tables 5.1a and 5.1b summarize the complete list of analytes for the RI landside and in-river portions, respectively. In addition, the list of analytes in groundwater samples collected beneath the River, in surface water, and in sediment samples may be modified based on the contaminants present or absent in grab and monitoring well groundwater samples. A technical memorandum will be prepared in advance of mobilizing for the in-river investigation that details which contaminants will be analyzed in sediment, groundwater beneath the River, and surface water.

Table 5-1a, below, summarizes the proposed analytes for the landside RI.

Table 5-1a Summary of RI Analytes for Landside RI

Analyte	Landside Groundwater Grab	Landside Groundwater Monitoring Well	NAPL & NAPL-Saturated Soil	Landside RI Surface Water
PAHs (17):				
Acenaphthene	✓	✓		
Acenaphthylene		✓		
Anthracene		✓		
Benz(a)anthracene		✓		
Benzo(a)pyrene		✓		
Benzo(b)fluoranthene		✓		
Benzo(g,h,i)perylene		✓		
Benzo(k)fluoranthene		✓		
Chrysene		✓		
Dibenz(a,h)anthracene		✓		
Fluoranthene		✓		
Fluorene		✓		
Indeno(1,2,3-cd)pyrene		✓		
Naphthalene	✓	✓		
Phenanthrene		✓		
Pyrene		✓		
2-Methylnapththalene		✓		
VOCs:				
Benzene	✓	✓	✓	
Ethylbenzene		✓	✓	
Toluene	✓	✓	✓	
Total Xylenes		✓	✓	
MTBE	✓	✓		
Cyanide:				
Total cyanide	✓	✓	✓	
Free/Physiologically available cyanide		✓	✓	
Metals:				
Arsenic		✓	✓	
Barium		✓	✓	
Cadmium		✓	✓	
Chromium		✓	✓	
Lead		✓	✓	
Mercury		✓	✓	
Selenium		✓	✓	

Table 5-1a Summary of RI Analytes for Landside RI

Analyte	Landside Groundwater Grab	Landside Groundwater Monitoring Well	NAPL & NAPL-Saturated Soil	Landside RI Surface Water
Silver		✓	✓	
Phenolics:				
Phenol		✓	✓	
2-Methylphenol		✓	✓	
4-Methylphenol		✓	✓	
2,4-Dimethylphenol		✓	✓	
PCBs				
Aroclors	✓		✓ (Landside: NAPL-saturated soil during first drilling mobilization and NAPL in existing monitoring and recovery wells)	
209 PCB Congeners		✓ (If present in groundwater grab samples and/or landside NAPL; locations to be identified in technical memorandum)		
Fingerprinting:				
40+ PAHs (extended PAH fingerprint list and aliphatic hydrocarbon aliphatic fingerprint list)			✓	
High resolution hydrocarbon fingerprint analysis (TPH) using high-resolution gas chromatography equipped with an FID			✓	
Tidal Interaction Parameters:				
Hardness, sodium, calcium, magnesium, potassium, chloride, sulfate, bicarbonate,		✓		✓

Table 5-1a Summary of RI Analytes for Landside RI

Analyte	Landside Groundwater Grab	Landside Groundwater Monitoring Well	NAPL & NAPL-Saturated Soil	Landside RI Surface Water
total dissolved solids				

Table 5-1b, below, summarizes the proposed analytes for the in-river RI, but is subject to change based on the landside RI results.

Table 5-1b Summary of RI Analytes for In-River RI

Analyte	Sediments	Groundwater Beneath the River	Surface Water	Pore Water in Surficial Sediments	NAPL
PAHs (17)		✓	✓		
VOCs:					
Benzene	✓	✓	✓	✓	✓
Ethylbenzene	✓	✓	✓	✓	✓
Toluene	✓	✓	✓	✓	✓
Total Xylenes	✓	✓	✓	✓	✓
MTBE	✓ If in landside groundwater				
Cyanide:					
Total cyanide	✓	✓	✓	✓	✓
Free/Physiologically available cyanide	✓	✓	✓	✓	✓
Metals:					
Arsenic	✓	✓	✓	✓	✓
Barium	✓	✓	✓	✓	✓
Cadmium	✓	✓	✓	✓	✓
Chromium	✓	✓	✓	✓	✓
Lead	✓	✓	✓	✓	✓
Mercury	✓	✓	✓	✓	✓
Selenium	✓	✓	✓	✓	✓
Silver	✓	✓	✓	✓	✓
Phenolics:					
Phenol	✓	✓	✓	✓	✓
2-Methylphenol	✓	✓	✓	✓	✓
4-Methylphenol	✓	✓	✓	✓	✓
2,4-Dimethylphenol	✓	✓	✓	✓	✓

Table 5-1b Summary of RI Analytes for In-River RI

Analyte	Sediments	Groundwater Beneath the River	Surface Water	Pore Water in Surficial Sediments	NAPL
PCBs (209 Congeners)	If in landside NAPL, NAPL-saturated soils, and/or at elevated concentrations in monitoring well samples; locations and media to be identified in technical memorandum				
Fingerprinting:					
40+ PAHs	✓			✓(24 for Pore Water)	✓
High resolution hydrocarbon fingerprint analysis (TPH) using high-resolution gas chromatography equipped with a FID	✓				✓
Risk assessment:					
SEM/AVS metals: Cadmium, copper, silver, nickel, lead, and zinc	✓ (Surficial)				

In addition to the chemical analytes listed in Tables 5-1a and 5-1b, other physical and chemical testing will be performed during the OU2 RI. The following analyses related to NAPL encountered in the upland sub-surface will be performed: residual saturation point (RSP) of the medium and organic content (for NAPL-saturated soil or sediment), and physical characteristics including density and viscosity at various temperatures where NAPL can be collected separately from soil.

For the in-River portion of the RI, in addition to the above-tabulated chemical analyte list, sediment samples will be analyzed for TOC, pH, and grain size. A sub-set of surficial sediment samples will also be selected for laboratory toxicity testing and benthic community evaluation

Sample Analysis/Validation: Samples for analysis will be submitted to qualified analytical laboratories having the capability to produce high-quality, defensible data and to report that data in a consistent and timely manner. The analytical laboratories used on this project will have current certification (or have certification pending) under the National Environmental Laboratory Accreditation Program (NELAP) and will be certified in the regulatory program applicable and relevant to the analyses requested. In addition, the laboratory must operate a quality assurance (QA) program that meets the requirements of the national consensus standard, ANSI/ASQC E4-1994, Specifications and Guidelines for Environmental Data Collection and Environmental Technology Programs and NELAP.

Data validation will be performed on all data generated by analytical laboratories. Laboratories will be required to provide full (Contract Laboratory Program [CLP] – type) data packages for all samples. These data packages will include all raw data required to reproduce the reported values. All data packages will be reviewed and qualifiers will be added, as applicable, to the associated data to indicate data usability. The details of data validation will be included in the QAPP submitted as part of the POP.

Laboratory-generated data will be provided by the laboratory in electronic format. All laboratory data will be maintained in an EarthSoft EQuIS project database.

5.2.2 RI Screening Levels

For presentation purposes, analytical results will be compared to the groundwater, surface water, and sediment screening levels selected in the SAP. These screening levels will include the USEPA MCLs; District of Columbia Department of the Environment Class G1 Groundwater Standards 21 DCMR § 1150 (1994); and the NPS January 2014 Ecological Screening Values (ESVs) for freshwater sediment and for surface water, which can also be applied conservatively to groundwater. Screening levels will not be used to eliminate any analytes from consideration in determining the nature and extent of contamination at the Site.

5.3 RI Field Investigation Logistics

The following tasks will be performed to implement the RI field investigation.

5.3.1 Planning and Mobilization

Upon approval of the POP, general planning and organizational activities for the RI field investigation will be implemented. These activities include identifying and contracting with qualified and licensed subcontractors, obtaining the required permits to implement the RI field investigation, and procurement of equipment and supplies necessary to implement the RI field investigation.

