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FINAL GROUNDWATER FEASIBILITY STUDY AT SITE 17 NSWC INDIAN HEAD MD
10/1/2008
CH2MHILL

FINAL
Site 17 Groundwater Feasibility Study

**Naval Support Facility, Indian Head
Indian Head, Maryland**

Contract Task Order 053

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Prepared by



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Executive Summary

This report presents the Feasibility Study (FS) for the shallow groundwater at Site 17, Disposed Metal Parts Along Shoreline, at the Naval Support Facility, Indian Head (NSF-IH) in Indian Head, Maryland. This FS report is prepared by CH2M HILL under the Naval Facilities Engineering Command, Atlantic Division (LANTDIV), Comprehensive Long-Term Environmental Action Navy (CLEAN) III Contract 62470-02-D-3052, Contract Task Order 53, for submittal to the United States Navy (Navy), the United States Environmental Protection Agency (USEPA), and the Maryland Department of the Environment (MDE).

This study uses information gathered from various investigations conducted by CH2M HILL at Site 17 to document the analyses and evaluations used to develop remedial action objectives (RAOs) and alternatives for the site. The information presented herein will be used by the Navy and regulatory agencies to select an RA for the site that complies with the requirements of the National Contingency Plan (NCP; 40 Code of Federal Regulations [CFR] 300).

In 2000, a remedial investigation (RI) was conducted at Site 17 (CH2M HILL, 2004a). The RI concluded that there are potentially unacceptable human health and ecological risks associated with soil, sediment, and groundwater at Site 17. No risks were identified for the surface water.

Consequently, an Engineering Evaluation / Cost Analysis (EE/CA) was completed in November 2004 (CH2M HILL, 2004b), which resulted in a non-time-critical removal action (NTCRA) of soil and rusted drums that was completed in December 2005 (FSSI and Shaw E&I, 2006). The purpose of the removal action was to reduce risks to ecological receptors associated with site soil to acceptable levels through excavation and removal of affected soil, and to remove rusted drums from the site.

The EE/CA did not address potential ecological risks from metals contamination in the near-shore sediment resulting from historical disposal of metal parts along the Mattawoman Creek shoreline or human health risks associated with groundwater. Risks in sediment were evaluated in a baseline ecological risk assessment (BERA) (CH2M HILL, 2005a). The results from the BERA indicated that there are no unacceptable risks to ecological receptors in sediment adjacent to Site 17. Therefore, this FS addresses only risks in groundwater.

The contaminants of concern (COCs) addressed in the FS are trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), vinyl chloride (VC), toluene, trinitrotoluene (TNT), Royal Demolition Explosive (RDX), aluminum, arsenic, chromium, iron, manganese, and vanadium. The site-specific RAOs for the shallow groundwater at Site 17 are:

1. Prevent unacceptable risks to human receptors from exposure to contaminants in the shallow groundwater.
2. Prevent migration or discharge of groundwater with COCs above Preliminary Remediation Goals (PRGs) to Mattawoman Creek.
3. Return the shallow groundwater to its beneficial use to the extent practicable.

Potential RAs that would be suitable to address the RAOs were selected and evaluated based on the criteria set forth in the NCP to assemble and evaluate technical and policy considerations and to develop the rationale for selecting a remedy for Site 17. The RAs considered for Site 17 are:

- Alternative 1: No Action**
- Alternative 2: Monitored Natural Attenuation (MNA) and Institutional Controls (ICs):** Alternative 2 involves a continuous implementation of ICs in the form of land- and groundwater-use restrictions, in conjunction with long-term monitoring program for groundwater and surface water to monitor changes in water quality, NA of COCs, and the potential for off-site migration of COCs.
- Alternative 3: Source Zone Treatment using ISCO, MNA, and ICs:** Alternative 3 uses ISCO technology for treatment of TCE in the source zone, in conjunction with MNA components and ICs described in Alternative 2.
- Alternative 4: Source Zone Treatment using ISCR, MNA, and ICs:** Alternative 4 uses ISCR technology for treatment of TCE in the source zone, in conjunction with MNA components and ICs described in Alternative 2.
- Alternative 5: Source Zone Removal and Offsite Disposal, MNA, and ICs:** Alternative 4 removes contaminant mass in the source zone through excavation and off-site disposal, in conjunction with MNA components described in Alternative 2 for the plume treatment, and ICs.

The alternatives were evaluated against the nine criteria set forth in the NCP. The criteria permit comparison of the relative performance of the alternatives and provide a means to identify their advantages and disadvantages.

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Acronyms and Abbreviations

95%UCL	95 percent upper confidence limit
AA	Area of Attainment
ARAR	applicable or relevant and appropriate requirement
ASG	Applied Sciences Group
BERA	baseline ecological risk assessment
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
cis-1,2-DCE	cis-1,2-dichloroethylene, cis-1,2-dichloroethene
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	contaminant of concern
cVOC	chlorinated volatile organic compounds
CW	contingency well
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DPT	direct-push technology
EC	electrical conductivity
EE/CA	Engineering Evaluation / Cost Analysis
ERA	ecological risk assessment
FS	Feasibility Study
FFS	Focused Feasibility Study
GIS	Geographic Information System
GRA	general response actions
HHRA	human health risk assessment
HI	hazard index
IAS	Initial Assessment Study
IC	Institutional Control
ISCO	<i>in situ</i> chemical oxidation
ISCR	<i>in situ</i> chemical reduction
K	hydraulic conductivity
LANTDIV	Atlantic Division (of the Naval Facilities Engineering Command)
LUC	land use control
LUCIP	land use control implementation plan
MCL	maximum contaminant level

MDE	Maryland Department of the Environment
MEC	munitions and explosives of concern
MIP	membrane interface probe
MNA	monitored natural attenuation
msl	mean sea level
µg/L	micrograms per liter
NA	natural attenuation
NAPL	non-aqueous phase liquid
NAVFAC	Naval Facilities Engineering Command
NCP	National Contingency Plan (40 CFR 300)
NOD	natural oxidant demand
NSF-IH	Naval Support Facility, Indian Head
NTCRA	non-time-critical removal action
ORP	oxidation-reduction potential
OSWER	Office of Solid Waste and Emergency Response (U.S. Environmental Protection Agency)
PMW	performance monitoring well
PRB	permeable reactive barrier
PRG	preliminary remediation goal
RA	remedial alternative
RAO	remedial action objectives
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act of 1976
RDX	Royal Demolition Explosive
RFA	RCRA Facility Assessment
RI	remedial investigation
RI/FS	remedial investigation / feasibility study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SRG	site remediation goal
SERA	screening-level ecological risk assessment
SOD	soil oxidant demand
SVOC	semivolatile organic compound
TAL	target analyte list
TBC	to be considered
TCE	trichloroethylene, trichloroethene
TCL	target compound list
TeCA	tetrachloroethane
TOC	total organic carbon
TNT	trinitrotoluene
USEPA	U.S. States Environmental Protection Agency

VC	vinyl chloride
VOC	volatile organic compound
ZVI	zero valent iron

Introduction

This report presents the Feasibility Study (FS) for groundwater at Site 17, Disposed Metal Parts Along Shoreline, Naval Support Facility, Indian Head (NSF-IH) in Indian Head, Maryland. This FS report was prepared by CH2M HILL under the Naval Facilities Engineering Command, Atlantic Division (LANTDIV), Comprehensive Long-Term Environmental Action Navy (CLEAN) III Contract Number N62470-02-D-3052, Contract Task Order 0053, for submittal to the United States Navy (Navy), the U.S. Environmental Protection Agency (USEPA), and the Maryland Department of the Environment (MDE). The Indian Head Facility was placed on USEPA's National Priorities List (NPL) in September 1995.

The FS for Site 17 has been developed to the extent applicable in accordance with USEPA's guidance document, *Interim Final, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988), other Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) requirements, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and implemented by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; 40 CFR 300), and other relevant USEPA guidance.

NSF-IH is a Navy facility located in northwestern Charles County, Maryland, approximately 25 miles southwest of Washington, District of Columbia. Site 17 is located in the southeast portion of the facility (Figure 1-1) and is defined as a 1,000-foot stretch of Mattawoman Creek shoreline where metal parts were discarded. The majority of the metal parts, which were placed along the shoreline for erosion control, were removed in the early 1990s. The defined area of Site 17 was expanded in 1997 to include the forested area 100 feet from the shoreline where dozens of rusted drums were identified. The horizontal extent of the site is approximately 3.5 acres.

1.1 Objective and Approach

This report uses information gathered from various investigations, described in Section 2. These investigations were used as a basis for developing and evaluating cost-effective alternatives to remediate groundwater contamination. The remedial alternatives (RAs) developed in this FS address remedial action objectives (RAOs) and risks associated with the groundwater at Site 17. This FS includes a site-specific explanation of how each alternative satisfies the NCP's seven site-specific remedy selection criteria.

This FS documents the analyses and evaluations used to develop remedial action alternatives for Site 17. The information presented herein will be used by the Navy and regulatory agencies to select an RA for Site 17 that complies with the requirements of the NCP. The FS report is not intended to serve as a design document; rather, it gives a conceptual overview of RAs and an assessment of their feasibility. The FS report discusses criteria used to evaluate RAs and to determine the benefits of implementing them.

This report documents the evaluation of RAs to address groundwater contamination associated with Site 17. Contamination in soil was addressed by a non-time-critical removal action (NTCRA). An Engineering Evaluation/Cost Analysis (EE/CA) (CH2M HILL, 2004b) was prepared to address soil (0 to 12 inches below ground surface [bgs]) and rusted drums at the site. A non-time-critical removal action was completed in December 2005 (FSSI and Shaw E&I, 2006). The purpose of the removal action was to reduce risks to ecological receptors associated with site soil to acceptable levels through excavation and removal of affected soil, and to remove rusted drums from the site. The removal action included the excavation and offsite disposal of materials, consisting of ordnance items and soil contaminated with metals. Following the removal action, confirmatory sampling was conducted to confirm the removal of the contaminated soil to levels protective of the environment. The excavated area was restored with clean fill material that met the preliminary remediation goals (PRG) for lead, mercury, and zinc. The results of the confirmatory sampling are presented in a technical memorandum entitled *Site Visit, Confirmatory Sampling, and Analytical Results for the Southwest Area at Site 17, NSF-IH, Indian Head, MD* (CH2M HILL, 2006). In conclusion, the removal action addressed the potential ecological risk drivers (lead, mercury, and zinc) identified for soil at Site 17.

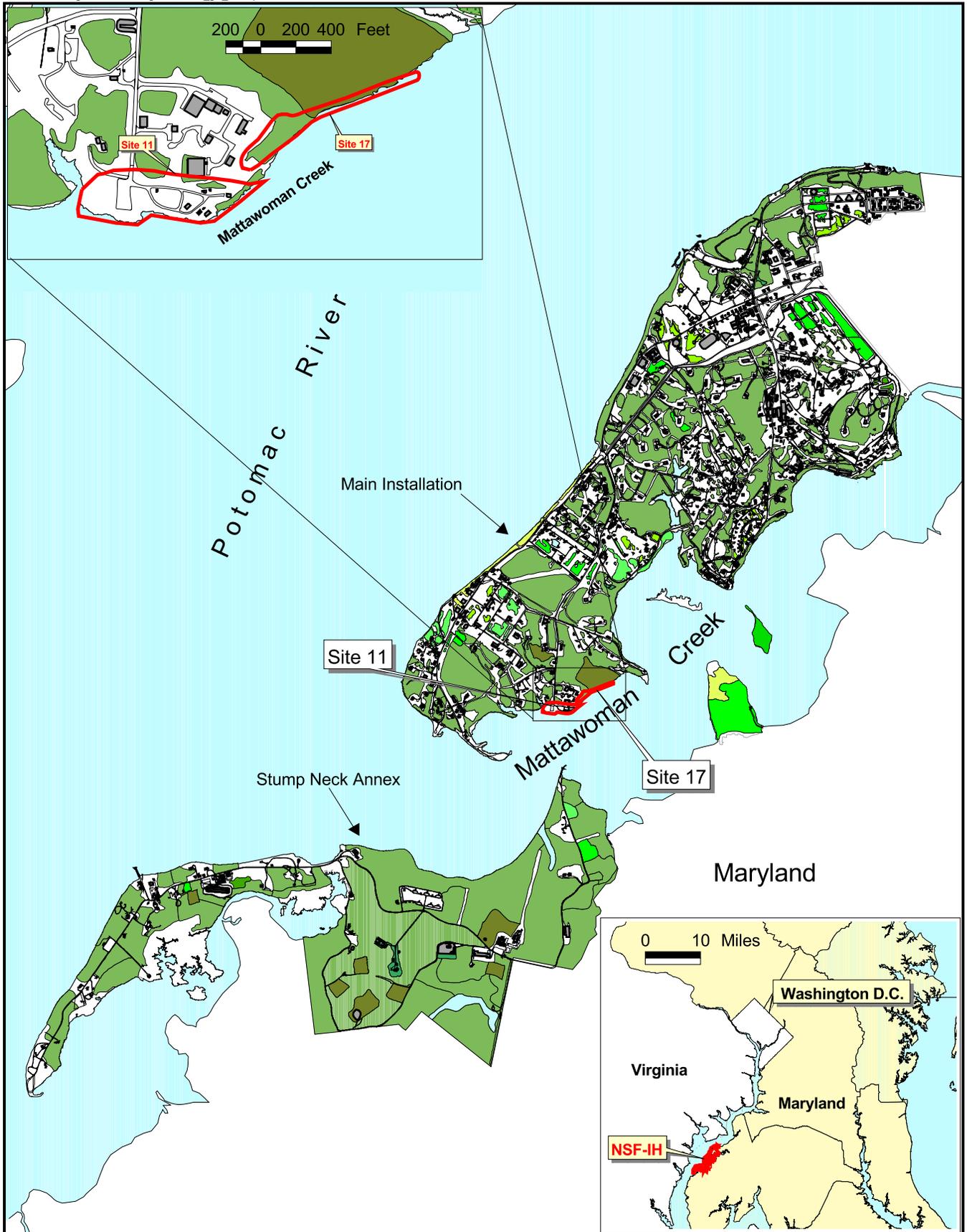
A baseline ecological risk assessment (BERA) was performed to address potential ecological risks from metals contamination in the near-shore sediment along the Mattawoman Creek shoreline (CH2M HILL, 2005a). The results from the BERA indicated that there are no unacceptable risks to ecological receptors in sediment adjacent to Site 17.

1.2 Report Organization

This FS report is organized into six sections:

1. Introduction
2. Background Information
3. Remedial Action Objectives, Applicable or Relevant and Appropriate Requirements, and Site Remediation Goals
4. Technology Screening and Development of Remedial Alternatives
5. Description and Detailed Analysis of Remedial Alternatives
6. References

Figures and tables are provided at the end of each section. Appendices follow Section 6.



LEGEND

-  Approximate IR Site Boundary
-  Buildings
-  Road
-  Wooded Area

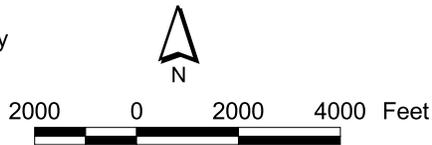


Figure 1-1
Facility Location
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Background Information

This section presents information on site history and characteristics, previous investigations, previous removal actions, human health and ecological risks, and nature and extent of impact at Site 17. Detailed information is provided in the following documents:

- *Pre-Feasibility Study Field Activities and Results, Site 17, Indian Head Division – Naval Surface Warfare Center* (herein referred to as Pre-FS Study) (CH2M HILL, 2002)
- *Final Remedial Investigation Report for Sites 11, 13, 17, 21, and 25, Indian Head Division - NSWC* (herein referred to as RI Report) (CH2M HILL, 2004a)
- *Final Baseline Ecological Risk Assessment Sites 11 and 17, Naval District Washington, Indian Head* (herein referred to as BERA Report) (CH2M HILL, 2005a)
- *Final Technical Memorandum, Results of Site 17 Bench-Scale Studies* (herein referred to as the Bench-Scale Studies Report) (CH2M HILL, 2008a)

2.1 Site History and Characteristics

2.1.1 Site History

Site 17 is a 1,000-ft stretch of shoreline along the Mattawoman Creek where metal parts were discarded from the 1960s until the early 1980s. The discarded materials included rocket motor casings, shipping containers, empty drums, and various metal parts. An Initial Assessment Study (IAS) conducted in 1983 by Fred C. Hart Associates, Inc. (Hart, 1983), identified the presence of rusted metal parts in the vicinity of the reported disposal area. The study also noted that the submerged materials were covered over with bottom sediments.

In 1997, the area of the site was expanded to include the forested area 100 feet from the shoreline, where dozens of rusted drums were identified. During a site reconnaissance conducted in January 2000, disintegrated drums containing a yellow, waxlike material were observed at the site. In addition, some drums were partially exposed in the soil. Base personnel could not verify the origin of the drums. NSF-IH personnel analyzed the contents and determined that the substance was wax, which indicated that the substance was safe to handle (e.g., was not explosive).

2.1.2 Site Characteristics

Geology

Information on the site geology is obtained from the RI Report, the Pre-FS, and the Bench-Scale Studies Report. The locations of the geologic cross sections and the cross sections are presented in Figures 2-1, 2-2, and 2-3, respectively.

During the RI, three boreholes were advanced by hollow-stem auger and then converted to monitoring wells (IS17MW01, IS17MW02, and IS17MW03). Soil borings for wells IS17MW01 and IS17MW02 were advanced to 10 feet bgs and soil boring for well IS17MW03 was advanced to 16 feet bgs. Based on the soil boring logs (Appendix A), soil underlying the site consists of fill material in the upper 10 to 12 feet of the subsurface. The fill is characterized by greenish clay with silt containing wood fragments. The fill is underlain by fine to medium sand with some clay.

During the Pre-FS, membrane interface probe (MIP) and electrical conductivity (EC) profiles of the subsurface were performed at locations MP 1 through MP 11 to further characterize the extent of contaminants in groundwater and to collect subsurface lithologic information, respectively. As presented in the technical memorandum in Appendix B, the EC logs suggest that in the area of drum disposal, the subsurface is characterized by sands and silts (as represented by lower EC values) to a depth of approximately 10 feet bgs. Underlying the sands and silts is a layer dominated by clay (as represented by higher EC values). The layer appears continuous across the site; however, at some locations there appears to be a sharp contact between sand and clay (e.g., MIP 1 and MIP 10), and at other locations there appears to be a more gradational contact (e.g., MIP 2 and MIP 4). The memo also documented that the clay was not observed at two locations, MIP 6 and MIP 8. At MIP 6, the boring was advanced to refusal, which occurred at 15 feet bgs. It was speculated that the clay layer was present beneath this depth but could not be penetrated. MIP 8 was advanced in an area upslope of the drum disposal area and was terminated at a depth of 15 feet bgs, likely too shallow to encounter the clay.

During the bench-scale studies in 2006, visual observations of the soil were made during advancement of the direct-push technology (DPT) Macro-Core™ sampling at locations IS17DP64A and IS17DP65. These soil borings were advanced to a total depth of 20 feet bgs. As part of the study, grain size analysis was also conducted on a composite sample, which was taken from the two boring locations within the depth interval of 8 to 20 feet bgs. The results of the grain size analysis indicated that the soil is classified as silty clay (CH2M HILL, 2008a).

Hydrogeology

Information on site hydrogeology is obtained from the RI Report, Pre-FS, and the 2004/2005 Additional Investigation. Table 2-1- presents the groundwater elevation for each monitoring well measured during the three investigations. Table 2-2 presents the calculated hydraulic conductivities calculated based on *in situ* hydraulic conductivity (K) (“slug”) tests conducted during the Pre-FS and the Additional Investigation. In general, the groundwater table ranges from 0.8 feet above mean sea level (msl) to 3.1 feet above msl along the shoreline (IS17MW02) to 4.5 feet above msl to 8.6 feet above msl upgradient of Site 17 (IS17MW03). Hydraulic gradient at the Site was interpreted as 0.04 ft/ft, and groundwater flow is from northwest to southeast and discharges to Mattawoman Creek.

As part of the Pre-FS investigation, a tidal study was conducted and two Shelby-tube samples were collected from two depth intervals (MIP locations 1 [depth 9–11 feet bgs] and 7 [depth 13–15 feet bgs] that EC logs suggested to be a confining layer that underlies the site. The results are presented in the Pre-FS tech memo (Appendix B). The K of the Shelby-tube

samples was approximately 6.5×10^{-4} feet per day, which is in the range reported by Domenico and Schwartz (1990) for clay.

2.2 Previous Investigations

2.2.1 Initial Assessment Study

The objective of the IAS (Fred C. Hart Associates, 1983) was to identify and assess sites posing a threat to human health or to the environment owing to contamination from past hazardous materials operations at NSF-IH. The IAS identified the area now known as Site 17 as the location of discarded metal parts. The study did not recommend a Confirmation Study for this site because of the inert nature of the materials.

2.2.2 Phase II Resource Conservation and Recovery Act Facility Assessment

A Phase II Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) (A.T. Kearney, Inc., 1988) was conducted in 1988 by USEPA and consisted of a preliminary review of available documents and a visual site inspection that included Site 17. During the visual site inspection, rusted large metal parts were noted in the reported disposal area, many of which were covered with sediment. The RFA conveyed that Naval Ordnance Station representatives stated the metal parts would be removed in late 1988 or early 1989 under the direction of the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

2.2.3 Remedial Investigation

Because no sampling had been conducted at this site up to the Phase II RFA point, groundwater, surface soil, subsurface soil, surface water, and sediment sampling was conducted in 2000 as part of the RI conducted at Site 17 and four other sites (CH2M HILL, 2004a). Three groundwater monitoring wells (IS17MW01 through IS17MW03) were installed in the shallow aquifer to assess groundwater contamination. Wells IS17MW01 (total depth 12.5 feet bgs and IS17MW02 (12 feet bgs) were installed along the shore of Mattawoman Creek at the southwestern and northeastern ends of the site, respectively (Figure 2-1). Well IS17MW03 (19 feet bgs) was installed hydraulically upgradient of the site waste material.

Fifteen surface soil and fifteen subsurface soil samples including background samples (i.e., samples in areas considered to be uncontaminated) were collected and analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), target analyte list (TAL) inorganics, and explosives. Several samples were also sampled for total organic carbon (TOC) and pH. Groundwater samples were collected from the three monitoring wells and analyzed for VOCs, SVOCs, total and filtered TAL inorganics, and explosives. Six sediment samples were analyzed for TAL inorganics, explosives, TOC, and pH. Six surface water samples were analyzed for total and filtered TAL inorganics, explosives, and hardness. Figure 2-1 illustrates the locations of all sampling points. Figure 2-4 shows the analytical results for trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), and vinyl chloride (VC) in the monitoring wells. Figure 2-5 shows the analytical results for select metals in the monitoring wells. A summary of the analytical results is presented in the RI Report.

Human health and ecological risk assessments (HHRAs and ERAs) were performed as part of the RI. Human health risks were evaluated only for those media with complete exposure pathways. These media include soil, groundwater, and surface water. Exposure to the Mattawoman Creek sediment was not considered a complete pathway for human exposure because the sediment is completely covered by water and there is no shoreline with exposed sediment. The risk assessment indicated that human health hazards and risks above USEPA target levels are associated with potential future exposure to iron in combined surface and subsurface soil and VOCs and inorganics in groundwater. The concentration of iron detected in the soil was greater than the concentrations detected in the site-specific background soil samples. However, iron is considered an essential human nutrient, and the concentration of iron detected in the soil would result in a daily intake of iron of 5.4 mg/day, which is below the recommended daily intake established by the National Academy of Sciences of 10 mg/day. Therefore, exposure to combined surface and subsurface soil likely would not result in an unacceptable hazard. Future construction at the site may result in a hazard slightly above USEPA target levels associated with exposure to groundwater (mainly because of VC detected in the groundwater) by a construction worker. The RI determined that potentially unacceptable human health risks in groundwater will be addressed in an FS. No contaminants of potential concern were retained for the surface water. Therefore, surface water was eliminated as a medium of potential concern.

Ecological risks were identified in sediment and soil. Risk in sediment was further evaluated in a BERA. Lead, mercury, and zinc risks in surface soil were addressed in an EE/CA.

2.2.4 Pre-Feasibility Study (2002)

Following the RI, a Pre-Feasibility Study was conducted in 2002 to define the distribution of VOCs (specifically, TCE, cis-1,2-DCE, and VC) in groundwater, to determine if VOCs in groundwater are adversely affecting Mattawoman Creek, and to assess the viability of monitored natural attenuation (MNA) as an RA for groundwater. A tidal study was also conducted to determine the influence of the tides on groundwater levels. Additionally, two Shelby-tube samples were collected from 9-11 feet bgs at MIP 1 and from 13-15 feet bgs at MIP 7 to estimate the K of the samples interpreted as a confining layer based on the EC logs.

Figure 2-4 shows the sample locations and analytical results of TCE, cis-1,2-DCE, and VC. The results of the investigation are presented in more detail in a technical memorandum provided in Appendix B. However, key findings are summarized below:

- The potential presence of a presumably small and isolated area of dense non-aqueous phase liquid (DNAPL) was indicated by a TCE concentration of 310,000 micrograms per liter ($\mu\text{g}/\text{L}$) from the DPT groundwater sample collected at IS17GW02 (Figure 2-6). The value represents 28.2% of the pure-phase solubility of TCE ($1.1 \times 10^6 \mu\text{g}/\text{L}$)¹. This relatively high percentage (greater than 1 percent) suggests the presence of DNAPL in close proximity to the groundwater sample (USEPA, 1994).
- There were no detections of TCE, cis-1,2-dichloroethylene (cis-1,2-DCE), and VC in surface water samples taken from Mattawoman Creek. Therefore, VOCs in groundwater are not adversely affecting Mattawoman Creek.

¹ Source for aqueous solubility: USEPA. 2004. *In Situ Thermal Treatment of Chlorinated Solvents – Fundamentals and Field Applications*. EPA 542-R-04-010.

- The tidal study indicated a mean head differential of approximately 1 foot between the site groundwater and the creek, which suggested the possibility of a hydraulic gradient reversal, if groundwater extraction is considered as a remedy.
- The K of the Shelby-tube soil samples was approximately 6.5×10^{-4} feet per day.
- Presence of key natural attenuation (NA) indicators and favorable geochemical conditions for natural biodegradation.

2.2.5 Baseline Ecological Risk Assessment (2004)

The BERA field activities were performed in August 2004, and the results are documented in the BERA Report. The BERA results concluded no unacceptable risk associated with the sediment at Site 17.

2.2.6 Additional Investigation (2004-2005)

The Pre-Draft Focused Feasibility Study (FFS) Report for Site 17 groundwater (CH2M HILL, 2004c) recommended an additional investigation to address data gaps before preparation of this Final FS Report. Field activities and results of the additional investigation have not been documented in a technical memorandum; thus, the information is documented herein.

The rationale for and objectives of the field investigation and sampling approach are presented in the *Final Work Plan for the Additional Investigation at Site 17, Technical Memorandum, NDWIH, Indian Head, Maryland* (CH2M HILL, 2005b). Field work started in December 2004; however, work halted because of the presence of munitions and explosives of concern (MEC). As a result, the sampling approach was modified as documented in the *Revised Final Work Plan for the Additional Investigation at Site 17, Technical Memorandum, NDWIH, Indian Head, Maryland*, (CH2M HILL, 2006). The objectives of this additional investigation are as follows:

- Define the boundary and estimate the mass of the chlorinated VOCs (cVOCs) in groundwater for *in situ* chemical oxidation (ISCO) treatment;
- Evaluate NA characteristics of groundwater; and
- Determine temporal trends in cVOC concentration in groundwater.

MIP Investigation

On December 6, 2004, MIP advancement was attempted at five locations. MIPA4, MIPB4, MIPC4, and MIPD3 were advanced to depths of 22 feet, 19 feet, 15 feet, and 14 feet bgs, respectively. At location MIPD4, the MIP system hit refusal. The location was relocated several times, but refusal was encountered. Because of the presence of MEC, the MIP investigation was halted. The MIP logs are presented in Appendix C.

Monitoring Wells

On February 2, 2005, a round of water levels was measured in monitoring wells IS17MW01, IS17MW02, and IS17MW03 (Table 2-1). On February 3, 2005, another round of water levels was taken (Table 2-1) before well purging and sampling. The water levels measured during this investigation and during the RI and the Pre-FS investigation are presented in Table 2-1.

Each well was purged with a peristaltic pump at a discharge rate of approximately 0.1 to 0.5 liters per minute. During well purging, field indicator parameters were measured using a Horiba U-22® fitted with a flow-through cell. The field parameters include pH, specific conductivity, turbidity, dissolved oxygen (DO), temperature, and oxidation-reduction potential (ORP). Purging was considered complete when all parameters had stabilized (variations within 10 percent, pH +/- 0.2 units) for three consecutive readings taken at 3- to 5-minute intervals. Table 2-3 presents the physico-chemical parameters (pH, specific conductivity, turbidity, DO, temperature, and ORP) measured in the field during purging of the wells.

Groundwater samples were collected from the wells for the parameters shown on Table 2-4. The samples were analyzed by Katahdin Analytical Services Laboratory of Westbrook, Maine. Data validation was performed by a third-party independent validator.

Tables D-1 and D-2 in Appendix D present the raw and exceedance data, respectively, from the RI Report, Pre-FS Study, and this investigation for the groundwater samples.

In Situ K ("Slug") Tests

Falling head and rising head *in situ* K tests were performed during at groundwater monitoring wells IS17MW01, IS17MW02, and IS17MW03 on February 23, 2005. The slug testing procedures, results, and analysis are presented in Appendix E and summarized in Table 2-2.

Direct-Push Technology

Groundwater. Forty-one groundwater grab samples were collected from 30 locations (IS17DP21 through IS17DP50) using a DPT rig (Figure 2-7) from February 22, 2005, through March 2, 2005. Table 2-5 presents information on the samples collected and the parameters for which they were analyzed. Twenty-eight shallow (2-foot depth interval below the water table) groundwater samples were collected from all locations except locations IS17DP30 and IS17DP43 because groundwater was not encountered at these locations. Thirteen deep (2-foot depth interval above the low-conductivity clay layer) groundwater samples were collected from locations IS17DP22 through 24, IS17DP26 through 28, IS17DP32 through 34, IS17DP36, and IS17DP40.

Ten shallow and deep groundwater samples were further analyzed for filtered organic carbon. These samples were collected from six locations: IS17DP32, IS17DP35, IS17DP37, IS17DP40, IS17DP42, and IS17DP48. The raw data for all analyses are presented in Table D-3 in Appendix D. Shaded cells indicate the constituents are detected. The detected constituents were compared to their respective adjusted tap water USEPA Region III risk-based concentration in Table D-4 in Appendix D (USEPA, 2004).

VOCs were detected in all groundwater samples collected. The most commonly detected VOCs (detected in greater than 50% of the samples) were cis-1,2-DCE, total 1,2-DCE, VC, and TCE. Both cis-1,2-DCE and total 1,2-DCE were detected in 37 of 41 samples in concentrations ranging from 1 µg/L to 220,000 µg/L and 1 µg/L to 170,000 µg/L, respectively. Of these, 33 samples exceeded the adjusted RBC for tap water of 5.5 µg/L. VC concentrations ranged from 1 µg/L to 80,000 µg/L in 33 of the 41, all of which exceed the RBC for tap water of 0.015 µg/L. Detections of TCE ranged from 2 µg/L to 490,000 µg/L in

26 of the samples, all of which exceed the tap water RBC of 0.026 µg/L. While exceedances of at least one RBC concentration were detected in all samples except the shallow sample from IS12DP24 and the one sample collected at IS17DP41, the highest constituent concentrations were detected in samples collected from IS17DP27, IS17DP34, and IS17DP42 in both shallow and deep samples.

Soil. From February 24, 2005, through March 2, 2005, 13 subsurface soil samples were collected from six locations: IS17DP32, IS17DP35, IS17DP37, IS17DP40, IS17DP42, and IS17DP48. Two samples were collected from each location: one from a dry interval above the water table, which was analyzed for TOC, and the other from the saturated interval below the water table, which was analyzed for target compound list (TCL) VOCs. An additional sample was collected from location IS17DP35 for soil oxidant demand (SOD) testing. The results for all tests are presented in Table D-5 in Appendix D.

VOCs were detected in all subsurface soil samples for which they were analyzed. Butanone was detected in all samples in concentrations ranging from 2 µg/kg to 10 µg/kg. Butanone was the only detection in samples IS17DP32 and IS17DP37. Total 1,2-DCE was detected in the remaining samples in concentrations ranging from 2 µg/kg to 200 µg/kg. Cis-1,2-DCE was detected in four samples (IS17DP35, IS17DP40, IS17DP42 and IS17DP48) in concentrations ranging from 2 µg/kg to 450 µg/kg. VC was detected in two samples, IS17DP35 and IS17DP40, at concentrations of 2 µg/kg and 250 µg/kg, respectively. The remaining detections were limited to a single sample and included toluene (2 µg/kg) in IS17DP35, trichlorofluoromethane (2 µg/kg) in IS17DP40, and carbon disulfide (3 µg/kg), TCE (14 µg/kg), and trans-1,2-DCE (2 µg/kg) in IS17DP42. The greatest number of detection and generally highest concentrations were found in the soil sample collected at location IS17DP42. The higher VOC concentrations in soil appear to be collocated with the higher VOC concentrations in groundwater and may possibly indicate the source area for the groundwater contamination.

As stated in the work plan, SOD testing was performed to determine the amount of a nonselective oxidant, permanganate, needed to oxidize natural organic matter and reduced mineral species in the soil and groundwater. The test was also performed to determine the stoichiometric demand exerted by contaminants. The results of the SOD testing are reported in milligrams of potassium permanganate consumed per kilograms of soil (mg KMnO₄ per kg soil).

The SOD testing was performed by CH2M HILL's Applied Sciences Group (ASG) in Corvallis, Oregon, on March 3, 2005. The saturated soil sample IS17DS35-0405 was collected from a depth interval of 4 to 5 feet bgs. This material was described as very moist, grayish, and plastic. A SiREM test kit was initially used to perform the SOD test. The SiREM's MOD-48™ Matrix Oxidant Demand test kit is a qualitative screening tool that measures the permanganate oxidant demand exerted by reduced organic and inorganic soil and/or groundwater constituents during a 48-hour period. The standard procedure is to inject 2 grams of saturated soil mixed with deionized water into the reaction tube containing potassium permanganate powder. Following the injection, a mixture of solution and gas will be produced through a series of exothermic reactions. After 48 hours, the supernatant is then extracted, filtered, and compared to the colorimetric chart indicating the SOD value.

The attempt to use the SiREM test kit failed because excessive gas production caused the seal of reaction tube to rupture, indicating an extremely high SOD value. As a result, ASG had to modify the sample preparation before testing. The saturated soil was dried at 105°C to volatilize the VOCs, including the COC mass. Two grams of the dry soil were then mixed with 10,000 milligrams-per-liter solution of sodium permanganate and allowed to sit. After 48 hours, the supernatant was filtered and its color was compared to the SiREM kit color chart to determine the SOD. The result indicated an SOD demand of 48,000 mg KMnO₄ per kilogram of dry soil (Appendix F). Because of the drying process, this result does not account for the oxidant demand for the VOCs. Furthermore, because of the relatively shallow depth interval where the sample was collected in the source area, the SOD value may not truly represent the oxidant demand in the DNAPL interval.

2.2.7 Upgradient Investigation (2005)

The results of the 2004-2005 Additional Investigation indicated that the extent of cVOCs to the west of the site was not delineated. Consequently, an upgradient MIP and DPT sampling field effort occurred from August 29, 2005, through September 1, 2005, to accomplish the objectives described in the *Final Work Plan for the Additional Investigation at Site 17, Technical Memorandum, NDWIH, Indian Head, Maryland* (CH2M HILL, 2005b). The objectives as outlined in the plan were:

- Determine if there is an upgradient source of cVOCs; and
- Delineate the cVOCs on the western portion of the site.

The work plan proposed collection of MIP data from 13 locations: IS17DP51 through IS17DP63. The upgradient area MIP logs are provided in Appendix G. In addition, groundwater samples were proposed for collection from two depth intervals at each location: approximately 0 to 2 feet below the water table (shallow) and 0 to 2 feet above the basal clay layer (deep). A groundwater sample, however, was not collected from location IS17DP57 because groundwater was not encountered in the area, even going down to a depth of 22 feet bgs. Furthermore, because of difficulty encountering groundwater, samples were collected from one depth interval at the 12 locations where water was encountered except at locations IS17DP54, IS17DP55, and IS17DP56. Table 2-6 presents information on the samples collected and the parameter (TCL VOCs) for which they were analyzed.

A total of 17 DPT groundwater samples were collected from 12 locations (Figure 2-7) and analyzed for TCL VOCs at an offsite laboratory. Of the 17 samples collected, 12 samples were collected from one depth interval at each location, 3 samples were collected from a second depth interval at three locations (IS17DP54, IS17DP55, and IS17DP56), and 2 samples were duplicate samples. The raw data for all analyses are presented in Table D-3 in Appendix D. Shaded cells indicate the constituents are detected. The detected constituents were compared to their respective adjusted tap water RBCs in Table D-4 in Appendix D. In general, the DPT groundwater results indicated that the cVOC plume was laterally delineated to the west of the site.

VOCs were detected in 11 of the 17 groundwater samples collected. The most commonly detected VOC was TCE, which was detected in 7 of the samples in concentrations ranging from 1 µg/L to 23 µg/L. The next most commonly occurring VOC detections were total 1,2-DCE, 2-butanone, and cis-1,2-DCE, with five detections each. Concentrations ranges for

these constituents were 1 µg/L to 220 µg/L, 3 µg/L to 6 µg/L, and 1 µg/L to 210 µg/L, respectively. The other constituents detected were 1,1,4-dichloroethane, 1,1-dichloroethene, chloroethane, chloroform, 2-hexanone, toluene, and VC. Exceedances of the adjusted RBC for tap water (one tenth of the RBC tap water value) occurred in eight of the samples collected and were limited to total 1,2-DCE, cis-1,2-DCE, chloroform, and VC, each with two exceedances; and TCE with seven exceedances.

2.2.8 Bench-Scale Studies (2006-2008)

The Draft FS report (CH2M HILL, 2006) identified uncertainties associated with the effectiveness of ISCO technologies for treating TCE detected at concentrations suggesting the local presence of pure-phase TCE. As a result, bench-scale studies were conducted to evaluate the effectiveness of several chemical oxidation technologies for treating TCE *in situ*.

The specific objectives of the bench-scale studies were to 1) evaluate the effectiveness of select ISCO in treating DNAPL TCE, 2) determine the site-specific demand of reagents, and 3) identify potential side effects of the select technologies that may not be compatible with the current site use. CH2M HILL and its subcontractor, Xpert Design & Diagnostics, LLC, of Stratham, New Hampshire, conducted the bench-scale studies in accordance with the final work plan (CH2M HILL, 2007a) and the subsequent modifications to the final work plan (CH2M HILL 2007b, 2007c, and 2007d).

The overall findings of the bench-scale studies are summarized below:

- The saturated soil at Site 17 consists mostly of silty clay; TCE is distributed primarily within the vertical interval of approximately 10 to 18 feet bgs.
- Using potassium permanganate as an oxidant is ineffective for treating TCE at Site 17 because the high SOD, limited solubility, and clay lithology would make contacting a sufficient mass of oxidant with the contaminant difficult.
- Using alkaline-activated persulfate as an oxidant was eliminated from consideration for treating TCE at Site 17 because of the high soil buffering capacity and comparable performance with the other persulfate activation methods.
- Both unactivated and iron-activated persulfate are comparably applicable for treating TCE at Site 17.
- Oxidant delivery via injection and soil mixing shall be considered for the field implementation of both unactivated and iron-activated persulfate technologies.
- A pilot study is recommended before implementing any of the technologies to obtain the design parameters of the full-scale technology implementation. As part of the pilot study using ISCO (if determined to be favorable in the FS), further monitoring of 1,1,2,2-tetrachloroethane (TeCA) and total and dissolved metals in groundwater would be required to assess the nature of the longevity of 1,1,2,2-TeCA and metal solubilization.

The results of the bench-scale studies have been used throughout this document to refine assumptions made in the Draft FS. Results of the bench-scale study can be found in the Bench-Scale Studies Report (CH2M HILL, 2008a).

2.3 Summary of Risk Assessments

2.3.1 Human Health Risk Assessment

A baseline HHRA was prepared as Section 6.6 in the RI Report. The baseline risk assessment included an evaluation of the potential human health risks associated with the exposure to site-related soil (surface, subsurface, and combined surface and subsurface), surface water, sediment, and groundwater at Site 17. Exposure pathways evaluated included:

Current Land Use

- Adult Trespasser/Visitor: incidental ingestion of and dermal contact with surface soil.
- Adolescent Trespasser/Visitor: incidental ingestion of and dermal contact with surface soil.

Future Land Use

- Industrial Worker: incidental ingestion of and dermal contact with soil (combined surface and subsurface soil).
- Adult Trespassers/Visitors: incidental ingestion of and dermal contact with soil (combined surface and subsurface soil).
- Adolescent Trespassers/Visitors: incidental ingestion of and dermal contact with soil (combined surface and subsurface soil).
- Adult Resident: incidental ingestion of and dermal contact with soil (combined surface and subsurface soil), ingestion of and dermal contact with shallow groundwater, and inhalation of volatiles from shallow groundwater.
- Child Resident: incidental ingestion of and dermal contact with soil (combined surface and subsurface soil), ingestion of and dermal contact with shallow groundwater, and inhalation of volatiles from shallow groundwater.
- Construction Worker: incidental ingestion of and dermal contact with soil (combined surface and subsurface soil), and dermal contact with and inhalation of volatiles from shallow groundwater.

The HHRA concluded that there were no carcinogenic and noncarcinogenic risks to current users from surface soil and to future industrial worker, adult trespasser/visitor, and adolescent trespasser/visitor from combined surface and subsurface soils. The HHRA further concluded that primary risks were associated with future exposure (primarily residential and construction worker) to groundwater and combined soil (surface and subsurface). Table 6-10 of the RI Report presents a summary of the calculated risk estimates for exposure to combined surface and subsurface soil and groundwater.

The HHRA identified the following human health risks:

Combined surface and subsurface soils:

- Noncarcinogenic hazard for a child resident (hazard index [HI] = 2.7) associated with incidental ingestion of iron. Based on the current condition, this hazard is likely overestimated because the drums and surface soil (1 foot layer) that served as a

continuing source of iron contamination were removed during the 2005 NTCRA (FSSI and Shaw E&I, 2006).

Groundwater:

- Noncarcinogenic hazard (HI = 64) due to use of the groundwater as a potable residential water supply for future adult resident; hazard is associated with exposure mostly to VC, and cis-1,2-DCE, with iron, manganese, and vanadium contributing.
- Noncarcinogenic hazard (HI = 131) due to use of the groundwater as a potable residential water supply for future child resident; hazard is associated with exposure to VC, cis-1,2-DCE, aluminum, chromium, iron, manganese, and vanadium.
- Carcinogenic risk (6.9×10^{-2}) to future lifetime resident associated with exposure to VC.
- Noncarcinogenic hazard (HI = 1.7) for future construction worker associated with exposure to VC in groundwater during excavation.

Though elevated levels of TCE were observed in DPT groundwater samples, an HHRA was previously not performed for TCE during the RI because it was not detected in the monitoring well groundwater samples. In April 2006, a technical memorandum (Appendix H) was prepared, which presented the procedures used to select COCs and, subsequently, calculate the PRGs for groundwater. Table 2-7 presents a list of the COCs determined from the HHRA.

2.3.2 Ecological Risk Assessment

A screening-level ERA (SERA) was conducted for Site 17 to estimate the risks the site would pose to ecological receptors if no action was taken. The SERA provided a conservative assessment of potential ecological risk. The general approach and site-specific approach for the ERA are provided in Section 3.4 and Section 6.7, respectively, in the RI Report.

Ecological risks were identified in soil and sediment. Lead, mercury, and zinc risks in surface soil were addressed through a removal action, which was completed in December 2005. Risk in sediment was further evaluated in the BERA discussed in Section 2.2.5 of this report. The BERA results concluded that there is no unacceptable risk associated with the sediment at Site 17. Therefore, the COCs to be addressed in this FS report will focus only on the HHRA COCs.

2.4 FS Contaminants of Concern

2.4.1 Determination of FS COCs

The final shallow groundwater COCs to be addressed in the FS, referred to as FS COCs, are determined based only on the human health risk-driving COCs (HHRA COCs; Figure 2-8). The HHRA COCs were compared to the 95 percent upper confidence limit (95% UCL) presented in the *Background Soil Investigation Report for Indian Head and Stump Neck Annex* (herein referred to as Background Report; Tetra Tech NUS, Inc., 2002)² and provided as

² Facility-wide background concentrations are found in the TTNUS (2002) report entitled "Background Investigation Soil Report for Indian Head and Stump Neck Annex." The facility-wide groundwater background dataset may not meet Navy guidance

Appendix E in the RI Report. If the concentration of an HHRA COC exceeds the background value, the constituent is retained as an FS COC. Table 2-7 shows a comparison of the maximum concentration of some of the HHRA COCs (RDX, aluminum, chromium, iron, manganese, and vanadium) to their respective facility-wide background concentrations. As shown on the table, the HHRA COCs exceed their respective facility-wide background concentrations; thus, they are carried forward as the FS COCs. Because the other HHRA COCs (cis-1,2-DCE, VC, TNT, and arsenic) do not have corresponding facility-wide background concentrations for comparison, these COCs are also carried forward as FS COCs. Furthermore, TCE is included in the list of FS COCs because it is observed at elevated concentrations in the post-RI DPT groundwater samples.

2.4.2 Extent of FS COCs

This section discusses the extent of the FS COCs: TCE, cis-1,2-DCE, VC, TNT, RDX, aluminum, arsenic, chromium, iron, manganese, and vanadium in the shallow groundwater at Site 17. Complete analytical results of the detected constituents in the shallow groundwater at Site 17 are presented in Appendix D of this report and the RI Report. Figure 2-1 shows the concentrations of TCE, cis-1,2-DCE, and VC in the three monitoring wells at the site. Figure 2-4 shows the concentrations of TCE, cis-1,2-DCE, and VC in groundwater samples collected with a MIP during the Pre-FS investigation in 2002. Figure 2-5 shows metals concentrations in the three monitoring well samples (RI Report). Figure 2-7 shows all the groundwater MIP and DPT locations.

VOCs

Data used to discuss TCE, cis-1,2-DCE, and VC distributions in groundwater summarized below were obtained from the RI Report, Pre-FS (2002), Additional Investigation (2004-2005), and Upgradient Investigation (2005). To better understand the distribution of these COCs in groundwater, the shallow groundwater has been divided into two units: the upper surficial aquifer (2-12 feet bgs) and lower surficial aquifer (6 to 18 feet bgs). In addition to evaluating the distribution of COCs in each unit, the entire shallow unit referred to as “combined upper/lower surficial aquifer” was evaluated. Figures 2-9 through 2-11 present isoconcentration plots for TCE, cis-1,2-DCE, and VC, respectively, in the upper surficial aquifer. Figures 2-12 through 2-14 present isoconcentration plots for TCE, cis-1,2-DCE, and VC, respectively, in the lower surficial aquifer. Figures 2-15 through 2-17 present isoconcentration plots for TCE, cis-1,2-DCE, and VC, respectively, in the combined upper and lower surficial aquifers. In Figures 2-15 through 2-17, the maximum result from the upper or lower surficial aquifer is used at each location to create the isoconcentration plot.

The site remediation goals (SRGs; discussed in Section 3.4) for TCE, cis-1,2-DCE, and VC are 5 µg/L, 150 µg/L, and 2 µg/L, respectively. Figures 2-9, 2-12, and 2-15 show the distribution of TCE and area exceeding the 5 µg/L in the upper (21,758 square feet [ft²]), lower (23,396 ft²), and combined upper/lower surficial aquifer (27,746 ft²), respectively. Figures 2-10, 2-13, and 2-16 show the distribution of cis-1,2-DCE and area exceeding the 150 µg/L in the upper

policy for background datasets (*Guidance for Environmental Background Analysis Volume III: Groundwater*, Naval Facilities Engineering Command (NAVFAC) User's Guide UG-2059-ENV, April 2004; located at: <http://enviro.nfesc.navy.mil/scripts/WebObjects.dll/erbweb>) due to an absence of seasonal data and comparison of element chemistry and geochemistry. However, regardless of any flaws it may have, the dataset is inherently more supportable than use of the single site-specific background reference.

(10,855 ft²), lower (10,613 ft²), and combined upper/lower surficial aquifer (15,305 ft²), respectively. Figures 2-11, 2-14, and 2-17 show the distribution of VC and area exceeding the 2 µg/L in the upper (23,292 ft²), lower (21,438 ft²), and combined upper/lower surficial aquifer (24,915 ft²), respectively. As shown in Figures 2-9 through 2-17, the extent of cVOCs exist as two plumes at the site: North Plume and South Plume, except in the lower surficial aquifer.

The combined isoconcentration contour plots for TCE (Figure 2-15), cis-1,2-DCE (Figure 2-16), and VC (Figure 2-17), show that the cVOC contamination in the South Plume area extends to locations IS17DP52 and IS17DP59 to the west, IS17DP54 to the north, IS17DP39 to the south, and IS17DP31, IS17DP38, and IS17DP45 to the east. The North Plume area surrounds locations IS17DP46 through IS17DP50, as defined by DPT sampling; however, while concentrations of TCE, cis-1,2-DCE, and VC in groundwater are elevated in this area, this plume appears to be isolated and the source of the VOCs is unknown.

Metals

The monitoring well groundwater samples collected during the RI in 2000 were analyzed for total and filtered (dissolved) TAL metals, whereas the samples collected during the Additional Investigation (2004-2005) were analyzed only for total iron and total manganese. Figure 2-5 presents the distribution of metal FS COCs in Site 17 groundwater, which are: aluminum, arsenic, chromium, iron, manganese, and vanadium. A comparison of the metal FS COC concentrations to the facility-wide background concentrations was also made to assess the contribution of past site activities. The facility-wide background concentrations used are the 95% UCL values for the non-turbid unfiltered groundwater samples (Table A-8 in Appendix A, TTNUS, 2002).

Aluminum. Total aluminum was detected in the three RI groundwater samples at concentrations that range from 420 µg/L (IS17MW02) to 31,500 µg/L (IS17MW03), while filtered aluminum was detected in monitoring wells IS17MW02 at 108 µg/L and IS17MW03 (upgradient well) at 90.4 µg/L. A comparison of the total aluminum concentration for each sample to the base-wide background 95% UCL for non-turbid unfiltered aluminum (9,620 µg/L) indicates that only the sample from well IS17MW03 exceeds this concentration.

Arsenic. Total arsenic was detected in the RI groundwater sample from IS17MW03 at a concentration of 4 µg/L. The value is estimated (“J”-qualified³) below the reporting limit, but above the laboratory’s method detection limit. Filtered arsenic was not detected in any of the three monitoring well samples. A comparison of the total arsenic concentration in IS17MW03 to the base-wide background 95% UCL for non-turbid unfiltered arsenic in the background study could not be made because it was not detected in the background study.

Chromium. Total chromium was detected in the three RI groundwater samples at concentrations that range from 5.8 J µg/L (IS17MW02) to 86.9 µg/L (IS17MW03), while filtered chromium was detected in monitoring wells IS17MW02 at 1.8 J µg/L and IS17MW01 at 12.3 µg/L. A comparison of the total chromium concentration for each sample to the base-

³ Most J-qualified data are detected at low concentrations. When the concentration of a chemical is near the instrument’s threshold of detection, the random contribution of instrument noise causes uncertainty. Other reasons data may be flagged with a “J” qualifier include quality control problems such as poor calibrations, blank spikes, surrogates, etc. (i.e., analytical variability).

wide background 95% UCL for non-turbid unfiltered chromium (16.4 µg/L) indicates that the samples from wells IS17MW01 and IS17MW03 exceed this concentration.

Iron. Total iron was detected in the three RI groundwater samples at concentrations of 27,100 µg/L (IS17MW01), 71,000 µg/L (IS17MW02), and 31,400 µg/L (IS17MW03). Total iron was detected at concentrations of 33,600 µg/L (IS17MW01), 46,000 µg/L (IS17MW02), and 2,470 µg/L (IS17MW03) in the Additional Investigation (2004-2005) groundwater samples. Filtered iron was detected in monitoring wells IS17MW01 at 25,000 µg/L and IS17MW02 at 77,200 µg/L. A comparison of the total iron concentration for each sample during each sampling event to the facility-wide background 95% UCL for non-turbid unfiltered iron (19,900 µg/L) indicates that all samples, with the exception of the Additional Investigation (2004-2005) from well IS17MW03, exceed the facility-wide background 95% UCL concentration.

Manganese. Total manganese was detected in the three RI groundwater samples at concentrations of 1,210 µg/L (IS17MW01), 2,620 µg/L (IS17MW02), and 540 µg/L (IS17MW03). Total manganese was detected at concentrations of 1,660 µg/L (IS17MW01), 1,930 µg/L (IS17MW02), and 410 µg/L (IS17MW03) in the Additional Investigation (2004-2005) groundwater samples. Filtered manganese was detected in monitoring wells IS17MW01 at 1,310 µg/L, IS17MW02 at 2,890 µg/L, and IS17MW03 at 339 µg/L. A comparison of the total manganese concentration for each sample during each sampling event to the 95% UCL for non-turbid unfiltered iron (824 µg/L) indicates that all samples, with the exception of the Additional Investigation (2004-2005) from well IS17MW03, exceed the facility-wide background 95% UCL concentration.

Vanadium. Total vanadium was detected in the three RI groundwater samples at concentrations of 9.4 J µg/L (IS17MW01), 1.4 J µg/L (IS17MW02), and 49 J µg/L (IS17MW03). Filtered vanadium was detected at concentrations of 1.3 J µg/L in IS17MW01 and 0.96 J µg/L in IS17MW02; it was a non-detect in IS17MW03. A comparison of the total vanadium concentration for each sample to the facility-wide background 95% UCL for non-turbid unfiltered vanadium (20.9 µg/L) indicates that only the upgradient well IS17MW03 exceeds this concentration.

Explosives

TNT was detected in two RI groundwater samples at concentrations of 5.8 J µg/L (IS17MW01) and 1 µg/L (IS17MW03). A comparison of TNT concentration to the facility-wide background 95% UCL concentration could not be made because it was not detected.

RDX was detected in one RI groundwater sample at a concentration of 3.3 J µg/L (IS17MW01). A comparison of the RDX concentration to the facility-wide background 95% UCL concentration (1.2 µg/L) indicates that it exceeds the facility-wide background 95% UCL. However, the 95% UCL concentration is based on a single detection of 1.2 J µg/L at well RN3MW001U001 (Table A-7 in Appendix A, TTNUS, 2002).

Table 2-1
Summary of Groundwater Elevation Data
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Monitoring Well			Remedial Investigation (2000)		Pre-FS (2002)		Additional Investigation (February/March 2005)	
	Elevation at Top of Casing (ft msl)	Groundwater Elevation (ft msl)	DTW (ft BTOC)	Groundwater Elevation (ft msl)	DTW (ft BTOC)	Groundwater Elevation (ft msl)	DTW (ft BTOC)	Groundwater Elevation (ft msl)
IS17MW01	6.67	3.98	5.32	1.35	5.37	1.3	4.49	2.18
IS17MW02	6.98	4.43	5.34	1.64	6.18	0.8	3.73	3.25
IS17MW03	15.41	13.01	8.69	6.72	10.94	4.47	6.07	9.34

Notes:

1. DTW = Depth to water
2. ft msl = feet above mean sea level
3. ft BTOC = feet from below top of casing
4. During the remedial investigation, water levels were measured in IS17MW03 on Oct 20, 2000 and in IS17MW01 and IS17MW02 on Oct. 24, 2000.
5. During the Pre-FS, water levels were measured in all wells on July 17, 2002.
6. During the Additional Investigation, water levels were measured in all wells on Feb. 2 and Feb. 3, 2005 (prior to well purging and sampling). Because the wells were sampled on Feb. 3, 2005, the water levels on this date are shown on this table.

Table 2-2
 Summary of Hydraulic Conductivity Values
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

	Location	Analyses	Calculated Hydraulic Conductivity (feet/day)	Range of Hydraulic Conductivity (feet/day)	Average Hydraulic Conductivity (feet/day)
Monitoring Wells	IS17MW01	Falling Head - Slug Test 1	4.4	4.4 - 14.4	8.3
		Falling Head - Slug Test 2	5.1		
		Rising Head - Slug Test 1 (early data slope)	14.4		
		Rising Head - Slug Test 1 (late data slope)	9.4		
	IS17MW02	Falling Head - Slug Test 1	4.5	4.5 - 9.2	6.1
		Falling Head - Slug Test 2	4.6		
		Rising Head - Slug Test 1	9.2		
	IS17MW03	Falling Head - Slug Test 1 (early data slope)	1.2	0.5 - 1.2	0.9
		Falling Head - Slug Test 1 (late data slope)	0.5		
		Falling Head - Slug Test 2 (early data slope)	1.2		
Falling Head - Slug Test 2 (late data slope)		0.7			
Basal Low Hydraulic Conductivity Layer	MIP1	Permeability tests on Shelby-tube samples	6.2×10^{-4}	$6.2 \times 10^{-4} - 6.8 \times 10^{-4}$	6.5×10^{-4}
	MIP7		6.8×10^{-4}		

Notes

1. bgs - below ground surface
2. Slug testing was done on the monitoring wells on February 23, 2005.
3. Permeability test was conducted on Shelby-tube samples collected from locations MIP1 at 9-11 feet bgs and MIP7 from 13-15 feet bgs. The samples were collected during the 2002 Pre-FS Investigation. The samples were collected from this depth interval based on MIP results, which indicated that the soil is clay.
4. The results are taken from Appendix E.

Table 2-3
 Physio-Chemical Properties
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Monitoring well	Date	pH	Temperature (°C)	Conductivity (mS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTUs)	Ferrous Iron (mg/L)
IS17MW01	7/17/2002	6.1	23.0	1.43	-143	0.40	35	3.6
	2/3/2005	5.82	14.8	0.442	37	4.99	1.9	NA
IS17MW02	7/17/2002	6.2	21.7	0.626	-103	0.42	12	3.2
	2/3/2005	5.87	17.5	0.446	-54	10.1*	1.7	NA
IS17MW03	7/17/2002	5.0	21.7	0.161	143	0.60	174	0.6
	2/3/2005	4.92	11.9	0.142	123	13.11*	3.3	NA

Notes

Measurements were taken using Horiba 22 Flow-Trough Instrument.

mS/cm = milliSiemens per centimeter

NTUs = Nephelometric turbidity units

mg/L = milligram per liter

°C = degrees celsius

mV = millivolts

Table 2-4
Monitoring Well Groundwater Samples and Analyses - Additional Investigation (February/March 2005)
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	Sample Identification	TCL VOCs	Filtered Organic Carbon	Iron and Manganese	Chloride	Nitrate	Nitrite	Sulfate	Methane, Ethane, & Ethene
		CLP OLM04	9060	6010B	325.2	353.2	353.2	375.4	RSK-175
IS17MW01	IS17MW010205	x	x	x	x	x	x	x	x
	IS17MW01P0205	x		x					
IS17MW02	IS17MW020205	x	x	x	x	x	x	x	x
IS17MW03	IS17MW030205	x	x	x	x	x	x	x	x

Notes

TCL - Target Contaminant List

VOCs - volatile organic compounds

Sample IS17MW01P0205 is a duplicate sample collected from well IS17MW01.

Table 2-5
DPT Groundwater and Soil Samples and Analyses - Additional Investigation (February/March 2005)
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Location	Sample Identification	Sample Media	Groundwater		Soil		
			TCL VOCs	Filtered Organic Carbon	Saturated Soil TCL VOCs	Dry Soil Total Organic Carbon	Saturated Soil Total Oxidant Demand
			CLP OLM04	9060	CLP OLM04	Lloyd Kahn	SiREM
IS17DP21	IS17GW21-0507	Shallow GW	X				
IS17DP22	IS17GW22-0607	Shallow GW	X				
	IS17GW22-0911	Deep GW	X				
IS17DP23	IS17GW23-0608	Shallow GW	X				
	IS17GW23-0911	Deep GW	X				
IS17DP24	IS17GW24-0812	Shallow GW	X				
	IS17GW24-1418	Deep GW	X				
IS17DP25	IS17GW25-0406	Shallow GW	X				
IS17DP26	IS17GW26-0507	Shallow GW	X				
	IS17GW26-0911	Deep GW	X				
IS17DP27	IS17GW27-0406	Shallow GW	X				
	IS17GW27-0810	Deep GW	X				
IS17DP28	IS17GW28-0610	Shallow GW	X				
	IS17GW28-1418	Deep GW	X				
IS17DP29	IS17GW29-0406	Shallow GW	X				
IS17DP30	No groundwater flow	—					
IS17DP31	IS17GW31-0204	Shallow GW	X				
IS17DP32	IS17GW32-0406	Shallow GW	X	x			
	IS17GW32-1112	Deep GW	X	x			
	IS17DS32-0203	Soil				X	
	IS17DS32-1112	Soil			X		
IS17DP33	IS17GW33-0406	Shallow GW	X				
	IS17GW33-0810	Deep GW	X				
IS17DP34	IS17GW34-0406	Shallow GW	X				
	IS17GW34-0810	Deep GW	X				
IS17DP35	IS17GW35-0405	Shallow GW	X	x			
	IS17DS35-0304	Soil				X	
	IS17DS35-0405	Soil					X
	IS17DS35-0607	Soil			X		
IS17DP36	IS17GW36-0507	Shallow GW	X				

Table 2-5
DPT Groundwater and Soil Samples and Analyses - Additional Investigation (February/March 2005)
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Location	Sample Identification	Sample Media	Groundwater		Soil		
			TCL VOCs	Filtered Organic Carbon	Saturated Soil TCL VOCs	Dry Soil Total Organic Carbon	Saturated Soil Total Oxidant Demand
			CLP OLM04	9060	CLP OLM04	Lloyd Kahn	SiREM
IS17DP37	IS17GW37-0406	Shallow GW	X	x			
	IS17GW37-1012	Deep GW	X	x			
	IS17DS37-0203	Soil				X	
	IS17DS37-1112	Soil			X		
IS17DP38	IS17GW38-0407	Shallow GW	X				
IS17DP39	IS17GW39-0608	Shallow GW	X				
IS17DP40	IS17GW40-0304	Shallow GW	X	x			
	IS17GW40-0607	Deep GW	X	x			
	IS17DS40-0203	Soil				X	
	IS17DS40-0607	Soil			X		
IS17DP41	IS17GW41-0406	Shallow GW	X				
IS17DP42	IS17GW42-0203	Shallow GW	X	x			
	IS17GW42-0607	Deep GW	X	x			
	IS17DS42-0001	Soil				X	
	IS17DS42-0607	Soil			X		
IS17DP43	No groundwater	-					
IS17DP44	IS17GW44-0004	Shallow GW	X				
IS17DP45	IS17GW45-0507	Shallow GW	X				
	IS17GW45-1214	Deep GW	X				
IS17DP46	IS17GW46-0406	Shallow GW	X				
IS17DP47	IS17GW47-0406	Shallow GW	X				
IS17DP48	IS17GW48-0406	Shallow GW	X	x			
	IS17DS48-0203	Soil				X	
	IS17DS48-0405	Soil			X		
IS17DP49	IS17GW49-0305	Shallow GW	X				
IS17DP50	IS17GW50-0406	Shallow GW	X				

Notes

Attempted to collect groundwater samples from two depths: One just below the water table and one just above the basal low hydraulic conductivity layer.

TCL - Target Compound List

VOCs - volatile organic compounds

Table 2-6
DPT Groundwater Samples and Analysis - Upgradient Investigation (August/September 2005)
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Location	Sample Identification	TCL VOCs
		CLP OLM04
IS17DP51	IS17GW51-1115	x
IS17DP52	IS17GW52-2426	x
IS17DP53	IS17GW53-2123	x
IS17DP54	IS17GW54-1214	x
	IS17GW54-2325	x
IS17DP55	IS17GW55-1214	x
	IS17GW55P-1214	x
	IS17GW55-2224	x
IS17DP56	IS17GW56-0608	x
	IS17GW56-1315	x
IS17DP57	No groundwater	
IS17DP58	IS17GW58-2224	x
IS17DP59	IS17GW59-3032	x
IS17DP60	IS17GW60-1820	x
	IS17GW60P-1820	x
IS17DP61	IS17GW61-1921	x
IS17DP62	IS17GW62-2527	x
IS17DP63	IS17GW63-2426	x

Notes

1. Attempted to collect groundwater samples from two depths: below the water table and above the basal low hydraulic conductivity layer.
2. The last four digits in the sample identification indicates the depth interval in feet below ground surface that the sample was collected.
3. "P" in the sample identification indicates it is a duplicate sample.

TCL - Target Compound List

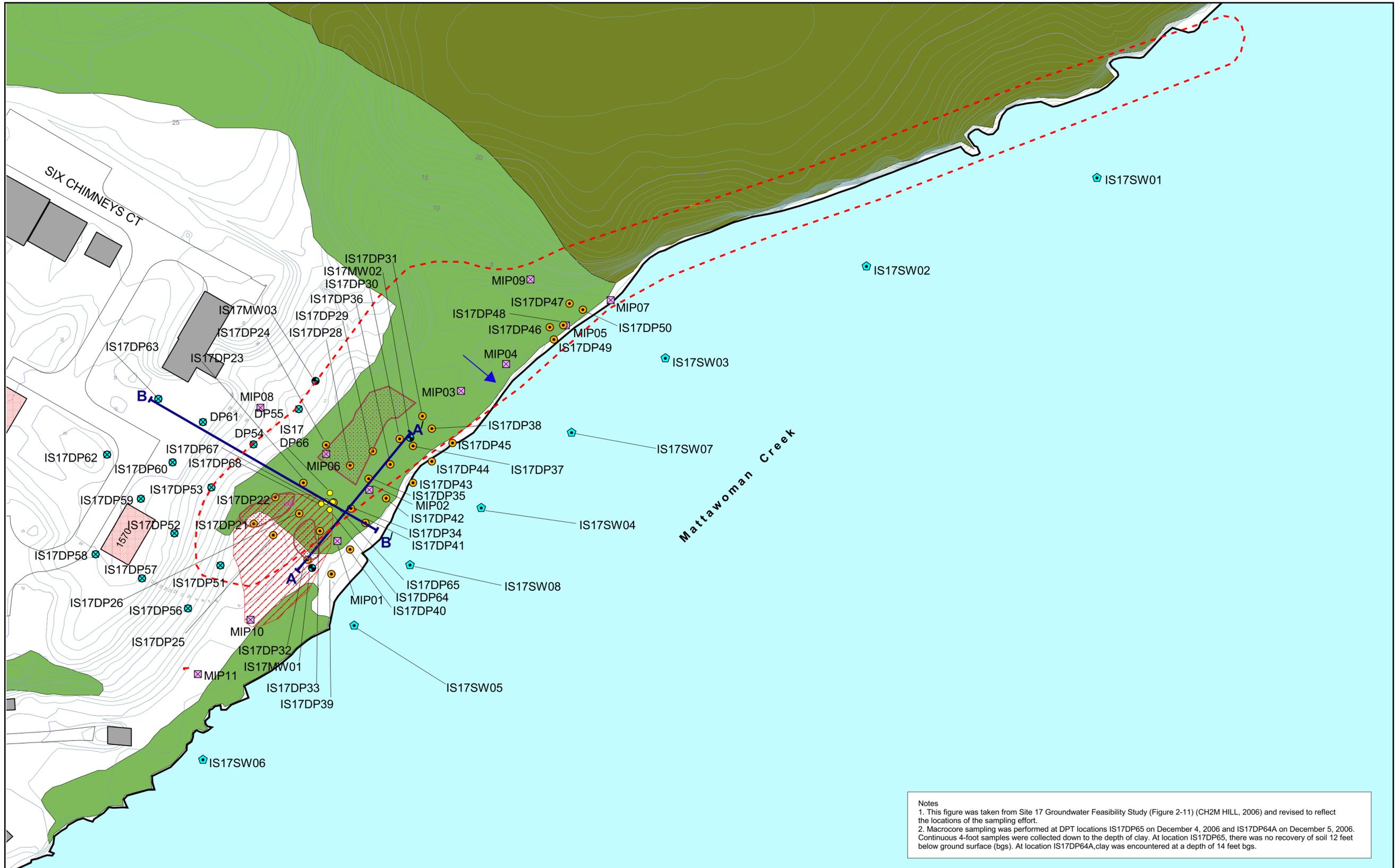
VOCs - volatile organic compounds

Table 2-7
 Comparison of HHRA COCs to Facility-Wide Background Concentrations
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

HHRA COCs	Maximum Concentration in Monitoring Wells (µg/L)	Facility-Wide Background Concentration (µg/L)
VOCs		
cis-1,2-Dichloroethylene (cis-1,2-DCE)	4,200	No value
Vinyl chloride (CE)	3,000	No value
Explosives		
2,4,6-Trinitrotoluene (TNT)	5.8	No value
Hexahydro-1,3,5-trinitro-1,3,5-triazine (Royal Demolition Explosive - RDX)	3.3	1.2
Inorganics		
Aluminum	31,500	9,620
Arsenic	4	Non detect
Chromium	86.9	16.4
Iron	71,000	19,900
Manganese	2,620	824
Vanadium	49	20.9

Notes

1. µg/L - micrograms per liter
2. All HHRA COCs were carried through after comparison to facility-wide background concentration.
3. Facility-wide Background Concentration is the 95 percent upper confidence limit value taken from Table A-8 (Non-Turbid Unfiltered Groundwater Samples) in Appendix A of TTNUS' (2002) Background Investigation Report.



Notes
 1. This figure was taken from Site 17 Groundwater Feasibility Study (Figure 2-11) (CH2M HILL, 2006) and revised to reflect the locations of the sampling effort.
 2. Macrocore sampling was performed at DPT locations IS17DP65 on December 4, 2006 and IS17DP64A on December 5, 2006. Continuous 4-foot samples were collected down to the depth of clay. At location IS17DP65, there was no recovery of soil 12 feet below ground surface (bgs). At location IS17DP64A, clay was encountered at a depth of 14 feet bgs.

LEGEND

- Monitoring Wells
- ⊠ July 2002 Membrane Interface Probe/Direct Push Technique Locations
- December 2004 MIP/DPT and March 2005 DPT Locations
- ⊠ August 2005 MIP/DPT Locations
- December 2006 DPT Locations
- ⊠ Surface Water Sample Location
- Buildings
- Demolished Buildings
- ▨ Excavation Area; backfill with 1-foot layer of soil and 0.5-foot layer of gravel (2005 NTCRA; FSSI, 2006)
- Wooded Area
- ▨ Drum Removal Area (2005 NTCRA; FSSI, 2006)
- Approximate IR Site Boundary
- ~ Road
- ~ Topographic Elevation Contours (1 foot Intervals)
- ~ Base Boundary
- Cross Section Location
- Groundwater Flow Direction

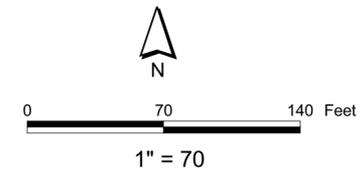
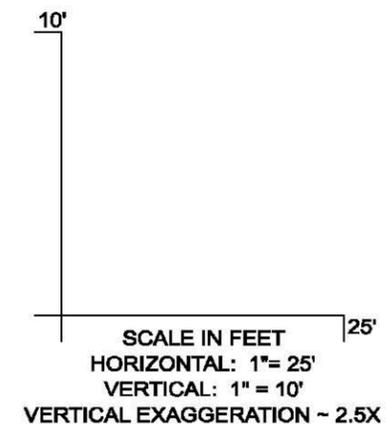
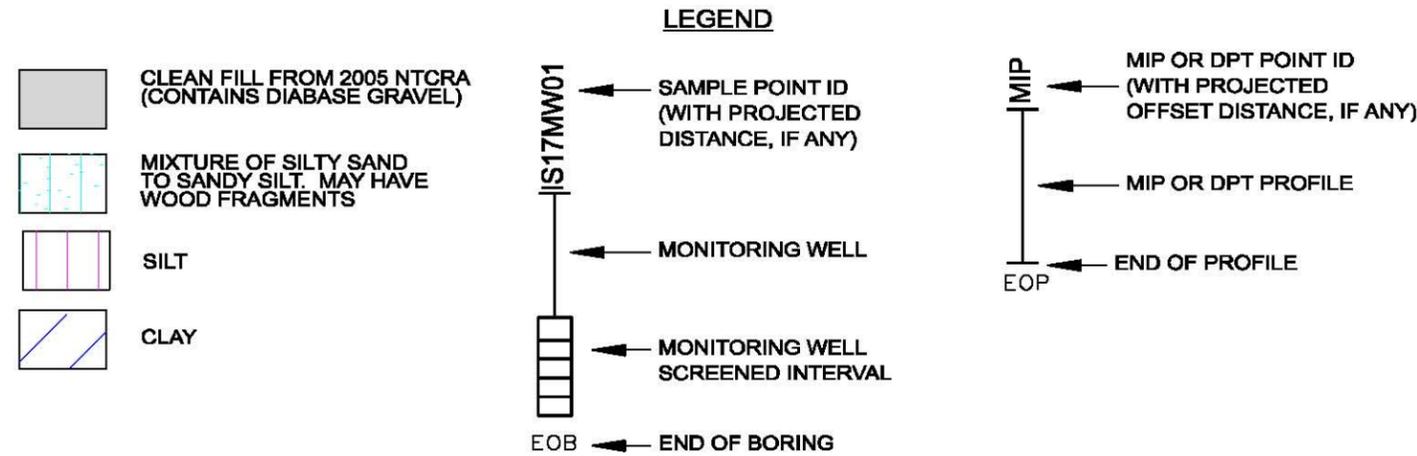
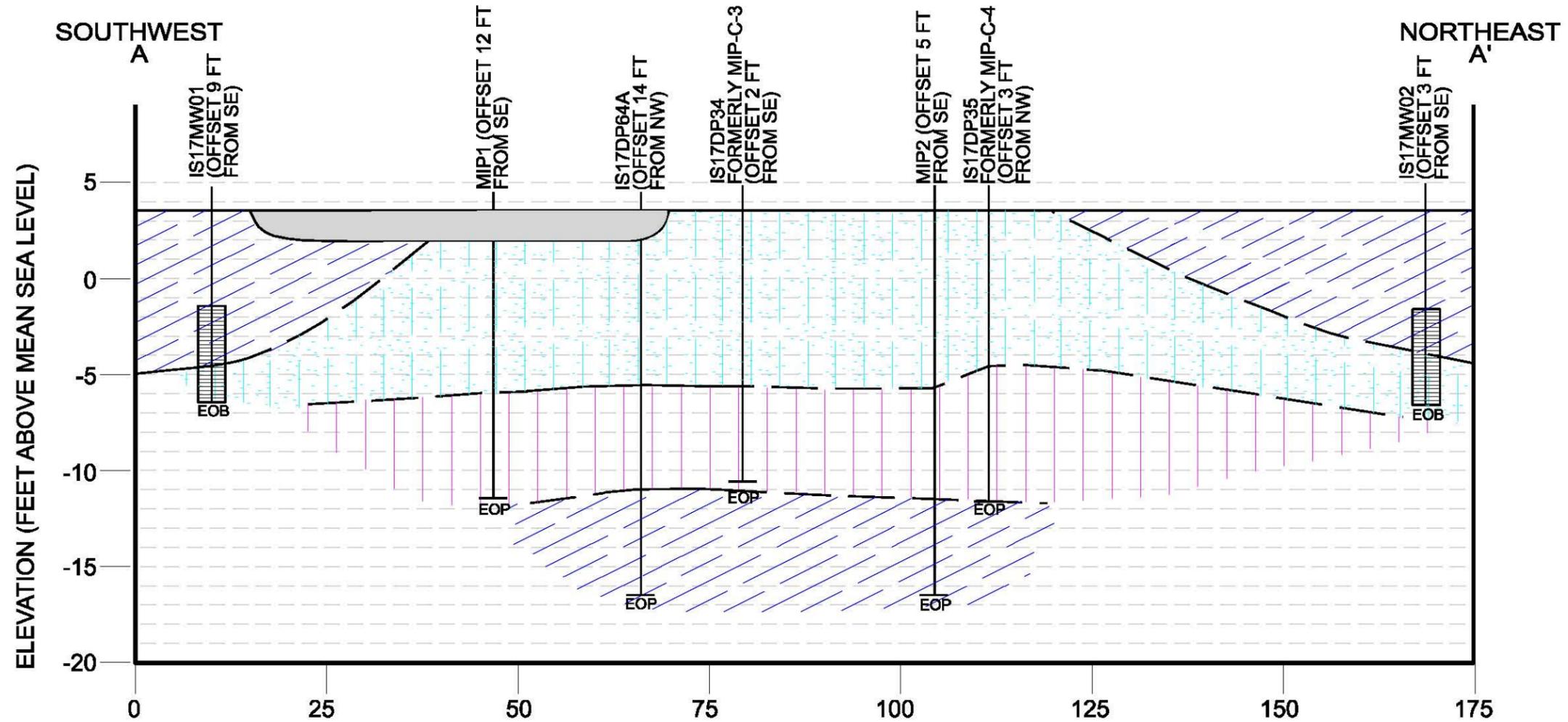
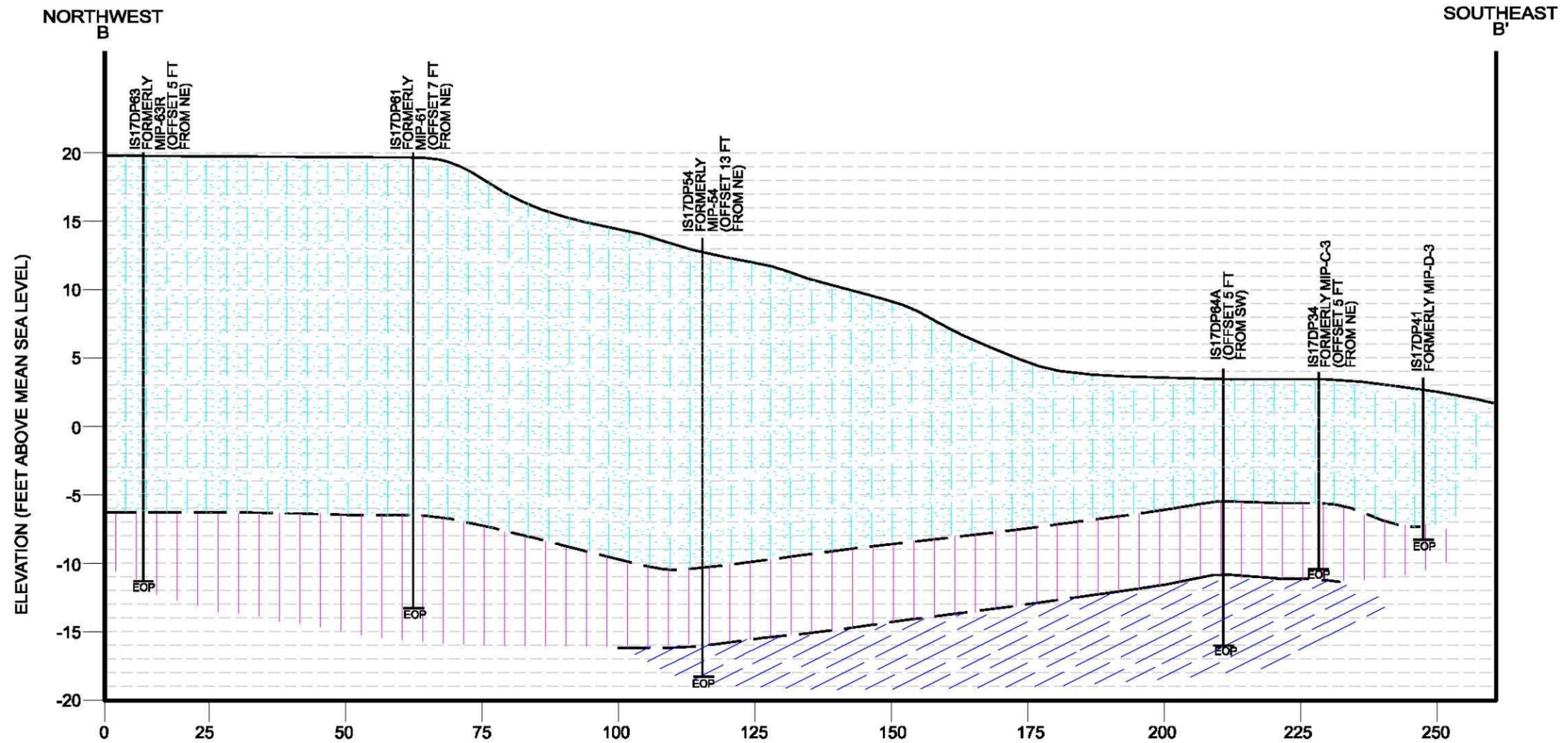


Figure 2-1
 Locations of Groundwater Samples
 and Geologic Cross Sections
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

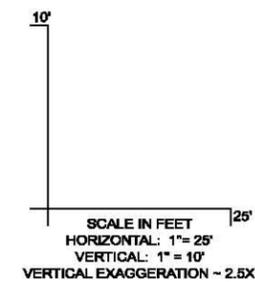
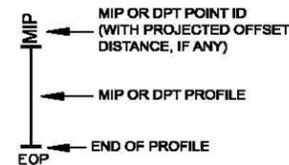
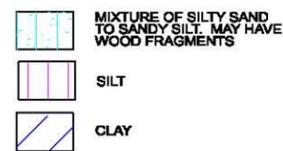


- NOTES:**
- MONITORING WELLS WERE SURVEYED BY BALDWIN AND GREGG OF NORFOLK, VA.
 - DIRECT PUSH TECHNIQUE (DPT) AND MEMBRANE INTERFACE PROBE (MIP) LOCATIONS WERE SURVEYED WITH A GLOBAL POSITIONING SYSTEM (GPS) UNIT BY CH2M HILL AT THE TIME THE WORK WAS DONE.
 - DESCRIPTION OF THE LITHOLOGY IS OBTAINED FROM SOIL BORING AND MONITORING WELL LOGS AND INFERRED BASED ON MIP PROFILES.
 - SEE APPENDICES A AND B IN THE FINAL REMEDIAL INVESTIGATION REPORT (CH2M HILL, 2004) FOR SOIL BORING AND MONITORING WELL LOGS.
 - SEE APPENDICES B AND C IN THE DRAFT FEASIBILITY STUDY REPORT (CH2M HILL, 2006) FOR THE MIP PROFILES.
 - LOCATIONS OF THE UNIT BOUNDARIES SHOWN ON THE CROSS SECTION ARE ESTIMATED AND ARE BASED ON BORING LOGS AND MIP PROFILES.
 - NTCRA - NON TIME CRITICAL REMOVAL ACTION (FSS, 2006 REPORT).

Figure 2-2
Geologic Cross Section A - A'
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland



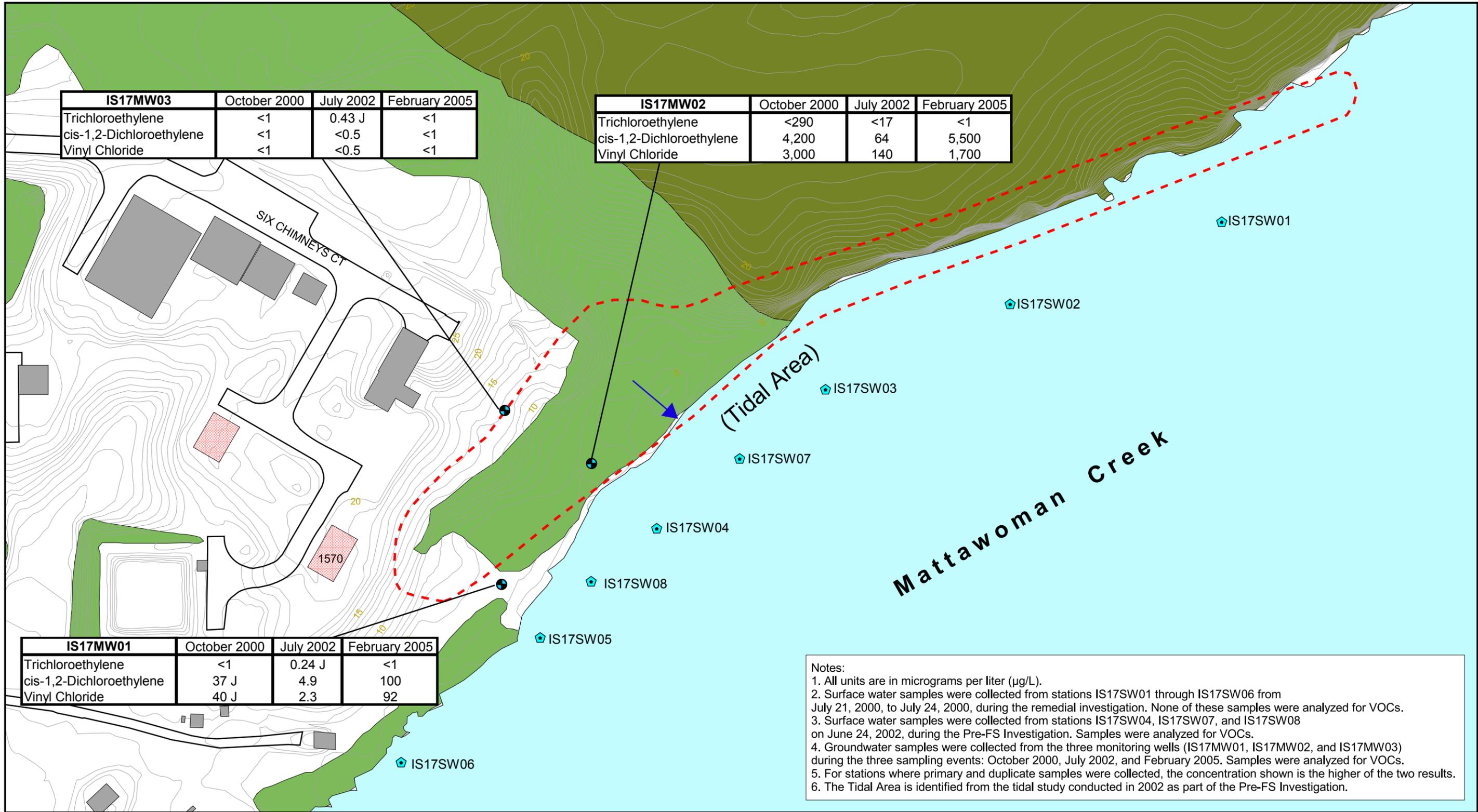
LEGEND



NOTES:

1. MONITORING WELLS WERE SURVEYED BY BALDWIN AND GREGG OF NORFOLK, VA.
2. DIRECT PUSH TECHNIQUE (DPT) AND MEMBRANE INTERFACE PROBE (MIP) LOCATIONS WERE SURVEYED WITH A GLOBAL POSITIONING SYSTEM (GPS) UNIT BY CH2M HILL AT THE TIME THE WORK WAS DONE.
3. DESCRIPTION OF THE LITHOLOGY IS OBTAINED FROM SOIL BORING AND MONITORING WELL LOGS AND INFERRED BASED ON MIP PROFILES.
4. SEE APPENDICES A AND B IN THE FINAL REMEDIAL INVESTIGATION REPORT (CH2M HILL, 2004) FOR SOIL BORING AND MONITORING WELL LOGS.
5. SEE APPENDICES B AND C IN THE DRAFT FEASIBILITY STUDY REPORT (CH2M HILL, 2008) FOR THE MIP PROFILES.
6. LOCATIONS OF THE UNIT BOUNDARIES SHOWN ON THE CROSS SECTION ARE ESTIMATED AND ARE BASED ON BORING LOGS AND MIP PROFILES.