5.3.2 Subcontractors

Subcontractors will be selected who demonstrate past experience with similar projects and similar work activities, who have previous work experience at CERCLA sites, and who have the proper licenses to perform the work. The following types of subcontractors will be required to implement the RI field investigation:

- Drilling subcontractor(s) to perform boring advancement and monitoring well installation.
- Boat-based subcontractor or subcontractors to perform hydrographic surveys, collect beneath the River groundwater samples, and collect sediment samples.
- Surveying subcontractor to survey boring, well, and staff gauge locations and elevations.
- Laboratory or laboratories to perform chemical analyses, toxicity testing, pore water analysis, fingerprinting analysis, and NAPL mobility analysis.
- Waste hauling subcontractor to transport investigation-derived waste (IDW).
- Waste disposal subcontractor to receive IDW.

5.3.3 Landside RI Activities

The landside field activities will be supported by several field and laboratory subcontractors. The field activities will be conducted in three mobilizations of field subcontractors. A different field subcontractor may be used for each of these mobilizations.

5.3.4 In-River RI Activities

The River survey and sampling activities will be supported by one field subcontractor and several laboratory subcontractors. The field subcontractor will perform the hydrographic survey and will collect the grab and core sediment samples and the beneath the River groundwater samples. At the time of the preparation of this Work Plan, it is anticipated that up to four laboratories will be required to perform the analyses.

5.3.5 Field Decision Process

During the field program timely decisions will be required to keep the field program moving ahead, particularly while subcontractors are on site. The NPS technical On-Site Representative will be present during field activities to observe the performance of work and to observe the technical data collected, e.g., soil sampling. To facilitate NPS decisions WG will periodically submit field and laboratory data to the NPS and the District during the implementation of the field program. In addition, WG will submit proposed changes to the field program, as follows.

- **Field decisions described in the SAP**, such as choosing the appropriate screen depth for a well, will be made with the concurrence of the NPS On-Site Representative.
- Field decisions that require **emergency action and a minor variance** from the SAP will be communicated to the NPS On-Site Representative at the time of or immediately after the emergency action is performed. WG will send a written summary of the emergency action to the NPS and the District. Unless an emergency action results in collecting equivalent data to that required by the SAP, WG will attempt to repeat or modify the action to comply with the SAP.
- Field decisions that require **minor variance** from the approved SAP or apply **to non-emergency responses to unforeseen circumstances** will be submitted in writing as sequentially numbered, proposed minor modifications and sent to the NPS and the District by email. If necessary, proposed minor modifications may be decided during a conference call with, at minimum, the project coordinators (or their designated representatives) from NPS, the District, and WG. The NPS, District, and WG may choose to have other attendees on the call. Technical details and decisions discussed during the call regarding the minor modification will be summarized in an email from WG to the NPS immediately following the call. NPS will reply to WG's email acknowledging the minor modification summary.
- Field decisions that are **foreseen and require a major variance** from the SAP will be proposed in a SAP amendment (if new methods or techniques will be required) or a SAP modification (if approved methods or techniques will be changed or used in additional locations). All SAP amendments and modifications are subject to NPS and District review and approval.

5.3.6 Planned Investigation Sequence

It is anticipated that the OU2 RI field activities will occur after the completion of the OU1 remedial activities, which is planned for summer of 2015. Measures will be taken during the OU2 RI field activities to protect the OU1 remedy.

Figure 5-1 presents a flow chart of how the RI field work will be conducted. WG will perform the RI field activities in following order (additional details are provided in the following section):

1) Advance geological borings, and submit a technical memorandum selecting profiling locations. Collect and analyze NAPL-saturated soil encountered in soil borings. Collect and analyze NAPL samples from existing monitoring wells and recovery wells.
2) Perform hydraulic profiling, collect and analyze grab groundwater samples, analyze intrinsic permeability data, and submit a technical memorandum selecting groundwater monitoring well locations including screen intervals.
3) Install, develop, and slug test new groundwater monitoring wells, collect and analyze NAPL-saturated soil encountered in soil borings.
4) Initiate six month tidal survey and twice a month water level monitoring.
5) Prepare a technical memorandum summarizing the initial results of the tidal survey at least two months after initiating the tidal survey and select optimum sampling time for collecting groundwater samples relative to low tide.
6) Collect initial groundwater samples from all new and select existing groundwater monitoring wells and three surface water sample locations along the seawall at the time specified in the technical memorandum (one of the two sampling events must occur in the spring). Collect and analyze samples of any NAPL that accumulates in new monitoring wells during the first groundwater sampling round.
7) Prepare a technical memorandum at the end of the tidal survey confirming or modifying the optimal sampling time, and collect the second set of groundwater samples from all new and select existing monitoring wells (one of the two sampling events must occur in the spring).
8) Prepare a technical memorandum summarizing the mass flux/discharge calculations and results, and proposing in-river sediment sampling locations and sampling depths and beneath the River groundwater sampling locations, depths, and analytes. This technical memorandum will also include the background data set for sediment samples and propose reference area sample locations and analytes.
9) Perform a hydrographic survey in the River in the area of the proposed in-river sampling locations; submit a technical memorandum to NPS with maps of the findings. This memorandum will also include any proposed modifications to sampling locations and depths, if necessary based on the hydrographic survey results.
10) Perform in-river sampling. Collect sediment samples for chemical analysis, fingerprinting, and toxicity testing; collect pore water samples for chemical analysis, collect sediment samples containing NAPL for NAPL parameters. Collect in-river groundwater and surface water elevations, and collect beneath the River groundwater samples. Collect surface water samples. Submit a technical memorandum identifying the samples selected for toxicity testing.
11) Prepare a technical memorandum mapping the results of the sediment and beneath the River groundwater sampling. If the extent of Site-related contaminants in the River sediments and groundwater is not delineated to background concentrations additional sampling locations and depths may be required.
12) Perform additional in-river sampling, if necessary.
13) Submit the RI report, in accordance with the procedures in the SOW.

5.4 RI Field Investigation Details

The following sections provide a summary of the RI field investigation details. Further details are presented in the SAP.

During the implementation of the field program WG will periodically submit field and laboratory data as it is generated to the NPS and the District. These data submittals will facilitate discussions between the NPS, the District, and WG when it may be necessary to make field decisions regarding potential adjustments in the Work Plan, e.g., advancing additional geologic borings. The procedure to be followed for field decisions is presented in Section 5.3.5.

5.4.1 Landside Drilling Boring - Mobilization 1

On the landside, once subcontractors and other logistics are in place, the first field activity will be to advance the geologic borings from 23 borings along the seawall and 3 borings between MW-10 and MW-18. If additional borings are required to complete the geologic boring program, the drilling subcontractor will be prepared to install these borings without demobilizing from the Site.

Initial Borings: The initial set of borings includes 26 borings, with 23 borings along the seawall and 3 borings between MW-10 and MW-18. The borings along the seawall will be spaced approximately 50 ft. apart and the borings along between MW-10 and MW-18 will be spaced approximately 80 ft. apart (Figure 4-1).

These borings will be advanced from the ground surface to approximately 10 ft. into the Arundel Clay or when consistently dense, hard clay without sand or silt is encountered, whichever is deeper. Based on existing Site geologic data, the depth to the top of the Arundel Clay is estimated on the average to be approximately 45 ft. below land surface. Thus, the borings are expected to be drilled to an average approximate depth of 55 ft. below land surface.

Borings will be advanced using a Geoprobe™ drill. Soil sampling will proceed using either a Macro-Core or Larger Bore Soil Sampler depending on which sampler provides better soil sample recovery. Sample liners will be used. Soil cores will be collected continuously for the full length of the boring. The samples will be examined for olfactory evidence of contamination and visual evidence of NAPL. The samples will also be photographed.

Geologic materials encountered during boring advancement will be described on boring log forms. The log forms will include notations of olfactory evidence of contamination and of visual indications of NAPL. The details of the logging procedures will be presented in the OU2 RI/FS SAP.

During boring advancement, if NAPL is observed in the soil samples, all samples of the NAPL-saturated soil will be collected and submitted for analysis, unless borings are closely spaced or lenses of NAPL-saturated soil are closely spaced and compelling evidence is presented to NPS and the District that the NAPL from two or more locations or zones of NAPL-saturated soil at one location will have very similar chemical characteristics and only one sample is required for analysis, and NPS and DOEE agree.

During the same mobilization, samples of NAPL that has accumulated in all existing monitoring wells at the government property and East Station property will be collected. All soil boring, monitoring well, and recovery well NAPL samples will be analyzed for the list of analytes shown in Table 5-1a, in addition to RSP of the medium and organic content (for NAPL present in soil), and physical characteristics including density and viscosity at various temperatures.

Technical Memorandum: A technical memorandum will be prepared that includes boring logs and cross-sections incorporating new data. Cross-sections will show observed NAPL and locations of potential relatively high permeability. The technical memorandum will propose hydraulic profiling locations, and the number and approximate depth of groundwater grab samples to be collected during hydraulic profiling. The memorandum will also include analytical results from all samples including the PCB Aroclor NAPL sampling results. This technical memorandum will be submitted within 70 days after the end of the field work, and an additional 45 days will be allowed for NPS review, discussion, and finalization.

5.4.2 Landside Drilling Profiling - Mobilization 2

The second drilling mobilization will focus on obtaining in situ intrinsic hydraulic conductivity data and collecting groundwater grab samples. It is anticipated that up to six groundwater samples will be collected from each profiling location: 1) in the fill unit; 2) the transition zone of sand lenses between the fill and silt unit; 3) in the silt unit; 4) the transition zone of sand lenses from the silt to the sand and gravel unit; 5) in the sand and gravel unit; and 6) in the transition zone of sand lenses from the sand and gravel unit to the Arundel Clay. Fewer samples may be collected where these transition zones do not exist, or additional samples may be collected if a significant sand lens is encountered in the silt unit and/or a sample is desired in the Arundel Clay to establish an area of no detections below the sand and gravel unit.

In-situ intrinsic hydraulic conductivity data will be obtained using a hydraulic profiling tool (HPT). The HPT estimates in-situ hydraulic conductivity by measuring the pressure required to inject a small flow of water into the soil as the HPT probe is advanced. Grab groundwater samples will be collected by reversing the water injection circulation and then collecting a grab groundwater sample. Grab groundwater samples will be collected and analyzed for the list of contaminants on Table 5-1a. Details for obtaining the in-situ hydraulic conductivity data and the collection of grab groundwater samples will be presented in the SAP.

Technical Memorandum. A technical memorandum will be prepared at the end of the profiling and grab groundwater sampling program to summarize all the data collected and to make recommendations for the locations and screen intervals for new monitoring well installation and sampling. While much of the field data will have already been submitted to the NPS and the District during the field program, this technical memorandum will update the geologic data and intrinsic hydraulic conductivity data collected, along with the presence/absence of NAPL zones, presence/absence of preferential flow paths, and the results of the grab groundwater samples. The memorandum will also summarize all NAPL observations, and NAPL-saturated soil and groundwater grab PCB Aroclor analytical results. The proposed monitoring well network will be designed to determine the extent and mass flux of all contaminants of potential concern.

This memorandum is intended to be an informal submittal of data and summary of proposed work for the well installation mobilization, but the proposed work will not be implemented until approved in writing by NPS and the District. Amendments to the proposed work will be discussed by conference call, if necessary, and summarized in writing in a revised technical memorandum. This technical memorandum will be submitted within 70 days after the end of the field work, and an additional 60 days will be allowed for NPS review, discussion, and finalization.

5.4.3 Landside Monitoring Well Installation - Mobilization 3

The third field mobilization, following receipt of the NPS and District approval of the planned work, will be to install and develop the groundwater monitoring wells.

Groundwater Monitoring Well Installation: Groundwater monitoring wells will be installed using hollow stem auger drilling techniques. Wells will be 2-inch diameter PVC wells. Screen slot size and lengths will be detailed in the technical memorandum for each proposed well, but in general, it is anticipated that 5 foot, 10 slot screens will be installed. If NAPL is discovered along the seawall during the Geoprobe™ and/or profiling programs, drilling methods for well installations will be adapted to avoid vertical NAPL migration such as use of multiple casing diameters.

During boring advancement, if NAPL is observed in the soil samples, all samples of the NAPL-saturated soil will be collected and submitted for analysis of the analytes shown in Table 5-1a, in addition to RSP of the medium and organic content (for NAPL present in soil), and physical characteristics including density and viscosity at various temperatures. Some NAPL samples may not be submitted for analysis if borings are closely spaced or lenses of NAPL-saturated soil are closely spaced and compelling evidence is presented to NPS and the District that the NAPL from two or more locations or zones of NAPL-saturated soil at one location will have very similar chemical characteristics and only one sample is required for analysis, and NPS and District agree.

5.4.4 Landside Tidal Survey, and Monitoring Well Groundwater and NAPL Sampling and Surface Water Sampling (Mobilization 3 Continued)

Concurrent with the completion of the installation of the monitoring wells, the water level monitoring stations on the River will be established and all existing and new monitoring well locations along with the River stations will be surveyed to a common datum. The program of twice monthly and continuous water level monitoring will be started and will continue for six months after installation of the River water level monitoring points and the new monitoring wells.

The tidal survey will also be started as soon as feasible after the water level monitoring program is established, depending on other activities that may be taking place. Since the tidal survey relies on the deployment of pressure transducers at several locations over an extended period of time, it should be conducted during a period when the chance of disruption is minimal. When active construction is taking place, the risk of wells being disturbed and/or destroyed is relatively high, and construction equipment can alter pressure measurements; the tidal survey should not be conducted at these times.

One of the objectives of the tidal survey is to confirm the ideal time related to tide cycle to collect groundwater samples. Therefore, the first sample round will occur after a minimum of two months of the tidal survey has been completed. The early tidal survey results will be used to predict the lowest tide conditions on the landside, when samples will be collected. The second round of samples will be collected after the six month tidal survey is complete. To assess potential seasonal variability, one set of samples will be collected in the spring.

Three monitoring stations (e.g., stilling wells, which will be installed without impacting the seawall) will be established to collect water level data for the River. All existing and new wells and the River monitoring locations will be surveyed to a common datum. Additionally, a reference point will be established and surveyed on the seawall to be used as a reference point to measure River water level elevations during beneath the River groundwater sampling. This survey will ensure measured water levels are tied into a consistent and known datum so that all elevations can be quantitatively compared.

Water levels in all wells (existing and proposed new wells) and the three surface water River monitoring stations will be gauged on a twice per month basis over a six-month period. Water levels will be measured with an oil/water interface probe. Each monitoring event will be performed when the

maximum hydraulic gradient to the River occurs, plus or minus 1.5 hours (initially at low tide, and later as determined by the tidal evaluation described in the following paragraph). The data will be used to evaluate hydraulic gradients in all geologic units, horizontal and vertical groundwater gradients, the capture zones of the groundwater pumping systems, and the relationship between groundwater levels and the River. Water levels in the pumping wells will be measured during these water level measurement rounds, but because pumping wells are never 100 percent efficient and therefore measured water levels do not represent the elevation in the geologic unit, these water levels will not be used in quantitative evaluation of water level gradients.

During the same six month period, continuous water level data will be collected using electronic pressure transducers at seven locations including: one River location, four nested wells near the seawall (one in each geologic unit [fill, silt, sand and gravel, and Arundel Clay] for a total of 16 transducers in these four nested wells), one fill unit well located inland from the seawall and one sand and gravel unit well located inland from the seawall for a total of 19 transducers. The automated pressure transducer data loggers will be downloaded, and their reference elevation confirmed during each twice a month groundwater monitoring event. Precipitation and barometric data will be obtained from the nearest available recording weather station for the full monitoring period. This precipitation and barometric data will be considered in the evaluation of the water level monitoring data.