Figure 2-3
Geologic Cross Section B - B'
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland



LEGEND

- Monitoring Wells
- Surface Water
- Approximate IR Site Boundary
- Buildings
- Demolished Buildings
- Wooded Area
- Dense Wooded Area
- Groundwater Flow Direction
- Topographic Elevation Contours (feet msl)
- Road
- < = Not detected
- J = Estimated value below the detection limit

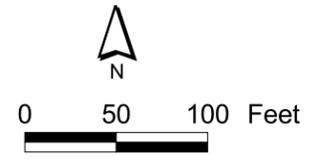
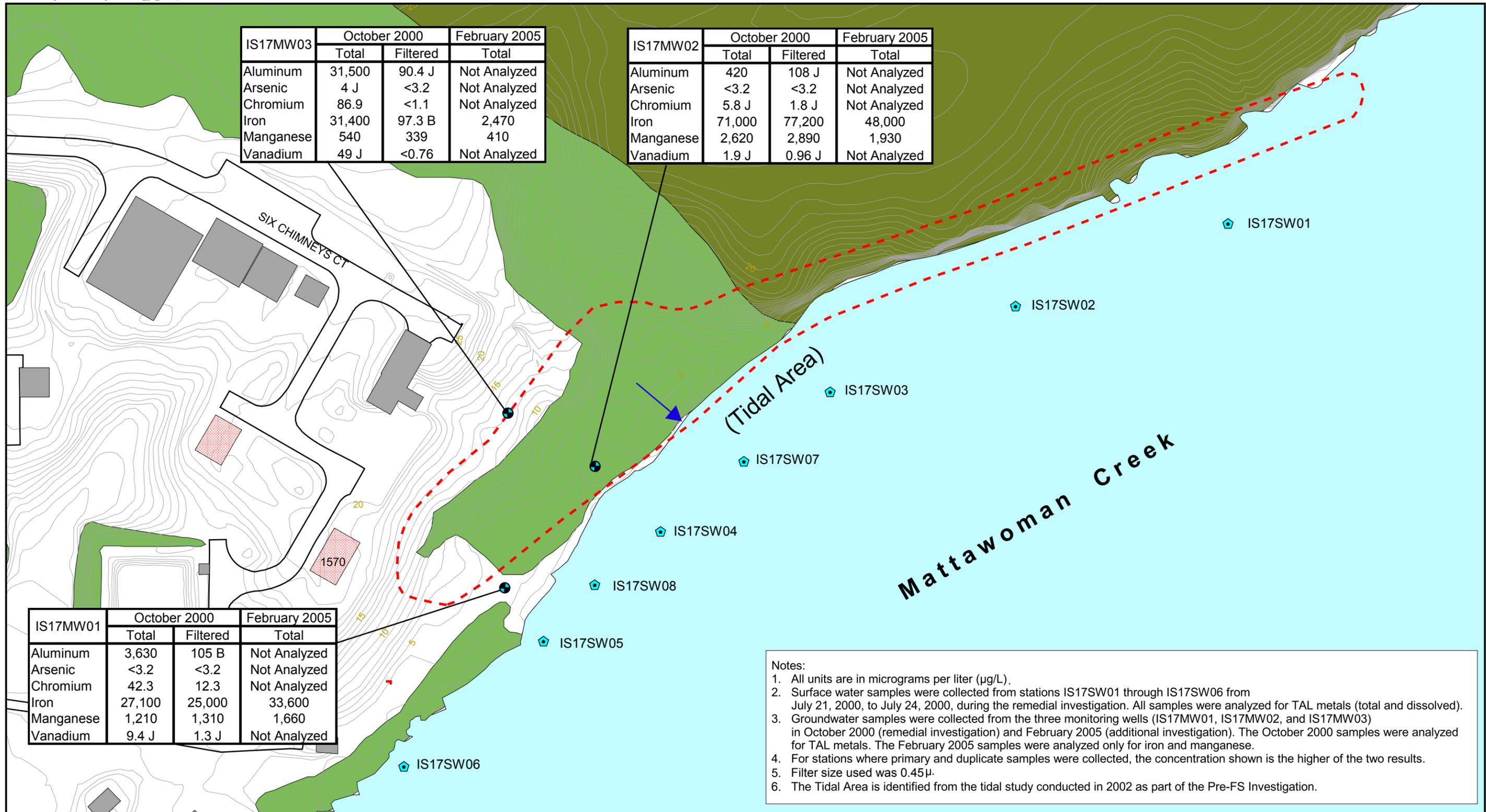


Figure 2-4
 Analytical Results for TCE
 Cis -1,2-DCE and VC in Monitoring Well Groundwater
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland



IS17MW03	October 2000		February 2005
	Total	Filtered	Total
Aluminum	31,500	90.4 J	Not Analyzed
Arsenic	4 J	<3.2	Not Analyzed
Chromium	86.9	<1.1	Not Analyzed
Iron	31,400	97.3 B	2,470
Manganese	540	339	410
Vanadium	49 J	<0.76	Not Analyzed

IS17MW02	October 2000		February 2005
	Total	Filtered	Total
Aluminum	420	108 J	Not Analyzed
Arsenic	<3.2	<3.2	Not Analyzed
Chromium	5.8 J	1.8 J	Not Analyzed
Iron	71,000	77,200	48,000
Manganese	2,620	2,890	1,930
Vanadium	1.9 J	0.96 J	Not Analyzed

IS17MW01	October 2000		February 2005
	Total	Filtered	Total
Aluminum	3,630	105 B	Not Analyzed
Arsenic	<3.2	<3.2	Not Analyzed
Chromium	42.3	12.3	Not Analyzed
Iron	27,100	25,000	33,600
Manganese	1,210	1,310	1,660
Vanadium	9.4 J	1.3 J	Not Analyzed

- Notes:
1. All units are in micrograms per liter (µg/L).
 2. Surface water samples were collected from stations IS17SW01 through IS17SW06 from July 21, 2000, to July 24, 2000, during the remedial investigation. All samples were analyzed for TAL metals (total and dissolved).
 3. Groundwater samples were collected from the three monitoring wells (IS17MW01, IS17MW02, and IS17MW03) in October 2000 (remedial investigation) and February 2005 (additional investigation). The October 2000 samples were analyzed for TAL metals. The February 2005 samples were analyzed only for iron and manganese.
 4. For stations where primary and duplicate samples were collected, the concentration shown is the higher of the two results.
 5. Filter size used was 0.45µ.
 6. The Tidal Area is identified from the tidal study conducted in 2002 as part of the Pre-FS Investigation.

- LEGEND**
- Monitoring Wells
 - ◊ Surface Water
 - - - Approximate IR Site Boundary
 - Buildings
 - Demolished Buildings
 - Wooded Area
 - Dense Wooded Area

- ~ Topographic Elevation Contours (feet msl)
- ∧ Road
- Groundwater Flow Direction
- < = Not detected
- B = Some or all of the detected value may be due to laboratory or field contamination. (Equivalent to ND)
- J = Estimated value below the detection limit

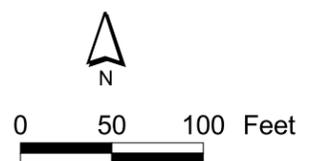
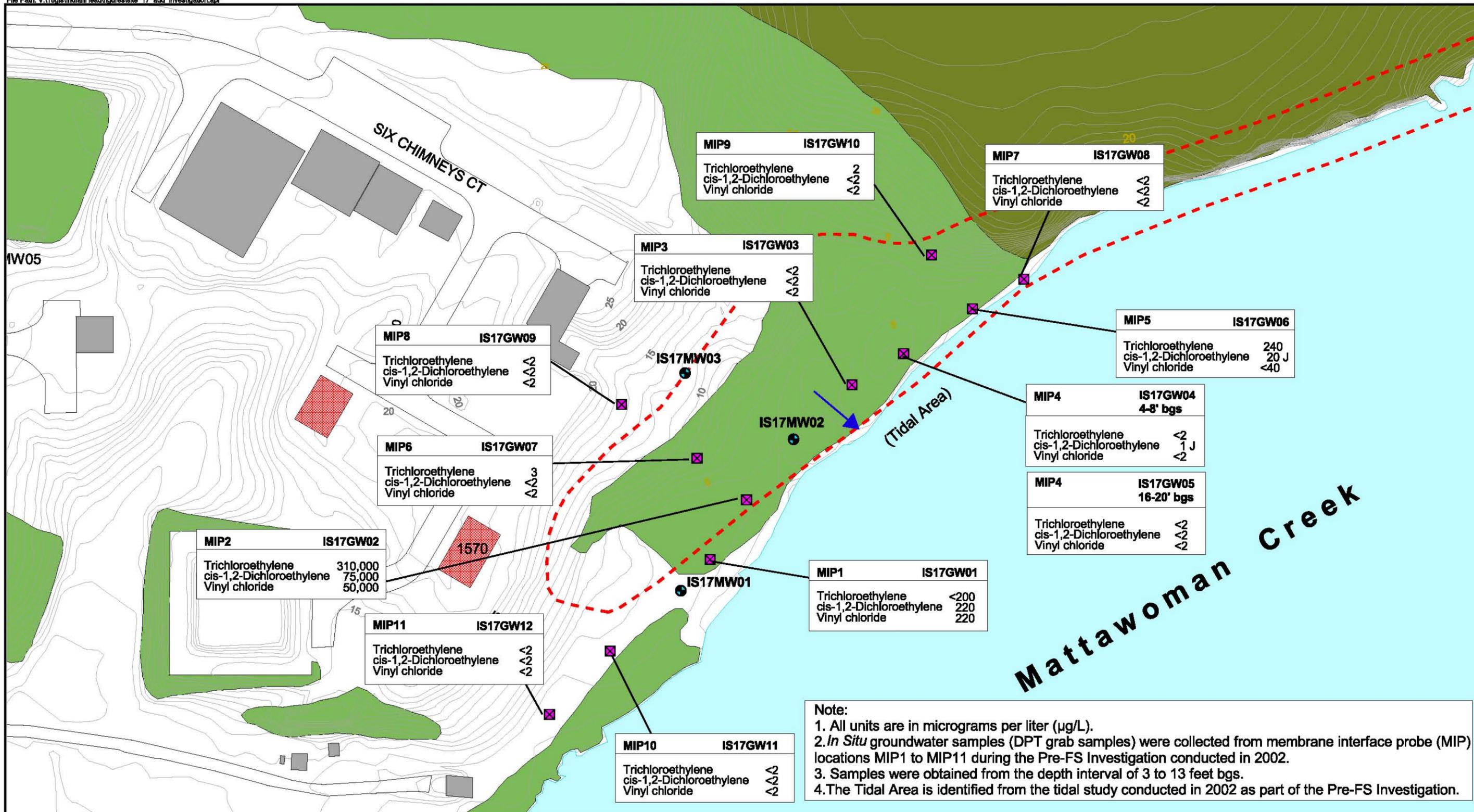


Figure 2-5
Analytical Results for Various Metals in Monitoring Well Groundwater
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland



Note:
 1. All units are in micrograms per liter (µg/L).
 2. *In Situ* groundwater samples (DPT grab samples) were collected from membrane interface probe (MIP) locations MIP1 to MIP11 during the Pre-FS Investigation conducted in 2002.
 3. Samples were obtained from the depth interval of 3 to 13 feet bgs.
 4. The Tidal Area is identified from the tidal study conducted in 2002 as part of the Pre-FS Investigation.

LEGEND

- Monitoring Wells
- July 2002 MIP/Direct Push Sample Locations
- Approximate IR Site Boundary
- Buildings
- Demolished Buildings
- Wooded Area
- Dense Wooded Area
- Groundwater Flow Direction
- Topographic Elevation Contours (feet msl)
- Road
- < = Not detected
- J= Estimated value below the detection limit

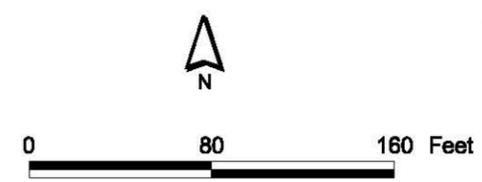
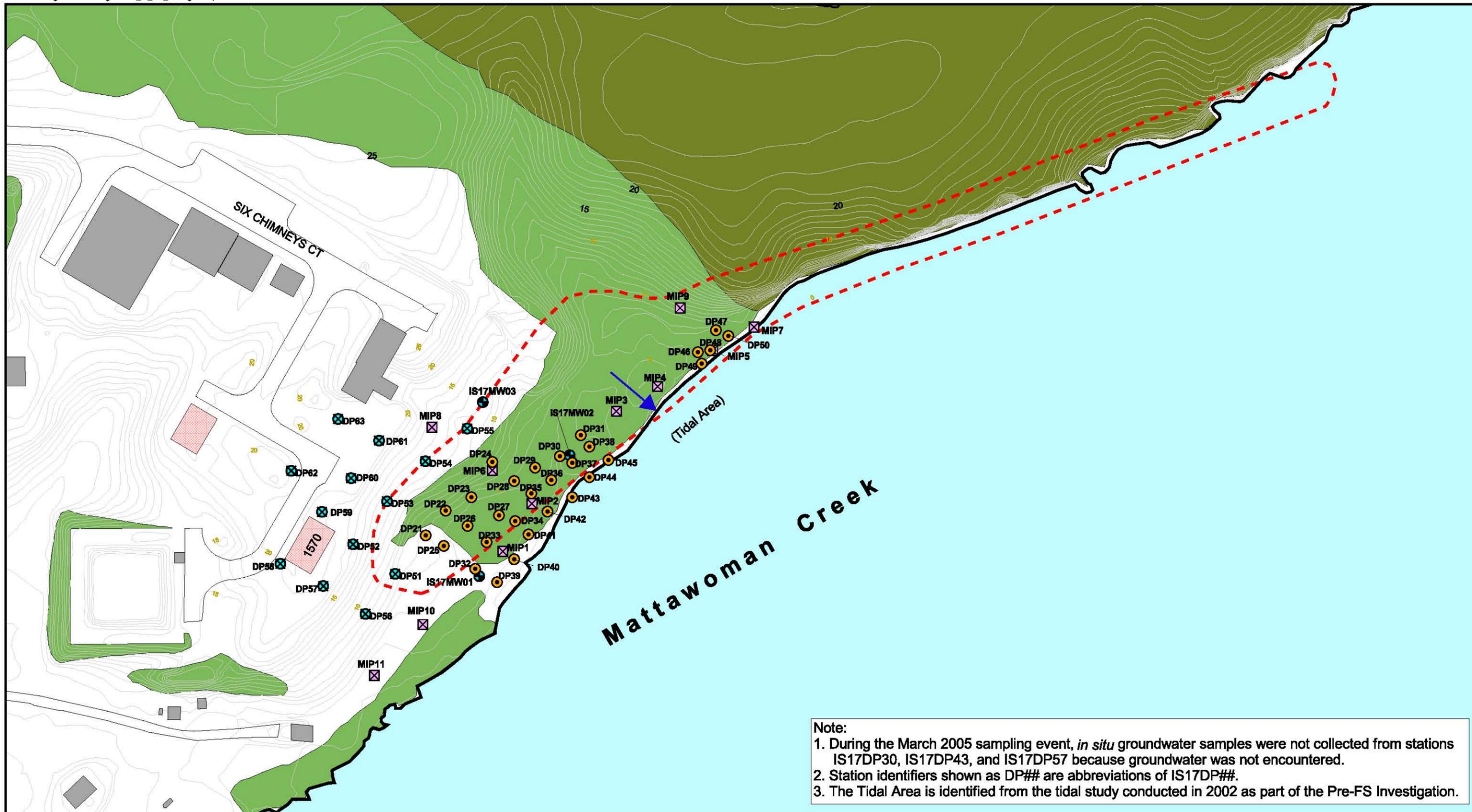


Figure 2-6
 Analytical Results for TCE, Cis-1,2-DCE, and VC in *In Situ* groundwater
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland



Note:
 1. During the March 2005 sampling event, *in situ* groundwater samples were not collected from stations IS17DP30, IS17DP43, and IS17DP57 because groundwater was not encountered.
 2. Station identifiers shown as DP## are abbreviations of IS17DP##.
 3. The Tidal Area is identified from the tidal study conducted in 2002 as part of the Pre-FS Investigation.

LEGEND

Monitoring Wells	Groundwater Flow Direction
July 2002 MIP/DPT Locations	Road
December 2004 MIP/DPT and March 2005 DPT Locations	Topographic Elevation Contours (feet msl)
August 2005 MIP/DPT Locations	Base Boundary
Wooded Area	Approximate IR Site Boundary
Dense Wooded Area	Buildings
	Demolished Buildings

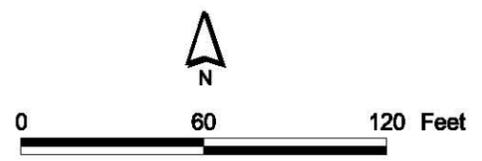


Figure 2-7
 MIP/DPT Locations
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

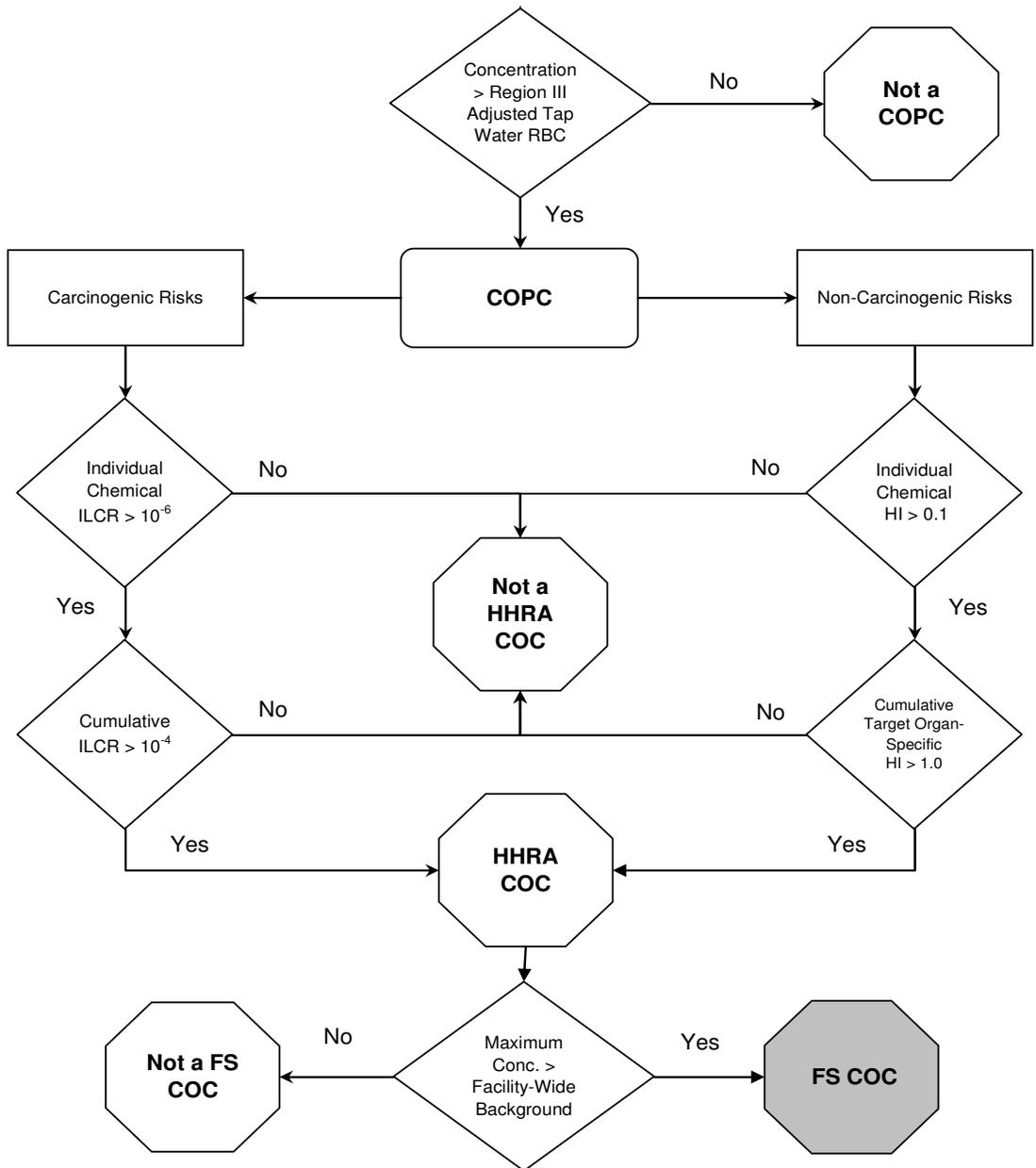
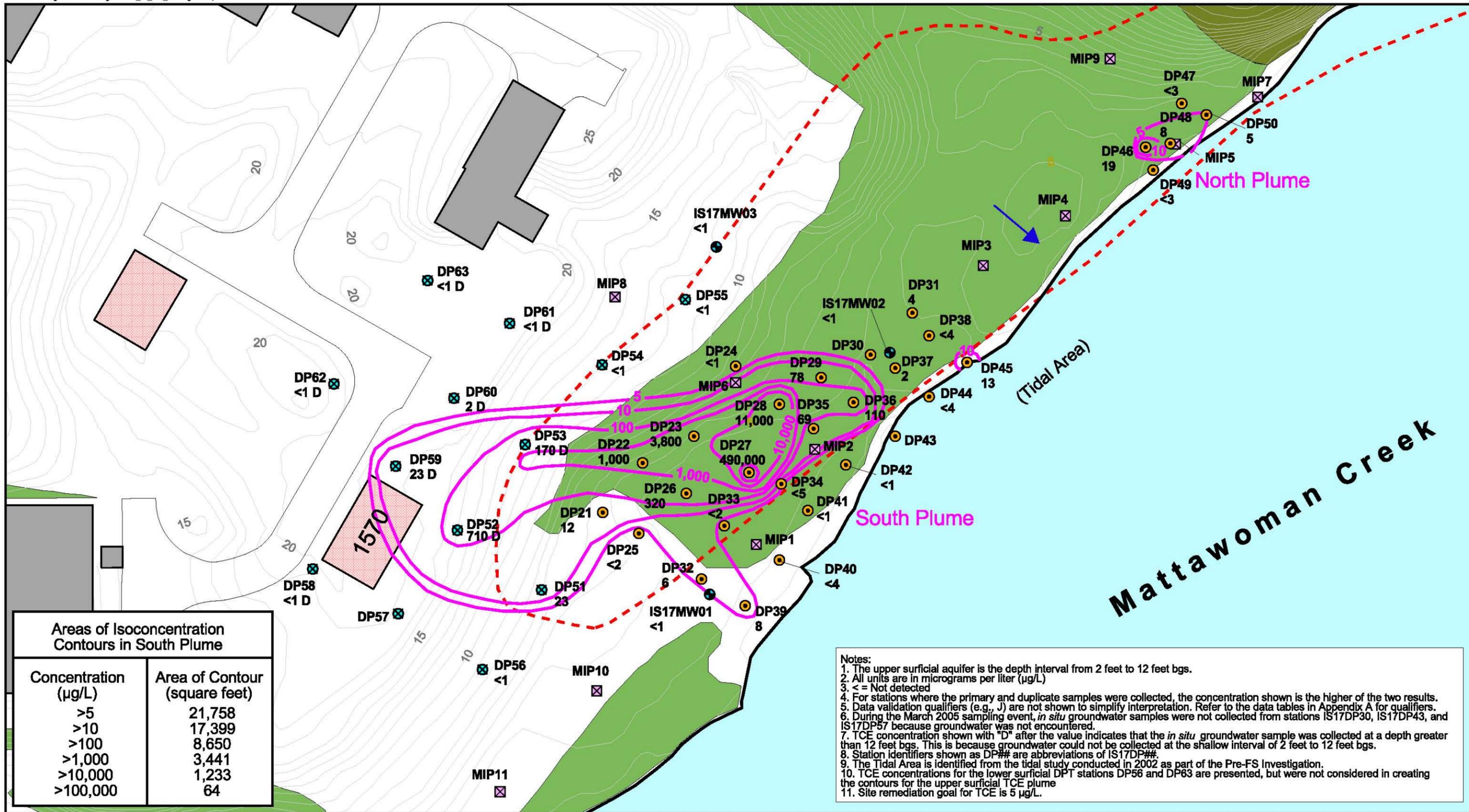


Figure 2-8
 FS COC Selection Diagram Based on HHRA COC
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland



Areas of Isoconcentration Contours in South Plume	
Concentration (µg/L)	Area of Contour (square feet)
>5	21,758
>10	17,399
>100	8,650
>1,000	3,441
>10,000	1,233
>100,000	64

Notes:

1. The upper surficial aquifer is the depth interval from 2 feet to 12 feet bgs.
2. All units are in micrograms per liter (µg/L)
3. < = Not detected
4. For stations where the primary and duplicate samples were collected, the concentration shown is the higher of the two results.
5. Data validation qualifiers (e.g., J) are not shown to simplify interpretation. Refer to the data tables in Appendix A for qualifiers.
6. During the March 2005 sampling event, *in situ* groundwater samples were not collected from stations IS17DP30, IS17DP43, and IS17DP57 because groundwater was not encountered.
7. TCE concentration shown with "D" after the value indicates that the *in situ* groundwater sample was collected at a depth greater than 12 feet bgs. This is because groundwater could not be collected at the shallow interval of 2 feet to 12 feet bgs.
8. Station identifiers shown as DP## are abbreviations of IS17DP##.
9. The Tidal Area is identified from the tidal study conducted in 2002 as part of the Pre-FS Investigation.
10. TCE concentrations for the lower surficial DPT stations DP56 and DP63 are presented, but were not considered in creating the contours for the upper surficial TCE plume
11. Site remediation goal for TCE is 5 µg/L.

- LEGEND**
- Monitoring Wells with TCE Results
 - July 2002 MIP/DPT Locations with TCE Results
 - December 2004 MIP/DPT and March 2005 DPT Locations with TCE Results
 - August 2005 MIP/DPT Locations with TCE Results
 - Approximate IR Site Boundary
 - Buildings
 - Demolished Buildings
 - Wooded Area
 - Dense Wooded Area
 - Groundwater Flow Direction
 - Road
 - Topographic Elevation Contours (feet msl)
 - Base Boundary
 - Isoconcentration Contour

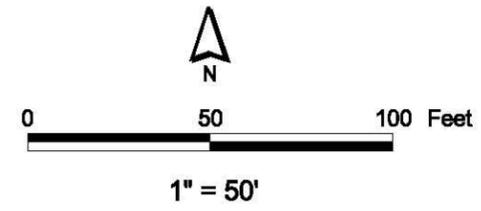
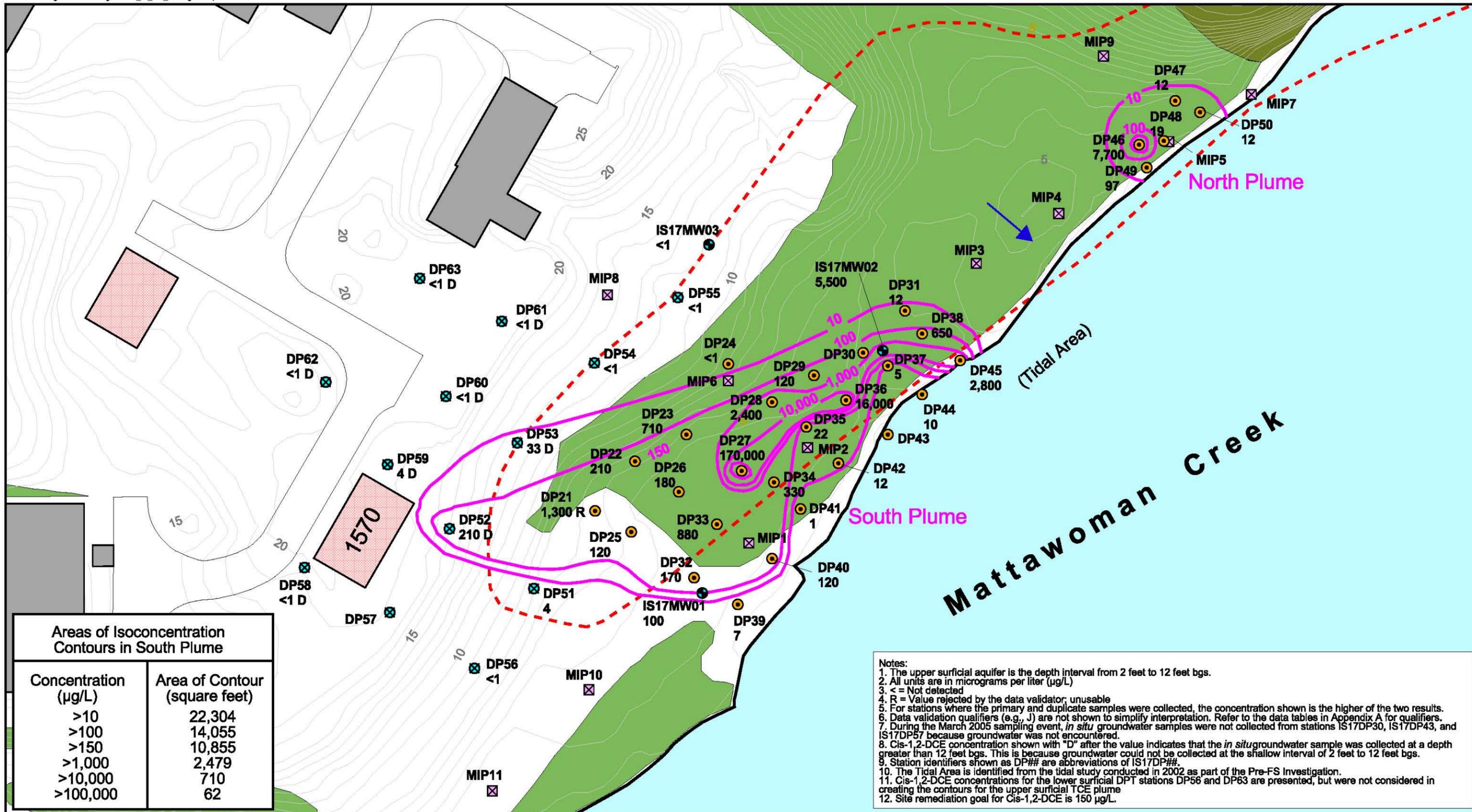


Figure 2-9
Interpolated TCE Plume for Upper Surficial Aquifer
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland



Areas of Isoconcentration Contours in South Plume	
Concentration (µg/L)	Area of Contour (square feet)
>10	22,304
>100	14,055
>150	10,855
>1,000	2,479
>10,000	710
>100,000	62

Notes:

- The upper surficial aquifer is the depth interval from 2 feet to 12 feet bgs.
- All units are in micrograms per liter (µg/L)
- < = Not detected
- R = Value rejected by the data validator; unusable
- For stations where the primary and duplicate samples were collected, the concentration shown is the higher of the two results.
- Data validation qualifiers (e.g., J) are not shown to simplify interpretation. Refer to the data tables in Appendix A for qualifiers.
- During the March 2005 sampling event, *in situ* groundwater samples were not collected from stations IS17DP30, IS17DP43, and IS17DP57 because groundwater was not encountered.
- Cis-1,2-DCE concentration shown with "D" after the value indicates that the *in situ* groundwater sample was collected at a depth greater than 12 feet bgs. This is because groundwater could not be collected at the shallow interval of 2 feet to 12 feet bgs.
- Station identifiers shown as DP## are abbreviations of IS17DP##.
- The Tidal Area is identified from the tidal study conducted in 2002 as part of the Pre-FS Investigation.
- Cis-1,2-DCE concentrations for the lower surficial DPT stations DP56 and DP63 are presented, but were not considered in creating the contours for the upper surficial TCE plume
- Site remediation goal for Cis-1,2-DCE is 150 µg/L.

- LEGEND**
- Monitoring Wells with Cis-1,2-DCE Results
 - July 2002 MIP/DPT Locations with Cis-1,2-DCE Results
 - December 2004 MIP/DPT and March 2005 DPT Locations with Cis-1,2-DCE Results
 - August 2005 MIP/DPT Locations with Cis-1,2-DCE Results
 - Approximate IR Site Boundary
 - Buildings
 - Demolished Buildings
 - Wooded Area
 - Dense Wooded Area
 - Groundwater Flow Direction
 - Road
 - Topographic Elevation Contours (feet msl)
 - Base Boundary
 - Isoconcentration Contour

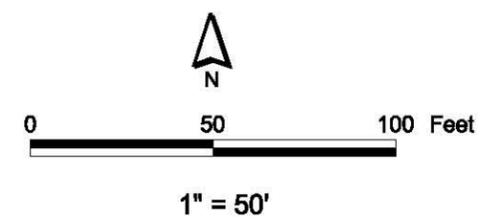
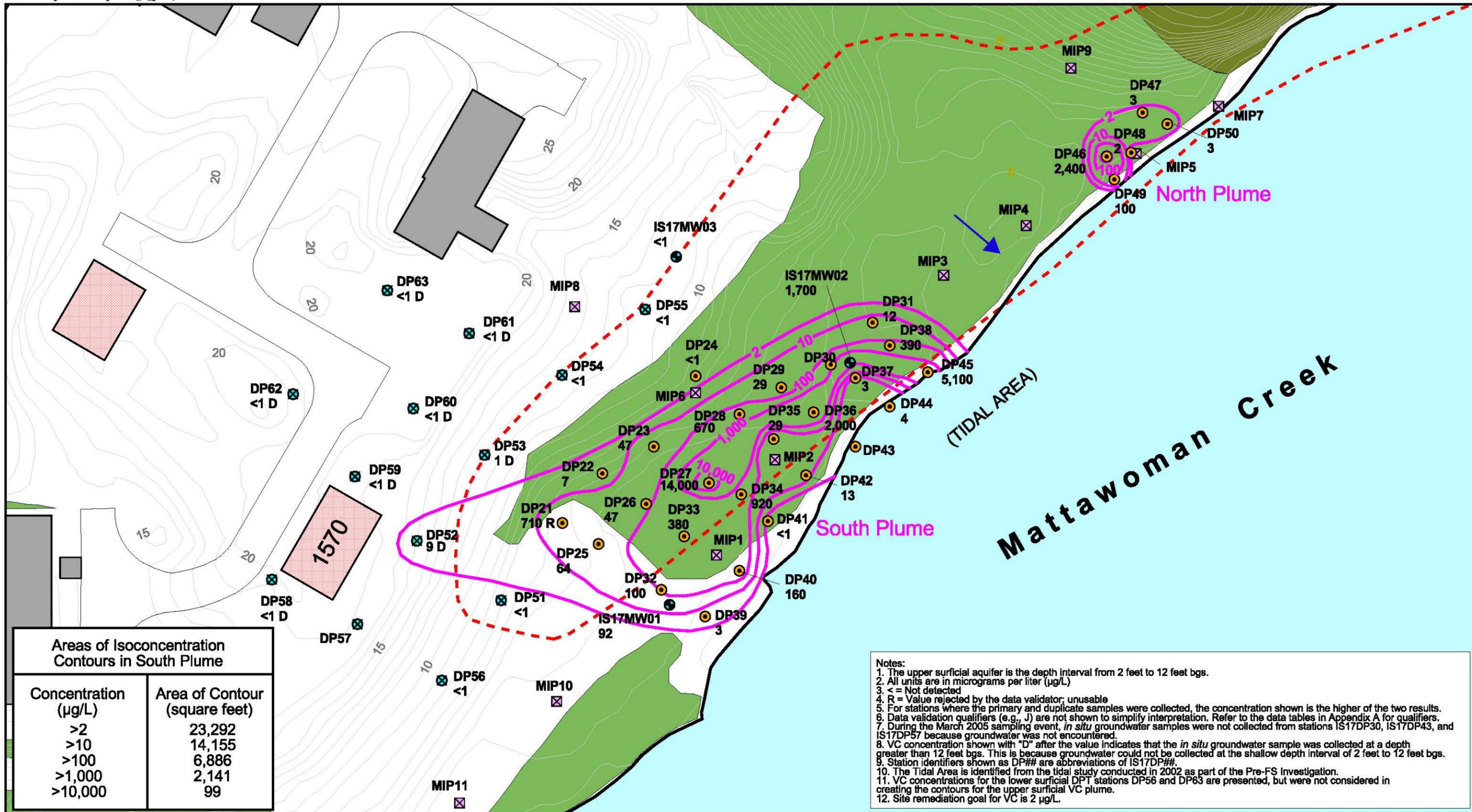


Figure 2-10
Interpolated Cis-1,2-DCE Plume for Upper Surficial Aquifer
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland



Areas of Isoconcentration Contours in South Plume	
Concentration (µg/L)	Area of Contour (square feet)
>2	23,292
>10	14,155
>100	6,886
>1,000	2,141
>10,000	99

Notes:

1. The upper surficial aquifer is the depth interval from 2 feet to 12 feet bgs.
2. All units are in micrograms per liter (µg/L)
3. < = Not detected
4. R = Value rejected by the data validator; unusable
5. For stations where the primary and duplicate samples were collected, the concentration shown is the higher of the two results.
6. Data validation qualifiers (e.g., J) are not shown to simplify interpretation. Refer to the data tables in Appendix A for qualifiers.
7. During the March 2005 sampling event, *in situ* groundwater samples were not collected from stations IS17DP30, IS17DP43, and IS17DP57 because groundwater was not encountered.
8. VC concentration shown with "D" after the value indicates that the *in situ* groundwater sample was collected at a depth greater than 12 feet bgs. This is because groundwater could not be collected at the shallow depth interval of 2 feet to 12 feet bgs.
9. Station identifiers shown as DP## are abbreviations of IS17DP##.
10. The Tidal Area is identified from the tidal study conducted in 2002 as part of the Pre-FS Investigation.
11. VC concentrations for the lower surficial DPT stations DP56 and DP63 are presented, but were not considered in creating the contours for the upper surficial VC plume.
12. Site remediation goal for VC is 2 µg/L.

- LEGEND**
- Monitoring Wells with VC Results
 - July 2002 MIP/DPT Locations with VC Results
 - December 2004 MIP/DPT and March 2005 DPT Locations with VC Results
 - August 2005 MIP/DPT Locations with VC Results
 - Approximate IR Site Boundary
 - Buildings
 - Demolished Buildings

- Wooded Area
- Dense Wooded Area
- Groundwater Flow Direction
- Road
- Topographic Elevation Contours (feet msl)
- Base Boundary
- Isoconcentration Contour

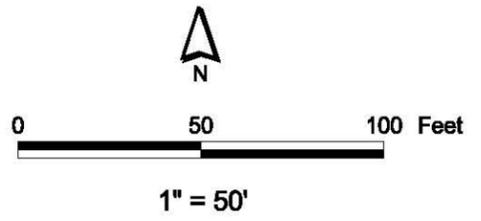
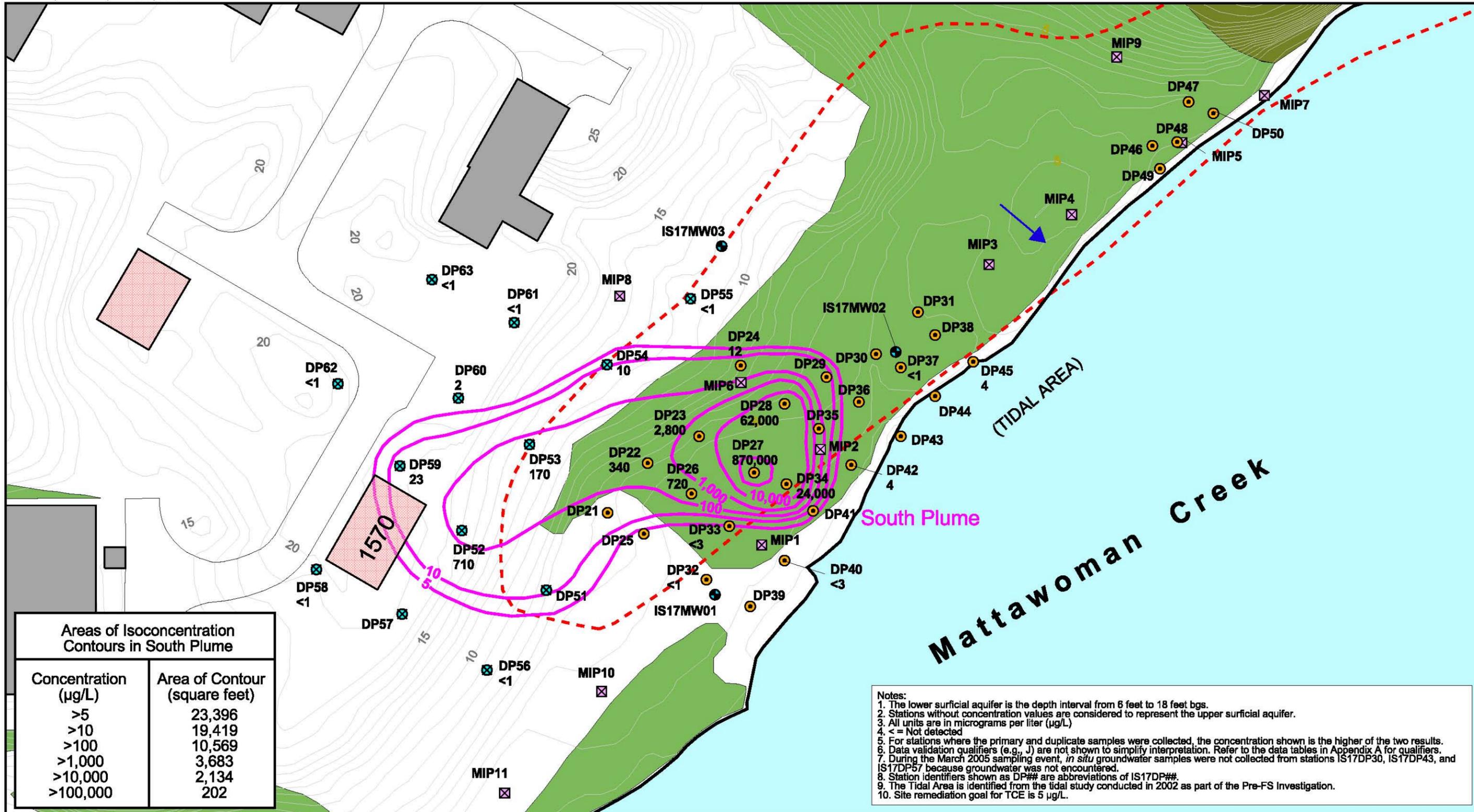


Figure 2-11
Interpolated VC Plume for Upper Surficial Aquifer
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland



Areas of Isoconcentration Contours in South Plume	
Concentration (µg/L)	Area of Contour (square feet)
>5	23,396
>10	19,419
>100	10,569
>1,000	3,683
>10,000	2,134
>100,000	202

- Notes:
1. The lower surficial aquifer is the depth interval from 6 feet to 18 feet bgs.
 2. Stations without concentration values are considered to represent the upper surficial aquifer.
 3. All units are in micrograms per liter (µg/L)
 4. < = Not detected
 5. For stations where the primary and duplicate samples were collected, the concentration shown is the higher of the two results.
 6. Data validation qualifiers (e.g., J) are not shown to simplify interpretation. Refer to the data tables in Appendix A for qualifiers.
 7. During the March 2005 sampling event, *in situ* groundwater samples were not collected from stations IS17DP30, IS17DP43, and IS17DP57 because groundwater was not encountered.
 8. Station identifiers shown as DP## are abbreviations of IS17DP##.
 9. The Tidal Area is identified from the tidal study conducted in 2002 as part of the Pre-FS Investigation.
 10. Site remediation goal for TCE is 5 µg/L.

- LEGEND**
- Monitoring Wells with TCE Results
 - July 2002 MIP/DPT Locations with TCE Results
 - December 2004 MIP/DPT and March 2005 DPT Locations with TCE Results
 - August 2005 MIP/DPT Locations with TCE Results
 - Approximate IR Site Boundary
 - Buildings
 - Demolished Buildings
 - Wooded Area
 - Dense Wooded Area
 - Groundwater Flow Direction
 - Road
 - Topographic Elevation Contours (feet msl)
 - Base Boundary
 - Isoconcentration Contour

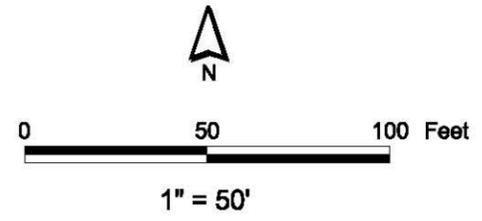
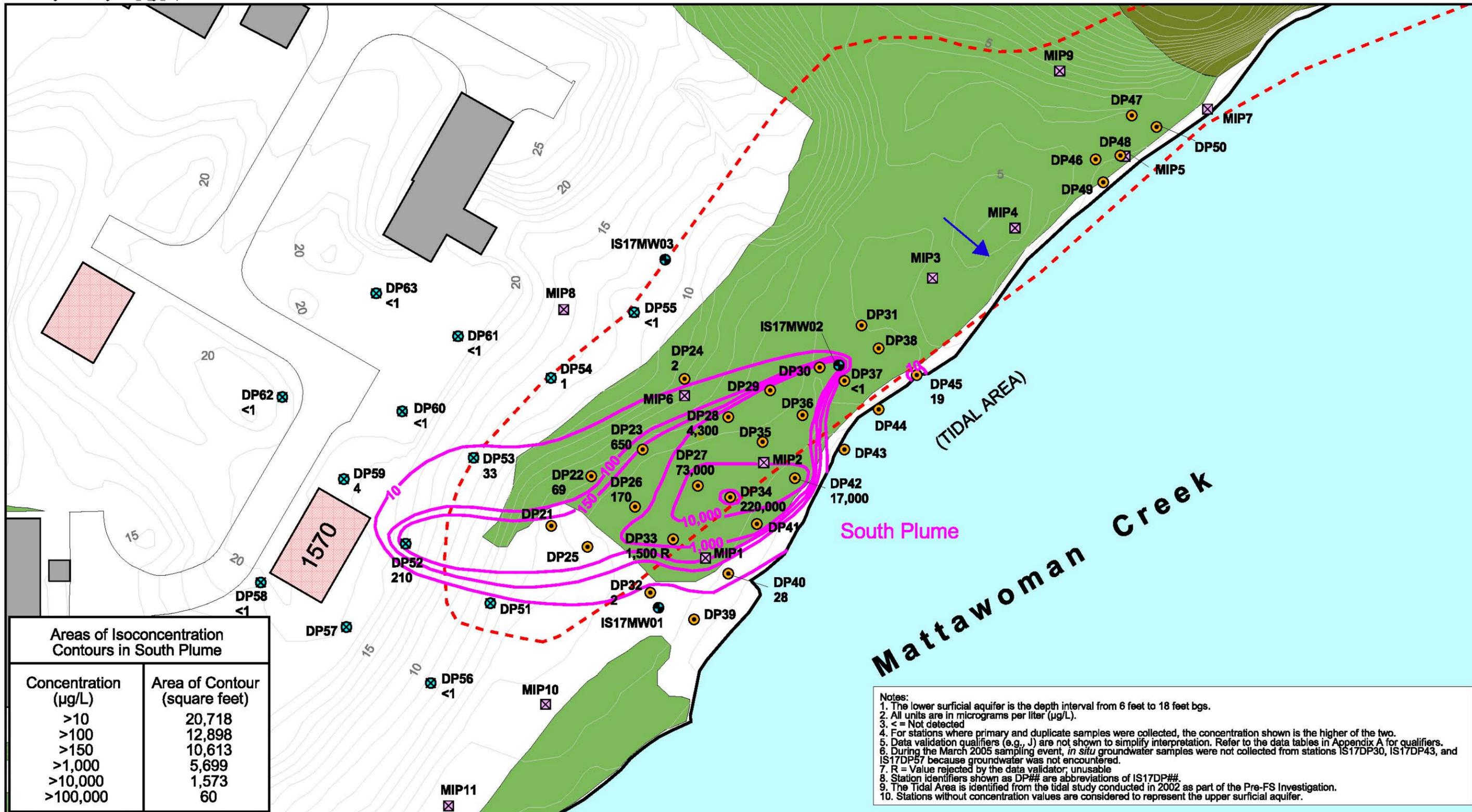


Figure 2-12
Interpolated TCE Plume for Lower Surficial Aquifer
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland



LEGEND

	Monitoring Wells with Cis-1,2-DCE Results		Wooded Area
	July 2002 MIP/DPT Locations with Cis-1,2-DCE Results		Dense Wooded Area
	December 2004 MIP/DPT and March 2005 DPT Locations with Cis-1,2-DCE Results		Groundwater Flow Direction
	August 2005 MIP/DPT Locations with Cis-1,2-DCE Results		Road
	Approximate IR Site Boundary		Topographic Elevation Contours (feet msl)
	Buildings		Base Boundary
	Demolished Buildings		Isoconcentration Contour

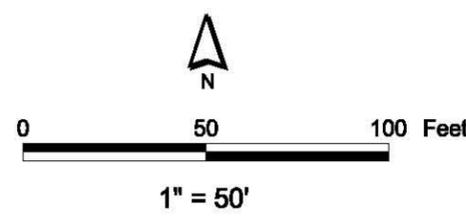
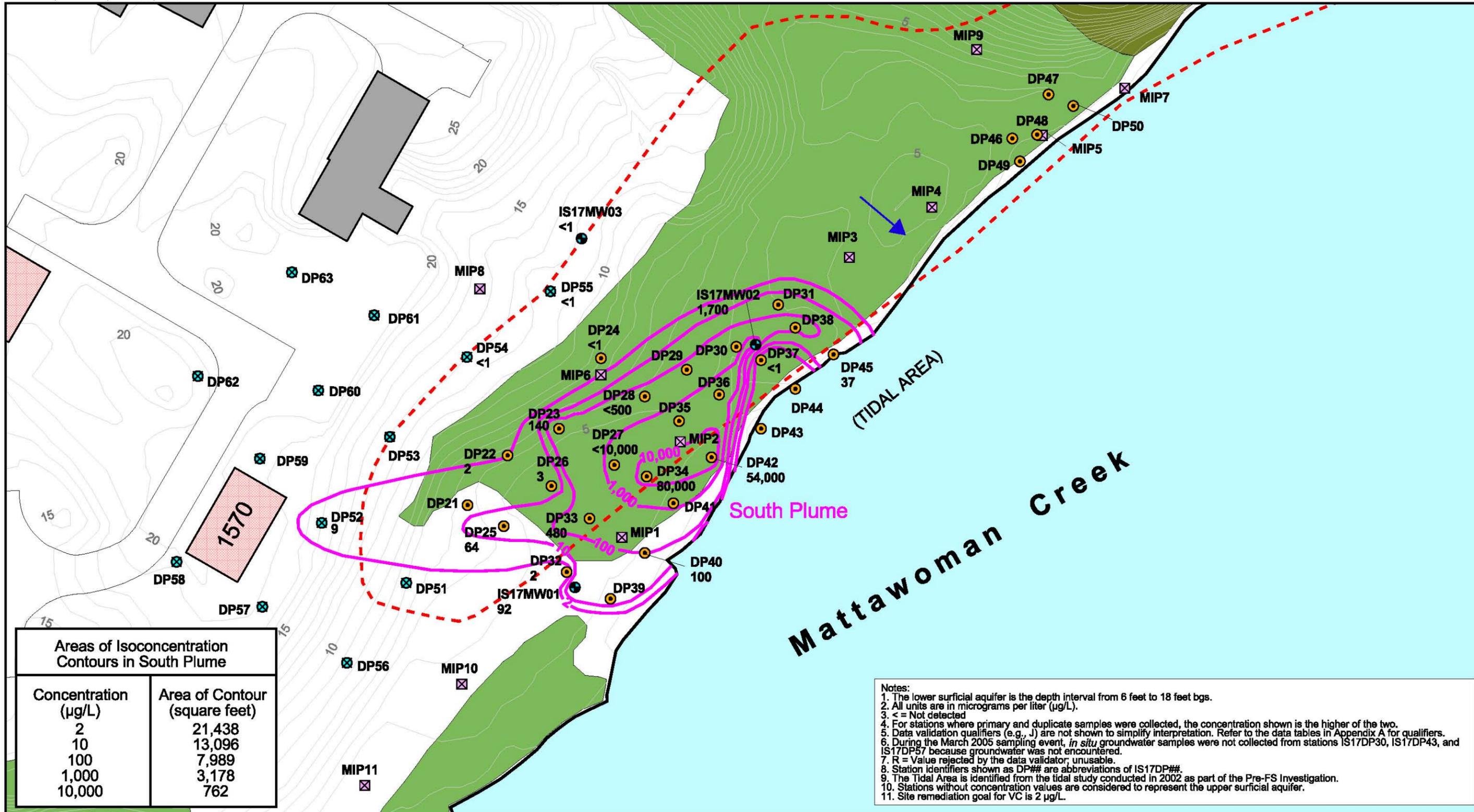


Figure 2-13
Interpolated Cis-1,2-DCE Plume for Lower Surficial Aquifer
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland



Areas of Isoconcentration Contours in South Plume

Concentration (µg/L)	Area of Contour (square feet)
2	21,438
10	13,096
100	7,989
1,000	3,178
10,000	762

- Notes:**
1. The lower surficial aquifer is the depth interval from 6 feet to 18 feet bgs.
 2. All units are in micrograms per liter (µg/L).
 3. < = Not detected
 4. For stations where primary and duplicate samples were collected, the concentration shown is the higher of the two.
 5. Data validation qualifiers (e.g., J) are not shown to simplify interpretation. Refer to the data tables in Appendix A for qualifiers.
 6. During the March 2005 sampling event, *in situ* groundwater samples were not collected from stations IS17DP30, IS17DP43, and IS17DP57 because groundwater was not encountered.
 7. R = Value rejected by the data validator; unusable.
 8. Station identifiers shown as DP## are abbreviations of IS17DP##.
 9. The Tidal Area is identified from the tidal study conducted in 2002 as part of the Pre-FS Investigation.
 10. Stations without concentration values are considered to represent the upper surficial aquifer.
 11. Site remediation goal for VC is 2 µg/L.

- LEGEND**
- Monitoring Wells
 - July 2002 MIP/Direct Push Locations
 - December 2004 MIP/Direct Push and March 2005 Direct Push Locations
 - August 2005 MIP/Direct Push Locations
 - Approximate IR Site Boundary
 - Buildings
 - Demolished Buildings

- Waterbodies
- Wooded Area
- Dense Wooded Area
- Groundwater Flow Direction
- Road
- Elevation Contours (feet msl)
- Base Boundary
- Isoconcentration Contour

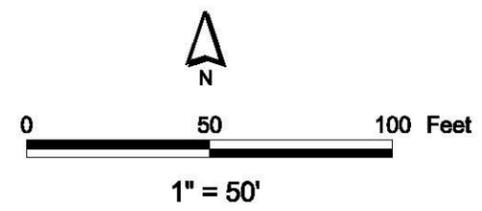
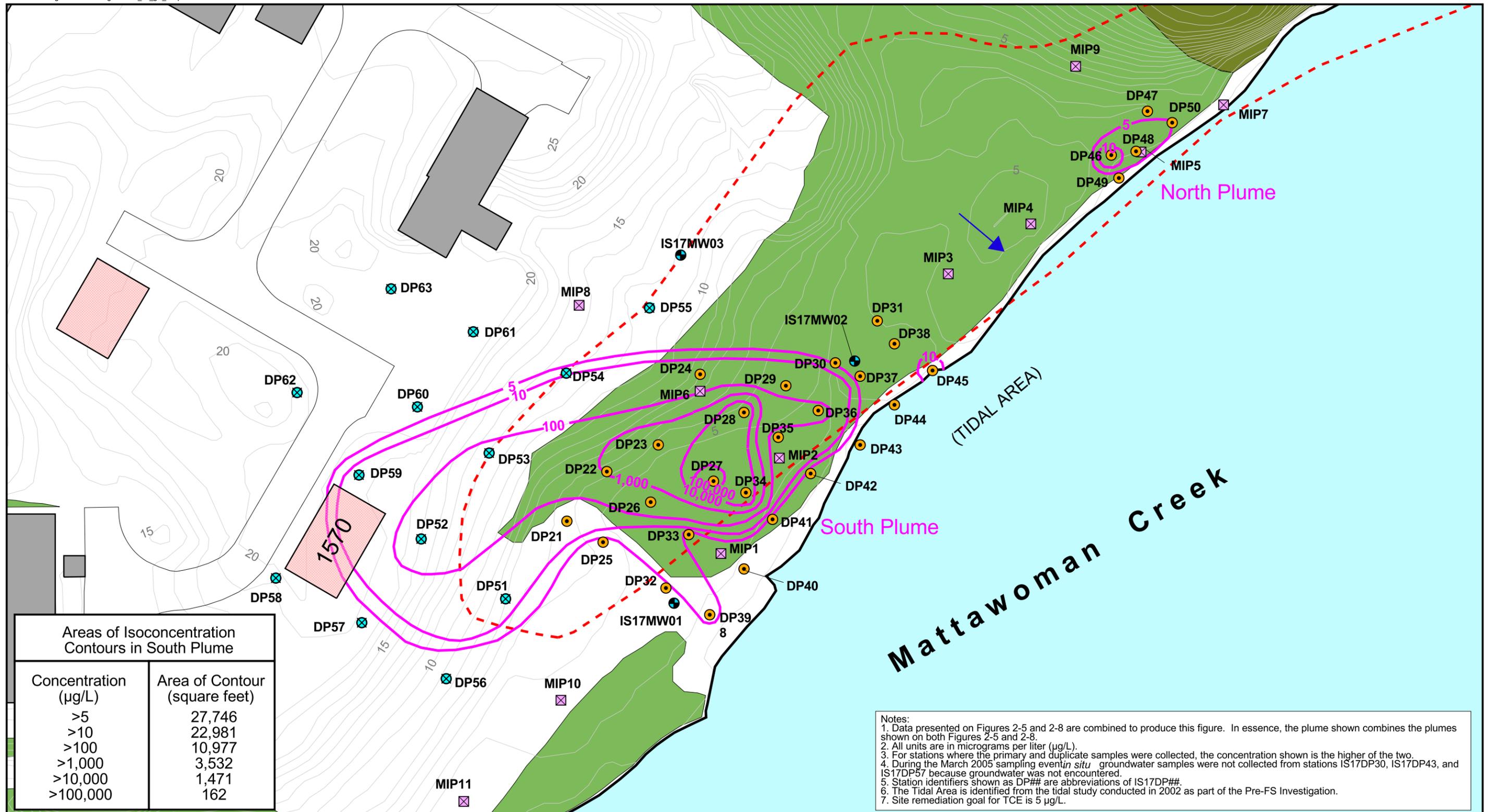


Figure 2-14
Interpolated VC Plume for Surficial Aquifer
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland



Areas of Isoconcentration Contours in South Plume

Concentration (µg/L)	Area of Contour (square feet)
>5	27,746
>10	22,981
>100	10,977
>1,000	3,532
>10,000	1,471
>100,000	162

Notes:

1. Data presented on Figures 2-5 and 2-8 are combined to produce this figure. In essence, the plume shown combines the plumes shown on both Figures 2-5 and 2-8.
2. All units are in micrograms per liter (µg/L).
3. For stations where the primary and duplicate samples were collected, the concentration shown is the higher of the two.
4. During the March 2005 sampling event *in situ* groundwater samples were not collected from stations IS17DP30, IS17DP43, and IS17DP57 because groundwater was not encountered.
5. Station identifiers shown as DP## are abbreviations of IS17DP##.
6. The Tidal Area is identified from the tidal study conducted in 2002 as part of the Pre-FS Investigation.
7. Site remediation goal for TCE is 5 µg/L.

- LEGEND**
- Monitoring Wells with TCE Results
 - July 2002 MIP/DPT Locations with TCE Results
 - December 2004 MIP/DPT and March 2005 DPT Locations with TCE Results
 - August 2005 MIP/DPT Locations with TCE Results
 - Approximate IR Site Boundary
 - Buildings
 - Demolished Buildings
 - Wooded Area
 - Dense Wooded Area
 - Groundwater Flow Direction
 - Road
 - Topographic Elevation Contours (feet msl)
 - Base Boundary
 - Isoconcentration Contour

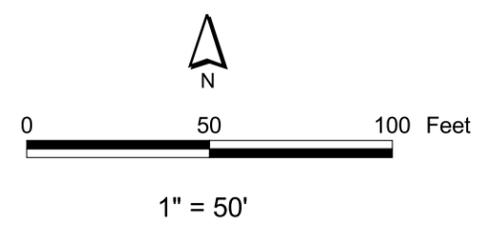
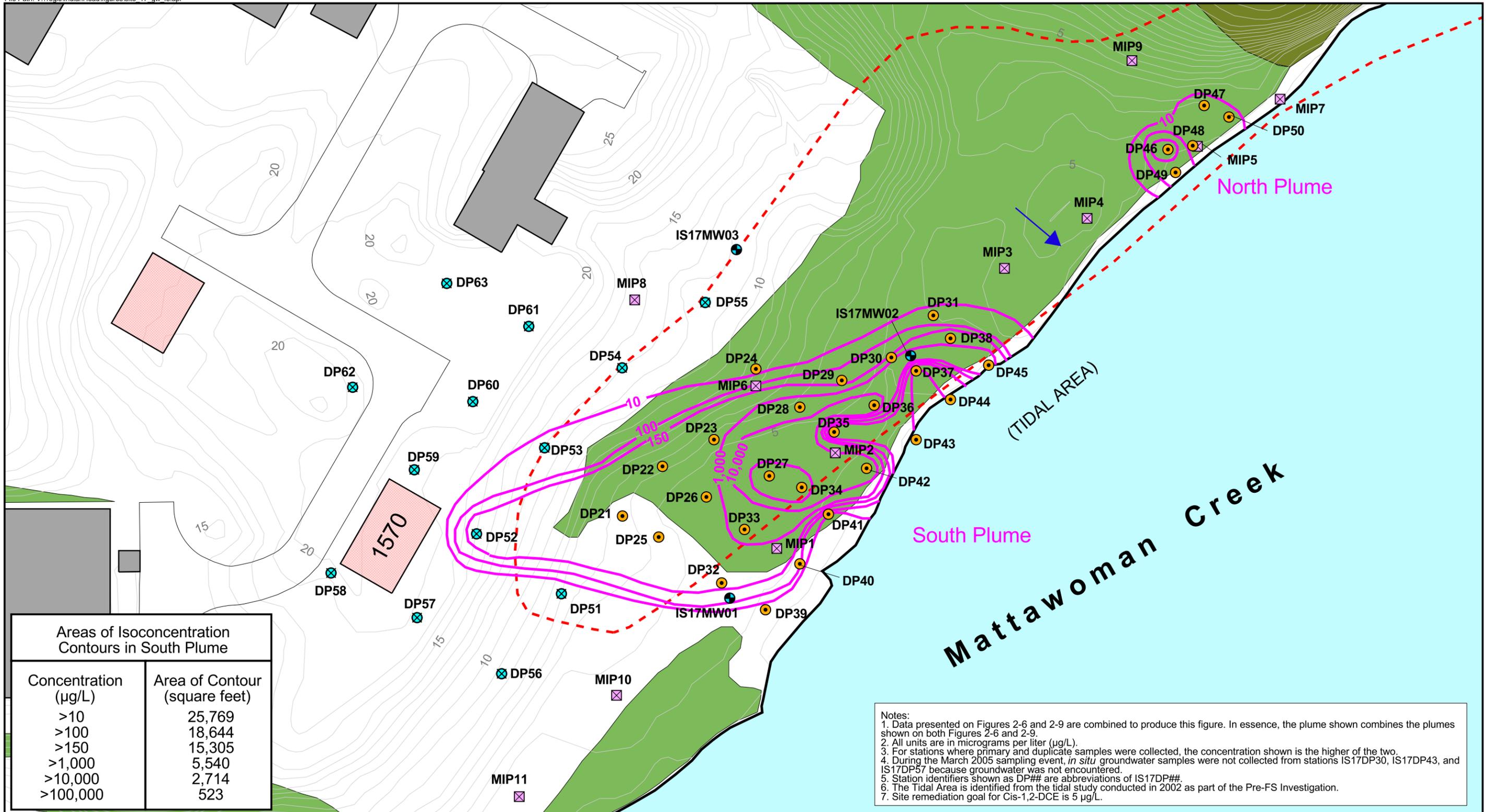


Figure 2-15
Interpolated TCE Plume for Combined
Upper and Lower Surficial Aquifers
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland



Notes:
 1. Data presented on Figures 2-6 and 2-9 are combined to produce this figure. In essence, the plume shown combines the plumes shown on both Figures 2-6 and 2-9.
 2. All units are in micrograms per liter (µg/L).
 3. For stations where primary and duplicate samples were collected, the concentration shown is the higher of the two.
 4. During the March 2005 sampling event, *in situ* groundwater samples were not collected from stations IS17DP30, IS17DP43, and IS17DP57 because groundwater was not encountered.
 5. Station identifiers shown as DP## are abbreviations of IS17DP##.
 6. The Tidal Area is identified from the tidal study conducted in 2002 as part of the Pre-FS Investigation.
 7. Site remediation goal for Cis-1,2-DCE is 5 µg/L.

LEGEND

- Monitoring Wells with Cis-1,2-DCE Results
- July 2002 MIP/DPT Locations with Cis-1,2-DCE Results
- December 2004 MIP/DPT and March 2005 DPT Locations with Cis-1,2-DCE Results
- August 2005 MIP/DPT Locations with Cis-1,2-DCE Results
- Approximate IR Site Boundary
- Buildings
- Demolished Buildings
- Wooded Area
- Dense Wooded Area
- Groundwater Flow Direction
- Road
- Topographic Elevation Contours
- Base Boundary
- Isoconcentration Contour

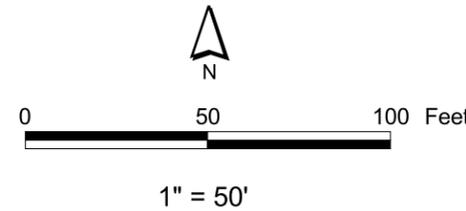
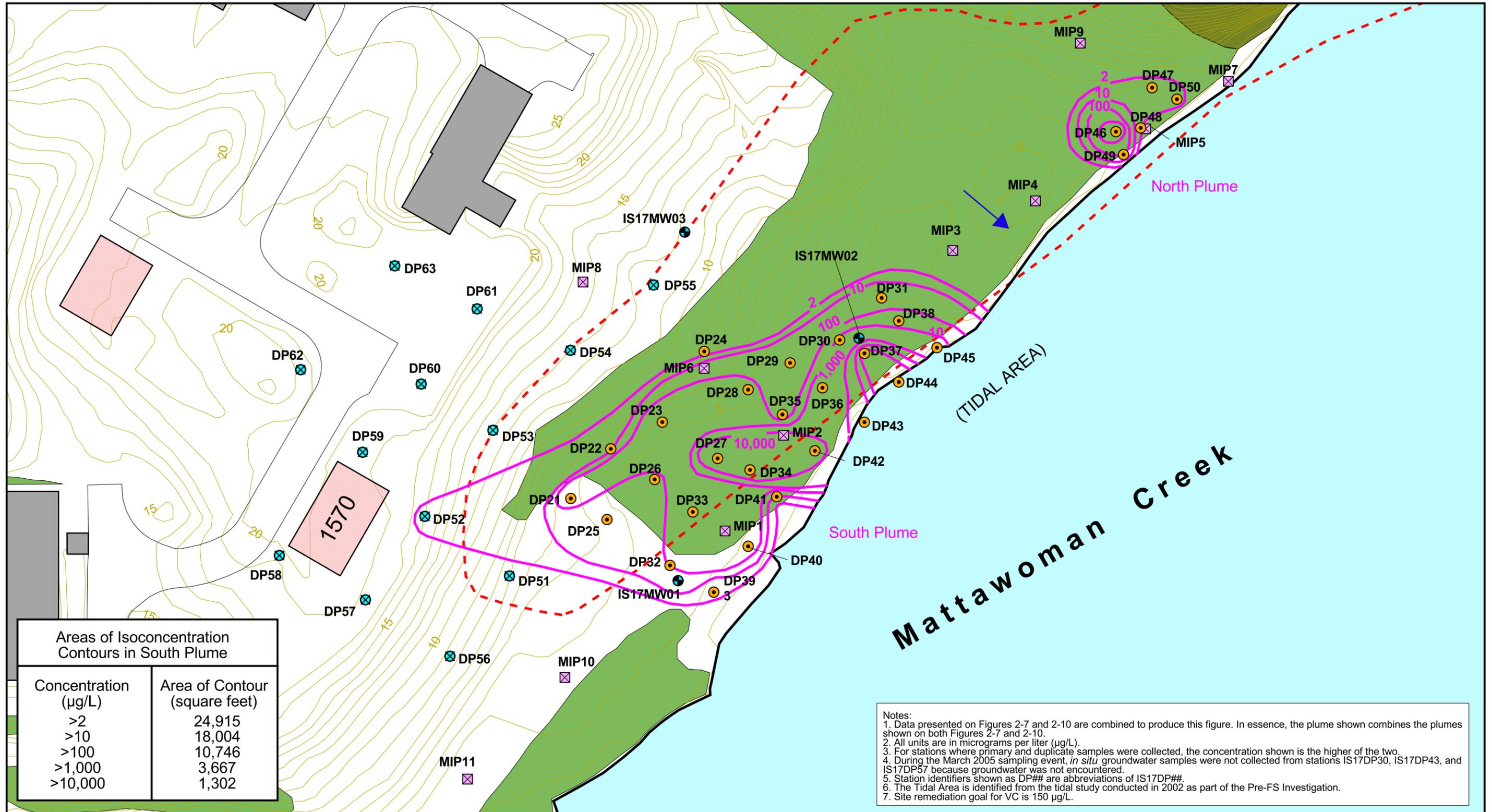


Figure 2-16
 Interpolated Cis-1,2-DCE Plume for Combined
 Upper and Lower Surficial Aquifers
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland



- LEGEND**
- Monitoring Wells
 - ⊠ July 2002 MIP/Direct Push Locations
 - ⊙ December 2004 MIP/Direct Push and March 2005 Direct Push Locations
 - ⊗ August 2005 MIP/Direct Push Locations
 - - - Approximate IR Site Boundary
 - Buildings
 - Demolished Buildings
 - Waterbodies
 - Wooded Area
 - Dense Wooded Area
 - Groundwater Flow Direction
 - ∧ Road
 - ∨ Elevation Contours (feet msl)
 - ∩ Base Boundary
 - ∞ Isoconcentration Contour

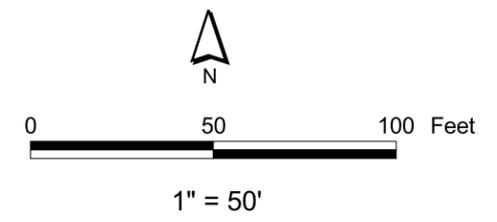


Figure 2-17
Interpolated VC Plume for Combined
Upper and Lower Surficial Aquifers
Site 17 Groundwater Focused Feasibility Study
NSF-IH, Indian Head, Maryland

Remedial Action Objectives, Applicable or Relevant and Appropriate Requirements, Site Remediation Goals, and Areas of Attainment

This section presents general and site-specific RAOs and identifies corresponding applicable or relevant and appropriate requirements (ARARs) for Site 17. General RAOs are defined by the NCP (40 CFR 300.430 et seq.) and CERCLA (42 USC §§ 9601 et seq.), as amended by SARA.

CERCLA § 121(d) of SARA mandates that site remediation under CERCLA must achieve a level or standard of control for hazardous substances that at least attains such levels as specified in ARARs. Only promulgated federal and State of Maryland laws and regulations can be considered ARARs. In addition to ARARs, proposed rules, guidance documents, directives, and similar documents that might affect a CERCLA remedial action are “to-be-considered” (TBC) documents.

ARARs and the facility-wide background concentrations of COCs in shallow groundwater determine the SRGs. SRGs then determine the areas of attainment (AAs).

This section also presents the estimated total contaminant mass and contaminant distribution used in the screening of remedial technologies in Section 4.

3.1 NCP Requirements

The NCP requires that the selected remedy meet the following objectives:

- Each remedial action selected shall be protective of human health and the environment [40 CFR 300.430 (f)(1)(ii)(A)].
- Onsite remedial actions that are selected must attain those ARARs that are identified at the time of the record of decision signature [40 CFR 300.430(f)(1)(ii)(B)].
- Each remedial action selected shall be cost-effective, provided that it first satisfies the threshold criteria set forth in 40 CFR 300.430 (f)(1)(ii)(A) and (B). A remedy shall be cost-effective if its costs are proportional to its overall effectiveness [40 CFR 300.430 (f)(1)(ii)(D)].
- Each remedial action shall use permanent solutions and alternative treatment technologies or resource-recovery technology to the maximum extent practicable [40 CFR 300.430(f)(1)(ii)(E)].

The statutory scope of CERCLA was amended by SARA to include the following general objectives for remedial action at all CERCLA sites:

- Remedial actions “...shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further releases at a minimum which assures protection of human health and the environment” [CERCLA Section 121(d)].
- Remedial actions “...in which treatment that permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances, pollutants, and contaminants is a principal element” [CERCLA Section 121(b)] are preferred. If the treatment or recovery technologies selected are not a permanent solution, an explanation must be published.
- The least-favored remedial actions are those that include “off-site transport and disposal of hazardous substances or contaminated materials without treatment where practicable treatment technologies are available” [Section 121(b)].
- The selected remedy must comply with or attain the level of any “standard, requirement, criteria, or limitation under any federal environmental law or any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any federal standard, requirement, criteria, or limitation” [Section 121(d)(2)(A)].

3.2 Site-Specific RAOs

Site-specific RAOs are based on the exposure setting for which protection would be provided (e.g., protection from ingestion of or direct contact with contaminated shallow groundwater). The potential exposure routes and risks for Site 17 were identified in the HHRA, presented in the RI Report, and summarized in Section 1 of this FS.

Both the level of contamination and the potential exposure routes are considered when developing site-specific RAOs for protecting public health and the environment. The future protection of environmental resources and the means of minimizing long-term disruption to existing facility operations are also considered.

Section 2.4 presents the FS COCs, as identified from the HHRA from using the shallow groundwater in future residential and construction scenarios. The human health COCs are cis-1,2-DCE, VC, toluene, TNT, RDX, aluminum, arsenic, chromium, iron, manganese, and vanadium posed to the future child and adult resident, as well as the future construction worker. TCE is also an FS COC based on its concentrations and spatial distribution in the shallow groundwater. The site-specific RAOs for the shallow groundwater at Site 17 are:

1. Prevent unacceptable risks to human receptors from exposure to contaminants in the shallow groundwater.
2. Prevent migration or discharge of groundwater with FS COCs above SRGs to Mattawoman Creek.
3. Return the shallow groundwater to its beneficial use to the extent practicable.

The remedial action alternatives screened and evaluated in this FS were selected with the objective of meeting the site-specific RAOs. The RAs must also meet the standards defined by ARARs of USEPA and MDE. If the ARARs do not address a particular situation,

remedial actions may be based on the TBC criteria or guidelines. ARARs and TBC criteria are described below.

3.3 Applicable or Relevant and Appropriate Requirements

As required by Section 121 of CERCLA, remedial actions carried out under Section 104 or secured under Section 106 must attain the levels of standards of control for hazardous substances, pollutants, or contaminants specified by the ARARs of federal and State of Maryland environmental laws and state facility-siting laws, unless waivers are obtained. According to USEPA guidance, remedial actions also must be based on non-promulgated TBC criteria or guidelines if the ARARs do not address a particular situation. ARARs are distinguished by the USEPA as either being applicable to a situation or relevant and appropriate to it. These distinctions are critical to understanding the constraints imposed on RAs by environmental regulations other than CERCLA. The definitions of ARARs below are from USEPA guidance (1988).

“Applicable requirements” are standards and other environmental protection requirements of federal or State of Maryland law dealing with a hazardous substance, pollutant, or contaminant and its remedial action. “Relevant and appropriate requirements” are standards and environmental protection criteria associated with federal or State of Maryland law that, although not “applicable” to a hazardous substance or remedial action, address situations sufficiently similar to those at the site that their use is suitable. A requirement may be “relevant” to a particular situation but not “appropriate” because of differences in the duration of the regulated activity or the physical characteristics of the affected media. A requirement that is relevant and appropriate must be met as if it were applicable. Relevant and appropriate requirements that are more stringent than applicable requirements take precedence. However, determining the relevancy and appropriateness of these requirements inherently is a subjective process.

Another factor in determining which response or remedial requirements must be met is whether the requirement is substantive or administrative. CERCLA response actions must meet substantive requirements but not administrative requirements. Substantive requirements are those dealing directly with actions or with conditions in the environment. Administrative requirements implement the substantive requirements by prescribing procedures such as fees, permitting, and inspection that make substantive requirements effective. This distinction applies to onsite actions only; offsite response actions are subject to all applicable standards and regulations, including administrative requirements such as permits.

3.3.1 Other Criteria or Guidelines to Be Considered

Many federal and State of Maryland programs have criteria, advisories, guidelines, and proposed standards that provide recommended procedures if no ARARs exist or if existing ARARs are inadequate. In such instances, the TBC criteria or guidelines may be used to set remedial action levels.

3.3.2 Determination of ARARs

Federal and state ARARs are summarized in Appendix I. The tables summarize the potential ARARs by classification and the TBC criteria, which are included as appropriate for each classification. There are three classifications of ARARs: chemical-specific, location-specific, and action-specific, as further described in this section.

The remedial action alternatives developed in this FS report were analyzed for compliance with federal and state ARARs. The analyses involved identifying potential requirements for each of the alternatives, evaluating their applicability or relevance, and determining if the RAs can achieve the ARARs. Results of that analysis are presented in Section 4 of this report. Any remedial action at the site must meet standards as defined by the ARARs of USEPA and MDE because Site 17 is located within the State of Maryland. If the ARARs do not address a particular situation, remedial actions must be based on the TBC criteria or guidelines.

Chemical-Specific ARARs

Chemical-specific ARARs set health-based concentration limits or discharge limits in various environmental media for specific hazardous substances, pollutants, or contaminants. Examples of federal chemical-specific ARARs for Site 17 are Safe Drinking Water Act maximum contaminant levels (MCLs) and MCL goals that are enforceable standards for drinking water sources and water quality criteria, which set limits for the discharge of water to surface water bodies. TBC criteria would include USEPA Region III risk-based criteria and other site-specific, human health risk-based criteria developed for Site 17 PRGs for the shallow groundwater, which were developed based on the chemical-specific ARARs and TBCs, and are discussed in Appendix I. Chemical-specific ARARs and TBCs for Site 17 are presented in Table I-1 in Appendix I.

Location-specific ARARs

Location-specific ARARs are design requirements or activity restrictions that are based on the geographical position of a site. An example is RCRA location requirements that set USEPA policy for carrying out provisions of Executive Order 11988 (Flood Plain Management) and Executive Order 11990 (Protection of Wetlands). Location-specific ARARs for Site 17 are presented in Table I-2 in Appendix I.

Action-specific ARARs

Action-specific ARARs set performance, design, or other standards for particular activities in managing hazardous substances or pollutants. For example, the design requirements for landfilling hazardous waste, established in RCRA 40 CFR Section 264.301, are action-specific. RCRA contains the greatest number of action-specific ARARs because it regulates hazardous waste management. Action-specific ARARs for Site 17 are presented in Table I-3 in Appendix I.

3.4 SRGs and FS COCs Requiring Remediation

This section presents a discussion of how the SRGs for Site 17 are developed for all FS COCs in groundwater. The SRGs are determined based on the greater of site-specific, risk-based

PRGs, facility-wide background concentrations, or State of Maryland or federal groundwater MCLs, unless this value is determined to provide insufficient protection of human health, in which case an SRG that is protective and/or conforms with EPA, MDE, and Navy guidance⁴ will be selected by risk managers. The MCLs are the applicable chemical-specific ARARs, whereas the risk-based PRGs are the applicable TBCs identified in Section 3.3.2.

A risk-based PRG was not developed for TCE because it was not detected in the monitoring well groundwater samples. Based on the Additional Investigation and Upgradient Investigation analytical results, it was determined that these three RI monitoring wells were constructed on the periphery of the cVOC plumes. Furthermore, the DPT groundwater result at location DP-27 was observed at a concentration of 870,000 µg/L; this translates to approximately 82% of its solubility limit, a strong indication of DNAPL. In addition, TCE represents a constituent that would be originally released to the environment rather than a breakdown product like cis-1,2-DCE and VC. For these reasons, the SRG evaluation for TCE will not follow the steps outlined above for the other FS COCs. The MCL of 5 µg/L will be used as the SRG for TCE.

For the FS COCs other than TCE, risk-based PRGs for the shallow groundwater were calculated for the potential future adult resident, future child resident, future lifetime resident, and future construction worker, although it is unlikely that the site will become a residential area. The technical memorandum provided in Appendix H presents a summary of the risk results used to identify the constituents for inclusion in the PRG calculations and the results. The groundwater PRGs for both residential and construction worker exposure scenarios are summarized in Table 3-1.

Table 3-2 presents the results of the comparison of the risk-based PRGs to the facility-wide background concentration (95% UCL) and the MCLs for the FS COCs. The greater concentration among the PRG, background concentration, and MCL was selected as the SRG for each FS COC.

To evaluate the FS COCs that require remediation, their respective maximum concentration was compared to the SRGs. If the maximum concentration was greater than the SRG, then the FS COC was retained for remediation; if the maximum concentration was less than the SRG, then the FS COC was eliminated for remediation. The retained FS COCs were further evaluated against the NTCRA for soil and drums completed in December 2005, and maximum concentrations of FS COCs detected in the upgradient well at the site.

Table 3-3 presents a summary of the evaluation process for determining the FS COCs requiring remediation. Based on a comparison to the SRGs, TNT, RDX, arsenic, and chromium were eliminated because their maximum concentrations were less than the SRGs. Iron and manganese were eliminated for remediation because the NTCRA removed soil and rusted drums, which are considered to be the source of contamination in groundwater. Although iron and manganese are eliminated for remediation, their potential influence on several remediation technologies for VOC treatment will be considered in the evaluation of RAs. Vanadium was eliminated because the SRG exceedance was observed only in the

⁴ The Navy's policy generally is not to remediate to levels below background concentrations. MCLs are the minimum levels required by federal law. The NSF-IH Risk Managers (i.e., EPA, MDE, NSF-IH, and NAVFAC Washington) can make decisions based on guidance and/or site conditions.

upgradient groundwater well (IS17MW03). Aluminum was eliminated because it is considered to be in the sorbed phase, as indicated by the difference between the total and dissolved concentrations (Figure 2-5); hence, its mobility would be limited. This consideration is based on the comparison of the total aluminum concentrations to the filtered aluminum concentrations, as provided in Section 2.4.2.2. Furthermore, it should be noted that the facility-wide background data suggest that the concentrations of aluminum, iron, and manganese may be related to natural subsurface conditions due to weathering processes. Consequently, the FS COCs requiring remediation are TCE, cis-1,2-DCE, and VC based on their exceedance of the SRGs (Table 3-4).

3.5 Area of Attainment

The AA is defined as the area over which RAOs, and, therefore, the SRGs, are to be met. The AA may not necessarily become the area of remediation, depending on the effectiveness, implementability, and cost for a particular RA.

The design of an effective remediation system considers the monitoring well groundwater data as well as DPT groundwater data in determining the area where most contaminant mass resides. For the shallow groundwater at Site 17, two AAs are identified: South Plume and North Plume (Figure 3-1). The North Plume is approximately 2,000 ft² and encompasses locations DP46 through DP50, MIP5, and MIP7. The South Plume is approximately 38,000 ft² and encompasses the area shown as the AA on Figure 3-1.

Within the South Plume lies the source zone area that is defined as the area where TCE concentrations are greater than 1,000 µg/L. The rationale for selecting the 1,000 µg/L as a cutoff point is based on the results of the SourceDK model (later discussed in Section 4.3.2). The source zone area consists of two sub areas: the inferred DNAPL area (TCE > 10,000 µg/L⁵) and the dissolved area (10,000 µg/L < TCE < 1,000 µg/L) (Figure 3-1).

3.6 Contaminant Mass Estimate

TCE, cis-1,2-DCE, and VC in groundwater are present as adsorbed phase, dissolved phase, and DNAPL free-residual phase. The adsorbed contaminant mass was estimated using the organic carbon partition coefficient (K_{oc}) properties of each of the COCs and the fraction of organic carbon of the soil. Dissolved mass estimates were based on hydrogeologic characteristics presented in the RI Report and on measured aqueous concentrations. The equivalent DNAPL free-residual volume contained within the dissolved groundwater plume was estimated for the South Plume by multiplying the total dissolved and adsorbed mass of TCE with its density of 1.46 kg/L (Cohen, 1993). A DNAPL free-residual volume was not calculated for the North Plume because the observed concentrations do not suggest the presence of DNAPL.

Table 3-5 shows the equations used to estimate the distribution and total mass of these COCs within the two AAs and the corresponding results. The calculation estimated a total

⁵ Although the presence of DNAPL is inferred when TCE concentration is greater than 1% of its pure solubility limit (11,000 µg/L), to be conservative and for simplification, the inferred DNAPL area is defined as area where TCE concentrations exceed 10,000 µg/L.

contaminant mass of 878 pounds of TCE, cis-1,2-DCE, and VC within the two AAs; of which approximately 777 pounds represent the total mass of TCE, which is equivalent to approximately 310 gallons of pure-phase TCE. Table 3-5 also indicates that the contaminant mass is mostly associated with the adsorbed phase. The distribution of TCE mass in the South Plume was further assessed, and the results show that approximately 98 percent of the TCE mass resides in the source zone (Table 3-6); the size of the mass is approximately 15 percent of the total area, exceeding the TCE SRG.

Table 3-1
 Summary of Risk-Based PRGs
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Contaminant of Concern	PRG (µg/L)	Basis for PRG
Residential Scenario		
cis-1,2-Dichloroethylene (cis-1,2-DCE)	150	Target hazard = 1, Child resident
Vinyl chloride (VC)	0.43	Target cancer risk = 10^{-5} , Lifetime resident
	4	(Target cancer risk = 10^{-4})
2,4,6-Trinitrotoluene (TNT)	22	Target cancer risk = 10^{-5} , Lifetime resident
	220	(Target cancer risk = 10^{-4})
Hexahydro-1,3,5-trinitro-1,3,5-triazine (Royal Demolition Explosive - RDX)	6	Target cancer risk = 10^{-5} , Lifetime resident
	60	(Target cancer risk = 10^{-4})
Aluminum	7,800	Target hazard = 1, Child resident
Arsenic	0.45	Target cancer risk = 10^{-5} , Lifetime resident
	4.5	(Target cancer risk = 10^{-4})
Chromium	43	Target hazard = 1, Child resident
Iron	4,700	Target hazard = 1, Child resident
Manganese	150	Target hazard = 1, Child resident
Vanadium	14	Target hazard = 1, Child resident
Construction Worker Scenario		
Vinyl chloride (VC)	76	Target cancer risk = 10^{-5}
	760	(Target cancer risk = 10^{-4})

Notes

PRG - Preliminary Remediation Goal

PRGs based on 10^{-4} are provided for comparison only.

Table 3-2
Recommended Site Remediation Goals
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

FS COCs	Concentration (µg/L)					
	Maximum Concentration	Facility-Wide Background Concentration	EPA SDWA MCL	Human Health Preliminary Remediation Goal		
				Carcinogenic		Non-carcinogenic
				10 ⁻⁵	10 ⁻⁴	
Volatile Organic Compounds						
cis-1,2-Dichloroethylene	4,200	Not analyzed	70	NA	NA	<i>150</i>
Vinyl Chloride	3,000	Not analyzed	2	0.43	4	NA
Explosives						
2,4,6-Trinitrotoluene	5.8	Non detect	No standard	22	220	NA
Hexahydro-1,3,5-trinitro-1,3,5-triazine (Royal Demolition Explosive - RDX)	3.3	Non detect	No standard	6	60	NA
Inorganics						
Aluminum	31,500	9,620	No standard	NA	NA	7,800
Arsenic	4	Non detect	10	0.45	4.5	
Chromium	86.9	16.4	100	NA	NA	43
Iron	71,000	19,900	No standard	NA	NA	4,700
Manganese	2,620	824	No standard	NA	NA	150
Vanadium	49	20.9	No standard	NA	NA	14

Notes

1. µg/L - micrograms per liter
2. Feasibility Study Contaminants of Concern (FS COCs) are selected on the basis of the risk assessment conclusions and comparison to background concentrations (refer to Section
3. Facility-Wide Background Concentration is the 95 percent upper confidence limit from Table A-8 (Non-Turbid Unfiltered Groundwater Samples) in the TTNUS (2002) Background In
4. EPA SDWA MCL - United States Environmental Protection Agency Safe Drinking Water Act Maximum Contaminant Level.
5. Human Health Preliminary Remediation Goals are calculated in Appendix F.
6. Carcinogenic risk of 10⁻⁴ are presented for comparison to 10⁻⁵ risk
7. NA - Not applicable.
8. Recommended Site Remediation Goal are in bold and italics font.

Table 3-3
 Evaluation Process to Determine FS COCs
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Contaminant of Concern	SRG (µg/L)	Maximum Concentration (µg/L)	Considered for Remediation?
Trichloroethylene	5	490,000	Yes
cis-1,2-Dichloroethylene	150	4,200	Yes
Vinyl chloride	2	3,000	Yes
2,4,6-Trinitrotoluene	22	5.8	No – maximum concentration lower than SRG
Hexahydro-1,3,5-trinitro-1,3,5-triazine (Royal Demolition Explosive - RDX)	6	3.3	No – maximum concentration lower than SRG
Aluminum	9,620	31,500	No – mostly exists as sorbed phase, thus low mobility
Arsenic	10	4	No – maximum concentration lower than SRG
Chromium	100	86.9	No – maximum concentration lower than SRG
Iron	19,900	71,000	No – non-time critical removal of the soil and remaining drums in December 2005 removed the source
Manganese	824	2,620	No – non-time critical removal of the soil and remaining drums in December 2005 removed the source
Vanadium	20.9	49	No – maximum concentration was detected in the site's upgradient well IS17MW03. The concentrations within the contamination area are lower than SRG.

Notes

1. SRG - Site Remediation Goal
2. µg/L - micrograms per liter
3. The maximum concentration of TCE is from a DPT groundwater sample whereas the maximum concentrations of all other parameters are from monitoring well groundwater samples.

Table 3-4
 FS COCs Requiring Remediation
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

FS COC _c	SRG (µg/L)	Comment
Trichloroethylene (TCE)	5	Technically not a COC because maximum TCE concentration was not used in HHRA. TCE is presumed to present unacceptable risks to human health and is the presumed source for cis-1,2-DCE and VC.
cis-1,2-Dichloroethylene (cis-1,2-DCE)	150	Risk-driving COC
Vinyl chloride (VC)	2	Risk-driving COC

Notes

SRG - Site Remediation Goal
 µg/L - micrograms per liter

Table 3-5
 Estimate of Contaminant Mass in Shallow Groundwater
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Site Characteristics		
Parameter	Input Value	Notes
Effective porosity	0.20	Assumed based on sandy clay material
Bulk soil density (kg/L)	1.60	Assumed based on sandy clay material
TOC (mg/kg)	36,333	Average value from DP-32 (57,000), DP-37 (24,000), and DP-40 (28,000)
foc (fraction of organic carbon)	0.036	Calculated from TOC

Properties of Constituents				
Constituent	Koc (L/kg)	Kd (L/kg) = foc . Koc	MW/Density (L/kg)	Notes
TCE	97.00	3.52	131.5/1.46	Source: EPA soil screening guideline (http://www.epa.gov/superfund/health/conmedia/soil/pdfs/part_5.pdf)
cis-1,2-DCE	35.50	1.29	97.00	
VC	18.60	0.68	62.50	

Plume ¹	Groundwater Concentration Range (ug/L)	Plume Characteristics				Dissolved Phase			Adsorbed Phase			Subtotal Mass (lbs)		Total Mass (lbs) by Constituent	
		Plume Area (SF) ²	Thickness (ft) ³	Volume (CF)	Volume (L)	Cw (ug/L)	Vw (L)	Mass (lbs)	Vs (kg)	Cs - ug/kg (Cw x Kd)	Mass (lbs)	Dissolved	Adsorbed		
South Plume															
Lower Surficial Aquifer	TCE	870000 - 10000	1471	12	17,652	499,834	48000	99,967	11	639,788	552,332	715.5	13	764	777
		10000 - 1000	2061	12	24,732	700,311	5500	140,062	2	896,398	19,384	35.2			
		1000 - 100	6886	12	82,632	2,339,808	550	467,962	1	2,994,954	1,938	11.8			
		100 - 5	12827	12	153,924	4,358,512	52.5	871,702	0	5,578,895	185	2.1			
	cis12DCE	220000 - 10000	1573	12	18,876	534,493	15500	106,899	4	684,151	19,992	27.7	7	57	64
		10000 - 1000	4126	12	49,512	1,401,982	5500	280,396	3	1,794,537	7,094	25.8			
		1000 - 150	4914	12	58,968	1,669,738	575	333,948	0	2,137,264	742	3.2			
	VC	80000 - 10000	762	12	9,144	258,922	45000	51,784	5	331,420	30,411	20.4	8	30	38
		10000 - 1000	2416	12	28,992	820,937	5500	164,187	2	1,050,800	3,717	7.9			
		1000 - 100	4811	12	57,732	1,634,739	550	326,948	0	2,092,466	372	1.6			
100 - 10		5107	12	61,284	1,735,318	55	347,064	0	2,221,207	37	0.2				
	10 - 2	8342	12	100,104	2,834,545	6	566,909	0	3,628,217	4	0.0				
North Plume															
Shallow	VC	100 - 2	1068	8	8,544	241,932	51	48,386	0	309,673	34	0.0	0.01	0.02	0.03

Summary Total Mass (Dissolved + Adsorbed)		
TCE	777	lbs
cis-1,2-DCE	64	lbs
VC	38	lbs
Total Mass	879	lbs

Equivalent volume of DNAPL - TCE in South Plume only **310** gallons

Assumptions/Notes:

- 1) Based on the isoconcentration figures (Figures 2-5 through 2-11).
- 2) Area was calculated using the Arc View GIS software.
- 3) The shallow DPT groundwater samples were collected from 2 ft bgs to 12 ft bgs and the deep groundwater samples were collected from 8 ft bgs to 18 ft bgs. For the mass estimate calculation the shallow plume thickness was assumed to be 8 ft (2 ft bgs - 10 ft bgs) and the deep plume thickness to be 8 ft (10 ft bgs - 18 ft bgs).