Following installation and completion of the new monitoring wells and at least two months of the tidal survey, a summary of the completed portion of the tidal survey and the proposed optimal sampling times will be submitted for review and approval in a technical memorandum. Review, discussion, and finalization of the technical memorandum will be completed within 15 days of submittal, and the first round of groundwater sampling will be conducted. Surface water sampling to support the tidal survey will be performed at the same time as groundwater sampling. Additional surface water sampling will be conducted as part of the in-river RI and is discussed below (see Section 5.4.7).

Wells to be sampled will include all new monitoring wells installed during the landside RI, the 14 wells currently included in WG's biannual monitoring program (MW-4, MW-5, MW-6, MW-18, MW-20, MW-23, P-6S, WGL-01D, WGL-03D, MW-25, MW-27, MW-28, MW-29 and MW-31); WGL-02D (located near the transect perpendicular to the River and a sand and gravel unit well with relatively higher concentrations of Site-related contaminants when it was last sampled in 1996), and WGL-01S (located between MW-10 and MW-18), and MW-19. Other existing well or piezometer locations will be considered for sampling following assessment of all new data collected prior to sampling.

Groundwater samples will be collected using bladder pumps or peristaltic pumps. Bladder pumps will be used whenever possible. Peristaltic pumps will be used for shallow wells where there is insufficient water to use a bladder pump. The pumps will be set with the intakes at the mid-point of the well screens for wells screened across the water table and at the top of screen for wells screened below the water table.

During the first sampling round, NAPL will be collected from each new monitoring well in which it is present on the government property. NAPL samples will be analyzed for the full list of analytes shown in Table 5-1a, and physical characteristics, including density and viscosity at various temperatures.

Surface water samples will be collected from the River concurrently with the groundwater samples. Surface water samples will be collected at three locations to be established (locations will be marked so that sampling will occur at the same locations each sampling round) along the seawall: one at either end and one in the approximate middle of the government property. These locations will be positioned adjacent to existing monitoring wells (MW-4, MW-6/MW-23, and MW- 18). The surface

water samples will be collected from the water column within 1-2 ft. of the sediment surface. Samples will be collected using bladder pumps or peristaltic pumps, depending on the depth of water at the time of sampling.

Slug tests will be performed using solid slugs of known volume inserted into the monitoring wells to below the standing water level. Rising head and/or falling head tests will be conducted as appropriate (i.e., if the unit is confined or unconfined). Slug test analyses will be performed using standard published analytical equations using Aqtesolve™ software.

The second round of groundwater sampling will be scheduled approximately six months after the first round and after the tidal survey is complete. The optimal sampling time will be reevaluated using the complete tidal survey data, and a brief technical memorandum will be submitted detailing the proposed sampling time relative to low tide. Review, discussion, and finalization of the technical memorandum will be completed within 30 days of submittal. The landside RI field investigation will be complete when the second groundwater sample round is completed.

5.4.5 Mass Flux/Discharge Reporting and In-River Sampling Technical Memorandum for Mobilization 3

At the completion of the collection and analysis of all groundwater samples, a technical memorandum will be prepared. This memorandum will provide a summary of the hydrogeologic data, in addition to all mass flux/mass discharge calculations and results. The technical memorandum will also finalize the in-river sediment and beneath the River groundwater sampling locations, depths, and analytes. As part of this technical memorandum, the background data set of existing sediment sample results, including double-ratio plots using available data and a discussion of data gaps discovered during the background data evaluation. Proposed reference location samples to address data gaps will be presented in this memorandum. This technical memorandum will be submitted within 100 days after the end of the field work, and an additional 60 days will be allowed for NPS review, discussion, and finalization.

Background Conditions: The background data compilation and evaluation approach will be conceptually based on an approach recently used by the Washington Navy Yard CERCLA site on the River (CH2M Hill, 2010). The following approach will be followed for the initial background analysis presented in the technical memorandum.

An upstream data set will be compiled from the NOAA DARRP database into a background data set. This background data set will include surficial sediment analytical chemistry, TOC, and grain size data from a wide variety of programs. The background data set will include sediment samples obtained from locations a minimum of 0.25 mi (selected to be beyond the estimated tidal flux from the Site) up to a maximum of 2 mi upstream of the Site. Data from areas of concern-related samples identified in AWTA (2002) will be excluded. Data to be included from the NOAA database will be determined in a collaborative review process with NPS. To the extent the data is available in the NOAA database, PAH data will be presented for each background sample in the double ratio plots. The background data set will be summarized and presented in the pre-sediment sampling technical memorandum, along with the proposed reference sample locations and analytes, chosen to address data gaps identified during data set compilation or to confirm initial background fingerprinting analyses.

This memorandum will include recommendations for potential modifications to the in-river remedial investigation, if any. Modifications to the in-river remedial investigation will not be implemented until submitted to and approved in writing by NPS.

5.4.6 In-River Hydrographic Survey – Mobilization 4

The in-river RI activities will be conducted during two mobilizations of the field subcontractor. The hydrographic survey will be performed first and will overlap with Mobilization 3 activities. The results of this survey may inform some adjustments to the location of sediment samples or may expand or contract the area where samples are collected. Adjustments to the field program, if any, along with the rationale for these adjustments will be communicated to the NPS and District in writing or, if time-critical, verbally. The proposed adjustments will be discussed during a conference call, with a written summary sent to the NPS and the District by email. This technical memorandum will be submitted in time to allow 30 days for NPS review, discussion, and finalization before the Mobilization 5 start date.

5.4.7 In-River Sampling - Mobilization 5

The in-river sampling mobilization will occur after the hydrographic study technical memorandum is approved in writing by NPS and the District. Surficial and sub-surficial sediment samples will be collected as described below.

Surficial Sediment Samples: Twenty-two samples will be collected to evaluate current potential for exposures in the BAZ. Samples will be collected using grab sampling techniques for some analyses and vibracore sampling techniques for other analyses. Sediment grab samples will be visually evaluated for indications of bioactivity to confirm the BAZ at each sampling location. Surficial sediment samples will be collected from the BAZ identified in the grab sample, which is currently assumed to be 0 to 0.5 ft. below the sediment surface. Surficial sediment samples for analyses that require large volumes of sample (i.e., toxicity testing and pore water) and samples that need to be quickly placed in laboratory sample containers (i.e., SEM/AVS and VOCs) will be collected with a grab sampler. Surficial samples for the remaining chemical analyses will be collected with a co-located vibracore. Samples will be analyzed for chemical parameters (see Table 5-1b). Instead of the 17 PAHs sampled during the landside groundwater investigation, PAH analysis will be performed for the 34 PAH list (including alkylated contaminants) used for fingerprinting (Section 5.4.8 describes the forensic use of these data). In addition, toxicity testing and pore water samples will be collected, as discussed below.

Sediment Toxicity Testing and Pore Water Sampling: At each of the 22 surface sediment sample locations, sufficient surficial sediment (from 0 to 0.5 ft.) volume will be collected with a grab sampler during the sediment sampling described in Section 4.3.2 to perform both toxicity testing and pore water sampling. These samples will be archived (hold times will be noted so that toxicity testing and pore water analyses are performed within hold times) and following receipt and review of the surficial bulk sediment sample chemistry results, 10 to 13 locations (3 reference stations and a minimum of 7 and up to 10 adjacent to the Site) will be selected for toxicity testing and pore water analysis. The 22 sediment sample locations adjacent to the Site are shown on Figure 4-2. The three reference stations are shown on Figure 4-3 (proposed locations, to be verified by the background conditions assessment described in Section 4.3.5).

The selection of locations for Site-related toxicity testing and pore water analyses cannot be finalized until the chemical results are received and reviewed. Once the range and distribution of contaminants are known, a minimum of seven locations (and up to 10 locations) adjacent to the Site will be selected to provide a range of sediment chemical concentrations focusing primarily on providing a range of

PAH concentrations, but also considering metals, VOCs, cyanide, and phenolics, if present in the sediment samples. The selection of locations for toxicity testing and pore water analysis will be submitted in a technical memorandum to and approved in writing by NPS. Review and approval will be completed as requested upon technical memorandum submittal to comply with sample hold times.

Toxicity testing will use 10 day *Chironomus dilutus* and 10 day *Hyalella azteca* laboratory tests. Besides the analytes listed in Section 4.3.2, each sediment sample used for toxicity testing will also be analyzed for SEM/AVS.