48,000 - Calculated as as weighted average because the maximum concentration only represents an isolated detection; it is assumed that the area where the maximum concentration was detected represents 10% of the total area.

552,332 - Calculated as as weighted average using mass profiling results from bench scale study; it is assumed that the bench scale mass profiling area represents one-third of the total DNAPL area.

TABLE 3-6
 Estimate of TCE Mass in Shallow Groundwater
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Area	Square Footage (SF)	Volume of Bulk Soil (CY)	Adsorbed TCE Mass (lbs)	Dissolved TCE Mass (lbs)	Total TCE Mass (lbs)	% of Total Area		% of Total TCE Mass	
Source Zone									
Inferred Residual DNAPL Area (TCE > 10,000 µg/L)	1,471	654	715	11	726	6%	15%	93%	98%
Dissolved Source - 10,000 µg/L > TCE > 1,000 µg/L	2,061	916	35	2	37	9%		5%	
Dissolved Plume									
1,000 µg/L > TCE > 100 µg/L	6,886	3,060	12	1	12	30%	85%	2%	2%
100 µg/L > TCE > 5 µg/L	12,827	5,701	2	0	2	55%		0%	
Total	23,245	10,331	764	13	777	100%		100%	

Notes:

SF – Square feet; CY – Cubic yard; lbs - pounds



Notes:
 1. All units are in micrograms per liter ($\mu\text{g/L}$).
 2. Station identifiers shown as DP## are abbreviations of IS17DP##.
 3. The Area of Attainment is derived from the area where SRGs were exceeded for TCE, cis-1,2-DCE, and VC as shown on Figures 2-14, 2-15, 2-16 respectively.
 4. Inferred DNAPL area is determined as the area where TCE concentration is greater than 10,000 $\mu\text{g/L}$.

LEGEND

Monitoring Wells	Wooded Area
July 2002 MIP/Direct Push Locations	Dense Wooded Area
December 2004 MIP/Direct Push and March 2005 Direct Push Locations	Groundwater Direction
August 2005 MIP/Direct Push Locations	Road
Approximate IR Site Boundary	Elevation Contours (feet msl)
Buildings	Inferred DNAPL Area
Waterbodies	Source Zone/Target Remediation Zone
	Area of Attainment

0 60 120 Feet

1" = 60'

Figure 3-1
 Area of Attainment and Target Remediation Zone
 Site 17 Groundwater Focused Feasibility Study
 NSF-IH, Indian Head, Maryland

Identification and Screening of Remedial Technologies and Assembly of Remedial Alternatives

This section discusses the general response actions (GRAs) developed to address the RAOs outlined in the previous section. Potential remedial technologies and specific process options, which underwent a primary screening to determine their suitability as part of an RA, are identified and described for each response action.

4.1 General Response Actions

GRAs are broad classes of responses or remedies developed to meet the site-specific RAOs defined for Site 17 groundwater in Section 3. Each action is intended to address specific constituents and the possible migration pathways and exposure routes in groundwater. Although an action may be capable of meeting an objective, combinations of actions may be more cost-effective in meeting all the objectives.

Table 4-1 presents the GRAs and the preliminary screening of various technologies within each GRA. *Ex situ* treatment technologies of contaminated groundwater were not considered in the preliminary screening of technologies and process options because the COC plumes at Site 17 appear to be stable (Figures 2-5 through 2-13). Furthermore, because of the proximity of the site to Mattawoman Creek, if groundwater is extracted, it is likely that creek water intrusion in the extraction well would occur, thereby decreasing the effectiveness of the remedy. *In situ* mass transfer-based technologies, such as soil vapor extraction and air sparging, within the *in situ* treatment GRA, were not considered. Because of the inferred presence of DNAPL, there will be a continuing source of contamination that cannot effectively be removed by these technologies because of mass-transfer rate limitations, thus prolonging the remediation timeframe.

The GRAs listed below have been identified as being potentially applicable for Site 17 groundwater:

- No action
- Institutional controls (ICs)
- Containment
- *In situ* Treatment
- Removal and Offsite Disposal

The *no action* response is included in the study because the NCP requires that a no-action alternative be developed as a baseline for evaluating the RAs.

The *institutional controls* response action is a category of alternatives that can be used as one or as part of another response action. Institutional controls include activities such as

restricting groundwater use through land-use or deed restrictions, access restrictions, and groundwater monitoring.

Containment response actions are technologies that prevent the migration of contaminated groundwater. Containment technologies include: physical barriers to flow such as slurry walls or sheet piling; hydraulic barrier such as extraction wells; and chemical barriers, such as permeable reactive barriers (PRBs) that allow groundwater flow but remove contaminants.

In situ Treatment response actions are *in situ* methods of reducing the toxicity, mobility, or volume of contaminants in groundwater. Treatment technologies include biological, chemical, and physical processes.

Removal and Offsite Disposal response actions include actions taken to physically remove contaminated soil (saturated soil and the associated groundwater) from the site and dispose of the material in an offsite permitted disposal facility or onsite facility.

4.2 Identification and Screening of Remedial Technologies and Process Options

The next step in the FS process is to identify remedial technologies and process options for each GRA. *Remedial technologies* are general categories of technologies such as chemical treatment, thermal destruction, or immobilization. *Process options* are specific processes within each technology type. For example, the chemical treatment remedial technology includes process options such as precipitation, ion exchange, and oxidation/reduction.

Technologies and process options that potentially apply to Site 17 groundwater were screened on the basis of their effectiveness, implementability, and relative cost for treating the FS COCs requiring remediation. Specific remedial technologies or process options were evaluated on the basis of their potential performance relative to other remedial technologies and process options within the same GRA.

In the screening process, *effectiveness* pertains to the following:

- The capability of the technology to attain RAOs for groundwater.
- The capability of a remedial technology to handle the estimated areas or volumes of groundwater and to prevent or minimize the release of hazardous substances to potential receptors.
- The degree of protection afforded to human health and the environment during construction and implementation of the remedial technology.
- The reliability and performance of the technology with respect to the site conditions.

Implementability pertains to the following:

- The availability and capacity of treatment, storage, and disposal services.
- The constructability of the remedial technology under facility conditions.

- The time needed to implement the remedial technology, to achieve beneficial results, and to satisfy the RAOs.

Relative cost screening considers the general capital and operation and maintenance (O&M) costs associated with the process options. During the screening phase, detailed, site-specific cost estimates were not developed. The relative cost of process options was considered only if the cost of an option was believed to be significantly higher than the cost for other process options comparably effective or implementable.

Table 4-1 presents the screening of the groundwater technologies and process options, as well as the rationale for why a technology or option is eliminated or retained for further consideration. Where possible, a single process option was selected as representative of a GRA. In some cases, more than one process option was selected because the options could not be differentiated in terms of effectiveness, implementability, or relative cost. The following sections briefly discuss the remedial technologies and process options that passed the effectiveness, implementability, and cost screening for each GRA.

4.2.1 No Action

The no-action response is required by the NCP and was retained to provide a basis for comparison with the other actions. This alternative, however, does not reduce COC migration or concentrations, and would not meet the RAOs for Site 17 groundwater.

4.2.2 IC Actions

The ICs retained comprise land use controls (LUCs) and groundwater monitoring. Neither option (i.e., LUCs or groundwater monitoring) reduces groundwater contaminant migration or concentrations, but, when combined with other RA(s), can help evaluate when RAOs are met and reduce the potential for exposure until RAOs are met.

Groundwater monitoring on a periodic basis would provide data to determine when RAOs are met and ICs are no longer needed. LUCs may be terminated upon demonstration that groundwater COCs no longer exceed relevant ARARs.

Because NSF-IH is an active military installation, some IC measures are currently in place, such as master plan regulations, base access restrictions, and a safety program. Specific IC measures applicable for Site 17 would be included in an NSF-IH LUC implementation plan (LUCIP).⁶

4.2.3 *In-situ* Treatment

The technologies evaluated were biological treatments (enhanced anaerobic bioremediation with carbon source materials, phytoremediation, and MNA) and physical/chemical treatments (ISCO, *in situ* chemical reduction [ISCR], and air sparging). However, the technologies that passed the screening are MNA, ISCO, and ISCR.

⁶ The conditions and boundaries of sites subject to LUCs, as well as the terms and conditions of the LUCs themselves, must be recorded on appropriate installation maps, master plans, real estate records and Geographic Information Systems (GIS). (Navy, 1999).

Monitored Natural Attenuation

As described in Table 4-1, MNA is the only retained option under the *in situ* biological treatment category. As defined by an OSWER Directive (USEPA, 1997), MNA is a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These *in situ* processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants. The term MNA, as used in the Directive, refers to the reliance on NA processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remedial objectives within a timeframe that is reasonable compared to that offered by other more active methods. To demonstrate that NA is occurring at a site, it is generally evaluated using a “lines of evidence” approach. They are:

1. Documented loss of contaminants over time.
2. Favorable chemical and geochemical data, including:
 - Depletion of terminal electron acceptors and donors,
 - Increasing metabolic byproduct concentrations, and
 - Increase and subsequent decrease of breakdown product concentrations.
3. Microbial data that support the occurrence of degradation and provide for the development of estimated biodegradation rates.

Implementation of MNA as an RA involves a significant investment in time, effort, and funding for long-term monitoring and modeling to ensure that MNA occurs at a rate that is protective of human health and the environment. The USEPA guidance entitled “*Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater*” (EPA/600/R-98/128; USEPA, 1998) recommends a screening process to determine if MNA is likely to be a viable RA before additional time and money are invested for further study.

Because of the absence of downgradient monitoring wells at Site 17, MNA assessment for groundwater contamination at this site is limited to the preliminary screening analysis. This analysis involves mostly qualitative assessment of the data. The following sections present a general overview; analysis of the NA processes for TCE, cis-1,2-DCE, and VC; the preliminary screening process to determine the viability of MNA as a remedy for Site 17 groundwater; and the site-specific remediation timeframes based on the SourceDK preliminary screening model (AFCEE, 2005).

Overview and Analysis of MNA Processes of Chlorinated Solvents

Chlorinated ethenes, such as TCE, cis-1,2-DCE, and VC, may be biodegraded through three different pathways: 1) as an electron acceptor – known as reductive dechlorination; 2) as an electron donor – known as anaerobic oxidation; and, 3) via co-metabolism (USEPA, 1998).

The most effective process for the natural biodegradation of the more highly chlorinated solvents is reductive dechlorination. In this process, the chlorinated hydrocarbon is used as an electron acceptor (not as a carbon source), and chlorine atoms are sequentially removed and replaced with hydrogen atoms in step-wise reactions. In general, TCE can be sequentially dechlorinated to cis-1,2-DCE, VC, and finally the innocuous end product,

ethene. It has been demonstrated that the fewer the number of chlorine atoms, the lesser tendency of chlorinated ethenes to undergo reductive dechlorination. Thus, typically under anaerobic conditions, PCE undergoes reductive dechlorination to TCE. Dechlorination of TCE to cis-DCE can only occur when the aquifer is under iron-reducing conditions at a minimum. Reduction of cis-DCE to VC has been documented to require at least sulfate-reducing conditions. Finally, dechlorination of VC to ethene would occur predominantly under methanogenic conditions. As a result, at most sites, reductive dechlorination of chloroethenes is often incomplete and frequently leads to the accumulation of cis-DCE and VC, which has been observed in Site 17 groundwater, indicating a strong evidence of reductive dechlorination. This conclusion is further supported by the fact that VC was not typically used as a solvent at most military facilities; therefore, VC is not normally present as a primary contaminant in solvent spills associated with military activities (Chapelle, 2003). As a result, the presence of VC in groundwater associated with a chlorinated ethene release is strong evidence of reductive dechlorination, with the process halting at VC because of a lack of methanogenesis or aerobic conditions (USEPA, 1998).

In addition to reductive dechlorination, VC has been demonstrated to undergo oxidation to carbon dioxide under anaerobic conditions when strong oxidants, such as iron(III) oxides, are sufficiently available in groundwater. Anaerobic oxidation provides an alternative to the slow reductive dechlorination of VC to ethene. Within Site 17 groundwater, anaerobic oxidation may contribute to the reduction in VC concentrations. The low concentration of iron(II) and the high concentration of total dissolved iron indicates that the aquifer is likely to have a high content of iron(III), an optimum condition for mineralization of VC (USEPA, 1998).

The third pathway, co-metabolism, occurs when the degradation is catalyzed by an enzyme or cofactor that is fortuitously produced by the organisms. This enzyme forms unstable intermediary products with chlorinated ethenes that degrade rapidly. An organic substrate such as methane or propane is typically required to induce co-metabolic degradation. The co-metabolism of chlorinated solvents has been primarily documented under aerobic conditions. Chlorinated ethenes, with the exception of PCE, have been reported to undergo cometabolic degradation under aerobic conditions. Typically, the rate of co-metabolism increases as the degree of dechlorination decreases.

Natural Attenuation Screening

USEPA (1998) developed a method of screening the potential for natural biodegradation of chlorinated compounds. The screening process determines if natural biodegradation of VOCs and subsequent breakdown products is likely to be a viable RA.

Table 4-2 presents the results of the screening process for MNA at Site 17. The worksheet was populated with data collected during the Pre-FS investigation (2002) and Additional Investigation (2004-2005). It should be noted that the 2002 data were collected during the summer season, while the 2005 data were obtained during the winter season. The total scores of 19 for monitoring wells IS17MW02 and 18 for IS17MW01 indicate that there is an adequate evidence of MNA through reductive dechlorination processes in groundwater at Site 17. These scores may be affected by the fact that well IS17MW01 is cross-gradient, rather than downgradient, from the source area, and well IS17MW02 is present in the probable DNAPL source area although it is not at the location of highest concentrations observed in

the DPT groundwater samples. The scores, however, provide an indication that NA processes are occurring.

Estimated Remediation Timeframes

To assess the viability, effectiveness, and implementability of MNA as the selected remedy for groundwater at Site 17, the remediation timeframe with associated uncertainties was assessed through modeling. Therefore, the objectives of the modeling are:

1. To assess the remediation timeframe based on sole reliance on NA processes to remediate the inferred DNAPL area.
2. To assess the target end-point TCE concentration during the source treatment that would result in a timeframe of less than 30 years if NA processes were solely to be used to achieve the TCE SRG from the target end point concentration.

To accomplish the above objectives, the SourceDK model was used. SourceDK is a planning-level screening model for estimating groundwater remediation timeframes with associated uncertainties. According to the SourceDK model, “remediation timeframe” is the time required for the high-concentration source zones at a site to reach a certain target concentration. The model uses Microsoft Excel™ and provides three different approaches or Tiers, from easiest to most complex conditions. Below is a summarized description of the tiers:

1. Tier 1 – Extrapolation: Source zones that have extended records of concentration versus time can be analyzed using the Tier 1 tool. With this tool, log concentration vs. time is plotted and then extrapolated to estimate the time needed to achieve a cleanup goal, assuming the current trend continues.
2. Tier 2 – Box Model: This tier consists of an enhanced BIOSCREEN model. The box model provides an estimate of the contaminant mass in the source zone and the mass flux of contaminants leaving the source zone as well as biodegradation processes possibly occurring within the source zones.
3. Tier 3 – Process Model: This tier employs more detailed fundamental process-based equations to determine the time and amount of naturally flowing groundwater required to flush out dissolved-phase and non aqueous phase liquid (NAPL) dominated constituents from the source zone.

Evaluation of NA as Sole Treatment Option At Site 17, none of the groundwater monitoring wells is placed within the TCE source area; therefore, for the purpose of SourceDK modeling, only DPT groundwater analytical data were used. The maximum TCE detection of 870,000 µg/L indicates that TCE is present as an inferred DNAPL phase. Thus, the Tier 3 approach was used to determine the time required to flush out both DNAPL and dissolved phases of TCE from the source zone to achieve the SRG.

Table 4-3 shows the input parameters, assumptions, and the results of the Tier 3 – NAPL Dissolution Model performed for the source area within Site 17 shallow groundwater, while Table 4-4 shows the results for Tier 3 – Dissolved Phase Model. Appendix J presents the detailed equations and the SourceDK model results. To be conservative, both the low and high values of K were used in the model. As shown in Table 2-2, the K values at Site 17 vary

greatly. The K values of 0.9 feet/day and 8.3 feet/day (estimated from *in situ* K testing) were used as the low and high values, respectively.

As shown in Table 4-3, the timeframes for incoming clean groundwater passing through the source zone to flush out the DNAPL TCE and achieve the cleanup goal of 5 µg/L range from 2.5 to 10 years using the high K value and from 23 to 94 years using the low K value. As shown in Table 4-4, the timeframes to flush out the dissolved TCE and achieve the cleanup goal in the source zone are even longer than the timeframes for DNAPL dissolution. The timeframes are approximately 34 years and 312 years for the high and low K values, respectively.

It is unlikely that the MCL cleanup goal will be achieved within 34 years because of the following: 1) If it is assumed that TCE was released during the same period as the drum disposal (1960s to 1980s), TCE is still present at high concentrations even 40 years after the likely original release as evidenced by the DPT groundwater results at locations IS17GW02 and DPT-27, within the likely source area; 2) High organic carbon content of the saturated soil (Table D-5 in Appendix D) indicates a high retardation factor for TCE. The projected timeframes indicate that sole reliance on MNA processes to treat the DNAPL and the dissolved phase in the source zone is not feasible; therefore, source treatment is highly recommended to expedite the overall remediation timeframe.

Evaluation of NA as Combined Treatment Option The next part of the modeling effort was performed to determine if MNA could be used in conjunction with another remedy, but as a polishing step in the dissolved plume area to achieve the SRG within a reasonable timeframe (i.e., less than 30 years). If MNA were feasible, the end point concentration for active treatment in the source area will not be as low as the SRG, which would translate to cost savings. Unlike the modeling conducted for NA as a sole treatment option, this combined treatment option considered biodegradation processes.

After an aggressive treatment is completed within the area where the TCE concentration is equal to or greater than 1,000 µg/L, it is assumed that TCE contamination will no longer be present in the DNAPL phase. Tier 2 - Box Model was used to estimate the NA timeframes. The following assumptions were used in the modeling:

- Because the site-specific biodegradation rate constant (λ) is not available for Site 17, literature values of biodegradation rate constants from the USEPA Biochlor Model User's Manual (Aziz, 2002) were used for the modeling. To be conservative, the model was run using the 25th percentile and median values of biodegradation rate constants for TCE. Based on the elevated concentrations of cis-1,2-DCE and VC⁷ and the high content of natural organic materials (NOM)⁸ that can serve as electron donors for reductive dechlorination of TCE, the site-specific biodegradation rate constant is likely in the high end of the literature median value.

⁷ Maximum concentrations of cis-1,2-DCE and VC at IS17DPT27 were 170,000 µg/L and 14,000 µg/L, respectively (Figures 2-10 and 2-11).

⁸ Soil TOC in the uncontaminated area was detected as high as 57,000 milligrams per kilogram (mg/kg), with an average TOC value of 36,333 mg/kg (Table D-5).

- A K value of 8.3 feet per day (ft/day) based on the results of the slug test⁹ was used in the modeling. This value is representative of the K within the plume and downgradient areas.
- The average source groundwater concentration at Time = 0 was assumed to be 1,000 µg/L. This assumption is conservative because after the aggressive ISCO or ISCR within the area where TCE concentration is equal to or greater than 1,000 µg/L is completed, the average source groundwater concentration will be below 1,000 µg/L.

Table 4-5 shows the input parameters, assumptions, and the results of the Tier 2 - Box Model for Site 17 shallow groundwater. The input and output runs of the model are presented in Appendix J. As shown in Table 4-5, the timeframes for achieving the TCE cleanup goal of 5 µg/L range from 9 to 37 years, using the 25th percentile λ value, and 8 to 33 years using the median λ value. The timeframes based on the 25th percentile λ value may not be applicable for Site 17 because of the elevated concentrations of cis-1,2-DCE and VC, the high content of NOM, and the fact that the groundwater plume has been stable for more than 5 years. Therefore, the timeframes resulting from the median λ value, which range from 8 to 33 years, with a midrange of 17 years, may be more representative of Site 17. Based on these assessments, it was concluded that NA processes are viable treatment mechanisms for reducing TCE from 1,000 µg/L to its cleanup goal of 5 µg/L within the recommended timeframe of fewer than 30 years. Therefore, MNA can be used as a treatment mechanism in the AA where the TCE concentration is less than 1,000 µg/L.

In situ Chemical Oxidation

ISCO involves injecting chemical reagents into the groundwater to oxidize contaminants. Because of its aggressiveness and sometimes relatively high cost, ISCO is typically implemented for the treatment of contamination source areas or when time for achieving remediation goals is a main factor. This technology, generally, is not cost effective for large plumes with low contaminant concentrations. Common oxidants are hydrogen peroxide-based Fenton's reagent, potassium or sodium permanganate, and persulfate. Ozone can also oxidize organic contaminants *in situ*, but has been used less frequently to date.

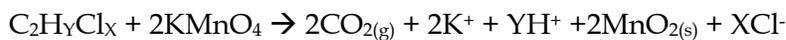
Ozone. Ozone gas can oxidize contaminants directly or through the formation of hydroxyl radicals. Like peroxide, ozone reactions are most effective in systems with acidic pH. The oxidation reaction proceeds with extremely fast, pseudo-first order kinetics. Ozone oxidation reactions occur in gas phase inside the "bubble." As such, ozone oxidation may be rate limited by aqueous phase diffusion and volatilization. Because of ozone's high reactivity and instability, ozone is produced on site, and requires closely spaced delivery points (e.g., air sparging wells). As a result, the process is complex and requires high capital investment; therefore, the use of ozone as an oxidant for the Site 17 shallow groundwater was not considered further.

Fenton's Reagent. Fenton's reagent is produced on site by adding an iron catalyst to a hydrogen peroxide solution (ITRC, 2005). A 4%–20% peroxide solution is common for this application. An amendment for pH adjustment may be needed, as Fenton's reagent is more

⁹ The slug test was conducted on three monitoring wells; the results indicated a range of K values from 0.9 ft/day, which represents the K for the upgradient area of Site 17, to 8.3 ft/day, which represents the K for the plume and the downgradient area of Site 17.

effective under acidic pH (2 to 4). The reaction is exothermic in nature, generating considerable heat and gases (mostly oxygen). The gases often form vertical preferential pathways in the subsurface. Because of the low pH and prolonged elevated subsurface temperature and gases it creates, application of Fenton's reagent at Site 17 groundwater has disadvantages, including potential hindrance of the ongoing NA processes and risks to the ecological receptors. The interbedded clay lenses in the Site 17 subsurface system may act as confining layers and trap the gas in the subsurface, filling the pore space and inhibiting the distribution of the oxidant. Vertical preferential pathways created by upward migrating gases may hinder any injection technologies after an application of Fenton's reagent, as daylighting becomes an issue. Based on these assessments, the use of Fenton's reagent as an oxidant for the Site 17 shallow groundwater was not considered further.

Permanganate. Permanganate is a strong oxidant, following this general oxidation reaction with chlorinated ethenes:



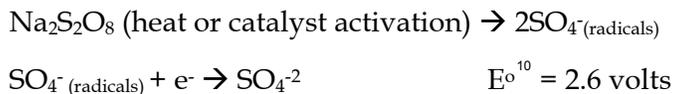
In this reaction, the chlorinated ethenes are destroyed, producing carbon dioxide gas, solid manganese dioxide, and several dissolved ions. Carbon dioxide (CO₂) exists naturally in subsurface from biological processes and bicarbonate partitioning in the groundwater. Manganese dioxide (MnO₂) is a mineral naturally present in many soils. Excessive precipitation of manganese dioxide can reduce the permeability of the soil, inhibiting injection of the oxidant. The reagent may oxidize natural organic matter (NOM) to which metals are sorbed, or the hydrogen cation generated may decrease groundwater pH if not buffered, leading to potential mobilization of redox-sensitive and exchangeable sorbed metals and biological perturbation (ITRC, 2005).

The permanganate total demand is based on the stoichiometric requirements of COC mass and the SOD. The latter is determined by the natural organic matter and reduced minerals. When delivered in stoichiometric excess, permanganate is relatively stable and persistent in the subsurface, allowing migration by advective and diffusive processes. For potassium permanganate applications, a 1 to 5 weight percent solution is prepared on site from potassium permanganate crystals. For sodium permanganate a 40% weight solution is diluted on site to the required weight percent for injection. Permanganate contains trace amounts of metallic impurities, such as chromium and lead. Permanganate also is known to mobilize sorbed metals temporarily.

The bench-scale studies concluded that using permanganate as an oxidant is ineffective for treating TCE at Site 17 because of the high SOD (> 15 grams per kilogram) and the short subsurface longevity (almost exhausted after Day 1 of oxidant contact) (CH2M HILL, 2008a). Brown (2003) has suggested that in the oxidative reactions using permanganate, the consumptions of permanganate in the subsurface is primarily because of its reaction with organic material and reduced soil minerals. Delivering a high quantity of permanganate would also entail potential aesthetic and ecological impacts to the adjacent creek. Discoloration of water (purple water) may occur and potentially linger for several months. Based on these assessments, the use of permanganate as an oxidant for Site 17 shallow groundwater was not considered further.

Persulfate. Sodium persulfate is a stable and strong oxidant. However, activation of persulfate to form sulfate radicals requires heating typically accomplished by steam injection or catalysis by transition metals such as iron (II), copper, silver, and manganese. The optimum temperatures for the oxidation reactions of CT are between 35°C and 45°C (FMC, 2001). Adverse ecological effects associated with heat are likely to be attenuated well before discharge to receiving waters.

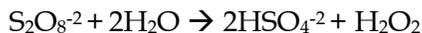
The persulfate anion is a more powerful oxidant than hydrogen peroxide. The addition of heat or a ferrous salt or iron(II) dramatically increases the oxidative strength of persulfate. This increase is attributed to the production of sulfate-free radicals, a very strong oxidant roughly equivalent to the hydroxyl radical generated by ozone or peroxide reactions.



The persulfate anion itself is a strong oxidizer:



Under acidic conditions, persulfate also reacts with water to produce hydrogen peroxide, a kinetically faster oxidant than persulfate (FMC, 2001). Hydrogen peroxide, as in Fenton's reagent, has been demonstrated to be capable of oxidizing chlorinated solvents including TCE. The general reaction is as follows:



Similar to the other oxidants, pH will decrease following the application because of acid anion generation. However, the decrease in pH can be mitigated by adding sodium carbonate (approximately 20 percent of persulfate loading on a mole basis) to effectively buffer the aquifer pH. Carbonate also appears to provide better stability to and increase activity of persulfate. Another advantage compared to other oxidants is that persulfate does not appear to react readily with NOM, resulting in lower loading compared to the other oxidants. In general, less persulfate mass is required to satisfy the same amount oxidant demand compared to permanganate. Persulfate's total demand is determined by the stoichiometric requirement, the SOD, and its decomposition. Persulfate is less reactive toward organic matter (Brown, 2003).

The use of soluble peroxygen compounds, such as persulfate for ISCO of VOCs is a patented process. Two U.S. patents exist for this process, developed by the University of Connecticut, under Patent Numbers 6,019,548 and 6,474,908. Three forms of persulfate were evaluated in the bench-scale studies: unactivated persulfate, iron-activated persulfate, and alkaline-activated persulfate. The results of the bench-scale studies indicated that both unactivated and iron-activated forms of persulfate were comparably effective for treating TCE in the Site 17 shallow groundwater.

Because of Site 17's predominantly clay lithology and proximity to Mattawoman Creek, two oxidant delivery methods are viable at the site: soil mixing and injection. Oxidant delivery through soil mixing has the ability to provide more-uniform contact between the oxidant

¹⁰ Standard oxidation potential.

and the target COCs, and it minimizes the risks of oxidant daylighting into the creek. Although its risk for oxidant daylighting into the creek is relatively high, the injection delivery method was also evaluated because of the ease of implementing these standardized approaches. Based on the findings of the bench-scale study and oxidant delivery consideration, there are several technically feasible ISCO implementation scenarios for Site 17 groundwater. These scenarios include the use of two oxidants, unactivated and iron-activated sodium persulfate, and two delivery methods, soil mixing and injection. Seven ISCO implementation scenarios were evaluated to identify the most suitable scenario for inclusion in this FS. The evaluation of these scenarios and its recommendation is documented in a technical memorandum, *ROM Costs Comparison of Various ISCO Scenarios for Groundwater Remediation at Site 17, NSF-IH, Indian Head, Maryland* dated January 25, 2008 (CH2M HILL, 2008b). The memo concluded that three implementation scenarios were comparable in cost. In all three scenarios, the unit cost per volume of treated soil using soil mixing is less expensive than using injection because to achieve the same effectiveness, the treatment reagent can be delivered via one-time soil mixing. If injection were to be used, multiple events would be needed. Further evaluation (CH2M HILL, 2008c) indicated that one-time application of iron-activated persulfate via soil mixing within the source zone was considered the most cost-efficient ISCO alternative to be carried forward in the final FS.

In Situ Chemical Reduction

ISCR technologies may be applicable for the treatment of Site 17 shallow groundwater contamination because, unlike ISCO, the reductant demand may not be affected by the high natural organic carbon content of the subsurface soil. Some types of dissolved organic carbon fractions could potentially coat the surface of the iron particles and negatively affect their reactivity; however, virtually all of the organic carbon at Site 17 is in the suspended form.

The discussion in this section focuses only on zero valent iron (ZVI) because of its demonstrated ability for TCE treatment¹¹ (Gavaskar, 2005).

The dehalogenation process by ZVI can be best described as anaerobic corrosion, an abiotic reaction. Four processes would occur simultaneously (Vance, 2004), including:

- ZVI acts as a reductant by supplying electrons directly from the metal surface to an adsorbed halogenated compound or metal. $2\text{Fe}^0_{(s)} \rightarrow 2\text{Fe}^{2+}_{(aq)} + 4e^-$
- Hydrogen gas is generated by the anaerobic corrosion of the metallic iron by water. $\text{Fe}^0_{(s)} + 2\text{H}_2\text{O}_{(aq)} \rightarrow \text{Fe}^{2+}_{(aq)} + \text{H}_{2(g)} + 2\text{OH}^-_{(aq)}$
- Metallic iron may act as a catalyst for the reaction of hydrogen with the halogenated hydrocarbon using the hydrogen produced on the surface of the iron metal as the result of anaerobic corrosion with water. For example:
 $\text{C}_2\text{HCl}_3 + 3\text{H}_{2(g)} \xrightarrow{\text{catalyzed}} \text{C}_2\text{H}_{4(g)} + 3\text{HCl}$
 Theoretically, these reactions are not kinetically effective without a catalyst; thus, it is thought that impurities in the iron or surface defects act as that catalyst.

¹¹ Not to achieve MCL but to reduce mass.

- Solubilized ferrous iron can also act as a reductant. $\text{Fe}^{2+}_{(\text{aq})} \longrightarrow \text{Fe}^{3+}_{(\text{aq})} + \text{e}^-$

ZVI is available in different particle sizes to accommodate various application and delivery systems. Based on its particle size, ZVI can be categorized as granular and injectable ZVI. Granular ZVI ranges in millimeters in size (mean of 0.7 mm) and is typically implemented via trenching for PRB and soil mixing. Injectable ZVI ranges between nanometers and micrometers in size. The smaller-sized ZVI particles (typical size for micron particles is 1 to 74 micrometer and for nano particles is 1 to 100 nanometers) increases the available surface areas, resulting in multiplicative reaction rates of degradation. One of the findings of the bench-scale studies (CH2M HILL, 2008a) suggested that soil mixing would be the most efficient delivery for the treatment reagent because of the characteristics of Site 17. If the injection delivery method were to be used, enhancement using fracturing would likely be necessary to achieve practical lateral influence. To identify the most cost-effective delivery method and ZVI particle form for use at Site 17, two ISCR scenarios (soil mixing with granular ZVI and injection and fracturing with micron-scale ZVI) were further evaluated (CH2M HILL, 2008c). The evaluation indicated that soil mixing with granular ZVI would be the most-cost efficient ISCR alternative for further consideration for Site 17 shallow groundwater.

Therefore, granular ZVI will be carried forward for further consideration in the RA assemblies because it is equally as effective as other ZVI particle forms and the least costly for use in soil mixing application.

4.2.4 Removal and Offsite Disposal

Removal through excavation and offsite disposal has become standard practice. At Site 17, however, several implementability limitations would present because the removal would be intended to mitigate groundwater contamination. These limitations include:

1. Because of the past and ongoing mission of NSF-IH, ordnance could be encountered during the excavation activities. For this reason, MEC clearing and recovery, as well as the demilitarization, treatment, transportation, and disposal, may be required. These requirements not only significantly increase the cost but also the potential safety risks to the remediation workers. Under the *in situ* remediation scenario, the locations of reagent injection points can be adjusted to avoid the location of MEC anomaly; therefore, no MEC object recovery will be required.
2. There could be additional cost associated with stabilization measures due to the depth of excavation. The data indicated that the highest TCE concentration of 870,000 $\mu\text{g}/\text{L}$ was observed at a depth interval of 8 feet to 18 feet bgs. In actuality, the excavation may be deeper based on the uncertainty associated with the vertical extent of the AA because the boundary of the confining layer is unknown.
3. There could be additional cost associated with dewatering, water treatment, and the off-site transportation and disposal of the excavated material. The excavated material would likely be considered hazardous.

The primary advantage of removal and offsite disposal would be complete removal of contaminant mass from the removal/excavation area.

Although it may not be a cost-effective approach, this technology was carried forward into the RA assembly as the worst-case scenario for comparison purposes only.

4.3 Conceptual Remediation Approach and Development of RAs

4.3.1 Conceptual Remediation Approach

South Plume

As discussed in Section 4.2.3, to mitigate the shallow groundwater contamination at Site 17, an active treatment or remedy is recommended for the source zone followed by NA of the dissolved phase plume within the AAs. Within the South Plume, the source zone is characterized as the area where TCE concentrations were equal to or greater than 1,000 µg/L. The source zone consists of two sub areas: the inferred DNAPL area (TCE > 10,000 µg/L¹²) and the dissolved area (10,000 µg/L < TCE < 1,000 µg/L; Figure 3-1). An active treatment or removal would be implemented in the source zone to reduce TCE concentrations initially from 870,000 µg/L to a target concentration of 1,000 µg/L. At this target concentration, NA processes would likely be capable to reduce the concentrations further to achieve the cleanup goal of 5 µg/L within 30 years or less (Section 4.2.3). Treatment of the South Plume outside the source zone (i.e., TCE concentrations less than 1,000 µg/L) would rely solely on NA processes and ICs.

North Plume

The North Plume is approximately 2,000 square feet in size with a maximum TCE concentration of 19 µg/L at location IS17DP46. TCE concentrations at four other DPT sampling locations (IS17DP47 through IS17DP50) ranged between 3 and 9 µg/L, which suggests that the plume is isolated and likely self-attenuating based on the TOC content discussed in Section 4.2.3. Based on this condition, the remediation approach for the North Plume will consist of NA processes and ICs.

4.3.2 Development of RAs

Based on the conceptual remediation approach described in Section 4.3.1, the remedial technologies and process options that passed the initial screening process were assembled into RAs. The RAs for Site 17 groundwater are:

Alternative 1: No Action

Alternative 2: Monitored Natural Attenuation (MNA) and ICs: Alternative 2 involves a continuous implementation of ICs in the form of land- and groundwater-use restrictions, in conjunction with long-term monitoring program for groundwater and surface water to monitor changes in water quality, NA of COCs, and the potential for offsite

¹² Although the presence of DNAPL is inferred when TCE concentration is greater than 1% of its pure solubility limit (11,000 µg/L), to be conservative and for simplification, the inferred DNAPL area is defined as area where TCE concentrations exceed 10,000 µg/L.

migration of COCs.

- Alternative 3: Source Zone Treatment using ISCO, MNA, and ICs:** Alternative 3 uses ISCO technology for treatment of TCE in the source zone, in conjunction with MNA components and ICs described in Alternative 2.
- Alternative 4 Source Zone Treatment using ISCR, MNA, and ICs:** Alternative 4 uses ISCR technology for treatment of TCE in the source zone, in conjunction with MNA components and ICs described in Alternative 2.
- Alternative 5: Source Zone Removal and Offsite Disposal, MNA, and ICs:** Alternative 4 removes contaminant mass in the source zone through excavation and offsite disposal, in conjunction with MNA components described in Alternative 2 for the plume treatment, and ICs.

Table 4-6 presents a matrix of the retained technologies and the RAs. The major components of each RA are defined in the following section.

**Table 4-1
Screening of Remedial Process Options for Groundwater
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland**

General Response Action	Technology	Process Options	Effectiveness	Implementability	Relative Cost	Evaluation Action		Screening Comments
						Retain	Reject	
No Action	None	Not applicable	Does not protect human health or the environment; does not satisfy RAOs	Easily implemented	None	X		Retain as baseline alternative
Institutional Control Actions	Administrative restrictions	Deed or groundwater use restrictions	Effectiveness depends on continued future implementation regardless of property use or ownership; does not reduce contaminant levels	Easily implemented on NSF-IH property	Low	X		Will likely be used with other remedial alternative(s) until RAOs are met
	Monitoring	Groundwater Monitoring	Effective in tracking contaminant migration and reduction; does not satisfy RAOs	Easily implemented. Existing monitoring wells may be used for a groundwater monitoring program	Low capital, low O&M	X		Will likely be used with other remedial alternative(s) until RAOs are met
Containment	Vertical barriers	Sheet piling (mechanically driven into ground, forming a physical barrier around areas of contamination)	Standard sheeting is not completely impermeable	Relatively easy implementation due to shallow contamination	High capital		X	May be unnecessary because the outer fringe of the plume is attenuating and the source zone has been isolated and stable
		Slurry wall (trench around areas of contamination filled with a low-permeability soil-bentonite or cement bentonite slurry material)	Effective for containment of COC plumes	Relatively easy implementation due to shallow contamination	High capital		X	May be unnecessary because the outer fringe of the plume is attenuating and the source zone has been isolated and stable
		Permeable reactive barrier (downgradient reactive barrier using granular iron or other types of iron)	Effective for containment of COC plumes	Technically infeasible - due to the fast groundwater velocity at Site 17, a downgradient PRB has to be designed with a significant thickness (almost the same thickness as the width of the source zone plume to yield an adequate residence time)	Extremely high capital		X	See explanation in the implementability criterion
Removal	Removal	Excavation and Off-site Disposal	Effective because contaminant mass would be removed	Relatively easy implementation due to shallow contamination	High capital and disposal cost	X		Retained to represent the worst-case scenario; potentially applicable for source zone removal only, because the area is isolated
In-Situ Treatment	Biological Treatment	Enhanced anaerobic bioremediation with carbon sources materials (HRC, lactate, vegetable oil, etc.)	Effective for treatment of dissolved phase VOCs; not effective for DNAPL.	Implementable, though will likely require bench and/or pilot scale testing	Moderate capital, low O&M		X	May be unnecessary because the outer fringe of the plume is attenuating and the technology will not be applicable for the source zone.
		Phytoremediation (degradation through the use of plants using processes such as enhanced rhizosphere biodegradation, hydraulic control, phytodegradation, and phytovolatilization)	May be effective for dissolved phase VOCs. But not effective for DNAPL and uncertainties are higher due to the innovative status of the technology.	Implementable, though will likely require bench and/or pilot scale testing	Moderate to low		X	Considered innovative; Potentially prolonged remediation time frame
		Monitored Natural Attenuation	NA processes are likely occurring within the outer fringe of the dissolved plume.	Easily implemented	Low capital, low O&M costs	X		Technically feasible; Not effective for DNAPL but previous data indicating that NA is occurring and the plume is stable
	Physical/Chemical Treatment	Chemical oxidation (Fenton's reagent, permanganate, persulfate, ozone)	Considered aggressive and effective for both dissolved and DNAPL phases	Technically implementable; however, some oxidants are highly reactive to the natural organic matters (NOM), which was demonstrated as high at Site 17	High to moderate	X		Has been demonstrated applicable for TCE DNAPL and dissolved phase

Table 4-1
Screening of Remedial Process Options for Groundwater
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

General Response Action	Technology	Process Options	Effectiveness	Implementability	Relative Cost	Evaluation Action		Screening Comments
						Retain	Reject	
		Chemical reduction (ZVI)	Effective for both dissolved and DNAPL phases	Technically implementable, less dependent on the NOM than oxidation technologies	High to moderate	X		Has been demonstrated applicable for TCE DNAPL and dissolved phase
		Air sparging (air is injected into the aquifer to maximize contaminant volatilization to the vapor phase)	Effective on dissolved phase. Not effective on DNAPL; Process will induce an aerobic condition, unfavorable for reductive dechlorination; Rate-limited by dissolution and diffusion; Geometry unfavorable	Easily implemented because contamination is shallow and subsurface is permeable	Moderate capital, moderate O&M		X	Rejected because other technologies for organics removal are more cost effective and not effective for DNAPL

Table 4-2
 Screening of Natural Attenuation as a Groundwater Remedy
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Parameter	Screening Criteria for Concentration in Most Contaminated Zone			Upgradient Well	Concentration in Contaminated Zone ²			
	Range	Value	Interpretation	IS17MW03	IS17MW02	Points Awarded	IS17MW01	Points Awarded
Oxygen	<0.5 mg/L	3	Tolerated, suppresses the reductive pathway at higher concentrations	-	-	-	-	-
	>5 mg/L	-3	Not tolerated.	13.11	10.1	-3	4.99	-3
Nitrate	<1 mg/L	2	At higher concentration may compete with reductive pathway	0.013 J	< 0.005	2	< 0.05	2
Iron (II)	>1 mg/L	3	Reductive pathway possible	0.6	3.2	3	3.6	3
Sulfate	<20 mg/L	2	At higher concentration may compete with reductive pathway	34	6.5	2	5.6	2
Sulfide	>1 mg/L	3	Reductive pathway possible	-	-	0	-	0
Methane	>0.5 mg/L	3	Ultimate reductive product	0	8.4	3	16	3
ORP	<50 millivolts (mV)	1	Reductive pathway possible	123	-54	1	37	1
	<-100 mV	2	Reductive pathway likely	-	-	-	-	-
pH	5< pH < 9	0	Optimal range for reductive pathway	5.01	6.2	0	6.06	0
	pH<5 or pH>9	-2	Outside optimal range for reductive pathway	-	-	0	-	0
TOC	>20 mg/L	2	Carbon and energy source; drives dechlorination	12	11	0	15	0
Temperature ¹	>20°C	1	Biochemical process is accelerated	11.9	17.5	-	14.8	-
Alkalinity	2x background	1	Results from interaction between CO2 and aquifer minerals	-	-	0	-	0
Chloride	2x background	2	Reaction product of organic chlorine	8.5	41	2	44	2
BTEX	>0.1 mg/L	2	Carbon and energy source; drives dechlorination	-	0.002 J	0	0.1324	2
TCE		0	Material released	< 1	< 1	0	< 1	0
Cis-1,2-DCE		2	Intermediate daughter product	< 1	5,500	2	100	2
CE		2	Intermediate daughter product	< 1	1,700	2	92	2
Ethene/Ethane	>0.01 mg/L	2	Ultimate breakdown product	< 1		2		2
	>0.1 mg/L	3	Ultimate breakdown product	-	0.32/0.57	3	0.017/0.078	0
				NA		19	18	

¹Temperature measurements collected in summer months. Temperatures may decrease with seasonal fluctuation.

²Located within the outer fringe of the dissolved TCE, DCE, and VC plumes.

increase in solubility compared to 2002 readings due to lower temperatures (taken during winter season vs. summer in 2002).

Total Score	Interpretation
0 to 5	Inadequate evidence for reductive dechlorination
6 to 14	Limited evidence for reductive dechlorination
15 to 20	Adequate evidence for reductive dechlorination
>20	Strong evidence for reductive dechlorination

Table 4-3
SourceDK Tier-3 NAPL Dissolution Model, Scenario and Results for TCE
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Source Zone (IS17DP-27)																						
INPUT PARAMETERS																						
Type of Media	Non-uniform fine sand																					
Initial Aqueous-Phase Concentration in Source Zone	To be conservative, the highest concentration of applicable constituent is used.																					
	TCE = 870 mg/L From DP-27 (2005)																					
Desired Cleanup Level	0.005 mg/L (MCL)																					
Density NAPL Fluid	1.46 kg/L																					
	Table 3-2 Physical Properties of Organic Compounds 6th Edition, 1984 of Perry's Chemical Engineers																					
Initial NAPL Saturation	Represents the soil pore space that is filled with NAPL. It is assumed that this is equal to the effective porosity of 0.25																					
Uncertainty in NAPL Saturation	This unit less factor represents an estimate of how much uncertainty is associated with the NAPL saturation being modeled in Source DK. Default value range of 2 to 100 with 2 being the least uncertain.																					
	The source zone has been isolated based on the DPT data from 2000 through 2005, therefore, it is assumed that the uncertainties are low (2).																					
Natural Groundwater Seepage Velocity	This unit is average linear groundwater velocity of travel; Darcy velocity divided by the effective porosity. Involves several estimates including:																					
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">High</th> <th style="text-align: center;">Low</th> </tr> </thead> <tbody> <tr> <td>K (ft/sec) - Table 2-2 =</td> <td style="text-align: center;">9.61E-05</td> <td style="text-align: center;">1.04E-05</td> </tr> <tr> <td>hydraulic gradient (h) = 0.033 ft/ft between applicable wells (determined from Figure 6-3 in the RI Report)</td> <td></td> <td></td> </tr> <tr> <td>effective porosity (n) =</td> <td colspan="2" style="text-align: center;">0.25</td> </tr> <tr> <td>V (ft/year) = K.h/n.31536000</td> <td></td> <td></td> </tr> <tr> <td></td> <th style="text-align: center;">High</th> <th style="text-align: center;">Low</th> </tr> <tr> <td>V (ft/year) =</td> <td style="text-align: center;">400</td> <td style="text-align: center;">43</td> </tr> </tbody> </table>		High	Low	K (ft/sec) - Table 2-2 =	9.61E-05	1.04E-05	hydraulic gradient (h) = 0.033 ft/ft between applicable wells (determined from Figure 6-3 in the RI Report)			effective porosity (n) =	0.25		V (ft/year) = K.h/n.31536000				High	Low	V (ft/year) =	400	43
		High	Low																			
	K (ft/sec) - Table 2-2 =	9.61E-05	1.04E-05																			
	hydraulic gradient (h) = 0.033 ft/ft between applicable wells (determined from Figure 6-3 in the RI Report)																					
	effective porosity (n) =	0.25																				
	V (ft/year) = K.h/n.31536000																					
	High	Low																				
V (ft/year) =	400	43																				
Length of Source Zone Parallel to Groundwater Flow	An estimated value of 60 ft was used from interpolated isopleth maps depicted concentration contours equivalent to the DNAPL zone.																					
Is this a Pumping Scenario	NO. The objective is estimate the timeframe to flush DNAPL based on sole reliance of NA processes.																					
RESULTS																						
Estimated timeframe to Flush Out Constituent and Achieve Desired	High K	Low K																				
Upper (years)	10	94																				
Median (years)	5	47																				
Lower (years)	2.5	23																				

Table 4-4
SourceDK Tier-3 Dissolved Phase Attenuation, Scenario and Results for TCE
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Source Zone (DP-27)													
INPUT PARAMETERS													
Original Constituent Concentration (Co) – mg/L	Concentration will be varied to yield the timeframe to flush out constituent and achieve the cleanup goal within 30 years or less.												
	The initial concentration would become the end point for the active source treatment.												
Desired Cleanup Level	0.005 mg/L (MCL)												
Length of Source Zone Parallel to Groundwater Flow	An estimated value of 60 ft was used from interpolated isopleth maps depicted concentration contours equivalent to the DNAPL zone.												
Natural Groundwater Seepage Velocity	This unit is the average linear velocity of groundwater; Darcy velocity divided by the effective porosity. Involves several estimates including:												
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">High</th> <th style="text-align: center;">Low</th> <th style="text-align: center;">Average</th> </tr> </thead> <tbody> <tr> <td>K (ft/sec) =</td> <td style="text-align: center;">9.61E-05</td> <td style="text-align: center;">1.04E-05</td> <td style="text-align: center;">5.32E-05</td> </tr> </tbody> </table>		High	Low	Average	K (ft/sec) =	9.61E-05	1.04E-05	5.32E-05				
		High	Low	Average									
	K (ft/sec) =	9.61E-05	1.04E-05	5.32E-05									
	hydraulic gradient (h) = 0.033 ft/ft between applicable wells (determined from Figure 6-3 in the RI Report)												
	effective porosity (n) =	0.25											
V (ft/year) = K.h/n.31536000													
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">High</th> <th style="text-align: center;">Low</th> <th style="text-align: center;">Average</th> </tr> </thead> <tbody> <tr> <td>V (ft/year) =</td> <td style="text-align: center;">400</td> <td style="text-align: center;">43</td> <td style="text-align: center;">222</td> </tr> </tbody> </table>		High	Low	Average	V (ft/year) =	400	43	222					
	High	Low	Average										
V (ft/year) =	400	43	222										
Fraction of organic carbon (f _{oc}) - unitless	f _{oc} = 0.036 (see Table 3-5 for derivation of the value)												
Bulk density (ρ _d) g/ml	1.85 g/ml (Table 7-3, RI Report)												
Effective porosity (n _e) – unitless	0.25												
Octanol Water Partition Coefficient (K _{oc})	K _{oc} = 97 L/kg												
RESULTS													
Timeframe to reduce TCE to achieve desired cleanup level (years)	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">870 mg/L to 0.005 mg/L</th> <th colspan="2" style="text-align: center;">0.5 mg/L to 0.005 mg/L</th> </tr> <tr> <th style="text-align: center;">High K</th> <th style="text-align: center;">Low K</th> <th style="text-align: center;">High K</th> <th style="text-align: center;">Low K¹</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">34</td> <td style="text-align: center;">312</td> <td style="text-align: center;">15.6</td> <td style="text-align: center;">145</td> </tr> </tbody> </table>	870 mg/L to 0.005 mg/L		0.5 mg/L to 0.005 mg/L		High K	Low K	High K	Low K¹	34	312	15.6	145
	870 mg/L to 0.005 mg/L		0.5 mg/L to 0.005 mg/L										
High K	Low K	High K	Low K¹										
34	312	15.6	145										
Timeframe to reduce TCE to achieve desired cleanup level (years)	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="3" style="text-align: center;">0.25 mg/L to 0.005 mg/L</th> </tr> <tr> <th style="text-align: center;">High K</th> <th style="text-align: center;">Average K</th> <th style="text-align: center;">Low K</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">14</td> <td style="text-align: center;">25</td> <td style="text-align: center;">129</td> </tr> </tbody> </table>	0.25 mg/L to 0.005 mg/L			High K	Average K	Low K	14	25	129			
0.25 mg/L to 0.005 mg/L													
High K	Average K	Low K											
14	25	129											

Note

¹ Under the low K scenario, 30-year timeframe can only be achieved by actively treating the AA to nearing the SRG.

Table 4-5
SourceDK Tier-2 Box Model, Scenario and Results for TCE
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

INPUT PARAMETERS				
Hydraulic Conductivity -K (ft/day)	6.10E+00			
Hydraulic Gradient - i (ft/ft) between applicable wells (determined from Figure 6-3 in the RI Report)	0.033			
Average Source Groundwater Concentration at Time = 0	1,000 ug/L The initial concentration would become the end point for the active source treatment.			
Length of Source Zone Parallel to Groundwater Flow	An estimated value of 60 ft was used from interpolated isopleth maps depicted concentration contours equivalent to the 1,000 ug/L contour line			
Source Length	100 feet			
Source Thickness	10 ft (8 to 18 ft bgs)			
Source Mass (kg)	Calculated based on:			
Source Decay Constant (Biodegradation Rate) - lambda -	Range	Low (Poor)	25th Percentile	Median
	1/year	0.3	0.5	1.2
Uncertainty Range for ks Estimate	2 (low because the evidence of highly elevated cis-1,2-DCE and VC concentrations)			
RESULTS				
Timeframe to reduce TCE to achieve desired cleanup level (years) - low K value	Timeframe Range	Low (Poor) lambda	25th Percentile lambda	Median lambda
	Upper	242	194	115
	Mid	121	97	57
	Lower	60	49	29
Timeframe to reduce TCE to achieve desired cleanup level (years) - average K value	Timeframe Range	Low (Poor) lambda	25th Percentile lambda	Median lambda
	Upper	67	63	51
	Mid	34	31	26
	Lower	17	16	13
Timeframe to reduce TCE to achieve desired cleanup level (years) - high K value	Timeframe Range	Low (Poor) lambda	25th Percentile lambda	Median lambda
	Upper	39	37	33
	Mid	19	19	17
	Lower	10	9	8

Table 4-6
 Assembly of Remedial Alternatives
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Technology/ Process Option	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
	No Action	MNA and ICs	ISCO, MNA, and ICs	ISCR, MNA, and ICs	Source Zone Excavation, Off-site Disposal, MNA, and ICs
No Action	X				
Administrative Restrictions on Site and Groundwater Use		X	X	X	X
Groundwater and Creek Monitoring		X	X	X	X
Monitored Natural Attenuation		X	X	X	X
Excavation and Off-site Disposal					X
ISCO - persulfate			X		
ISCR - Peerless granular ZVI				X	

Notes

ISCO - *In situ* chemical oxidation
 ISCR - *In situ* chemical reduction
 MNA - Monitored natural attenuation

Descriptions and Detailed Analysis of Remedial Alternatives

5.1 Descriptions of RAs

The RAs discussed in Section 4 are further described and evaluated both individually and comparatively in this section. Additional screening of RAs was not necessary because of the limited number of technologies remaining following the technology screening discussed in Section 4.

This section describes four RAs developed in Section 4.3.2 in further detail. Under all alternatives, a contingency plan would be evaluated if COC concentrations in the surface water along the site shoreline of Mattawoman Creek are determined to exceed the regulatory levels and groundwater contamination. The need of a contingency plan for Site 17 groundwater is unlikely given historic surface water quality data, tidal influence, and plume stability. Therefore, the costs for a contingency plan were not estimated herein. In addition, it is expected that CERCLA statutory 5-year reviews would be conducted under each alternative if it is implemented, with the exception of the no-action alternative.

5.1.1 Alternative 1: No Action

The no-action alternative is required by the NCP and serves as the baseline alternative. All other remedial action alternatives are judged against the no-action alternative. Under this alternative, no controls or remedial technologies will be implemented. CERCLA [Section 121(c)], as amended by SARA (1986), requires that the site be reviewed every 5 years because contamination would remain on site. However, in accordance to *A Guide to Developing and Documenting Cost Estimates during the Feasibility Study* (USEPA, 2000), costs associated with the 5-year reviews were not included in this alternative.

NSF-IH is an active military installation that has certain ICs in place, such as the access and land use restrictions.

5.1.2 Alternative 2: MNA and ICs

Alternative 2 consists of continued implementation of ICs in the form of groundwater use restrictions, MNA of contaminants in groundwater, and long-term surface water monitoring.

Monitored Natural Attenuation

MNA involves collection and analysis of groundwater samples and interpretation of the sample data to demonstrate that MNA is occurring, verify that the dissolved contaminant plume is not expanding, and verify progress toward attainment of RAOs. The design of an effective MNA monitoring program involves correct placement of a monitoring well

network, site-specific groundwater sampling and analysis strategy, and a contingency plan (Wiedemeier et al., 2000).

Two types of monitoring wells are typically used to monitor the plume behavior over time, performance monitoring wells (PMWs) and contingency wells (CWs). PMWs, located upgradient of, within, and immediately downgradient of the plume, are used to monitor the attenuation process. CWs are placed beyond the hydraulic downgradient boundaries of the plume to ensure that the potential receptors are not affected. Exceedance of trigger levels at the CWs may prompt implementation of a contingency plan.

The three existing groundwater monitoring wells will be used as PMWs. In addition, five additional PMWs would be constructed, two in the center of the South Plume at or near the 870,000 µg/L TCE detection, one in the center of the North Plume, and two directly downgradient of the South Plume. Because of the plume proximity to Mattawoman Creek, three surface water samples along the shoreline of the Creek will be used as the contingency monitoring points. If the concentrations of COCs in the surface water exceed the surface water trigger levels, the contingency plan will be evaluated. Statistical analysis will be used in the determination of the trigger level's exceedances. A detailed description of the contingency plan and trigger level(s) will be developed after the Record of Decision (ROD) is signed as part of the long-term monitoring plan. As discussed in Section 4.2.3, for cost-estimating purposes, the timeframe is assumed to be 100 years. This duration was selected based on the range of timeframes of 34 to 312 years based on the low and high K values scenario presented in Table 4-4.

Samples would be collected on a biennial basis for the first 3 years, annually for the following 5 years, and then once every 5 years for the remaining years until SRGs are achieved. All samples will be analyzed for TCL VOCs, TOC, sulfate, nitrate, chloride, methane, ethane and ethene, and alkalinity. In addition, field measurements such as DO, ORP, pH, and temperature will be collected. The frequency and duration of the long-term monitoring program may be altered based on the results of the 5-year reviews. Detailed description of the monitoring program will be included in the long-term monitoring plan, expected to be included with the remedial action work plan. Because of the past and ongoing mission of NSF-IH, ordnance could be encountered during the monitoring wells installation. Therefore, Alternative 2 also includes MEC avoidance and clearing survey. Based on the results of the MEC survey, locations of the monitoring wells may need to be adjusted.

Groundwater Use Restrictions and Surface Water Monitoring

Under Alternative 2, the site would be designated as a “restricted use” area in the base Geographic Information System (GIS) database. This designation would prohibit intrusive activities such as excavation, residential development, or use of groundwater. Records of the groundwater contamination would also be kept in the base GIS/environmental database. The restricted use designation would remain in place until groundwater monitoring indicates that the SRGs have been met. Surface water within Mattawoman Creek adjacent to the site would be sampled periodically as part of the remedy. The sampling program would continue to monitor to ensure that Site 17 COCs remain below the ambient water quality criteria until the groundwater SRGs are met. Three locations along the shore of

Mattawoman Creek would be sampled and surface water would be analyzed for TCL VOCs during each sampling event.

5.1.3 Alternative 3: Source Zone Treatment Using ISCO, MNA, and ICs

Alternative 3 consists of:

- Implementing ISCO in the source zone (TCE > 1,000 µg/L) using iron-activated sodium persulfate;
- Using NA processes for the remaining dissolved plume within the South and North Plumes and the source zone following the active treatment;
- Conducting long-term groundwater and surface water monitoring as described in Alternative 2; and
- Enforcing ICs in the form of land and groundwater use restrictions as described in Alternative 2.

Alternative 3 relies on NA processes to achieve the SRGs within the AA outside the source zone. As discussed in Section 4.3.2, the source zone treatment would have to reduce the concentrations of TCE within the source area to at least 1,000 µg/L in order for NA processes to achieve the SRGs within the AA within 25 years. Therefore, under Alternative 3, the target TCE concentration for ISCO treatment within the source zone is assumed to be 1,000 µg/L. The estimated remediation timeframe to achieve the SRGs and the proposed groundwater monitoring duration is 30 years based on this assumption.

For the full-scale implementation, persulfate would be delivered into shallow groundwater using a soil mixing application. Table 5-1 presents the estimated persulfate demand and the conceptual delivery system of the persulfate. Demand of oxidant is contaminant and site-specific and determined based on the following equation (Brown, 2003):

$$\text{Total oxidant demand (TOD)} = \text{stoichiometric demand} + \text{NOD}^{13} / \text{soil oxidant demand (SOD)} + \text{oxidant decomposition}$$

The stoichiometric demand to degrade TCE using persulfate as an oxidant is roughly 1 mol of TCE per 3 mols of persulfate (Brown, 2003). Although there are uncertainties associated with the decomposition rate at Site 17, the greatest uncertainties are associated with the SOD value. SOD value is typically attributed to two factors, demand of oxidizable NOM and demand of reduced metals. SOD was calculated to be 22 to 70 g/kg for iron-activated sodium persulfate during the bench-scale study (CH2M HILL, 2008a). As presented in Table 5-1, the total persulfate demand is approximately 66,000 pounds.

The persulfate mass will be delivered through mechanical mixing using a crane-mounted auger or Lang tool within the interval of 2 and 18 feet bgs. Before mixing activities, a geophysical survey and clearing and recovery of MEC objects may be required. After mixing, the site will be restored into its original condition as an open, grassy area.

¹³ Natural oxidant demand

For cost-estimating purposes, the performance monitoring associated with Alternative 3 is assumed to consist of a 12-month (short-term) and a long-term monitoring program. Five additional monitoring wells are assumed to be installed. Three wells are to be installed during the baseline sampling event (two within the South Plume and one within the North Plume) and two wells within the South Plume are to be installed approximately 12 months after the completion of soil mixing. These wells, along with the three existing monitoring wells, will be used to assess the effectiveness of the technology. The short-term monitoring will be conducted at 6 months, 9 months, and 12 months following the soil mixing to assess the effectiveness of the persulfate application. The long-term monitoring would be conducted after completing the short-term monitoring program for an assumed duration of 30 years. The assumed requirements for each performance monitoring event are as follows:

Baseline, 6-month, and 9-month post-mixing sampling events:

- Soil and grab groundwater samples from four DPT soil boring locations within the target area; samples are to be analyzed for target VOCs; measurements of field parameters such as pH, DO, ORP, and conductivity will be taken from the groundwater samples.
- Groundwater samples from three existing and three new wells; samples are to be analyzed for target VOCs, total and dissolved metals, water quality parameters (sulfate, nitrate, sulfide, chloride, alkalinity, ferrous iron, and methane-ethene-ethane [MEE]) and similar field parameter measurements as the grab groundwater samples.

12-month post-mixing sampling event and subsequent long-term monitoring events:

- Similar to the other monitoring events, except that additional groundwater samples will be collected from the two new wells installed within the soil mixing target area.

At each event, surface water samples would also be collected from three locations along Mattawoman Creek and analyzed for target COCs. For cost-estimating purposes, it is assumed that ISCO will reduce the TCE concentration in the source zone to 1,000 µg/L within a 6-month period, which would reduce the timeframe for MNA monitoring to 30 years for the AA, relative to 100 years if MNA is used as the only remedy. Following the short-term monitoring, groundwater and surface water will be sampled quarterly for a period of 2 years (years 1 and 2) and analyzed for the same parameters as for the confirmatory monitoring. Sampling and analyses of groundwater and surface water samples will be conducted biannually during year 3 and annually for years 4 and 5 and every 5 years thereafter through year 30. A detailed description of the monitoring program will be included in the long-term monitoring plan, which will be prepared after the ROD is signed.

5.1.4 Alternative 4: Source Zone Treatment using ISCR, MNA, and ICs

Alternative 4 consists of:

- Implementing ISCR using the peerless ZVI (granular) within the source zone;
- Using NA processes for the remaining dissolved plume within the AA and the source zone following the active treatment;

- Conducting long-term groundwater and surface water monitoring similar to those in Alternative 2; and
- Enforcing LUCs in the form of land and groundwater use restrictions similar to those in Alternative 2.

The assumed remediation timeframe to meet the SRGs for Alternative 3 would be 30 years. ISCR is assumed to be capable to reduce the TCE concentrations to 1,000 µg/L within 6 months.

For the full-scale implementation, similar to ISCO, a soil mixing process would be used to mechanically deliver the granular ZVI. A mixing process similar to that described in Alternative 3 would be applicable for this alternative. Approximately 36,000 pounds of the peerless ZVI (1 percent iron-to-soil ratio) would be mixed into the subsurface (Gavaskar, 2005; CH2M HILL, 2008c). Table 5-2 shows the conceptual design of the ZVI dosing under Alternative 4.

Under this alternative, ISCR is also assumed to be capable of reducing the TCE concentrations to 1,000 µg/L within 6 months. Alternative 4 includes components for MEC avoidance and clearance; potential MEC demilitarization, treatment, and offsite disposal; long-term groundwater and surface water monitoring programs; and ICs similar to those described in Alternative 3.

5.1.5 Alternative 5: Source Zone Removal and Offsite Disposal, MNA, and ICs

Alternative 4 involves the removal (excavation and dewatering) of the soil and groundwater within the source zone, transportation and disposal of excavated soil and groundwater to an offsite facility and MNA monitoring for the remaining AAs (i.e., North and South Plumes) in conjunction with implementation and enforcement of ICs as described in Alternative 2.

Because of the limitations of the source zone removal through excavation at Site 17 as described in Section 4.2.5, the excavation activities are assumed to involve the following components:

1. MEC avoidance survey and clearing, as well as the demilitarization, treatment, transportation, and disposal. For cost-estimating purposes, because of the uncertainties involved, the cost for demilitarization, treatment, transportation, and disposal of MEC cannot be determined and, therefore, they are excluded from the total cost for this alternative.
2. Stabilization measures, such as temporary retaining walls/sheet pile because of the depth of excavation; the data indicated that the highest TCE concentration of 870,000 µg/L was observed at a depth interval of 8 feet to 18 feet bgs; therefore, the excavation depth is assumed to be 18 feet bgs.
3. Dewatering and storage systems for extracted groundwater.

Assuming the source zone area of 3,885 square feet¹⁴ and the excavation depth of 20 feet, the estimated total volume of excavation would be 69,900 cubic feet, or 2,590 cubic yards.

¹⁴ Including 10% area increase from 3,500-square-foot plume area.

The excavated soil and groundwater would be transported to and disposed of at a permitted offsite facility. Because of the high concentrations of TCE, cis-1,2-DCE, and CE in groundwater, the saturated soil and groundwater would be assumed as hazardous. For cost-estimating purposes, the excavated material is assumed can be directly disposed of to a RCRA C Landfill.

Following the completion of the source zone removal, MNA will be implemented for the remaining AA, in conjunction with the implementation and enforcement of ICs. For cost-estimating purposes, the assumed timeframe for implementing MNA and ICs is 30 years. Throughout the 30-year duration, groundwater and surface water monitoring programs similar to those described in Alternative 2 would be implemented; except for in the source zone, where a groundwater monitoring well would not be constructed because the soil will be excavated. Detailed description of the monitoring program will be included in the long-term monitoring plan, prepared as part of the remedial action work plan, as well as the detailed plan for the implementation of the ICs after the ROD is signed.

5.2 Evaluation Criteria

Each alternative was developed to address potential threats to human health and the environment posed by contaminated groundwater. The NCP requires the RAs be evaluated against the nine criteria [40 CFR 300.430(e)(9)(iii)(A) through (I)] listed below:

Threshold Criteria

- Protection of human health and the environment
- Compliance with ARARs

Balancing Criteria

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Modifying Criteria

- State acceptance
- Community acceptance

The first two criteria are requirements that must be met unless specific ARARs are waived. The first seven criteria are addressed in this FFS. The last two criteria will be addressed in the Proposed Plan and ROD. Figure 5-1 summarizes the NCP criteria.

It should be noted that the cost estimates presented in this FS only provide an accuracy of +50 percent to -30 percent. The alternative cost estimates are in 2008 dollars and are based on conceptual design from information available at the time of this study. The actual cost of the project would depend on the final scope and design of the selected remedial action, the schedule of implementation, competitive market conditions, and other variables. Most of these factors are not expected to affect the relative cost differences between alternatives. The cost estimates were prepared in general conformance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (USEPA, 2000).

Expenditures that occur over different time periods are returned to present worth, which discounts all future costs to a common base year. Present-worth analysis allows the cost of remedial action alternatives to be compared on the basis of a single figure representing the amount of money that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the life of the remedial project. Assumptions associated with the present-worth calculations include a discount rate of 5.2 percent for a 30-year or longer timeframe (OMB, 2006), cost estimates in the planning years in constant dollars, and a period of performance that would vary depending on the activity, but would not exceed 100 years.

5.3 Detailed Evaluation of RAs

This section analyzes in detail all the RAs assembled in Section 4.0.

5.3.1 Alternative 1—No Action

This alternative is required under the NCP. Under this alternative, no further effort or resources would be expended to remediate contaminated groundwater at Site 17. Because contaminated media would be left on the site, a review of site conditions would be required every 5 years, as specified by the NCP. Alternative 1 serves as the baseline against which the effectiveness of other alternatives is judged.

Overall Protection of Human Health and the Environment

This alternative does not contain measures to prevent potential future onsite residents from using and contacting contaminated groundwater. The risk posed by contaminated groundwater would not be decreased because the risk of potential future exposures would continue. Alternative 1 does not address the second RAO concerning potential impacts to the creek. Residual risks are identical to those identified in the baseline risk assessment. Accordingly, the no-action alternative is not protective of human health and the environment.

Compliance with ARARs

This alternative will comply with the chemical-specific ARARs identified in Appendix I. Cis-1,2-DCE and VC in the shallow aquifer would remain out of compliance with their SRGs for 60 to 400 years or may be longer. As discussed previously, the time estimates are for comparative purposes only. There are no applicable location- and action-specific ARARs because no remedial actions will be undertaken.

Long-Term Effectiveness and Permanence

The residual risk associated with groundwater contamination under this alternative would be reduced over the long term. The concentrations of COCs in the alluvial aquifer would diminish over a prolonged timeframe. Because this alternative involves no controls or monitoring component and relies solely on the ongoing NA processes, the adequacy and reliability of this alternative is very low. Because contaminants are left at the site above cleanup levels, a review of site conditions would be required every 5 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative does not include treatment. Therefore, the estimated 430 pounds of total COC mass would diminish over a prolonged timeframe solely through NA processes, without verification. The timeframe would be considered as not reasonable.

Short-Term Effectiveness

There is no construction associated with this alternative, so there are no short-term impacts on workers, the community, or the environment. However, the RAOs and thus the SRGs cannot be achieved within a reasonable timeframe.

Implementability

This alternative does not have a monitoring or construction component associated with it. Therefore, there are no issues concerning its technical implementation. However, the administrative implementability of this alternative is low in terms of its ability to obtain approvals from other agencies. Furthermore, Alternative 1 requires an extended allocation of administrative resources to implement and enforce the 5-year reviews.

Cost

Taking no action would require no capital expenditure.

5.3.2 Alternative 2—MNA and ICs

Alternative 3 consists of continued implementation of an IC measures in the form of groundwater use restrictions, groundwater monitoring of NA contributions to the COC reductions, and a long-term surface water monitoring.

Overall Protection of Human Health and the Environment

Alternative 2 is not considered protective of human health because the groundwater use restrictions would prevent or minimize future exposure to the groundwater but no active treatment is proposed. This alternative would not prevent the migration or discharge of Site 17 groundwater with unacceptable concentrations of COCs to Mattawoman Creek. MNA monitoring would allow early assessment if discharge with unacceptable COC concentration occurs. At that point, a contingency plan would be evaluated.

Compliance with ARARs

This alternative will comply with the location- and action-specific ARARs identified in Appendix I. With respect to chemical-specific ARARs, cis-1,2-DCE and VC in the shallow aquifer would remain out of compliance with their SRGs for 60 to 400 years or possibly longer. This alternative includes a groundwater monitoring program to monitor constituent migration and concentrations, thereby confirming if NA would meet the SRGs within the remediation period. Location- and action-specific ARARs apply to the locations and construction, respectively, of the new groundwater monitoring wells.

Long-Term Effectiveness and Permanence

Magnitude of Residual Risks. The residual risk associated with groundwater contamination under this alternative would be reduced over the long term. COCs concentrations in the

alluvial aquifer would diminish during estimated 60- to 400-year periods (100 years is assumed for cost estimating purposes). However, the capability of NA processes to degrade the DNAPL phase is essentially non-existent. As a result, the long-term effectiveness and permanence of this alternative are uncertain.

Adequacy and Reliability of Controls. The ICs in place are expected to be adequate and reliable particularly given the lack of a need for this groundwater as a potable source during the foreseeable future. The adequacy of groundwater use restrictions is based on their continued implementation. Use restrictions, which prevent future installation or use of wells for potable water, must be enforced until groundwater monitoring indicates natural processes have resulted in the groundwater SRGs being met.

Groundwater and surface water monitoring activities, including NA parameters are considered adequate and can be reliably used to track groundwater and creek quality and constituent migration.

Reduction of Toxicity, Mobility, and Volume through Treatment

Treatment under this alternative is limited to the natural biodegradation and NA processes that will occur within the plume. The estimated 436 pounds of total COCs in the groundwater and adsorbed to the aquifer matrix would diminish over time primarily through biological degradation, geochemical processes, and volatilization. Although the NA assessment at this site indicates that NA processes are likely occurring within the outer fringe of the AA, these processes alone would not be capable to reduce the mass of COCs in the source zone within a reasonable timeframe. This alternative is incapable of reducing the mass of DNAPL, which will continually replenish dissolved phase contamination for a long period of time.

Short-Term Effectiveness

Minor construction activities would be associated with this alternative; therefore, the short-term impacts on workers, the community, or the environment are considered minimal. The activities would be primarily associated with construction of the new groundwater monitoring wells. Appropriate procedures for MEC avoidance and clearing survey would be followed.

However, similar to Alternative 1, the RAOs and thus the SRGs cannot be achieved within a reasonable timeframe.

Implementability

Implementability evaluation for this alternative primarily includes technical and administrative feasibility.

Technical Feasibility. There are no technical difficulties associated with the implementation of this alternative. Locations of monitoring wells may be adjusted depending on the results of the MEC avoidance and clearing survey.

Administrative Feasibility. Groundwater would likely remain contaminated for years under this alternative. Therefore, long-term administrative resources must be expended to conduct the 5-year site reviews required by the NCP. In addition, administrative resources would be

required on an ongoing basis to administer the LUCs and groundwater and surface water monitoring program.

The long-term implementation of LUCs would require coordination with NSF-IH staff and local government agencies.

Cost

This alternative has an approximate capital cost of \$24,300. This cost includes creation of an LUCIP, submittal of the field sampling plan, and construction of three groundwater monitoring wells. The total O&M present worth cost of approximately \$460,600 consists primarily of field labor and analytical costs to collect groundwater and surface water data, and office labor to analyze trends and prepare a monitoring report after each monitoring event. The present worth, assuming a 100-year project life, is \$484,900. The RI/FS guidance requires 30-year projections for a site with limited information to determine site-specific projection. However, for Site 17, there is abundant information to project the timeframe beyond 30 years. The cost estimate details are provided in Appendix K.

5.3.3 Alternative 3—Source Zone Treatment Using ISCO, MNA, and ICs

Alternative 3 uses ISCO technology for treatment of TCE in the source zone using soil mixing, in conjunction with MNA and IC components described in Alternative 2.

Overall Protection of Human Health and the Environment

Alternative 3 is considered protective of human health and the environment. This alternative would actively treat the COC mass in the source area. This alternative would also prevent or minimize the migration or discharge of unacceptable COC concentrations into the creek. Following the completion of the active treatment, NA processes would be used as a polishing step to degrade the COCs to achieve the SRGs.

Under this alternative, the RAOs, and therefore the SRGs, would be achieved within a period of 30 years or less. The estimated timeframe is considered reasonable for Site 17 because the groundwater is not currently used.

Compliance with ARARs

This alternative will comply with the location-, action-, and chemical-specific ARARs identified in Appendix I. Chemical-specific ARARs for cis-1,2-DCE and CE could be achieved within 30 years or less. Metals may be introduced into the subsurface from the impurities in permanganate crystals; however, considering the size of the treatment area, the potential mobilization of metals would likely be temporary. This alternative is anticipated to meet all the location-specific ARARs. Erosion and sediment controls are action-specific ARARs as well as location-specific ARARs. These controls would be used during the oxidant mixing to prevent adverse effects on the Creek. Therefore, the requirements of the Wild and Scenic Rivers Act [16 USC 1271 et seq. and Section 7(a)] would be met. Well construction spoils are anticipated to be disposed offsite as a hazardous waste. If dewatering is required to support MEC clearing and recovery, extracted water would be treated onsite and discharged to the onsite wastewater treatment plant or to an offsite facility.

Long-Term Effectiveness and Permanence

Magnitude of Residual Risks. TCE is expected to decline from the current maximum concentration of about 870,000 µg/L to the 1,000 µg/L over a 6-month period within the persulfate soil mixing area. NA is expected to reduce TCE, cis-1,2-DCE, and CE to below the SRGs over a longer period of 30 years.

As with Alternative 2, ICs would prevent human exposure to groundwater. Risks associated with migration to the Creek would be reduced as COC mass within the source area is aggressively treated through ISCO, and MNA will treat the remaining AA.

Adequacy and Reliability of Controls. As with Alternative 2, ICs are expected to be adequate and reliable, and groundwater monitoring is adequate and can be reliably used to track groundwater quality and constituent migration.

Persulfate as an oxidant has been shown to effectively treat the DNAPL and dissolved phases of chlorinated VOCs, including TCE. The effectiveness of the treatment will be greatly enhanced by soil mixing because it optimizes contact between the COCs and the reagents.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative would significantly reduce or potentially eliminate the toxicity, mobility, and volume of target COCs within the source zone. With the absence of the free-phase residual TCE and the majority of the target COC masses, the timeframe for NA processes are expected to be expedited for the remaining masses of TCE, cis-1,2-DCE, and VC within the AA.

Short-Term Effectiveness

Because the site is located in an open area, impact and disturbance to NSF-IH operations would be minimal. Remediation activities will stop if live munitions are encountered. The activities will resume after the Navy provides the notice to proceed. No short-term impact is anticipated to the community during implementation of this alternative. A large-diameter auger would be used during the soil mixing process, so clearing and recovery of potential MEC objects should be conducted before mixing activities begin. The clearing and recovery procedures of MEC may pose high safety risks to the remediation workers. These risks would be managed by following the appropriate procedures for MEC avoidance and clearing.

The short-term risk to Mattawoman Creek would be minimal because the soil mixing method would minimize the risk of oxidant daylighting. The soil mixing area was disturbed during the 2005 NTCRA. Currently, the area is a grassy, open space. After soil mixing, the area would be restored as a grassy, open space. Achievement of SRGs would be expected within 30 years.

Implementability

Technical Feasibility. ISCO technology using persulfate is less mature compared to Fenton's or permanganate technologies. However, it has been implemented in a full-scale application for treatment of residual DNAPL and dissolved phases of TCE; therefore, it is considered readily implementable. The soil mixing method has become a standard remediation

practice. The technical challenge lies with clearing and recovering MEC or other large metallic objects that could be buried to minimize the interference with the soil mixing operations.

Administrative Feasibility. Although MEC clearing and recovery procedures have also been established; they require coordination with and approval by several agencies. In addition, long-term administrative resources for implementation of ICs would also be required throughout the entire duration of this alternative (30 years).

Cost

The capital costs of this alternative are approximately \$1.53 million. This cost includes the implementation of groundwater use restrictions as part of the ICs, obtaining permits for soil mixing and drilling of new groundwater monitoring wells, submitting the work and sampling plans, application of the persulfate via soil mixing, and restoration of the site. As shown in Table 5-1, the projected persulfate demand is approximately 66,000 pounds. O&M activities under this alternative were mostly associated with post-mixing monitoring and MNA monitoring. Periodic costs are primarily associated with the 5-year reviews. The total present worth lifetime O&M cost is estimated at \$348,200. The total present worth cost of this alternative is estimated at \$1.87 million. The cost estimate details are provided in Appendix K.

5.3.4 Alternative 4—Source Zone Treatment Using ISCR, MNA, and ICs

Alternative 4 uses ISCR technology for treatment of TCE in the source zone using soil mixing, in conjunction with MNA and IC components described in Alternative 2.

Overall Protection of Human Health and the Environment

Alternative 4 is considered protective of human health and the environment. This alternative would actively treat the COC mass in the source area. This alternative would also minimize the migration or discharge of unacceptable COC concentrations into the creek. Following the completion of the active treatment, NA processes would be used as the primary treatment mechanism to degrade the COCs to achieve the SRGs. Under this alternative, the RAOs, and therefore the SRGs, would be achieved within a period of 30 years or less. The estimated timeframe is considered reasonable for Site 17 because the groundwater is not currently used.

Compliance with ARARs

This alternative will comply with the location-, action-, and chemical-specific ARARs identified in Appendix I. Chemical specific ARARs for cis-1,2-DCE and CE would be able to be achieved within 30 years or less. This alternative is anticipated to meet all the location-specific ARARs. Erosion and sediment controls are action-specific ARARs as well as location-specific ARARs. These controls would be used during the ZVI mixing to prevent adverse effects on the Creek. Therefore, the requirements of the Wild and Scenic Rivers Act [16 USC 1271 et seq. and Section 7(a)] would be met. Well construction spoils are anticipated to be disposed off site as a RCRA hazardous waste. If dewatering is required to support MEC clearing and recovery, extracted water would be treated onsite and discharged to the onsite wastewater treatment plant.

Long-Term Effectiveness and Permanence

Magnitude of Residual Risks. TCE is expected to decline from the current maximum concentration of approximately 870,000 µg/L to the 1,000 µg/L during a 6-month period within the ZVI treatment area. NA is expected to reduce TCE, cis-1,2-DCE, and CE to below the SRGs during a longer period of 25 years. As with Alternatives 2 and 3, ICs would minimize human exposure to groundwater. Risks associated with migration to the Creek would be reduced as COC mass within the source area are aggressively treated through ISCR, and MNA will treat the remaining AAs.

Adequacy and Reliability of Controls. As with Alternatives 2 and 3, the ICs are expected to be adequate and reliable, and groundwater monitoring is adequate and can be reliably used to track groundwater quality and constituent migration. Granular ZVI has been shown to effectively treat the DNAPL and dissolved phases of chlorinated VOCs, including TCE. Soil mixing will greatly improve the contact of the ZVI and target COCs, increasing the success and effectiveness of the remedy.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative would significantly reduce or potentially eliminate the toxicity, mobility and volume of DNAPL TCE and the COC mass within the source zone area. With the absence of the free-phase TCE, NA processes are expected to occur at an accelerated rate for the remaining mass of TCE, cis-1,2-DCE, and CE.

Short-Term Effectiveness

Because the site is located in an open area, impact and disturbance to the NSF-IH operations would be minimal. Remediation activities will stop if live munitions are encountered. The activities will resume after the Navy provides the notice to proceed. No short-term impact is anticipated to the community during implementation of this alternative. A large-diameter auger would be used during the soil mixing process, so clearing and recovery of potential MEC objects should be conducted before mixing activities begin. The clearing and recovery procedures of MECs may pose high safety risks to the remediation workers. These risks would be managed by following the appropriate procedures for MEC avoidance and clearing.

The short-term risk to Mattawoman Creek would be minimal because the soil mixing method would minimize the risk of oxidant daylighting. The soil mixing area was disturbed during the 2005 NTCRA. Currently, the area is a grassy open space. After soil mixing, the area would be restored as a grassy open space. Achievement of SRGs would be expected within 30 years.

Implementability

Technical Feasibility. ISCR using granular ZVI via soil mixing has been demonstrated in several full-scale applications for treating DNAPL TCE; therefore, it is readily implementable. The likely success rate at Site 17 would be high because it is least affected by the high NOD, and soil mixing will greatly improve the contact of the ZVI and target COCs, increasing the success and effectiveness of the remedy.

Administrative Feasibility. Although MEC clearing and recovery procedures have also been established; they require coordination with and approval by several agencies. In addition, long-term administrative resources for implementation of ICs would also be required throughout the entire duration of this alternative (30 years).

Cost

The capital cost of this alternative is approximately \$1.4 million. This cost was associated with the implementation of groundwater use restrictions as part of the ICs, obtaining permits for ZVI mixing, and drilling of new groundwater monitoring wells, submittal of the work and sampling plans, injection and mixing of ZVI, monitoring and reporting. As shown in Table 5-2, the projected iron demand is approximately 36,000 pounds. O&M activities under this alternative were mostly associated with the long-term groundwater and surface water monitoring to assess the performance of the ISCR technology and the rate of NA processes. Periodic costs incurred were primarily associated with the 5-year reviews. The present worth lifetime O&M cost is approximately \$348,200, and the total present worth value of this alternative is estimated at \$1.74 million. The cost estimate details are provided in Appendix K.

5.3.5 Alternative 5—Source Zone Excavation and Offsite Disposal, MNA, and ICs

Alternative 5 removes contaminant mass in the source zone through excavation and offsite disposal, in conjunction with MNA components described in Alternative 2 for the plume treatment, and ICs.

Overall Protection of Human Health and the Environment

Alternative 5 is considered protective of human health and the environment. The COCs mass in the source zone would be removed, thereby, indirectly minimizing the migration or discharge of unacceptable COC concentrations into the creek. Following the removal, NA processes would be used as a polishing step to degrade the COCs to achieve the SRGs. Under this alternative, the RAOs, and therefore the SRGs, would be achieved within a period of 25 years or less. The estimated timeframe is considered reasonable for Site 17 because the groundwater is not currently used.

Compliance with ARARs

This alternative will comply with the location-, action-, and chemical-specific ARARs identified in Appendix I. Chemical-specific ARARs for cis-1,2-DCE and CE could be achieved within 25 years or less. This alternative is anticipated to meet all the action-specific ARARs. Rigorous compliance with the MEC policies is anticipated because of the potential needs for treatment, demilitarization, or disposal of MEC.

Long-Term Effectiveness and Permanence

Because the potential sources of contamination will be permanently removed from the site, Alternative 5 is expected to address long-term effectiveness and permanence. Rebound of COC concentrations within the source zone would be highly unlikely because the COC mass would be removed. The success of NA as a polishing treatment step to achieve the SRGs is expected to be high.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 5 reduces the toxicity, mobility, and volume of contaminants within the source zone area (TCE>1,000 µg/L) through a removal action, not through treatment. However, the reduction of toxicity, mobility, and volume of contaminants within the remaining area of the AA would be accomplished through natural processes as the primary treatment mechanism.

Short-Term Effectiveness

Under this alternative, RAOs, in terms of soil removal and disposal, will be met within 3 to 6 months. During this period, the NSF-IH daily operations may be impacted because of the excavation activities and transportation of the excavated material off site. It is expected to take longer with the management, and potential treatment and demilitarization of MEC. Short-term impacts to the remediation workers resulting from the implementation of this alternative will be minimized through the implementation of good health and safety practices. OSHA-trained personnel will be required for all the site-related activities and a UXO technician will be involved throughout the duration of the field activities. Therefore, short-term hazards to the remediation workers will be minimized as much as possible. Also, erosion control measures will be used to prevent any discharge of waste from Site 11 to surface water during excavation.

Implementability

Excavation and landfill disposal are technically and administratively feasible because the technologies have become standard practices. Because of the potential MEC encounter, Alternative 5 may involve rigorous procedures associated with MEC avoidance, clearing, removal, treatment, demilitarization, and disposal.

Cost

Alternative 5 has an approximate estimated capital cost of \$2.87 million. This cost is associated primarily with the removal (excavation), transportation and offsite disposal, and site restoration. O&M activities under this alternative were mostly associated with the long-term groundwater and surface water monitoring to assess the rate of NA processes of COCs within the AA outside the source zone area. Periodic costs incurred were primarily associated with the 5-year reviews. The present worth lifetime O&M cost is approximately \$348,200, and the total present worth value of this alternative is estimated at \$3.21 million. The cost estimate details are provided in Appendix K.

5.4 Comparative Analysis of RAs

In the following analysis, the RAs are evaluated in relation to one another based on each of the seven criteria. The purpose of this analysis is to identify the relative advantages and disadvantages of each alternative. Table 5-3 presents the results of comparative analysis of the RAs.

5.4.1 Overall Protection of Human Health and the Environment

Alternatives 1 and 2 are not protective of human health and the environment. Alternatives 3 and 4 are considered comparably protective of human health and the environment because

they would actively treat the residual DNAPL and the high concentrations of dissolved COCs as the source of groundwater contamination. Alternatives 3 and 4 also prevent human exposure through the continuous implementation of ICs during the implementation of the remedy until RAOs are met. Alternatives 3 and 4 would also minimize the migration or discharge of Site 17 groundwater with unacceptable COC concentrations (above SRGs) to Mattawoman Creek. Alternative 5 provides the greatest extent of protection for human health and the environment because the source zone area (TCE>1,000 µg/L) would be removed.

5.4.2 Compliance with ARARs

Alternatives 1 and 2 do not comply with the chemical-specific ARARs. Chemical-specific ARARs for the COCs will be achieved within a projected timeframe of 30 years or less under Alternatives 3 through 5. Alternatives 2 through 5 would equally meet all the location-specific ARARs. Location-specific ARARs will not be applicable for Alternative 1 because no planned activities will be performed. Under Alternatives 3 through 5, appropriate MEC procedures will be closely followed to minimize any safety risks and interferences with the ongoing activities at the site. Action-specific ARARs will not be applicable for Alternative 1 because no planned activities will be performed. Alternatives 2 through 5 entail rigorous MEC procedures because of the potential treatment, demilitarization, or disposal of MEC.

5.4.3 Long-Term Effectiveness and Permanence

Magnitude of Residual Risks. Under Alternatives 1 and 2, the magnitude of residual risks would remain the same as the current conditions because no planned activities would be performed and based on sole reliance of natural processes. Natural processes will reduce contamination, but at environmentally slow rates.

Under Alternatives 3 and 4, TCE is expected to decline from the current maximum concentration of approximately 870,000 µg/L to 1,000 µg/L within 6 months within the source zone area. Following the active treatment, natural processes are expected to reduce the COC concentrations to SRGs within the AA during a projected timeframe of less than 30 years.

Under Alternative 5, the achievement of 1,000 µg/L in TCE concentration from the initial concentration of 870,000 µg/L would be the shortest (<3 months) because the COC mass would be removed through excavation. However, the overall achievement of the SRGs with the AA is projected to be similar to Alternatives 3 and 4.

Under Alternatives 2 through 5, ICs are required to prevent human exposure to groundwater. Alternative 2 would not as aggressively reduce the risks associated with migration of contamination to the Creek as Alternatives 3 through 5 because under these alternatives, the contamination sources are removed through active treatment or excavation and natural processes would mitigate the remaining AA.

Adequacy and Reliability of Controls. The adequacy and reliability of controls under Alternative 1 is very poor. Under Alternatives 2 through 5, ICs are expected to be adequate and reliable, and groundwater and surface water monitoring can be reliably used to track remedy performance, groundwater and surface water quality, and the behavior of COCs over time.

ISCR technology using granular ZVI via soil mixing (Alternative 4) has been widely implemented in full-scale applications compared to ISCO using persulfate via soil mixing (Alternative 3).

Alternative 5 would be the most reliable approach because the contaminant mass would be removed through excavation.

5.4.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 1 and 2 do not reduce the toxicity, mobility, or volume of contamination through treatment.

Alternative 5 would not reduce the toxicity, mobility, and volume of contamination through treatment because the contaminant mass within the source zone area would be removed to an offsite facility without treatment.

Alternatives 3 and 4 provide equal reduction of the toxicity, mobility, and volume of contaminants because an active treatment would be implemented within the source zone area. The treatment of the remaining contaminant masses within the AA would rely primarily on the natural processes.

5.4.5 Short-Term Effectiveness

Among all RAs considered for Site 17, Alternative 5 entails the greatest safety risks to the remediation workers, as well as disturbance to the daily operation of NSF-IH and the surrounding community. The safety risks potentially posed by the potential existence of MEC include its associated handling and management procedures, such as potential needs for removal, treatment, demilitarization, and disposal of MEC. Because approximately 2,590 cubic yards of contaminated soil would be excavated and disposed of off site, disturbance to the facility and local community would be attributed to the operation of heavy equipment during the excavation activities, as well as the offsite transportation of the excavated materials that may cause a significant alteration in the traffic patterns. The excavation activities would be anticipated to be complete within 3 months. It should be noted that this duration excludes the duration for the management and potential treatment and demilitarization of MEC.

Implementation of Alternatives 3 and 4 would entail comparable short-term impacts to the remediation workers and the environment, as well as to NSF-IH operations and the community. Because the site is located in an open area, impact and disturbance to NSF-IH operations would be minimal under Alternatives 3 and 4. No short-term impact is anticipated to the community during implementation of these alternatives. A large-diameter auger would be used during the soil mixing process, so clearing and recovery of potential MEC objects will be conducted prior to the mixing activities. The clearing and recovery procedures of MEC may pose high safety risks to the remediation workers. These risks would be managed by following the appropriate procedures for MEC avoidance and clearing.

The short-term risk to Mattawoman Creek would be minimal because the soil mixing method would minimize the risk of oxidant daylighting into the creek. The soil mixing area was disturbed during the 2005 NTCRA. Currently, the area is a grassy, open space. After

soil mixing, the area would be restored as a grassy, open space. Achievement of SRGs would be expected within 30 years.

Alternatives 1 and 2 are considered incapable of meeting the RAOs and, thus, SRGs. Under the scenario of Alternatives 3 through 5, the RAOs, and therefore the SRGs, would be achieved within a period of 30 years or less. The estimated timeframe is considered reasonable for Site 17 because the groundwater is not currently used.

5.4.6 Implementability

Technical Implementability. Alternative 5 is technically implementable because excavation, dewatering, and offsite transportation and disposal of the excavated soil have become standard practices. The complexity in terms of its technical implementability would be exponentially increased because the potential needs for treatment, demilitarization, and offsite disposal of MEC.

Both Alternatives 3 and 4 are technically implementable for the Site 17 shallow groundwater because they have been demonstrated in a full-scale application for DNAPL treatment of TCE.

Alternatives 1 and 2 would be technically implementable because none or minimal planned activities would be performed.

Administrative Implementability. Alternatives 3 and 4 have a comparable administrative implementability. Although MEC clearing and recovery procedures have also been established; they require coordination with and approval by several agencies. In addition, long-term commitment of resources would be required for the implementation of the groundwater and surface water monitoring, as well as the implementation of ICs throughout the entire duration of this alternative (30 years).

Excavation and offsite disposal under Alternative 5 are technically and administratively feasible because the technologies have become standard practices. However, Alternative 5 may involve a rigorous administrative procedure for the handling and management of MEC.

Alternatives 1 and 2 have a poor administrative feasibility because a prolonged commitment in administrative resources (100 years) would be required and, therefore, the likely approval of its implementation from other agencies would be unlikely.

5.4.7 Cost

Alternative 1 implies zero cost, although it should be noted that the cost for performing the 5-year reviews as required by CERCLA when the contamination is left in place would not be included in the no-action alternative cost.

Alternative 5 would be the most expensive remedy, primarily because of the capital cost associated with the removal and offsite disposal of the COC mass within the source zone area. It should be noted that the capital cost does not account for the cost potentially incurred for the demilitarization, treatment, transportation, and offsite disposal of the recovered MEC.

Because of the persulfate NOD as determined during the bench-scale studies, Alternative 3 is more expensive than Alternative 4.

The capital cost of Alternative 4 is less than Alternative 3, primarily because the unit cost of granular ZVI is lower than sodium persulfate. In terms of the lifetime O&M activities, Alternatives 3 through 5 entail the same requirements, and thereby the same O&M cost, because all of these alternatives rely on natural processes as a polishing step for the achievement of the SRGs within the AA, which was projected could occur in 30 years. Therefore, these alternatives would involve a long-term monitoring program of the groundwater and surface water to verify the rates of the NA processes.

Alternative 2 is the least expensive remedial approach. However, the remediation timeframe for Alternative 2 is assumed at 100 years, which in reality could be much longer.

Table 5-1
 Conceptual Design of ISCO via Soil Mixing
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Mass of Soil within Source Zone:			
Soil Mixing Area (>1000 ppb TCE)			
Source Zone Area	3,532	SF	(Table 3-5)
Thickness	10	ft	(Cross Section)
Volume (cf)	35,320	CF	
Volume (L)	1,000,121	L	
Bulk Density	1.6	kg/L	SourceDK User Manual
Mass of saturated soil	1,600,194	kg	
	3,527,787	lbs	
Porosity	0.2		SourceDK User Manual
Volume of groundwater:	200,024.2	L	
One target zone pore volume =	52,841	gallons	
Volume of dry soil	1,280,155.0	kg	
Mass of TCE within the Source Zone:			
Dissolved TCE in lower surficial aquifer interval:	12.3	lbs	(Table 3-5)
Adsorbed TCE in lower surficial aquifer interval:	750.6	lbs	(Table 3-5)
Total TCE Mass in Source Zone	762.9	lbs	(Table 3-5)
Iron-Activated Persulfate Demand:			
Oxidant Required = Stoichiometric Demand + Natural/Soil Oxidant Demand + Oxidant Decomposition			
<i>Stoichiometric Demand:</i>			
Molecular weight of TCE	131.4	g/mol	
Molecular weight of sodium persulfate	238.05	g/mol	
Stoichiometric persulfate demand (mol TCE: mol persulfate)	1	:	3 (ITRC, 2005)
Stoichiometric persulfate demand (massTCE: mass persulfate)	1	:	5.5
Total stoichiometric demand:	4,196.00	lbs	
<i>NOD/Soil Oxidant Demand:</i>			
	Iron-Activated		
NOD/soil persulfate demand (Table A.9)	22	g/kg (lowest)	
Total NOD persulfate demand	62090	lbs	
Subtotal stoichiometric + NOD demand:	66,286	lbs	
Total Theoretical Persulfate Demand:	66,286 lbs		
Concentration of oxidant (Recommended range from bench-scale is 70 - 200 g/L for DNAPL plume)			
Total volume of oxidant:			
Estimated Demand of Chelated Iron:	0.10	lb/lb of persulfate (XDD, 2007)	
Total Demand of Chelated Iron:	6,629 lbs		
Delivery System Design:			
Total persulfate for Soil Mixing Area will be administered via a one-time soil mixing event.			
Rough Order of Magnitude Cost (-30% to +50% Accuracy):			
Soil Mixing	3-ft Diameter Auger		6-ft Diameter Auger
Unit cost for substrate delivery	\$240	/cY	\$120 /cY (Enviro-Con, 2008; assuming to a max depth of 20 feet using crane-mounted auger)
Total cost for substrate delivery	\$313,642		\$156,821
Unit cost of sodium persulfate	\$1.75	/lb	\$1.75 /lb (including shipping; from Site 47 Pilot Study unit rate adjusted for shipping cost)
Unit cost of chelated iron	\$1.10	/lb	\$1.10 /lb
Total cost for reagent:	\$123,292		\$123,292
Daily mixing output:	60		130 CY/day (Enviro-Con, 2008)
Mixing duration without MEC clearance and avoidance:	22		11 days (10-hr field days)
Mobilization/Demobilization duration:	4		4 days (10-hr field days)
Total duration	26		15 days (10-hr field days)

□ Denotes input parameters

XDD, 2007 - Email from Annette Lee of XDD dated 12/11/07.
 Enviro-Con, 2008 - Email from Ken Andromolos of Enviro-con dated 4/3/2008.

Table 5-2
 Conceptual Design of ISCR via Soil Mixing
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Mass of Soil within Source Zone:			
Soil Mixing Area (>1000 ppb TCE)			
Source Zone Area	3,532	SF	(Table 3-5)
Thickness	10	ft	(Cross Section)
Volume (cf)	35,320 CF		
Volume (L)	1,000,121 L		
Bulk Density	1.6	kg/L	SourceDK User Manual
Mass of saturated soil	1,600,194 kg		
	3,527,787 lbs		
Porosity	0.2		SourceDK User Manual
Volume of groundwater:	200,024.2 L		
One target zone pore volume =	52,841 gallons		
Volume of dry soil	1,280,155.0 kg		
Mass of TCE within the Source Zone:			
Dissolved TCE in lower surficial aquifer interval:	12.3 lbs		(Table 3-5)
Adsorbed TCE in lower surficial aquifer interval:	750.6 lbs		(Table 3-5)
Total TCE Mass in Source Zone	762.9 lbs		(Table 3-5)
Theoretical ZVI Requirement per Event			
Ratio of ZVI:soil mass (decimal):	1%		To determine subsurface dilution. Min 0.4% recommended for most CVOCs regardless of iron form. Max % may be 1% to 3% depending on type and concentration of main CVOCs)
Minimum ZVI required:	36,000 lbs		
Delivery System Design:			
Total persulfate for Soil Mixing Area will be administered via a one-time soil mixing event.			
Rough Order of Magnitude Cost (-30% to +50% Accuracy):			
Soil Mixing	3-ft Diameter Auger		6-ft Diameter Auger
Unit cost for substrate delivery	\$240	/cY	\$120
			(Enviro-Con, 2008; assuming to a max depth of 20 feet using crane-mounted
Total cost for substrate delivery	\$313,642		\$156,821
Total cost for reagent (include shipping):	\$0.47		\$0.47
			(Peerless Metals, 2008)
Daily mixing output:	60	CY/day	130
			(Enviro-Con, 2008)
Mixing duration without MEC clearance and avoidance:	22 days		11 days
			(10-hr field days)
Mobilization/Demobilization duration:	4		4 days
			(10-hr field days)
Total duration	26		15 days
			(10-hr field days)

Denotes input parameters

XDD, 2007 - Email from Annette Lee of XDD dated 12/11/07.
 Enviro-Con, 2008 - Email from John Liskowitz of ARS dated 4/3/2008.

**Table 5-3
Comparative Analysis of Remedial Alternatives
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland**

Evaluation Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
	No Action	MNA and ICs	Source Treatment Using ISCO, MNA, and ICs	Source Zone Area Treatment Using ISCR, MNA, and ICs	Source Zone Area Excavation and Off-site Disposal, MNA, and ICs
Overall Protection of Human Health and the Environment	Not protective of human health and the environment	Poor protection of human health through ICs but inadequate protection of the environment Incapable of preventing migration or discharge of groundwater with unacceptable COC concentrations to the Creek	Expected adequate protection of human health and the environment because DNAPL and hot spot area representing the contamination sources would be treated, reducing contaminant mass significantly.	Adequate protection of human health and the environment because DNAPL and hot spot area representing the contamination sources would be treated, reducing contaminant mass significantly	Adequate protection of human health and the environment because DNAPL and hot spot area representing the contamination sources would be removed, reducing contaminant mass significantly
Compliance With ARARs	Not applicable	Would not comply with chemical-specific ARARs for 100 years or longer but in compliance with location- and action-specific ARARS	Compliance with chemical specific ARARs within 30 years or less and in compliance with location- and action-specific ARARS.	Compliance with chemical specific ARARs within 30 years or less and in compliance with location- and action-specific ARARS	Compliance with chemical specific ARARs within 30 years or less and in compliance with location- and action-specific ARARS
Long-Term Effectiveness and Permanence	Magnitude of residual risk would diminish over prolonged time frame; treatment mechanism relies on unverified NA processes Adequacy and reliability of controls are very poor	Magnitude of residual risk would diminish but rate-limited by DNAPL dissolution and greatly depends on the rate of verifiable NA Adequacy and reliability of controls are poor because of the reliance on slow natural processes to achieve SRGs	Magnitude of residual risk in the source zone area would diminish significantly within shorter time frame (6 months). Adequacy and reliability of controls are high.	Magnitude of residual risk in the source zone area would diminish significantly within shorter time frame (6 months) Adequacy and reliability of controls are high.	Magnitude of residual risk in the source zone area would diminish significantly within shorter time frame (3 months or less) Adequacy and reliability of controls are high
Reduction of Toxicity, Mobility, or Volume Through Treatment	Reduction of toxicity through NA processes COCs mass is assumed to be removed by unverified NA	Reduction of toxicity through NA processes; very slow rate because source zone is not actively treated	Reduction of toxicity, mobility, and volume through ISCO and NA processes. The COC mass within the source zone area (TCE>1,000 ug/L) would be treated and NA processes would treat the remaining COC mass within the source zone area and the area outside the source zone area within the AA for the SRG achievement within approximately 30 years.	Reduction of toxicity, mobility, and volume through ISCR and NA processes The COC mass within the source zone area (TCE>1,000 ug/L) would be treated and NA processes would treat the remaining COC mass within the source zone area and the area outside the source zone area within the AA for the SRG achievement within approximately 30 years	Reduction of toxicity, mobility, and volume through removal and NA processes The COC mass within the source zone area (TCE>1,000 ug/L) would be removed and disposed of off-site and NA processes would treat the remaining COC mass within the source zone area and the area outside the source zone area within the AA for the SRGs achievement within approximately 30 years
Short-Term Effectiveness	No impact to community, workers, and the environment from remedial activities because this alternative involves doing nothing RAOs be achieved within 100 years or longer	Very minimal impact to the remediation workers during the installation of new groundwater monitoring wells and the sample collections Can be eliminated with proper planning and safe practices RAOs be achieved within 100 years or longer	Moderate safety risk to the remediation workers during MEC clearing and recovery and oxidant mixing/. These risks can be minimized or eliminated through stringent compliance w/ MEC procedures. RAOs be achieved within 30 years or less.	Moderate safety risk to the remediation workers during MEC clearing and recovery and oxidant mixing/. These risks can be minimized or eliminated through stringent compliance w/ MEC procedures. RAOs be achieved within 30 years or less.	Highest safety risk to the remediation workers during the excavation activities due to the potential encounters with MEC Highest disturbance to the daily facility operations and the surrounding community due to the potential traffic alteration during the transportation of the excavated material to the off-site facility
Implementability	Has no ability to monitor the effectiveness of this remedy and ability to obtain approvals from other agencies is unlikely	Easily implemented but requires long-term administrative commitment	Readily implementable but application of persulfate via soil mixing are not commonly used Rigorous and stringent procedures for MEC clearing and recovery	Readily implementable; ZVI granular application via soil mixing has been demonstrated successful in full-scale applications Rigorous and stringent procedures for MEC clearing and recovery.	Technical and administrative implementability Complicated due to the potential needs for the removal, demilitarization, treatment, transportation, and off-site disposal of the MEC
Cost	\$0-	Capital: \$24,300 Lifetime Present Worth O&M: \$460,600 Total Present Worth: \$484,900	Capital: \$1.53 million Lifetime Present Worth O&M: \$348,200 Total Present Worth: \$1.87 million	Capital: \$1.4 million Lifetime Present Worth O&M: \$348,200 Total Present Worth: \$1.74 million	Capital: \$2.9 million Lifetime Present Worth O&M: \$348,200 Total Present Worth: \$3.2 million
		Cost is based on 100-year time frame assumption. In reality, the time frame could be much longer.			The capital cost does not account for the potential needs for the removal, demilitarization, treatment, transportation, and off-site disposal of MEC. Because the same remediation time frame is likely required under this alternative as those required for Alternatives 3 and 4, this alternative appears to be overkill.

Notes: NA = natural attenuation

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

- How Alternatives Provide Human Health and Environmental Protection

COMPLIANCE WITH ARARs

- Compliance With Chemical-Specific ARARs
- Compliance With Action-Specific ARARs
- Compliance With Location-Specific ARARs
- Compliance With Other Criteria, Advisories, and Guidance (TBC Guidance)

LONG-TERM EFFECTIVENESS AND PERMANENCE

- Magnitude of Residual Risk
- Adequacy and Reliability of Controls

REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT

- Treatment Process Used and Materials Treated
- Amount of Hazardous Materials Destroyed or Treated
- Degree of Expected Reductions in Toxicity, Mobility, and Volume
- Degree to Which Treatment is Irreversible
- Type and Quantity of Residuals Remaining After Treatment

SHORT-TERM EFFECTIVENESS

- Protection of Community During Remedial Construction
- Protection of Workers During Remedial Construction
- Environmental Impacts
- Time Until Remedial Action Objectives Are Achieved

IMPLEMENTABILITY

- Ability to Construct and Operate the Technology
- Reliability of the Technology
- Ease of Undertaking Additional Remedial Action, if Necessary
- Ability to Monitor Effectiveness of Remedy
- Ability to Obtain Approvals From Other Agencies
- Coordination With Other Agencies
- Availability of Off-site Treatment, Storage, and Disposal Services and Capacity
- Availability of Necessary Equipment, Materials, and Personnel
- Availability of Prospective Technologies

COST

- Capital Costs
- Operating and Maintenance Costs
- Present Worth Cost

STATE ⁽¹⁾
ACCEPTANCE

COMMUNITY ⁽¹⁾
ACCEPTANCE

¹ These criteria are assessed following comment on the FS and the Proposed Plan.

Figure 5-1
Detailed Evaluation Criteria
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland
CH2MHILL

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Appendix A

Soil Boring Logs



PROJECT NUMBER 156175	BORING NUMBER IS17MW02
SHEET 1 OF 1	
SOIL BORING LOG	

PROJECT : NDWIH LOCATION : Site 17
 ELEVATION : See survey report DRILLING CONTRACTOR : Parratt-Wolff Inc.
 DRILLING METHOD AND EQUIPMENT USED : ATV Rotary Drill Rig, CME 850, 8" hollow stem augers, 2' split spoon sampling
 WATER LEVELS : First encountered at 4 ft bgs START : 8/11/00 END : 8/11/00 LOGGER : Fred Calef

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)			STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION	COMMENTS
	RECOVERY (FT)	#/TYPE				
0 - 2	1	1S	2-20-24-50 (44)	Dry, stiff clay. Yellow-brown. Some organics. Slight organic smell. Refusal at 2'. Wood at tip of spoon.	Breathing zone PID = 0	
2 - 4	0.5	2S	2-2-1-1 (3)	Wet clay. Soft. Dull yellow-brown.	Breathing zone PID = 0	
5 4 - 6	0.25	3S	wH-wH-wH-4 (wH)	greenish gray clay with some silt. Wet. Some organics	Breathing zone PID = 0	
6 - 8	1.5	4S	2-1-2-2 (3)	1' of greenish gray clay. Wet. Soft. 6" of fine medium well sorted sand. Gray. Moist to wet. Black rotten wood at bottom.	Breathing zone PID = 0	
8 - 10	0	5S	3-2-2-2 (4)	Spoon was wet/saturated.	Breathing zone PID = 0	
10				Will set well at 10 feet bgs.		
15						
20						
25						



PROJECT NUMBER 156175	BORING NUMBER IS17MW03	SHEET 1 OF 1
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SOIL BORING LOG

PROJECT : NDWIH LOCATION : Site 17
 ELEVATION : See survey report DRILLING CONTRACTOR : Parratt-Wolff Inc.
 DRILLING METHOD AND EQUIPMENT USED : ATV Rotary Drill Rig, CME 850, 8" hollow stem augers, 2' split spoon sampling
 WATER LEVELS : First encountered at 11 ft bgs START : 8/11/00 END : 8/11/00 LOGGER : Fred Calef

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)		STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION	COMMENTS
	RECOVERY (FT)	#/TYPE			
0 - 2	1.3	1S	3-3-4-5 (7)	Clay. Med-stiff. Dry to moist. Orange.	Breathing zone PID = 0
2 - 4	1.5	2S	5-7-5-9 (12)	Clay. Med-stiff. Dry to moist. Orange to gray with orange "streaks." Slightly wetter than previous spoon.	Breathing zone PID = 0
5 4 - 6	0.25	3S	wH-wH-wH-4 (wH)	greenish gray clay with some silt. Wet. Some organics	Breathing zone PID = 0
6 - 8	2	4S	6-9-9-9 (18)	Clay. Med-stiff. Dry to moist. Light gray with orange "streaks."	Breathing zone PID = 0
10 8 - 10	2	5S	3-2-2-2 (4)	Clay. Med-stiff. Dry to moist. More moist than previous spoon. Reddish-gray. Some orange "streaks."	Breathing zone PID = 0
10 - 12	2	6S	6-7-7-8 (14)	0-18" clay. Med-soft. Moist. Reddish gray. 18-24" fine-med sand. Orange. Wet. Well sorted.	Breathing zone PID = 0
12 - 14	2	7S	8-9-9-6 (18)	0-12" fine-med sand. Orange. Saturated. Well sorted. 12-24" Fine sand. Wet to saturated. Med-soft. Well sorted. Orange.	Breathing zone PID = 0
15 14 - 16	2	8S	5-7-6-3 (13)	Fine sand with clay. Saturated to wet. Well sorted. Orange.	Breathing zone PID = 0
20				Setting well at 16 feet bgs	
25					

Appendix B
Site 17 Pre-FS Investigation Memo

Pre-Feasibility Study Field Activities and Results, Site 17, Indian Head Division-NSWC, Indian Head, Maryland

PREPARED FOR: Jeff Morris/EFA CHES
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COPIES: Bob Root/CH2M HILL
Anne Estabrook/CH2M HILL

DATE: September 30, 2002

This technical memorandum (memo) describes the activities performed to collect additional data for the feasibility study (FS) at Site 17 at the Indian Head Division-NSWC as described in the work plan (CH2M HILL, 2002). This memo also presents the results of the investigation.

The remedial investigation (RI) conducted at the site identified contaminants of concern in groundwater (CH2M HILL, 2002). Additional data needs were identified in order to evaluate potential remedial alternatives. This investigation was undertaken to address those needs and meet the following specific objectives:

- More fully define the distribution of contaminants in groundwater.
- Determine whether or not volatile organic compounds (VOCs) in groundwater are impacting Mattawoman Creek.
- Generate data to assess the viability of monitored natural attenuation (MNA) as a remedial alternative.
- Determine the influence of Mattawoman Creek's tidal cycle on shallow groundwater.
- Estimate the hydraulic conductivity of the subsurface.

In order to meet these objectives, the investigation was performed in two phases, the investigation of groundwater contamination and tidal monitoring, which are discussed below.

Investigation of Groundwater Contamination

Groundwater sampling conducted at Site 17 during the initial field effort (October, 2000) detected VOCs in groundwater. Specifically, the groundwater sample collected from monitoring well IS17MW02 contained cis-1,2-dichloroethene (cis-DCE) at 4,200 micrograms per liter ($\mu\text{g}/\text{l}$) and vinyl chloride (VC) at 3,000 $\mu\text{g}/\text{l}$ (Figure 1). Soil samples collected at Site 17 contained low levels of trichloroethene (TCE; Figures 2 and 3), the likely source of the cis-DCE and VC. Based on groundwater elevations measured at the three site wells, groundwater flows to the southeast and discharges to Mattawoman Creek (Figure 4).

This phase of the investigation was conducted to: 1) better define the distribution of contaminants in groundwater; 2) determine whether or not VOCs are impacting Mattawoman Creek; and 3) generate data to assess the viability MNA as a remedial alternative.

Field Activities

The following field activities were undertaken to meet the stated objectives:

- Membrane interface probe/electrical conductivity (MIP/EC) profiling
- *In situ* groundwater sampling
- Shelby-tube soil sampling
- Surface water sampling
- Monitoring well sampling

The field effort was conducted between June 24, 2002 and July 17, 2002.

MIP/EC Profiling and *In Situ* Groundwater Sampling

MIP/EC profiling and *in situ* groundwater sampling were performed in order to define the extent of contaminants in groundwater in an efficient and economical manner. This portion of the investigation utilized a direct-push rig to collect the samples and an onsite, mobile laboratory to perform the VOC analyses. The MIP/EC rig was utilized to collect qualitative VOC and lithologic data prior to groundwater sampling. Mobilizing the MIP/EC rig prior to the *in situ* groundwater sampling phase of the investigation provided data that focused the sampling effort without substantially increasing the length of the field effort. The MIP/EC data was also used to help determine the appropriate sampling depths by identifying areas of elevated VOC concentrations and lithologic variations in the subsurface.

Twelve *in situ* groundwater samples were collected at the locations shown in Figure 5. Nine of the samples were collected at locations along a transect parallel to Mattawoman Creek (normal to the direction of groundwater flow). These locations were designed to define the extent of VOCs along the northeast/southwest transect and to identify the source area assumed to be located near IS17MW02. The three additional samples were collected at locations upgradient of areas identified as containing VOCs from the samples collected along the initial transect. The two secondary transects created by the additional samples were designed to define the extent of VOCs in the northwest/southeast direction (along groundwater flow lines).

Prior to *in situ* groundwater sampling, MIP/EC borings were installed at each sampling location (Appendix A). The MIP data was used to help focus the groundwater sampling event by identifying areas of elevated VOC concentrations. The EC data was used to better define the lithology of the subsurface and to identify the depth to groundwater at Site 17.

With the exception of groundwater samples IS17GW04 (collected at a depth of 4-8 feet below ground surface [bgs]) and IS17GW05 (collected at a depth of 16-20 feet bgs), which were collected at the same location, one groundwater sample was collected at each location. Two samples were proposed at each location in the work plan; however, EC data indicated that, in the area of drum disposal, the water table was encountered approximately 3-5 feet bgs and an underlying confining layer was present at a depth between 8 feet bgs and 13 feet bgs. Therefore, the interval available for groundwater sampling was limited. All samples were analyzed for VOCs using United States Environmental Protection Agency (EPA) Method 8260.

Following the completion of the MIP/EC *in situ* and groundwater sampling portion of the investigation, all locations were horizontally located using the global position system (GPS). Additionally, investigation derived waste (IDW) was characterized and disposed of in accordance with state and federal regulations and IHDIW-NSWC Standard Operating Procedures (SOPs).

Results

The MIP/EC logs are presented in Appendix A. The results of *in situ* groundwater sampling are presented in Table 1 and Figure 6. Raw data are presented in Appendix B.

Lithology

A review of the EC logs suggests that, in the area of drum disposal, the subsurface is characterized by sands and silts (as represented by lower values of electrical conductivity) to a depth of approximately 10 feet bgs. Underlying the sands and silts is a layer dominated by clay (as represented by higher values of electrical conductivity). The layer appears continuous across the site; however, at some locations there appears to be a sharp contact between sand and clay (e.g., MIP 1 and MIP 10) and at other locations there appears to be a more gradational contact (e.g., MIP 2 and MIP 4). It should be noted that the clay was not observed at two locations, MIP 6 and MIP 8. However, at MIP 6 the boring was advanced to refusal, which occurred at only 15 feet bgs. This likely indicates that the clay was present beneath this depth but could not be penetrated. MIP 8 was advanced in an area upslope of the drum disposal area and was terminated at a depth of 15 feet bgs, likely too shallow to encounter the clay.

VOCs

VOC concentrations suggestive of the presence of a dense non-aqueous phase liquid (DNAPL) were detected in the source area; however, the areal distribution of VOCs is small. The groundwater sample collected in the source area (IS17MW02), located to the southwest of IS17MW02, contained TCE, cis-DCE, and VC at concentrations of 310,000 µg/l, 75,000 µg/l, and 50,000 µg/l, respectively. Chloroethane was also detected in groundwater sample IS17GW02 at a concentration of 28,000 µg/l. Total VOC concentrations decrease to below 600 µg/l within 60 feet to the southwest and to non-detect within 175 feet. To the northeast, VOC concentrations decrease to non-detect within 130 feet. Of note, one groundwater

sample, IS17GW06, collected 260 feet northeast of the source area, contained TCE, cis-DCE, and 1,1-dichloroethane (DCA) at concentrations of 240 µg/l, 20 µg/l, and 20 µg/l. Given the disposal history of the site, this anomalous detection is likely due to a small surface release from one of the drums in this area. To confirm this, a sample was collected further cross-gradient (to the northeast; IS17GW08) and upgradient (IS17GW10); VOCs were not detected at either of these locations.

As presented in the RI (CH2M HILL, 2002), VOCs were not detected at concentrations suggestive of a source in unsaturated soil; therefore, vertically, VOCs appear constrained between the water table and the underlying confining unit.

Shelby-Tube Soil Sampling

Shelby-tube soil samples were collected from MIP locations 1 (depth 9-11 feet bgs) and 7 (depth 13-15 feet bgs; Figure 5). The samples were not proposed in the work plan; however, as noted above, the EC logs suggested that a confining layer underlies the site (Appendix A). It was decided in the field that quantitative hydraulic conductivity data from this layer would be critical to the FS and future risk management decisions at the site. Therefore, the samples were collected and sent to a geotechnical laboratory for hydraulic conductivity testing.

Results

Hydraulic conductivity of the underlying confining unit = 6.5×10^{-4} feet per day, which is in the range reported by Domenico and Schwartz (1990) of a clay (Appendix C).

Surface Water Sampling

Concurrently with *in situ* groundwater sampling, three surface water samples were collected in Mattawoman Creek (Figure 5) to evaluate the impact of VOCs in groundwater on the creek. The samples were analyzed for Low Concentration (LC) VOCs using Contract Laboratory Program (CLP) Method OLC03 at a fixed-base laboratory.

Results

Analytical results of surface water sample are presented in Table 2 and Figure 7. Raw data are presented in Appendix B. It should be noted that because the VOCs discussed below are not the primary contaminants of concern and were not detected at concentrations above action levels, these compounds are not presented in Figure 7.

Three VOCs were detected at each of the 3 sampling locations: methyl-tert-butyl ether (MTBE), methylene chloride, and toluene. Concentrations of each are relatively consistent from sample to sample. Concentrations of MTBE range from 4 µg/l in IS17SW07 and IS17SW08 to 4.1 µg/l in IS17SW04. Concentrations of methylene chloride range from 0.18 µg/l in IS17SW08 to 0.22 µg/l in IS17SW04 and IS17MW07. Concentrations of toluene range from 0.12 µg/l in IS17SW07 and to 0.18 µg/l in the duplicate sample of IS17SW08. Neither TCE, cis-DCE, nor VC were detected in the samples.

Monitoring Well Sampling

Following the completion of *in situ* groundwater sampling, the three site monitoring wells were sampled. The data were collected to identify potential temporal changes in the VOC concentrations observed in the wells and to provide data to aid the evaluation of MNA as a remedial alternative. Additionally, perchlorate samples were collected to determine whether or not perchlorate may be present at the site. All three samples were analyzed for Target Compound List (TCL) VOCs (CLP Method OLM03.2), perchlorate (EPA Method 314.0), total organic carbon (TOC; EPA Method 415.1), sulfate (EPA Method 300.0), nitrate (EPA Method 300.0), chloride (EPA Method 300.0), methane, ethane and ethene (SW-846 Method RSK 175). All samples were analyzed at a fixed-base laboratory. Other *in situ*/MNA parameters including dissolved oxygen, pH, and oxidation/reduction potential (ORP) were determined onsite using a Horiba U-22® fitted with a flow-through cell. Ferrous iron (Fe²⁺) concentrations were determined onsite using a Hach® kit.

Results

The results of monitoring well sampling are presented in Table 3 and Figure 7. Raw data are presented in Appendix B.

VOCs

VOCs were detected at reduced concentrations compared to those observed during the RI. The groundwater sample collected from IS17MW01 contained TCE, cis-DCE, and VC at concentrations of 0.24 µg/l, 4.9 µg/l, and 2.3 µg/l, respectively. The groundwater sample collected from IS17MW02 contained cis-DCE and VC at concentrations of 64 µg/l and 140 µg/l, respectively. TCE was not detected in the sample. The groundwater sample collected from IS17MW03 contained TCE at a concentration of 0.43 µg/l. Cis-DCE and VC were not detected in the sample. It should be noted that MTBE and toluene were detected in the duplicate sample collected from IS17MW01 at concentrations of 0.73 µg/l and 43 µg/l, respectively.

Perchlorate

Perchlorate was not detected in any of the monitoring wells at or above the laboratory detection limit.

MNA Parameters

TOC was detected in the samples collected from IS17MW01 and IS17MW02 at concentrations of 22.7 mg/l (28 mg/l in the duplicate sample) and 9.13 mg/l, respectively. TOC was not detected in the sample collected from IS17MW03.

Sulfate was detected in the samples collected from IS17MW02 and IS17MW03 at concentrations of 16.3 mg/l and 37.8 mg/l, respectively. Sulfate was not detected in the sample collected from IS17MW01.

Nitrate was not detected in any of the monitoring well samples.

Chloride was detected in the samples collected from IS17MW01, IS17MW02, and IS17MW03 at concentrations of 251 mg/l (214 mg/l in the duplicate sample), 70.4 mg/l, and 9.98 mg/l, respectively.

Methane was detected in the sample collected from IS17MW01 at a concentration of 1 µg/l; however, the duplicate sample contained a concentration of 540 µg/l. The reason for the discrepancy is not clear, although the higher value is likely more representative of subsurface conditions in the vicinity of IS17MW01, given the VOC concentrations observed nearby. Methane was also detected at IS17MWS02 and IS17MW03 at concentrations of 120 µg/l and 0.3 µg/l, respectively.

Ethane was detected in the sample collected from IS17MW02 and the duplicate sample collected from IS17MW01 at concentrations of 16 µg/l and 3 µg/l. Ethane was not detected in the sample collected from IS17MW03.

Ethene was detected in the sample collected from IS17MW02 at a concentration of 11 mg/l but not detected in the samples collected from IS17MW01 and IS17MW03.

In situ parameters including pH, oxidation-reduction potential, dissolved oxygen, and ferrous iron concentration are presented in Table 4.

Using these data to populate the EPA MNA screening table (USEPA, 1998; Table 5) returns a score of 26 for monitoring well IS17MW01. As noted in the referenced document, a score of greater than twenty is considered "strong evidence for anaerobic biodegradation (through reductive dechlorination) of chlorinated organics". However, it should be noted that assumptions were built in to this score: 1) IS17MW01 is cross-gradient from the source area as opposed to downgradient; 2) the value of 540 µg/l of methane was used in the calculation for the reason noted above; and 3) IS17MW02 was treated as the DNAPL source area although it is not at the location of highest concentrations as observed in the direct-push groundwater samples. These assumptions do not invalidate the score noted above; however, they will be considered further in the FS if MNA is evaluated as a remedial alternative.

Tidal Monitoring

Groundwater at Site 17 discharges to Mattawoman Creek, a tidal tributary of the Potomac River. Typically, when a water-bearing unit directly discharges to a tidal water body, the water table or potentiometric surface fluctuates in a harmonic motion. The fluctuation is a somewhat delayed and dampened reflection of the tidal fluctuation. The amplitude (or height) of the fluctuation decreases with increasing distance from the shoreline. The time between high tide and high water level also increases with increasing distance from the shore. Understanding the relationship between hydraulic head in Mattawoman Creek and groundwater at Site 17 is important from a remedial standpoint: if an active remediation (i.e., one that utilizes pumping) is required at Site 17, the groundwater flow regime needs to be well defined. This is because, as discussed below, it is likely that there are times during the tidal cycle when the hydraulic head in Mattawoman Creek is higher than the water table at Site 17 in the area near the shoreline; therefore, the design of any remedial system would need quantitative data pertaining to the tidal fluctuation of both Mattawoman Creek and the water table to avoid withdrawing creek water at these times. A quantitative analysis of the data can be used to estimate the hydraulic conductivity of the subsurface, as well.

This phase of the investigation was conducted to: 1) determine the influence of the tides on groundwater levels; and 2) estimate the hydraulic conductivity of the subsurface.

Field Activities

To quantify the relationship between hydraulic head in Mattawoman Creek and groundwater at Site 17, the tidal fluctuation in Mattawoman Creek and Site 17 monitoring wells were monitored over an entire lunar cycle (approximately one month). Monitoring was accomplished using InSitu MiniTrolls®. The Trolls, which are combination pressure transducers and data loggers, were installed in monitoring wells IS17MW02 and IS17MW03 and in Mattawoman Creek at a location that forms a line with the two wells normal to the shoreline (Figure 8). To facilitate data collection at the location in Mattawoman Creek, a temporary 'well' was installed at the desired location. The well consisted of a 2-inch inside diameter (ID), 4-foot long, stainless-steel screen with machined 0.010 slots. Following installation, its location was surveyed vertically and horizontally by a Maryland licensed surveyor. Data was collected between 1:00 PM on April 5, 2002 and 1:00 PM on May 5, 2002, at hourly intervals. Precipitation data for the monitored interval was provided by IHDIV-NSWC.

Results

The data were plotted graphically and reviewed to determine the relationship between hydraulic head in Mattawoman Creek and groundwater at Site 17. The mean hydraulic heads and in turn the mean hydraulic gradient were calculated using the method outlined in Serfes (1991) and the hydraulic conductivity of the subsurface was estimated using the stage-ratio and time-lag methods outlined in Ferris (1951).

The hydrographs of IS17TS01, IS17MW02, IS17MW03, and precipitation are presented in Figure 9. Mean head calculations are presented in Tables 4 through 6. The hydraulic conductivity calculations are presented in Tables 7 and 8. The hydrographs of the 71-hour intervals selected for the mean head and hydraulic conductivity calculations are presented in Appendix D. It should be noted that an explanation of the calculations presented in Tables 4 through 8 are beyond the scope of this memo. Detailed explanations are presented in the journal articles referenced above.

A review of the data presented in Figure 8 indicates that there are few periods when the gradient between IS17MW02 and Mattawoman Creek (as measured at IS17TS01) is reversed (i.e., the water level in Mattawoman Creek is higher than that of IS17MW02); however, as determined from the mean head calculations, the mean head differential between these two locations is approximately 1 foot. This suggests that the gradient likely could be reversed by pumping as part of a future remedy. Additionally, pumping wells would need to be installed downgradient of the source area (located near IS17MW02), where the mean head is nearer to that of Mattawoman Creek and gradient reversals likely occur more often and with greater magnitude. The potential for gradient reversal and magnitude will be evaluated further in the FS.

Hydraulic conductivity was estimated at 729 feet per day using the stage-ratio method and 1,556 feet per day using the time-lag method; however, due to invalid assumptions built-in to the calculations, the hydraulic conductivity is thought to be significantly over estimated. In particular, the calculations assume that the fluctuation of hydraulic head in the surface water body is small relative to the thickness of the aquifer. As was determined from this investigation, the depth to water is approximately 1 foot bgs and the site is underlain by a thick clay layer at approximately 10 feet bgs, therefore, the average fluctuation in

Mattawoman Creek, approximately 1.5 feet, is approximately 17% of the saturated thickness of the subsurface, making the results of this analysis unreliable. Actual hydraulic conductivity is likely closer to values calculated at Site 47 using slug test data (CH2M HILL, 2002 unpublished data; approximately 3 feet per day).

It should be noted that the lack of accurate quantitative hydraulic conductivity data at Site 17 does not present an obstacle to proceeding to the FS. In the event that precise measurements of hydraulic conductivity are required to evaluate a set of remedial alternatives, a pump test would likely be required regardless of the quality of the data presented above.

Feasibility Study

It should be noted that the data presented above is not intended to constitute a recommendation as to a remedial action. The data presented herein will be included in the forthcoming FS, which will present quantitative evaluations of several remedial alternatives.

References

- CH2M HILL. April 2002. *Work Plan for Pre-Feasibility Study Field Activities at Site 17 Indian Head Division-NSWC, Indian Head, Maryland*
- CH2M HILL. August 2002. *Draft Final Remedial Investigation Report, Sites 11, 13, 17, 21, and 25, Indian Head Division-NSWC, Indian Head, Maryland.*
- Domenico, P.A., and Schwartz, F.W. 1990. *Physical and Chemical Hydrogeology*. Second edition. John Wiley & Sons, Inc., New York.
- Ferris, J.G., 1951. *Cyclic Water-Level Fluctuations as a Basis for Determining Aquifer Transmissibility*, International Association of Scientific Hydrology Publication, v. 33, p. 148-155.
- Serfes, M.E., 1991. *Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations*, Ground Water, v. 29, no. 4, p. 549-555.
- United States Environmental Protection Agency, Office of Research and Development. September 1998. *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater*. EPA/600/R-98/128.

Table 1
 Detected Compounds in Direct-Push Groundwater Samples
 Site 17 Pre-FS Investigation
 IHDIV-NSWC
 Indian Head, Maryland

Station ID	IS17GW01	IS17GW02	IS17GW03		IS17GW04	IS17GW05	IS17GW06
Sample ID	IS17GW010602	IS17GW020602	IS17GW030602	IS17GW030602P	IS17GW040602	IS17GW050602	IS17GW060602
Sample Date	06/24/02	06/24/02	06/24/02	06/24/02	06/25/02	06/25/02	06/25/02
Chemical Name							
Volatile Organic Compounds (µg/l)							
1,1-Dichloroethane				1 J			20 J
1,2-Dichloroethane			3 J				
Carbon tetrachloride							
Chloroethane	160 J	28,000 D					
Chloroform							
Toluene					1 J		
Trichloroethene		310,000 D					240
Vinyl chloride	220	50,000 D					
cis-1,2-Dichloroethene	220	75,000 D			1 J		20 J
p-Isopropyltoluene					1 J		
tert-Butylbenzene							

D - Dilution result
 J - Estimated

Table 1
 Detected Compounds in Direct-Push Groundwater Samples
 Site 17 Pre-FS Investigation
 IHDIV-NSWC
 Indian Head, Maryland

Station ID	IS17GW07	IS17GW08	IS17GW09	IS17GW10	IS17GW11		IS17GW12
Sample ID	IS17GW070602	IS17GW080602	IS17GW090602	IS17GW100602	IS17GW110602	IS17GW110602P	IS17GW120602
Sample Date	06/25/02	06/26/02	06/26/02	06/26/02	06/27/02	06/27/02	06/27/02
Chemical Name							
Volatile Organic Compounds (µg/l)							
1,1-Dichloroethane							
1,2-Dichloroethane							
Carbon tetrachloride							2
Chloroethane							
Chloroform							1 J
Toluene				8	2	2	1 J
Trichloroethene	3			2			
Vinyl chloride							
cis-1,2-Dichloroethene							
p-Isopropyltoluene							2
tert-Butylbenzene							2

Table 2
 Detected Compounds in Surface Water Samples
 Site 17 Pre-FS Investigation
 IHDIV-NSWC
 Indian Head, Maryland

Station ID	IS17SW04	IS17SW07	IS17SW08	
Sample ID	IS17SW040602	IS17SW070602	IS17SW080602	IS17SW080602P
Sample Date	06/24/02	06/24/02	06/24/02	06/24/02
Chemical Name				
Volatile Organic Compounds (µg/l)				
Methyl-tert-butyl ether (MTBE)	4.1	4	4	4.1
Methylene chloride	0.22 J	0.22 J	0.18 J	0.21 J
Toluene	0.16 J	0.12 J	0.13 J	0.18 J

Table 3
Detected Compounds in Monitoring Well Samples
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

Station ID Sample ID Sample Date	IS17MW01		IS17MW02	IS17MW03
	IS17MW01071702 07/17/02	IS17MW01071702P 07/17/02	IS17MW02071702 07/17/02	IS17MW03071702 07/17/02
Chemical Name				
Volatile Organic Compounds (µg/l)				
1,1-Dichloroethane		0.22 J	6 J	
1,1-Dichloroethene		0.12 J		
Benzene		0.18 J		
Chloroethane			2 J	
Chloromethane		0.18 J		0.12 J
Ethylbenzene	89	89		
Methyl-tert-butyl ether (MTBE)	0.64	0.73		
Styrene	0.7			
Toluene	37	43		
Trichloroethene	0.2 J	0.24 J		0.43 J
Vinyl chloride	2.3	2 J	140	
Xylene, total	1 J	0.22 J		
cis-1,2-Dichloroethene	4.9	4.8	64	
trans-1,2-Dichloroethene	0.15 J	0.13 J		
Energetics				
Perchlorate				
MNA Parameters (µg/l)				
Methane	1	540	120	0.3 J
Ethane		3 J	16 J	
Ethene			11 J	
MNA Parameters (mg/l)				
Carbon	22.7	28	9.13	
Chloride	251	214	70.4	9.98
Sulfate			16.3	37.8

Table 4
***In Situ* Groundwater Parameters**
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

Parameter	Monitoring Well		
	IS17MW01	IS17MW02	IS17MW03
pH	6.1	6.2	5.0
Temperature(°C)	23.0	21.7	21.7
Conductivity(millisiemens/meter)	1.43	0.626	0.161
Oxidation/Reduction Potential (millivolts)	-143	-103	143
Dissolved Oxygen (mg/l)	0.40	0.42	0.60
Turbidity (NTUs)	35	12	174
Ferrous Iron (mg/l)	3.6	3.2	0.6

Table 5
Natural Attenuation Protocol Worksheet
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

Analysis	Concentration in the most Contaminated zone	Point Value	Concentration			Point Value		
			Background Well#	NAPL Source Area	Well	Well	NAPL Source Area	Well
Oxygen*	<0.5 mg/L	3						
	>5 mg/L	-3	0.6	0.4	0.4			
Nitrate*	<1mg/L	2	0.001	0.001	0.001			
Iron II*	>1 mg/L	3	0.6	3.2	3.6			
Sulfate*	<20 mg/L	2	37.8	16.3	0.001			
Sulfide*	>1mg/L	3				0	0	0
Methane ¹	<0.5 mg/L	0						
	>0.5 mg/L	3	0	0.12	0.54	0	3	0
ORP	<50 mV	1						
	<-100mV	2	143	-103	-143	2	2	0
pH*	5<pH<9	0						
	5>pH>9	-2	5.01	6.2	6.06	0	0	0
TOC	>20 mg/L	2	0	9.13	22.7	0	2	0
Temperature*	>20° C	1	21.7	21.7	23	1	1	0
Carbon Dioxide	>2x background	1				0	0	0
Alkalinity	>2x background	1				0	0	0
Chloride*	>2x background	2	9.98	70.4	251	2	2	0
Hydrogen	>1nM	3						
	<1nM	0				0	0	0
Volatile Fatty Acids	>0.1 mg/L	2				0	0	0
BTEX*	>0.1 mg/L	2				0	0	0
PCE*	Material Released	0						
TCE*	Material Released	0						
TCE*	Daughter Product of PCE	2 ²				0	0	0
DCE*	Material Released	0						
DCE*	Daughter Product of TCE	2 ²	0	64	4.9	2	2	0
VC*	Material Released	0						
VC*	Daughter Product of DCE	2 ²	0	140	2.3	2	2	0
Ethene/Ethane	>0.01 mg/L (Daughter Product)	2	0	0.011	0	2	0	0
Ethene/Ethane	>0.1 mg/L	3				0	0	0
Chloroethane*	Daughter Product	2 ²				0	0	0
1,1-DCE*		2 ²	0	0	0.12	0	2	0
TOTAL SCORE						21	26	0

* = Required analysis

1 = Based on duplicate sample

2 = Points awarded only if it can be shown that the compound is a daughter product

Table 6
Mean Hydraulic Head Calculations IS17TS01
Site 17 Pre-FS Investigation
IHDIV-NSWC

Date & Time	Hour	Indian Head, Maryland				M
		Head O(K)	O(K)/24	Xi	Xi/24	
04/10/02 12:00:00 PM	1	-0.73	-0.03	-0.02	0.00	0.34
	2	-0.74	-0.03	-0.01	0.00	0.37
	3	-0.61	-0.03	0.00	0.00	0.40
	4	-0.30	-0.01	0.02	0.00	0.43
	5	0.03	0.00	0.05	0.00	0.46
	6	0.21	0.01	0.08	0.00	0.49
	7	0.28	0.01	0.12	0.00	0.52
	8	0.19	0.01	0.16	0.01	0.55
	9	0.00	0.00	0.21	0.01	0.57
	10	-0.30	-0.01	0.27	0.01	0.60
	11	-0.60	-0.03	0.32	0.01	0.62
	12	-0.72	-0.03	0.37	0.02	0.64
	13	-0.74	-0.03	0.42	0.02	0.66
	14	-0.61	-0.03	0.45	0.02	0.67
	15	-0.18	-0.01	0.48	0.02	0.69
	16	0.21	0.01	0.50	0.02	0.70
	17	0.54	0.02	0.52	0.02	0.71
	18	0.79	0.03	0.54	0.02	0.72
	19	0.99	0.04	0.56	0.02	0.73
	20	0.93	0.04	0.58	0.02	0.74
	21	0.72	0.03	0.60	0.02	0.75
	22	0.35	0.01	0.63	0.03	0.76
	23	-0.01	0.00	0.66	0.03	0.76
	24	-0.30	-0.01	0.68	0.03	0.77
04/11/02 12:00:00 PM	25	-0.47	-0.02	0.71	0.03	0.77
	26	-0.44	-0.02	0.74	0.03	
	27	-0.09	0.00	0.75	0.03	
	28	0.38	0.02	0.76	0.03	
	29	0.75	0.03	0.76	0.03	
	30	1.11	0.05	0.76	0.03	
	31	1.34	0.06	0.77	0.03	
	32	1.41	0.06	0.77	0.03	
	33	1.29	0.05	0.78	0.03	
	34	0.98	0.04	0.78	0.03	
	35	0.65	0.03	0.79	0.03	
	36	0.34	0.01	0.80	0.03	
	37	0.11	0.00	0.80	0.03	
	38	0.04	0.00	0.80	0.03	
	39	0.30	0.01	0.80	0.03	
	40	0.67	0.03	0.78	0.03	
	41	1.02	0.04	0.77	0.03	
	42	1.27	0.05	0.76	0.03	
	43	1.43	0.06	0.76	0.03	
	44	1.49	0.06	0.76	0.03	
	45	1.37	0.06	0.77	0.03	
	46	1.06	0.04	0.77	0.03	
	47	0.69	0.03	0.79	0.03	
	48	0.36	0.02	0.80	0.03	
04/12/02 12:00:00 PM	49	0.09	0.00			
	50	-0.06	0.00			
	51	0.04	0.00			
	52	0.45	0.02			
	53	0.85	0.04			
	54	1.22	0.05			
	55	1.46	0.06			
	56	1.54	0.06			
	57	1.45	0.06			
	58	1.17	0.05			
	59	0.81	0.03			
	60	0.44	0.02			
	61	0.12	0.00			
	62	-0.11	0.00			
	63	-0.06	0.00			
	64	0.35	0.01			
	65	0.82	0.03			
	66	1.20	0.05			
	67	1.48	0.06			
	68	1.63	0.07			
	69	1.61	0.07			
	70	1.37	0.06			
	71	0.99	0.04			

Table 7
Mean Hydraulic Head Calculations IS17MW02
Site 17 Pre-FS Investigation
IHDIV-NSWC

Date & Time	Hour	Indian Head, Maryland				Yj	M
		Head O(K)	O(K)/24	Xi	Xi/24		
04/10/02 12:00:00 PM	1	1.62	0.07	1.60	0.07	1.60	1.60
	2	1.62	0.07	1.60	0.07	1.60	
	3	1.63	0.07	1.60	0.07	1.60	
	4	1.64	0.07	1.60	0.07	1.60	
	5	1.64	0.07	1.60	0.07	1.60	
	6	1.64	0.07	1.60	0.07	1.60	
	7	1.63	0.07	1.60	0.07	1.60	
	8	1.62	0.07	1.60	0.07	1.60	
	9	1.61	0.07	1.60	0.07	1.60	
	10	1.60	0.07	1.59	0.07	1.60	
	11	1.59	0.07	1.59	0.07	1.60	
	12	1.59	0.07	1.59	0.07	1.60	
	13	1.59	0.07	1.59	0.07	1.60	
	14	1.59	0.07	1.59	0.07	1.60	
	15	1.60	0.07	1.59	0.07	1.61	
	16	1.60	0.07	1.59	0.07	1.61	
	17	1.60	0.07	1.59	0.07	1.61	
	18	1.60	0.07	1.59	0.07	1.61	
	19	1.60	0.07	1.60	0.07	1.61	
	20	1.59	0.07	1.60	0.07	1.61	
	21	1.58	0.07	1.60	0.07	1.61	
	22	1.58	0.07	1.60	0.07	1.61	
	23	1.57	0.07	1.60	0.07	1.62	
	24	1.57	0.07	1.60	0.07	1.62	
04/11/02 12:00:00 PM	25	1.58	0.07	1.60	0.07	1.62	
	26	1.58	0.07	1.60	0.07		
	27	1.59	0.07	1.61	0.07		
	28	1.60	0.07	1.61	0.07		
	29	1.61	0.07	1.61	0.07		
	30	1.62	0.07	1.61	0.07		
	31	1.62	0.07	1.61	0.07		
	32	1.61	0.07	1.61	0.07		
	33	1.60	0.07	1.61	0.07		
	34	1.59	0.07	1.61	0.07		
	35	1.59	0.07	1.62	0.07		
	36	1.59	0.07	1.62	0.07		
	37	1.59	0.07	1.62	0.07		
	38	1.58	0.07	1.62	0.07		
	39	1.60	0.07	1.62	0.07		
	40	1.61	0.07	1.62	0.07		
	41	1.62	0.07	1.62	0.07		
	42	1.62	0.07	1.63	0.07		
	43	1.62	0.07	1.63	0.07		
	44	1.62	0.07	1.63	0.07		
	45	1.61	0.07	1.63	0.07		
	46	1.61	0.07	1.63	0.07		
	47	1.60	0.07	1.63	0.07		
	48	1.60	0.07	1.63	0.07		
04/12/02 12:00:00 PM	49	1.61	0.07				
	50	1.61	0.07				
	51	1.62	0.07				
	52	1.63	0.07				
	53	1.64	0.07				
	54	1.65	0.07				
	55	1.65	0.07				
	56	1.65	0.07				
	57	1.64	0.07				
	58	1.64	0.07				
	59	1.63	0.07				
	60	1.62	0.07				
	61	1.62	0.07				
	62	1.62	0.07				
	63	1.63	0.07				
	64	1.63	0.07				
	65	1.64	0.07				
	66	1.64	0.07				
	67	1.64	0.07				
	68	1.64	0.07				
	69	1.64	0.07				
	70	1.64	0.07				
	71	1.63	0.07				

Table 8
Mean Hydraulic Head Calculations IS17MW03
Site 17 Pre-FS Investigation
IHDIV-NSWC

Date & Time	Hour	Indian Head, Maryland				Yj	M
		Head O(K)	O(K)/24	Xi	Xi/24		
04/10/02 12:00:00 PM	1	6.23	0.26	6.20	0.26	6.17	6.19
	2	6.24	0.26	6.20	0.26	6.17	
	3	6.26	0.26	6.19	0.26	6.17	
	4	6.28	0.26	6.19	0.26	6.17	
	5	6.28	0.26	6.18	0.26	6.17	
	6	6.28	0.26	6.18	0.26	6.17	
	7	6.28	0.26	6.18	0.26	6.17	
	8	6.26	0.26	6.17	0.26	6.17	
	9	6.23	0.26	6.17	0.26	6.17	
	10	6.21	0.26	6.17	0.26	6.17	
	11	6.20	0.26	6.17	0.26	6.18	
	12	6.19	0.26	6.17	0.26	6.18	
	13	6.18	0.26	6.16	0.26	6.18	
	14	6.18	0.26	6.16	0.26	6.18	
	15	6.19	0.26	6.16	0.26	6.19	
	16	6.19	0.26	6.16	0.26	6.19	
	17	6.19	0.26	6.16	0.26	6.19	
	18	6.19	0.26	6.16	0.26	6.20	
	19	6.17	0.26	6.16	0.26	6.20	
	20	6.15	0.26	6.16	0.26	6.21	
	21	6.13	0.26	6.16	0.26	6.21	
	22	6.11	0.25	6.17	0.26	6.21	
	23	6.10	0.25	6.17	0.26	6.22	
	24	6.10	0.25	6.17	0.26	6.22	
04/11/02 12:00:00 PM	25	6.11	0.25	6.18	0.26	6.23	
	26	6.13	0.26	6.18	0.26		
	27	6.16	0.26	6.18	0.26		
	28	6.18	0.26	6.19	0.26		
	29	6.20	0.26	6.19	0.26		
	30	6.21	0.26	6.19	0.26		
	31	6.21	0.26	6.20	0.26		
	32	6.20	0.26	6.20	0.26		
	33	6.18	0.26	6.21	0.26		
	34	6.16	0.26	6.21	0.26		
	35	6.15	0.26	6.22	0.26		
	36	6.14	0.26	6.22	0.26		
	37	6.14	0.26	6.23	0.26		
	38	6.15	0.26	6.24	0.26		
	39	6.17	0.26	6.24	0.26		
	40	6.19	0.26	6.25	0.26		
	41	6.20	0.26	6.25	0.26		
	42	6.21	0.26	6.26	0.26		
	43	6.20	0.26	6.26	0.26		
	44	6.20	0.26	6.27	0.26		
	45	6.19	0.26	6.27	0.26		
	46	6.19	0.26	6.28	0.26		
	47	6.18	0.26	6.28	0.26		
	48	6.18	0.26	6.29	0.26		
04/12/02 12:00:00 PM	49	6.20	0.26				
	50	6.21	0.26				
	51	6.24	0.26				
	52	6.26	0.26				
	53	6.28	0.26				
	54	6.30	0.26				
	55	6.30	0.26				
	56	6.31	0.26				
	57	6.31	0.26				
	58	6.30	0.26				
	59	6.30	0.26				
	60	6.29	0.26				
	61	6.29	0.26				
	62	6.29	0.26				
	63	6.30	0.26				
	64	6.32	0.26				
	65	6.33	0.26				
	66	6.34	0.26				
	67	6.33	0.26				
	68	6.32	0.26				
	69	6.32	0.26				
	70	6.31	0.26				
	71	6.31	0.26				

Table 9
Stage Ratio Method of Determining Hydraulic Conductivity
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

IS17TS01

Stage	Head Ft. MSL	Delta Head Feet	Time Hours	Delta Time Hours
1	0.28		1	
2	-0.74	1-2	7	1-2
3	0.99	2-3	13	2-3
4	-0.47	3-4	19	3-4
5	1.41	4-5	26	4-5
6	0.04	5-6	32	5-6
			Average =	6.2

IS17MW02

Stage	Head Ft. MSL	Delta Head Feet
1	1.6	
2	1.57	1-2
3	1.62	2-3
4	1.58	3-4
5	1.62	4-5
6	1.6	5-6

IS17MW03

Stage	Head Ft. MSL	Delta Head
1	6.2	
2	6.1	1-2
3	6.2	2-3
4	6.1	3-4
5	6.2	4-5
6	6.2	5-6

Ratio MW02/TS01

0.029
0.029
0.027
0.021
0.015
Average = 0.024

Ratio MW03/TS01

0.098
0.058
0.068
0.053
0.000
Average = 0.056

Plot Data

100	0.02
200	0.06

$$T = \left[\frac{4.4 \Delta X^2}{t_0} \right] S$$

$\Delta X = 210$ feet
 $t_0 = 12.4$ hours

T =	38808 g/d/ft	5188.235 ft ² /day (S=0.1)
	77616 g/d/ft	10376.47 ft ² /day (S=0.2)
	116424 g/d/ft	15564.71 ft ² /day (S=0.3)

K =	519 feet/day	1.83E-01 cm/sec (S=0.1)
	1038 feet/day	3.66E-01 cm/sec (S=0.2)
	1556 feet/day	5.49E-01 cm/sec (S=0.3)

Table 10
Time Lag Method of Determining Hydraulic Conductivity
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

<u>Raw Data</u>						<u>Time Lag</u>				
IS17TS01		IS17MW02		IS17MW03		IS17TS01 - IS17MW02		IS17TS01 - IS17MW03		
Stage	Time Minutes	Stage	Time Minutes	Stage	Time Minutes	Stage	Time Lag Minutes	Stage	Time Lag Minutes	
1	10820	1	10970	1	11120	1	150	1	300	
2	11180	2	11270	2	11600	2	90	2	420	
3	11600	3	11720	3	11960	3	120	3	360	
4	11900	4	11990	4	12320	4	90	4	420	
5	12320	5	12500	5	12740	5	180	5	420	
6	12260	6	12740	6	13100	6	480	6	840	
							Average =	185	Average =	460

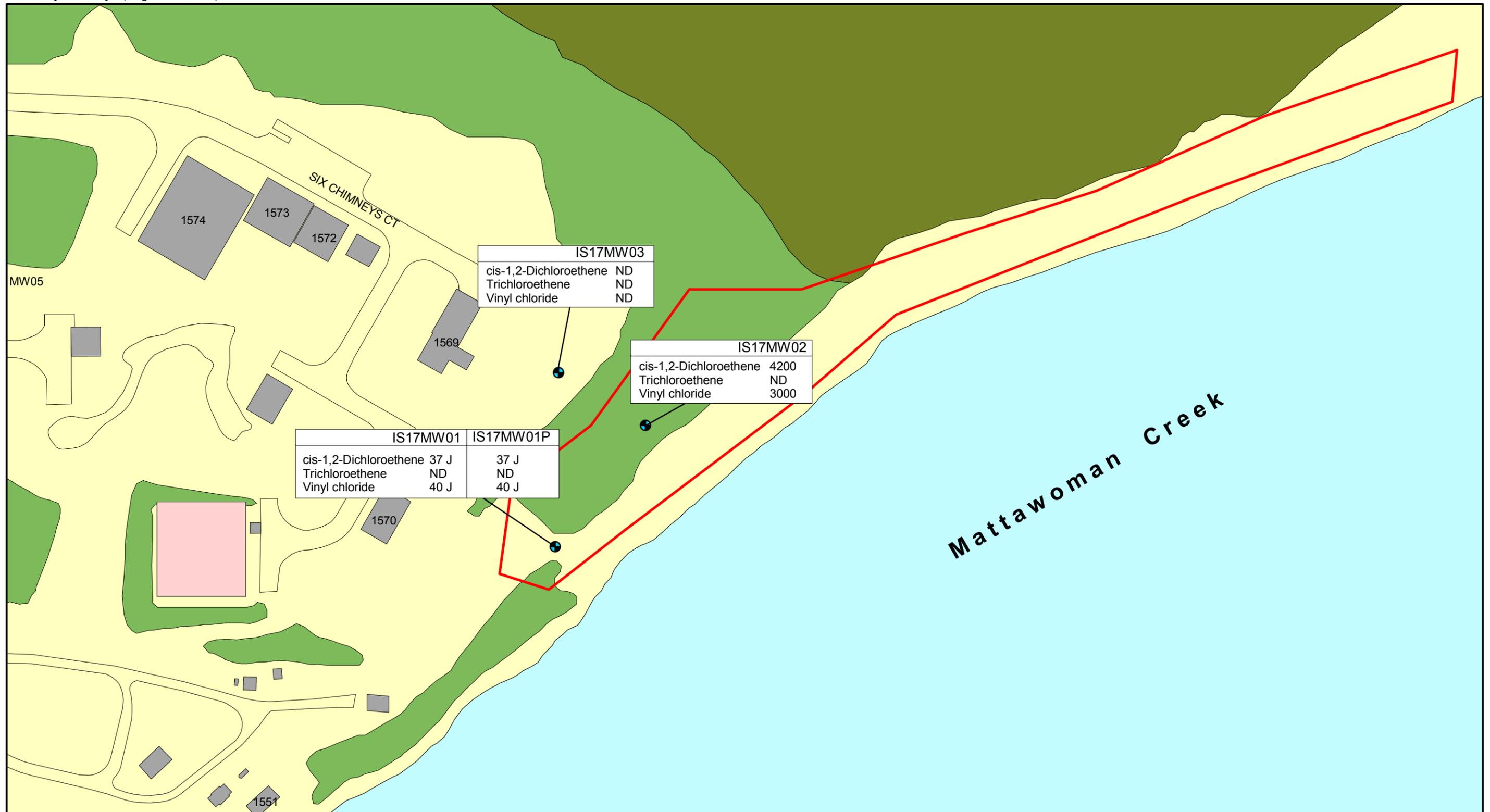
Plot data

100 185
 200 460

$$T = \left[\frac{0.6 \Delta X^2 t_0}{\Delta t_1} \right] S$$

X² = 100
 T1 = 185

T =	18176 g/d/ft	2430 ft ² /day (S=0.1)	K =	243 feet/day	8.57E-02 cm/sec (S=0.1)
	36352 g/d/ft	4860 ft ² /day (S=0.2)		486 feet/day	1.71E-01 cm/sec (S=0.2)
	54529 g/d/ft	7290 ft ² /day (S=0.3)		729 feet/day	2.57E-01 cm/sec (S=0.3)



LEGEND

- Monitoring Wells
- ▭ IR Sites
- ▭ Buildings
- ▭ Demolished Buildings
- ▭ Wooded Area
- ▭ Dense Wooded Area
- ∧ Road

ND = Non Detect
 J = Estimated Value Below the Detection Limit

Note: All concentrations are measured in micrograms per liter (ug/l)

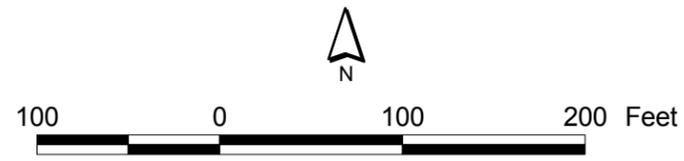
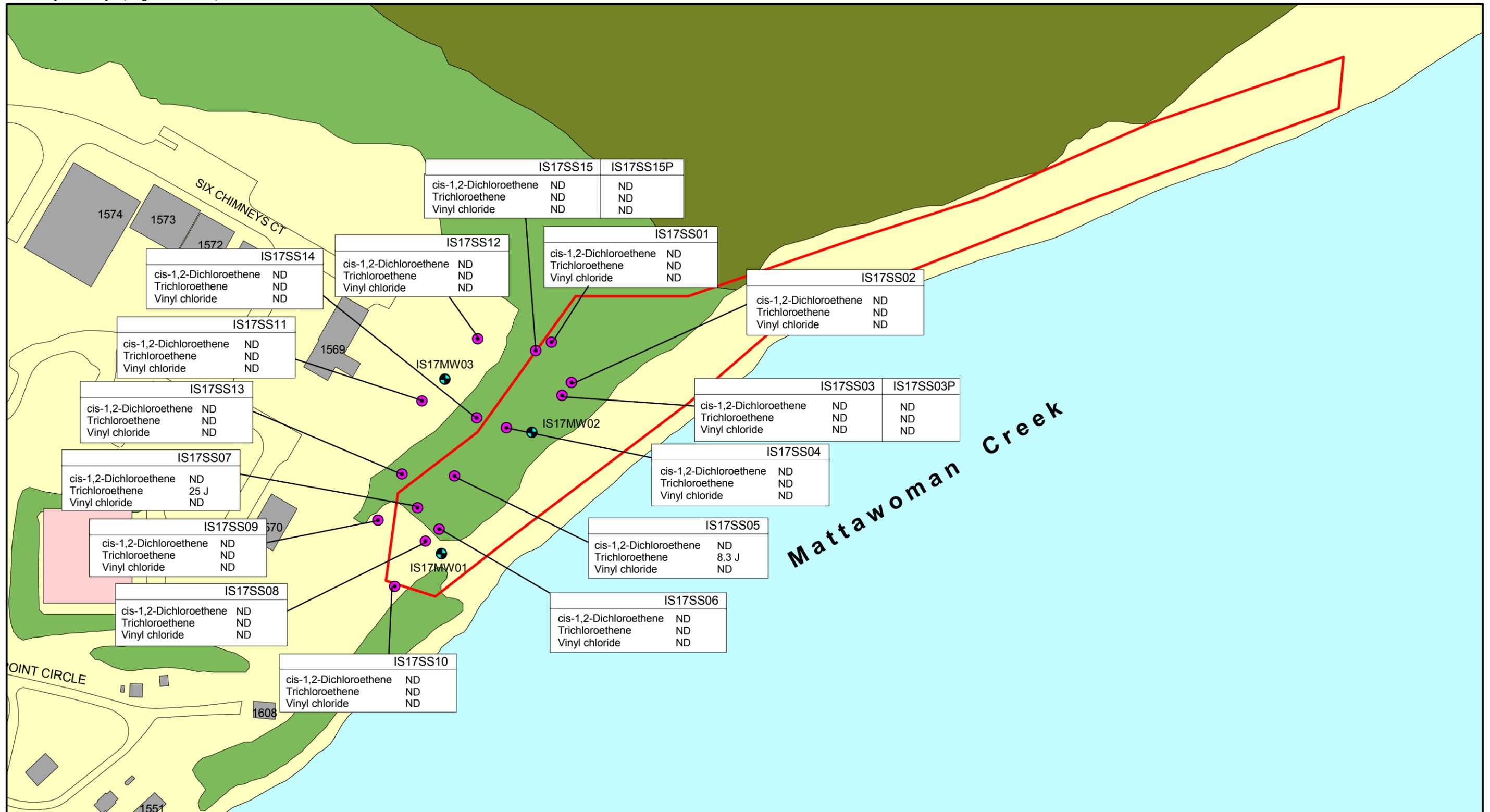


Figure 1
 Selected VOCs in Groundwater - October 2000
 Site 17 Pre-FS Investigation
 IHDIV-NSWC, Indian Head, Maryland



LEGEND

- Surface Soil
- Monitoring Wells
- ▭ IR Sites
- ▭ Buildings
- ▭ Demolished Buildings
- ▭ Wooded Area
- ▭ Dense Wooded Area
- ▭ Road

Note: All concentrations are measured in micrograms per kilogram (ug/kg)

ND = Non Detect

J = Estimated Value Below the Detection Limit

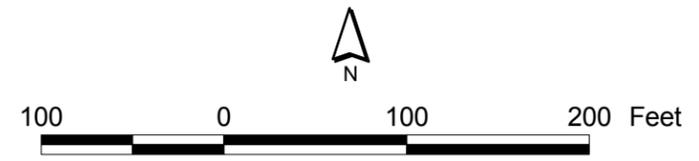
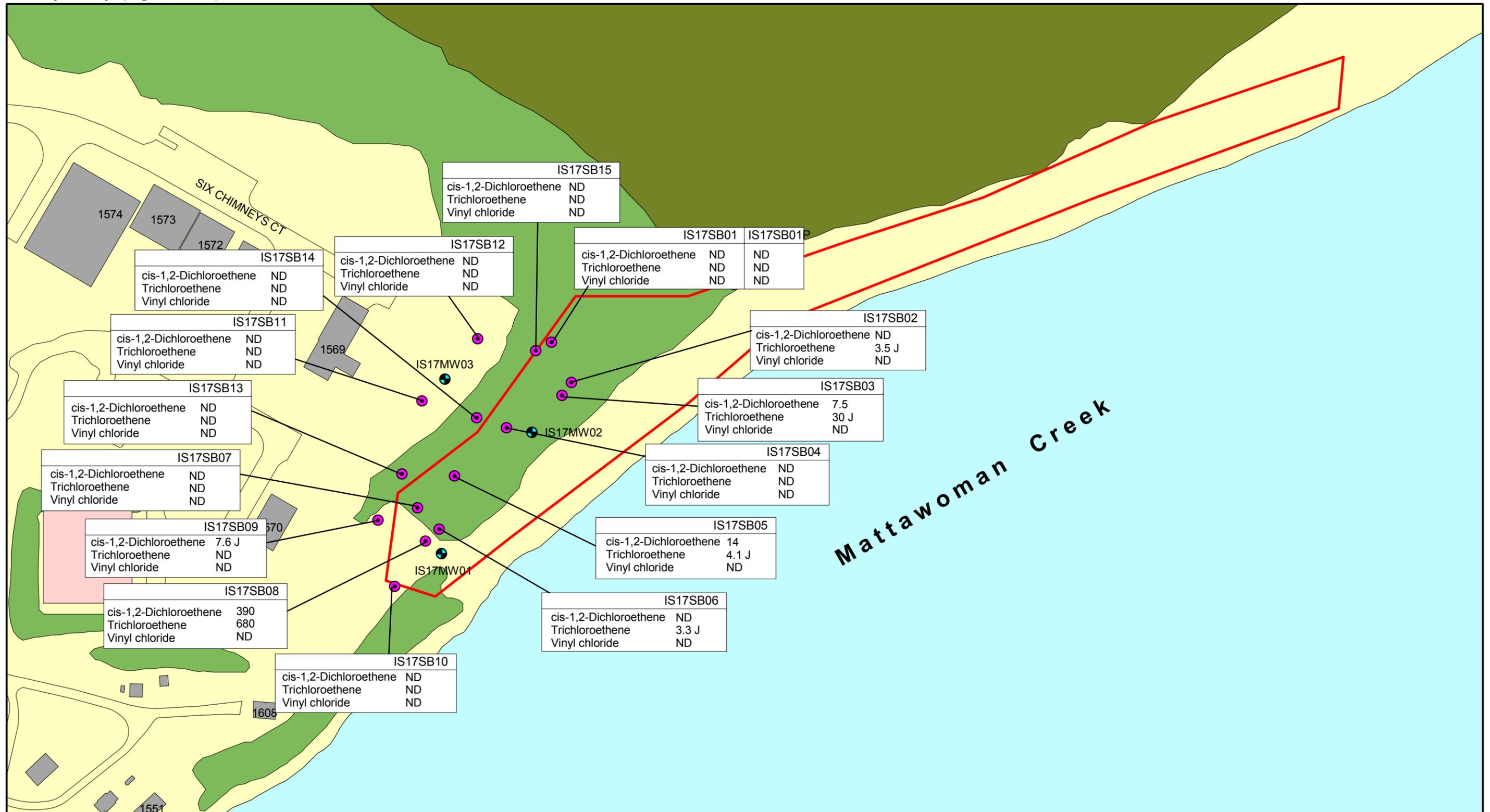


Figure 2
 Selected VOCs In Surface Soil - October 2000
 Site 17 Pre-FS Investigation
 IHDIV-NSWC, Indian Head, Maryland



LEGEND

- Subsurface Soil
- Monitoring Wells
- IR Sites
- Buildings
- Demolished Buildings
- Wooded Area
- Dense Wooded Area
- Road

Note: All concentrations are measured in micrograms per kilogram (ug/kg)

ND = Non Detect
 J = Estimated Value Below the Detection Limit

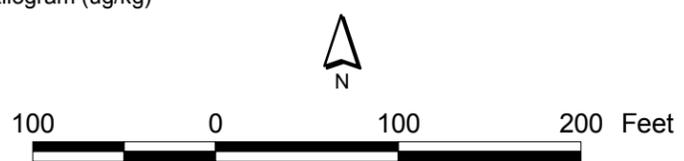


Figure 3
 Selected VOCs In Subsurface Soil - October 2000
 Site 17 Pre-FS Investigation
 IHDIV-NSWC, Indian Head, Maryland



LEGEND

- Monitoring Wells
 - Interpolated Groundwater Contours
 - Inferred Groundwater Contours
 - IR Site Boundary
 - Buildings
 - Wooded Area
 - Dense Wooded Area
- 1.35 = Feet above mean sea level

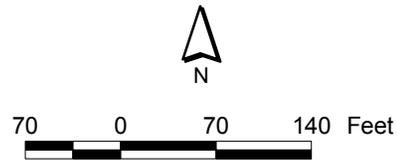


Figure 4
Groundwater Contours - October 2000
Site 17 Pre-FS Investigation
IHDIV-NSWC, Indian Head, Maryland



LEGEND

- Monitoring Wells
- MIP/Direct Push Sample Locations
- MIP/Direct Push and Shelby Tube Sample Locations
- Surface Water Sample Locations
- IR Sites
- Buildings

- Wooded Area
- Dense Wooded Area
- Road

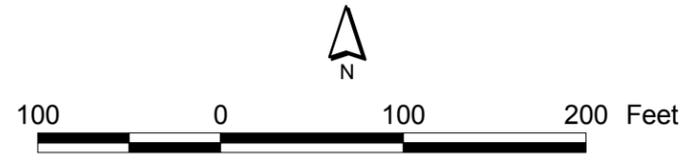
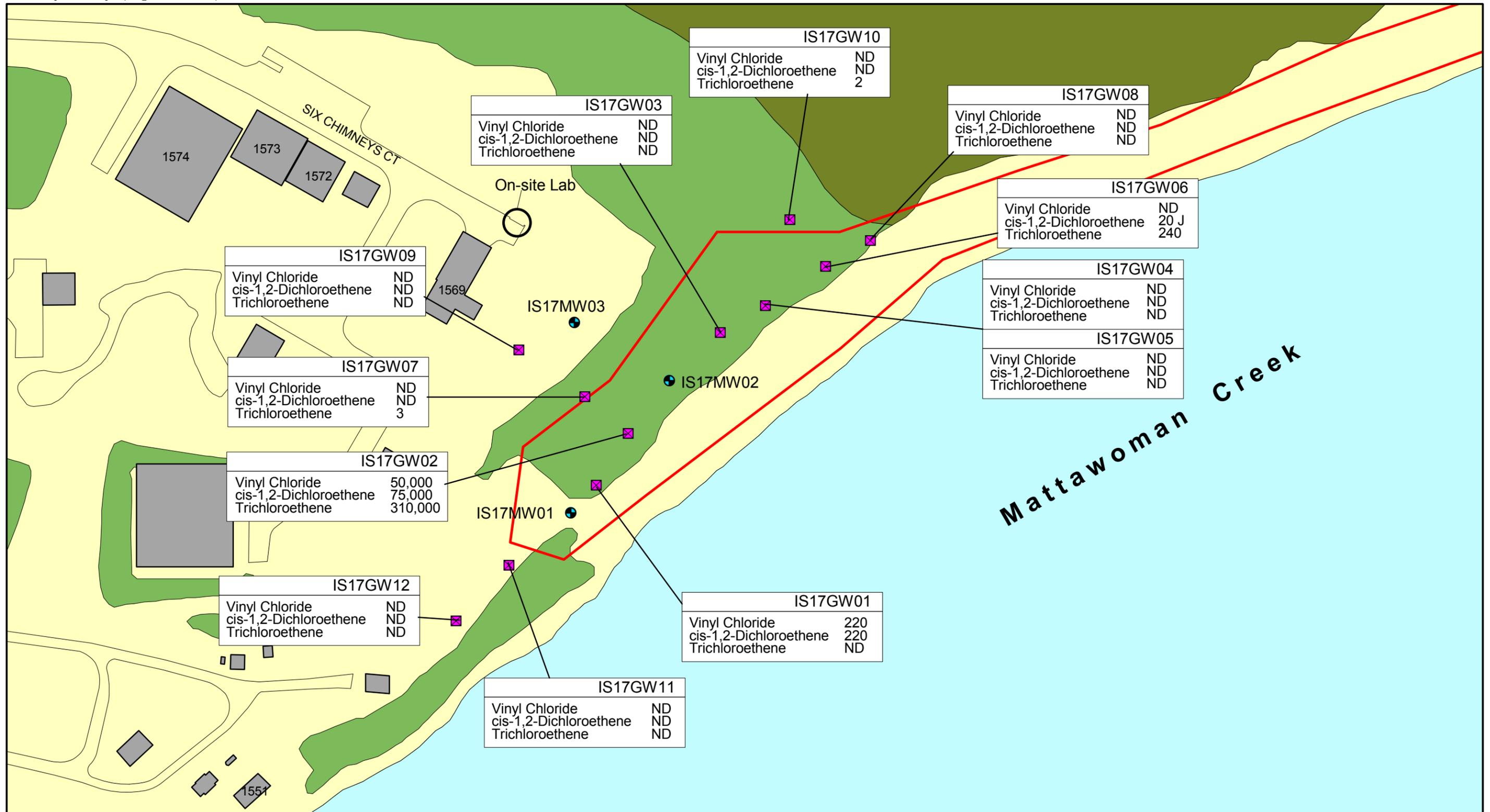


Figure 5
MIP/EC/Direct Push Groundwater
and Surface Water Sampling Locations
Site 17 Pre-FS Investigation
IHDIV-NSWC, Indian Head, Maryland



LEGEND

- Monitoring Wells
- MIP/Direct Push Sample Locations
- IR Sites
- Buildings

Note: All concentrations are measured in micrograms per liter (ug/l).

- Wooded Area
- Dense Wooded Area
- Road
- ND = Non Detect
- J = Estimated Value Below the Detection Limit

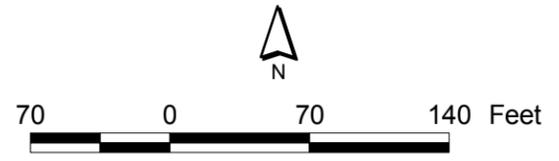
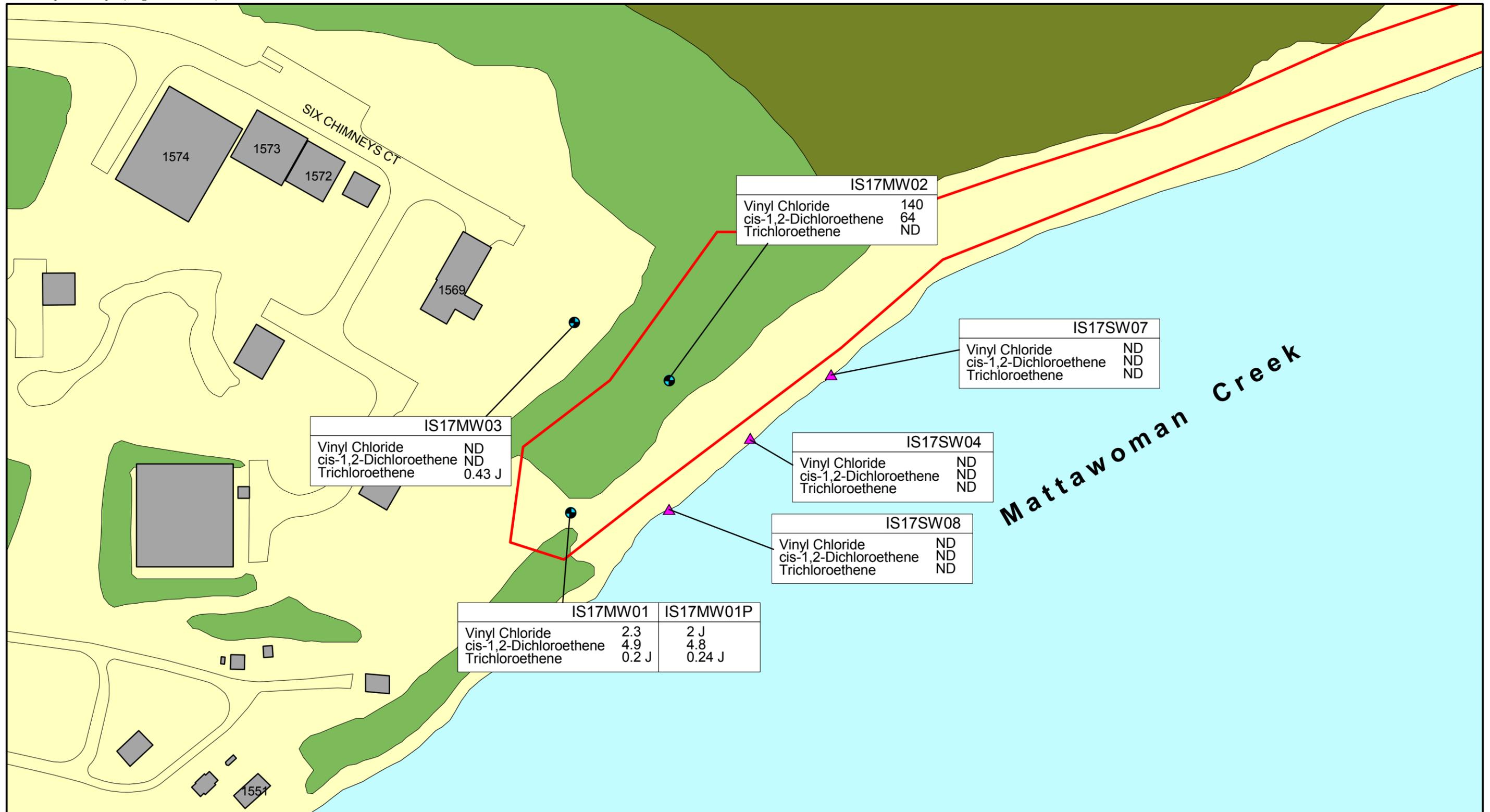


Figure 6
Selected VOCs in Direct Push Groundwater Samples
Site 17 Pre-FS Investigation
IHDIV-NSWC, Indian Head, Maryland



Mattawoman Creek

LEGEND

- Monitoring Wells
- Surface Water Sample Locations
- IR Sites
- Buildings

Note: All concentrations are measured in micrograms per liter (ug/l).