The pore water analysis will measure the 34 PAHs used for fingerprinting, Site-related VOCs, dissolved COPC metals, and dissolved cyanide (total and free/physiologically available cyanide) as an indicator of bioavailability. The pore water samples will be analyzed for dissolved PAHs by the flocculation and solid-phase microextraction (SPME) method. The pore water samples for dissolved COPC metals and cyanide will be extracted from the sediment by centrifuge.

Sub-surficial Sediment Samples: Subsurface sediment sampling will be collected below the surficial sediment samples (0.5 ft.) to a maximum depth of 10 ft. below the sediment surface or refusal. If there is evidence of MG contamination at 10 ft. subsurface sediment sampling will be advanced deeper. The subsurface sediment samples will be collected using a vibracore sampler, which has a practical coring depth limit of approximately 20 ft. in shallow water. If the landside RI indicates a different contaminant mass discharge than that assumed in the CSM (i.e., if the transport depth is greater or less than assumed, or if the location of highest mass discharge are different than assumed), a new maximum sampling depth will be proposed in the Technical Memorandum prepared in advance of the in-river RI.

Sediment core samples will be processed on the shore and shipped to the laboratories. Cores will not be processed on the boat, but both ends of the core barrels will be sealed on the boat immediately after collection and prior to transport to the shore. When the cores are opened on the shore for processing, VOC samples will be collected immediately and prior to any other sample processing.

Each core will be logged in detail for lithologic changes and visual evidence of Site-related contamination. A minimum of one 2-ft. long sample for laboratory analysis will be collected per 5 ft. interval of core from 0.5 to 5 ft. and 5 to 10 ft. If the maximum sampling depth presented in the Technical Memorandum prepared in advance of the in-river RI is increased to 20 ft., one additional 2-ft. long sample will be collected of the 15 to 20 ft. interval. These samples will generally be collected from the bottom of each sample interval. The sampling interval may be modified in the field at the time of sampling based on the grain size (e.g., lenses of coarser sediment) and/or visual indications of MG contamination (e.g., NAPL). Additional samples may be collected for laboratory analysis for intervals where 1) NAPL is observed, and 2) relatively coarse grained media are present (e.g. sand seams, sand and gravel). Samples will be analyzed for the list of analytes on Table 5-1b, and TOC and grain size. If NAPL is collected for analysis, it will be analyzed as described in Section 5.2.1.

The sediment sampling program includes collecting and archiving sediment samples of sufficient volume for toxicity testing, pore water sampling, and fingerprinting/forensic analysis. Upon receipt and evaluation of the results of the chemical analyses, proposed locations for the benthic toxicity and fingerprint/forensic analyses along with rationale will be submitted in a technical memorandum to the NPS and DOEE for rapid review so that samples can be analyzed within method hold times. The proposed samples selected for these analyses will be discussed by conference call, if required, with a written summary sent to the NPS and the District by email.

Forensic/Fingerprint Analysis: In addition to the 40+ PAH analyte list that will be used for all sediment samples, sediment samples from the locations adjacent to the government property and the reference locations will be submitted for high resolution hydrocarbon fingerprint analysis (TPH). Section 5.4.8 describes the forensic interpretation methods.

Surface Water: Surface water samples will be collected from the River immediately before the beneath the River groundwater samples at ten of the 22 locations. The surface water samples will be collected from the water column within 1-2 ft. of the sediment surface. Samples will be collected using bladder pumps or peristaltic pumps, depending on the depth of water at the time of sampling. The surface water samples will be analyzed the list of analytes on Table 5-1b.

Beneath the River Groundwater: After cores have been opened and observed at each of the 22 sediment sampling locations, the beneath the River groundwater samples will be collected and groundwater water levels measured at 10 of the sediment sampling locations. Five, two location transects oriented perpendicular to the seawall will be selected. Samples will be collected at two depths, 5 ft. and 10 ft. beneath the sediment-surface water interface, or at two similar depths from layers of higher permeability materials, if present within the sediments. Samples will be collected within a three hour window of low tide, 1.5 hours before and 1.5 hours after low tide. Conceptually, one transect (i.e., two locations and two depths or a total of four samples) will be collected per low tide cycle.

Groundwater samples from beneath the River will be collected by advancing a temporary small diameter sampling probe fitted with a fine mesh screen or pre-packed small diameter well screen at the bottom (5/8 inch diameter AMS, Inc. Gas Vapor Probe Sampler, or equivalent) into the sediment. Following a short period of purging or surging, as necessary, to develop the sampling probe, samples will be collected with a peristaltic pump. The shallowest sample will be collected first and the deeper sample will be collected without removing the sampler from the sediments. If NAPL is observed in the shallower sample, the deeper sample will not be collected because the sampler may be contaminated by the presence of the NAPL.

Samples will be analyzed for the list of analytes on Table 5-1b. Samples will be collected at greater depths if the nature and extent of Site-related contaminants is not satisfactorily characterized following initial sampling.

Coincident with the beneath the River groundwater sampling, groundwater level measurements will be obtained with a small diameter probe that fits inside the groundwater sampling probe. The beneath the River groundwater level measurement will be made by first measuring outside of the sampling probe the depth from the top of the sampling probe to the River surface water and then measuring the depth from the top of the sampling probe to the groundwater surface inside the probe. These two measurements along with the surface water elevation calculated at the seawall will allow the calculation of the groundwater elevation beneath the River. During beneath the River groundwater sampling a continuous reading pressure transducer will be installed at the seawall at the surveyed reference point (see Section 5.4.4). This pressure transducer will allow the calculation of the surface water elevation at the time of the groundwater measurements.

Sediment Stability Sampling: As described in Section 4.3.7 sufficient sediment data are available for the area of the Site to support the sediment stability analysis. Data collected as part of this work plan, and as described above, will supplement this existing data set. These new data include the bathymetry survey, grain size analyses, and contaminant distributions, both horizontally and vertically. The general approach to evaluating the historical and new data is presented below in Section 5.4.8.

5.4.8 Summary of Sediment Sample Results for Mobilization 5

A technical memorandum will be prepared providing the results of the sediment sampling, in-river groundwater sampling, and surface water sampling. Toxicity and pore water results will not be provided in this memorandum, which is intended to show whether the nature and extent of Site-related contaminants in sediments has been satisfactorily delineated or if additional sampling is required. Figures illustrating the horizontal and vertical extent of site-related contaminants will be included in this technical memorandum. As described below, the background analysis, forensic analysis, and sediment stability analysis results will also be presented in the technical memorandum. This technical memorandum will be submitted within 180 days after the end of the field work, and an additional 60 days will be allowed for NPS review, discussion, and finalization.

Background Conditions: The background data compilation and evaluation approach will be conceptually based on an approach recently used by the Washington Navy Yard CERCLA site on the River (CH2M Hill, 2010). The following approach will be followed for the background analysis:

1. Create an upstream surficial sediment background data set by combining the background data set developed and presented in the Mass Flux/Discharge Reporting and In-River Technical Memorandum (see Section 5.4.5 above) with newly collected reference data.
2. Review newly created background data set to ensure that DQOs are adequate to support statistical analysis.
3. Pending the results of Steps 1 to 2, additional surficial sediment samples may be collected to ensure that a sufficient number of sediment samples are available to represent naturally occurring and anthropogenic background conditions (i.e., if the existing data obtained from the NOAA database, and supplemented by the three reference condition samples, is sufficient for statistical analysis [ten or more detected concentrations of site-related contaminants with supporting data such as TOC and grain size]. If the number of samples is sufficient no additional background data will be collected following discussion with and concurrence of the NPS. Conversely, if the number of samples is insufficient for statistical analysis, then additional background sampling will be considered.
4. Consistency with background analyses:
    a. Evaluation of Site data relative to background conditions will be done using statistical methods outlined in USEPA (2002) and USEPA ProUCL software and technical guidance (USEPA Version 5.0 or recent version). This evaluation will, depending upon the distribution of the data, likely include evaluation of Site and background data sets for outliers, parametric and/or non-parametric statistical hypothesis testing, and/or calculation of background threshold values (BTVs) to further provide estimates of naturally occurring and anthropogenic background conditions in the River. One or more of the following evaluations may be performed:
        - Outlier analysis consistent with methods provided in ProUCL (version 5.0 or recent versions).
        - Establish background exposure point concentrations (EPC).
        - Plot Site and background data using both quantile/probability plots and box plots.
        - Compare Site sediment samples to the background data set using population-based statistical methods (USEPA, 2002).