- Wooded Area
- Dense Wooded Area
- Road
- ND = Non Detect
- J = Estimated Value Below the Detection Limit

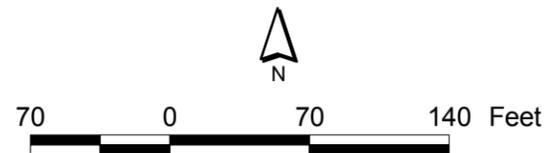


Figure 7
Selected VOCs in Groundwater and Surface Water Samples
Site 17 Pre-FS Investigation
IHDIV-NSWC, Indian Head, Maryland



LEGEND

- Monitoring Well
 - Temporary "Monitoring Well"
 - Interpolated Groundwater Contours
 - Inferred Groundwater Contours
 - IR Site Boundary
 - Wooded Area
 - Dense Wooded Area
 - Buildings
- 1.35 = Feet above mean sea level

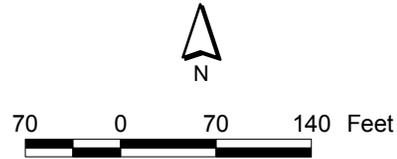


Figure 8
Tidal Monitoring Stations
Site 17 Pre-FS Investigation
IHDIV-NSWC, Indian Head, Maryland

Hydrographs of IS17TS01, IS17MW02, IS17MW03, and Precipitation
4/5/02 1:00 PM - 5/5/02 1:00 PM

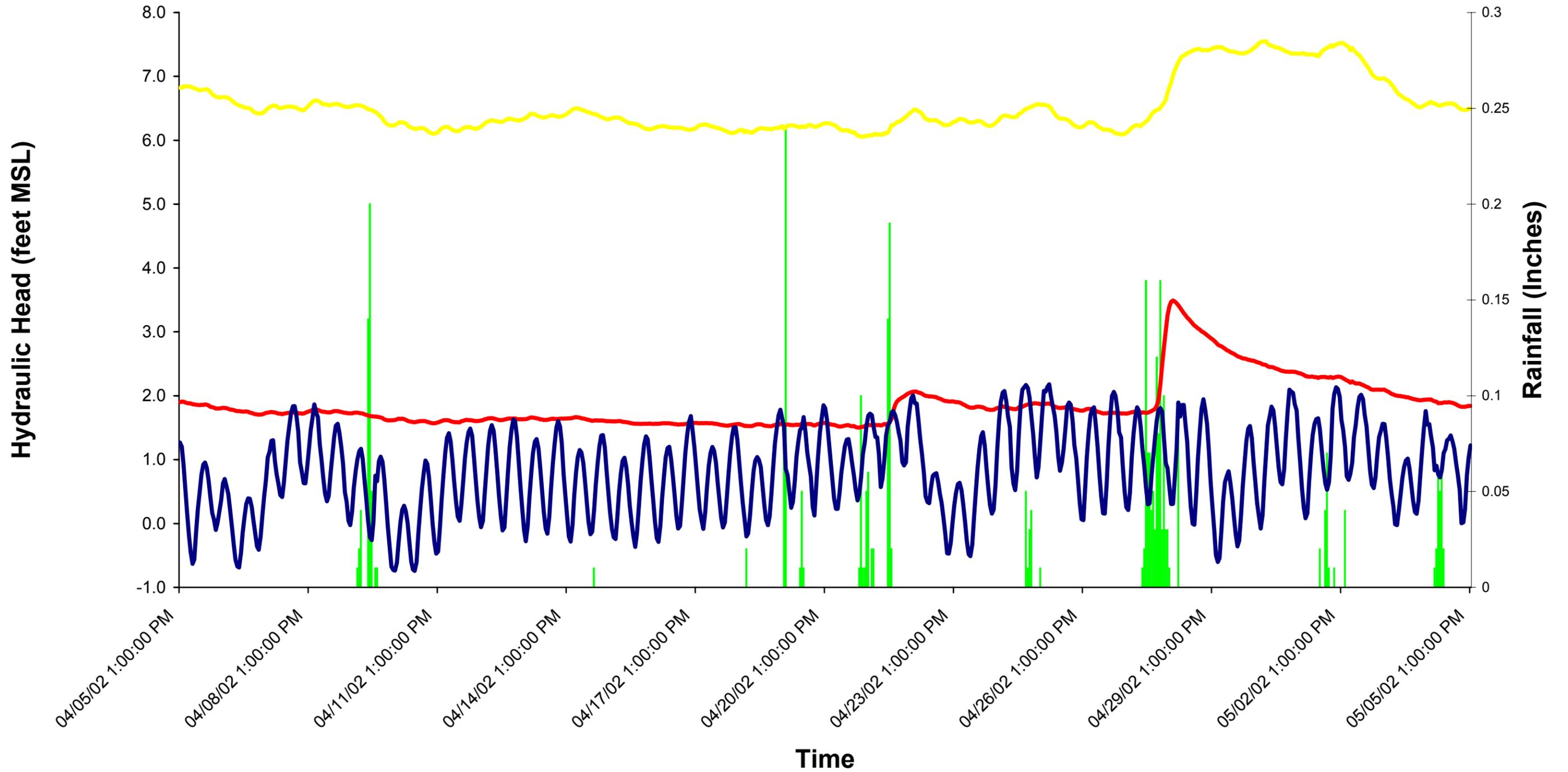
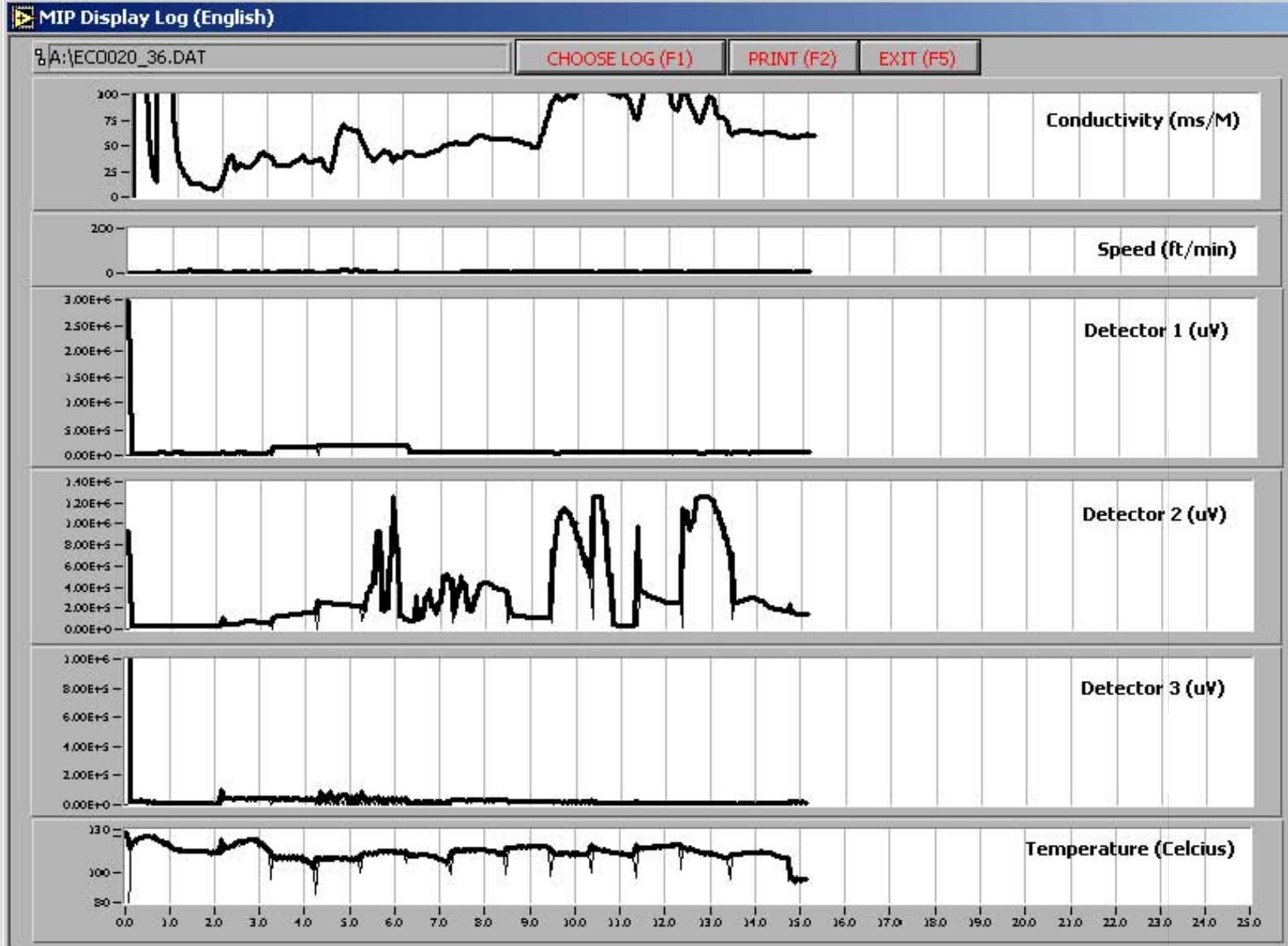
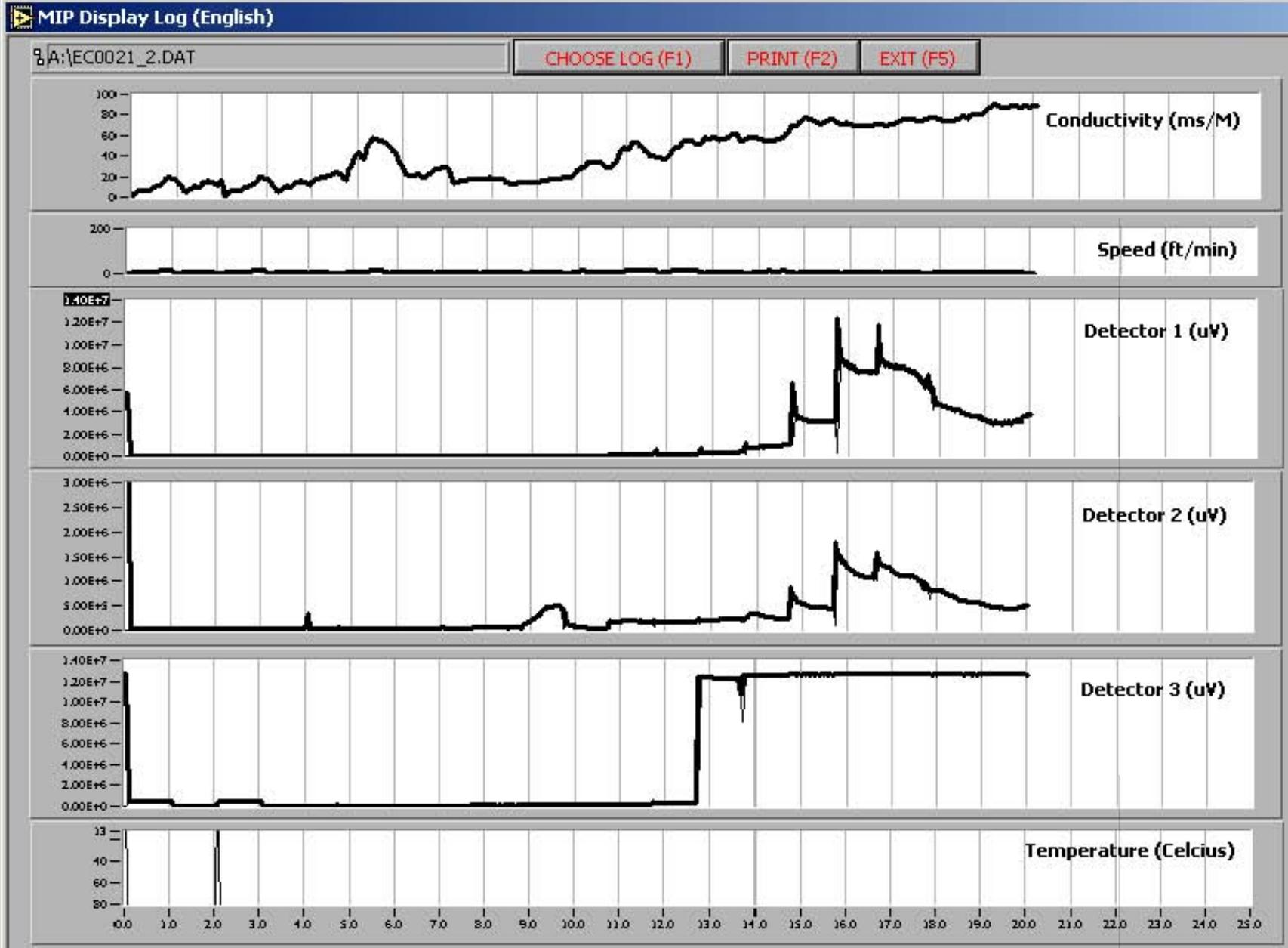


Figure 9
Tidal Study Hydrographs
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

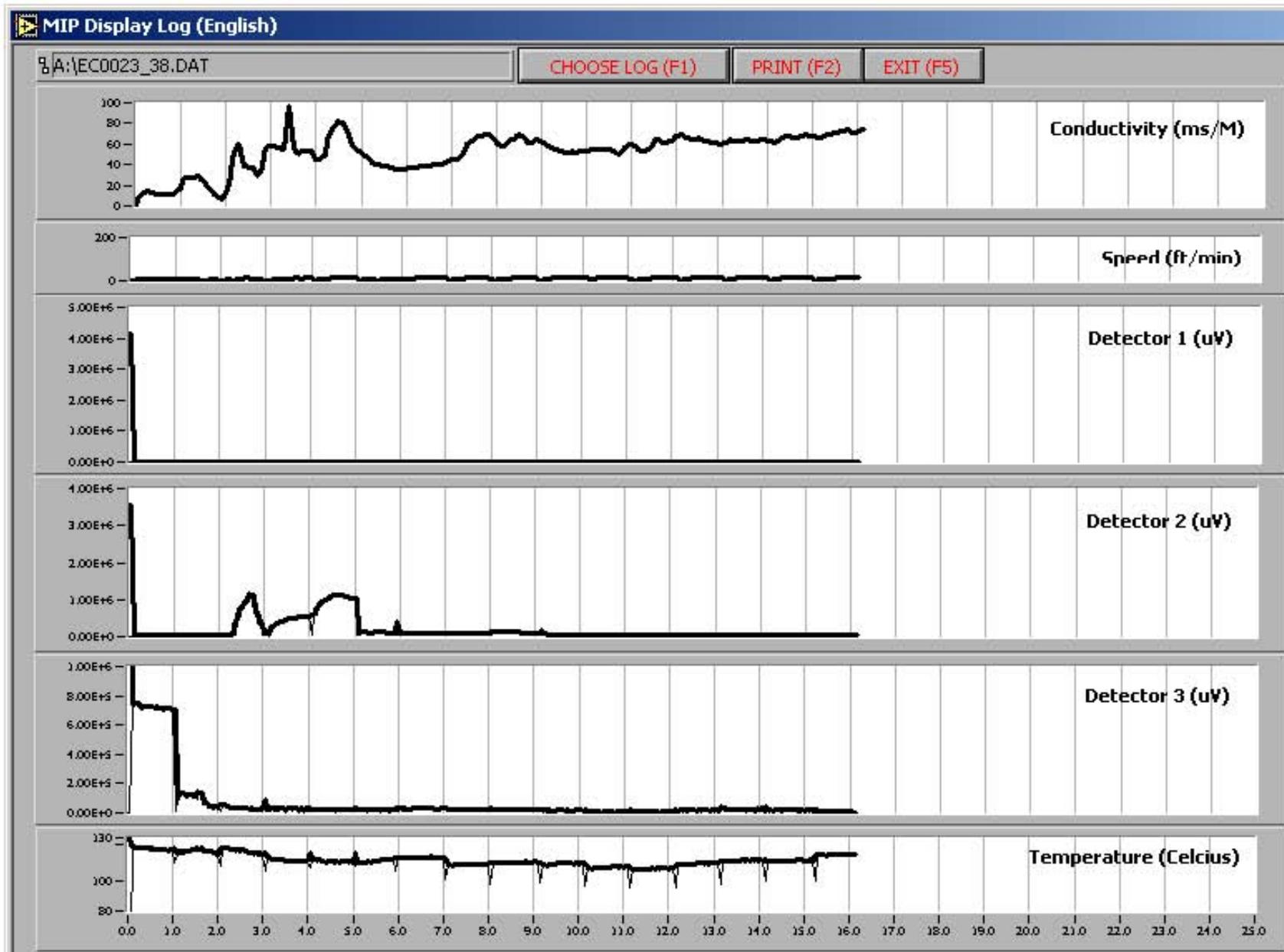
MIP1



MIP2

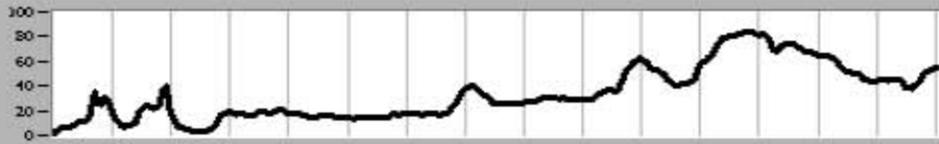


MIP3



MIP4

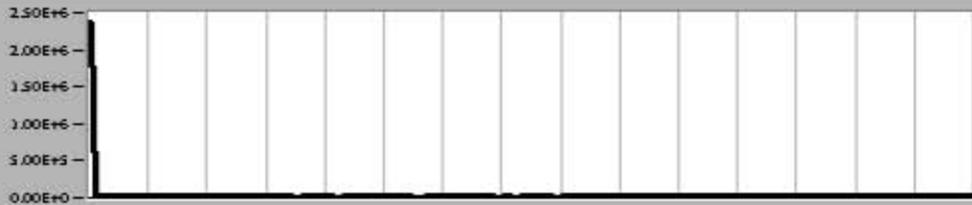
Conductivity (ms/M)



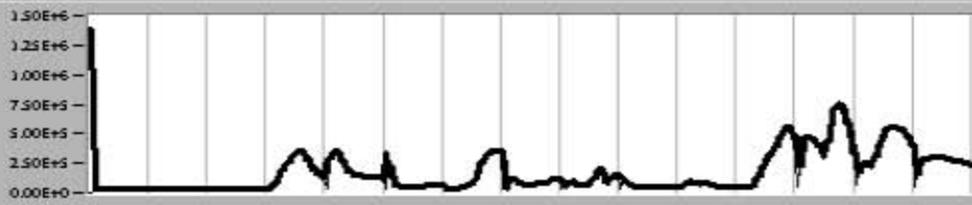
Speed (ft/min)



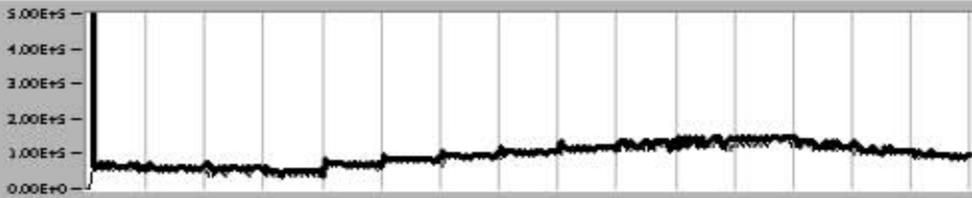
Detector 1 (uV)



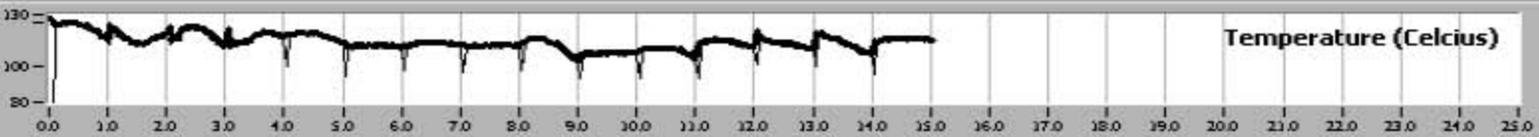
Detector 2 (uV)



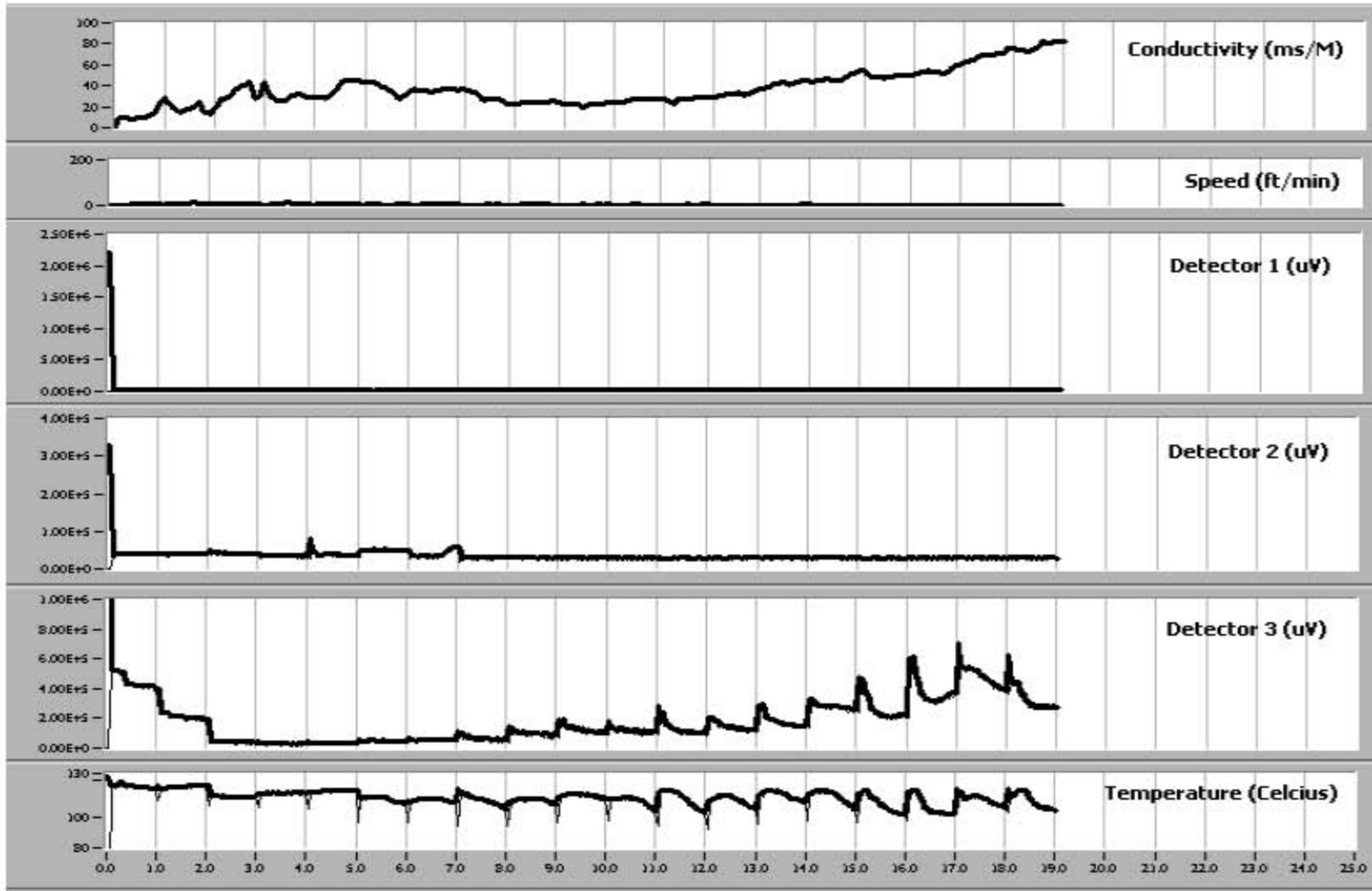
Detector 3 (uV)



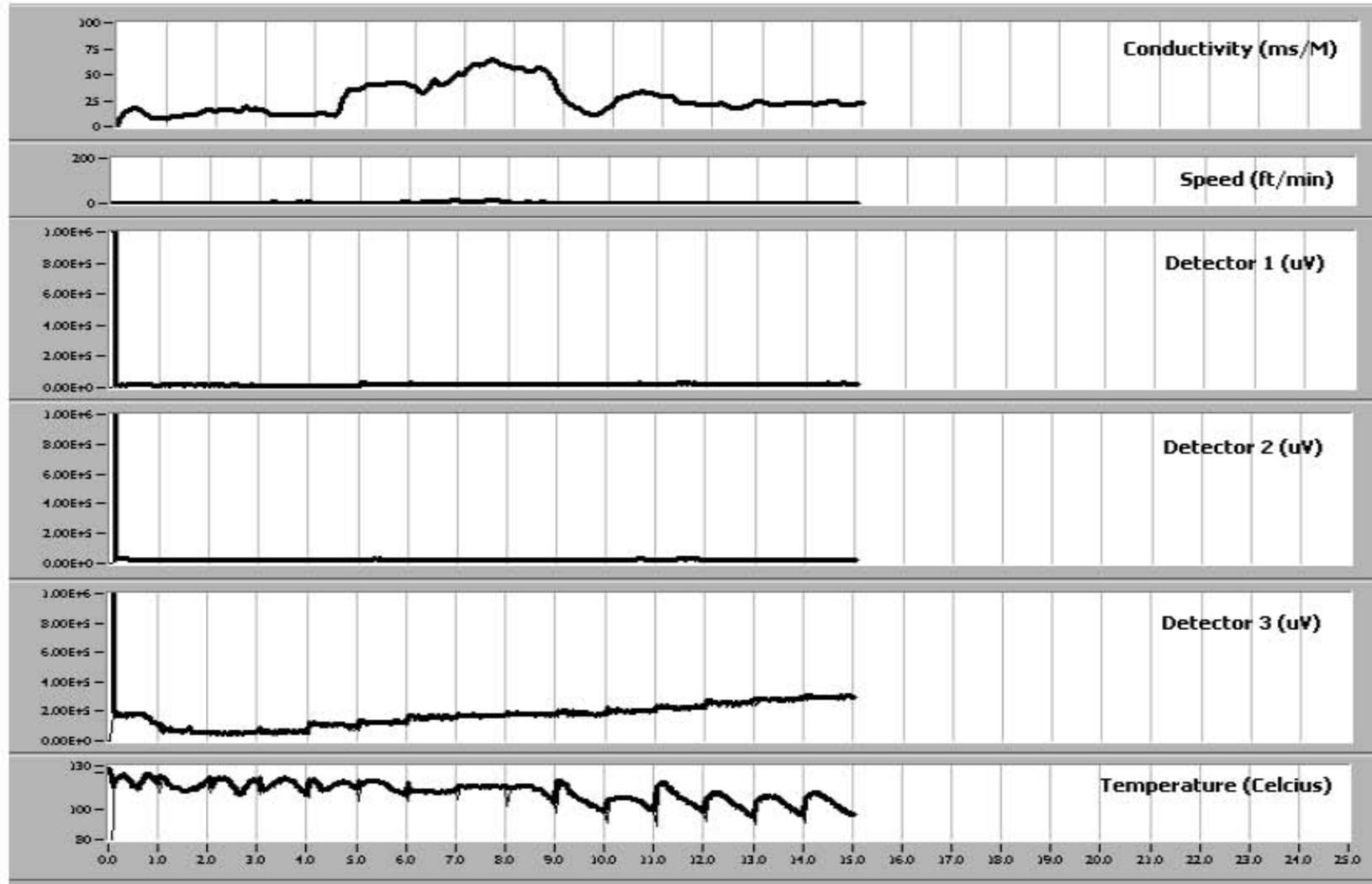
Temperature (Celcius)



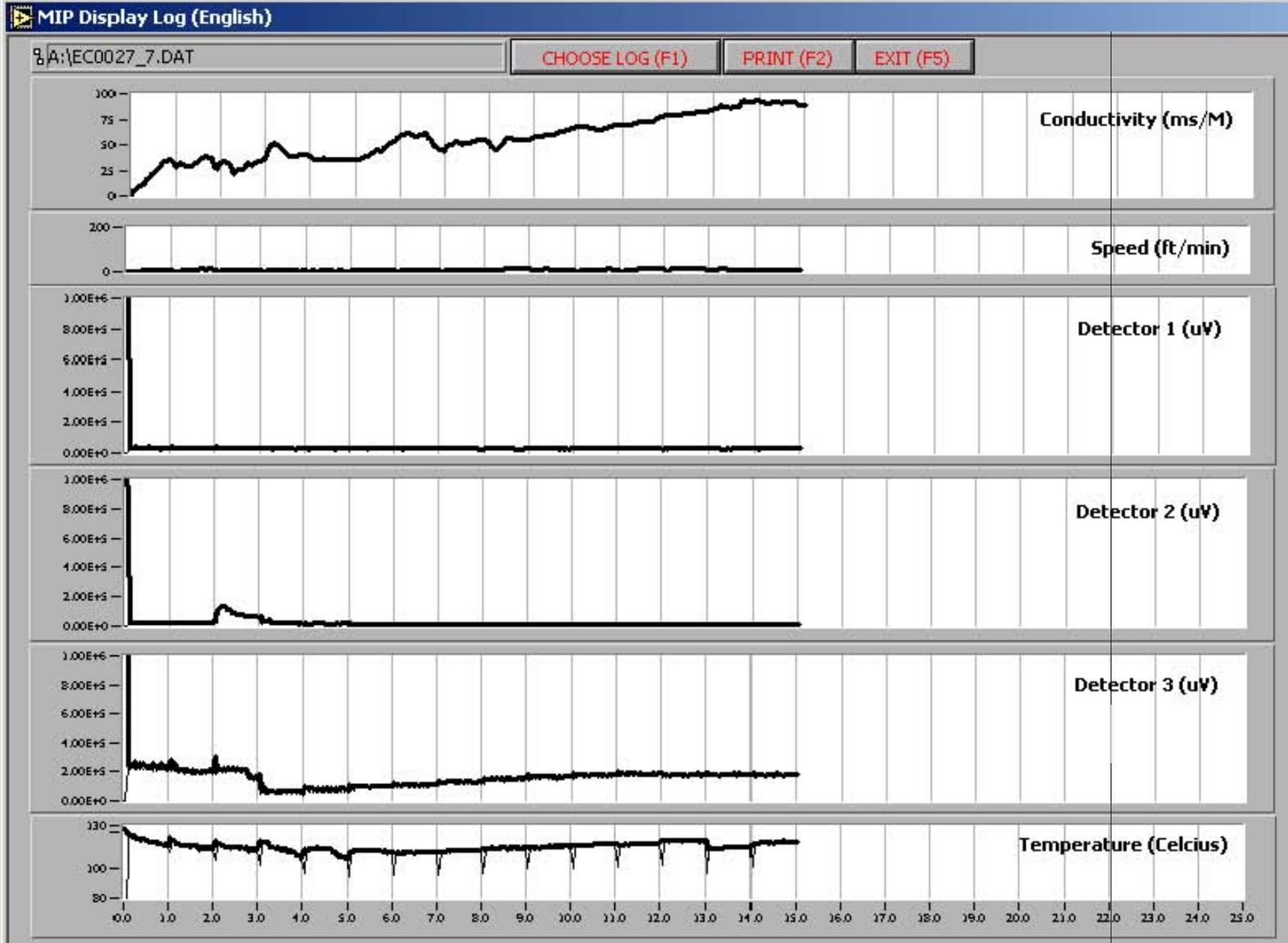
MIP5



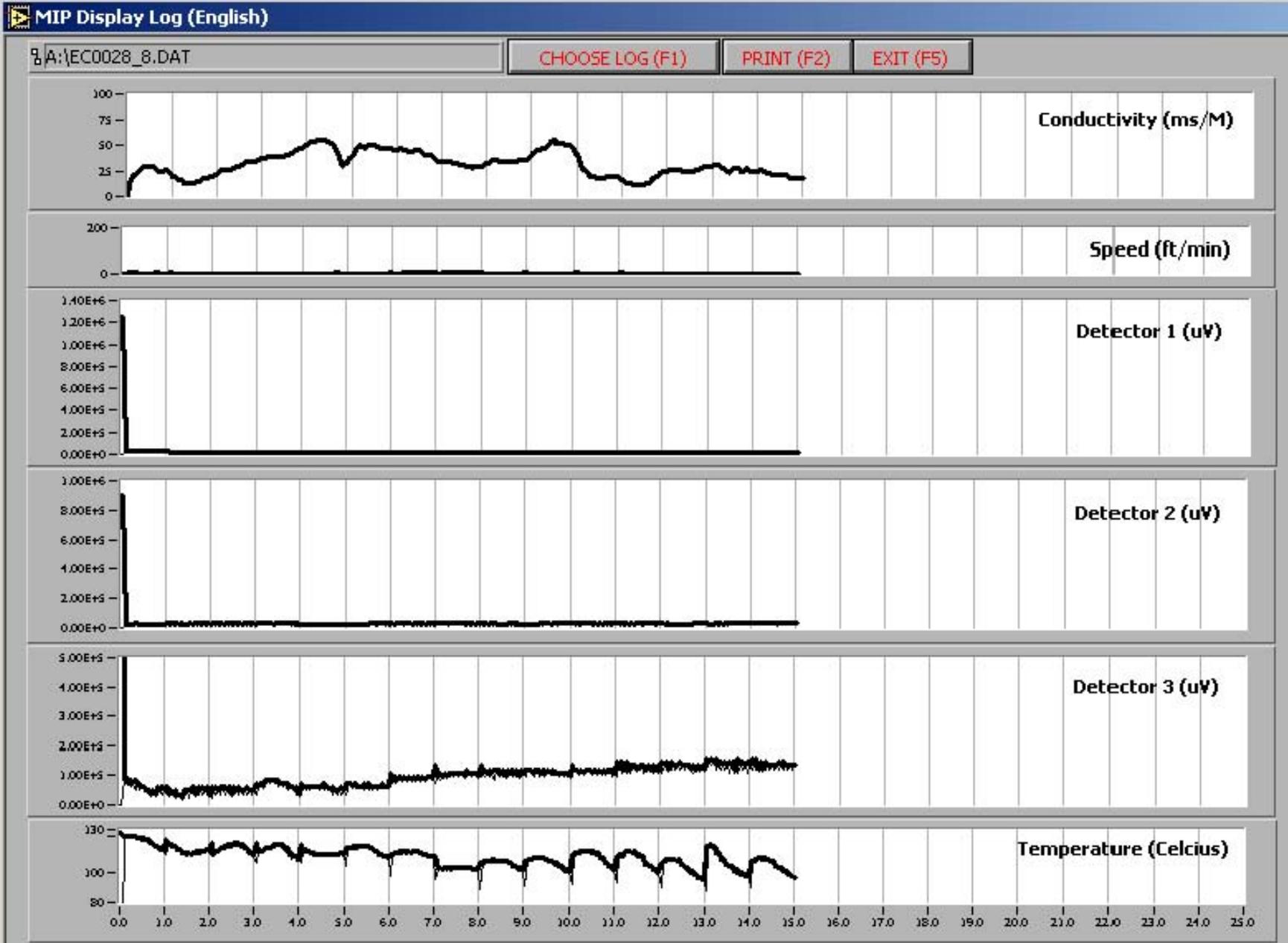
MIP6



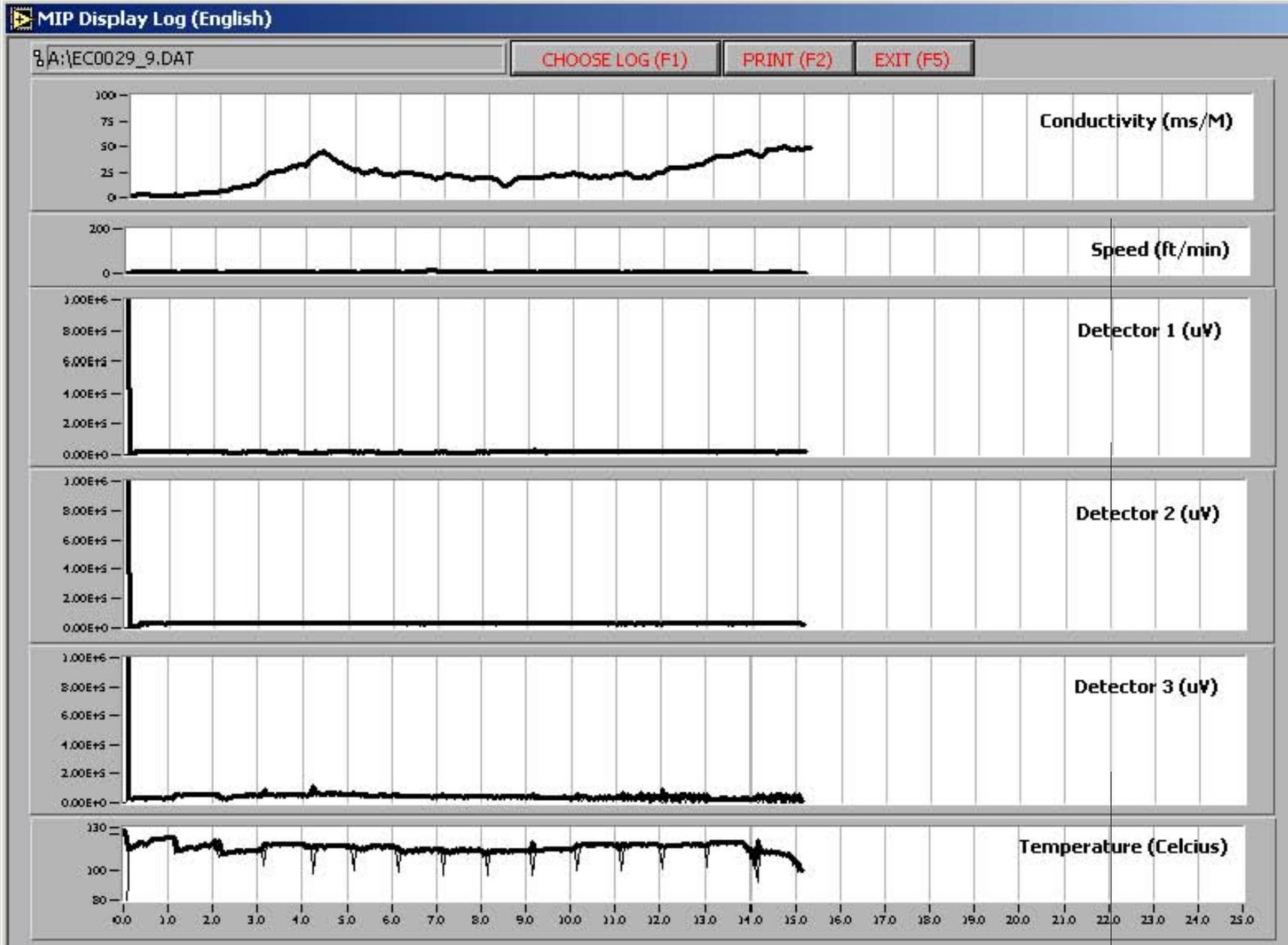
MIP7



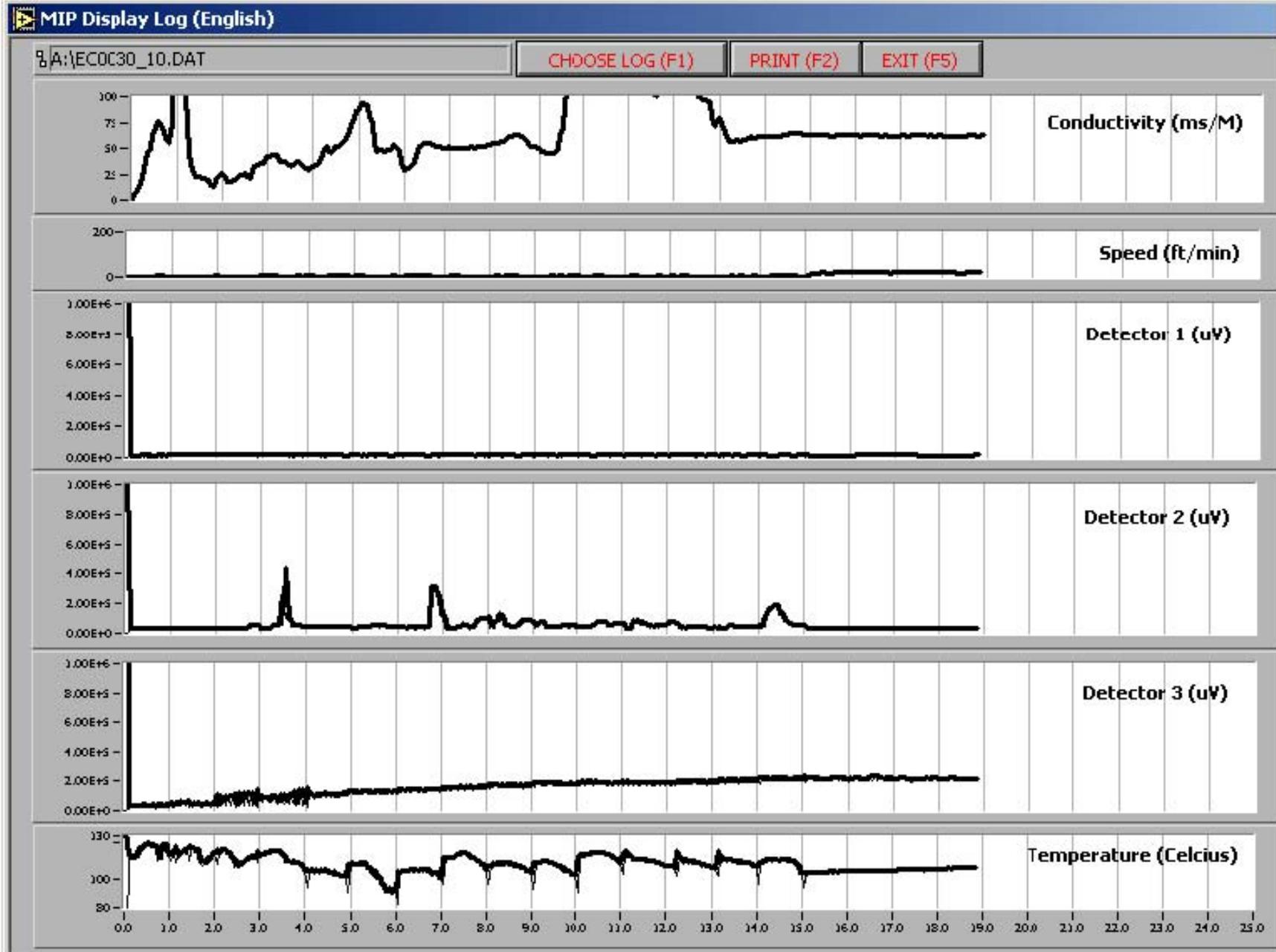
MIP8



MIP9



MIP10



MIP11

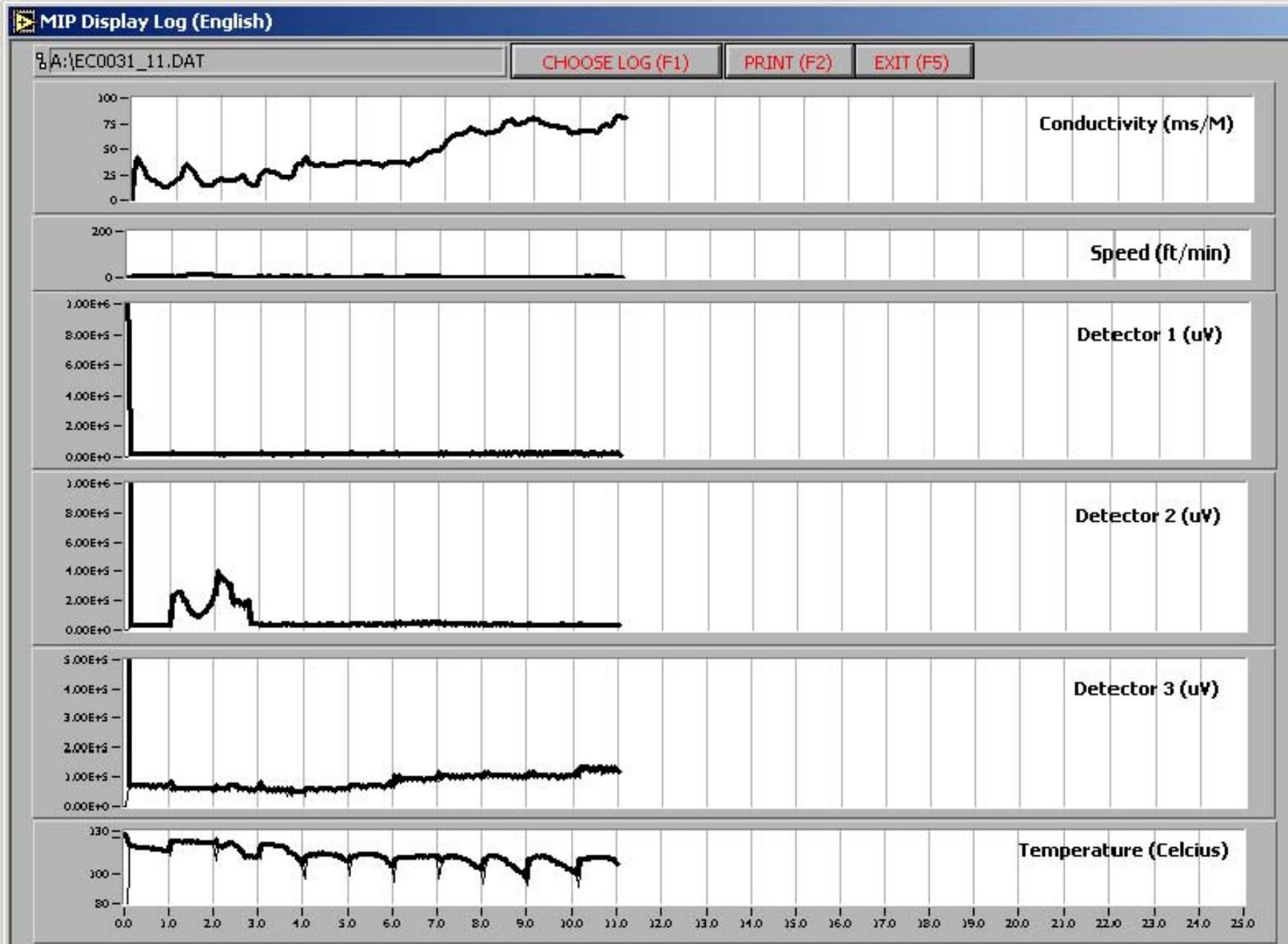


Table B-1
Raw Data Direct-Push Groundwater Samples
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

Station ID	IS17GW01	IS17GW02	IS17GW03		IS17GW04	IS17GW05	IS17GW06
Sample ID	IS17GW010602	IS17GW020602	IS17GW030602	IS17GW030602P	IS17GW040602	IS17GW050602	IS17GW060602
Sample Date	06/24/02	06/24/02	06/24/02	06/24/02	06/25/02	06/25/02	06/25/02
Chemical Name							
Volatile Organic Compounds (UG/L)							
1,1,1-Trichloroethane	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
1,1,2-Trichloroethane	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
1,1-Dichloroethane	200 U	1,000 U	2 U	1 J	2 U	2 U	20 J
1,1-Dichloroethene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
1,2,3-Trichlorobenzene	300 U	1,500 U	3 U	3 U	3 U	3 U	60 U
1,2,4-Trichlorobenzene	300 U	1,500 U	3 U	3 U	3 U	3 U	60 U
1,2,4-Trimethylbenzene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
1,2-Dibromoethane	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
1,2-Dichlorobenzene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
1,2-Dichloroethane	300 U	1,500 U	3 J	3 U	3 U	3 U	60 U
1,2-Dichloropropane	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
1,3,5-Trimethylbenzene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
1,3-Dichlorobenzene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
1,3-Dichloropropane	300 U	1,500 U	3 U	3 U	3 U	3 U	60 U
1,4-Dichlorobenzene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Benzene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Bromodichloromethane	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Bromoform	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Bromomethane	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Carbon tetrachloride	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Chlorobenzene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Chloroethane	160 J	28,000 D	2 U	2 U	2 U	2 U	40 U
Chloroform	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Chloromethane	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U

NA - Not analyzed
D - Dilution result
J - Estimated
JB - Below detection limit, estimated
U - Undetected

Table B-1
Raw Data Direct-Push Groundwater Samples
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

Station ID	IS17GW01	IS17GW02	IS17GW03		IS17GW04	IS17GW05	IS17GW06
Sample ID	IS17GW010602	IS17GW020602	IS17GW030602	IS17GW030602P	IS17GW040602	IS17GW050602	IS17GW060602
Sample Date	06/24/02	06/24/02	06/24/02	06/24/02	06/25/02	06/25/02	06/25/02
Cumene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Dibromochloromethane	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Dichlorodifluoromethane(Freon-12)	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Ethylbenzene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Hexachlorobutadiene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Methylene chloride	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Naphthalene	300 U	1,500 U	3 U	3 U	3 U	3 U	60 U
Styrene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Tetrachloroethene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Toluene	200 U	1,000 U	2 U	2 U	1 J	2 U	40 U
Trichloroethene	200 U	310,000 D	2 U	2 U	2 U	2 U	240
Trichlorofluoromethane(Freon-11)	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
Vinyl chloride	220	50,000 D	2 U	2 U	2 U	2 U	40 U
cis-1,2-Dichloroethene	220	75,000 D	2 U	2 U	1 J	2 U	20 J
cis-1,3-Dichloropropene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
m- and p-Xylene	400 U	2,000 U	4 U	4 U	4 U	4 U	80 U
n-Butylbenzene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
n-Propylbenzene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
o-Xylene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
p-Isopropyltoluene	200 U	1,000 U	2 U	2 U	1 J	2 U	40 U
sec-Butylbenzene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
tert-Butylbenzene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U
trans-1,2-Dichloroethene	200 U	500 JB	2 U	2 U	2 U	2 U	40 U
trans-1,3-Dichloropropene	200 U	1,000 U	2 U	2 U	2 U	2 U	40 U

NA - Not analyzed
D - Dilution result
J - Estimated
JB - Below detection limit, estimated
U - Undetected

Table B-1
Raw Data Direct-Push Groundwater Samples
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

Station ID	IS17GW07	IS17GW08	IS17GW09	IS17GW10	IS17GW11		IS17GW12
Sample ID	IS17GW070602	IS17GW080602	IS17GW090602	IS17GW100602	IS17GW110602	IS17GW110602P	IS17GW120602
Sample Date	06/25/02	06/26/02	06/26/02	06/26/02	06/27/02	06/27/02	06/27/02
Chemical Name							
Volatile Organic Compounds (UG/L)							
1,1,1-Trichloroethane	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1,2-Trichloroethane	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1-Dichloroethane	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1-Dichloroethene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,2,3-Trichlorobenzene	3 U	3 U	3 U	3 U	3 U	3 U	3 U
1,2,4-Trichlorobenzene	3 U	3 U	3 U	3 U	3 U	3 U	3 U
1,2,4-Trimethylbenzene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,2-Dibromoethane	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,2-Dichlorobenzene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,2-Dichloroethane	3 U	3 U	3 U	3 U	3 U	3 U	3 U
1,2-Dichloropropane	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,3,5-Trimethylbenzene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,3-Dichlorobenzene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,3-Dichloropropane	3 U	3 U	3 U	3 U	3 U	3 U	3 U
1,4-Dichlorobenzene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Benzene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Bromodichloromethane	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Bromoform	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Bromomethane	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Carbon tetrachloride	2 U	2 U	2 U	2 U	2 U	2 U	2
Chlorobenzene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Chloroethane	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Chloroform	2 U	2 U	2 U	2 U	2 U	2 U	1 J
Chloromethane	2 U	2 U	2 U	2 U	2 U	2 U	2 U

NA - Not analyzed
D - Dilution result
J - Estimated
JB - Below detection limit, estimated
U - Undetected

Table B-1
Raw Data Direct-Push Groundwater Samples
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

Station ID	IS17GW07	IS17GW08	IS17GW09	IS17GW10	IS17GW11		IS17GW12
Sample ID	IS17GW070602	IS17GW080602	IS17GW090602	IS17GW100602	IS17GW110602	IS17GW110602P	IS17GW120602
Sample Date	06/25/02	06/26/02	06/26/02	06/26/02	06/27/02	06/27/02	06/27/02
Cumene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Dibromochloromethane	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Dichlorodifluoromethane(Freon-12)	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Ethylbenzene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Hexachlorobutadiene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Methylene chloride	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Naphthalene	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Styrene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Tetrachloroethene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Toluene	2 U	2 U	2 U	8	2	2	1 J
Trichloroethene	3	2 U	2 U	2	2 U	2 U	2 U
Trichlorofluoromethane(Freon-11)	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Vinyl chloride	2 U	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,3-Dichloropropene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
m- and p-Xylene	4 U	4 U	4 U	4 U	4 U	4 U	4 U
n-Butylbenzene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
n-Propylbenzene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
o-Xylene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
p-Isopropyltoluene	2 U	2 U	2 U	2 U	2 U	2 U	2
sec-Butylbenzene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
tert-Butylbenzene	2 U	2 U	2 U	2 U	2 U	2 U	2
trans-1,2-Dichloroethene	2 U	2 U	2 U	2 U	2 U	2 U	2 U
trans-1,3-Dichloropropene	2 U	2 U	2 U	2 U	2 U	2 U	2 U

NA - Not analyzed
D - Dilution result
J - Estimated
JB - Below detection limit, estimated
U - Undetected

Table B-2
Raw Data Surface Water Samples
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

Station ID	IS17SW04	IS17SW07	IS17SW08	
Sample ID	IS17SW040602	IS17SW070602	IS17SW080602	IS17SW080602P
Sample Date	06/24/02	06/24/02	06/24/02	06/24/02
Chemical Name				
Volatile Organic Compounds (µg/l)				
1,1,1-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U
1,2,4-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromoethane	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U
2-Butanone	5 U	5 U	5 U	5 U
2-Hexanone	5 U	5 U	5 U	5 U
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U
Acetone	4.2 B	4.4 B	2.6 B	3.4 B
Benzene	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	0.2 B	0.17 B	0.25 B	0.18 B
Bromomethane	0.5 U	0.5 U	0.5 U	0.5 U
Carbon disulfide	0.5 U	0.5 U	0.5 U	0.5 U
Carbon tetrachloride	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U
Chloroethane	0.5 U	0.5 U	0.5 U	0.5 U

NA - Not analyzed
B - Blank contamination
J - Estimated
U - Undetected

Table B-2
Raw Data Surface Water Samples
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

Station ID	IS17SW04	IS17SW07	IS17SW08	
Sample ID	IS17SW040602	IS17SW070602	IS17SW080602	IS17SW080602P
Sample Date	06/24/02	06/24/02	06/24/02	06/24/02
Chemical Name				
Chloroform	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	0.5 U	0.5 U	0.5 U	0.5 U
Cumene	0.5 U	0.5 U	0.5 U	0.5 U
Cyclohexane	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane(Freon-12)	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U
Methyl acetate	0.5 U	0.5 U	0.5 U	0.5 U
Methyl-tert-butyl ether (MTBE)	4.1	4	4	4.1
Methylcyclohexane	0.5 U	0.5 U	0.5 U	0.5 U
Methylene chloride	0.22 J	0.22 J	0.18 J	0.21 J
Styrene	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	0.16 J	0.12 J	0.13 J	0.18 J
Trichloroethene	0.5 U	0.5 U	0.5 U	0.5 U
Trichlorofluoromethane(Freon-11)	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl chloride	0.5 U	0.5 U	0.5 U	0.5 U
Xylene, total	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U

NA - Not analyzed
B - Blank contamination
J - Estimated
U - Undetected

Table B-3
Raw Data Monitoring Well Samples
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

Station ID	IS17MW01		IS17MW02	IS17MW03
Sample ID	IS17MW01071702	IS17MW01071702P	IS17MW02071702	IS17MW03071702
Sample Date	07/17/02	07/17/02	07/17/02	07/17/02
Chemical Name				
Volatile Organic Compounds (µg/l)				
1,1,1-Trichloroethane	0.5 U	0.5 U	17 U	0.5 U
1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	17 U	0.5 U
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	0.5 U	0.5 U	17 U	0.5 U
1,1,2-Trichloroethane	0.5 U	0.5 U	17 U	0.5 U
1,1-Dichloroethane	0.23 U	0.22 J	6 J	0.5 U
1,1-Dichloroethene	0.5 U	0.12 J	17 U	0.5 U
1,2,3-Trichlorobenzene	0.5 U	0.5 U	NA	0.5 U
1,2,4-Trichlorobenzene	0.5 U	0.5 U	17 U	0.5 U
1,2-Dibromo-3-chloropropane	0.5 U	0.5 U	17 U	0.5 U
1,2-Dibromoethane	0.5 U	0.5 U	17 U	0.5 U
1,2-Dichlorobenzene	0.5 U	0.5 U	17 U	0.5 U
1,2-Dichloroethane	0.5 U	0.5 U	17 U	0.5 U
1,2-Dichloropropane	0.5 U	0.5 U	17 U	0.5 U
1,3-Dichlorobenzene	0.5 U	0.5 U	17 U	0.5 U
1,4-Dichlorobenzene	0.5 U	0.5 U	17 U	0.5 U
2-Butanone	5 U	5 U	17 U	5 U
2-Hexanone	10 U	10 U	17 U	5 R
4-Methyl-2-pentanone	5 U	5 U	17 U	5 U
Acetone	4.9 B	7.7 B	17 U	1.9 B
Benzene	0.5 U	0.18 J	17 U	0.5 U
Bromochloromethane	0.5 U	0.5 U	NA	0.5 U
Bromodichloromethane	0.5 U	0.5 U	17 U	0.5 U
Bromoform	0.5 U	0.14 B	17 U	0.5 U
Bromomethane	0.5 U	0.5 U	17 U	0.5 U
Carbon disulfide	0.5 U	0.5 U	17 U	0.5 U
Carbon tetrachloride	0.5 U	0.5 U	17 U	0.5 U
Chlorobenzene	0.5 U	0.5 U	17 U	0.5 U
Chloroethane	0.5 U	0.5 U	2 J	0.5 U

NA - Not analyzed
B - Blank contamination
J - Estimated
R - Unusable
U - Undetected

Table B-3
Raw Data Monitoring Well Samples
Site 17 Pre-FS Investigation
IHDIV-NSWC
Indian Head, Maryland

Station ID	IS17MW01		IS17MW02	IS17MW03
Sample ID	IS17MW01071702	IS17MW01071702P	IS17MW02071702	IS17MW03071702
Sample Date	07/17/02	07/17/02	07/17/02	07/17/02
Chemical Name				
Chloroform	0.5 U	0.5 U	17 U	0.5 U
Chloromethane	0.5 U	0.18 J	17 U	0.12 J
Cumene	0.5 U	0.5 U	17 U	0.5 U
Cyclohexane	0.5 U	0.5 U	17 U	0.5 U
Dibromochloromethane	0.5 U	0.5 U	17 U	0.5 U
Dichlorodifluoromethane(Freon-12)	0.5 U	0.5 U	17 U	0.5 U
Ethylbenzene	89	89	17 U	0.5 U
Methyl acetate	0.5 U	0.5 U	17 U	0.5 U
Methyl-tert-butyl ether (MTBE)	0.64	0.73	17 U	0.5 U
Methylcyclohexane	0.5 U	0.5 U	17 U	0.5 U
Methylene chloride	0.18 B	0.22 B	5 B	0.28 B
Styrene	0.7	0.5 U	17 U	0.5 U
Tetrachloroethene	0.5 U	0.5 U	2 B	0.5 U
Toluene	37	43	3 B	0.33 B
Trichloroethene	0.2 J	0.24 J	17 U	0.43 J
Trichlorofluoromethane(Freon-11)	0.5 U	0.5 U	17 U	0.5 U
Vinyl chloride	2.3	2 J	140	0.5 U
Xylene, total	1 J	0.22 J	17 U	0.5 U
cis-1,2-Dichloroethene	4.9	4.8	64	0.5 U
cis-1,3-Dichloropropene	0.5 U	0.12 B	17 U	0.11 B
trans-1,2-Dichloroethene	0.15 J	0.13 J	17 U	0.5 U
trans-1,3-Dichloropropene	0.5 U	0.5 U	17 U	0.5 U
Energetics				
Perchlorate	4 U	4 U	4 U	4 U
MNA Parameters (µg/l)				
Methane	1	540	120	0.3 J
Ethane	2 U	3 J	16 J	2 U
Ethene	2 U	75 U	11 J	2 U

NA - Not analyzed
B - Blank contamination
J - Estimated
R - Unusable
U - Undetected

Table B-3
 Raw Data Monitoring Well Samples
 Site 17 Pre-FS Investigation
 IHDIV-NSWC
 Indian Head, Maryland

Station ID	IS17MW01		IS17MW02	IS17MW03
Sample ID	IS17MW01071702	IS17MW01071702P	IS17MW02071702	IS17MW03071702
Sample Date	07/17/02	07/17/02	07/17/02	07/17/02
Chemical Name				
MNA Parameters (mg/l)				
Carbon	22.7	28	9.13	5 U
Chloride	251	214	70.4	9.98
Nitrate	0.05 U	0.05 U	0.05 U	0.05 U
Sulfate	5 U	5 U	16.3	37.8

NA - Not analyzed
 B - Blank contamination
 J - Estimated
 R - Unusable
 U - Undetected

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7/19/02

FROM: Lloyd C. Winters

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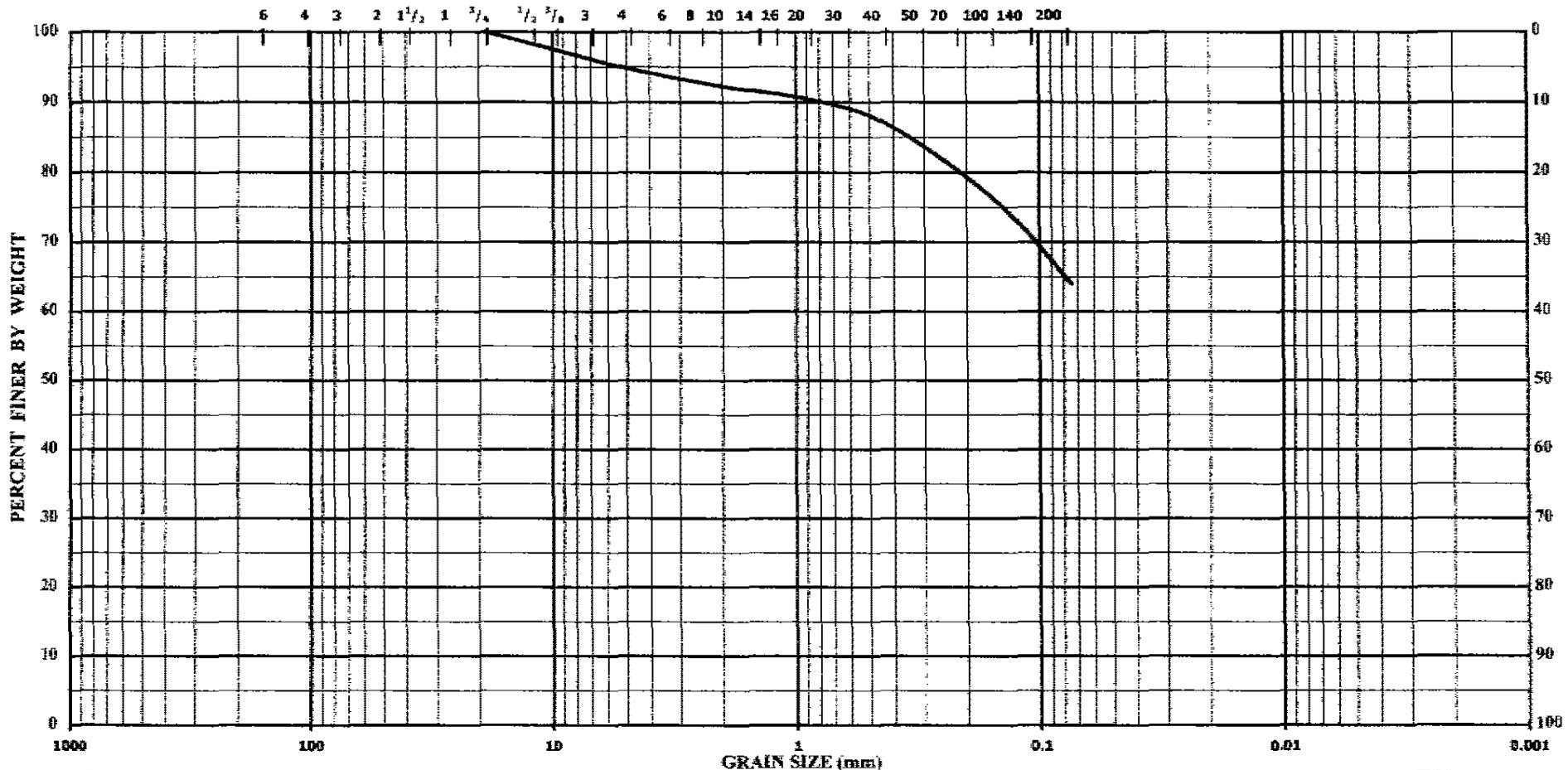
Results of gradation and permeability testing. Samples MIP #1 and #7.

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U.S. STANDARD SIEVE OPENING IN INCHES

U.S. STANDARD SIEVE NUMBERS

HYDROMETER



COBBLE	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

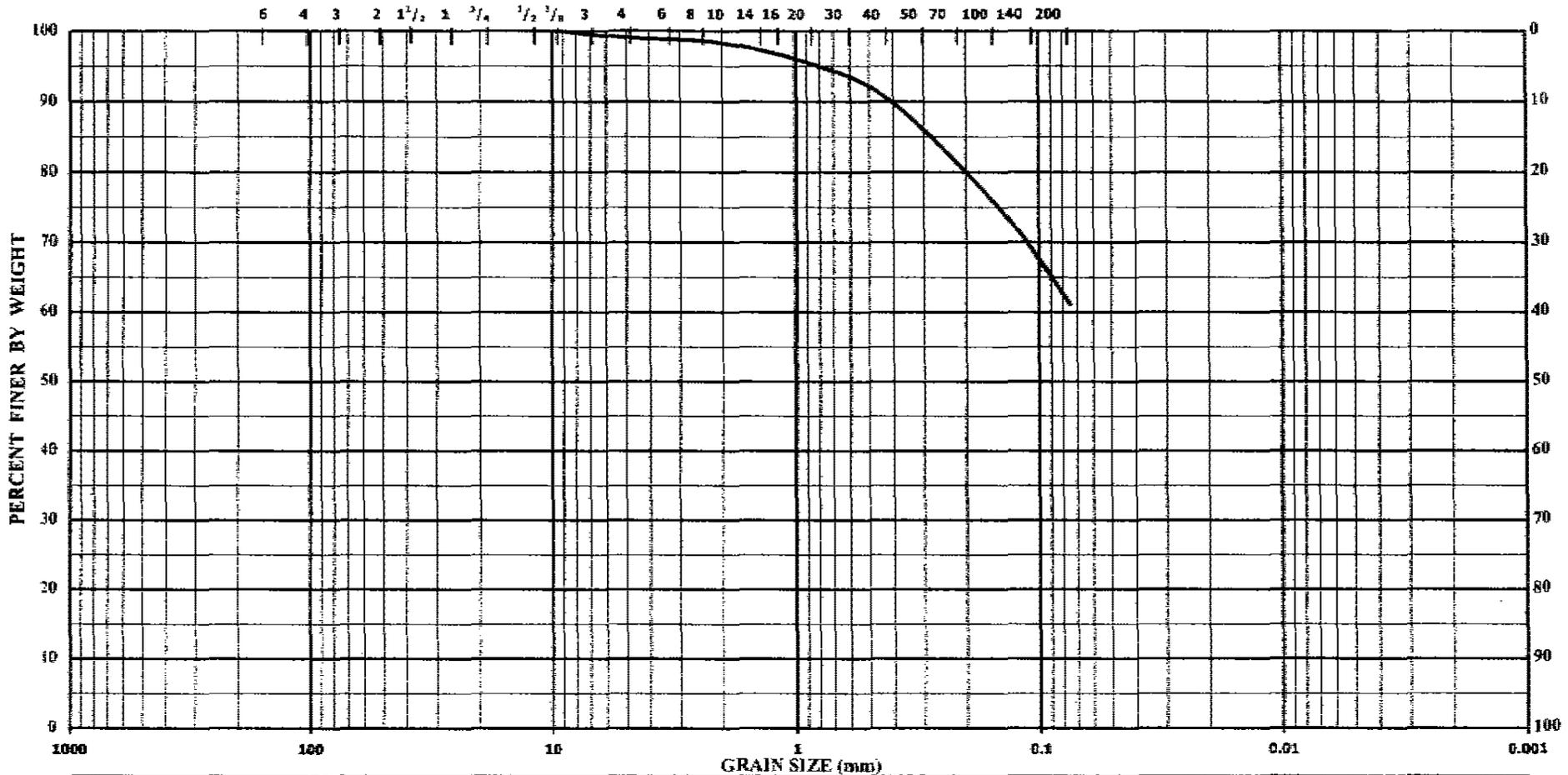
BORING OR SAMPLE NO.	ELEVATION OR DEPTH	SAMPLE DESCRIPTION	% GRAVEL	% SAND	% FINES	NATURAL % MOISTURE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	U.S.C.S. SYMBOL
MIP #1	9.0-11.0	Brown sandy SILT w/trace gravel	5	31	64	28.0	NT	NT	NT	
		$K = 2.19 \times 10^{-7} \text{ (cm/sec) @ } 86.0 \text{ pcf}$								

	TRIAD ENGINEERING, INC. P.O. BOX 2397 200 AVIATION DRIVE WINCHESTER, VA 22604	PROJECT NUMBER: 07-02-0156 PROJECT NAME:	GRAIN SIZE ANALYSIS TEST REPORT	PLATE C-1
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U.S. STANDARD SIEVE OPENING IN INCHES

U.S. STANDARD SIEVE NUMBERS

HYDROMETER



PERCENT COARSER BY WEIGHT

COBBLE	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

BOREING OR SAMPLE NO.	ELEVATION OR DEPTH	SAMPLE DESCRIPTION	% GRAVEL	% SAND	% FINES	NATURAL % MOISTURE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	U.S.C.S. SYMBOL
MIP #7	13.0-15.0	Brown sandy CLAY w/wood	1	38	61	17.1	NT	NT	NT	
		K= 2.40 X10 ⁻⁷ (cm/sec) @ 101.3 pcf								



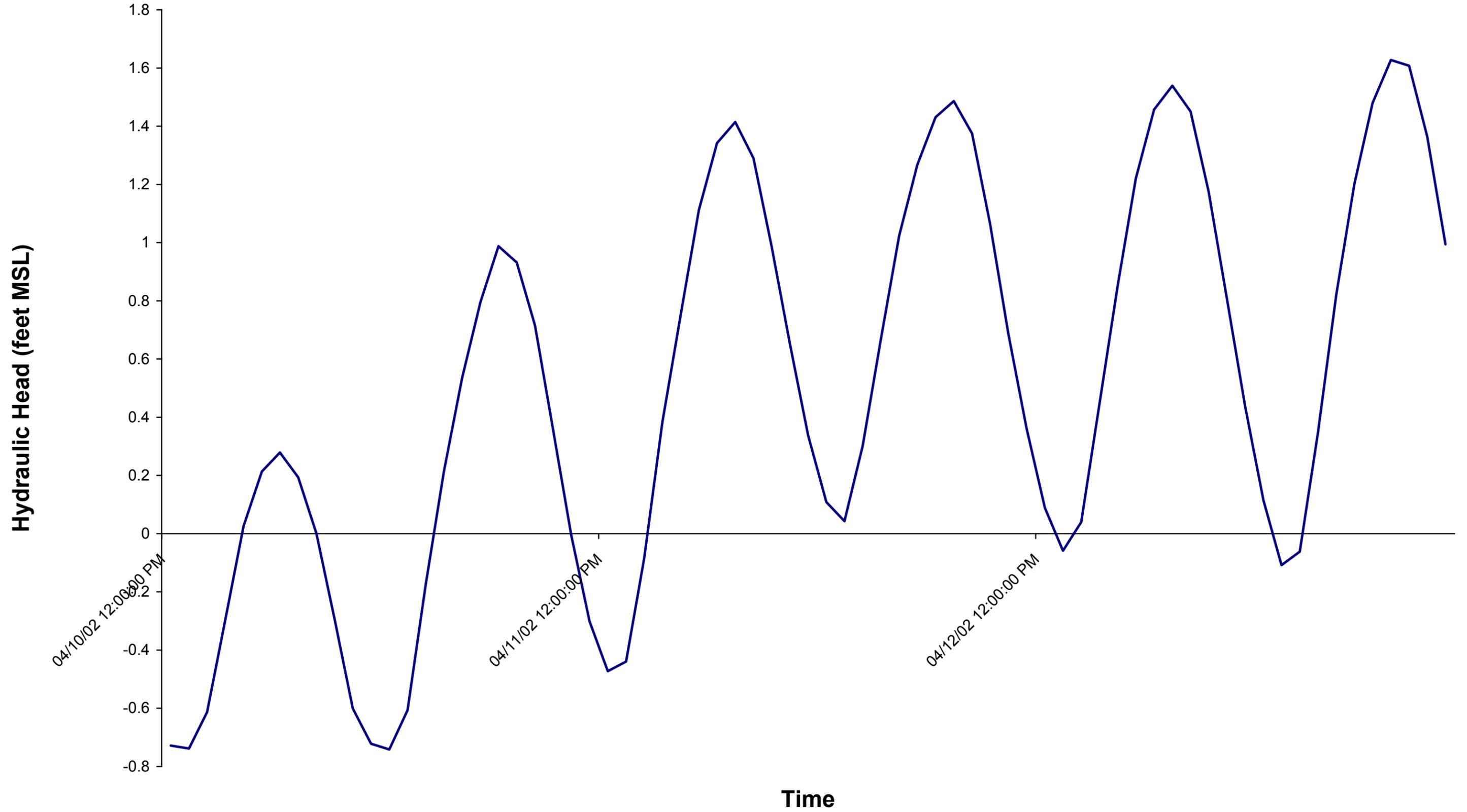
TRIAD ENGINEERING, INC.
P.O. BOX 2397
200 AVIATION DRIVE
WINCHESTER, VA 22604

PROJECT NUMBER: 07-02-0156
PROJECT NAME:

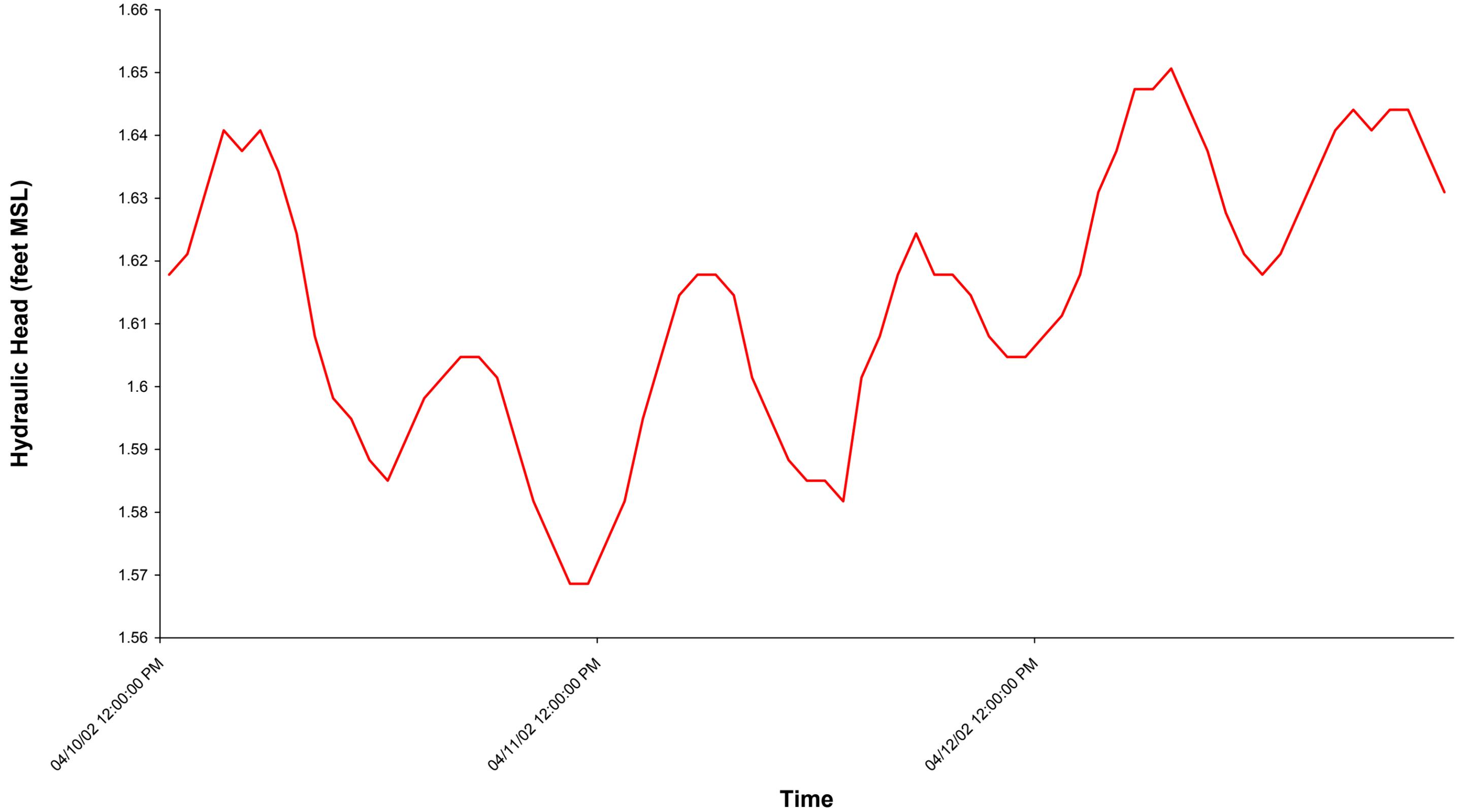
GRAIN SIZE ANALYSIS TEST REPORT

PLATE
C-2

Hydrograph of IS17TS01 4/10/02 12:00 PM - 4/12/02 10:00 AM



Hydrograph of IS17MW02 4/10/02 12:00 PM - 4/12/02 10:00AM



Appendix C
2004 MIP Data



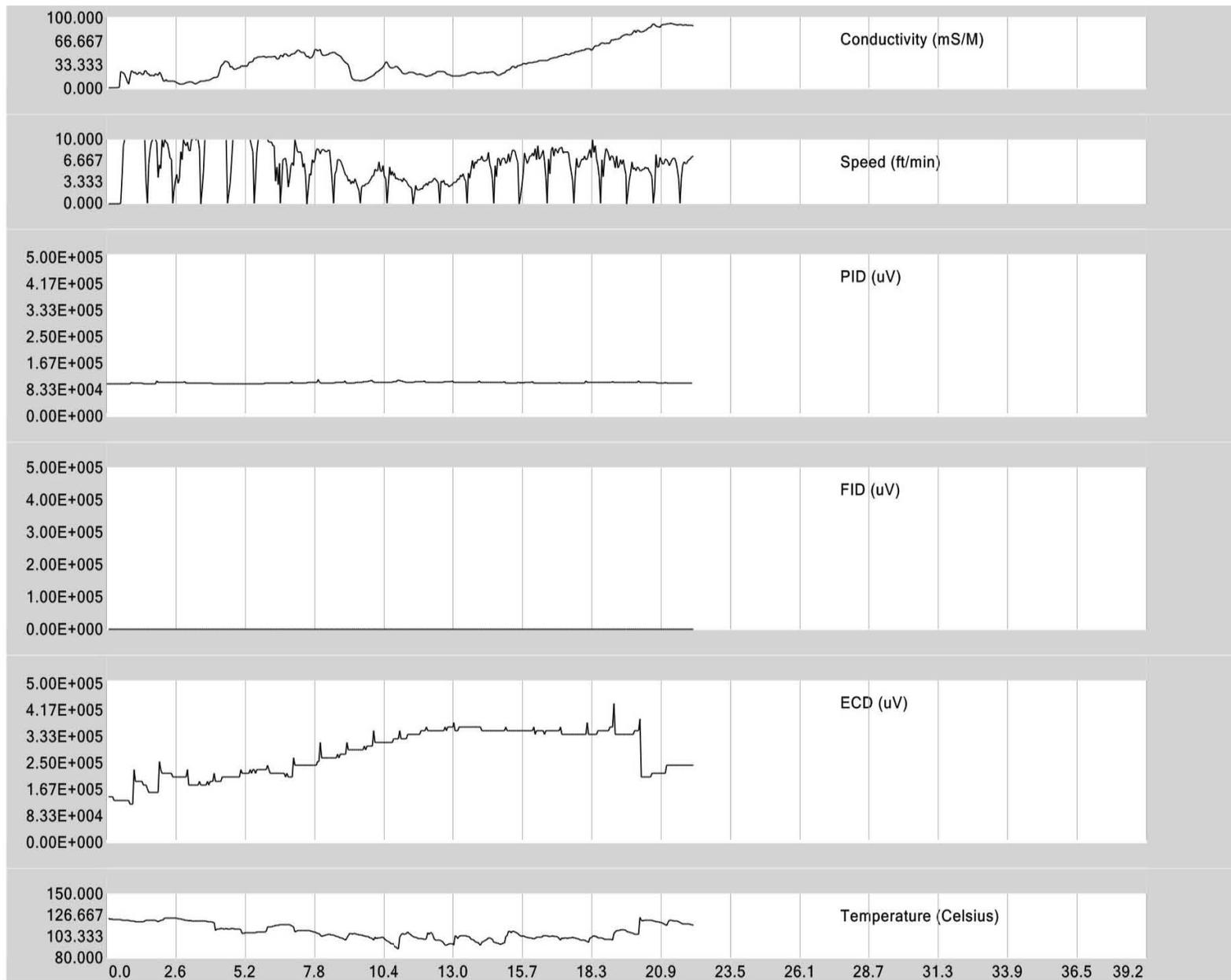
LEGEND

Monitoring Wells	Wooded Area
Proposed MIP/Direct Push Sample Locations	Dense Wooded Area
Previous MIP/Direct Push Sample Locations (2002)	Groundwater Direction
Previous Direct Push Sample Locations (2005)	Road
Approximate Site Boundary	Elevation Contours (feet msl)
Buildings	Base Boundary
Waterbodies	

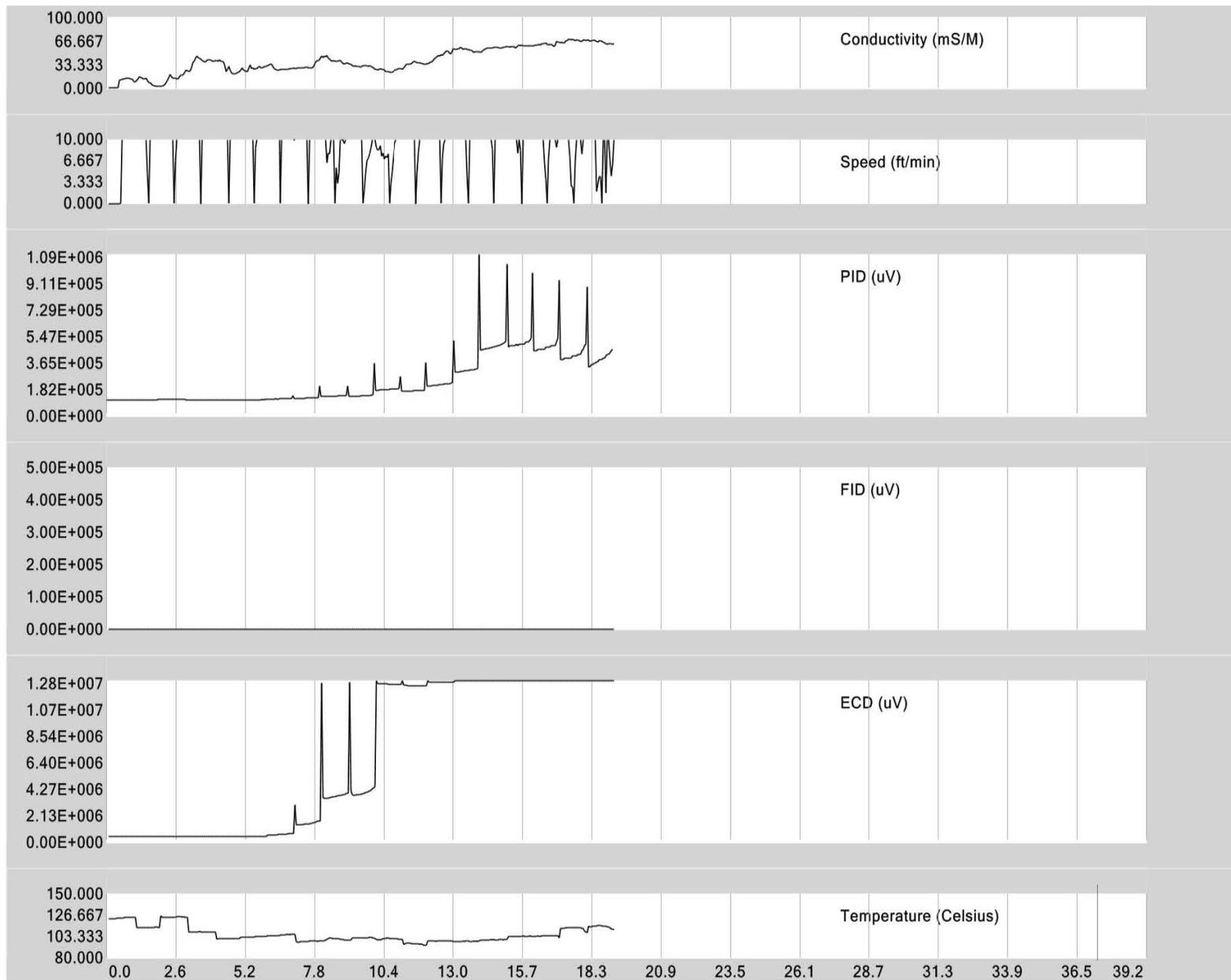
1" = 60'

Figure 2
 Site 17 Upgradient Investigation
 Site 17 Groundwater Focused Feasibility Study
 NDWIH, Indian Head, Maryland

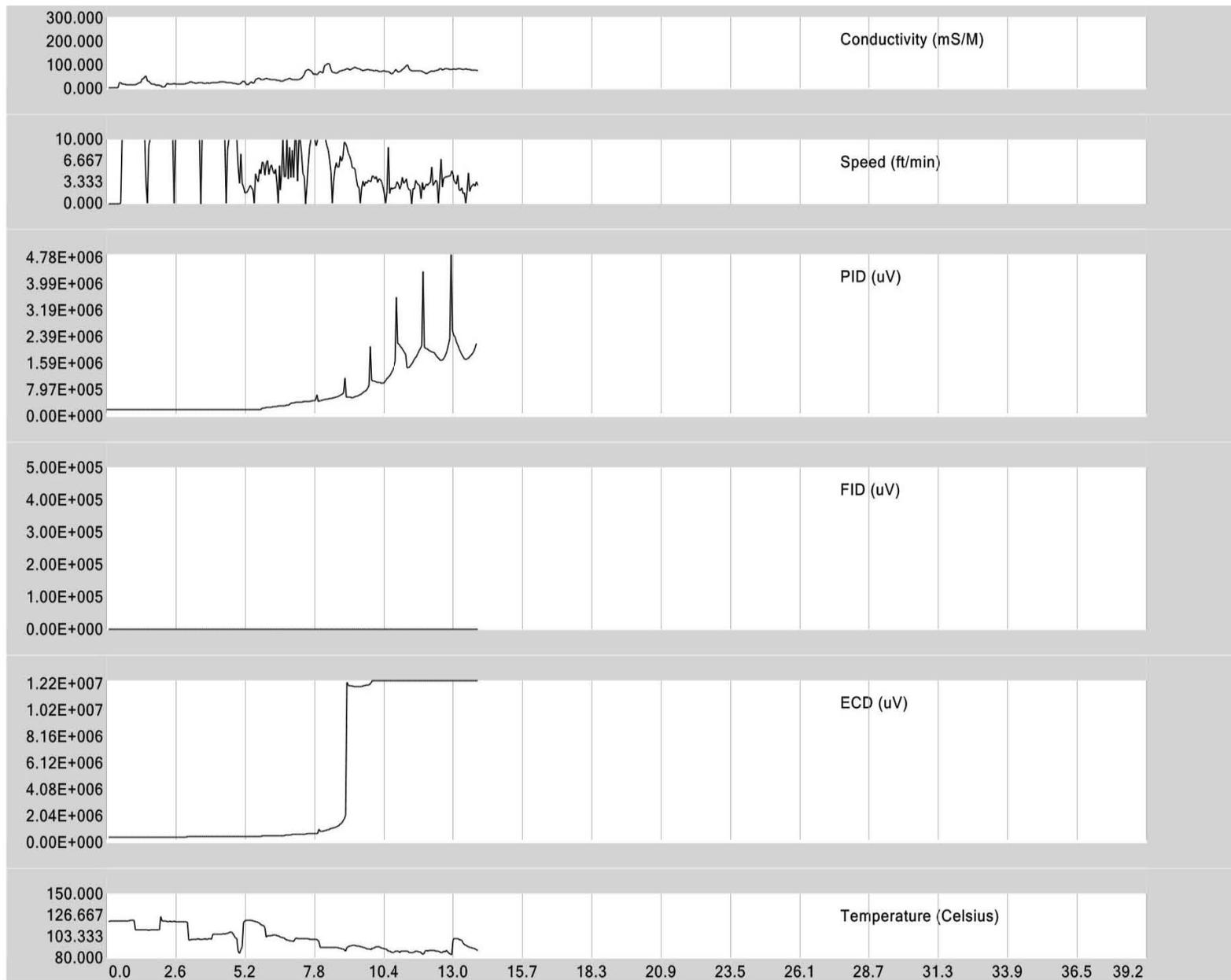
MIP-DP24



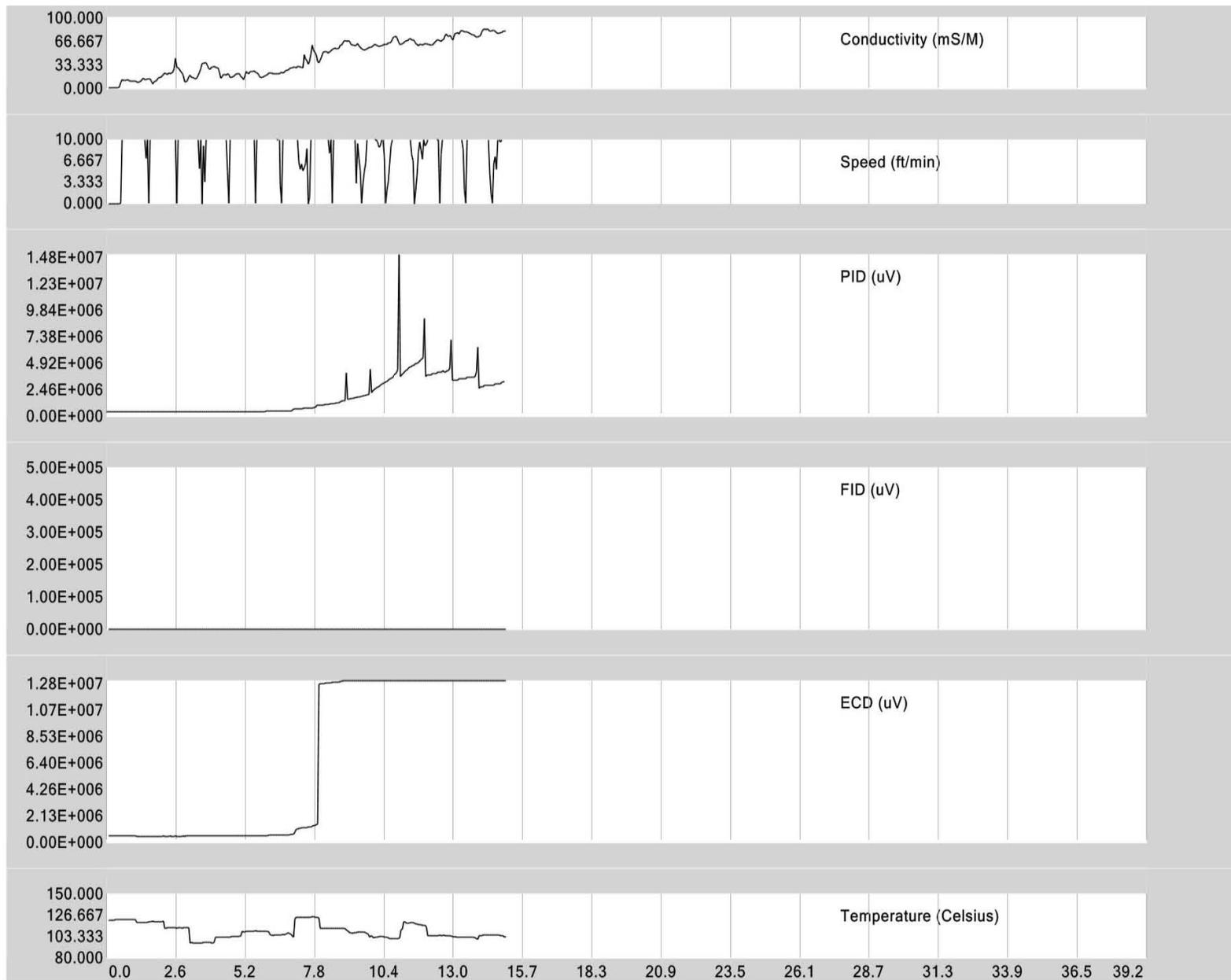
MIP-DP28



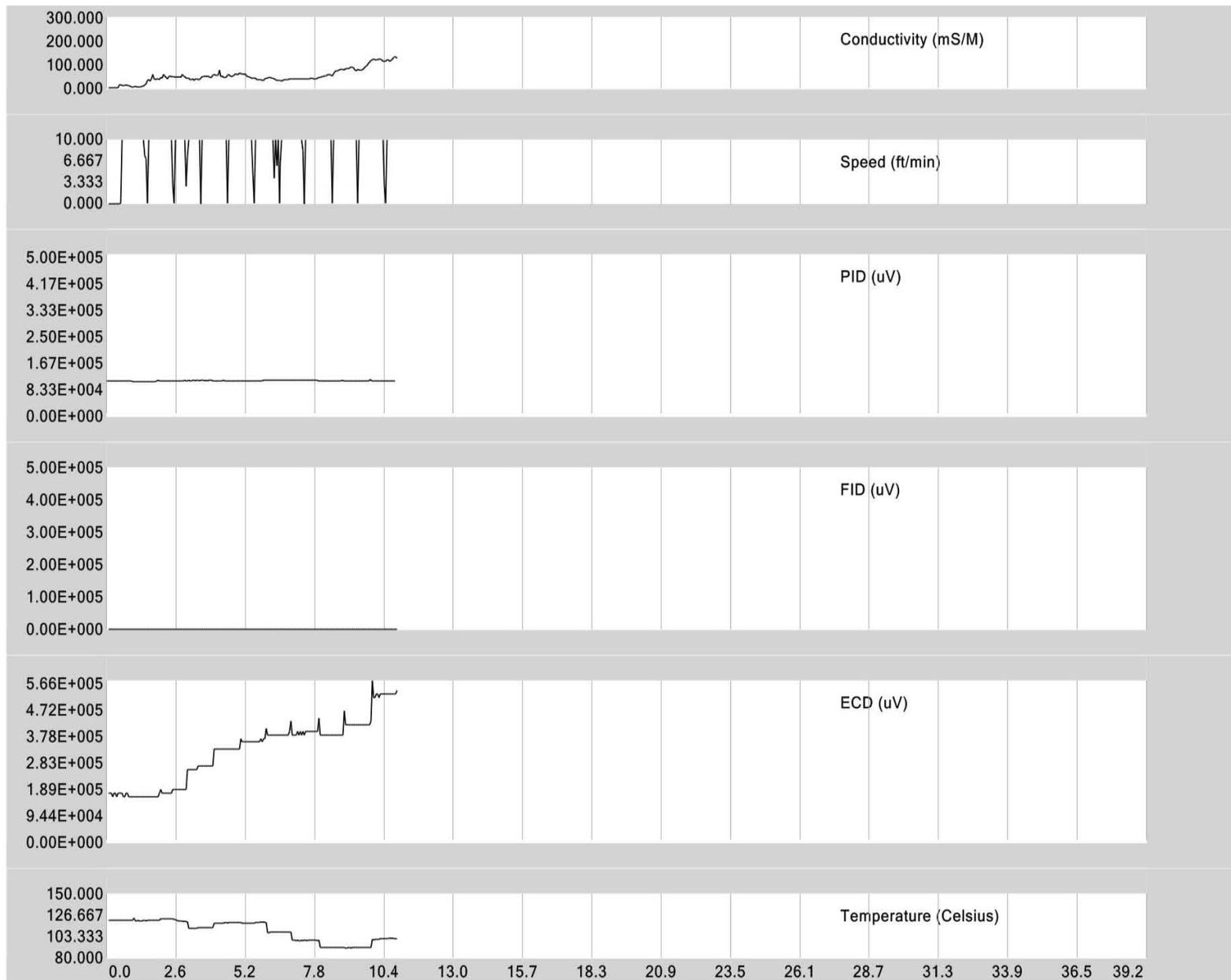
MIP-DP34



MIP-DP35



MIP-DP41



Appendix D
RI Groundwater Analytical Results

Table D-1
Raw and Detected Analytical Results for Monitoring Well Groundwater Samples
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID Sample ID Sample Date	IS17MW01						IS17MW02			IS17MW03		
	IS17MW011000P 10/24/00	IS17MW011000 10/24/00	IS17MW01071702 07/17/02	IS17MW01071702P 07/17/02	IS17MW010205 02/03/05	IS17MW01P0205 02/03/05	IS17MW021000 10/24/00	IS17MW02071702 07/17/02	IS17MW020205 02/03/05	IS17MW031000 10/20/00	IS17MW03071702 07/17/02	IS17MW030205 02/03/05
Chemical Name												
Volatile Organic Compounds (UG/L)												
1,1,1-Trichloroethane	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
1,1,2,2-Tetrachloroethane	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	2.1 B	0.5 U	10 U
1,1,2-Trichloroethane	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
1,1-Dichloroethane	100 U	100 U	0.23 U	0.22 J	10 U	10 U	290 U	6 J	9 J	10 U	0.5 U	10 U
1,1-Dichloroethene	100 U	100 U	0.5 U	0.12 J	10 U	10 U	290 U	17 U	41	10 U	0.5 U	10 U
1,2,3-Trichlorobenzene	NA	NA	0.5 U	0.5 U	NA	NA	NA	NA	NA	NA	0.5 U	NA
1,2,4-Trichlorobenzene	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
1,2-Dibromo-3-chloropropane	100 R	100 R	0.5 U	0.5 U	10 R	10 R	290 R	17 U	400 R	10 R	0.5 U	10 R
1,2-Dibromoethane	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
1,2-Dichlorobenzene	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
1,2-Dichloroethane	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
1,2-Dichloroethene (total)	NA	NA	NA	NA	100	75	NA	NA	5,500	NA	NA	10 U
1,2-Dichloropropane	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
1,3-Dichlorobenzene	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
1,4-Dichlorobenzene	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
2-Butanone	100 U	100 U	5 U	5 U	10 U	10 U	290 U	17 U	10 U	10 U	5 U	10 U
2-Hexanone	100 U	100 U	10 U	10 U	10 U	10 U	290 U	17 U	10 U	10 U	5 R	10 U
4-Methyl-2-pentanone	100 U	100 U	5 U	5 U	10 U	10 U	290 U	17 U	10 U	10 U	5 U	10 U
Acetone	76 B	78 B	4.9 B	7.7 B	10 U	10 U	140 B	17 U	10 U	7.3 B	1.9 B	10 U
Benzene	100 U	100 U	0.5 U	0.18 J	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Bromochloromethane	NA	NA	0.5 U	0.5 U	NA	NA	NA	NA	NA	NA	0.5 U	NA
Bromodichloromethane	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Bromoform	100 U	100 U	0.5 U	0.14 B	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Bromomethane	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Carbon disulfide	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Carbon tetrachloride	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Chlorobenzene	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Chloroethane	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	2 J	10 U	10 U	0.5 U	10 U
Chloroform	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Chloromethane	100 U	100 U	0.5 U	0.18 J	10 U	10 U	290 U	17 U	10 U	10 U	0.12 J	10 U
Cumene	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Cyclohexane	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Dibromochloromethane	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Dichlorodifluoromethane (Freon-12)	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Ethane	NA	NA	2 U	3 J	NA	NA	NA	16 J	NA	NA	2 U	NA
Ethene	NA	NA	2 U	75 U	NA	NA	NA	11 J	NA	NA	2 U	NA
Ethylbenzene	47 J	50 J	89	89	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Methane	NA	NA	1	540	NA	NA	NA	120	NA	NA	0.3 J	NA
Methyl acetate	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Methyl-tert-butyl ether (MTBE)	100 U	100 U	0.64	0.73	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Methylcyclohexane	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Methylene chloride	100 U	100 U	0.18 B	0.22 B	10 U	10 U	430 B	5 B	10 U	20 B	0.28 B	14 B
Styrene	100 U	100 U	0.7	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Tetrachloroethene	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	2 B	10 U	10 U	0.5 U	10 U
Toluene	200	200	37	43	10 U	10 U	290 U	3 B	2 J	10 U	0.33 B	10 U
Trichloroethene	100 U	100 U	0.2 J	0.24 J	10 U	10 U	290 U	17 U	10 U	10 U	0.43 J	10 U

Table D-1
 Raw and Detected Analytical Results for Monitoring Well Groundwater Samples
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID Sample ID Sample Date	IS17MW01						IS17MW02			IS17MW03		
	IS17MW011000P 10/24/00	IS17MW011000 10/24/00	IS17MW01071702 07/17/02	IS17MW01071702P 07/17/02	IS17MW010205 02/03/05	IS17MW01P0205 02/03/05	IS17MW021000 10/24/00	IS17MW02071702 07/17/02	IS17MW020205 02/03/05	IS17MW031000 10/20/00	IS17MW03071702 07/17/02	IS17MW030205 02/03/05
Chemical Name												
Trichlorofluoromethane(Freon-11)	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Vinyl chloride	40 J	40 J	2.3	2 J	92	70	3,000	140	1,700	10 U	0.5 U	10 U
Xylene, total	100 U	100 U	1 J	0.22 J	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
cis-1,2-Dichloroethene	37 J	37 J	4.9	4.8	100	75	4,200	64	5,500	10 U	0.5 U	10 U
cis-1,3-Dichloropropene	100 U	100 U	0.5 U	0.12 B	10 U	10 U	290 U	17 U	10 U	10 U	0.11 B	10 U
m- and p-Xylene	NA	NA	NA	NA	10 U	10 U	NA	NA	10 U	NA	NA	10 U
o-Xylene	NA	NA	NA	NA	10 U	10 U	NA	NA	10 U	NA	NA	10 U
trans-1,2-Dichloroethene	100 U	100 U	0.15 J	0.13 J	10 U	10 U	290 U	17 U	29	10 U	0.5 U	10 U
trans-1,3-Dichloropropene	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Semi-volatile Organic Compounds (UG/L)												
1,1-Biphenyl	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
2,4,5-Trichlorophenol	250 U	250 U	NA	NA	NA	NA	25 U	NA	NA	25 U	NA	NA
2,4,6-Trichlorophenol	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
2,4-Dichlorophenol	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
2,4-Dimethylphenol	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
2,4-Dinitrophenol	250 U	250 U	NA	NA	NA	NA	25 U	NA	NA	25 U	NA	NA
2-Chloronaphthalene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
2-Chlorophenol	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
2-Methylnaphthalene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
2-Methylphenol	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
2-Nitroaniline	250 U	250 U	NA	NA	NA	NA	25 U	NA	NA	25 U	NA	NA
2-Nitrophenol	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
3,3'-Dichlorobenzidine	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
3-Nitroaniline	250 U	250 U	NA	NA	NA	NA	25 U	NA	NA	25 U	NA	NA
4,6-Dinitro-2-methylphenol	250 U	250 U	NA	NA	NA	NA	25 U	NA	NA	25 U	NA	NA
4-Bromophenyl-phenylether	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
4-Chloro-3-methylphenol	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
4-Chloroaniline	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
4-Chlorophenyl-phenylether	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
4-Methylphenol	62 J	42 J	NA	NA	NA	NA	4 J	NA	NA	10 U	NA	NA
4-Nitroaniline	250 U	250 U	NA	NA	NA	NA	25 U	NA	NA	25 U	NA	NA
4-Nitrophenol	250 U	250 U	NA	NA	NA	NA	25 U	NA	NA	25 U	NA	NA
Acenaphthene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Acenaphthylene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Acetophenone	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Anthracene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Atrazine	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Benzaldehyde	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Benzo(a)anthracene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Benzo(a)pyrene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Benzo(b)fluoranthene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Benzo(g,h,i)perylene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Benzo(k)fluoranthene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Butylbenzylphthalate	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Caprolactam	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Carbazole	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Chrysene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Di-n-butylphthalate	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA

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Station ID Sample ID Sample Date	IS17MW01						IS17MW02			IS17MW03		
	IS17MW011000P 10/24/00	IS17MW011000 10/24/00	IS17MW01071702 07/17/02	IS17MW01071702P 07/17/02	IS17MW010205 02/03/05	IS17MW01P0205 02/03/05	IS17MW021000 10/24/00	IS17MW02071702 07/17/02	IS17MW020205 02/03/05	IS17MW031000 10/20/00	IS17MW03071702 07/17/02	IS17MW030205 02/03/05
Chemical Name												
Di-n-octylphthalate	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Dibenz(a,h)anthracene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Dibenzofuran	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Diethylphthalate	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Dimethyl phthalate	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Fluoranthene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Fluorene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Hexachlorobenzene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Hexachlorobutadiene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Hexachlorocyclopentadiene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Hexachloroethane	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Indeno(1,2,3-cd)pyrene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Isophorone	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Naphthalene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Pentachlorophenol	250 U	250 U	NA	NA	NA	NA	25 U	NA	NA	25 U	NA	NA
Phenanthrene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Phenol	19 J	13 J	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Pyrene	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
bis(2-Chloro-1-methylethyl) ether	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
bis(2-Chloroethoxy)methane	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
bis(2-Chloroethyl)ether	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
bis(2-Ethylhexyl)phthalate	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
n-Nitroso-di-n-propylamine	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
n-Nitrosodiphenylamine	100 U	100 U	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Explosives (UG/L)												
1,3,5-Trinitrobenzene	6 U	4 J	NA	NA	NA	NA	0.2 U	NA	NA	0.2 U	NA	NA
1,3-Dinitrobenzene	1.4 J	6 U	NA	NA	NA	NA	0.2 U	NA	NA	0.2 U	NA	NA
2,4,6-Trinitrotoluene	5.8 J	4.4 J	NA	NA	NA	NA	0.2 U	NA	NA	1	NA	NA
2,4-Dinitrotoluene	1.8 J	6 U	NA	NA	NA	NA	0.28	NA	NA	1.2	NA	NA
2,6-Dinitrotoluene	6 U	6 U	NA	NA	NA	NA	0.14 J	NA	NA	0.12 J	NA	NA
2-Amino-4,6-dinitrotoluene	6 U	6 U	NA	NA	NA	NA	0.2	NA	NA	0.2 U	NA	NA
2-Nitrotoluene	6 U	6 U	NA	NA	NA	NA	0.53 U	NA	NA	0.32 U	NA	NA
3-Nitrotoluene	6 U	6 U	NA	NA	NA	NA	0.78 U	NA	NA	0.18 J	NA	NA
4-Amino-2,6-dinitrotoluene	6 U	6 U	NA	NA	NA	NA	0.2 U	NA	NA	0.39	NA	NA
4-Nitrotoluene	6.9 U	2.8 J	NA	NA	NA	NA	0.59 U	NA	NA	0.37 U	NA	NA
HMX	15 U	15 U	NA	NA	NA	NA	0.5 U	NA	NA	0.5 U	NA	NA
Nitrobenzene	6 U	6 U	NA	NA	NA	NA	0.098 J	NA	NA	0.2 U	NA	NA
Nitroglycerin	30 U	30 U	NA	NA	NA	NA	30 U	NA	NA	30 U	NA	NA
Nitroguanidine	20 U	20 U	NA	NA	NA	NA	20 U	NA	NA	20 U	NA	NA
PETN	75 U	75 U	NA	NA	NA	NA	2.5 U	NA	NA	2.5 U	NA	NA
Perchlorate	20 U	20 U	4 U	4 U	NA	NA	4 U	4 U	NA	4 U	4 U	NA
RDX	15 U	3.3 J	NA	NA	NA	NA	0.5 U	NA	NA	0.5 U	NA	NA
Tetryl	5 J	5.9 J	NA	NA	NA	NA	0.12 J	NA	NA	0.2 U	NA	NA
Total Metals (UG/L)												
Aluminum	3,630	2,520	NA	NA	NA	NA	420	NA	NA	31,500	NA	NA
Antimony	3.1 U	3.6 J	NA	NA	NA	NA	3.1 U	NA	NA	3.1 U	NA	NA
Arsenic	3.2 U	3.2 U	NA	NA	NA	NA	3.2 U	NA	NA	4 J	NA	NA

Table D-1
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Station ID Sample ID Sample Date	IS17MW01						IS17MW02			IS17MW03		
	IS17MW011000P 10/24/00	IS17MW011000 10/24/00	IS17MW01071702 07/17/02	IS17MW01071702P 07/17/02	IS17MW010205 02/03/05	IS17MW01P0205 02/03/05	IS17MW021000 10/24/00	IS17MW02071702 07/17/02	IS17MW020205 02/03/05	IS17MW031000 10/20/00	IS17MW03071702 07/17/02	IS17MW030205 02/03/05
Chemical Name												
Barium	93.5 J	83.7 J	NA	NA	NA	NA	138 J	NA	NA	202	NA	NA
Beryllium	0.26 B	0.17 B	NA	NA	NA	NA	0.18 J	NA	NA	0.99 B	NA	NA
Cadmium	0.35 B	0.3 J	NA	NA	NA	NA	0.54 B	NA	NA	0.3 B	NA	NA
Calcium	23,800	22,900	NA	NA	NA	NA	37,800	NA	NA	5,440	NA	NA
Chromium	42.3	22.7	NA	NA	NA	NA	5.8 J	NA	NA	86.9	NA	NA
Cobalt	4 J	3.1 J	NA	NA	NA	NA	2.6 J	NA	NA	32.7 J	NA	NA
Copper	5.7 J	4.1 J	NA	NA	NA	NA	6.3 J	NA	NA	39.7	NA	NA
Cyanide	10 U	0.1 J	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Iron	27,100	24,600	NA	NA	34,100	33,600	71,000	NA	46,300	31,400	NA	2,470
Lead	4.9	3.1	NA	NA	NA	NA	1.9 U	NA	NA	13.9	NA	NA
Magnesium	11,600	11,000	NA	NA	NA	NA	15,700	NA	NA	5,330	NA	NA
Manganese	1,210	1,120	NA	NA	1,660	1,590	2,620	NA	1,930	540	NA	410
Mercury	0.1 U	0.1 U	NA	NA	NA	NA	0.1 U	NA	NA	0.1 U	NA	NA
Nickel	31 J	20.4 J	NA	NA	NA	NA	7 J	NA	NA	73.4	NA	NA
Potassium	5,440	5,110	NA	NA	NA	NA	7,720	NA	NA	3,350 J	NA	NA
Selenium	4.3 J	4 U	NA	NA	NA	NA	4 U	NA	NA	4 U	NA	NA
Silver	1.1 U	1.1 U	NA	NA	NA	NA	1.1 U	NA	NA	1.1 U	NA	NA
Sodium	46,400	44,600	NA	NA	NA	NA	41,100	NA	NA	26,800	NA	NA
Thallium	6.8 U	6.8 U	NA	NA	NA	NA	6.8 U	NA	NA	6.8 U	NA	NA
Vanadium	9.4 J	6.6 J	NA	NA	NA	NA	1.4 J	NA	NA	49 J	NA	NA
Zinc	22.6 B	19.2 B	NA	NA	NA	NA	15.7 B	NA	NA	128	NA	NA
Dissolved Metals (UG/L)												
Aluminum	105 B	95.2 B	NA	NA	NA	NA	108 J	NA	NA	90.4 J	NA	NA
Antimony	3.1 U	3.1 U	NA	NA	NA	NA	3.3 J	NA	NA	3.1 U	NA	NA
Arsenic	3.2 U	3.2 U	NA	NA	NA	NA	3.2 U	NA	NA	3.2 U	NA	NA
Barium	82.1 J	77.3 J	NA	NA	NA	NA	152 J	NA	NA	33.2 J	NA	NA
Beryllium	0.18 B	0.08 U	NA	NA	NA	NA	0.33 B	NA	NA	0.12 B	NA	NA
Cadmium	0.41 B	0.25 U	NA	NA	NA	NA	0.48 B	NA	NA	0.25 U	NA	NA
Calcium	26,900	25,300	NA	NA	NA	NA	42,000	NA	NA	3,440 J	NA	NA
Chromium	5.5 J	12.3	NA	NA	NA	NA	1.8 J	NA	NA	1.1 U	NA	NA
Cobalt	2.1 J	6.8 J	NA	NA	NA	NA	2.4 J	NA	NA	14.5 J	NA	NA
Copper	1.3 U	3 J	NA	NA	NA	NA	1.7 J	NA	NA	1.4 J	NA	NA
Iron	25,000	23,800	NA	NA	NA	NA	77,200	NA	NA	97.3 B	NA	NA
Lead	1.9 U	1.9 U	NA	NA	NA	NA	1.9 U	NA	NA	1.9 U	NA	NA
Magnesium	12,900	12,000	NA	NA	NA	NA	17,500	NA	NA	2,060 J	NA	NA
Manganese	1,310	1,230	NA	NA	NA	NA	2,890	NA	NA	339	NA	NA
Mercury	0.1 U	0.1 U	NA	NA	NA	NA	0.1 U	NA	NA	0.1 U	NA	NA
Nickel	3.4 J	7 J	NA	NA	NA	NA	4.8 J	NA	NA	16.3 J	NA	NA
Potassium	5,750	5,470	NA	NA	NA	NA	8,490	NA	NA	495 B	NA	NA
Selenium	4 U	4 U	NA	NA	NA	NA	4 U	NA	NA	4 U	NA	NA
Silver	1.1 U	1.1 U	NA	NA	NA	NA	1.1 U	NA	NA	1.1 U	NA	NA
Sodium	53,200	50,100	NA	NA	NA	NA	46,300	NA	NA	31,400	NA	NA
Thallium	6.8 U	6.8 U	NA	NA	NA	NA	6.8 U	NA	NA	6.8 U	NA	NA
Vanadium	1.3 J	0.79 J	NA	NA	NA	NA	0.96 J	NA	NA	0.76 U	NA	NA
Zinc	7 B	9.8 B	NA	NA	NA	NA	10 B	NA	NA	17.8 B	NA	NA

Table D-1
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 NSF-IH, Indian Head, Maryland

Station ID Sample ID Sample Date	IS17MW01						IS17MW02			IS17MW03		
	IS17MW011000P 10/24/00	IS17MW011000 10/24/00	IS17MW01071702 07/17/02	IS17MW01071702P 07/17/02	IS17MW010205 02/03/05	IS17MW01P0205 02/03/05	IS17MW021000 10/24/00	IS17MW02071702 07/17/02	IS17MW020205 02/03/05	IS17MW031000 10/20/00	IS17MW03071702 07/17/02	IS17MW030205 02/03/05
Chemical Name												
Wet Chemistry (MG/L)												
Carbon	NA	NA	22.7	28	NA	NA	NA	9.13	NA	NA	5 U	NA
Chloride	NA	NA	251	214	44	NA	NA	70.4	41	NA	9.98	8.5
Dissolved organic carbon	NA	NA	NA	NA	15	NA	NA	NA	11	NA	NA	12
Nitrate	NA	NA	0.05 U	0.05 U	0.05 U	NA	NA	0.05 U	0.05 U	NA	0.05 U	0.013 J
Nitrite	NA	NA	NA	NA	0.019 J	NA	NA	NA	0.018 J	NA	NA	0.026 J
Sulfate	NA	NA	5 U	5 U	5.6	NA	NA	16.3	6.5	NA	37.8	34

Notes

Shaded cell indicates constituent is detected.

Monitoring well screened intervals for IS17MW01, IS17MW02, and IS17MW03 are 5-10 feet bgs, 5-10, feet bgs, and 11-16 feet bgs, respectively.

µg/L - micrograms per liter

mg/L - milligrams per liter

NA - Not analyzed

B - Value may be due to laboratory or field blank contamination

J - Value is estimated below the reporting limit but above the method detection limit

U - Not detected above associated value

UJ - Not detected above associated value,value is estimated

Table D-2
 Detections and Screening Criterion Exceedance for Monitoring Well Groundwater Samples
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	RBC-Tap Water Adjusted	IS17MW01						IS17MW02			IS17MW03		
		IS17MW011000P	IS17MW011000	IS17MW01071702	IS17MW01071702P	IS17MW010205	IS17MW01P0205	IS17MW021000	IS17MW02071702	IS17MW020205	IS17MW031000	IS17MW03071702	IS17MW030205
Sample ID		10/24/00	10/24/00	07/17/02	07/17/02	02/03/05	02/03/05	10/24/00	07/17/02	02/03/05	10/20/00	07/17/02	02/03/05
Sample Date													
Chemical Name													
Volatile Organic Compounds (UG/L)													
1,1-Dichloroethane	80	100 U	100 U	0.23 U	0.22 J	10 U	10 U	290 U	6 J	9 J	10 U	0.5 U	10 U
1,1-Dichloroethene	35	100 U	100 U	0.5 U	0.12 J	10 U	10 U	290 U	17 U	41	10 U	0.5 U	10 U
1,2-Dichloroethene (total)	5.5	NA	NA	NA	NA	100	75	NA	NA	5,500	NA	NA	10 U
Benzene	0.34	100 U	100 U	0.5 U	0.18 J	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Chloroethane	3.6	100 U	100 U	0.5 U	0.5 U	10 U	10 U	290 U	2 J	10 U	10 U	0.5 U	10 U
Chloromethane	19	100 U	100 U	0.5 U	0.18 J	10 U	10 U	290 U	17 U	10 U	10 U	0.12 J	10 U
Ethane	--	NA	NA	2 U	3 J	NA	NA	NA	16 J	NA	NA	2 U	NA
Ethene	--	NA	NA	2 U	75 U	NA	NA	NA	11 J	NA	NA	2 U	NA
Ethylbenzene	130	47 J	50 J	89	89	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Methane	--	NA	NA	1	540	NA	NA	NA	120	NA	NA	0.3 J	NA
Methyl-tert-butyl ether (MTBE)	2.6	100 U	100 U	0.64	0.73	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Styrene	160	100 U	100 U	0.7	0.5 U	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
Toluene	75	200	200	37	43	10 U	10 U	290 U	3 B	2 J	10 U	0.33 B	10 U
Trichloroethene	0.026	100 U	100 U	0.2 J	0.24 J	10 U	10 U	290 U	17 U	10 U	10 U	0.43 J	10 U
Vinyl chloride	0.015	40 J	40 J	2.3	2 J	92	70	3,000	140	1,700	10 U	0.5 U	10 U
Xylene, total	21	100 U	100 U	1 J	0.22 J	10 U	10 U	290 U	17 U	10 U	10 U	0.5 U	10 U
cis-1,2-Dichloroethene	6.1	37 J	37 J	4.9	4.8	100	75	4,200	64	5,500	10 U	0.5 U	10 U
trans-1,2-Dichloroethene	12	100 U	100 U	0.15 J	0.13 J	10 U	10 U	290 U	17 U	29	10 U	0.5 U	10 U
Semi-volatile Organic Compounds (UG/L)													
4-Methylphenol	18	62 J	42 J	NA	NA	NA	NA	4 J	NA	NA	10 U	NA	NA
Phenol	1,100	19 J	13 J	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Explosives (UG/L)													
1,3,5-Trinitrobenzene	110	6 U	4 J	NA	NA	NA	NA	0.2 U	NA	NA	0.2 U	NA	NA
1,3-Dinitrobenzene	0.37	1.4 J	6 U	NA	NA	NA	NA	0.2 U	NA	NA	0.2 U	NA	NA
2,4,6-Trinitrotoluene	1.8	5.8 J	4.4 J	NA	NA	NA	NA	0.2 U	NA	NA	1	NA	NA
2,4-Dinitrotoluene	7.3	1.8 J	6 U	NA	NA	NA	NA	0.28	NA	NA	1.2	NA	NA
2,6-Dinitrotoluene	3.7	6 U	6 U	NA	NA	NA	NA	0.14 J	NA	NA	0.12 J	NA	NA
2-Amino-4,6-dinitrotoluene	--	6 U	6 U	NA	NA	NA	NA	0.2	NA	NA	0.2 U	NA	NA
3-Nitrotoluene	12	6 U	6 U	NA	NA	NA	NA	0.78 U	NA	NA	0.18 J	NA	NA
4-Amino-2,6-dinitrotoluene	--	6 U	6 U	NA	NA	NA	NA	0.2 U	NA	NA	0.39	NA	NA
4-Nitrotoluene	0.62	6.9 U	2.8 J	NA	NA	NA	NA	0.59 U	NA	NA	0.37 U	NA	NA
Nitrobenzene	0.35	6 U	6 U	NA	NA	NA	NA	0.098 J	NA	NA	0.2 U	NA	NA
RDX	0.61	15 U	3.3 J	NA	NA	NA	NA	0.5 U	NA	NA	0.5 U	NA	NA
Tetryl	37	5 J	5.9 J	NA	NA	NA	NA	0.12 J	NA	NA	0.2 U	NA	NA
Total Metals (UG/L)													
Aluminum	3,700	3,630	2,520	NA	NA	NA	NA	420	NA	NA	31,500	NA	NA
Antimony	1.5	3.1 U	3.6 J	NA	NA	NA	NA	3.1 U	NA	NA	3.1 U	NA	NA
Arsenic	0.045	3.2 U	3.2 U	NA	NA	NA	NA	3.2 U	NA	NA	4 J	NA	NA
Barium	260	93.5 J	83.7 J	NA	NA	NA	NA	138 J	NA	NA	202	NA	NA
Beryllium	7.3	0.26 B	0.17 B	NA	NA	NA	NA	0.18 J	NA	NA	0.99 B	NA	NA
Cadmium	1.8	0.35 B	0.3 J	NA	NA	NA	NA	0.54 B	NA	NA	0.3 B	NA	NA
Calcium	--	23,800	22,900	NA	NA	NA	NA	37,800	NA	NA	5,440	NA	NA
Chromium	11	42.3	22.7	NA	NA	NA	NA	5.8 J	NA	NA	86.9	NA	NA
Cobalt	73	4 J	3.1 J	NA	NA	NA	NA	2.6 J	NA	NA	32.7 J	NA	NA

Table D-2
 Detections and Screening Criterion Exceedance for Monitoring Well Groundwater Samples
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	RBC-Tap Water Adjusted	IS17MW01						IS17MW02			IS17MW03		
		IS17MW011000P	IS17MW011000	IS17MW01071702	IS17MW01071702P	IS17MW010205	IS17MW01P0205	IS17MW021000	IS17MW02071702	IS17MW020205	IS17MW031000	IS17MW03071702	IS17MW030205
Sample ID		10/24/00	10/24/00	07/17/02	07/17/02	02/03/05	02/03/05	10/24/00	07/17/02	02/03/05	10/20/00	07/17/02	02/03/05
Sample Date													
Chemical Name													
Copper	150	5.7 J	4.1 J	NA	NA	NA	NA	6.3 J	NA	NA	39.7	NA	NA
Cyanide	73	10 U	0.1 J	NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA
Iron	1,100	27,100	24,600	NA	NA	34,100	33,600	71,000	NA	46,300	31,400	NA	2,470
Lead	15	4.9	3.1	NA	NA	NA	NA	1.9 U	NA	NA	13.9	NA	NA
Magnesium	--	11,600	11,000	NA	NA	NA	NA	15,700	NA	NA	5,330	NA	NA
Manganese	73	1,210	1,120	NA	NA	1,660	1,590	2,620	NA	1,930	540	NA	410
Nickel	73	31 J	20.4 J	NA	NA	NA	NA	7 J	NA	NA	73.4	NA	NA
Potassium	--	5,440	5,110	NA	NA	NA	NA	7,720	NA	NA	3,350 J	NA	NA
Selenium	18	4.3 J	4 U	NA	NA	NA	NA	4 U	NA	NA	4 U	NA	NA
Sodium	--	46,400	44,600	NA	NA	NA	NA	41,100	NA	NA	26,800	NA	NA
Vanadium	3.7	9.4 J	6.6 J	NA	NA	NA	NA	1.4 J	NA	NA	49 J	NA	NA
Zinc	1,100	22.6 B	19.2 B	NA	NA	NA	NA	15.7 B	NA	NA	128	NA	NA
Dissolved Metals (UG/L)													
Aluminum	3,700	105 B	95.2 B	NA	NA	NA	NA	108 J	NA	NA	90.4 J	NA	NA
Antimony	1.5	3.1 U	3.1 U	NA	NA	NA	NA	3.3 J	NA	NA	3.1 U	NA	NA
Barium	260	82.1 J	77.3 J	NA	NA	NA	NA	152 J	NA	NA	33.2 J	NA	NA
Calcium	--	26,900	25,300	NA	NA	NA	NA	42,000	NA	NA	3,440 J	NA	NA
Chromium	11	5.5 J	12.3	NA	NA	NA	NA	1.8 J	NA	NA	1.1 U	NA	NA
Cobalt	73	2.1 J	6.8 J	NA	NA	NA	NA	2.4 J	NA	NA	14.5 J	NA	NA
Copper	150	1.3 U	3 J	NA	NA	NA	NA	1.7 J	NA	NA	1.4 J	NA	NA
Iron	1,100	25,000	23,800	NA	NA	NA	NA	77,200	NA	NA	97.3 B	NA	NA
Magnesium	--	12,900	12,000	NA	NA	NA	NA	17,500	NA	NA	2,060 J	NA	NA
Manganese	73	1,310	1,230	NA	NA	NA	NA	2,890	NA	NA	339	NA	NA
Nickel	73	3.4 J	7 J	NA	NA	NA	NA	4.8 J	NA	NA	16.3 J	NA	NA
Potassium	--	5,750	5,470	NA	NA	NA	NA	8,490	NA	NA	495 B	NA	NA
Sodium	--	53,200	50,100	NA	NA	NA	NA	46,300	NA	NA	31,400	NA	NA
Vanadium	3.7	1.3 J	0.79 J	NA	NA	NA	NA	0.96 J	NA	NA	0.76 U	NA	NA
Wet Chemistry (MG/L)													
Carbon	--	NA	NA	22.7	28	NA	NA	NA	9.13	NA	NA	5 U	NA
Chloride	--	NA	NA	251	214	44	NA	NA	70.4	41	NA	9.98	8.5
Dissolved organic carbon	--	NA	NA	NA	NA	15	NA	NA	NA	11	NA	NA	12
Nitrate	10	NA	NA	0.05 U	0.05 U	0.05 U	NA	NA	0.05 U	0.05 U	NA	0.05 U	0.013 J
Nitrite	1	NA	NA	NA	NA	0.019 J	NA	NA	NA	0.018 J	NA	NA	0.026 J
Sulfate	--	NA	NA	5 U	5 U	5.6	NA	NA	16.3	6.5	NA	37.8	34

Notes

Shaded cell indicates that constituent exceeds the screening criterion.

Monitoring well screened intervals for IS17MW01, IS17MW02, and IS17MW03 are 5-10 feet bgs, 5-10, feet bgs, and 11-16 feet bgs, respectively.

µg/L - micrograms per liter

mg/L - milligrams per liter

NA - Not analyzed

B - Value may be due to laboratory or field blank contamination

J - Value is estimated below the reporting limit but above the method detection limit

U - Not detected above associated value

UJ - Not detected above associated value,value is estimated

Table D-3
Analytical Results for Direct-Push Technology Groundwater Samples
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS17DP21	IS17DP22		IS17DP23		IS17DP24		IS17DP25	IS17DP26		IS17DP27	
Sample ID	IS17GW21-0507	IS17GW22-0607	IS17GW22-0911	IS17GW23-0608	IS17GW23-0911	IS17GW24-0812	IS17GW24-1418	IS17GW25-0406	IS17GW26-0507	IS17GW26-0911	IS17GW27-0406	IS17GW27-0810
Sample Date	02/24/05	02/23/05	02/23/05	02/23/05	02/23/05	02/22/05	02/22/05	02/24/05	02/23/05	02/23/05	02/23/05	02/23/05
Sample Depth (feet)	5 - 7	6 - 7	9 - 11	6 - 8	9 - 11	8 - 12	12 - 18	4 - 6	5 - 7	9 - 11	4 - 6	8 - 10
Shallow/Deep Designation	Shallow	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Shallow	Deep	Shallow	Deep
Volatile Organic Compounds (µg/L)												
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	1 UJ	5,000 U	10,000 U									
1,1,1-Trichloroethane	1 UJ	1 UJ	1 J	1 J	2 J	1 UJ	1 UJ	1 UJ	1 UJ	1 J	5,000 U	10,000 U
1,1,2,2-Tetrachloroethane	1 UJ	5,000 U	10,000 U									
1,1,2-Trichloroethane	1 UJ	5,000 U	10,000 U									
1,1-Dichloroethane	1 UJ	1 UJ	2 J	2 J	3 J	1 UJ	1 UJ	1 UJ	5 J	4 J	550 J	10,000 U
1,1-Dichloroethene	2 J	1 J	3 J	5 J	11 J	1 UJ	1 UJ	1 UJ	3 J	4 J	1900 J	1900 J
1,2,4-Trichlorobenzene	1 UJ	5,000 U	10,000 U									
1,2-Dibromoethane	1 UJ	5,000 U	10,000 U									
1,2-Dichlorobenzene	1 UJ	5,000 U	10,000 U									
1,2-Dichloroethane	1 UJ	5,000 U	10,000 U									
1,2-Dichloroethene (total)	1,300 R	210	69	710	650	1 UJ	2 J	120	180 J	170	170000	73000
1,2-Dichloropropane	1 UJ	5,000 U	10,000 U									
1,3-Dichlorobenzene	1 UJ	5,000 U	10,000 U									
1,4-Dichlorobenzene	1 UJ	5,000 U	10,000 U									
2-Butanone	1 UJ	1 UJ	1 UJ	1 J	1 J	5 J	1 UJ	1 UJ	1 UJ	1 UJ	5,000 U	10,000 U
2-Hexanone	1 UJ	5,000 U	10,000 U									
4-Methyl-2-pentanone	1 UJ	5,000 U	10,000 U									
Acetone	1 UJ	6 J	1 UJ	4 J	4 J	18	4 J	1 UJ	5 J	1 J	5,000 U	10,000 U
Benzene	1 UJ	5,000 U	10,000 U									
Bromodichloromethane	1 UJ	5,000 U	10,000 U									
Bromoform	1 UJ	5,000 U	10,000 U									
Bromomethane	1 UJ	5,000 U	10,000 U									
Carbon disulfide	1 UJ	2 J	1 UJ	5,000 U	10,000 U							
Carbon tetrachloride	1 UJ	5,000 U	10,000 U									
Chlorobenzene	1 UJ	5,000 U	10,000 U									
Chloroethane	1 UJ	5,000 U	10,000 U									
Chloroform	1 UJ	5,000 U	10,000 U									
Chloromethane	1 UJ	5,000 U	10,000 U									
cis-1,2-Dichloroethylene	1,300 R	210	69	710	650	1 UJ	2 J	120	180 J	170	170000	73000
cis-1,3-Dichloropropene	1 UJ	5,000 U	10,000 U									
Cumene	1 UJ	5,000 U	10,000 U									
Cyclohexane	1 UJ	5,000 U	10,000 U									
Dibromochloromethane	1 UJ	5,000 U	10,000 U									
Dichlorodifluoromethane (Freon-12)	1 UJ	5,000 U	10,000 U									
Ethylbenzene	1 UJ	5,000 U	10,000 U									
m- and p-Xylene	1 UJ	1 J	5,000 U	10,000 U								
Methyl acetate	1 UJ	5,000 U	10,000 U									
Methylcyclohexane	1 UJ	5,000 U	10,000 U									
Methylene chloride	1 UJ	11 J	5,000 U	10,000 U								

Table D-3
Analytical Results for Direct-Push Technology Groundwater Samples
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS17DP21	IS17DP22		IS17DP23		IS17DP24		IS17DP25	IS17DP26		IS17DP27	
Sample ID	IS17GW21-0507	IS17GW22-0607	IS17GW22-0911	IS17GW23-0608	IS17GW23-0911	IS17GW24-0812	IS17GW24-1418	IS17GW25-0406	IS17GW26-0507	IS17GW26-0911	IS17GW27-0406	IS17GW27-0810
Sample Date	02/24/05	02/23/05	02/23/05	02/23/05	02/23/05	02/22/05	02/22/05	02/24/05	02/23/05	02/23/05	02/23/05	02/23/05
Sample Depth (feet)	5 - 7	6 - 7	9 - 11	6 - 8	9 - 11	8 - 12	12 - 18	4 - 6	5 - 7	9 - 11	4 - 6	8 - 10
Shallow/Deep Designation	Shallow	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Shallow	Deep	Shallow	Deep
Methyl-tert-butyl ether (MTBE)	1 UJ	5,000 U	10,000 U									
o-Xylene	1 UJ	5,000 U	10,000 U									
Styrene	1 UJ	5,000 U	10,000 U									
Tetrachloroethylene	1 UJ	1 UJ	1 UJ	2 J	1 J	1 UJ	5,000 U	10,000 U				
Toluene	1 J	2 J	1 UJ	6 J	4 J	2 J	1 UJ	3 J	2 J	3 J	1000 J	10,000 U
trans-1,2-Dichloroethylene	3 J	3 J	1 UJ	3 J	4 J	1 UJ	1 UJ	1 UJ	1 UJ	1 J	610 J	10,000 U
trans-1,3-Dichloropropene	1 UJ	5,000 U	10,000 U									
Trichloroethylene	12	1000	340	3800	2800	1 UJ	12	2 B	320	720	490000	870000
Trichlorofluoromethane(Freon-11)	1 UJ	5,000 U	10,000 U									
Vinyl chloride	710 R	7 J	2 J	47 J	140 J	1 UJ	1 UJ	64	47 J	3 J	14000	10,000 U
Xylene, total	1 UJ	1 J	5,000 U	10,000 U								
Wet Chemistry (mg/L)												
Dissolved organic carbon	NA											

Notes
Shaded cell indicates constituent is detected.
Monitoring well screened intervals for IS17MW01, IS17MW02, and IS17MW03 are 5-10 feet bgs, 5-10, feet bgs, and 11-16 feet bgs, respectively.
µg/L - micrograms per liter
mg/L - milligrams per liter
NA - Not analyzed
B - Value may be due to laboratory or field blank contamination
J - Value is estimated below the reporting limit but above the method detection limit
U - Not detected above associated value
UJ - Not detected above associated value,value is estimated

Table D-3
Analytical Results for Direct-Push Technology Groundwater Samples
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS17DP28		IS17DP29	IS17DP31	IS17DP32		IS17DP33		IS17DP34		IS17DP35	IS17DP36	IS17DP37	
Sample ID	IS17GW28-0610	IS17GW28-1418	IS17GW29-0406	IS17GW31-0204	IS17GW32-0406	IS17GW32-1112	IS17GW33-0406	IS17GW33-0810	IS17GW34-0406	IS17GW34-0810	IS17GW35-0405	IS17GW36-0507	IS17GW37-0406	IS17GW37-10
Sample Date	02/22/05	02/22/05	02/28/05	03/01/05	03/02/05	03/02/05	02/24/05	02/24/05	02/23/05	02/23/05	03/02/05	02/28/05	03/02/05	03/02/05
Sample Depth (feet)	6 - 10	14 - 18	4 - 6	2 - 4	4 - 6	11 - 12	4 - 6	8 - 10	4 - 6	8 - 10	4 - 5	5 - 7	Shallow	10 - 12
Shallow/Deep Designation	Shallow	Deep	Shallow	Shallow	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Shallow	Shallow	Deep
Volatile Organic Compounds (µg/L)														
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
1,1,1-Trichloroethane	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
1,1,2,2-Tetrachloroethane	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
1,1,2-Trichloroethane	4 J	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
1,1-Dichloroethane	1 UJ	500 U	1 UJ	1 UJ	1 UJ	1 UJ	24	34	3 J	160 J	1 UJ	1 UJ	1 UJ	1
1,1-Dichloroethene	27	500 U	1 UJ	1 UJ	1 UJ	1 UJ	4 J	21	1 UJ	240 J	1 UJ	36	1 UJ	1
1,2,4-Trichlorobenzene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
1,2-Dibromoethane	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
1,2-Dichlorobenzene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
1,2-Dichloroethane	1 UJ	500 U	1 UJ	1 UJ	1 UJ	1 UJ	1 J	2 J	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1
1,2-Dichloroethene (total)	2400	4400	120	12	170	2 J	880	1,500 R	390	220000	22	16000	5 J	1
1,2-Dichloropropane	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
1,3-Dichlorobenzene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
1,4-Dichlorobenzene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
2-Butanone	3 J	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
2-Hexanone	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1,000 R	1 UJ	1						
4-Methyl-2-pentanone	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Acetone	12	500 U	1 UJ	3 J	1 UJ	1 UJ	1 UJ	1 UJ	3 J	1,000 U	1 UJ	1 UJ	1 UJ	2
Benzene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Bromodichloromethane	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Bromoform	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Bromomethane	1 UJ	500 U	1 UJ	1,000 U	1 UJ	10 U	1 UJ	1						
Carbon disulfide	2 J	500 U	1 UJ	1 J	1,000 U	1 UJ	1 J	1 UJ	1					
Carbon tetrachloride	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Chlorobenzene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Chloroethane	1 UJ	500 U	1 UJ	1 UJ	1 UJ	1 UJ	9 J	9 J	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	15
Chloroform	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Chloromethane	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
cis-1,2-Dichloroethylene	2400	4300	120	12	170	2 J	880	1,500 R	330	220000	22	16000	5 J	1
cis-1,3-Dichloropropene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Cumene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Cyclohexane	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Dibromochloromethane	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Dichlorodifluoromethane (Freon-12)	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Ethylbenzene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
m- and p-Xylene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Methyl acetate	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Methylcyclohexane	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Methylene chloride	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 B	1 UJ	1						

Table D-3
Analytical Results for Direct-Push Technology Groundwater Samples
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS17DP28		IS17DP29	IS17DP31	IS17DP32		IS17DP33		IS17DP34		IS17DP35	IS17DP36	IS17DP37	
Sample ID	IS17GW28-0610	IS17GW28-1418	IS17GW29-0406	IS17GW31-0204	IS17GW32-0406	IS17GW32-1112	IS17GW33-0406	IS17GW33-0810	IS17GW34-0406	IS17GW34-0810	IS17GW35-0405	IS17GW36-0507	IS17GW37-0406	IS17GW37-10
Sample Date	02/22/05	02/22/05	02/28/05	03/01/05	03/02/05	03/02/05	02/24/05	02/24/05	02/23/05	02/23/05	03/02/05	02/28/05	03/02/05	
Sample Depth (feet)	6 - 10	14 - 18	4 - 6	2 - 4	4 - 6	11 - 12	4 - 6	8 - 10	4 - 6	8 - 10	4 - 5	5 - 7		10 - 12
Shallow/Deep Designation	Shallow	Deep	Shallow	Shallow	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Shallow	Shallow	Deep
Methyl-tert-butyl ether (MTBE)	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
o-Xylene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Styrene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Tetrachloroethylene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Toluene	1 UJ	500 U	1 UJ	1 J	1 UJ	1 UJ	1 UJ	2 J	4 J	1,000 U	1 J	1 J	1 UJ	1
trans-1,2-Dichloroethylene	30	51 J	1 UJ	1 UJ	1 UJ	1 UJ	2 J	6 J	1 J	1200	1 UJ	110	1 UJ	1
trans-1,3-Dichloropropene	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Trichloroethylene	11000	62000	78	4 J	6 J	1 UJ	2 B	3 B	5 B	24000	69	110	2 J	1
Trichlorofluoromethane(Freon-11)	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Vinyl chloride	670	500 U	29	12	100	1 J	380	480 R	920	80000	29	2000	3 J	1
Xylene, total	1 UJ	500 U	1 UJ	1,000 U	1 UJ	1 UJ	1 UJ	1						
Wet Chemistry (mg/L)														
Dissolved organic carbon	NA	NA	NA	NA	6.3	16	NA	NA	NA	NA	18	NA	11	14

Notes
Shaded cell indicates constituent is detected.
Monitoring well screened intervals for IS17MW01, IS17
µg/L - micrograms per liter
mg/L - milligrams per liter
NA - Not analyzed
B - Value may be due to laboratory or field blank conta
J - Value is estimated below the reporting limit but abov
U - Not detected above associated value
UJ - Not detected above associated value,value is estim

Table D-3
Analytical Results for Direct-Push Technology Groundwater Samples
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID		IS17DP38	IS17DP39	IS17DP40		IS17DP41	IS17DP42		IS17DP44	IS17DP45		IS17DP46	IS17DP47	IS17DP48
Sample ID	2	IS17GW38-0407	IS17GW39-0608	IS17GW40-0304	IS17GW40-0607	IS17GW41-0406	IS17GW42-0203	IS17GW42-0607	IS17GW44-0204	IS17GW45-0507	IS17GW45-1214	IS17GW46-0406	IS17GW47-0406	IS17GW48-0406
Sample Date		03/01/05	02/24/05	02/24/05	02/24/05	02/23/05	02/24/05	02/24/05	02/28/05	02/28/05	02/28/05	03/01/05	03/01/05	03/02/05
Sample Depth (feet)		4 - 7	6 - 8	3 - 4	6 - 7	4 - 6	2 - 3	6 - 7	2 - 4	5 - 7	12 - 14	4 - 6	4 - 6	4 - 6
Shallow/Deep Designation		Shallow	Shallow	Shallow	Deep	Shallow	Shallow	Deep	Shallow	Shallow	Deep	Shallow	Shallow	Shallow
Volatile Organic Compounds (µg/L)														
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
1,1,1-Trichloroethane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
1,1,2,2-Tetrachloroethane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
1,1,2-Trichloroethane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
1,1-Dichloroethane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	2 J	1 UJ	4 J	1 UJ	38	27	1 UJ	1 UJ	1 UJ
1,1-Dichloroethene	UJ	2 J	1 UJ	13 J	1 UJ	2 J	1 UJ	10 J	1 UJ	1 UJ				
1,2,4-Trichlorobenzene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
1,2-Dibromoethane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
1,2-Dichlorobenzene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
1,2-Dichloroethane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 J	1 J	1 UJ	1 UJ	1 UJ
1,2-Dichloroethene (total)	UJ	650	7 J	120	28	1 J	12	17000	10	2800	19	7700	12	19
1,2-Dichloropropane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
1,3-Dichlorobenzene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
1,4-Dichlorobenzene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
2-Butanone	UJ	1 UJ	1 UJ	1 UJ	1 UJ	2 J	1 UJ							
2-Hexanone	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
4-Methyl-2-pentanone	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Acetone	J	1 J	1 UJ	1 UJ	2 J	9 J	1 UJ	4 J	2 J	4 J	1 J	1 UJ	3 J	2 J
Benzene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Bromodichloromethane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Bromoform	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Bromomethane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Carbon disulfide	UJ	1 UJ	1 UJ	1 J	1 UJ	1 UJ	1 J	1 UJ						
Carbon tetrachloride	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Chlorobenzene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Chloroethane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	2 J	1 UJ	1 UJ	1 UJ	1 UJ	28	1 UJ	1 UJ	1 UJ
Chloroform	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Chloromethane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
cis-1,2-Dichloroethylene	UJ	650	7 J	120	28	1 J	12	17000	10	2800	19	7700	12	19
cis-1,3-Dichloropropene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Cumene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Cyclohexane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Dibromochloromethane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Dichlorodifluoromethane (Freon-12)	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Ethylbenzene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	2 J	1 UJ	1 UJ	1 UJ
m- and p-Xylene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Methyl acetate	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Methylcyclohexane	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Methylene chloride	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	9 J	1 UJ	1 UJ	1 UJ	2 B	1 UJ	1 UJ

Table D-3
Analytical Results for Direct-Push Technology Groundwater Samples
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID		IS17DP38	IS17DP39	IS17DP40		IS17DP41	IS17DP42		IS17DP44	IS17DP45		IS17DP46	IS17DP47	IS17DP48
Sample ID	2	IS17GW38-0407	IS17GW39-0608	IS17GW40-0304	IS17GW40-0607	IS17GW41-0406	IS17GW42-0203	IS17GW42-0607	IS17GW44-0204	IS17GW45-0507	IS17GW45-1214	IS17GW46-0406	IS17GW47-0406	IS17GW48-0406
Sample Date		03/01/05	02/24/05	02/24/05	02/24/05	02/23/05	02/24/05	02/24/05	02/28/05	02/28/05	02/28/05	03/01/05	03/01/05	03/02/05
Sample Depth (feet)		4 - 7	6 - 8	3 - 4	6 - 7	4 - 6	2 - 3	6 - 7	2 - 4	5 - 7	12 - 14	4 - 6	4 - 6	4 - 6
Shallow/Deep Designation		Shallow	Shallow	Shallow	Deep	Shallow	Shallow	Deep	Shallow	Shallow	Deep	Shallow	Shallow	Shallow
Methyl-tert-butyl ether (MTBE)	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
o-Xylene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Styrene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Tetrachloroethylene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Toluene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
trans-1,2-Dichloroethylene	UJ	2 J	1 UJ	200 J	1 UJ	11	1 UJ	68	1 UJ	1 UJ				
trans-1,3-Dichloropropene	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Trichloroethylene	UJ	4 B	8 J	4 B	3 B	1 UJ	1 UJ	4 J	4 B	13	4 J	19	3 B	8 J
Trichlorofluoromethane(Freon-11)	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Vinyl chloride	UJ	390	3 J	160	100	1 UJ	13	54000	4 J	5100	37	2400	3 J	2 J
Xylene, total	UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Wet Chemistry (mg/L)														
Dissolved organic carbon		NA	NA	10	15	NA	13	13	NA	NA	NA	NA	NA	14

Notes

Shaded cell indicates constituent is detected.

Monitoring well screened intervals for IS17MW01, IS17

µg/L - micrograms per liter

mg/L - milligrams per liter

NA - Not analyzed

B - Value may be due to laboratory or field blank conta

J - Value is estimated below the reporting limit but abov

U - Not detected above associated value

UJ - Not detected above associated value,value is estim

Table D-3
Analytical Results for Direct-Push Technology Groundwater Samples
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS17DP49	IS17DP50	IS17DP51	IS17DP52	IS17DP53	IS17DP54		IS17DP55		
Sample ID	IS17GW49-0305	IS17GW50-0406	IS17GW51-1115	IS17GW52-2426	IS17GW53-2123	IS17GW54-1214	IS17GW54-2325	IS17GW55-1214	IS17GW55P-1214 (Duplicate)	IS17GW55-2224
Sample Date	03/01/05	03/01/05	09/07/05	09/07/05	09/06/05	08/31/05	09/01/05	08/31/05	08/31/05	08/31/05
Sample Depth (feet)	3 - 5	4 - 6	11 -15	24 - 26	Deep	12 - 14	23 - 25	12 - 14	12 - 14	22 - 24
Shallow/Deep Designation	Shallow	Shallow	Deep	Deep	21 - 23	Shallow	Deep	Shallow	Shallow	Deep
Volatile Organic Compounds (µg/L)										
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	1 UJ	1 UJ								
1,1,1-Trichloroethane	1 UJ	1 UJ								
1,1,2,2-Tetrachloroethane	1 UJ	1 UJ								
1,1,2-Trichloroethane	1 UJ	1 UJ								
1,1-Dichloroethane	1 UJ	1 UJ	1 UJ	14	3 J	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
1,1-Dichloroethene	1 UJ	1 UJ	1 UJ	18	4 J	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
1,2,4-Trichlorobenzene	1 UJ	1 UJ								
1,2-Dibromoethane	1 UJ	1 UJ								
1,2-Dichlorobenzene	1 UJ	1 UJ								
1,2-Dichloroethane	1 UJ	1 UJ								
1,2-Dichloroethene (total)	97	12	4 J	220	34	1 UJ	1 J	1 UJ	1 UJ	1 UJ
1,2-Dichloropropane	1 UJ	1 UJ								
1,3-Dichlorobenzene	1 UJ	1 UJ								
1,4-Dichlorobenzene	1 UJ	1 UJ								
2-Butanone	1 UJ	3 J	1 UJ	1 UJ	1 UJ	1 UJ				
2-Hexanone	1 UJ	1 UJ								
4-Methyl-2-pentanone	1 UJ	1 UJ								
Acetone	1 UJ	1 UJ	9 B	3 B	5 B	6 B	1 UJ	1 UJ	1 UJ	1 UJ
Benzene	1 UJ	1 UJ								
Bromodichloromethane	1 UJ	1 UJ								
Bromoform	1 UJ	1 UJ								
Bromomethane	1 UJ	1 UJ								
Carbon disulfide	1 UJ	1 UJ								
Carbon tetrachloride	1 UJ	1 UJ								
Chlorobenzene	1 UJ	1 UJ								
Chloroethane	1 UJ	1 UJ								
Chloroform	1 UJ	1 J	1 UJ	1 UJ	1 UJ	1 UJ				
Chloromethane	1 UJ	1 UJ								
cis-1,2-Dichloroethylene	97	12	4 J	210	33	1 UJ	1 J	1 UJ	1 UJ	1 UJ
cis-1,3-Dichloropropene	1 UJ	1 UJ								
Cumene	1 UJ	1 UJ								
Cyclohexane	1 UJ	1 UJ								
Dibromochloromethane	1 UJ	1 UJ								
Dichlorodifluoromethane (Freon-12)	1 UJ	1 UJ								
Ethylbenzene	1 UJ	1 UJ								
m- and p-Xylene	1 UJ	1 UJ								
Methyl acetate	1 UJ	1 UJ								
Methylcyclohexane	1 UJ	1 UJ								
Methylene chloride	1 UJ	1 UJ	1 UJ	1 UJ	2 B	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ

Table D-3
Analytical Results for Direct-Push Technology Groundwater Samples
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS17DP49	IS17DP50	IS17DP51	IS17DP52	IS17DP53	IS17DP54		IS17DP55		
Sample ID	IS17GW49-0305	IS17GW50-0406	IS17GW51-1115	IS17GW52-2426	IS17GW53-2123	IS17GW54-1214	IS17GW54-2325	IS17GW55-1214	IS17GW55P-1214 (Duplicate)	IS17GW55-2224
Sample Date	03/01/05	03/01/05	09/07/05	09/07/05	09/06/05	08/31/05	09/01/05	08/31/05	08/31/05	08/31/05
Sample Depth (feet)	3 - 5	4 - 6	11 -15	24 - 26	Deep	12 - 14	23 - 25	12 - 14	12 - 14	22 - 24
Shallow/Deep Designation	Shallow	Shallow	Deep	Deep	21 - 23	Shallow	Deep	Shallow	Shallow	Deep
Methyl-tert-butyl ether (MTBE)	1 UJ	1 UJ								
o-Xylene	1 UJ	1 UJ								
Styrene	1 UJ	1 UJ								
Tetrachloroethylene	1 UJ	1 UJ								
Toluene	1 UJ	1 UJ								
trans-1,2-Dichloroethylene	1 UJ	1 UJ	1 UJ	2 J	1 J	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
trans-1,3-Dichloropropene	1 UJ	1 UJ								
Trichloroethylene	3 B	5 J	23	710	170	1 UJ	10 J	1 UJ	1 UJ	1 UJ
Trichlorofluoromethane(Freon-11)	1 UJ	1 UJ								
Vinyl chloride	100	3 J	1 UJ	9 J	1 J	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Xylene, total	1 UJ	1 UJ								
Wet Chemistry (mg/L)										
Dissolved organic carbon	NA	NA								

Notes

Shaded cell indicates constituent is detected.
Monitoring well screened intervals for IS17MW01, IS17
µg/L - micrograms per liter
mg/L - milligrams per liter
NA - Not analyzed
B - Value may be due to laboratory or field blank conta
J - Value is estimated below the reporting limit but abov
U - Not detected above associated value
UJ - Not detected above associated value,value is estim

Table D-3
Analytical Results for Direct-Push Technology Groundwater Samples
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS17DP56		IS17DP58	IS17DP59	IS17DP60		IS17DP61	IS17DP62	IS17DP63
Sample ID	IS17GW56-0608	IS17GW56-1315	IS17GW58-2224	IS17GW59-3032	IS17GW60-1820	IS17GW60P-1820	IS17GW61-1921	IS17GW62-2527	IS17GW63-2426
Sample Date	09/07/05	09/07/05	09/02/05	09/01/05	09/06/05	09/06/05	09/06/05	09/02/05	09/02/05
Sample Depth (feet)	6 - 8	13 - 15	22 - 24	30 - 32	18 - 20	18 - 20	19 - 21	25 - 27	24 - 26
Shallow/Deep Designation	Shallow	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep
Volatile Organic Compounds (µg/L)									
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	1 UJ	1 UJ	1 UJ	1 UJ					
1,1,1-Trichloroethane	1 UJ	1 UJ	1 UJ	1 UJ					
1,1,2,2-Tetrachloroethane	1 UJ	1 UJ	1 UJ	1 UJ					
1,1,2-Trichloroethane	1 UJ	1 UJ	1 UJ	1 UJ					
1,1-Dichloroethane	1 UJ	1 UJ	1 UJ	1 UJ					
1,1-Dichloroethene	1 UJ	1 UJ	1 UJ	1 UJ					
1,2,4-Trichlorobenzene	1 UJ	1 UJ	1 UJ	1 UJ					
1,2-Dibromoethane	1 UJ	1 UJ	1 UJ	1 UJ					
1,2-Dichlorobenzene	1 UJ	1 UJ	1 UJ	1 UJ					
1,2-Dichloroethane	1 UJ	1 UJ	1 UJ	1 UJ					
1,2-Dichloroethene (total)	1 UJ	1 UJ	1 UJ	4 J	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
1,2-Dichloropropane	1 UJ	1 UJ	1 UJ	1 UJ					
1,3-Dichlorobenzene	1 UJ	1 UJ	1 UJ	1 UJ					
1,4-Dichlorobenzene	1 UJ	1 UJ	1 UJ	1 UJ					
2-Butanone	1 UJ	1 UJ	1 UJ	6 J	1 UJ	1 UJ	3 J	4 J	4 J
2-Hexanone	1 UJ	1 UJ	1 UJ	2 J	1 UJ	1 UJ	1 J	1 UJ	1 UJ
4-Methyl-2-pentanone	1 UJ	1 UJ	1 UJ	1 UJ					
Acetone	10 B	7 B	6 B	19 B	10 B	9 B	32 B	32 B	30 B
Benzene	1 UJ	1 UJ	1 UJ	1 UJ					
Bromodichloromethane	1 UJ	1 UJ	1 UJ	1 UJ					
Bromoform	1 UJ	1 UJ	1 UJ	1 UJ					
Bromomethane	1 UJ	1 UJ	1 UJ	1 UJ					
Carbon disulfide	1 UJ	1 UJ	1 UJ	1 UJ					
Carbon tetrachloride	1 UJ	1 UJ	1 UJ	1 UJ					
Chlorobenzene	1 UJ	1 UJ	1 UJ	1 UJ					
Chloroethane	1 UJ	1 UJ	1 UJ	1 UJ					
Chloroform	1 UJ	2 J	1 UJ	1 UJ					
Chloromethane	1 UJ	1 UJ	1 UJ	1 UJ					
cis-1,2-Dichloroethylene	1 UJ	1 UJ	1 UJ	4 J	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
cis-1,3-Dichloropropene	1 UJ	1 UJ	1 UJ	1 UJ					
Cumene	1 UJ	1 UJ	1 UJ	1 UJ					
Cyclohexane	1 UJ	1 UJ	1 UJ	1 UJ					
Dibromochloromethane	1 UJ	1 UJ	1 UJ	1 UJ					
Dichlorodifluoromethane (Freon-12)	1 UJ	1 UJ	1 UJ	1 UJ					
Ethylbenzene	1 UJ	1 UJ	1 UJ	1 UJ					
m- and p-Xylene	1 UJ	1 UJ	1 UJ	1 UJ					
Methyl acetate	1 UJ	1 UJ	1 UJ	1 UJ					
Methylcyclohexane	1 UJ	1 UJ	1 UJ	1 UJ					
Methylene chloride	1 UJ	1 UJ	1 UJ	1 UJ	2 B	2 B	1 UJ	1 UJ	1 UJ

Table D-3
Analytical Results for Direct-Push Technology Groundwater Samples
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS17DP56		IS17DP58	IS17DP59	IS17DP60		IS17DP61	IS17DP62	IS17DP63
Sample ID	IS17GW56-0608	IS17GW56-1315	IS17GW58-2224	IS17GW59-3032	IS17GW60-1820	IS17GW60P-1820	IS17GW61-1921	IS17GW62-2527	IS17GW63-2426
Sample Date	09/07/05	09/07/05	09/02/05	09/01/05	09/06/05	09/06/05	09/06/05	09/02/05	09/02/05
Sample Depth (feet)	6 - 8	13 - 15	22 - 24	30 - 32	18 - 20	18 - 20	19 - 21	25 - 27	24 - 26
Shallow/Deep Designation	Shallow	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep
Methyl-tert-butyl ether (MTBE)	1 UJ	1 UJ	1 UJ	1 UJ					
o-Xylene	1 UJ	1 UJ	1 UJ	1 UJ					
Styrene	1 UJ	1 UJ	1 UJ	1 UJ					
Tetrachloroethylene	1 UJ	1 UJ	1 UJ	1 UJ					
Toluene	1 UJ	1 UJ	1 UJ	1 UJ					
trans-1,2-Dichloroethylene	1 UJ	1 UJ	1 UJ	1 UJ					
trans-1,3-Dichloropropene	1 UJ	1 UJ	1 UJ	1 UJ					
Trichloroethylene	1 UJ	1 UJ	1 UJ	23	2 J	2 J	1 UJ	1 UJ	1 UJ
Trichlorofluoromethane(Freon-11)	1 UJ	1 UJ	1 UJ	1 UJ					
Vinyl chloride	1 UJ	1 UJ	1 UJ	1 UJ					
Xylene, total	1 UJ	1 UJ	1 UJ	1 UJ					
Wet Chemistry (mg/L)									
Dissolved organic carbon	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes

Shaded cell indicates constituent is detected.

Monitoring well screened intervals for IS17MW01, IS17

µg/L - micrograms per liter

mg/L - milligrams per liter

NA - Not analyzed

B - Value may be due to laboratory or field blank conta

J - Value is estimated below the reporting limit but abov

U - Not detected above associated value

UJ - Not detected above associated value,value is estim

Table D-4
 Detection and Screening Criterion Exceedance for Direct-Push Technology Groundwater Samples
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	RBC-Tap Water Adjusted	IS17DP21	IS17DP22		IS17DP23		IS17DP24		IS17DP25	IS17DP26		IS17DP27	
Sample ID		IS17GW21-0507	IS17GW22-0607	IS17GW22-0911	IS17GW23-0608	IS17GW23-0911	IS17GW24-0812	IS17GW24-1418	IS17GW25-0406	IS17GW26-0507	IS17GW26-0911	IS17GW27-0406	IS17GW27-0810
Sample Date		02/24/05	02/23/05	02/23/05	02/23/05	02/23/05	02/22/05	02/22/05	02/24/05	02/23/05	02/23/05	02/23/05	02/23/05
Chemical Name													
Volatile Organic Compounds (UG/L)													
1,1,1-Trichloroethane	170	10 U	10 U	1 J	1 J	2 J	10 U	10 U	10 U	10 U	1 J	5,000 U	10,000 U
1,1,2-Trichloroethane	0.19	10 U	5,000 U	10,000 U									
1,1-Dichloroethane	90	10 U	10 U	2 J	2 J	3 J	10 U	10 U	10 U	5 J	4 J	550 J	10,000 U
1,1-Dichloroethene	35	2 J	1 J	3 J	5 J	11 J	10 U	10 U	10 U	3 J	4 J	1,900 J	1,900 J
1,2-Dichloroethane	0.12	10 U	5,000 U	10,000 U									
1,2-Dichloroethene (total)	5.5	1,300 R	210	69	710	650	10 U	2 J	120	180 J	170	170,000	73,000
2-Butanone	700	10 U	10 U	10 U	1 J	1 J	5 J	10 U	10 U	10 U	10 U	5,000 U	10,000 U
2-Hexanone	--	10 UJ	10 U	5,000 U	10,000 U								
Acetone	550	10 U	6 J	10 U	4 J	4 J	18	4 J	10 U	5 J	1 J	5,000 U	10,000 U
Carbon disulfide	100	10 U	2 J	10 U	5,000 U	10,000 U							
Chloroethane	3.6	10 U	5,000 U	10,000 U									
Chloroform	0.15	10 U	5,000 U	10,000 U									
Ethane	--	NA											
Ethene	--	NA											
Ethylbenzene	130	10 U	5,000 U	10,000 U									
Methane	--	NA											
Methylene chloride	4.1	10 U	11 J	5,000 U	10,000 U								
Tetrachloroethene	0.1	10 U	10 U	10 U	2 J	1 J	10 U	5,000 U	10,000 U				
Toluene	230	1 J	2 J	10 U	6 J	4 J	2 J	10 U	3 J	2 J	3 J	1,000 J	10,000 U
Trichloroethene	0.026	12	1,000	340	3,800	2,800	10 U	12	2 B	320	720	490,000	870,000
Vinyl chloride	0.015	710 R	7 J	2 J	47 J	140 J	10 U	10 U	64	47 J	3 J	14,000	10,000 U
Xylene, total	21	10 U	1 J	5,000 U	10,000 U								
cis-1,2-Dichloroethene	6.1	1,300 R	210	69	710	650	10 U	2 J	120	180 J	170	170,000	73,000
m- and p-Xylene	--	10 U	1 J	5,000 U	10,000 U								
trans-1,2-Dichloroethene	11	3 J	3 J	10 U	3 J	4 J	10 U	10 U	10 U	10 U	1 J	610 J	10,000 U
Wet Chemistry (MG/L)													
Dissolved organic carbon	--	NA											

Notes
 Shaded cell indicates that constituent exceeds the screening criterion.
 µg/L - micrograms per liter
 mg/L - milligrams per liter
 NA - Not analyzed
 B - Value may be due to laboratory or field blank contamination
 J - Value is estimated below the reporting limit but above the method detection limit
 U - Not detected above associated value
 UJ - Not detected above associated value, value is estimated

Table D-4
 Detection and Screening Criterion Exceedance for Direct-Push Technology Groundwater Samples
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	RBC-Tap Water Adjusted	IS17DP28		IS17DP29	IS17DP31	IS17DP32		IS17DP33		IS17DP34		IS17DP35	IS17DP36
Sample ID		IS17GW28-0610	IS17GW28-1418	IS17GW29-0406	IS17GW31-0204	IS17GW32-0406	IS17GW32-1112	IS17GW33-0406	IS17GW33-0810	IS17GW34-0406	IS17GW34-0810	IS17GW35-0405	IS17GW36-0507
Sample Date		02/22/05	02/22/05	02/28/05	03/01/05	03/02/05	03/02/05	02/24/05	02/24/05	02/23/05	02/23/05	03/02/05	02/28/05
Chemical Name													
Volatile Organic Compounds (UG/L)													
1,1,1-Trichloroethane	170	10 U	500 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1,000 U	10 U	10 U
1,1,2-Trichloroethane	0.19	4 J	500 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1,000 U	10 U	10 U
1,1-Dichloroethane	90	10 U	500 U	10 U	10 U	10 U	10 U	24	34	3 J	160 J	10 U	10 U
1,1-Dichloroethene	35	27	500 U	10 U	10 U	10 U	10 U	4 J	21	10 U	240 J	10 U	36
1,2-Dichloroethane	0.12	10 U	500 U	10 U	10 U	10 UJ	10 U	1 J	2 J	10 U	1,000 U	10 U	10 U
1,2-Dichloroethene (total)	5.5	2,400	4,400	120	12	170	2 J	880	1,500 R	390	220,000	22	16,000
2-Butanone	700	3 J	500 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1,000 U	10 U	10 U
2-Hexanone	--	10 U	500 U	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	1,000 U	10 U	1,000 R
Acetone	550	12	500 U	10 U	3 J	10 U	10 U	10 U	10 U	3 J	1,000 U	10 U	10 U
Carbon disulfide	100	2 J	500 U	10 U	10 U	10 U	10 U	10 U	10 U	1 J	1,000 U	10 U	1 J
Chloroethane	3.6	10 U	500 U	10 U	10 U	10 U	10 U	9 J	9 J	10 U	1,000 U	10 U	10 U
Chloroform	0.15	10 U	500 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1,000 U	10 U	10 U
Ethane	--	NA											
Ethene	--	NA											
Ethylbenzene	130	10 U	500 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1,000 U	10 U	10 U
Methane	--	NA											
Methylene chloride	4.1	10 U	500 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1,000 U	10 U	1 B
Tetrachloroethene	0.1	10 U	500 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1,000 U	10 U	10 U
Toluene	230	10 U	500 U	10 U	1 J	10 U	10 U	10 U	2 J	4 J	1,000 U	1 J	1 J
Trichloroethene	0.026	11,000	62,000	78	4 J	6 J	10 U	2 B	3 B	5 B	24,000	69	110
Vinyl chloride	0.015	670	500 U	29	12	100	1 J	380	480 R	920	80,000	29	2,000
Xylene, total	21	10 U	500 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1,000 U	10 U	10 U
cis-1,2-Dichloroethene	6.1	2,400	4,300	120	12	170	2 J	880	1,500 R	330	220,000	22	16,000
m- and p-Xylene	--	10 U	500 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1,000 U	10 U	10 U
trans-1,2-Dichloroethene	11	30	51 J	10 U	10 U	10 U	10 U	2 J	6 J	1 J	1,200	10 U	110
Wet Chemistry (MG/L)													
Dissolved organic carbon	--	NA	NA	NA	NA	6.3	16	NA	NA	NA	NA	18	NA

Notes
 Shaded cell indicates that constituent exceeds the screening crit
 µg/L - micrograms per liter
 mg/L - milligrams per liter
 NA - Not analyzed
 B - Value may be due to laboratory or field blank contamination
 J - Value is estimated below the reporting limit but above the me
 U - Not detected above associated value
 UJ - Not detected above associated value,value is estimated

Table D-4
 Detection and Screening Criterion Exceedance for Direct-Push Technology Groundwater Samples
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	RBC-Tap Water Adjusted	IS17DP37		IS17DP38	IS17DP39	IS17DP40		IS17DP41	IS17DP42		IS17DP44	IS17DP45	
Sample ID		IS17GW37-0406	IS17GW37-1012	IS17GW38-0407	IS17GW39-0608	IS17GW40-0304	IS17GW40-0607	IS17GW41-0406	IS17GW42-0203	IS17GW42-0607	IS17GW44-0204	IS17GW45-0507	IS17GW45-1214
Sample Date		03/02/05	03/02/05	03/01/05	02/24/05	02/24/05	02/24/05	02/23/05	02/24/05	02/24/05	02/28/05	02/28/05	02/28/05
Chemical Name													
Volatile Organic Compounds (UG/L)													
1,1,1-Trichloroethane	170	10 U											
1,1,2-Trichloroethane	0.19	10 U											
1,1-Dichloroethane	90	10 U	10 U	1 J	10 U	10 U	10 U	2 J	10 U	4 J	10 U	38	27
1,1-Dichloroethene	35	10 U	10 U	2 J	10 U	13 J	10 U	2 J	10 U				
1,2-Dichloroethane	0.12	10 U	1 J	1 J									
1,2-Dichloroethene (total)	5.5	5 J	10 U	650	7 J	120	28	1 J	12	17,000	10	2,800	19
2-Butanone	700	10 U	2 J	10 U									
2-Hexanone	--	10 U	10 U	10 UJ	10 U	10 UJ	10 U						
Acetone	550	10 U	2 J	1 J	10 U	10 U	2 J	9 J	10 U	4 J	2 J	4 J	1 J
Carbon disulfide	100	10 U	10 U	10 U	10 U	1 J	10 U	10 U	1 J	10 U	10 U	10 U	10 U
Chloroethane	3.6	10 U	15	10 U	10 U	10 U	10 U	2 J	10 U	10 U	10 U	10 U	28
Chloroform	0.15	10 U											
Ethane	--	NA											
Ethene	--	NA											
Ethylbenzene	130	10 U											
Methane	--	NA											
Methylene chloride	4.1	10 U	9 J	10 U	10 U	10 U							
Tetrachloroethene	0.1	10 U											
Toluene	230	10 U											
Trichloroethene	0.026	2 J	10 U	4 B	8 J	4 B	3 B	10 B	10 U	4 J	4 B	13	4 J
Vinyl chloride	0.015	3 J	10 U	390	3 J	160	100	10 U	13	54,000	4 J	5,100	37
Xylene, total	21	10 U											
cis-1,2-Dichloroethene	6.1	5 J	10 U	650	7 J	120	28	1 J	12	17,000	10	2,800	19
m- and p-Xylene	--	10 U											
trans-1,2-Dichloroethene	11	10 U	10 U	2 J	10 U	200 J	10 U	11	10 U				
Wet Chemistry (MG/L)													
Dissolved organic carbon	--	11	14	NA	NA	10	15	NA	13	13	NA	NA	NA

Notes
 Shaded cell indicates that constituent exceeds the screening crit
 µg/L - micrograms per liter
 mg/L - milligrams per liter
 NA - Not analyzed
 B - Value may be due to laboratory or field blank contamination
 J - Value is estimated below the reporting limit but above the me
 U - Not detected above associated value
 UJ - Not detected above associated value,value is estimated

Table D-4
 Detection and Screening Criterion Exceedance for Direct-Push Technology Groundwater Samples
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	RBC-Tap Water Adjusted	IS17DP46	IS17DP47	IS17DP48	IS17DP49	IS17DP50	IS17DP51	IS17DP52	IS17DP53	IS17DP54		IS17DP55		
Sample ID		IS17GW46-0406	IS17GW47-0406	IS17GW48-0406	IS17GW49-0305	IS17GW50-0406	IS17GW51-1115	IS17GW52-2426	IS17GW53-2123	IS17GW54-1214	IS17GW54-2325	IS17GW55-1214	IS17GW55P-1214	IS17GW55-2224
Sample Date		03/01/05	03/01/05	03/02/05	03/01/05	03/01/05	09/07/05	09/07/05	09/06/05	08/31/05	09/01/05	08/31/05	08/31/05	08/31/05
Chemical Name														
Volatile Organic Compounds (UG/L)														
1,1,1-Trichloroethane	170	10 U	10 U											
1,1,2-Trichloroethane	0.19	10 U	10 U											
1,1-Dichloroethane	90	2 J	10 U	14	3 J	10 U	10 U	10 U	10 U	10 U				
1,1-Dichloroethene	35	10 J	10 U	18	4 J	10 U	10 U	10 U	10 U	10 U				
1,2-Dichloroethane	0.12	10 U	10 U											
1,2-Dichloroethene (total)	5.5	7,700	12	19	97	12	4 J	220	34	10 U	1 J	10 U	10 U	10 U
2-Butanone	700	10 U	3 J	10 U	10 U	10 U	10 U							
2-Hexanone	--	10 UJ	10 UJ	10 U	10 UJ	10 U	10 U							
Acetone	550	10 U	3 J	2 J	10 U	10 U	9 B	3 B	5 B	6 B	10 U	10 U	10 U	10 U
Carbon disulfide	100	10 U	10 U											
Chloroethane	3.6	10 U	10 U											
Chloroform	0.15	10 U	1 J	10 U	10 U	10 U	10 U	10 U						
Ethane	--	NA	NA											
Ethene	--	NA	NA											
Ethylbenzene	130	2 J	10 U	10 U										
Methane	--	NA	NA											
Methylene chloride	4.1	2 B	10 U	2 B	10 U	10 U	10 U	10 U	10 U					
Tetrachloroethene	0.1	10 U	10 U											
Toluene	230	1 J	10 U	10 U										
Trichloroethene	0.026	19	3 B	8 J	3 B	5 J	23	710	170	10 U	10 J	10 U	10 U	10 U
Vinyl chloride	0.015	2,400	3 J	2 J	100	3 J	10 U	9 J	1 J	10 U	10 U	10 U	10 U	10 U
Xylene, total	21	10 U	10 U											
cis-1,2-Dichloroethene	6.1	7,700	12	19	97	12	4 J	210	33	10 U	1 J	10 U	10 U	10 U
m- and p-Xylene	--	10 U	10 U											
trans-1,2-Dichloroethene	11	68	10 U	2 J	1 J	10 U	10 U	10 U	10 U	10 U				
Wet Chemistry (MG/L)														
Dissolved organic carbon	--	NA	NA	14	NA	NA								

Notes
 Shaded cell indicates that constituent exceeds the screening crit
 µg/L - micrograms per liter
 mg/L - milligrams per liter
 NA - Not analyzed
 B - Value may be due to laboratory or field blank contamination
 J - Value is estimated below the reporting limit but above the me
 U - Not detected above associated value
 UJ - Not detected above associated value,value is estimated

Table D-4
 Detection and Screening Criterion Exceedance for Direct-Push Technology Groundwater Samples
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	RBC-Tap Water Adjusted	IS17DP56		IS17DP58	IS17DP59	IS17DP60		IS17DP61	IS17DP62	IS17DP63
Sample ID		IS17GW56-0608	IS17GW56-1315	IS17GW58-2224	IS17GW59-3032	IS17GW60-1820	IS17GW60P-1820	IS17GW61-1921	IS17GW62-2527	IS17GW63-2426
Sample Date		09/07/05	09/07/05	09/02/05	09/01/05	09/06/05	09/06/05	09/06/05	09/02/05	09/02/05
Chemical Name										
Volatile Organic Compounds (UG/L)										
1,1,1-Trichloroethane	170	10 U	10 U	10 U	10 U					
1,1,2-Trichloroethane	0.19	10 U	10 U	10 U	10 U					
1,1-Dichloroethane	90	10 U	10 U	10 U	10 U					
1,1-Dichloroethene	35	10 U	10 U	10 U	10 U					
1,2-Dichloroethane	0.12	10 U	10 U	10 U	10 U					
1,2-Dichloroethene (total)	5.5	10 U	10 U	10 U	4 J	10 U	10 U	10 U	10 U	10 U
2-Butanone	700	10 U	10 U	10 U	6 J	10 U	10 U	3 J	4 J	4 J
2-Hexanone	--	10 U	10 U	10 U	2 J	10 U	10 U	1 J	10 U	10 U
Acetone	550	10 B	7 B	6 B	19 B	10 B	9 B	32 B	32 B	30 B
Carbon disulfide	100	10 U	10 U	10 U	10 U					
Chloroethane	3.6	10 U	10 U	10 U	10 U					
Chloroform	0.15	10 U	2 J	10 U	10 U					
Ethane	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethene	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	130	10 U	10 U	10 U	10 U					
Methane	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	4.1	10 U	10 U	10 U	10 U	2 B	2 B	10 U	10 U	10 U
Tetrachloroethene	0.1	10 U	10 U	10 U	10 U					
Toluene	230	10 U	10 U	10 U	10 U					
Trichloroethene	0.026	10 U	10 U	10 U	23	2 J	2 J	10 U	10 U	10 U
Vinyl chloride	0.015	10 U	10 U	10 U	10 U					
Xylene, total	21	10 U	10 U	10 U	10 U					
cis-1,2-Dichloroethene	6.1	10 U	10 U	10 U	4 J	10 U	10 U	10 U	10 U	10 U
m- and p-Xylene	--	10 U	10 U	10 U	10 U					
trans-1,2-Dichloroethene	11	10 U	10 U	10 U	10 U					
Wet Chemistry (MG/L)										
Dissolved organic carbon	--	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes

- Shaded cell indicates that constituent exceeds the screening crit
- µg/L - micrograms per liter
- mg/L - milligrams per liter
- NA - Not analyzed
- B - Value may be due to laboratory or field blank contamination
- J - Value is estimated below the reporting limit but above the me
- U - Not detected above associated value
- UJ - Not detected above associated value, value is estimated

Table D-5
Analytical Results for Direct-Push Technology Soil Samples
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS17DP32		IS17DP35		IS17DP37		IS17DP40		IS17DP42		IS17DP48	
Sample ID	IS17DS32-0203	IS17DS32-1112	IS17DS35-0304	IS17DS35-0607	IS17DS37-0203	IS17DS37-1112	IS17DS40-0203	IS17DS40-0607	IS17DS42-0001	IS17DS42-0607	IS17DS48-0203	IS17DS48-0405
Sample Date	03/02/05	03/02/05	02/24/05	02/24/05	03/02/05	03/02/05	02/24/05	02/24/05	02/24/05	02/24/05	03/02/05	03/02/05
Chemical Name												
Volatile Organic Compounds (µg/kg)												
1,1,1-Trichloroethane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
1,1,2,2-Tetrachloroethane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
1,1,2-Trichloroethane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
1,1-Dichloroethane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
1,1-Dichloroethene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
1,2,4-Trichlorobenzene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
1,2-Dibromo-3-chloropropane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
1,2-Dibromoethane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
1,2-Dichlorobenzene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
1,2-Dichloroethane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
1,2-Dichloroethene (total)	NA	16 U	NA	3 J	NA	16 U	NA	2 J	NA	500	NA	2 J
1,2-Dichloropropane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
1,3-Dichlorobenzene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
1,4-Dichlorobenzene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
2-Butanone	NA	6 J	NA	4 J	NA	5 J	NA	10 J	NA	7 J	NA	2 J
2-Hexanone	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
4-Methyl-2-pentanone	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Acetone	NA	18 B	NA	21 B	NA	20 B	NA	34 B	NA	27 B	NA	14 B
Benzene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Bromodichloromethane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Bromoform	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Bromomethane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Carbon disulfide	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	3 J	NA	11 U
Carbon tetrachloride	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Chlorobenzene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Chloroethane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Chloroform	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Chloromethane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Cumene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Cyclohexane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Dibromochloromethane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Dichlorodifluoromethane (Freon-12)	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Ethylbenzene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Methyl acetate	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Methyl-tert-butyl ether (MTBE)	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Methylcyclohexane	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U

Table D-5
Analytical Results for Direct-Push Technology Soil Samples
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS17DP32		IS17DP35		IS17DP37		IS17DP40		IS17DP42		IS17DP48	
Sample ID	IS17DS32-0203	IS17DS32-1112	IS17DS35-0304	IS17DS35-0607	IS17DS37-0203	IS17DS37-1112	IS17DS40-0203	IS17DS40-0607	IS17DS42-0001	IS17DS42-0607	IS17DS48-0203	IS17DS48-0405
Sample Date	03/02/05	03/02/05	02/24/05	02/24/05	03/02/05	03/02/05	02/24/05	02/24/05	02/24/05	02/24/05	03/02/05	03/02/05
Methylene chloride	NA	7 JB	NA	10 JB	NA	7 JB	NA	16 B	NA	13 JB	NA	4 JB
Styrene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Tetrachloroethene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Toluene	NA	16 U	NA	2 J	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Trichloroethene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	14 J	NA	11 U
Trichlorofluoromethane(Freon-11)	NA	16 U	NA	14 U	NA	16 U	NA	2 J	NA	18 U	NA	11 U
Vinyl chloride	NA	16 U	NA	2 J	NA	16 U	NA	16 U	NA	720 J	NA	11 U
Xylene, total	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
cis-1,2-Dichloroethene	NA	16 U	NA	3 J	NA	16 U	NA	2 J	NA	450 J	NA	2 J
cis-1,3-Dichloropropene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
m- and p-Xylene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
o-Xylene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
trans-1,2-Dichloroethene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	2 J	NA	11 U
trans-1,3-Dichloropropene	NA	16 U	NA	14 U	NA	16 U	NA	16 U	NA	18 U	NA	11 U
Wet Chemistry (mg/kg)												
% Solids	84	70	82	68	82	61	79	74	78	57	84	81
Total organic carbon (TOC)	57,000	NA	5,100	NA	24,000	NA	28,000	NA	12,000	NA	17,000	NA
Notes												
Shaded cell indicates constituent is detected.												
µg/L - micrograms per liter												
mg/L - milligrams per liter												
NA - Not analyzed												
B - Value may be due to laboratory or field blank contamination												
J - Value is estimated below the reporting limit but above the method detection limit												
U - Not detected above associated value												
UJ - Not detected above associated value,value is estimated												

Appendix E
Hydraulic Conductivity Analysis

Indian Head Site 17 Hydraulic Conductivity Analyses

PREPARED FOR: Gunarti Coghlan/WDC
Ed Corack/WDC

PREPARED BY: Ian Zmudzin/PHL

COPIES: John Mason/PHL

DATE: January 13, 2006

PROJECT NUMBER: 314446.FS.DF

To support the Indian Head Site 17 Feasibility Study, a range of site-specific hydraulic conductivity values were calculated based on the data from the hydraulic conductivity test results (also known as slug tests) conducted at three groundwater monitoring wells at the site. Groundwater monitoring wells were installed in the first-encountered groundwater at the site and the well screen straddled the water table. Slug tests were conducted at these three site monitoring wells and included falling-head and rising-head tests. A falling-head test is where the static water level in a monitoring well is artificially and instantaneously raised by inserting either a slug of inert material or water into the water column, and recording the rate at which the water level (or head) returns to static conditions (equilibrium). Once equilibrium is achieved, a rising-head test is conducted where the slug is rapidly withdrawn from the well causing the static water level to temporarily fall, and the rate that the water level rises to return to static conditions. The data collected during these tests are water-level and elapsed-time data pairs (raw data). The hydraulic conductivity is related to the rate at which water returns to static conditions after being artificially raised or lowered (e.g., a water level that rapidly returns to static conditions reflects a higher hydraulic conductivity than a water level that slowly returns to static conditions).

The interpreted (or calculated) hydraulic conductivity value is derived from a mathematical analysis of the raw data. Several computer programs are available to assist with the data analysis and AQTESOLV version 2.5 was used for this analysis. The raw data was entered into the program and the curve-matching method was selected using the Bouwer-Rice analysis for unconfined aquifers. During curve-matching, it was important to note that early-time data (i.e., less than 1 second elapsed-time) and late-time data were considered as not representative of the aquifer due to filter-pack effects (early-time data) and measurement sensitivity (late-time data). A best-fit curve (which plots as a straight line on semi-log graph) was visually matched to the representative data points and the calculated hydraulic conductivity value was provided by the AQTESOLV program. The values from the best-fit line matching technique were summarized and provided to the project team.

NSF-IH Site 17 Hydraulic Conductivity Summary

	FALLING HEAD		RISING HEAD	
IS17MW01	5.076 x 10 ⁻⁵ to 5.924 x 10 ⁻⁵		Early	Late
			1.671 x 10 ⁻⁴	1.083 x 10 ⁻⁴
IS17MW02	5.251 x 10 ⁻⁵ to 5.293 x 10 ⁻⁵		1.062 x 10 ⁻⁴	
IS17MW03	Early	Late	N/A	
	1.336 x 10 ⁻⁵ to 1.342 x 10 ⁻⁵	5.986 x 10 ⁻⁶ to 7.546 x 10 ⁻⁶		

K-Values in ft/sec

Data Set: C:\Documents and Settings\izmudzin\Desktop\Indian Head Slug Test Data\Slug Test Analysis 2\Final In
 Date: 01/12/06
 Time: 11:03:56

PROJECT INFORMATION

Company: CH2M Hill
 Client: NDWIH
 Project: 314446
 Location: Indian Head, MD
 Test Date: 02/23/2005
 Test Well: IS17MW01

AQUIFER DATA

Saturated Thickness: 7.5 ft
 Anisotropy Ratio (Kz/Kr): 1.