- Evaluate COPC/COPECs that are not found to be consistent with background (i.e., null hypothesis not rejected) using methods provided in ProUCL version 5.0 (or more recent version) and calculate BTVs.

In the risk assessments, the background data will not be used to eliminate any COPCs or COPECs. Rather, per USEPA OSWER 2002, "COPCs with high background concentrations [will]…be discussed in the risk characterization, and if the data are available, the contribution of background to site concentrations [will]… be distinguished."

Forensic/Fingerprint Evaluation. Based on patterns observed in the data, the fingerprint/forensic analysis will include, but may not be limited to the following evaluations:

- Visual comparisons of the GC/FID chromatograms and normalized parent and alkylated PAH patterns to determine how well samples collected adjacent to the government property match upstream samples.
- Double ratio plots of PAHs, which include the ratio of two PAH contaminants on the x-axis plotted against the ratio of two other PAH contaminants on the y-axis, will be used. Common double ratio plots used in sediment forensics (O'Reilly, et al., 2012) include plotting:
  - fluoranthene/pyrene against indeno(1,2,3-cd)pyrene/benzo(g,h,i)perylene
  - benzo(b)fluoranthene/benzo(k)fluoranthene against benzo(a)anthracene/chrysene
  - benzo(a)pyrene/benzo(e)pyrene against phenanthrene/anthracene
- PAH histograms
- TPH histograms
- Relative contribution correlations consistent with USEPA (2004) guidance – Falcon Analysis.

Sediment Stability Analysis: The sediment stability analysis will be a weight of evidence approach conducted following the guidelines in the Technical Guidelines on Performing a Sediment Erosion and Deposition Assessment (SEDA) at Superfund Sites (USACE, 2014) and will include, but not be limited to:

- Comparing bathymetry data over time (historical and bathymetry data collected as part of this work plan).
- Evaluating the bathymetry data collected as part of this work plan for types of forces that may impact sediment stability (e.g., linear furrows indicative ship or boat movement or prop wash scars),
- Reviewing grain size profiles, stratigraphy, and contaminant distributions for time markers (correlation of a relatively elevated concentration with a past industrial activity), buried contamination (indicative of stable or accumulating conditions), and other changes in profiles that may be indicators of eroding or accumulating sediments,
- Evaluating timeline profiles available from historical studies of the River for indications of sediment erosion or accumulation.
- Evaluating basin-wide characteristics, e.g., areas of deposition and erosion, presence of bridges that may cause differential River flow, and basin hydrodynamic data, e.g., tidal forces, water level fluctuations, and river flow and water level fluctuations associated with storm events.

5.4.9 Additional In-River Sampling, if Necessary

Additional in-river sampling will be performed if the nature and extent of Site-related contaminants has not been delineated to background concentrations. Additionally, if the beneath the River groundwater sampling shows the potential for groundwater discharge farther into the River than the sediment samples collected, additional in-river sampling may be performed.

5.5 RI Report

After completion of the RI field investigation, a comprehensive RI Report will be prepared to present and evaluate the efficacy of the data for meeting the stated RI objectives. Following completion of the RI field investigation, an ERA and HHRA will be prepared (see Section 5.6 and Appendices C and D). These risk assessments will be included in the RI Report. The RI Report will also include the following:

- A conclusion that identifies the nature and extent of Site-related contaminants in groundwater discharging to the River, surface water, and River sediments, and provides the calculated results of mass flux/discharge to the River.
- A preliminary list of ARARs provided by the District and NPS (if ARARs have not been provided by NPS and DOEE at least three months before the RI draft report deadline, WG will send a letter formally requesting ARARs from both agencies);
- A comparison of sediment COPC results with PRGs to identify volumes or areas to which general response actions may be applied.
- Recommendations for additional work, if any.

5.6 Risk Assessments

A HHRA and an ERA will be performed following appropriate USEPA guidance. The work plan for the ERA is presented in Appendix C and the work plan for the HHRA is presented in Appendix D of this RI/FS Work Plan.

As described in Appendix D, a technical memorandum presenting the proposed exposure assumptions for recreational use of the River will be submitted before the HHRA is performed.

5.7 Treatability Studies

Additional data may be necessary to evaluate the extent and effectiveness of potential technologies so that the FS can be used to develop and evaluate alternatives for remediation of the Site. Among other information, these data needs may include the performance of treatability studies to assess the applicability of specific technologies under conditions present at the Site. If treatability studies are required, they will be conducted generally following the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988) and the Guidance for Conducting Treatability Studies under CERCLA (USEPA, 1992). A Work Plan and POP will be prepared for any treatability studies. The results of these studies will be incorporated into the FS Report.

5.8 Feasibility Study

The FS activities will include the following general steps and considerations, and will be conducted in accordance with the USEPA Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, 2005a).

- Describing the baseline and/or current Site conditions and summarizing and synthesizing the results of the RI, the HHRA and ERA, the CSM, and related documents.
- Establishing Remediation Goals (RGs).
- Developing response actions that may be taken to meet the RAOs.
- Identifying and screening general response actions, remedial technology types, and specific process options best suited to Site conditions.
- Assembling the technology types and process options into remedial alternatives and then completing the screening and final assembly of remedial alternatives.
- Identifying candidate technologies for a treatability study program and implementing and evaluating treatability studies and pilot studies, as necessary, through a FS field program.
- Completing a detailed evaluation and comparative analysis of retained remedial alternatives using USEPA's seven evaluation criteria.

5.8.1 Development and Screening of Alternatives

A representative range of applicable technologies and responses will be assembled into a set of potential remedial alternatives. The following five-step process will be used to develop the remedial alternatives. ARARs will be considered in each step of this process.

1. RAOs will be established, specifying the COPCs, media of interest, and exposure pathways.
2. General Response Actions that could be used to meet the RAOs will be identified. General Response Actions are overall approaches such as natural recovery, removal, containment, and treatment.
3. Media COPC results will be compared to RGs.
4. Applicable remedial technologies for each medium will be identified and screened. The screening process will eliminate technologies that cannot be implemented for technical reasons and identify the technologies that may be suited to Site conditions.
5. A set of appropriate remedial alternatives will be formed by combining selected representative technologies and responses.

Remedial alternatives will be screened and analyzed in accordance with Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA, 1988). The remedial alternatives evaluation will include the guidance provided by the Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, 2005a). Specifically, the first step of the screening process will be conducted for the purpose of reducing the number of alternatives that are carried into the detailed analysis stage.

In the preliminary screening stage of the FS, remedial alternatives will be evaluated using three general criteria: effectiveness, implementability (technical and administrative), and cost. Each of these categories contains additional considerations, nine in total, as detailed in Section 5.8.2.

Effectiveness refers to the ability of a remedial action to protect human health and the environment. The short-term impacts during remedial construction and implementation are considered at this stage, as well as the long-term effectiveness of the remedial action after it is completed. The expected duration of the effectiveness is estimated for each alternative. Implementability refers to the realistic capability to actually implement an alternative. Technical implementability of a remedial alternative involves the ability to construct and operate the alternative, and to rely on the alternative to meet the performance requirements and consistently achieve the RAOs. At this stage of the FS, the performance of technologies will be reviewed. Administrative implementability refers to the ability to obtain the required permits and stakeholder approvals for the action, regulatory compliance, and the availability and capacity for off-site services such as treatment, storage, and disposal. Cost refers to the relative estimated cost of all aspects (i.e., design, capital costs, and operation and maintenance costs) to implement each alternative. In addition to these three criteria, the preliminary screening stage of the FS will include evaluation of alternatives that include opportunities for reducing the environmental footprint of remedial design and construction activities and will include a consideration of the sustainability of the alternative.

The development and screening of alternatives will be submitted to the NPS and District in a technical memorandum. This document will also include an evaluation of the need for a treatability study to complete the screening of one or more of the alternatives.

5.8.2 FS Report

The FS report will include a detailed analysis of alternatives, the result of which will provide the basis for NPS's identification of a preferred alternative and preparation of the proposed plan. Upon completion of the detailed analysis of alternatives, the FS report, along with the proposed plan (and the RI report if not previously released), is submitted for public review and comment. The results of the detailed analysis support the final selection of a remedial action and are the foundation for the Record of Decision.

The following factors will be considered in the alternatives analysis:

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term impacts and effectiveness;
- Implementability; and
- Cost-effectiveness.

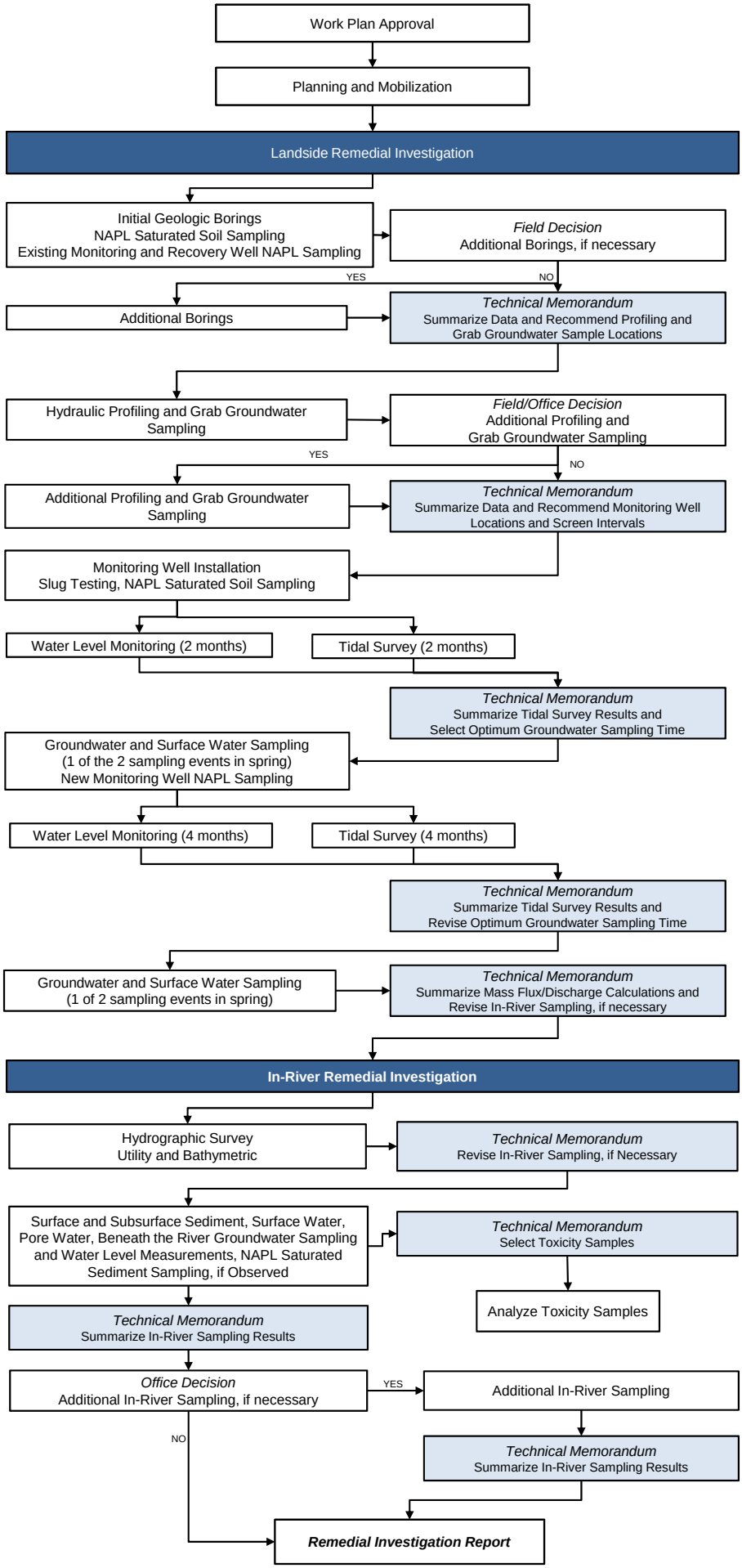
In addition to these seven criteria evaluated in the FS, the NPS and District will evaluate two additional modifying criteria in the proposed plan: District acceptance and community acceptance.

NPS and the District will provide WG with a list of site-specific ARARs to be incorporated in the preliminary list included in the RI report. These site-specific ARARs will be incorporated into the FS report and included in the detailed alternatives analysis. As part of the analysis, estimates will be made of the short-term and long-term risks to human health and the environment that may be introduced by implementing each of the remedial alternatives.

A comparative analysis of the alternatives will be prepared once the evaluation of each of the individual alternatives is complete. The comparative analysis will discuss the advantages and disadvantages of the alternatives in relation to one another with respect to each criterion, and how reasonable variations of key uncertainties could change the expectations of their relative performance, so that the important issues for final remedial action are clearly identified. The presentation of differences among alternatives can be measured either qualitatively or quantitatively, as appropriate, and should identify substantive differences (e.g., greater short-term effectiveness concerns, greater cost, etc.). Quantitative information that was used to assess the alternatives (e.g., specific cost estimates, time until response objectives would be obtained, and levels of residual contamination) should be included in these discussions.

In addition to the requirements in the Consent Decree, SOW, and this Work Plan, the FS Report will be completed following the guidance on FS presentations that is provided in the Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA, 1988). The EPA guidance provides a FS report format in Table 6-5, which will be followed.

Figure 5-1
RI Field Work Sequencing
Operable Unit 2 - Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site



6.0 Schedule

The schedule for OU2 RI/FS activities is presented in Table 6-1. It is based on Table 2, "OU2 Remedial Investigation and Feasibility Study Document Requirement Summary," in the Consent Decree SOW and assumes a treatability study will be performed. Upon approval of this Work Plan, the schedule in Table 6-1, as well as any other timeframes outlined in the Work Plan, will be considered approved and enforceable and will only be changed with prior approval by NPS and DOEE, pursuant to the relevant provisions in the Consent Decree. NPS and DOEE recognize that the Work Plan includes the possibility of expanding the scope of work beyond current requirements and will consider requests for modifications of the Work Plan schedule in Table 6.1 during the following four milestones of the RI/FS Work:

(1) In the Technical Memorandum summarizing the hydraulic profiling data (completed at the end of Mobilization 2);

(2) in the Technical Memorandum summarizing the hydrogeological data, mass flux results, and proposed in-river sampling locations (completed at the end of Mobilization 3);

(3) in the Technical Memorandum that provides the sediment results (nature and extent of contamination) for the Anacostia (completed at the end of Mobilization 5); and

(4) in the Treatability Study Work Plan.

Timeframes related to submittal, review, and finalization of the technical memoranda are described in Section 5. Previous technical memoranda submission, review, and finalization durations along with requirements for expanding the scope of work, if any, will factor into any decision to adjust the schedule. If NPS and DOEE approve modifications to the RI/FS schedule, new enforceable deadlines will be developed and Table 6-1 will be revised accordingly.

Table 6-1 OU2 RI/FS Schedule
Operable Unit 2 – Remedial Investigation and Feasibility Study Work Plan
Washington Gas East Station Site

Element	Critical Preceding Element	Duration	Start Date	End Date
Completed Tasks as of OU2 Work Plan Approval				
Consent Decree Effective Date	--	--	--	September 26, 2012
Propose/Accept Supervising Contractor (1)	Consent Decree Effective Date	10 days	September 26, 2012	October 6, 2012
NPS Authorization to Proceed	--	--	October 16, 2012	October 16, 2012
Draft OU2 RI/FS Work Plan	NPS Authorization to Proceed	90 days	October 17, 2012	January 14, 2013
NPS Review of Draft Final OU2 RI/FS Work Plan (2)	Receipt of Draft OU2 RI/FS Work Plan	--	January 15, 2013	January 31, 2014
Draft Final OU2 RI/FS Work Plan (3)	Receipt of NPS Comments on Draft OU2 RI/FS Work Plan	45 days per SOW, extended to 119 days	February 1, 2014	May 30, 2014
NPS Review of Draft Final OU2 RI/FS Work Plan (2)	Receipt of Draft Final OU2 RI/FS Work Plan	--	May 31, 2014	March 11, 2015
Draft OU2 RI/FS Project Operating Plan (POP)	Draft Final OU2 RI/FS Work Plan Submittal	90 days	May 31, 2014	August 28, 2014
Draft Final OU2 RI/FS Work Plan Resubmittal	Receipt of NPS Comments on Draft Final OU2 RI/FS Work Plan	30 days, extended to 45 days	March 12, 2015	April 24, 2015
Draft OU2 RI/FS POP Resubmittal	Draft Final OU2 RI/FS Work Plan Resubmittal	30 days	April 25, 2015	May 26, 2015
NPS Review of Draft Final RI/FS Work Plan Resubmittal (2)	Receipt of Draft Final OU2 RI/FS Work Plan Resubmittal	132 days	April 25, 2015	September 3, 2015
NPS Review of Draft POP Resubmittal (2)	Receipt of Draft OU2 RI/FS POP Resubmittal	92 days	May 27, 2015	August 27, 2015
Final OU2 RI/FS Work Plan	Receipt of NPS Comments on Draft Final OU2 RI/FS Work Plan Resubmittal	15 days	September 4, 2015	September 19, 2015
NPS Approval of OU2 RI/FS Work Plan	Submittal of Final OU2 RI/FS Work Plan	15 days	September 20, 2015	October 2, 2015
Draft Final OU2 RI/FS POP	Receipt of NPS Comments on Draft OU2 RI/FS POP Resubmittal	45 days, reduced to 0 days as redundant step		
NPS Review of Draft Final OU2 RI/FS POP (2)	Receipt of Draft Final OU2 RI/FS POP	15 days, reduced to 0 days as redundant step		
Final OU2 RI/FS POP	Receipt of NPS Comments on Draft Final OU2 RI/FS POP	15 days, extended to 20 days	August 28, 2015	September 17, 2015
Final OU2 RI/FS QAPP	Receipt of NPS Comments on Draft Final OU2 RI/FS QAPP	20 days	September 11, 2015	October 1, 2015
NPS Approve of Final OU2 RI/FS POP (QAPP will be approved before field work starts)	Submittal of Final OU2 RI/FS POP	14 days	September 18, 2015	September 30, 2015
Required Tasks upon OU2 Work Plan Approval				
Initiate RI Field Work	NPS Approval of Final OU2 RI/FS POP	30 days	October 1, 2015	October 31, 2015

Element	Critical Preceding Element	Duration	Start Date	End Date
Perform Landside RI Field Work (4) (schedule to be confirmed or modified in Technical Memoranda at end of Profiling Mobilization and at end of Landside RI Field Work) and Hydrographic Survey	Initiate RI Field Work	847 days (2.3 years)	November 1, 2015	February 25, 2018
Perform In-River RI Field Work (4) sampling (schedule to be confirmed or modified in Technical Memorandum at end of In-River RI Field Work)	Perform Landside RI Field Work and Hydrographic Survey	295 days (0.8 year)	February 26, 2018	December 18, 2018
Draft OU2 RI Report	Completion of Field Work	180 days	December 19, 2018	June 17, 2019
NPS Review of Draft RI Report (2)	Receipt of Draft OU2 RI Report	45 days	June 18, 2019	August 2, 2019
Draft Final OU2 RI Report	Receipt of NPS Comments on Draft OU2 RI Report	45 days	August 3, 2019	September 17, 2019
Alternatives Screening and Treatability Study Recommendation	Receipt of NPS Comments on Draft OU2 RI Report	45 days	August 3, 2019	September 17, 2019
NPS Review of Draft Final RI Report and Alternates Screening and Treatment Technology Recommendation (2)	Receipt of Draft Final OU2 RI Report	45 days	September 18, 2019	November 2, 2019
Final OU2 RI Report	Receipt of NPS Comments on Draft Final OU2 RI Report	15 days	November 3, 2019	November 18, 2019
NPS Approval Final OU2 RI Report	Submittal of Final OU2 RI Report	15 days	November 19, 2019	December 4, 2019
NPS Approval of Alternatives Screening and Treatability Study Recommendation	NPS Review of Alternatives Screening and Treatability Study Recommendation	15 days	November 3, 2019	November 18, 2019
Draft Treatability Study Work Plan and POP (5)	NPS Approval of Alternatives Screening and Treatability Study Recommendation	60 days	November 19, 2019	January 18, 2020
NPS Review of Draft Treatability Study Work Plan and POP (2)	Receipt of Draft Treatability Study Work Plan and POP	60 days	January 19, 2020	March 19, 2020
Draft Final Treatability Study Work Plan and POP	Receipt of NPS Comments on Draft Treatability Study Work Plan	30 days	March 20, 2020	April 19, 2020
NPS Review of Draft Final Treatability Study Work Plan and POP (2)	Receipt of Draft Final Treatability Study Work Plan and POP	15 days	April 20, 2020	May 5, 2020
Final Treatability Study Work Plan and POP	Receipt of NPS Comments on Draft Final Treatability Study Work Plan and POP	15 days	May 6, 2020	May 21, 2020
NPS Approval of Final Treatability Study Work Plan and POP (schedule to be confirmed or modified before NPS Approval of Final Treatability Study Work Plan)	Submittal of Final Treatability Study Work Plan and POP	15 days	May 22, 2020	June 6, 2020
Initiate Treatability Study	NPS Approval of Final Treatability Study Work Plan and POP	15 days	June 7, 2020	June 22, 2020
Treatability Study (6)	Initiate Treatability Study	90 days	June 23, 2020	September 21, 2020
Draft OU2 FS Report (7)	Completion of Treatability Study	60 days	September 22, 2020	November 21, 2020

Element	Critical Preceding Element	Duration	Start Date	End Date
NPS Review of Draft FS Report (2)	Receipt of Draft OU2 FS Report	45 days	November 22, 2020	January 6, 2021
Draft Final OU2 FS Report	Receipt of NPS Comments on Draft OU2 FS Report	45 days	January 7, 2021	February 21, 2021
NPS Review of Draft Final FS Report (2)	Receipt of Draft Final OU2 FS Report	30 days	February 22, 2021	March 24, 2021
Final OU2 FS Report	Receipt of NPS Comments on Draft Final OU2 FS Report	30 days	March 25, 2021	April 24, 2021
NPS Approval of Final FS Report	Submittal of Final OU2 FS Report	15 days	April 25, 2021	May 10, 2021

Notes:

1 Actual Submittal date: October 3, 2012

2 NPS review periods estimated

3 NPS granted an extension to May 30, 2014 in an e-mail from Emily Ferguson dated April 30, 2014.

4 Assumes (1) one phase of field work for each media/type of sampling (e.g., HPT borings), (2) reasonable content and timely review of technical memorandums, (3) temporal sampling does not delay the field program, and (4) no significant logistical and/or weather delays. Also assumes that the schedule will be adjusted and approved in accordance with changes in scope incorporated within the Technical Memorandum prepared at the end of the groundwater profiling and grab sampling mobilization, at the end of the Landside RI, at the end of the In-River RI, and as part of the Treatability Study Work Plan, if required..

5 Assumes NPS determines that a treatability study and POP are necessary.

6 Assumes 90 days to perform treatability study and that study report included in the FS Report.

7 If treatability study is not determined to be necessary, OU2 FS Report is due 60 days from approval of the Final RI Report.

Tasks in grey rows were completed as of Work Plan approval on October 2, 2015.

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