OBSERVATION WELL DATA

Number of observation wells: 1

Observation Well No. 1: IS17MW01

X Location: 0. ft
 Y Location: 0. ft

No. of observations: 20

<u>Observation Data</u>					
<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
0.	2.397	38.3	0.859	197.4	0.059
2.	2.207	53.	0.64	222.4	0.041
4.6	1.997	72.7	0.433	247.4	0.03
8.2	1.785	97.4	0.276	272.4	0.021
12.9	1.536	122.4	0.182	297.4	0.016
19.2	1.315	147.4	0.122	322.4	0.011
27.3	1.091	172.4	0.084		

SOLUTION

Aquifer Model: Unconfined
 Solution Method: Bouwer-Rice

VISUAL ESTIMATION RESULTS

Estimated Parameters

<u>Parameter</u>	<u>Estimate</u>	
K	0.0001671	ft/sec
y0	2.11	ft

AUTOMATIC ESTIMATION RESULTS

Estimated Parameters

<u>Parameter</u>	<u>Estimate</u>	<u>Std. Error</u>	
K	0.0001671	7.536E-06	ft/sec
y0	2.11	0.03669	ft

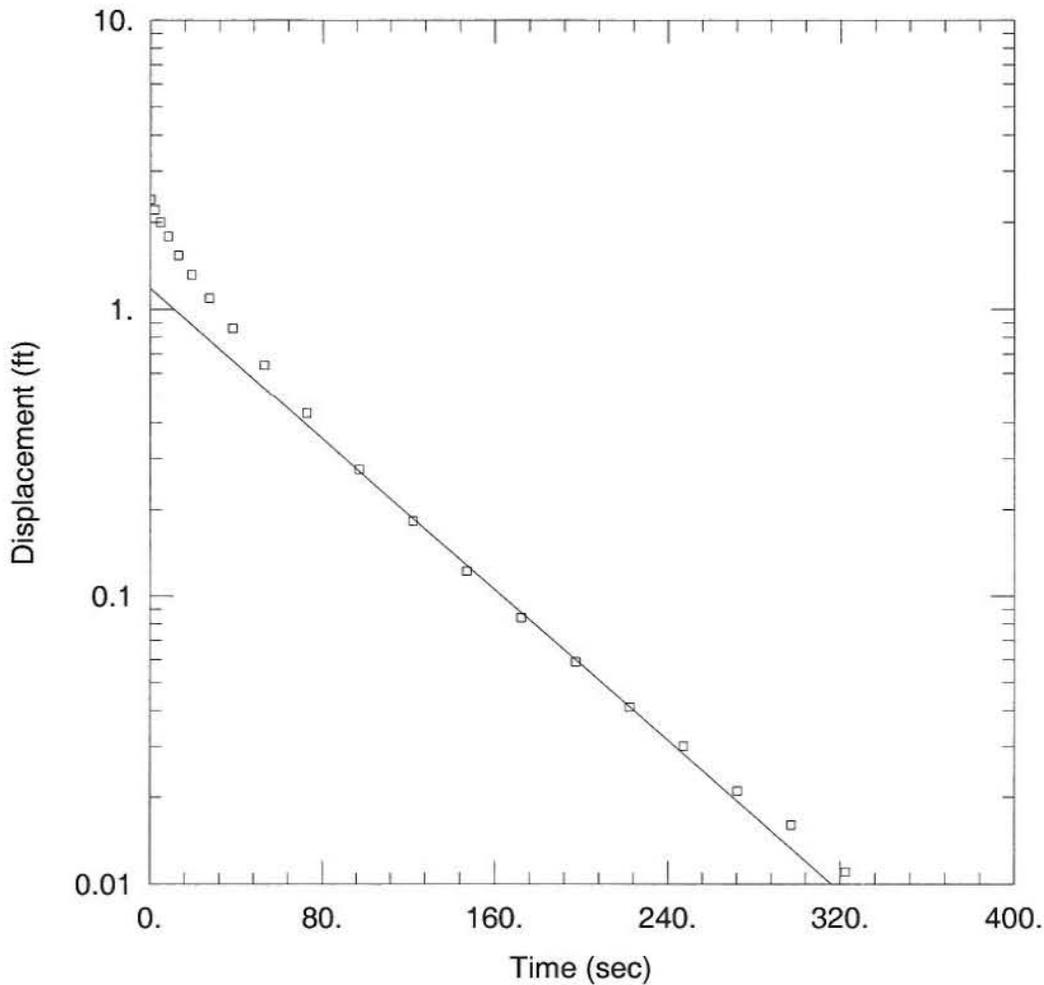
Parameter Correlations

	<u>K</u>	<u>y0</u>
K	1.00	0.60
y0	0.60	1.00

Residual Statistics

for weighted residuals

Sum of Squares ... 0.07426 ft²
 Variance 0.004126 ft²
 Std. Deviation 0.06423 ft
 Mean 0.02037 ft
 No. of Residuals... 20.
 No. of Estimates... 2



WELL TEST ANALYSIS

Data Set: C:\...\MW01_LateRising.aqt
 Date: 01/12/06

Time: 11:04:34

PROJECT INFORMATION

Company: CH2M Hill
 Client: NDWIH
 Project: 314446
 Test Location: Indian Head, MD
 Test Well: IS17MW01
 Test Date: 02/23/2005

AQUIFER DATA

Saturated Thickness: 7.5 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (IS17MW01)

Initial Displacement: 2.397 ft Water Column Height: 7.5 ft
 Casing Radius: 0.083 ft Wellbore Radius: 0.33 ft
 Screen Length: 5. ft Gravel Pack Porosity: 0.25

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice
 K = 0.0001083 ft/sec y0 = 1.179 ft

Data Set: C:\Documents and Settings\izmudzin\Desktop\Indian Head Slug Test Data\Slug Test Analysis 2\Final In
Date: 01/12/06
Time: 11:04:28

PROJECT INFORMATION

Company: CH2M Hill
Client: NDWIH
Project: 314446
Location: Indian Head, MD
Test Date: 02/23/2005
Test Well: IS17MW01

AQUIFER DATA

Saturated Thickness: 7.5 ft
Anisotropy Ratio (Kz/Kr): 1.

OBSERVATION WELL DATA

Number of observation wells: 1

Observation Well No. 1: IS17MW01

X Location: 0. ft

Y Location: 0. ft

No. of observations: 20

<u>Observation Data</u>					
<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
0.	2.397	38.3	0.859	197.4	0.059
2.	2.207	53.	0.64	222.4	0.041
4.6	1.997	72.7	0.433	247.4	0.03
8.2	1.785	97.4	0.276	272.4	0.021
12.9	1.536	122.4	0.182	297.4	0.016
19.2	1.315	147.4	0.122	322.4	0.011
27.3	1.091	172.4	0.084		

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

VISUAL ESTIMATION RESULTS

Estimated Parameters

<u>Parameter</u>	<u>Estimate</u>	
K	0.0001083	ft/sec
y0	1.179	ft

AUTOMATIC ESTIMATION RESULTS

Estimated Parameters

<u>Parameter</u>	<u>Estimate</u>	<u>Std. Error</u>	
K	0.0001083	7.536E-06	ft/sec
y0	1.179	0.03669	ft

Parameter Correlations

	<u>K</u>	<u>y0</u>
K	1.00	0.60
y0	0.60	1.00

Residual Statistics

for weighted residuals

Sum of Squares ... 0.07426 ft²
Variance 0.004126 ft²
Std. Deviation 0.06423 ft
Mean..... 0.02037 ft
No. of Residuals... 20.
No. of Estimates... 2

Data Set: C:\Documents and Settings\izmudzin\Desktop\Indian Head Slug Test Data\Slug Test Analysis 2\Final In
 Date: 01/12/06
 Time: 11:04:09

PROJECT INFORMATION

Company: CH2M Hill
 Client: NDWIH
 Project: 314446
 Location: Indian Head, MD
 Test Date: 02/23/2005
 Test Well: IS17MW01

AQUIFER DATA

Saturated Thickness: 7.5 ft
 Anisotropy Ratio (Kz/Kr): 1.

OBSERVATION WELL DATA

Number of observation wells: 1

Observation Well No. 1: IS17MW01

X Location: 0. ft
 Y Location: 0. ft

No. of observations: 66

<u>Observation Data</u>					
<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
0.	2.381	331.6	0.188	881.6	0.022
1.5	2.221	356.6	0.161	906.6	0.021
3.	2.174	381.6	0.139	931.6	0.02
4.6	2.133	406.6	0.119	956.6	0.02
6.6	2.087	431.6	0.105	981.6	0.02
9.5	2.032	456.6	0.091	1006.6	0.017
13.2	1.956	481.6	0.081	1031.6	0.017
18.2	1.868	506.6	0.072	1056.6	0.018
24.9	1.758	531.6	0.063	1081.6	0.018
33.4	1.632	556.6	0.057	1106.6	0.017
45.1	1.479	581.6	0.051	1131.6	0.016
60.7	1.306	606.6	0.046	1156.6	0.016
81.6	1.113	631.6	0.043	1181.6	0.016
106.6	0.92	656.6	0.038	1206.6	0.016
131.6	0.762	681.6	0.035	1231.6	0.014
156.6	0.634	706.6	0.033	1256.6	0.015
181.6	0.526	731.6	0.031	1281.6	0.015
206.6	0.441	756.6	0.028	1306.6	0.015
231.6	0.367	781.6	0.028	1331.6	0.015
256.6	0.309	806.6	0.025	1356.6	0.015
281.6	0.261	831.6	0.024	1381.6	0.015

AQTESOLV for Windows

<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
306.6	0.219	856.6	0.024	1406.6	0.014

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

VISUAL ESTIMATION RESULTS

Estimated Parameters

<u>Parameter</u>	<u>Estimate</u>	
K	5.076E-05	ft/sec
y0	1.975	ft

Data Set: C:\Documents and Settings\izmudzin\Desktop\Indian Head Slug Test Data\Slug Test Analysis 2\Final In
Date: 01/12/06
Time: 11:04:21

PROJECT INFORMATION

Company: CH2M Hill
Client: NDWIH
Project: 314446
Location: Indian Head, MD
Test Date: 02/23/2005
Test Well: IS17MW01

AQUIFER DATA

Saturated Thickness: 7.5 ft
Anisotropy Ratio (Kz/Kr): 1.

OBSERVATION WELL DATA

Number of observation wells: 1

Observation Well No. 1: IS17MW01

X Location: 0. ft
Y Location: 0. ft

No. of observations: 45

<u>Observation Data</u>					
<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
0.	2.341	156.6	0.471	531.6	0.035
1.5	2.102	181.6	0.383	556.6	0.032
3.	2.039	206.6	0.31	581.6	0.028
4.6	1.984	231.6	0.252	606.6	0.026
6.6	1.924	256.6	0.206	631.6	0.022
9.5	1.857	281.6	0.17	656.6	0.02
13.2	1.776	306.6	0.141	681.6	0.019
18.2	1.677	331.6	0.118	706.6	0.016
24.9	1.561	356.6	0.099	731.6	0.016
33.4	1.433	381.6	0.085	756.6	0.015
45.1	1.279	406.6	0.072	781.6	0.013
60.7	1.105	431.6	0.061	806.6	0.012
81.6	0.914	456.6	0.053	831.6	0.013
106.6	0.731	481.6	0.045	856.6	0.013
131.6	0.586	506.6	0.04	881.6	0.011

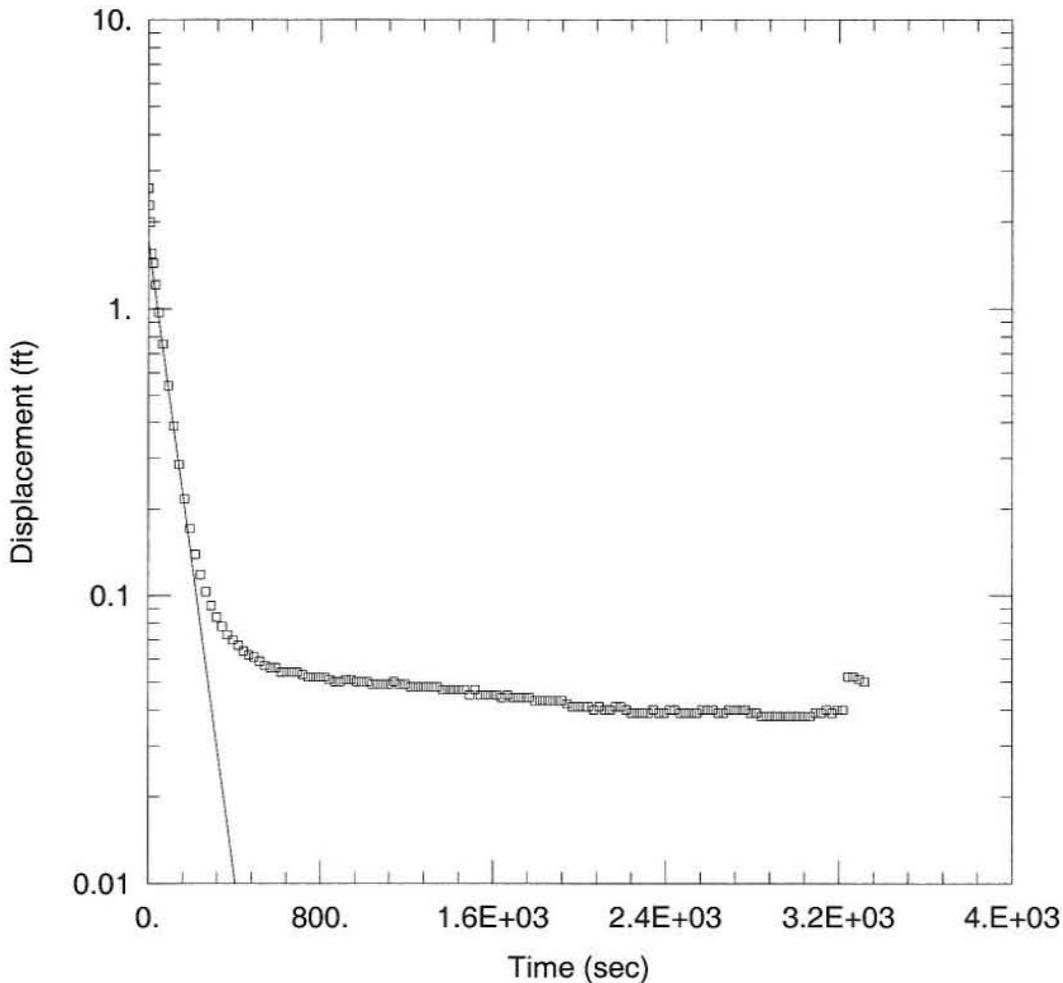
SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

VISUAL ESTIMATION RESULTS

Estimated Parameters

<u>Parameter</u>	<u>Estimate</u>	
K	5.924E-05	ft/sec
y0	1.73	ft



WELL TEST ANALYSIS

Data Set: C:\...\MW02_Rising.aqt
 Date: 01/12/06

Time: 11:05:03

PROJECT INFORMATION

Company: CH2M Hill
 Client: NDWIH
 Project: 314446
 Test Location: Indian Head, MD
 Test Well: IS17MW02
 Test Date: 02/23/2005

AQUIFER DATA

Saturated Thickness: 15. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (IS17MW02)

Initial Displacement: 2.611 ft
 Casing Radius: 0.083 ft
 Screen Length: 5. ft

Water Column Height: 15. ft
 Wellbore Radius: 0.33 ft
 Gravel Pack Porosity: 0.25

SOLUTION

Aquifer Model: Unconfined
 K = 0.0001062 ft/sec

Solution Method: Bower-Rice
 y0 = 1.71 ft

Data Set: C:\Documents and Settings\izmudzin\Desktop\Indian Head Slug Test Data\Slug Test Analysis 2\Final In
Date: 01/12/06
Time: 11:05:07

PROJECT INFORMATION

Company: CH2M Hill
Client: NDWIH
Project: 314446
Location: Indian Head, MD
Test Date: 02/23/2005
Test Well: IS17MW02

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

OBSERVATION WELL DATA

Number of observation wells: 1

Observation Well No. 1: IS17MW02

X Location: 0. ft
Y Location: 0. ft

No. of observations: 138

<u>Observation Data</u>					
<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
0.	2.611	1042.8	0.049	2192.8	0.041
3.6	2.285	1067.8	0.049	2217.8	0.04
8.3	1.991	1092.8	0.049	2242.8	0.039
14.6	1.549	1117.8	0.049	2267.8	0.039
22.7	1.441	1142.8	0.05	2292.8	0.039
33.7	1.211	1167.8	0.049	2317.8	0.039
48.4	0.97	1192.8	0.049	2342.8	0.04
68.1	0.755	1217.8	0.048	2367.8	0.039
92.8	0.542	1242.8	0.048	2392.8	0.039
117.8	0.389	1267.8	0.048	2417.8	0.04
142.8	0.286	1292.8	0.048	2442.8	0.04
167.8	0.217	1317.8	0.048	2467.8	0.039
192.8	0.171	1342.8	0.048	2492.8	0.039
217.8	0.139	1367.8	0.047	2517.8	0.039
242.8	0.118	1392.8	0.047	2542.8	0.039
267.8	0.103	1417.8	0.047	2567.8	0.04
292.8	0.092	1442.8	0.047	2592.8	0.04
317.8	0.084	1467.8	0.047	2617.8	0.04
342.8	0.078	1492.8	0.045	2642.8	0.039
367.8	0.073	1517.8	0.047	2667.8	0.039
392.8	0.07	1542.8	0.045	2692.8	0.04

<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
417.8	0.067	1567.8	0.045	2717.8	0.04
442.8	0.064	1592.8	0.045	2742.8	0.04
467.8	0.062	1617.8	0.045	2767.8	0.04
492.8	0.061	1642.8	0.044	2792.8	0.039
517.8	0.059	1667.8	0.045	2817.8	0.039
542.8	0.057	1692.8	0.044	2842.8	0.038
567.8	0.056	1717.8	0.044	2867.8	0.038
592.8	0.056	1742.8	0.044	2892.8	0.038
617.8	0.054	1767.8	0.044	2917.8	0.038
642.8	0.054	1792.8	0.043	2942.8	0.038
667.8	0.054	1817.8	0.043	2967.8	0.038
692.8	0.054	1842.8	0.043	2992.8	0.038
717.8	0.053	1867.8	0.043	3017.8	0.038
742.8	0.052	1892.8	0.043	3042.8	0.038
767.8	0.052	1917.8	0.043	3067.8	0.038
792.8	0.052	1942.8	0.042	3092.8	0.039
817.8	0.052	1967.8	0.041	3117.8	0.039
842.8	0.051	1992.8	0.041	3142.8	0.04
867.8	0.05	2017.8	0.041	3167.8	0.039
892.8	0.05	2042.8	0.041	3192.8	0.04
917.8	0.051	2067.8	0.04	3217.8	0.04
942.8	0.051	2092.8	0.041	3242.8	0.052
967.8	0.05	2117.8	0.04	3267.8	0.052
992.8	0.05	2142.8	0.04	3292.8	0.051
1017.8	0.05	2167.8	0.041	3317.8	0.05

SOLUTION

Aquifer Model: Unconfined
 Solution Method: Bouwer-Rice

VISUAL ESTIMATION RESULTS

Estimated Parameters

<u>Parameter</u>	<u>Estimate</u>	
K	0.0001062	ft/sec
y0	1.71	ft

Date: 01/12/06

Time: 11:04:45

PROJECT INFORMATION

Company: CH2M Hill

Client: NDWIH

Project: 314446

Location: Indian Head, MD

Test Date: 02/23/2005

Test Well: IS17MW02

AQUIFER DATA

Saturated Thickness: 15. ft

Anisotropy Ratio (Kz/Kr): 1.

OBSERVATION WELL DATA

Number of observation wells: 1

Observation Well No. 1: IS17MW02

X Location: 0. ft

Y Location: 0. ft

No. of observations: 63

<u>Observation Data</u>					
<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
0.	3.56	377.	0.096	902.	0.019
2.	2.78	402.	0.081	927.	0.019
4.9	2.572	427.	0.071	952.	0.017
8.6	2.44	452.	0.062	977.	0.016
13.6	2.288	477.	0.055	1002.	0.015
20.3	2.112	502.	0.052	1027.	0.014
28.8	1.917	527.	0.045	1052.	0.014
40.5	1.683	552.	0.042	1077.	0.014
56.1	1.422	577.	0.039	1102.	0.014
77.	1.143	602.	0.036	1127.	0.013
102.	0.888	627.	0.033	1152.	0.013
127.	0.695	652.	0.032	1177.	0.014
152.	0.551	677.	0.03	1202.	0.013
177.	0.44	702.	0.027	1227.	0.013
202.	0.355	727.	0.026	1252.	0.012
227.	0.289	752.	0.024	1277.	0.012
252.	0.238	777.	0.024	1302.	0.012
277.	0.193	802.	0.023	1327.	0.011
302.	0.16	827.	0.021	1352.	0.011
327.	0.132	852.	0.021	1377.	0.011
352.	0.111	877.	0.02	1402.	0.011

SOLUTION

Aquifer Model: Unconfined

Solution Method: Bouwer-Rice

Data Set: C:\Documents and Settings\izmudzin\Desktop\Indian Head Slug Test Data\Slug Test Analysis 2\Final In
Date: 01/12/06
Time: 11:04:54

PROJECT INFORMATION

Company: CH2M Hill
Client: NDWIH
Project: 314446
Location: Indian Head, MD
Test Date: 02/23/2005
Test Well: IS17MW02

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

OBSERVATION WELL DATA

Number of observation wells: 1

Observation Well No. 1: IS17MW02

X Location: 0. ft

Y Location: 0. ft

No. of observations: 46

Observation Data					
Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.	2.862	158.1	0.225	558.1	0.022
1.5	2.763	183.1	0.178	583.1	0.021
3.	2.675	208.1	0.143	608.1	0.018
4.5	2.452	233.1	0.116	633.1	0.017
6.1	2.336	258.1	0.095	658.1	0.016
8.1	2.198	283.1	0.079	683.1	0.016
11.	2.033	308.1	0.066	708.1	0.015
14.7	1.845	333.1	0.056	733.1	0.014
19.7	1.628	358.1	0.049	758.1	0.014
26.4	1.379	383.1	0.042	783.1	0.013
34.9	1.111	408.1	0.038	808.1	0.012
46.6	0.84	433.1	0.034	833.1	0.012
62.2	0.633	458.1	0.031	858.1	0.012
83.1	0.481	483.1	0.027	883.1	0.01
108.1	0.369	508.1	0.025		
133.1	0.287	533.1	0.023		

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

VISUAL ESTIMATION RESULTS

Estimated Parameters

<u>Parameter</u>	<u>Estimate</u>	
K	5.293E-05	ft/sec
y0	0.9017	ft

Data Set: C:\Documents and Settings\izmudzin\Desktop\Indian Head Slug Test Data\Slug Test Analysis 2\Final In
Date: 01/12/06
Time: 11:05:13

PROJECT INFORMATION

Company: CH2M Hill
Client: NDWIH
Project: 314446
Location: Indian Head, MD
Test Date: 02/23/2005
Test Well: IS17MW03

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

OBSERVATION WELL DATA

Number of observation wells: 1

Observation Well No. 1: IS17MWO3

X Location: 0. ft

Y Location: 0. ft

No. of observations: 116

<u>Observation Data</u>					
<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
0.	3.904	733.1	0.632	1708.1	0.215
1.5	3.67	758.1	0.611	1733.1	0.21
3.	3.494	783.1	0.591	1758.1	0.205
4.5	3.38	808.1	0.572	1783.1	0.201
6.1	3.286	833.1	0.553	1808.1	0.196
8.1	3.2	858.1	0.537	1833.1	0.191
11.	3.114	883.1	0.519	1858.1	0.187
14.7	3.019	908.1	0.504	1883.1	0.183
19.7	2.914	933.1	0.487	1908.1	0.18
26.4	2.798	958.1	0.472	1933.1	0.174
34.9	2.667	983.1	0.458	1958.1	0.171
46.6	2.519	1008.1	0.445	1983.1	0.168
62.2	2.349	1033.1	0.432	2008.1	0.164
83.1	2.186	1058.1	0.421	2033.1	0.16
108.1	2.029	1083.1	0.408	2058.1	0.157
133.1	1.893	1108.1	0.397	2083.1	0.154
158.1	1.774	1133.1	0.385	2108.1	0.151
183.1	1.668	1158.1	0.375	2133.1	0.149
208.1	1.574	1183.1	0.365	2158.1	0.146
233.1	1.488	1208.1	0.355	2183.1	0.142
258.1	1.409	1233.1	0.345	2208.1	0.139

<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
283.1	1.337	1258.1	0.336	2233.1	0.137
308.1	1.271	1283.1	0.327	2258.1	0.135
333.1	1.21	1308.1	0.318	2283.1	0.132
358.1	1.153	1333.1	0.31	2308.1	0.13
383.1	1.101	1358.1	0.303	2333.1	0.127
408.1	1.052	1383.1	0.295	2358.1	0.124
433.1	1.007	1408.1	0.288	2383.1	0.121
458.1	0.964	1433.1	0.281	2408.1	0.12
483.1	0.924	1458.1	0.274	2433.1	0.116
508.1	0.887	1483.1	0.267	2458.1	0.114
533.1	0.852	1508.1	0.26	2483.1	0.113
558.1	0.819	1533.1	0.254	2508.1	0.11
583.1	0.788	1558.1	0.248	2533.1	0.108
608.1	0.758	1583.1	0.242	2558.1	0.107
633.1	0.731	1608.1	0.237	2583.1	0.105
658.1	0.704	1633.1	0.231	2608.1	0.102
683.1	0.679	1658.1	0.226	2633.1	0.1
708.1	0.655	1683.1	0.22		

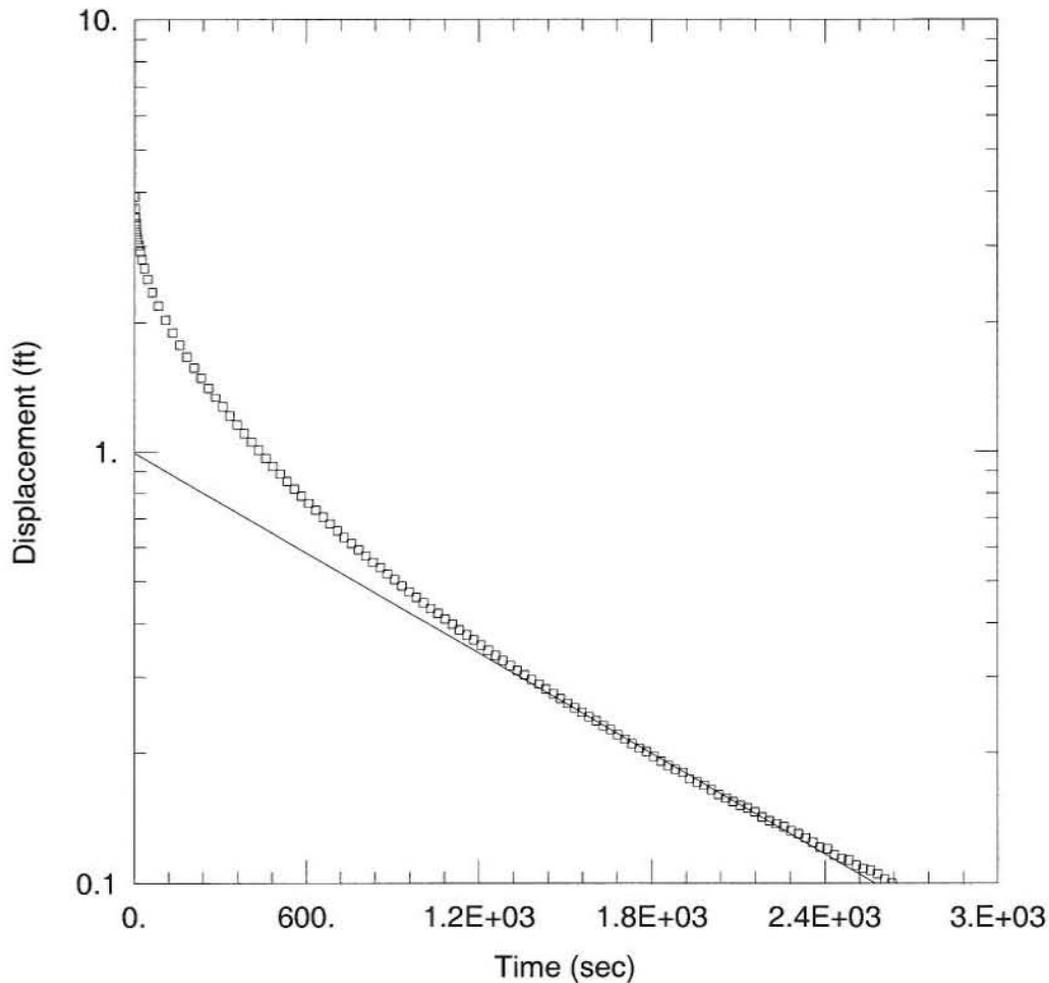
SOLUTION

Aquifer Model: Unconfined
 Solution Method: Bouwer-Rice

VISUAL ESTIMATION RESULTS

Estimated Parameters

<u>Parameter</u>	<u>Estimate</u>	
K	1.342E-05	ft/sec
y0	2.033	ft



WELL TEST ANALYSIS

Data Set: C:\...\MW03_LateFallingA.aqt
 Date: 01/12/06

Time: 11:05:36

PROJECT INFORMATION

Company: CH2M Hill
 Client: NDWIH
 Project: 314446
 Test Location: Indian Head, MD
 Test Well: IS17MW03
 Test Date: 02/23/2005

AQUIFER DATA

Saturated Thickness: 15. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (IS17MW03)

Initial Displacement: 3.904 ft
 Casing Radius: 0.083 ft
 Screen Length: 5. ft

Water Column Height: 16. ft
 Wellbore Radius: 0.33 ft
 Gravel Pack Porosity: 0.25

SOLUTION

Aquifer Model: Unconfined
 K = 7.546E-06 ft/sec

Solution Method: Bouwer-Rice
 y0 = 0.992 ft

Data Set: C:\Documents and Settings\izmudzin\Desktop\Indian Head Slug Test Data\Slug Test Analysis 2\Final In
 Date: 01/12/06
 Time: 11:05:40

PROJECT INFORMATION

Company: CH2M Hill
 Client: NDWIH
 Project: 314446
 Location: Indian Head, MD
 Test Date: 02/23/2005
 Test Well: IS17MW03

AQUIFER DATA

Saturated Thickness: 15. ft
 Anisotropy Ratio (Kz/Kr): 1.

OBSERVATION WELL DATA

Number of observation wells: 1

Observation Well No. 1: IS17MWO3

X Location: 0. ft
 Y Location: 0. ft

No. of observations: 116

Observation Data					
Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.	3.904	733.1	0.632	1708.1	0.215
1.5	3.67	758.1	0.611	1733.1	0.21
3.	3.494	783.1	0.591	1758.1	0.205
4.5	3.38	808.1	0.572	1783.1	0.201
6.1	3.286	833.1	0.553	1808.1	0.196
8.1	3.2	858.1	0.537	1833.1	0.191
11.	3.114	883.1	0.519	1858.1	0.187
14.7	3.019	908.1	0.504	1883.1	0.183
19.7	2.914	933.1	0.487	1908.1	0.18
26.4	2.798	958.1	0.472	1933.1	0.174
34.9	2.667	983.1	0.458	1958.1	0.171
46.6	2.519	1008.1	0.445	1983.1	0.168
62.2	2.349	1033.1	0.432	2008.1	0.164
83.1	2.186	1058.1	0.421	2033.1	0.16
108.1	2.029	1083.1	0.408	2058.1	0.157
133.1	1.893	1108.1	0.397	2083.1	0.154
158.1	1.774	1133.1	0.385	2108.1	0.151
183.1	1.668	1158.1	0.375	2133.1	0.149
208.1	1.574	1183.1	0.365	2158.1	0.146
233.1	1.488	1208.1	0.355	2183.1	0.142
258.1	1.409	1233.1	0.345	2208.1	0.139

<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
283.1	1.337	1258.1	0.336	2233.1	0.137
308.1	1.271	1283.1	0.327	2258.1	0.135
333.1	1.21	1308.1	0.318	2283.1	0.132
358.1	1.153	1333.1	0.31	2308.1	0.13
383.1	1.101	1358.1	0.303	2333.1	0.127
408.1	1.052	1383.1	0.295	2358.1	0.124
433.1	1.007	1408.1	0.288	2383.1	0.121
458.1	0.964	1433.1	0.281	2408.1	0.12
483.1	0.924	1458.1	0.274	2433.1	0.116
508.1	0.887	1483.1	0.267	2458.1	0.114
533.1	0.852	1508.1	0.26	2483.1	0.113
558.1	0.819	1533.1	0.254	2508.1	0.11
583.1	0.788	1558.1	0.248	2533.1	0.108
608.1	0.758	1583.1	0.242	2558.1	0.107
633.1	0.731	1608.1	0.237	2583.1	0.105
658.1	0.704	1633.1	0.231	2608.1	0.102
683.1	0.679	1658.1	0.226	2633.1	0.1
708.1	0.655	1683.1	0.22		

SOLUTION

Aquifer Model: Unconfined
 Solution Method: Bouwer-Rice

VISUAL ESTIMATION RESULTS

Estimated Parameters

<u>Parameter</u>	<u>Estimate</u>	
K	7.546E-06	ft/sec
y0	0.992	ft

Data Set: C:\Documents and Settings\izmudzin\Desktop\Indian Head Slug Test Data\Slug Test Analysis 2\Final In
 Date: 01/12/06
 Time: 11:05:28

PROJECT INFORMATION

Company: CH2M Hill
 Client: NDWIH
 Project: 314446
 Location: Indian Head, MD
 Test Date: 02/23/2005
 Test Well: IS17MW03

AQUIFER DATA

Saturated Thickness: 15. ft
 Anisotropy Ratio (Kz/Kr): 1.

OBSERVATION WELL DATA

Number of observation wells: 1

Observation Well No. 1: IS17MW03

X Location: 0. ft

Y Location: 0. ft

No. of observations: 120

<u>Observation Data</u>					
<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
0.	4.243	781.6	0.638	1806.6	0.263
1.5	3.821	806.6	0.619	1831.6	0.259
3.	3.615	831.6	0.602	1856.6	0.255
4.6	3.498	856.6	0.586	1881.6	0.25
6.6	3.393	881.6	0.57	1906.6	0.246
9.5	3.297	906.6	0.554	1931.6	0.243
13.2	3.2	931.6	0.54	1956.6	0.24
18.2	3.092	956.6	0.526	1981.6	0.235
24.9	2.974	981.6	0.513	2006.6	0.232
33.4	2.849	1006.6	0.499	2031.6	0.228
45.1	2.701	1031.6	0.487	2056.6	0.225
60.7	2.531	1056.6	0.476	2081.6	0.221
81.6	2.341	1081.6	0.464	2106.6	0.218
106.6	2.153	1106.6	0.454	2131.6	0.215
131.6	1.994	1131.6	0.442	2156.6	0.212
156.6	1.857	1156.6	0.432	2181.6	0.21
181.6	1.738	1181.6	0.422	2206.6	0.207
206.6	1.633	1206.6	0.414	2231.6	0.205
231.6	1.539	1231.6	0.404	2256.6	0.203
256.6	1.455	1256.6	0.396	2281.6	0.2
281.6	1.378	1281.6	0.388	2306.6	0.197

<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
306.6	1.308	1306.6	0.379	2331.6	0.195
331.6	1.245	1331.6	0.371	2356.6	0.193
356.6	1.186	1356.6	0.364	2381.6	0.191
381.6	1.13	1381.6	0.356	2406.6	0.188
406.6	1.081	1406.6	0.35	2431.6	0.186
431.6	1.036	1431.6	0.344	2456.6	0.184
456.6	0.996	1481.6	0.331	2481.6	0.182
481.6	0.957	1506.6	0.324	2506.6	0.179
506.6	0.922	1531.6	0.318	2531.6	0.178
531.6	0.887	1556.6	0.312	2556.6	0.176
556.6	0.855	1581.6	0.307	2581.6	0.174
581.6	0.826	1606.6	0.302	2606.6	0.172
606.6	0.797	1631.6	0.297	2631.6	0.17
631.6	0.771	1656.6	0.291	2656.6	0.169
656.6	0.746	1681.6	0.286	2681.6	0.167
681.6	0.722	1706.6	0.281	2706.6	0.165
706.6	0.699	1731.6	0.277	2731.6	0.164
731.6	0.677	1756.6	0.272	2756.6	0.162
756.6	0.657	1781.6	0.267	2781.6	0.159

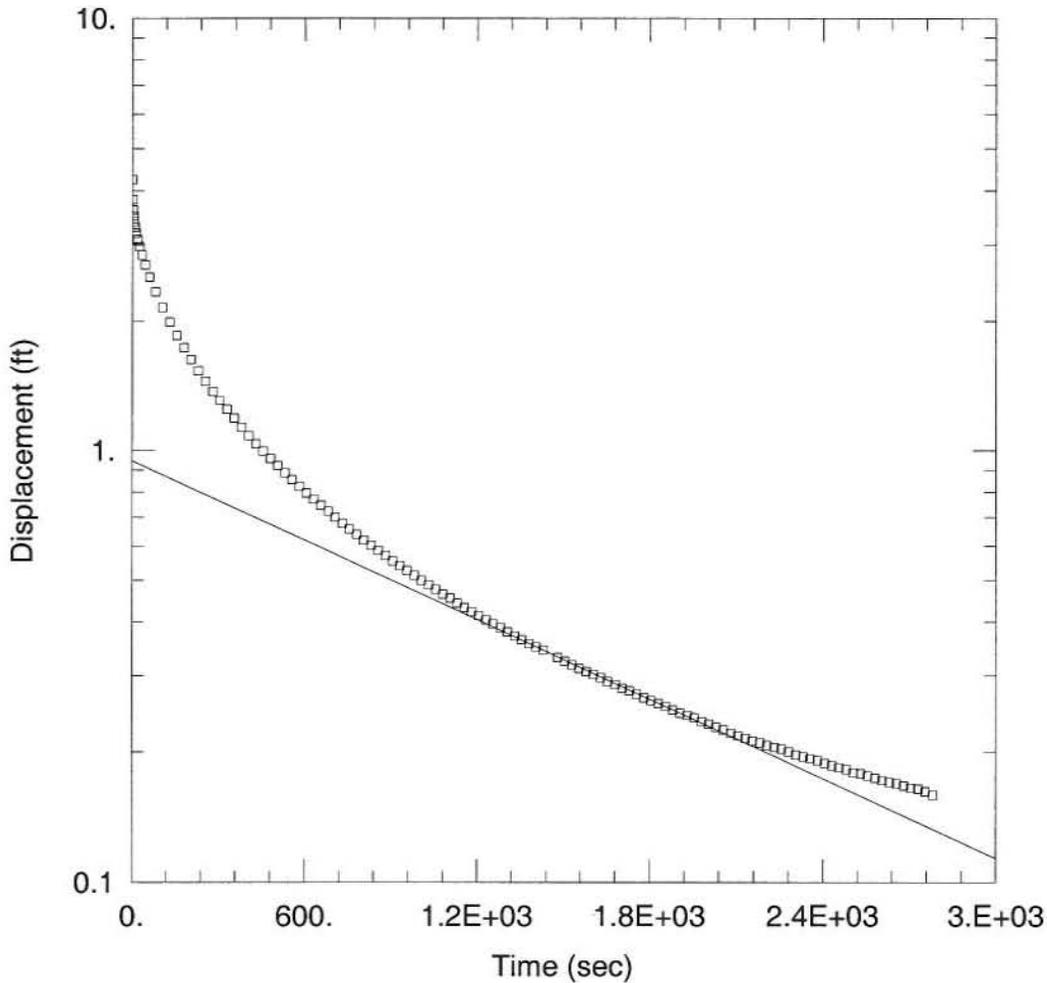
SOLUTION

Aquifer Model: Unconfined
 Solution Method: Bouwer-Rice

VISUAL ESTIMATION RESULTS

Estimated Parameters

<u>Parameter</u>	<u>Estimate</u>	
K	1.336E-05	ft/sec
y0	2.082	ft



WELL TEST ANALYSIS

Data Set: C:\...\MW03_LateFallingB.aqt

Date: 01/12/06

Time: 11:05:46

PROJECT INFORMATION

Company: CH2M Hill

Client: NDWIH

Project: 314446

Test Location: Indian Head, MD

Test Well: IS17MW03

Test Date: 02/23/2005

AQUIFER DATA

Saturated Thickness: 15. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (IS17MW03)

Initial Displacement: 4.243 ft

Water Column Height: 16. ft

Casing Radius: 0.083 ft

Wellbore Radius: 0.33 ft

Screen Length: 5. ft

Gravel Pack Porosity: 0.25

SOLUTION

Aquifer Model: Unconfined

Solution Method: Bouwer-Rice

K = 5.986E-06 ft/sec

y0 = 0.9466 ft

Data Set: C:\Documents and Settings\izmudzin\Desktop\Indian Head Slug Test Data\Slug Test Analysis 2\Final In
Date: 01/12/06
Time: 11:05:49

PROJECT INFORMATION

Company: CH2M Hill
Client: NDWIH
Project: 314446
Location: Indian Head, MD
Test Date: 02/23/2005
Test Well: IS17MW03

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

OBSERVATION WELL DATA

Number of observation wells: 1

Observation Well No. 1: IS17MW03

X Location: 0. ft

Y Location: 0. ft

No. of observations: 120

<u>Observation Data</u>					
<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
0.	4.243	781.6	0.638	1806.6	0.263
1.5	3.821	806.6	0.619	1831.6	0.259
3.	3.615	831.6	0.602	1856.6	0.255
4.6	3.498	856.6	0.586	1881.6	0.25
6.6	3.393	881.6	0.57	1906.6	0.246
9.5	3.297	906.6	0.554	1931.6	0.243
13.2	3.2	931.6	0.54	1956.6	0.24
18.2	3.092	956.6	0.526	1981.6	0.235
24.9	2.974	981.6	0.513	2006.6	0.232
33.4	2.849	1006.6	0.499	2031.6	0.228
45.1	2.701	1031.6	0.487	2056.6	0.225
60.7	2.531	1056.6	0.476	2081.6	0.221
81.6	2.341	1081.6	0.464	2106.6	0.218
106.6	2.153	1106.6	0.454	2131.6	0.215
131.6	1.994	1131.6	0.442	2156.6	0.212
156.6	1.857	1156.6	0.432	2181.6	0.21
181.6	1.738	1181.6	0.422	2206.6	0.207
206.6	1.633	1206.6	0.414	2231.6	0.205
231.6	1.539	1231.6	0.404	2256.6	0.203
256.6	1.455	1256.6	0.396	2281.6	0.2
281.6	1.378	1281.6	0.388	2306.6	0.197

<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>	<u>Time (sec)</u>	<u>Displacement (ft)</u>
306.6	1.308	1306.6	0.379	2331.6	0.195
331.6	1.245	1331.6	0.371	2356.6	0.193
356.6	1.186	1356.6	0.364	2381.6	0.191
381.6	1.13	1381.6	0.356	2406.6	0.188
406.6	1.081	1406.6	0.35	2431.6	0.186
431.6	1.036	1431.6	0.344	2456.6	0.184
456.6	0.996	1481.6	0.331	2481.6	0.182
481.6	0.957	1506.6	0.324	2506.6	0.179
506.6	0.922	1531.6	0.318	2531.6	0.178
531.6	0.887	1556.6	0.312	2556.6	0.176
556.6	0.855	1581.6	0.307	2581.6	0.174
581.6	0.826	1606.6	0.302	2606.6	0.172
606.6	0.797	1631.6	0.297	2631.6	0.17
631.6	0.771	1656.6	0.291	2656.6	0.169
656.6	0.746	1681.6	0.286	2681.6	0.167
681.6	0.722	1706.6	0.281	2706.6	0.165
706.6	0.699	1731.6	0.277	2731.6	0.164
731.6	0.677	1756.6	0.272	2756.6	0.162
756.6	0.657	1781.6	0.267	2781.6	0.159

SOLUTION

Aquifer Model: Unconfined
 Solution Method: Bouwer-Rice

VISUAL ESTIMATION RESULTS

Estimated Parameters

<u>Parameter</u>	<u>Estimate</u>	
K	5.986E-06	ft/sec
y0	0.9466	ft

Appendix F
Soil Oxidant Demand Results



CH2M HILL
Applied Sciences Group
2300 NW Walnut Blvd
Corvallis, OR
97330-3538
P.O. Box 428
Corvallis, OR
97339-0428
Tel 541.752.4271
Fax 541.752.0276

March 16, 2005

Indian Head Site 17

314446.SA.SM

RE: Laboratory Report for Indian Head Site 17
Applied Sciences Group Reference No. E1310

Ed Corack/WDC:

On March 03, 2005, CH2M HILL Applied Sciences Group received two samples with a request for analysis of selected parameters. All analyses were performed by CH2M HILL unless otherwise indicated below.

The analytical results and associated quality control data are enclosed. Any unusual difficulties encountered during the analysis of your samples are discussed in the case narrative. This data package meets standards requested by client and is not intended or implied to meet any other standard.

CH2M HILL Applied Sciences Group appreciates your business and looks forward to serving your analytical needs again. If you should have any questions concerning the data, or if you need additional information, please call Kathy McKinley at (541) 758-0235, extension 3144.

Sincerely,

A handwritten signature in cursive script that reads "Kathy McKinley".

Kathy McKinley
Analytical Manager

Enclosures

CLIENT SAMPLE CROSS-REFERENCE

CH2M HILL Applied Sciences Group Reference No. E1310

Sample ID	Client Sample ID	Date Collected	Time Collected
E131001	IS17DS35-0404	03/02/2005	10:45
E131002	IS17GW35-0405	03/02/2005	11:15

CASE NARRATIVE
SPECIAL ANALYTICS

Lab Reference No.: E1310

Client/Project: Indian Head Site 17

- I. Holding Time:
All acceptance criteria were met.
- II. Digestion Exceptions:
None
- III. Analysis:
- A. Calibration:
Not applicable.
- B. Matrix Spike Sample(s):
Not applicable.
- C. Duplicate Sample(s):
Not applicable.
- D. Lab Control Sample(s):
Not applicable.
- E. Other:
Although two (2) samples were received for analysis, site soil and site groundwater, the groundwater was not analyzed as part of the MOD-48 matrix per Gene Peters/WDC.
- III. Documentation Exceptions:
None.
- IV. I certify that this data package is in compliance with the terms and conditions agreed to by the client and CH2M HILL, both technically and for completeness, except for the conditions detailed above. Release of the data contained in this hardcopy data package has been authorized by the Laboratory Manager or his designee, as verified by the following signature.

Prepared by:  _____

Reviewed by: Kathy Machis _____

CH2M HILL Applied Sciences Laboratory

Client Information

Client Sample ID: IS17DS35-0404

Project Name: Indian Head Site 17
Project Manager: Ed Corack/WDC
Sampled By: D.M.
Sampling Date: 03/02/2005
Sampling Time: 10:45
Type: Grab
Matrix: Soil
Basis: Dry weight

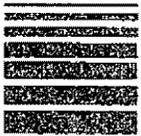
Lab Information

Lab Batch ID: E1310

Date Received: 03/03/2005
Report Revision No.: 0
Reported By: MCB
Reviewed By: *EM*

Analyte	MRL	Sample Result	Qualifier	Units	Analysis Method	Date Analyzed
General Chemistry						
Matrix Oxidant Demand 48-hr	1	48		g/kg	SIREM	03/14/2005

U=Not detected at specified reporting limits



CompuChem
a division of Liberty Analytical Corp.

CHAIN OF CUSTODY

501 Madison Ave.
Cary, NC 27513

Phone: 919-379-4100 Fax 919-379-4040

E1310

Courier *Fed Ex*
Airbill No.
Sampling Complete? Y or N

Client/Reporting Information		Project Information					Requested Analysis (include method and bottle type)										Matrices					
Company Name <i>Cham Hill / WDC</i>		Project Name <i>INDIAN HEAD</i>					<i>(SIREM)</i> <i>TOTAL OXIDANT DEMAND</i>										GW - Ground water					
Address <i>13921 PARK CENTER RD STE 600</i>		Sampling Location <i>SITE 17</i>															WW - Waste water					
City State Zip <i>HERNDON VA 20171</i>		Turnaround time															SW - Surface water					
Project Contact <i>Ed Corack</i>		Batch QC or Project Specific? If Specific, which Sample ID?															SO - Soil/Sediment					
Phone # <i>703 471 6405 x4125</i>		Are aqueous samples field filtered for metals? Y or N					TB - Trip Blank															
Sampler's Name <i>D. MARTINSON</i>		Are high concentrations expected? Y or N? If yes, which ID(s)?					RI - Rinsate															
CompuChem No (Lab Use)		Collection		Number of Preserved Bottles													WP - Wipe					
Field ID		Date	Time	Matrix	# of bottles	HCl	NaOH	NH ₃	H ₂ SO ₄	MeOH	Other											O - Other
<i>IS17DS35-0405</i>		<i>3/2</i>	<i>1045</i>	<i>S</i>	<i>1</i>						<i>1</i>											<i>-1</i>
<i>IS17GW35-0405</i>		<i>3/2</i>	<i>1115</i>	<i>W</i>	<i>2</i>						<i>2</i>											<i>-2</i>

Lab Use Only

Sample Unpacked By: _____ Cyanide samples checked for sulfide & chlorine? Y or N/

Sample Order Entry By: _____ 625 & Phenol samples checked for chlorine? Y or NA

Samples Received in Good Condition? Y or N _____ 608 samples checked for pH between 5.0-9.0? Y or NA

If no, explain: _____

Sample Custody

Relinquished by: *[Signature]* Date/Time: *3/2 1700* Received by: _____

Relinquished by: _____ Date/Time: _____ Received by: _____

Subcontact? Y or N If yes, where? _____ Custody Seal(s) intact

FedEx PRIORITY OVERNIGHT THU
 8504 7660 1200 8700
 97330 -OR- US PDX
XH CVOA
 Deliver By: 03MARCH
 Barcode: [Barcode]
 °C



Sample Receipt Record

Batch Number: 21310

Date received: 3/3/05

Client/Project: Indian Head

VERIFICATION OF SAMPLE CONDITIONS (verify all items) * HD = Client Hand delivered Samples

Observation	YES	NO
Radiological Screening for AFCEE		<input checked="" type="checkbox"/>
Were custody seals intact and on the outside of the cooler?	<input checked="" type="checkbox"/>	
If yes, Where? Front <input type="checkbox"/> Rear <input checked="" type="checkbox"/> Lt Side <input type="checkbox"/> Rt Side <input type="checkbox"/>		
Type of packing material: Ice <input checked="" type="checkbox"/> Blue Ice <input type="checkbox"/> Bubble wrap <input type="checkbox"/>	<input checked="" type="checkbox"/>	
Was the Chain of Custody inside the cooler?	<input checked="" type="checkbox"/>	
Was the Chain of Custody properly filled out?	<input checked="" type="checkbox"/>	
Were the sample containers in good condition?	<input checked="" type="checkbox"/>	
Containers supplied by ASL?	<input checked="" type="checkbox"/>	
Any sample with < 1/2 holding time remaining? If so contact LPM		<input checked="" type="checkbox"/>
Was there ice in the cooler? Enter temp. <u>22</u> C		
All VOCs free of air bubbles? <u>NA</u>		

If the answer to any of the questions above is NO, a Sample Receipt Exceptions Report Must be written.

VERIFICATION OF SAMPLE PRESERVATION (verify all preserved samples except HAAs, HANs and CH)

Sample No	Nutrients pH <2	Metals pH <2	Volatiles pH <2	Cyanides pH >12	TOC pH <2	TOX pH <2	Other (specify)	N/A (soils/unpres)
1								↓
2								↓
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								

LOGIN AND pH VERIFICATIONS PERFORMED BY
[Signature]
Date/Time

3/3/05 11:30
Date/Time

Appendix G
2005 Upgradient Investigation MIP Data

**Subsurface Characterization Using
Membrane Interface Probe (MIP) and
Soil Conductivity (SC) Technologies
Indian Head Naval Warfare Station Site 17
Indian Head, Maryland**

PREPARED FOR

CH2MHill
13921 Park Center Road, Suite 600
Herndon, Virginia 20171

September 3rd, 2005

PREPARED BY

COLUMBIA Technologies, LLC
1448 South Rolling Rd.
Baltimore, Maryland 21227
410-536-9911
www.columbiatechnologies.com

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Investigation Method.....	5
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FIGURES

Figure 1. Sitemap and MIP Locations

APPENDIX

Appendix A: MIP Logs (Best Fit Scale)

Introduction

CH2MHill (CH2MHill), contracted COLUMBIA Technologies, LLC (COLUMBIA) to conduct an investigation of subsurface contamination at the Indian Head Naval Warfare Station Site 17, located in Indian Head, Maryland. This investigation involved delineating the depth and horizontal extent of contamination using Membrane Interface Probe (MIP) and Soil Conductivity (SC) technologies. The purpose of this investigation was to characterize subsurface soils in the vadose and saturated zones, and delineate the nature and extent of soil and groundwater contamination.

The investigation was conducted August 29th, 2005 through September 1st, 2005. COLUMBIA personnel on-site during the third phase included Nikki Auth, Field Geochemist and Brian McGrath, Environmental Field Technician.

Objectives

The objectives of the MIP/SC investigation were to:

1. Characterize subsurface soils in the vadose and saturated zones.
2. Delineate the lateral boundaries of the contaminant in soil and groundwater.
3. Delineate the vertical extent of contamination in soil and groundwater.

Equipment Description

The MIP/SC probe is approximately 12-inches (30 cm) in length and 1.5-inches (3.8 cm) in diameter. The probe is driven into the ground at the nominal rate of one foot per minute using a Geoprobe® or similar direct push rig.

Soil conductivity, the inverse of soil resistivity, is measured using a dipole arrangement. In this process, an alternating electrical current is transmitted through the soil from the center, isolated pin of the probe. This current is then passed back to the probe body. The voltage response of the imposed current to the soil is measured across these same two points. Conductivity is measured in Siemens/meter, and due to the low conductivity of earth materials, the SC probe uses milliSiemens/meter (mS/m). The probe is reasonably accurate in the range of 5 to 400 mS/m. In general, at a given location, lower conductivity values indicate larger particles such as sands, while higher conductivities are representative of finer sized particles such as silts and clays.

The MIP portion of the probe was developed and patented by Geoprobe Systems, Inc. The operating principle is based on heating the soil and/or water around a semi-permeable polymer membrane to 121°C, which allows volatile organic compounds (VOCs) to partition across this membrane. The MIP can be used in saturated or unsaturated soils, as water does not pass through the membrane. Using nitrogen as a carrier gas, which sweeps across the back of the membrane, the VOCs are carried to the installed detectors. It takes approximately 37 seconds for the nitrogen gas stream to travel through 100 feet of inert tubing and reach the detectors.

COLUMBIA utilizes three detectors: a Photo Ionization Detector (PID), a Flame Ionization Detector (FID) and an Electron Capture Detector (ECD), mounted on a laboratory grade Shimadzu Model 14A gas chromatograph. The output signal from the detectors is captured by a MIP data logging system installed on a MIP Field Computer or laptop computer. Conductivity, speed, detector data and temperature are displayed continuously in real time during each push of the probe. In addition, the data logs can be printed for display and analysis following the data logging run or exported to common spreadsheet software for further analysis using COLUMBIA's *SmartData Solutions*[™] technology.

The PID detector consists of a special UV lamp mounted on a thermostat controlled, low volume, flow-through cell. The temperature is adjustable from ambient temperature to 250°C. The 10.2 electron volt (eV) UV lamp emits energy at a wavelength of 120 nanometers, which is sufficient to ionize most aromatics (benzene, toluene, xylene, etc.) and many other molecules (H₂S, hexane, ethanol) whose ionization potential is below 10.2 eV. The PID also emits a lower response for chlorinated compounds such as TCE and PCE. Methanol and water, which have ionization potentials greater than 10.2 eV, do not respond on the PID. Detection limits for aromatics are in the low picogram range. Since the PID is non-destructive, it is often run first in series with other detectors for multiple analyses from a single injection. Use of the PID is mandated in several EPA methods (8021, TO-14 etc.) because of its sensitivity and selectivity.

The most commonly used GC detector is the FID, which responds linearly from its minimum detectable quantity of about 100 picograms. The FID response is very stable from day to day, and is not susceptible to contamination from dirty samples or column bleed. This detector responds to any molecule with a carbon-hydrogen bond, but poorly to compounds such as H₂S, CCl₄, or NH₃. The carrier gas effluent from the GC column is mixed with hydrogen and burned. Hydrogen supports a flame and ionizes the analyte molecules. A collector electrode attracts the

negative ions to the electrometer amplifier, producing an analog signal, which is directed to the data system input.

The ECD detector consists of a sealed stainless steel cylinder containing radioactive Nickel-63. The Nickel-63 emits beta particles (electrons), which collide with the carrier gas molecules, ionizing them in the process. This forms a stable cloud of free electrons in the ECD cell. When electro-negative compounds (especially chlorinated, fluorinated or brominated molecules) such as carbon tetrachloride or TCE enter the cell, they immediately combine with the free electrons, temporarily reducing the number remaining in the electron cloud. The detector electronics, which maintain a constant current of about 1 nanoampere through the electron cloud, are forced to pulse at a faster rate to compensate for the decreased number of free electrons. The pulse rate is converted to an analog output, which is transmitted to the data system.

Response Test

Prior to logging each MIP location, performance tests with specific compounds are conducted to evaluate the sensitivity of the particular probe, transfer line and detector suite to be used. Using neat benzene to test the PID, and neat TCE to test the ECD, the headspace vapors are introduced to the membrane of the probe for four seconds. To test the FID, butane is released on the membrane for four seconds. These values are compared to predetermined values and recorded.

Investigation Methods

MIP/SC profiling was conducted at 13 locations total on the property of Indian Head Naval Warfare, Station Site 17, selected by CH2MHill's representative onsite. Drilling was completed using a Geoprobe® 66DT track mounted rig, and termination of MIP logging was determined by CH2MHill's representative onsite. The results from each location are shown in Appendix A.

MIP Log Interpretation

Each MIP log includes six separate graphs of data. The first graph is conductivity and is measured in mS/M. In general, lower conductivities are indicative of coarser grained particles, such as sands, and higher conductivities indicate finer grained particles, such as silts and clays.

The second graph is the rate of penetration (speed of the probe) and is measured in feet/min. This information can be used to determine how hard the subsurface is. The next three graphs are chemical data: PID, FID, and ECD, measured in microvolts (uV). These graphs are a linear scale, and give relative concentrations of contamination. The last graph displays the temperature of the probe as it is advanced in the subsurface. This graph can be useful to determine where the groundwater table is located.

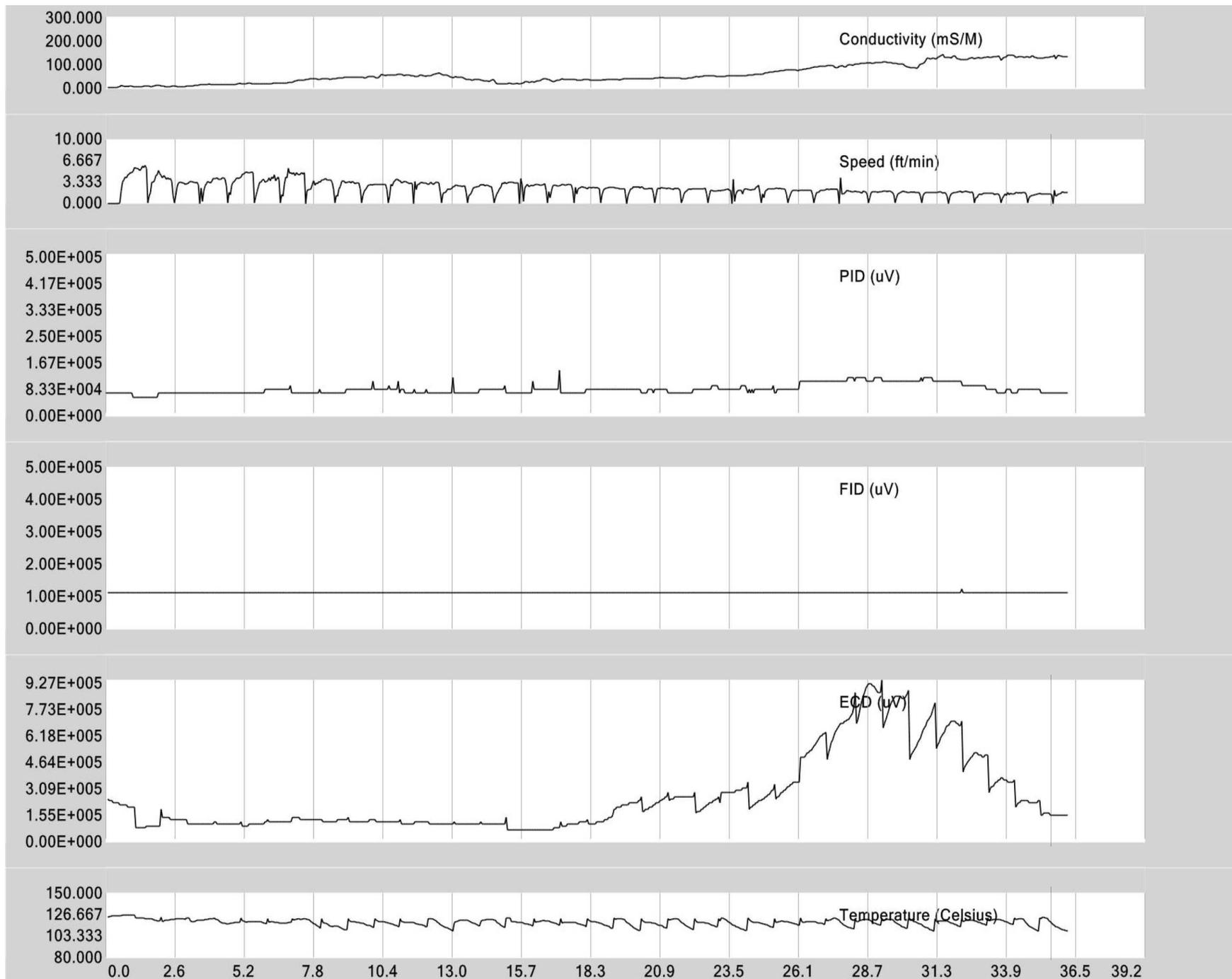


Figure 1
Sitemap and MIP Locations
Indian Head Naval Warfare Station Site 17
CH2MHill
August 29th, 2005 – September 1st, 2005

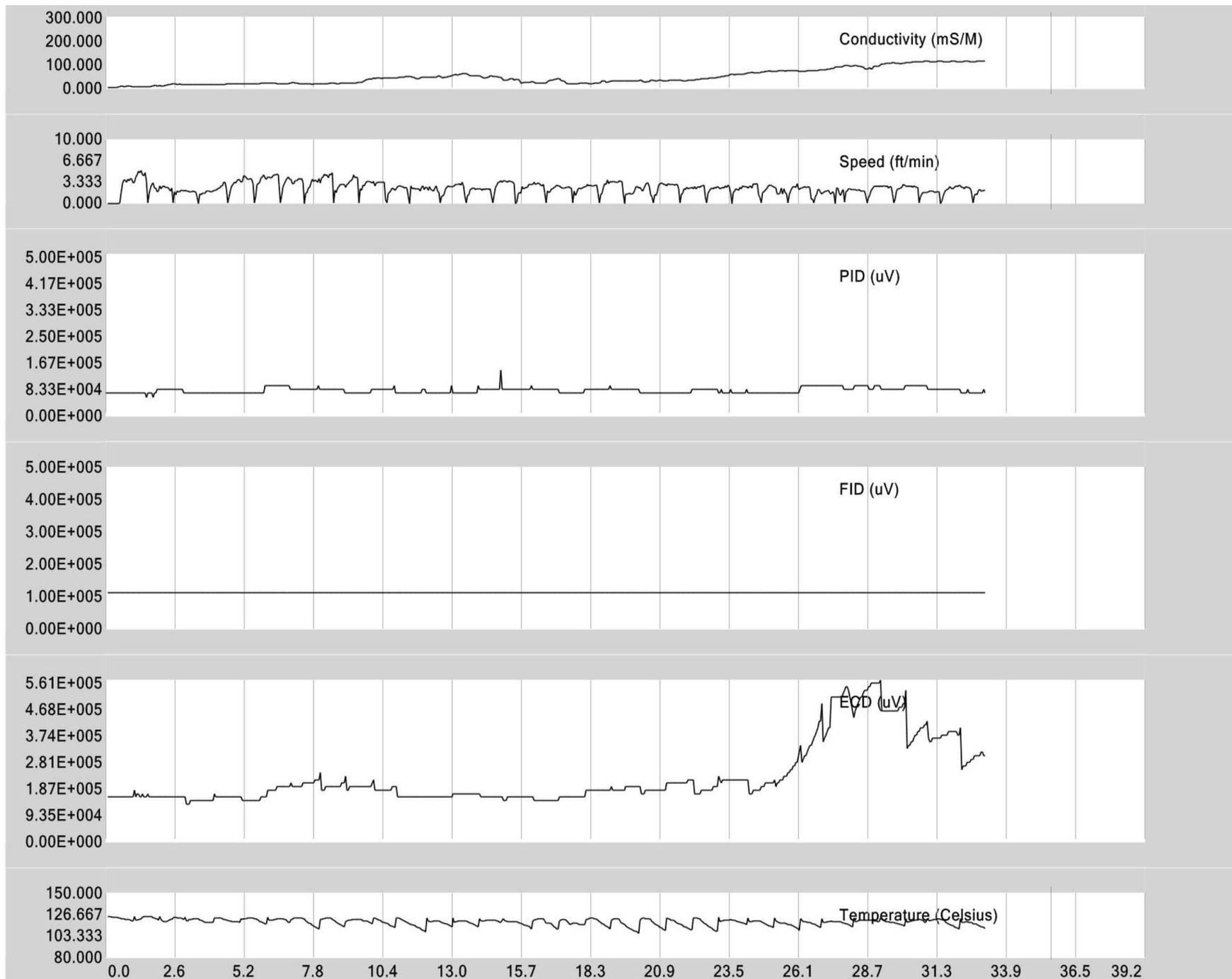
APPENDIX A:

MIP LOGS

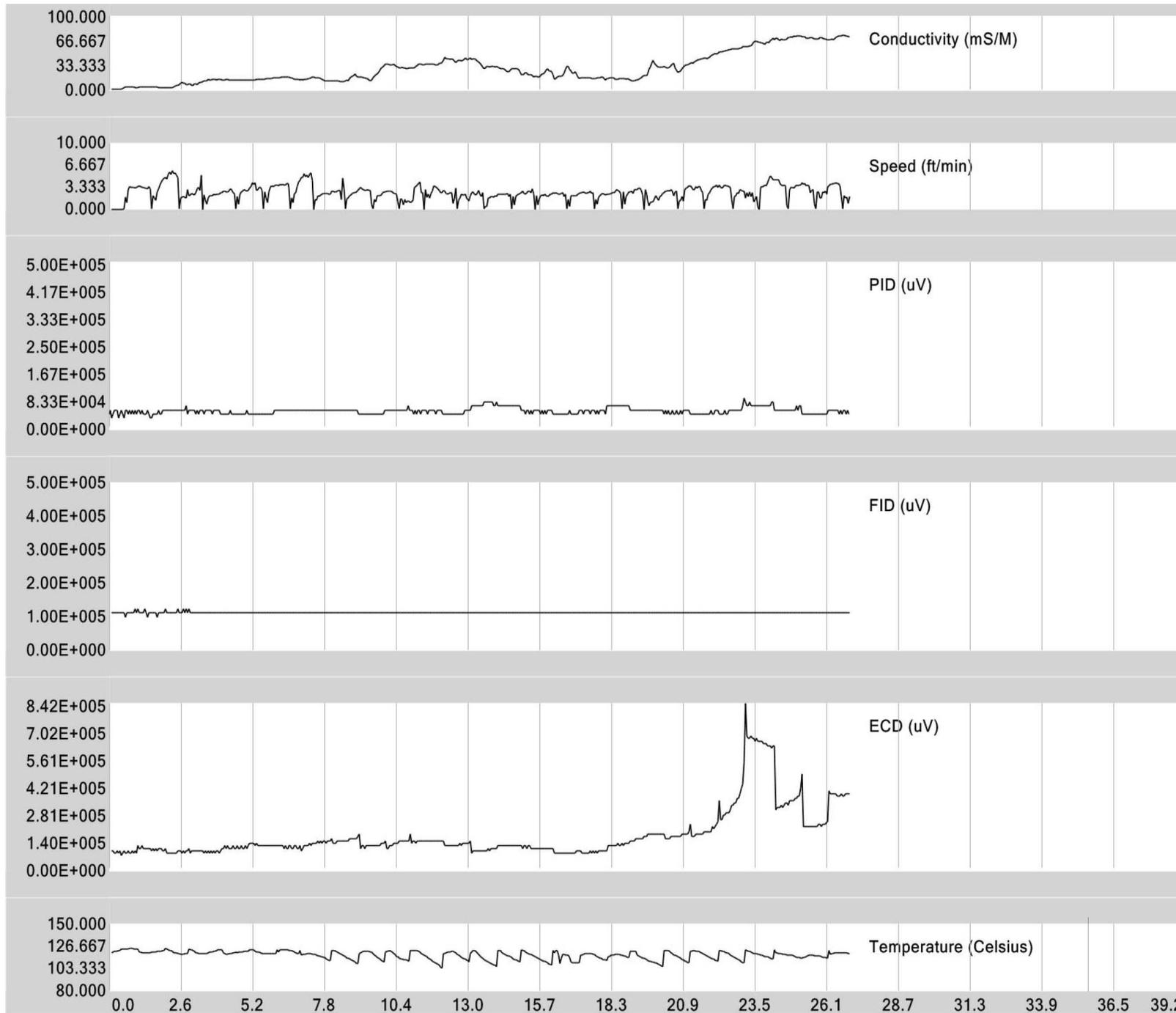
MIP-51



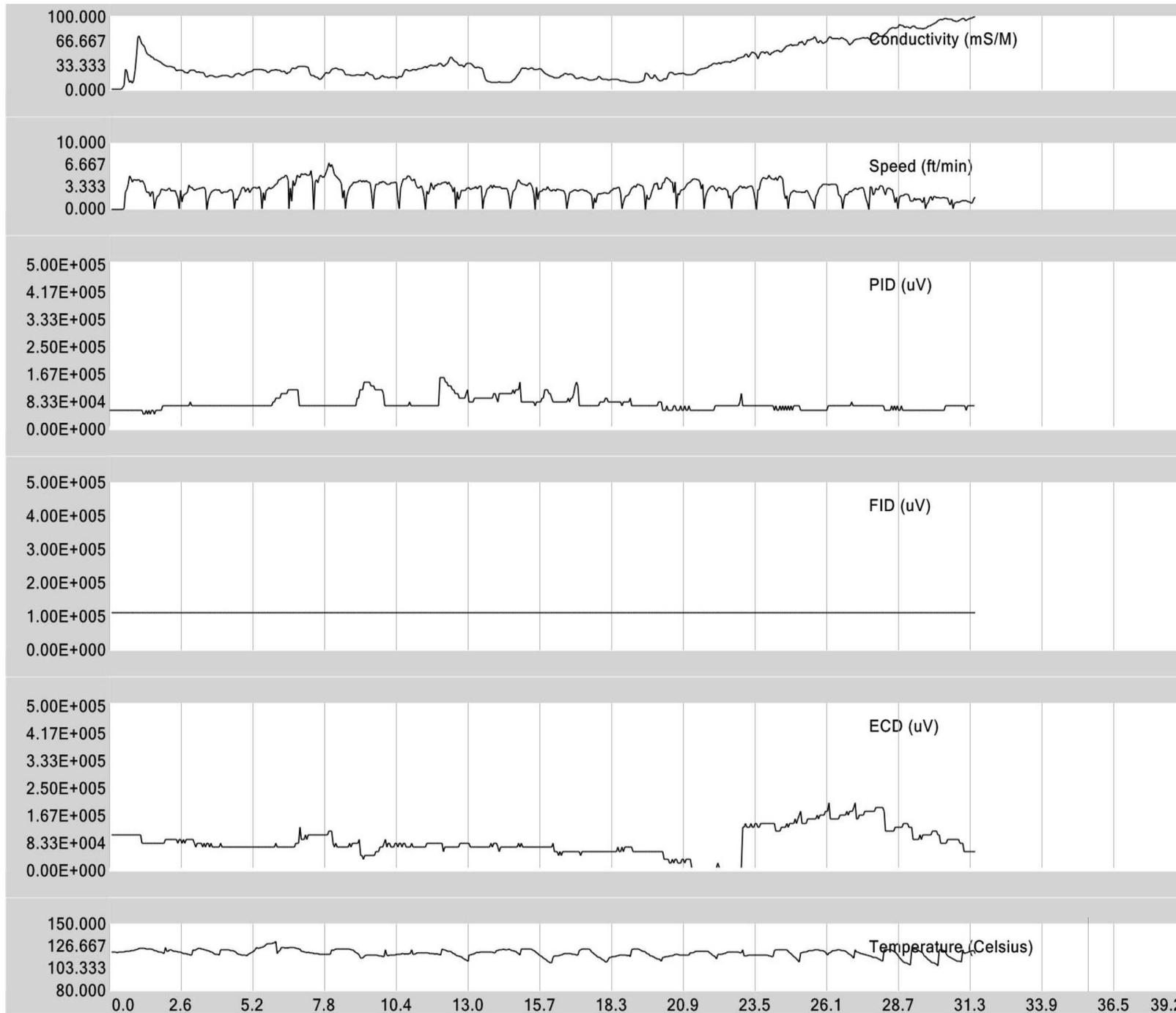
MIP-52



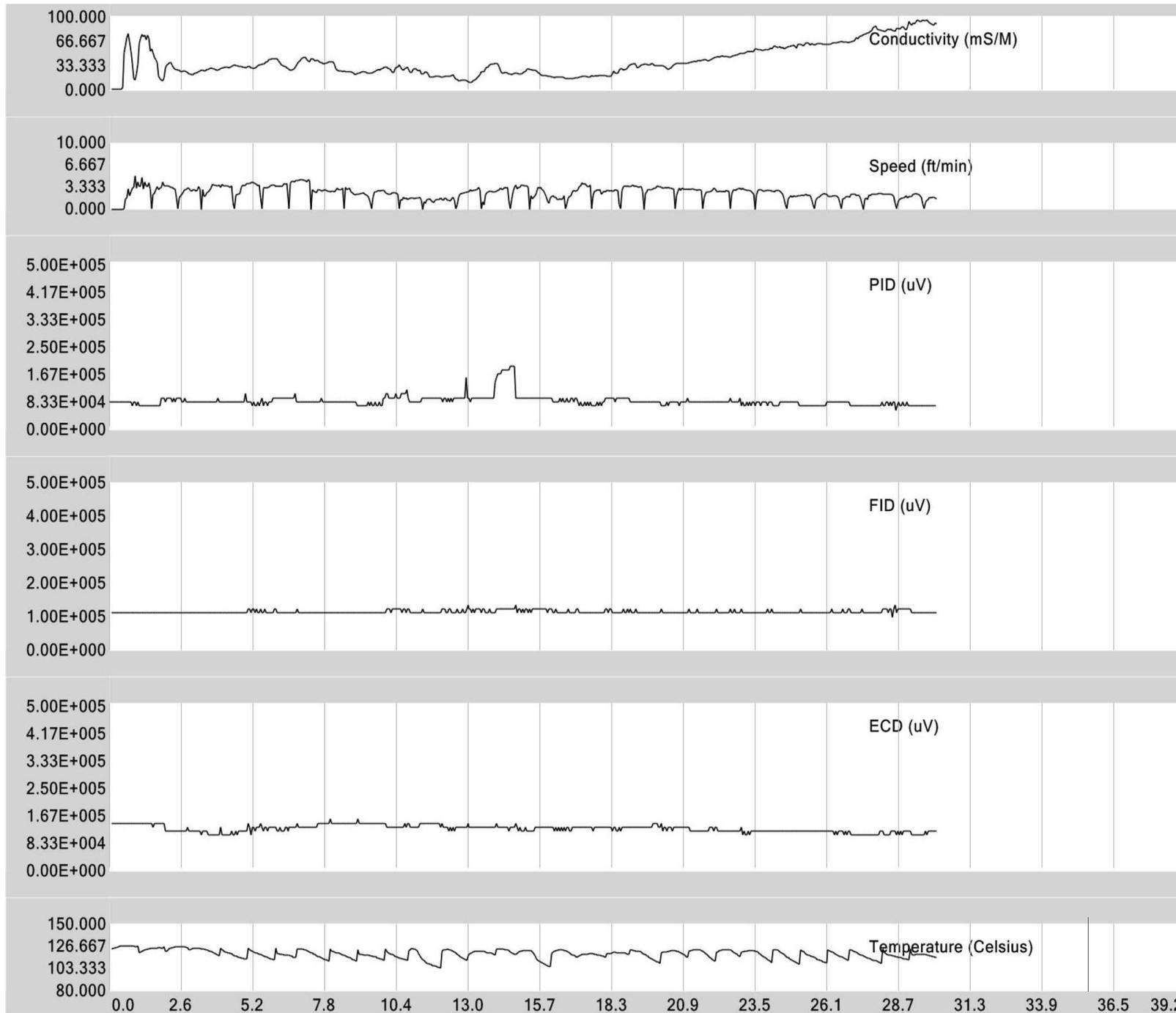
MIP-53



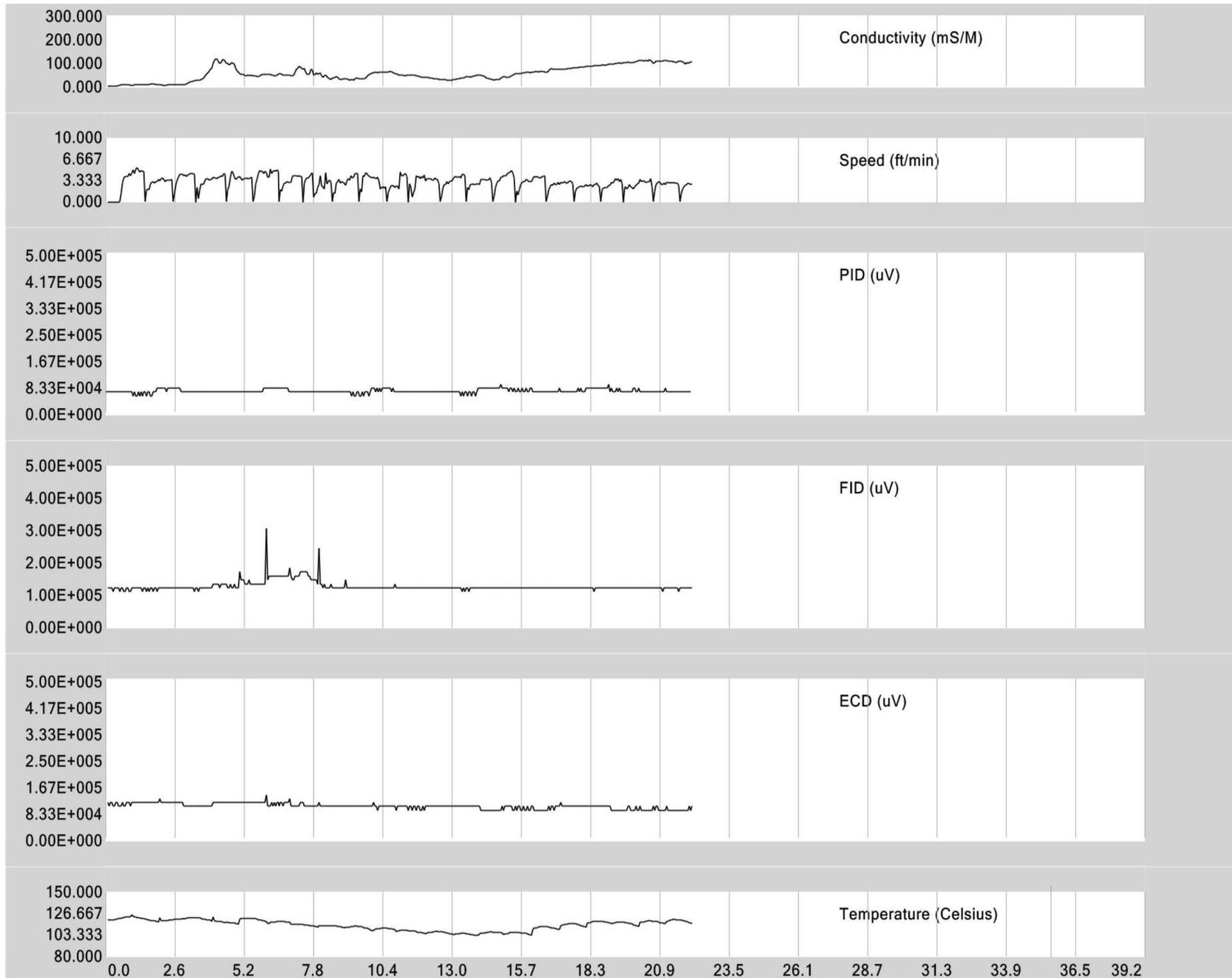
MIP-54



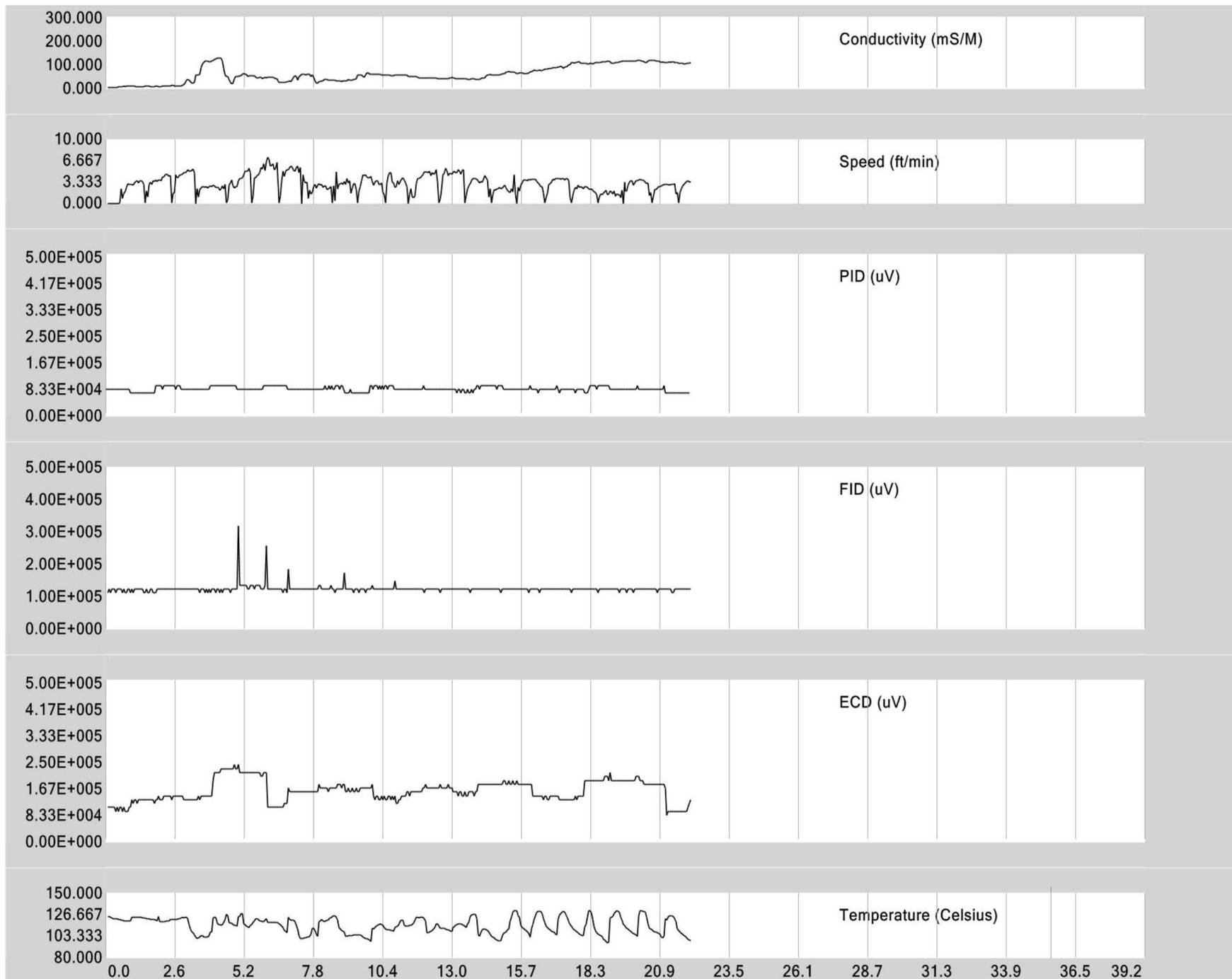
MIP-55



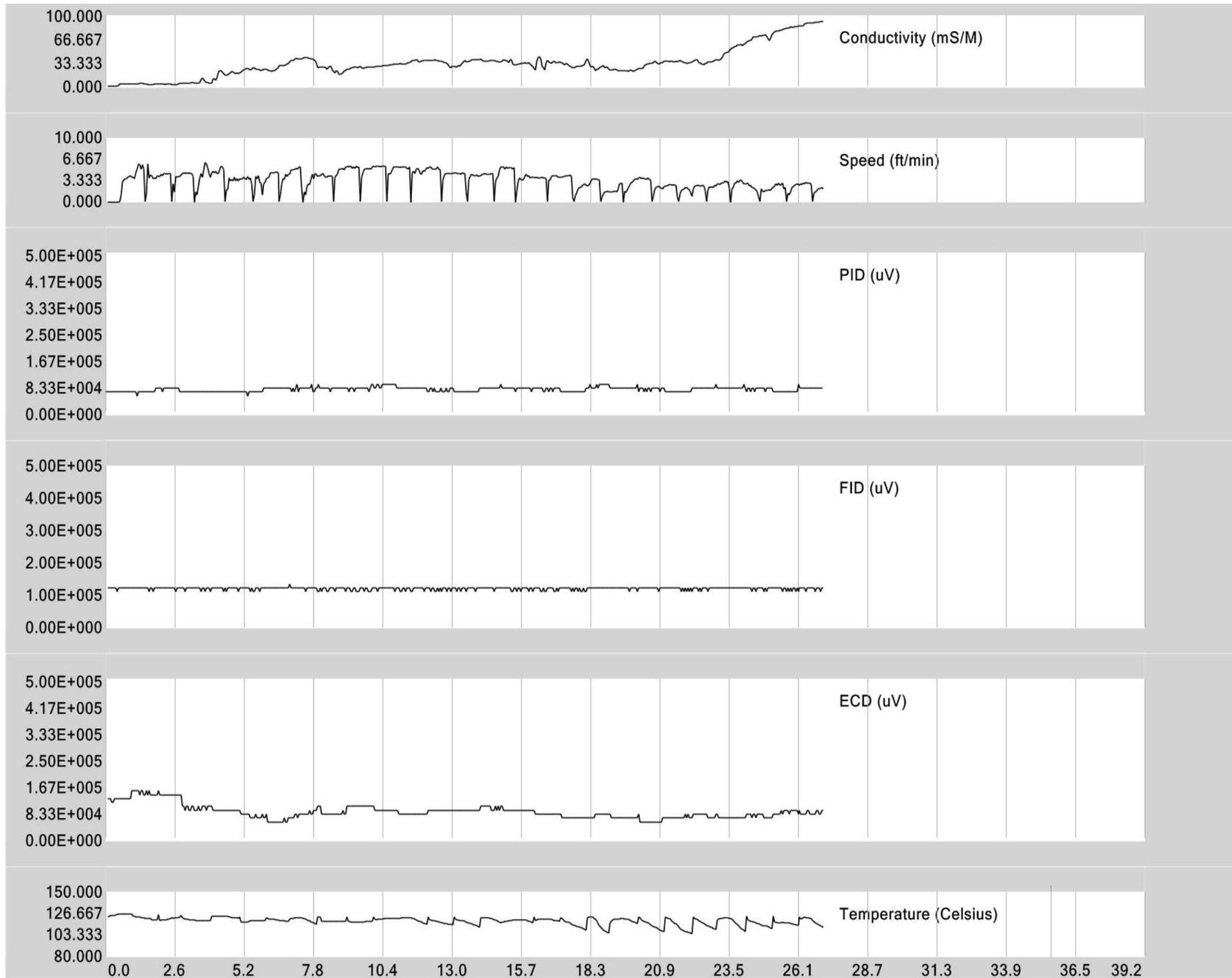
MIP-56



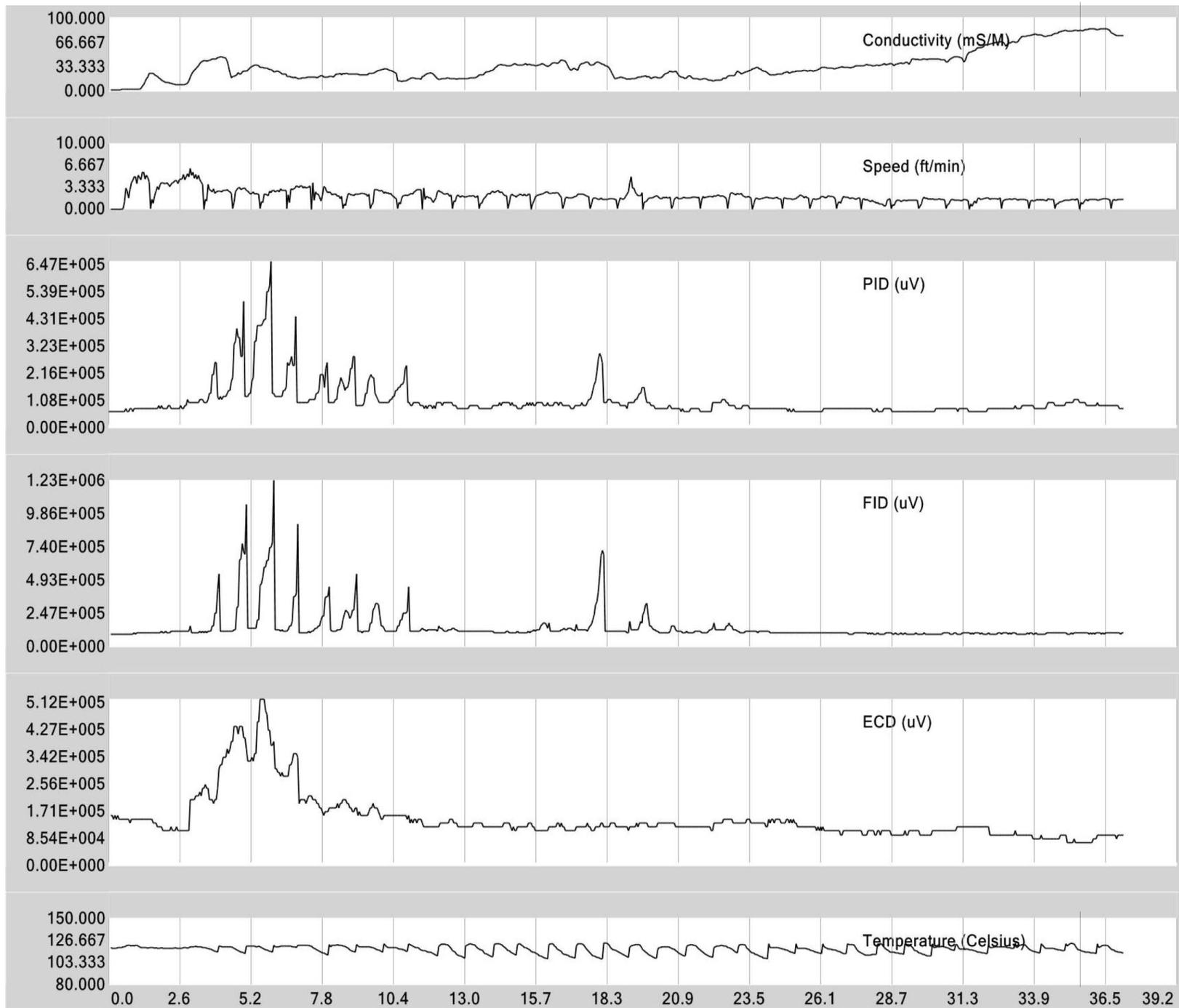
MIP-56R



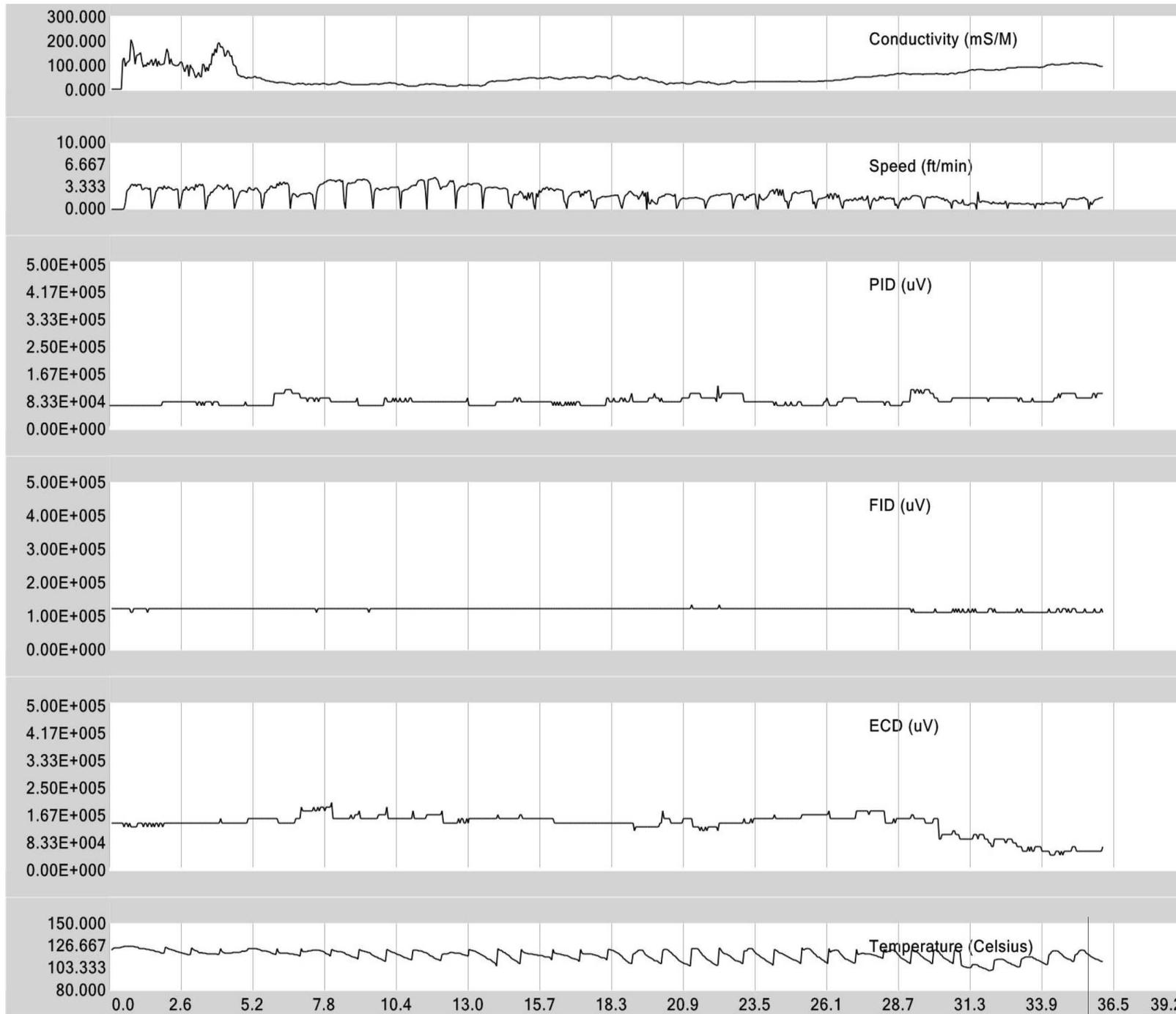
MIP-57



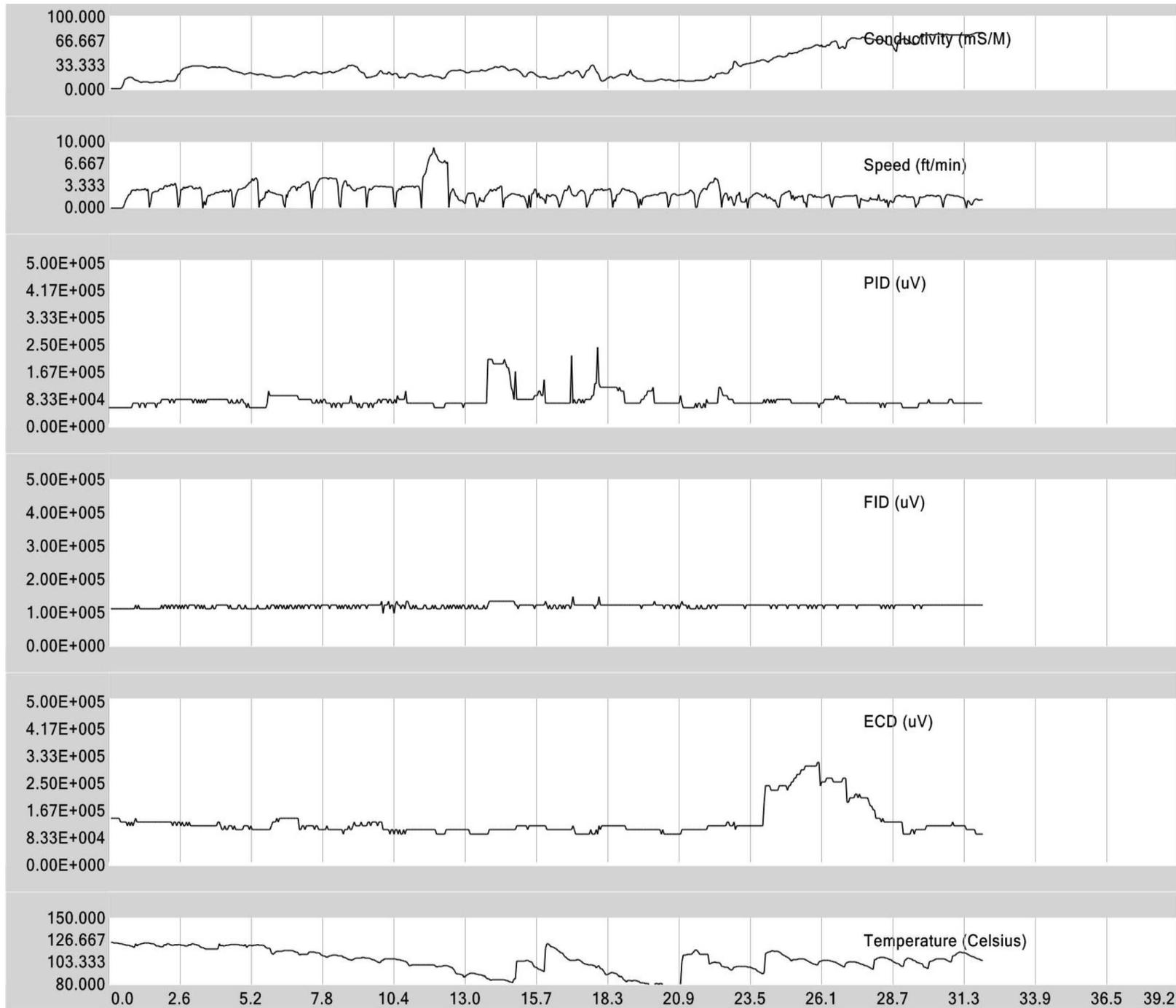
MIP-58



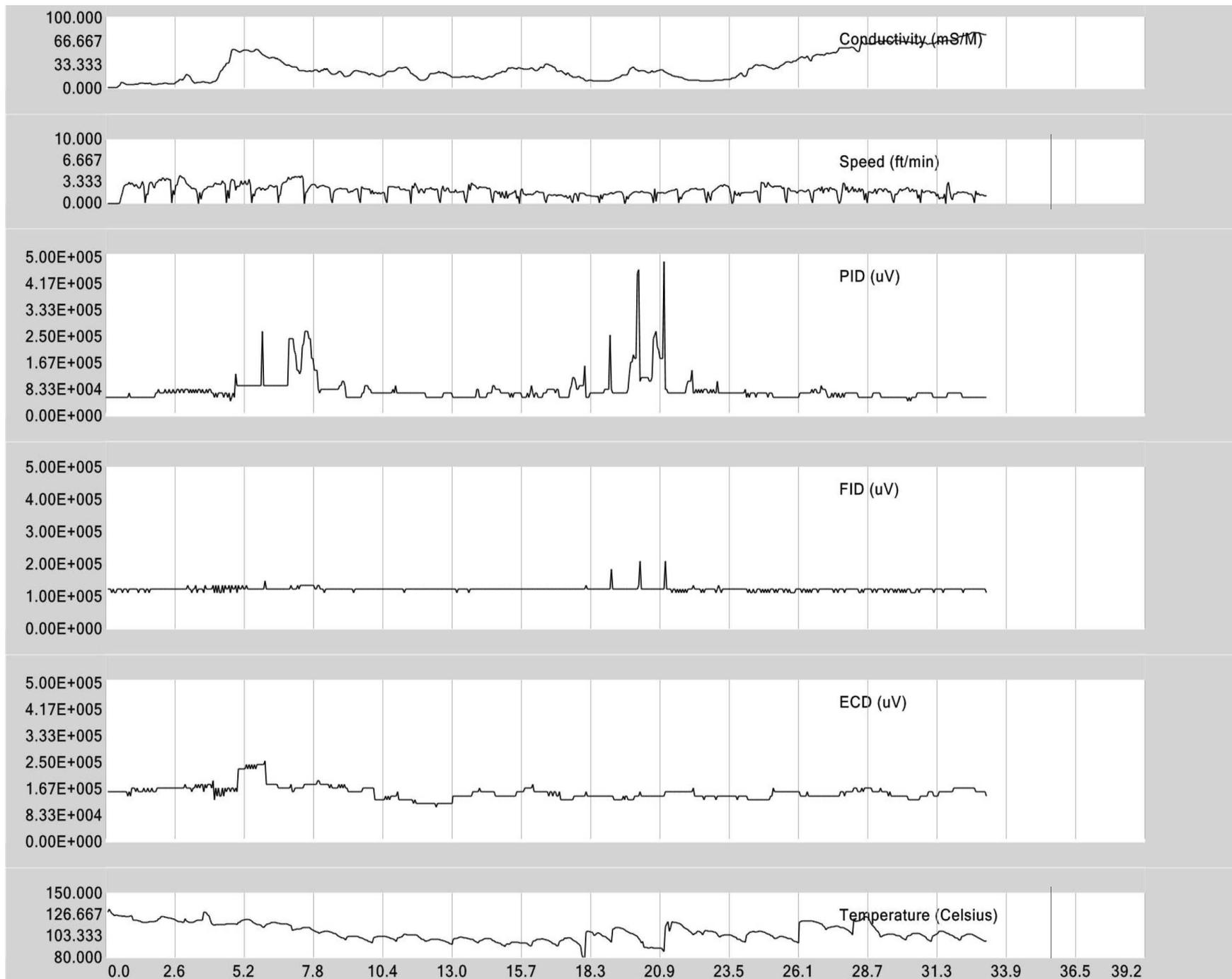
MIP-59



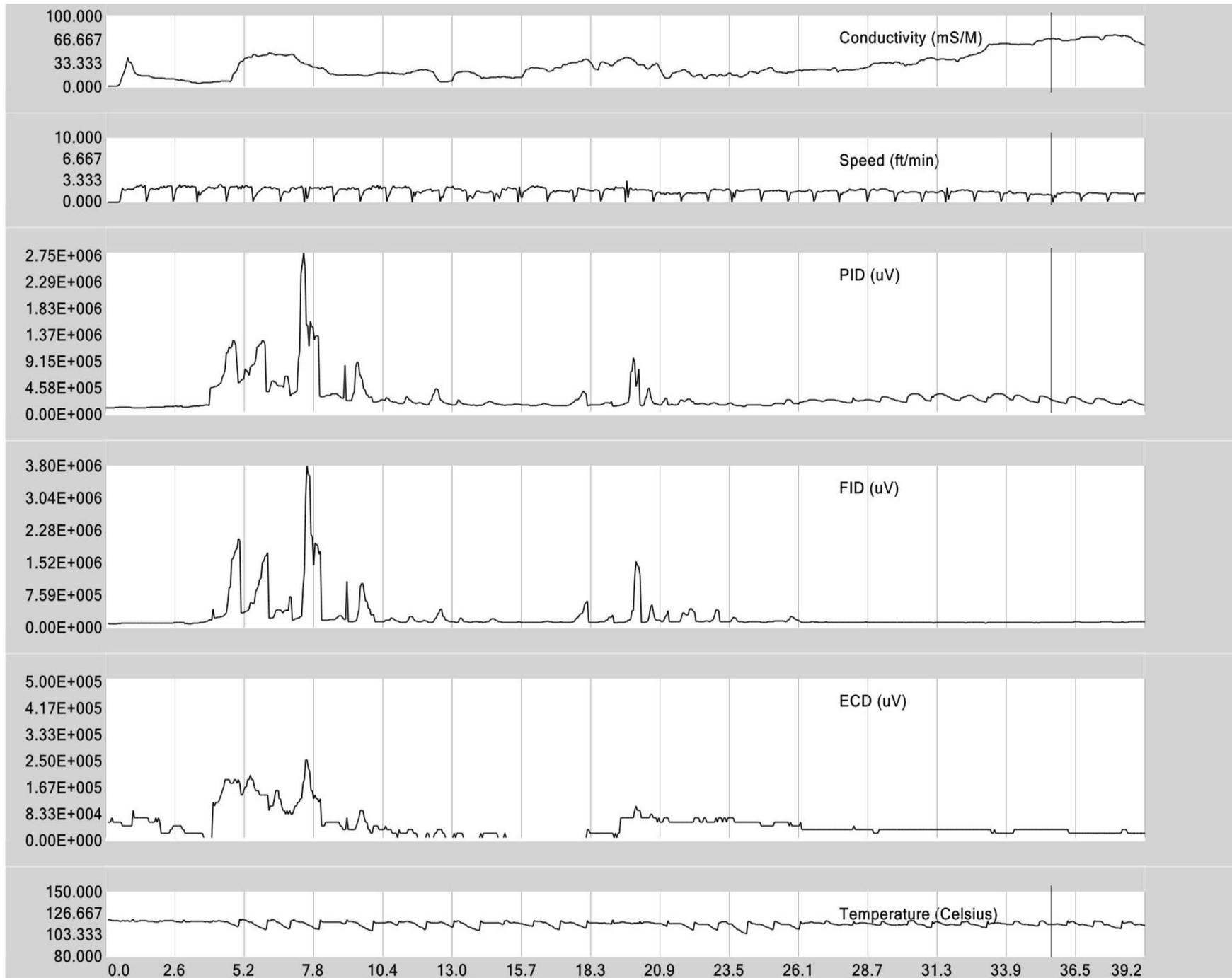
MIP-60



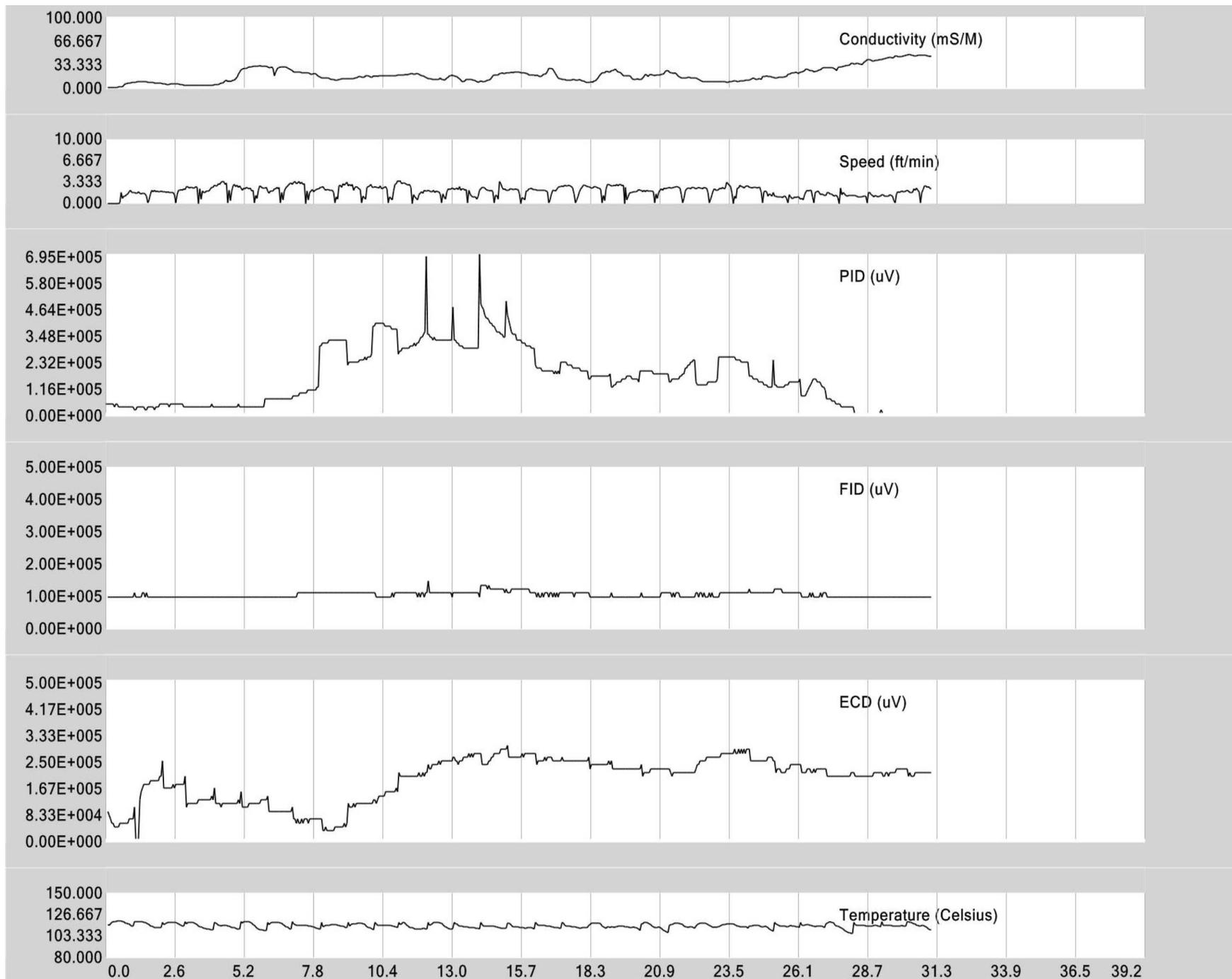
MIP-61



MIP-62



MIP-63R



Appendix H
Determination of Risk-Based PRGs

Calculation of Site 17 Groundwater Preliminary Remediation Goals, NSF-IH, Indian Head, MD

PREPARED FOR: Ed Corack/CH2M HILL
PREPARED BY: Roni Warren/CH2M HILL
COPIES:
DATE: April 3, 2006

This memo discusses the procedures used to select constituents of concern (COCs) and then calculate the preliminary remediation goals (PRGs) for the Naval Support Facility, Indian Head (NSF-IH) at Indian Head in Maryland, Site 17 shallow groundwater.

Identification of COCs

A human health risk assessment (HHRA) was performed as part of the Remedial Investigation (RI) at Site 17 (CH2M HILL, 2004). The RI HHRA identified several volatile organic compounds (VOCs) and inorganics in groundwater as potential risk drivers. The risk drivers selected in the RI HHRA were based on the central tendency evaluation (CTE) calculated hazards and risk and included the following:

Future Scenarios - Shallow Groundwater:

- Noncarcinogenic CTE hazard index (HI) exceeded 1 for adult resident exposed to cis-1,2-dichloroethene (hazard quotient [HQ] = 2.0), vinyl chloride (HQ = 4.6), and iron (HQ = 1.8).
- Noncarcinogenic CTE HI exceeded 1.0 for child resident exposed to cis-1,2-dichloroethene (HQ = 6.4), vinyl chloride (HQ = 15), iron (HQ = 6.2), and manganese (HQ = 3.3).
- Carcinogenic CTE risk exceeded 1×10^{-4} for lifetime resident exposed via ingestion and dermal contact to vinyl chloride (8×10^{-3}) and arsenic (2×10^{-5}), and inhalation while showering of vinyl chloride (2×10^{-4}).

Although the RI HHRA identified risk drivers based on the CTE scenarios, there were additional constituents that exceeded the USEPA target hazards and risk levels for the reasonable maximum exposure (RME) scenario. As a conservative measure this memorandum will consider the RI HHRA calculations for the RME scenario to identify preliminary COCs. This is a conservative measure since it will include additional compounds that were detected at Site 17 at concentrations that did not pose unacceptable risks under the median (a.k.a. CTE) exposure scenario.

Risk managers may decide that the inclusion of these additional compounds as COCs may not be necessary and therefore they can adjust the PRGs if they deem fit.

PRGs were calculated for the constituents identified COCs in the shallow groundwater. For this memorandum, this includes the individual constituents which contributed a

carcinogenic risk of 10^{-6} or greater or a noncarcinogenic hazard of 1 or above for individual target organs under the RME scenario in the baseline HHRA. A summary of the risks results used to identify constituents for inclusion in the PRG calculations, based on the criteria described above follows:

Future Scenarios- Shallow Groundwater:

- Noncarcinogenic hazard (HI exceeds 1.0) for adult resident associated with exposure to cis-1,2-dichloroethene (12.3) , vinyl chloride (35.9), iron (6.5), and manganese (3.6).
- Noncarcinogenic hazard (HI exceeds 1.0) for child resident associated with exposure to cis-1,2-dichloroethene (28.7), vinyl chloride (66.5), aluminum (2.0), chromium (2.3), iron (15.3), and manganese (8.4).
- Carcinogenic risk (exceeds 1×10^{-4}) for lifetime resident associated with ingestion and dermal contact with vinyl chloride (7×10^{-2}), 2,4,6-trinitrotoluene (3×10^{-6}), RDX (6×10^{-6}), and arsenic (9×10^{-5}), and inhalation of vinyl chloride (1×10^{-3}).
- Noncarcinogenic hazard (HI exceeds 1.0) for construction worker associated with exposure to vinyl chloride.

Procedures for Calculating PRGs

PRGs for groundwater were calculated for potential future adult, child, and lifetime residents (Tables GW-1, GW-2, and GW-3) , although it is unlikely that the area where the site is located will become a residential area. PRGs for groundwater were also calculated for a potential construction worker (Table GW-4).

The equations presented in USEPA's Risk Assessment Guidance for Superfund Volume 1, Part B (1991) were re-arranged into one equation to incorporate the ingestion, a dermal absorption, and/or inhalation pathways and calculate one PRG that combines all of these pathways, as opposed to individual PRGs for ingestion, dermal absorption, and inhalation. The groundwater PRG equation combined the ingestion, dermal absorption, and inhalation pathways for the adult and lifetime residents, the ingestion and dermal absorption pathways for the child resident, and the dermal absorption and inhalation pathways for the construction worker. The exposure assumptions used in the PRG calculation equations are the same as those used in the Site 17 human health risk assessment. However, the dermal exposure factors used to calculate the dermally absorbed dose were updated to reflect the values presented in *Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual, Part E Supplemental Guidance for Dermal Risk Assessment* (USEPA, 2004). Additionally, the absorption factors used to adjust the oral toxicity values for dermal exposure were updated to those presented in RAGS Part E.

The target noncarcinogenic hazard COC was determined based on the number of COCs that result in an effect to the same target (i.e. nervous system). Therefore, assuming an acceptable HI is 1, if two constituents effect the same target organ, the target noncarcinogenic hazard for each of those two constituents would be 0.5. If a PRG was calculated based on both carcinogenic and noncarcinogenic effects, the lower of the two was chosen as the applicable PRG for the site. The target carcinogenic risk for all of the constituents was set equal to 10^{-5} , to ensure that the overall carcinogenic risk based on exposure to all of the carcinogenic COCs remains below 10^{-4} .

The groundwater PRGs are summarized in Tables PRG-1 (residential scenario) and PRG-2 (construction worker scenario). Also included in the summary PRG tables are the background unfiltered groundwater concentrations (Tables PRG-1 and PRG-2) for the inorganic COCs. Consistent with the RI (CH2M HILL, 2004), background concentrations presented in the summary PRG tables are based on the 95 percent upper confidence limit (95% UCL) presented in Draft Background Investigation Report prepared by Brown and Root Environmental (B&RE, 1997).

If the calculated PRG is less than the facility-wide background 95% UCL, then the background 95% UCL was selected as the cleanup goal.

References

Brown and Root Environmental. 1997. *Project Specific Remedial Investigation (RI) Work Plan for Installation Restoration Program, Indian Head Division, Naval Surface Warfare Center, Indian Head, Maryland.*

CH2M HILL, 2004. *Final Remedial Investigation Report, Sites 11, 13, 17, 21, and 25. Naval district Washington, Indian Head, Indian Head, Maryland. April 2004.*

USEPA, 1991. *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part B, Interim Final.* Office of Solid Waste and Emergency Response. EPA/540/R-92/003. December.

USEPA, 2004. *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final.* EPA/540/R/99/005. OSWER 9285.7-02EP. July.

TABLE H-1
Summary of Residential Groundwater PRGs Calculated for COPCs in Site 17 Groundwater

Constituent	Facility Background 95% UCL (µg/L)	Applicable Residential Groundwater PRG (µg/L)	Maximum Detected Concentration in Site 17 Groundwater (µg/L)	Basis of PRG
cis-1,2-Dichloroethene	NA	150	4,200	Target hazard = 1, Child resident
2,4,6-Trinitrotoluene	NA	22 (220)	5.8	Target cancer risk = 10 ⁻⁵ , Lifetime resident (Target cancer risk = 10 ⁻⁴)
RDX	NA	6 (60)	3.3	Target cancer risk = 10 ⁻⁵ , Lifetime resident (Target cancer risk = 10 ⁻⁴)
Vinyl chloride	NA	0.43 (4)	3,000	Target cancer risk = 10 ⁻⁵ , Lifetime resident (Target cancer risk = 10 ⁻⁴)
Aluminum	9,620	7,800	31,500	Target hazard = 1 (Child resident)
Arsenic	ND	0.45 (4.5)	4	Target cancer risk = 10 ⁻⁵ , Lifetime resident (Target cancer risk = 10 ⁻⁴)
Chromium	16.4	43	86.9	Target hazard = 1, Child resident
Iron	19,900	4,700	71,000	Target hazard = 1, Child resident
Manganese	824	150	2,620	Target hazard = 1, Child resident

ND = Not detected.
Grey shading indicates applicable cleanup level for the given constituent.

TABLE H-2
Summary of Construction Worker Groundwater PRGs Calculated for COPCs in Site 17 Groundwater

Constituent	Facility Background 95% UCL ($\mu\text{g/L}$)	Applicable Residential Groundwater PRG ($\mu\text{g/L}$)	Maximum Detected Concentration in Site 17 Groundwater ($\mu\text{g/L}$)	Basis of PRG
Vinyl chloride	NA	76 (760)	3,000	Target cancer risk = 10^{-5} (Target cancer risk = 10^{-4})

Grey shading indicates applicable cleanup level for the given constituent.

Table 1
Preliminary Remediation Goals
Groundwater
Adult Residential Scenario

Chemical	Chronic Oral RfD (RfDo) (mg/kg-day)	Chronic Dermal RfD (RfDd) (mg/kg-day)	Chronic Inhalation RfD (RfDi) (mg/kg-day)	Target Organ	DAevent (L/cm ² -day)	Shower Exposure (L/day)	An (kg-L/mg)	Bn (kg-L/mg)	Cn (kg-L/mg)	Noncarcinogen				
										Groundwater PRG			Applicable HQ ¹ (mg/L)	Applicable PRG (mg/L)
										HQ = 0.1 (mg/L)	HQ = 0.5 (mg/L)	HQ = 1 (mg/L)		
VOCs														
cis-1,2-Dichloroethene	1.0E-02	1.0E-02	N/A	Blood	3.3E-06	6.5E+00	2.0E+02	6.5E+00		3.5E-02	1.8E-01	3.5E-01	1	3.5E-01
Vinyl chloride	3.0E-03	3.0E-03	2.9E-02	Liver	1.9E-06	7.7E+00	6.7E+02	1.3E+01	2.7E+02	7.7E-03	3.8E-02	7.7E-02	1	7.7E-02
Inorganics														
Iron	3.0E-01	3.0E-01	N/A	Gastrointestinal	2.0E-07		6.7E+00	1.3E-02		1.1E+00	5.5E+00	1.1E+01	1	1.1E+01
Manganese	2.0E-02	8.0E-04	N/A	CNS	2.0E-07		1.0E+02	5.0E+00		7.0E-02	3.5E-01	7.0E-01	1	7.0E-01
Vanadium	1.0E-03	2.6E-05	N/A	Kidney	2.0E-07		2.0E+03	1.5E+02		3.4E-03	1.7E-02	3.4E-02	1	3.4E-02

Noncarcinogenic calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{\text{THQ} \times \text{BW} \times \text{AT}_{nc}}{\text{EF} \times \text{ED} \times (\text{An} + \text{Bn} + \text{Cn})}$$

$$\text{An} = 1/\text{RfDo} \times \text{IR}$$

$$\text{Bn} = 1/\text{RfDd} \times \text{SA} \times \text{DAevent}$$

$$\text{Cn} = 1/\text{RfDi} \times \text{Shower Exposure}$$

EXPOSURE ASSUMPTIONS

BW - Body weight (kilograms)	70
ATnc - Averaging time for noncarcinogens (days)	8760
ATc - Averaging time for carcinogens (days)	25,550
EF - Exposure frequency (days/year)	350
ED - Exposure duration (year)	24
IR - Ingestion rate (L/day)	2
SA - Skin surface area (cm ²)	20,000

NA - No reference dose or slope factor available.

Table 1a
 Calculation of DAevent (Adult)
 Groundwater

Chemical of Potential Concern	Permeability Constant (PC) (cm/hr)	Lag Time (t) (hr)	Duration of Event (ET) (hr)	t*	B (dimensionless)	DAevent (L/cm ² -day)	Eq
cis-1,2-Dichloroethene ¹	7.7E-03	3.7E-01	2.0E-01	8.9E-01	2.9E-02	3.3E-06	2
Vinyl chloride	5.6E-03	2.4E-01	2.0E-01	5.7E-01	1.7E-02	1.9E-06	2
Iron	1.0E-03	N/A	2.0E-01	N/A	N/A	2.0E-07	1
Manganese	1.0E-03	N/A	2.0E-01	N/A	N/A	2.0E-07	1
Vanadium	1.0E-03	N/A	2.0E-01	N/A	N/A	2.0E-07	1

Inorganics: DAevent (mg/cm2-event) =

PC x ET x CF2 (eq 1)

Organics: DAevent (mg/cm2-event) =

ET<t*: DAevent (mg/cm2-event) =

2 x PC x (sqrt((6 x t x ET)/3.1415))

x CF2 (eq 2)

Notes:

Permeability constants from EPA 2001, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Interim)*. EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics not listed in this document.

N/A - not applicable.

¹ values for Dichloroethene-1,2 trans used as a surrogate.

Table 1b
Inhalation Exposure Concentrations from Foster and Chrostowski Shower Model

Chemical	Molecular weight (MW) (g/mole)	Henry's Law Constant (H) (atm-m ³ /mole)	Kg (VOC) (cm/hr)	KI(VOC) (cm/hr)	KL (cm/hr)	Kal (cm/hr)	Cwd	S (L/m ³ - min)	Inhalation Exposure (InExp) (L/kg-shower)	Shower Exposure (InExp X BW) (L/day)
cis-1,2-Dichloroethene	97	7.6E-03	1.3E+03	1.3E+01	1.3E+01	1.8E+01	4.4E+02	3.0E+03	9.2E-02	6.5E+00
Vinyl chloride	63	8.2E-02	1.6E+03	1.7E+01	1.7E+01	2.3E+01	5.3E+02	3.5E+03	1.1E-01	7.7E+00

Variables	Units	Exposure Assumptions
Kg(VOC) = gas-film mass transfer coefficient	cm/hr	Solved by Eq 1
KI(VOC) = liquid-film mass transfer coefficient	cm/hr	Solved by Eq 2
KL = overall mass transfer coefficient	cm/hr	Solved by Eq 3
Kal = adjusted overall mass transfer coeff.	cm/hr	Solved by Eq 4
TI = Calibration temp. of water	K (20C +273)	293
Ts = Shower water temperature	k (45C)	318
Us = water viscosity at Ts	centipoise	0.596
UI = water viscosity at TI	cp	1.002
Cwd = conc. leaving droplets after time sdt		Solved by Eq 5
sdt = shower droplet drop time	sec	2
d = shower droplet diameter	mm	1
FR = shower water flow rate	l/min	20
SV = shower room air volume	m ³	3
S = indoor VOC generation rate	L/m ³ -min	Solved by Eq 6
VR = ventilation rate	l/min	13.8
BW = body weight	kg	70
Ds = duration of shower	min	12
Dt = total duration in shower room	min	20
R = air exchange rate	min ⁻¹	0.0083
Ca = indoor air concentration of VOCs	L-ug/mg-m ³	Solved by Eq 7
Einh = inhalation exposure per shower	L/kg-shower	Solved by Eq 8

Equation 1:	Kg(VOC) =	$3000 * (18 / MW)^{0.5}$
Equation 2:	KI(VOC) =	$20 * (44 / MW)^{0.5}$
Equation 3:	KL =	$((1 / KI(VOC)) + (0.024 / (Kg (VOC) * H)))^{-1}$
Equation 4:	Kal =	$(KL * (((TI * Us) / (Ts * UI))^{-0.5}))$
Equation 5:	Cwd =	$((1-EXP((-1 * Kal * sdt)/(60 * d))))$
Equation 6:	S =	$(Cwd * FR / SV)$
Equation 7:	see time series example on Table I-GW-6	
Equation 8:	Einh =	$If t > Ds \quad (((VR * S) / (BW * R * 1000000)) * ((Ds + (EXP(-R * Dt) / R) - (EXP(R * (Ds - Dt)) / R)))$

Table 2
Preliminary Remediation Goals
Groundwater
Child Residential Scenario

Chemical	Chronic Oral RfD (RfDo) (mg/kg-day)	Chronic Dermal RfD (RfDd) (mg/kg-day)	Target Organ	DAevent (L/cm ² -day)	An (kg-L/mg)	Bn (kg-L/mg)	Noncarcinogen					
							Groundwater PRG			Applicable HQ ¹ (mg/L)	Applicable PRG (mg/L)	
							HQ = 0.1 (mg/L)	HQ = 0.5 (mg/L)	HQ = 1 (mg/L)			
VOCs												
cis-1,2-Dichloroethene	1.0E-02	1.0E-02	Blood	4.2E-06	1.0E+02	3.1E+00	1.5E-02	7.6E-02	1.5E-01	1	1.5E-01	
Vinyl chloride	3.0E-03	3.0E-03	Liver	2.5E-06	3.3E+02	6.1E+00	4.6E-03	2.3E-02	4.6E-02	1	4.6E-02	
Inorganics												
Aluminum	1.0E+00	1.0E+00	CNS	3.3E-07	1.0E+00	2.5E-03	1.6E+00	7.8E+00	1.6E+01	0.5	7.8E+00	
Chromium	3.0E-03	7.5E-05	NOAEL	3.3E-07	3.3E+02	3.3E+01	4.3E-03	2.1E-02	4.3E-02	1	4.3E-02	
Iron	3.0E-01	3.0E-01	Gastrointestinal	3.3E-07	3.3E+00	8.3E-03	4.7E-01	2.3E+00	4.7E+00	1	4.7E+00	
Manganese	2.0E-02	8.0E-04	CNS	3.3E-07	5.0E+01	3.1E+00	2.9E-02	1.5E-01	2.9E-01	0.5	1.5E-01	
Vanadium	1.0E-03	2.6E-05	Kidney	3.3E-07	1.0E+03	9.5E+01	1.4E-03	7.1E-03	1.4E-02	1	1.4E-02	

Noncarcinogenic calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{\text{THQ} \times \text{BW} \times \text{AT}_{nc}}{\text{EF} \times \text{ED} \times (\text{An} + \text{Bn})}$$

$$\text{An} = 1/\text{RfDo} \times \text{IR}$$

$$\text{Bn} = 1/\text{RfDd} \times \text{SA} \times \text{DAevent}$$

EXPOSURE ASSUMPTIONS

BW - Body weight (kilograms)	15
AT _{nc} - Averaging time for noncarcinogens (days)	2190
AT _c - Averaging time for carcinogens (days)	25,550
EF - Exposure frequency (days/year)	350
ED - Exposure duration (year)	6
IR - Ingestion rate (L/day)	1
SA - Skin surface area (cm ²)	7,500

NA - No reference dose or slope factor available.

Table 2a
 Calculation of DAevent (Child)
 Groundwater

Chemical of Potential Concern	Permeability Constant (PC) (cm/hr)	Lag Time (t) (hr)	Duration of Event (ET) (hr)	t*	B (dimensionless)	DAevent (L/cm ² -day)	Eq
cis-1,2-Dichloroethene ¹	7.7E-03	3.7E-01	3.3E-01	8.9E-01	2.9E-02	4.2E-06	2
Vinyl chloride	5.6E-03	2.4E-01	3.3E-01	5.7E-01	1.7E-02	2.5E-06	2
Aluminum	1.0E-03	N/A	3.3E-01	N/A	N/A	3.3E-07	1
Chromium	1.0E-03	N/A	3.3E-01	N/A	N/A	3.3E-07	1
Iron	1.0E-03	N/A	3.3E-01	N/A	N/A	3.3E-07	1
Manganese	1.0E-03	N/A	3.3E-01	N/A	N/A	3.3E-07	1
Vanadium	1.0E-03	N/A	3.3E-01	N/A	N/A	3.3E-07	1

Inorganics: DAevent (mg/cm²-event) =

$$PC \times ET \times CF2 \quad (\text{eq 1})$$

Organics: DAevent (mg/cm²-event) =

$$ET < t^*: DAevent \text{ (mg/cm}^2\text{-event)} = \\ 2 \times PC \times (\text{sqrt}((6 \times t \times ET)/3.1415)) \\ \times CF2 \quad (\text{eq 2})$$

Notes:

Permeability constants from EPA 2001, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Interim)*. EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics not listed in this document.

N/A - not applicable.

¹ values for Dichloroethene-1,2 trans used as a surrogate.

**Table 3
Preliminary Remediation Goals
Groundwater
Lifetime Residential Scenario**

Chemical	Oral Slope Factor (CSFo) (kg-day/mg)	Dermal Slope Factor (CSFd) (kg-day/mg)	Inhalation Slope Factor (CSFi) (kg-day/mg)	DAevent-a (L/cm ² -day)	DAevent-c (L/cm ² -day)	Shower Exposure (L/day)	Carcinogen Ingestion PRG		
							Risk = 1E-06	Risk = 1E-05	Risk = 1E-04
							(mg/L)	(mg/L)	(mg/L)
VOCs									
Vinyl chloride	1.5E+00	1.5E+00	1.5E-02	1.9E-06	2.5E-06	7.7E+00	4.3E-05	4.3E-04	4.3E-03
2,4,6-Trinitrotoluene	3.0E-02	3.0E-02	N/A	9.4E-07	1.2E-06		2.2E-03	2.2E-02	2.2E-01
RDX	1.1E-01	1.4E-01	N/A	3.2E-07	4.1E-07		6.1E-04	6.1E-03	6.1E-02
Inorganics									
Arsenic	1.5E+00	1.6E+00	N/A	2.0E-07	3.3E-07		4.5E-05	4.5E-04	4.5E-03

Carcinogen calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{\text{TR} \times \text{AT}_c}{\text{EF} \times (\text{Ac} + \text{Bc} + \text{Cc})}$$

$$\text{Ac} = \text{CSFo} \times \text{IR}_{\text{adj}}$$

$$\text{Bc} = \text{CSFd} \times [(\text{SAa} \times \text{DAevent-a} \times \text{EDa})/\text{BWa} + (\text{SAc} \times \text{DAevent-c} \times \text{EDc})/\text{BWc}]$$

$$\text{Cc} = \text{CSFi} \times \text{Shower Exposure} \times \text{EDa} \times 1/\text{BWa}$$

EXPOSURE ASSUMPTIONS	Lifetime	Adult (a)	Child (c)
BW - Body weight (kilograms)		70	15
ATc - Averaging time for carcinogens (days)		25,550	25,550
EF - Exposure frequency (days/year)		350	350
ED - Exposure duration (year)		24	6
IR - Ingestion rate (L/day)		2	1
IR _{adj} - Ingestion rate (L-year/kg-day)	1.09		
SA - Skin surface area (cm ²)		20,000	7,500
ET - Exposure Time (hours/day)		0.20	0.33

Table 3a
 Calculation of DAevent
 Groundwater, Child/Adult

Chemical of Potential Concern	Permeability Constant (PC) (cm/hr)	Lag Time (t) (hr)	Duration of Event (ETa) (hr)	Duration of Event (ETc) (hr)	DAevent Adult (L/cm ² -day)	DAevent Child (L/cm ² -day)	Eq
Vinyl chloride	5.6E-03	2.4E-01	2.0E-01	3.3E-01	1.9E-06	2.5E-06	2
2,4,6-Trinitrotoluene ¹	9.7E-04	2.0E+00	2.0E-01	3.3E-01	9.4E-07	1.2E-06	2
RDX ¹	3.4E-04	1.8E+00	2.0E-01	3.3E-01	3.2E-07	4.1E-07	2
Arsenic	1.0E-03	N/A	2.0E-01	3.3E-01	2.0E-07	3.3E-07	1

Inorganics: DAevent (mg/cm²-event) =
 $PC \times ET \times CF2$ (eq 1)

Organics: DAevent (mg/cm²-event) =
 $ET < t^*$: DAevent (mg/cm²-event) =
 $2 \times PC \times (\text{sqrt}((6 \times t \times ET)/3.1415)) \times CF2$ (eq 2)

Notes:

Permeability constants from EPA 2001, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Interim)*. EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics

not listed in this document.

N/A - not applicable.

¹ values for Dichloroethene-1,2 trans used as a surrogate.

**Table 4
Preliminary Remediation Goals
Groundwater
Construction Worker Scenario**

Chemical	Subchronic Dermal RfD (mg/kg-day)	Subchronic Inhalation RfD (mg/kg-day)	Target Organ	Dermal Slope Factor (CSFd) (kg-day/mg)	Inhalation Slope Factor (CSFi) (kg-day/mg)	DAevent (L/cm ² -day)	Ca (mg/m ³)	Noncarcinogen				Carcinogen				
								PRG			Applicable HQ ¹ (mg/L)	Applicable PRG (mg/L)	PRG			
								HQ = 0.1 (mg/L)	HQ = 0.5 (mg/L)	HQ = 1 (mg/L)			Risk = 1E-06 (mg/L)	Risk = 1E-05 (mg/L)	Risk = 1E-04 (mg/L)	
VOCs																
Vinyl Chloride	3.0E-03	3.0E-03	Liver	7.2E-01	1.5E-02	4.7E-05	4.2E-03	6.0E-01	3.0E+00	6.0E+00	1	6.0E+00	7.6E-03	7.6E-02	7.6E-01	

Noncarcinogenic calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{\text{THQ} \times \text{BW} \times \text{AT}_n}{\text{EF} \times \text{ED} \times (\text{An} + \text{Bn})}$$

$$\text{An} = 1/\text{RfDd} \times \text{SA} \times \text{DAevent}$$

$$\text{Bn} = 1/\text{RfDi} \times \text{Ca} \times \text{IN} \times \text{ET}$$

Carcinogen calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{\text{TR} \times \text{BW} \times \text{AT}_c}{\text{EF} \times \text{ED} \times (\text{Ac} + \text{Bc})}$$

$$\text{Ac} = \text{CSFd} \times \text{SA} \times \text{DAevent}$$

$$\text{Bc} = \text{CSFi} \times \text{Ca} \times \text{IN} \times \text{ET}$$

EXPOSURE ASSUMPTIONS

BW - Body weight (kilograms)	70
ATn - Averaging time for noncarcinogens (days)	365
ATc - Averaging time for carcinogens (days)	25,550
EF - Exposure frequency (days/year)	42
ED - Exposure duration (year)	1
ET - Exposure Time (hours/day)	8
IN - Inhalation Rate (m ³ /hour)	1.7
SA - Skin surface area (cm ²)	5,300

Subchronic RfDs used if available, if not chronic RfD used.

NA - No reference dose or slope factor available.

¹ Applicable HQ calculated so that total HQ for a target organ does not exceed 1.

Table 5b Supplement
 Calculation of DAevent
 Groundwater, Child/Adult

Chemical	MW	log Kow	Kow	log Kp ¹	Kp (cm/hr)	B ¹	log Dsc/lsc ¹	lsc (cm)	Dsc (cm ² /hr)	Tau ¹ (hr)	c ¹	b ¹	T* ¹ (hr)
2,4,6-Trinitrotoluene	227	1.6	3.98E+01	-3.02E+00	9.66E-04	5.60E-03	-4.07E+00	1.00E-03	8.49E-08	1.96E+00	3.37E-01	3.07E-01	4.71E+00
RDX	222.26	0.87	7.41E+00	-3.47E+00	3.38E-04	1.94E-03	-4.05E+00	1.00E-03	9.02E-08	1.85E+00	3.35E-01	3.04E-01	4.43E+00

1. Equations from EPA 2001, Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Interim). EPA/540/R/99/005.

Table 6a
 Calculation of DAevent (Construction Worker)
 Groundwater

Chemical of Potential Concern	Permeability Constant (PC) (cm/hr)	Lag Time (t) (hr)	Duration of Event (ET) (hr)	t*	B (dimensionless)	DAevent (L/cm ² -day)	Eq
Vinyl chloride	5.6E-03	2.4E-01	8.0E+00	5.7E-01	1.7E-02	4.7E-05	3

Inorganics: DAevent (mg/cm²-event) =

$$PC \times ET \times CF2 \quad (\text{eq 1})$$

Organics: DAevent (mg/cm²-event) =

ET < t*: DAevent (mg/cm²-event) =

$$2 \times PC \times (\text{sqrt}((6 \times t \times ET)/3.1415))$$

$$\times CF2 \quad (\text{eq 2})$$

ET > t*: DAevent (mg/cm²-event) =

$$PC \times (ET/(1+B) + 2 \times t \times ((1 + 3 \times B)/(1+B))) \times CF2 \quad (\text{eq 3})$$

Notes:

¹ Used permeability constant and lag time values for trans-1,2-dichloroethene.

N/A - not applicable.

Permeability constants from EPA 1992, Dermal Exposure Assessment: Principals and Applications.

ORD, EPA/600/8-91/001B. Default value of 0.001 cm/hour used for inorganics without published values.

Table 6b
 Inhalation of Volatiles from Groundwater During Construction
 Inhalation Exposure Concentrations Calculated Using a Two-Film Volatilization Model
 Future Construction Worker Scenario

Chemical	MW (mol/gram)	K _H (unitless)	k _l (cm/hr)	k _g (cm/hr)	K _v (cm/hr)	ER (mg/hr-cm ²)	ERa (g/sec-m ²)	Ca (mg/m ³)
Vinyl chloride	6.3E+01	1.11E+00	5.35E-02	2.26E+03	5.35E-02	5.35E-08	1.49E-10	4.22E-03
Equations								
Equation 1	$K_v = 1 / (1/k_l + 1/K_H * K_g)$							
Equation 2	$k_g = 700(18/MW)^{1/4}V$							
Equation 3	$k_l = (32/MW)^{1/4}Ka'$							
Equation 4	$ER = K_v * C_w * L/1000 \text{ cm}^3 * \text{mg}/1000 \mu\text{g}$							
Equation 5	$ERa = ER * \text{g}/1000 \text{ mg} * \text{hr}/60 \text{ min} * \text{min}/60 \text{ sec} * 10000 \text{ cm}^2/\text{m}^2$							

Variables	Units	Exposure Assumptions
C _w = groundwater concentration	(μg/L)	chem-specific
MW = molecular weight	(mol/gram)	chem-specific
K _H - Henry's Law Constant	(unitless)	chem-specific
K _v = volatilization rate	(cm/hr)	Solved by Eq 1
k _g = gas phase transfer coefficient	(cm/hr)	Solved by Eq 2
k _l = liquid phase transfer coefficient	(cm/hr)	Solved by Eq 3
V = wind speed	(m/s)	4.4
Ka' = aeration rate	(cm/hr)	0.0633
ER = emission rate	(mg/hr)	Solved by Eq 4
A = area of excavation (utility ditch) Length = 20 m, Width = 3 m	(m ²)	60
ERa = area emission rate	(g/sec-m ²)	Solved by Eq 5
Ca = air concentration	(mg/m ³)	Solved using SCREEN3 model

Note: aeration rate based on aeration rate for small pond (0.1/day) multiplied by depth of water in excavation (1/2 ft)

Appendix I

ARARs

**Table I-1
Chemical-Specific ARARs
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland**

Chemicals & Relevant Media	Requirement	Prerequisites	Citation	ARAR or TBC	Comments
Groundwater, residential water supplies	Meet National Primary Standards for maximum contaminant levels (MCLs).	Drinking water source or potential source	Safe Drinking Water Act (SDWA): 40 CFR 141 National Primary Drinking Water Regulations, CERCLA, RCRA	Relevant and appropriate	Regulation does not apply where groundwater quality has concentrations of total dissolved solids (TDS) greater than 2,500 mg/L. In these instances, the Medium-Specific Concentration for groundwater may be multiplied by 100. MCL used as PRG for groundwater.
Surface water	Water Management Program approval for short-term discharges and NPDES for long-term discharges.	None.	CWA: 40 CFR 122-123 NPDES permit program	TBC	This regulation is applicable for remedial actions that may affect surface water quality in the State of Maryland.
Surface waters of the State	Protect and maintain the quality of surface water in the State of Maryland. Criteria and standards for discharges. Limitations and policy for antidegradation of the State's surface water.	Activities that will pollute the State's surface waters	COMAR 26.08, chapters 1 through 7	TBC	This regulation is applicable for remedial actions that may affect surface water quality in the State of Maryland.
Surface water	Ambient Water Quality Criteria established to protect aquatic life and human consumers of water or aquatic life.	Activities that affect or may affect the surface water onsite	40 CFR 129	Applicable	Used in the development of PRGs.
Carcinogens in groundwater	Not to exceed media-specific concentration that causes a lifetime cancer risk no to exceed 1 in 10,000	Potential exposure	CERCLA, RCRA	TBC	Used to calculate site-specific PRGs for groundwater.
Systemic toxicants in groundwater	Not to exceed media-specific levels where people could be exposed by direct ingestion or inhalation on a daily basis without appreciable risk of deleterious effects.	Potential exposure	CERCLA, RCRA	TBC	Used to calculate site-specific PRGs for groundwater.
Air	Emissions limitations related to attainment of National Ambient Air Quality Standards and Emission Standards for Hazardous Air Pollutants.	Air emissions	Clean Air Act (CAA)	Applicable	Treatment alternatives such as air stripping will involve air emissions.
ARAR - Applicable or relevant and appropriate requirement CAA - Clean Air Act RCRA - Resource Conservation and Recovery Act CFR - Code for Federal Regulations CWA - Clean Water Act EPA - U.S. Environmental Protection Agency		NPDES - National Pollutant Discharge Elimination System. OSHA - Occupational Safety and Health Administration CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act SDWA - Safe Drinking Water Act SMCLs - Secondary Maximum Contaminant Levels TBC - To be considered			

**Table I-2
Location-Specific ARARs
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland**

Location	Requirement	Prerequisite	Citation	Applicability Determination	Comments
Federal Location-Specific ARARs					
Historic Sites, Buildings, and Antiquities Act					
Historic sites	Avoid undesirable impacts on landmarks.	Areas designated as historic sites.	16 USC 461-467; 40 CFR 6.301 (a)	Relevant and Appropriate	The regulations are relevant and appropriate in situations where remedial actions may adversely affect the historical structures located on the site.
Fish and Wildlife Coordination Act, Fish and Wildlife Improvement Act of 1978, Fish and Wildlife Conservation Act of 1980					
Area affecting streams or other water body	Provides protection for actions that would affect streams, wetlands, other water bodies or protected habitats. Any action taken should protect fish or wildlife.	Diversion, channeling or other activity that modifies a stream or other water body and affects fish or wildlife.	16 USC 661; 16 USC 662; 16 USC 742a; 16 USC 2901; 50 CFR 83	Applicable	Response actions will incorporate protection against any area water body, wetlands, or protected habitats.
Clean Water Act, Section 404					
Surface Water	Ambient Water Quality Criteria established to protect aquatic life and human consumers of water aquatic life.	Activities that affect or may affect the surface water onsite	40 CFR 129	Applicable	These regulations were used in the development of the PRGs for the site.
Hazardous Waste Control Act (HWCA)					
Within 100-year floodplain	Facility must be designed, constructed, operated, and maintained to avoid washout.	RCRA hazardous waste; treatment, storage, or disposal of hazardous waste.	40 CFR 264.18 (b)	TBC	Portions of the site are within the 100-year flood zones. However, actions are not expected to involve hazardous waste. This would be TBC for nonhazardous waste.
Executive Order 11988, Protection of Floodplains					
Within floodplain	Actions taken should avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values.	Action that will occur in a floodplain, i.e., lowlands, and relatively flat areas adjoining inland and coastal waters and other flood-prone areas.	40 CFR 6, Appendix A; excluding Sections 6(a)(2), 6(a)(4), 6(a)(6); 40 CFR 6.302	Applicable	Portions of the site are within the 100-year flood zones, therefore the requirements of this regulation are applicable for any response actions that might involve the use of these areas.
Maryland State Location-Specific ARARs					
Threatened and Endangered Species					
Critical habitat upon which endangered species or threatened species depend.	Requires action to conserve endangered or threatened fish species and the critical habitats they depend on. May not reduce the likelihood of either the survival or recovery of a listed species in the wild by reducing the reproduction, numbers or distribution of a listed species or otherwise adversely affect the species.	Determination of effect upon endangered or threatened species or its habitat.	COMAR 08.03.08	Relevant and Appropriate	Requires action to conserve endangered fish species and the critical habitats they depend on.
Threatened and Endangered Fish Species					
Critical habitat upon which endangered or threatened fish species depend.	Requires action to conserve endangered or threatened fish species and the critical habitats they depend on.	Determination of effect upon endangered or threatened fish species or its habitat.	COMAR 08.02.12	Relevant and Appropriate	These regulations are applicable if remedial actions may jeopardize endangered or threatened fish species. Currently, there are no federal or state endangered fish species at NSF-IH.
Fish and Fisheries					
Fisheries, locations where species of fish exist	Requirements to conserve species of fish for human enjoyment, for scientific purposes and to ensure their perpetuation as viable components of their ecosystems.	Determination of effect upon fish species or its habitat.	Annotated Code of Maryland Title 4	Applicable	Fish species inhabit in Mattawoman Creek. If response actions affect these species, the requirements of this title are applicable.
Wildlife					
Areas inhabited by wildlife	Requirements to conserve species of wildlife for human enjoyment, for scientific purposes and to ensure their perpetuation as viable components of their ecosystems.	Determination of effect upon wildlife species or its habitat.	Annotated Code of Maryland Title 10	Relevant and Appropriate	Wildlife species are present at NSF-IH. If response actions may affect wildlife species, the requirements of this title are applicable.
Construction on Nontidal Waters and Floodplains					
Nontidal waters and floodplains	Protect and maintain nontidal waterways and/or state of Maryland floodplains must follow these regulations	Activities that affect nontidal waterways and floodplains	COMAR 08.05.03	Relevant and Appropriate	Any remedial actions involving alteration to the streams bounding the site or floodplains (including temporary construction) are subject to these requirements.
Water Pollution Control Law					
Waters of the State	Establishes effective programs and provides additional and cumulative remedies to prevent, abate, and control pollution of the waters in the state.	Activities that will pollute the waters in the state.	COMAR 9, Parts 301-351	Relevant and Appropriate	This regulation is applicable for remedial actions that may affect water quality in local streams.
Maryland Water Pollution Control Regulations					
Surface waters of the State	Protect and maintain the quality of surface water in the State of Maryland. Criteria and standards for discharges limitations and policy for antidegradation of the State's limitations and policy for antidegradation of the State's surface water.	Activities that will pollute the surface waters of the state.	COMAR 26.08, Chapters 01-07	Applicable	This regulation is applicable for remedial actions that may affect surface water quality in the State of Maryland.
Water Management					

**Table I-2
Location-Specific ARARs
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland**

Location	Requirement	Prerequisite	Citation	Applicability Determination	Comments
Water resources of the State	Provides for the conservation and protection of the water resources of the State by requiring that any land-clearing, grading, or other earth disturbances require an erosion- and sediment-control plan. Also provides that stormwater must be managed to prevent offsite sedimentation and maintain current site conditions.	Activities that affect the water resources of the State.	COMAR 26.17.01 COMAR 26.17.02, Annotated Code of Maryland Title 4	Applicable	The design for the remedial actions will incorporate the requirements of this regulation.
Groundwater Pollution Control Act					
Groundwater	Achieve standards for purity and quality for groundwater in the State	Except as provided in Sections 3.2 and 3.3, the standards of purity and quality for groundwater in the state shall be the constituent concentrations found in Appendix A.	46CSR12-3.1 to 3.3	Applicable	
Groundwater	Constituents in groundwater shall not cause a violation of the standards found at 46 CSR Series I in any surface water		46CSR12-3.3	Applicable	
Groundwater	Subsurface borings shall be constructed, operated and closed in a manner that protects groundwater		47CSR58-4.2	Applicable	
Groundwater	New areas used for storage shall be designed, constructed and operated to prevent release of contaminants. Groundwater monitoring stations may be necessary to assure protection of the groundwater resource.		47CSR58-4.3.b	Relevant and Appropriate	
Groundwater	Loading and unloading stations including but not limited to drums, trucks and railcars shall have spill prevention and control facilities and procedures as well as secondary containment.		47CSR58-4.4.a	Relevant and Appropriate	
Groundwater	New impoundments shall be designed and operated to prevent contamination of groundwater.		47CSR58-4.5.b	Relevant and Appropriate	
Groundwater	Pipelines conveying contaminants shall preferentially be installed above ground. Ditches conveying contaminants must have appropriate liners. Pumps and related equipment must be installed to prevent or contain any leaks or spills.		47CSR58-4.7 to 4.7.d	Relevant and Appropriate	
Groundwater	Requirements for secondary containment for sumps and above ground tanks		47CSR58-4.8 to 4.8.e	Relevant and Appropriate	
Groundwater	Groundwater monitoring stations shall be located and constructed in a manner that allows accurate determination of groundwater quality and levels, and prevents contamination of groundwater through the finished well hole or casing. All groundwater monitoring stations shall be accurately located utilizing latitude and longitude by surveying, or other acceptable means, and coordinates shall be included with all data collected.		47CSR58-4.79.c to 4.9.g	Applicable	
Groundwater	Each industrial establishment shall have a comprehensive groundwater protection plan (GPP) including inventory of all operations that may reasonably be expected to contaminate the groundwater resources and procedures designed to protect groundwater, a summary of all activities carried out under other regulatory programs that have relevance to groundwater protection, a discussion of all available information reasonably available to the facility/activity regarding existing groundwater quality and provisions for employee training and quarterly inspections		47CSR58-4.11	Relevant and Appropriate	
Groundwater	Clean up actions shall be permanent and shall not rely primarily on dilution and dispersion if active remedial measures are technically and economically feasible.		47CSR58-8.1.a to 8.1.c	Relevant and Appropriate	
Groundwater	Facility or activity design must adequately address the issues arising from locating in karst, wetlands, faults, subsidence, delineated wellhead protection areas determined vulnerable.	Sensitive natural resource or geologic areas	47CSR58-4.10	Applicable	
Groundwater	Rule governing the certification of monitoring well drillers and monitoring well installations and alterations.	Well installation	47CSR59-4.1 to 4.7	Applicable	

Table I-2
Location-Specific ARARs
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland

Location	Requirement	Prerequisite	Citation	Applicability Determination	Comments
Groundwater	Requirements and procedures governing the installation and development and/or redevelopment and reconditioning or abandonment of temporary or permanent monitoring well(s), piezometer(s), recovery well(s), well(s), and boreholes.	Boring installation	47CSR60-5 to 22	Applicable	

**Table I-3
Action-Specific ARARs
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland**

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Federal Action-Specific ARARs					
Resource Conservation and Recovery Act (RCRA) 42 USC 6901 et seq.*					
Onsite waste generation	Waste generator shall determine if waste is hazardous waste.	Generator of hazardous waste.	40 CFR 262.10 (a), 262.11	Applicable	Applicable for any operation where waste is generated. Remedial alternatives for the site may generate contaminated wastes.
Hazardous waste accumulation	Generator may accumulate waste on site for 90 days or less or must comply with requirements for operating a storage facility.	Accumulate hazardous waste.	40 CFR 262.34	Applicable	If waste generated at ABL is determined to be hazardous, any storage of the hazardous waste will not exceed 90 days. Accumulation of hazardous wastes onsite for longer than 90 days would be subject to the substantive RCRA requirements for storage facilities.
Recordkeeping	Generator must keep records of types and quantities of wastes generated.	Generate hazardous waste.	40 CFR 262.40	Relevant and appropriate	Administrative requirements are not ARARs for onsite CERCLA actions.
Excavation	Movement of excavated materials to new location and placement in or on land will trigger land disposal restrictions for the excavated waste or closure requirements for the unit in which the waste is being placed.	Materials containing RCRA hazardous wastes subject to land disposal restrictions are placed in another unit.	40 CFR 268.40	Applicable	Applicable to disposal of soil to a new location and placement in or on land containing land-disposal-restricted RCRA hazardous waste. The wastes generated from response actions at Site 17 may be RCRA hazardous wastes.
Safe Drinking Water Act					
Actions that affect drinking water supply	Promulgates National Primary Drinking Water Standard Maximum Contaminant Levels (MCLs)	Actions that affect drinking water supply	40 CFR 141	Relevant and appropriate	These regulations are ARARs for remedial actions at the site that affect the groundwater.
U.S. Department of Transportation, 49 USC 1802, et seq.*					
Hazardous Materials Transportation	No person shall represent that a container or package is safe unless it meets the requirements of 49 USC 1802, et seq. or represent that a hazardous material is present in a package or motor vehicle if it is not.	Interstate carriers transporting hazardous waste and substances by motor vehicle. Transportation of hazardous material under contract with any department of the executive branch of the Federal Government.	49 CFR 171.2(f)	Applicable	Offsite transport of hazardous materials must comply with both substantive and administrative requirements.
	No person shall unlawfully alter or deface labels, placards, or descriptions, packages, containers, or motor vehicles used for transportation of hazardous materials.		49 CFR 171.2(g)	Applicable	
Hazardous Materials Marking, Labeling, and Placarding	Each person who offers hazardous material for transportation or each carrier that transports it shall mark each package, container, and vehicle in the manner required.	Person who offers hazardous material for transportation; carries hazardous material; or packages, labels, or placards hazardous material.	49 CFR 172.300	Applicable	Offsite transport of hazardous materials must comply with both substantive and administrative requirements.
	Each person offering non-bulk hazardous materials for transportation shall mark the proper shipping name and identification number (technical name) and consignee's name and address.		49 CFR 172.301	Applicable	
	Hazardous materials for transportation in bulk packages must be labeled with proper identification (ID) number, specified in 49 CFR 172.101 table, with required size of print. Packages must remain marked until cleaned or refilled with material requiring other marking.		49 CFR 172.302	Applicable	

**Table I-3
Action-Specific ARARs
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland**

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Hazardous Materials Marking, Labeling, and Placarding (cont.)	No package marked with a proper shipping name or ID number may be offered for transport or transported unless the package contains the identified hazardous material or its residue.	None	49 CFR 172.303	Applicable	Offsite transport of hazardous materials must comply with both substantive and administrative requirements.
	The marking must be durable, in English, in contrasting colors, unobscured, and away from other markings.		49 CFR 172.304	Applicable	
	Labeling of hazardous material packages shall be as specified in the list.	Person who offers hazardous material for transportation; carries hazardous material; or packages, labels, or placards hazardous material.	49 CFR 172.400	Applicable	
	Non-bulk combination packages containing liquid hazardous materials must be packed with closures upward, and marked with arrows pointing upward.		49 CFR 172.312	Applicable	
	Each bulk packaging or transport vehicle containing any quantity of hazardous material must be placarded on each side and each end with the type of placards listed in Tables 1 and 2 of 49 CFR 172.504.		49 CFR 172.504	Applicable	
Occupational Safety and Health Administration (OSHA)					
Hazardous waste work	Requirements for hazardous waste workers such as training, personal protective equipment (PPE), and clothing must be met.	Hazardous waste work.	29 CFR 1904, 29 CFR 1910, 29 CFR 1926	Applicable	Remedial action activities at ABL will involve hazardous waste workers; therefore the requirements of OSHA must be met.
EPA Final Military Munitions Rule					
EPA Final Military Munitions Rule	Remedial actions generate munitions that are subject to RCRA requirements.	The Federal Facility Compliance Act (FFCA) of 1992 requires federal facilities to comply with all applicable hazardous waste laws, including hazardous waste management under the Resource Conservation and Recovery Act (RCRA). Specifically, Section 107 of FFCA mandates the U.S. Environmental Protection Agency (EPA) to promulgate regulations identifying when military munitions become a hazardous waste subject to RCRA regulations. In response to this mandate, the EPA established the Military Munitions Rule (MMR).	40 CFR 260, et al.	Applicable	The FS/remedial actions will likely generate military munitions waste which may be classified as hazardous.

**Table I-3
Action-Specific ARARs
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland**

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Department of Defense					
UXO Technicians and Personnel	DoD minimum qualifications for essential personnel	This document provides minimum qualification standards for personnel performing UXO-related operations, with the exception of DoD Explosives Ordnance Disposal personnel. Such operations include, but may not be limited to: military munitions responses, range clearance activities, range maintenance, and inspection or certification of munitions debris and range-related debris being considered for transfer or release from DoD control	DDESB Technical Paper 18	Relevant and Appropriate	Personnel standards for Munitions Response (MR) operations
DoD Contractors Safety Manual for Ammunition and Explosives	Department of Defense Guidance	This Manual provides, safety requirements, guidance and information for contractual work or services involving ammunition and explosives (AE). The purpose of this Manual and any additional safety requirements in the contract is to minimize the potential for mishaps that could interrupt Department of Defense (DoD) operations, delay production, damage DoD property, cause injury to DoD personnel, or endanger the public. The Manual contains the minimum contractual safety requirements to support the objectives of DoD. These requirements are not, of themselves, a complete safety program, and nothing in this Manual relieves a contractor from the responsibility to comply with federal, state and local laws and regulations.	DOD 4145.26M	Applicable	Safety Standards for contractors working with Ammunitions and Explosives.
Defense Demilitarization Manual	Department of Defense Guidance	This manual, authorized by DoD 4140.1-R, Department of Defense (DoD) Materiel Management Regulation, implements the requirements of the Federal Property Management Regulation (FPMR), and other laws and regulations as appropriate, as they apply to the disposition of excess, surplus, and foreign excess personal property (FEPP). It takes precedence over conflicting instructions within the DoD. The Federal Property and Administrative Services Act of 1949, as amended (Act of 30 June 1949, 63 Stat. 377, 40 United States Code [USC] 471), hereafter referred to as the "Act", and the FPMR shall take precedence over this manual, unless otherwise provided by statute.	DOD 4160.21-M-1	Relevant and Appropriate	Demilitarization of live ordnance will follow the instructions provided.

**Table I-3
Action-Specific ARARs
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland**

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Ammunition and Explosives Safety Standards	Action involves a transfer of DOD lands.	This Standard is issued under the authority of DoD Directive 6055.9, "DoD Explosives Safety Board (DDESB) and DoD Component Explosives Safety Responsibilities," July 29, 1996. It establishes uniform safety standards applicable to ammunition and explosives, to associated personnel and property, and to unrelated personnel and property exposed to the potential damaging effects of an accident involving ammunition and explosives during development, manufacturing, testing, transportation, handling, storage, maintenance, demilitarization, and disposal.	DOD 6055.9-STD	Relevant and Appropriate	Explosive Safety
Safety and Occupational Health Policy for the Department of Defense	Actions taking place on DOD lands.	The requirements for Federal agencies to have safety standards, at least equivalent to the OSHA Standards, are established by law (Sec. 10a., PL 91-596 and 29 CFR 1960.42b.), by Presidential Directive (Sec. 2 and 3, Executive Order 12196)	DOD Directive 1000.3	Relevant and Appropriate	Safety Standard Conformance to OSHA
Protection and Enhancement of Environmental Quality	Actions taking place on DOD lands.	The purpose of this directive is to establish safety standards, procedures, and precautions for the prevention of injury to personnel from exposure to environmental electro-magnetic radiation and particle radiation.	DOD Directive 5100.5	Relevant and Appropriate	Remedial actions for the former VNTR will adhere to this Directive
Environmental Effects in the United States of DOD Actions	Actions taking place on DOD lands.	This directive implements the Council on Environmental Quality (CEQ) regulations (40 CFR Sections 1500-1508) implementing Section 102(2) of the National Environmental Policy Act (NEPA), and provides policy and procedures to enable DOD officials to take into account environmental considerations when considering the authorization or approval of major DOD actions within the United States. The directive requires DOD components to integrate the NEPA process during the initial planning stages of proposed DOD actions to ensure that planning and decisions reflect environmental values, and to preclude potential conflicts. See 32 CFR 188.	DOD Directive 6050.1	Relevant and Appropriate	Remedial actions will adhere to this Directive

**Table I-3
Action-Specific ARARs
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland**

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Solid Waste Management – Collection, Disposal, Resource Recovery, and Recycling Program	Actions taking place on DOD lands which include the generation of solid waste.	Provides DoD policy on the acquisition, management, and disposal of real property consistent with Executive Order 13327, "Federal Real Property Asset Management," February 6, 2004.	DOD Directive 4165.6	Relevant and Appropriate	Remedial actions for Real Property
Department of the Navy and Naval and Ordnance Security and Activity					
Ammunition and Explosive Safety Ashore	US Navy	To publish explosive safety regulations and emphasize ordnance safety precautions	NAVSEA OP 5 Volume 1 Seventh Revision	Applicable	Explosive Safety and MR Response Actions
Military munitions response program oversight	US Navy	This Instruction applies to Navy response actions involving military munitions, including unexploded ordnance (UXO), at other than operational ranges.	NOSSA 8020.15	Applicable	Explosive Safety Submission
DON Environmental Restoration Program - Munitions response Program	US Navy	To reduce risk to human health, and the environment from legacy waste disposal operations and hazardous substances resulting from the use of military munitions.	DON Environmental Restoration Manual	Applicable	The Munitions Response Program (MRP) is applicable to Munitions Response Sites (MRS) where Munitions and Explosives of Concern (MEC) and Munitions Constituents (MC) are present.
Operational Risk Assessment	US Navy	Previously established and reissue policy for Operational Risk Management (ORM) as an integral part of the decision-making process for all navy military and civilian personnel, on or off duty. It involves training and planning at all levels in order to optimize operational capability and readiness by teaching personnel to make sound decisions regardless of the activity in which they are involved.	OPNAV Inst 3500.39B	Applicable	Risk Assessment and Management
Inter-service Responsibilities for Explosive Ordnance Disposal	US Navy	The purpose of this regulation delineates the explosive Ordnance disposal (EOD) responsibilities of the Army, Marine Corps, Navy, and Air Force.	OPNAVINST 8027.1	Applicable	Explosive Ordnance Disposal (EOD) support
Maryland State Action-Specific ARARs					
Air Quality					
Actions that involve emissions to air	Provides ambient air quality standards, general emissions standards, and restrictions for air emissions from construction activities, vents, and treatment technologies such as incinerators. Also includes nuisance and odor control. Construction activities may emit particulate matter into the ambient air. Remedial activities must follow regulations.	Actions that involve emissions to air above specific limits.	COMAR 26.11	Relevant and appropriate	May apply to the alternative that includes air stripping as a treatment component for extracted groundwater.

**Table I-3
Action-Specific ARARs
Site 17 Groundwater Feasibility Study
NSF-IH, Indian Head, Maryland**

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Maryland Hazardous Waste Regulations					
Storage, treatment or disposal, and transportation of hazardous waste	Regulations and procedures for the identifications, listing, transportation, treatment, storage, and disposal of hazardous wastes must be met.	Handling of hazardous wastes	COMAR 26.13.01 through COMAR 26.13.04, Annotated Code of Maryland Title 7	Applicable	Any hazardous waste found during site remediation will be disposed of according to regulations. Any residues or by-products from treatment systems that are hazardous must be disposed of properly.
Solid Waste and Water Supply Regulations					
Well Construction and Abandonment	Specifications for well construction and abandonment must be met. Also provides a mechanism to provide the State of Maryland with a database of existing and abandoned wells. Permits are required for well construction.		COMAR 26.04.03 (A&D); COMAR 26.04.04	Applicable	The requirements of this regulation are applicable to the response actions at the site if monitoring wells have to be installed or abandoned.
Stormwater Management					
Design and construction	Regulations require the design and construction of a system necessary to control stormwater.	Design and construction activities	COMAR 26.17.02	Applicable	The remedial action will incorporate measures to control and manage stormwater as necessary.
Erosion and Sediment Control					
Land clearing, grading, and earth disturbances	Regulations require the preparation and implementation of a plan to control erosion and sediment for activities involving land clearing, and grading and earth disturbances. Erosion and sediment control criteria are also established.	Land clearing, grading, and earth disturbances	COMAR 26.17.01	Applicable	The remedial action will incorporate the standards required for clearing, grading, and other earth disturbances, including compliance with county and municipal erosion and sediment control ordinances, and the Commission's erosion- and sedimentation-control regulations.
Maryland Drinking Water Law					
Actions that affect state drinking water	Ensures that the State has the primary enforcement responsibility for drinking water standards under the Federal Safe Drinking Water Act.	Action causing pollution of drinking water supply	COMAR 9.04, Parts 401-413	Applicable	This regulation may be an ARAR for Site 47 if activities that affect water quality are conducted.
Occupational, Industrial, and Residential Hazards					
Action that will generate noise	Limits set on the levels of noise must be met; these limits are protective of the health, welfare, and property of the people in the State of Maryland. The maximum permitted levels for construction activities may not exceed 90 dBA during the day and 75 dBA during night.	Action that will generate noise	COMAR 26.02.03.02A (2) and B(2), COMAR 26.02.03.02.03A, Annotated Code of Maryland Title 3	Applicable	During site remediation work, the maximum allowable noise levels will not be exceeded at site boundaries.

Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs. Specific potential ARARs are addressed in the table below each heading.

Acronyms used in the table:

ARAR - Applicable or relevant and appropriate requirement
 CAA - Clean Air Act
 RCRA - Resource Conservation and Recovery Act
 CFR - Code for Federal Regulations
 CWA - Clean Water Act
 DOT - U.S. Department of Transportation
 EPA - U.S. Environmental Protection Agency

NPDES - National Pollutant Discharge Elimination System.
 OSHA - Occupational Safety and Health Administration
 CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
 SDWA - Safe Drinking Water Act
 SMCLs - Secondary Maximum Contaminant Levels
 TBC - To be considered
 USC - United States Code

Appendix J

SourceDK Model Results

**SourceDK Tier 3 Results
Various Hydraulic Conductivities**

SourcedK

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence

Version 1.0

TIER 3 Process Models

Data Input Instructions:

115

↑ or
115

115

1. Enter value directly....or
2. Calculate by filling in blue cells. Press Enter, then hit "Calculate"
3. Value calculated by model. (Don't enter any data.)

METHOD 1: DISSOLVED PHASE CONSTITUENTS

Original Constituent Concentration C_o (mg/L)

Desired Cleanup Level C_t (mg/L)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Groundwater Seepage Velocity V_x (ft/yr)

Retardation Factor R (-)

Soil Bulk Density Rho (kg/L)

Partition Coefficient K_{oc} (L/kg)

Fraction Organic Carbon f_{oc} (-)

Effective Porosity n_e (-)

Create Graph

HELP

METHOD 2: NAPL ZONE CONSTITUENTS

Type of Media

Initial Aqueous-Phase Concentration in Source Zone Under Natural Flow Conditions C_s (mg/L)

Desired Cleanup Concentration C_t (mg/L)

Density of NAPL Fluid Rho (g/mL)

Initial NAPL Saturation in Porous Media S_o (%)

Uncertainty in NAPL Saturation \pm Factor of

Natural Groundwater Seepage Velocity V_s (ft/yr)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Is This a Pumping Scenario? Yes No

Site Location: Site 17 DP-27

Constituent: TCE to SCL

METHOD 2: Continued

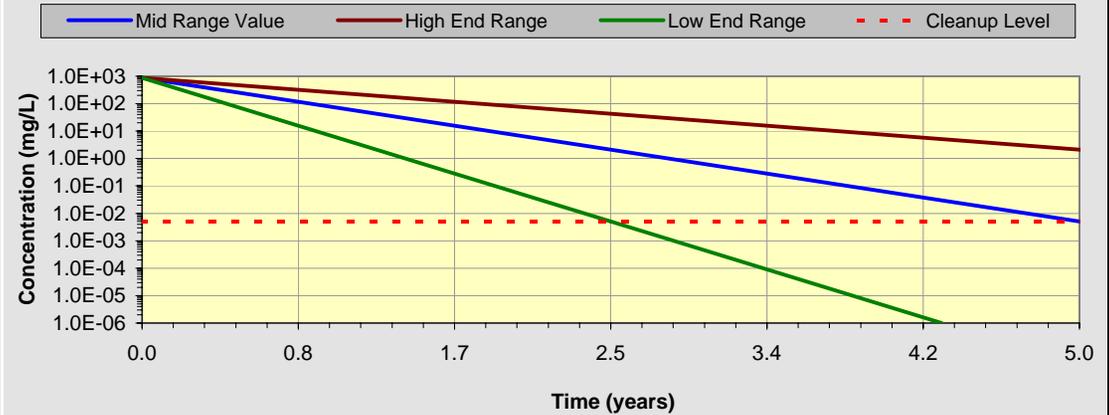
What is the Typical Groundwater Seepage Velocity While Pumping? (ft/yr)

Concentration in Produced Groundwater as a Result of Mass Transfer Effects is (mg/L)

Create Graph

HELP

OUTPUT GRAPH



RESULTS

- 1) The Number of Pore Volumes Required to Reach Desired Cleanup Level

1.68E+01 (-)	3.36E+01 (-)	6.71E+01 (-)
Low End Estimate	Mid Range Estimate	High End Estimate
- 2) Time to Flush Out Constituents and Achieve Desired Cleanup Level

2.52E+00 (yrs)	5.03E+00 (yrs)	1.01E+01 (yrs)
Low End Estimate	Mid Range Estimate	High End Estimate

Return to Main Screen

New Site/Clear Screen

Paste Example Data Set

**SourceDK Tier 2 Results
High Hydraulic Conductivity and Various
Biodegradation Rates**

SourcedK

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence

Version 1.0

TIER 3 Process Models

Data Input Instructions:

115

↑ or
115

115

1. Enter value directly....or
2. Calculate by filling in blue cells. Press Enter, then hit "Calculate"
3. Value calculated by model. (Don't enter any data.)

METHOD 1: DISSOLVED PHASE CONSTITUENTS

Original Constituent Concentration C_o (mg/L)

Desired Cleanup Level C_t (mg/L)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Groundwater Seepage Velocity V_x (ft/yr)

Retardation Factor R (-)

Soil Bulk Density Rho (kg/L)

Partition Coefficient K_{oc} (L/kg)

Fraction Organic Carbon f_{oc} (-)

Effective Porosity n_e (-)

Create Graph

HELP

METHOD 2: NAPL ZONE CONSTITUENTS

Type of Media

Initial Aqueous-Phase Concentration in Source Zone Under Natural Flow Conditions C_s (mg/L)

Desired Cleanup Concentration C_t (mg/L)

Density of NAPL Fluid Rho (g/mL)

Initial NAPL Saturation in Porous Media S_o (%)

Uncertainty in NAPL Saturation \pm Factor of

Natural Groundwater Seepage Velocity V_s (ft/yr)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Is This a Pumping Scenario? Yes No

Site Location: Site 17 DP-27

Constituent: TCE to SCL

METHOD 2: Continued

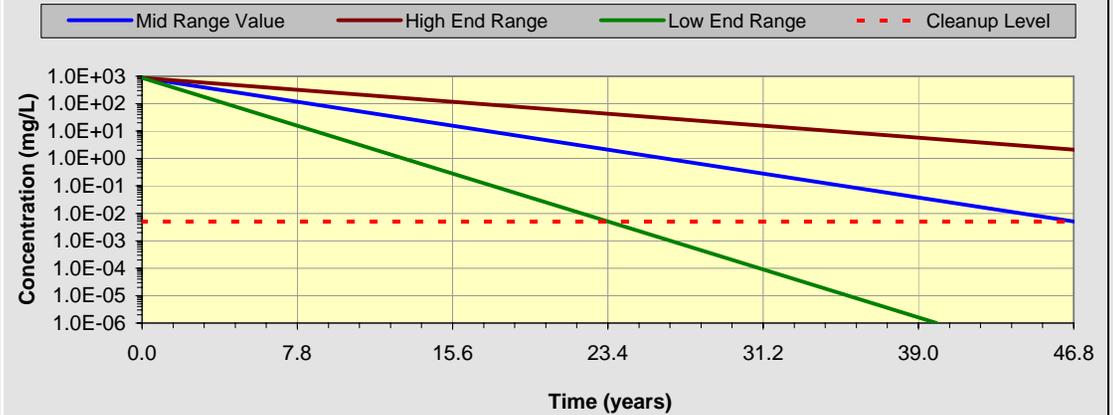
What is the Typical Groundwater Seepage Velocity While Pumping? (ft/yr)

Concentration in Produced Groundwater as a Result of Mass Transfer Effects is (mg/L)

Create Graph

HELP

OUTPUT GRAPH



RESULTS

- 1) The Number of Pore Volumes Required to Reach Desired Cleanup Level

1.68E+01 (-)	3.36E+01 (-)	6.71E+01 (-)
Low End Estimate	Mid Range Estimate	High End Estimate
- 2) Time to Flush Out Constituents and Achieve Desired Cleanup Level

2.34E+01 (yrs)	4.68E+01 (yrs)	9.37E+01 (yrs)
Low End Estimate	Mid Range Estimate	High End Estimate

Return to Main Screen

New Site/Clear Screen

Paste Example Data Set

SourcedK

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence

Version 1.0

TIER 3 Process Models

Data Input Instructions:

115

↑ or

115

115

1. Enter value directly....or

2. Calculate by filling in blue cells. Press Enter, then hit "Calculate"

3. Value calculated by model. (Don't enter any data.)

METHOD 1: DISSOLVED PHASE CONSTITUENTS

Original Constituent Concentration C_o (mg/L)

Desired Cleanup Level C_t (mg/L)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Groundwater Seepage Velocity V_x (ft/yr)

Retardation Factor R (-)
↑ or

Soil Bulk Density Rho (kg/L)

Partition Coefficient K_{oc} (L/kg)

Fraction Organic Carbon f_{oc} (-)

Effective Porosity n_e (-)

Calculate R

Create Graph

HELP

METHOD 2: NAPL ZONE CONSTITUENTS

Type of Media

Initial Aqueous-Phase Concentration in Source Zone Under Natural Flow Conditions C_s (mg/L)

Desired Cleanup Concentration C_t (mg/L)

Density of NAPL Fluid Rho (g/mL)

Initial NAPL Saturation in Porous Media S_o (%)

Uncertainty in NAPL Saturation \pm Factor of

Natural Groundwater Seepage Velocity V_s (ft/yr)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Is This a Pumping Scenario?

Site Location: Site 17 DP-27

Constituent: TCE to SCL

METHOD 2: Continued

What is the Typical Groundwater Seepage Velocity While Pumping? (ft/yr)

Concentration in Produced Groundwater as a Result of Mass Transfer Effects is (mg/L)

Create Graph

HELP

OUTPUT GRAPH

--- Cleanup Level



RESULTS

- The Number of Pore Volumes Required to Reach Desired Cleanup Level **2.24E+02** (-)
- Time to Flush Out Constituents and Achieve Desired Cleanup Level **3.36E+01** (yrs)

Return to Main Screen

New Site/Clear Screen

Paste Example Data Set

SourcedK

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence

Version 1.0

TIER 3 Process Models

Data Input Instructions:

115

↑ or

115

115

1. Enter value directly....or
2. Calculate by filling in blue cells. Press Enter, then hit "Calculate"
3. Value calculated by model. (Don't enter any data.)

METHOD 1: DISSOLVED PHASE CONSTITUENTS

Original Constituent Concentration C_o (mg/L)

Desired Cleanup Level C_t (mg/L)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Groundwater Seepage Velocity V_x (ft/yr)

Retardation Factor R (-)
↑ or

Soil Bulk Density Rho (kg/L)

Partition Coefficient K_{oc} (L/kg)

Fraction Organic Carbon f_{oc} (-)

Effective Porosity n_e (-)

Calculate R

Create Graph

HELP

METHOD 2: NAPL ZONE CONSTITUENTS

Type of Media

Initial Aqueous-Phase Concentration in Source Zone Under Natural Flow Conditions C_s (mg/L)

Desired Cleanup Concentration C_t (mg/L)

Density of NAPL Fluid Rho (g/mL)

Initial NAPL Saturation in Porous Media S_o (%)

Uncertainty in NAPL Saturation \pm Factor of

Natural Groundwater Seepage Velocity V_s (ft/yr)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Is This a Pumping Scenario?

Site Location: Site 17 DP-27

Constituent: TCE to SCL

METHOD 2: Continued

What is the Typical Groundwater Seepage Velocity While Pumping? (ft/yr)

Concentration in Produced Groundwater as a Result of Mass Transfer Effects is (mg/L)

Create Graph

HELP

OUTPUT GRAPH

--- Cleanup Level



RESULTS

- 1) The Number of Pore Volumes Required to Reach Desired Cleanup Level **2.24E+02** (-)
- 2) Time to Flush Out Constituents and Achieve Desired Cleanup Level **3.12E+02** (yrs)

Return to Main Screen

New Site/Clear Screen

Paste Example Data Set

SourcedK

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence

Version 1.0

TIER 3 Process Models

Data Input Instructions:

115

↑ or

115

115

1. Enter value directly...or

2. Calculate by filling in blue cells. Press Enter, then hit "Calculate"

3. Value calculated by model. (Don't enter any data.)

METHOD 1: DISSOLVED PHASE CONSTITUENTS

Original Constituent Concentration C_o (mg/L)

Desired Cleanup Level C_t (mg/L)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Groundwater Seepage Velocity V_x (ft/yr)

Retardation Factor R (-)

Soil Bulk Density Rho (kg/L)

Partition Coefficient K_{oc} (L/kg)

Fraction Organic Carbon f_{oc} (-)

Effective Porosity n_e (-)

Calculate R

Create Graph

HELP

METHOD 2: NAPL ZONE CONSTITUENTS

Type of Media

Initial Aqueous-Phase Concentration in Source Zone Under Natural Flow Conditions C_s (mg/L)

Desired Cleanup Concentration C_t (mg/L)

Density of NAPL Fluid Rho (g/mL)

Initial NAPL Saturation in Porous Media S_o (%)

Uncertainty in NAPL Saturation \pm Factor of

Natural Groundwater Seepage Velocity V_s (ft/yr)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Is This a Pumping Scenario?

Site Location: Site 17 DP-21

Constituent: TCE to SCL

METHOD 2: Continued

What is the Typical Groundwater Seepage Velocity While Pumping? (ft/yr)

Concentration in Produced Groundwater as a Result of Mass Transfer Effects is (mg/L)

Create Graph

HELP

OUTPUT GRAPH

--- Cleanup Level



RESULTS

- 1) The Number of Pore Volumes Required to Reach Desired Cleanup Level **1.04E+02** (-)
- 2) Time to Flush Out Constituents and Achieve Desired Cleanup Level **2.95E+01** (yrs)

Return to Main Screen

New Site/Clear Screen

Paste Example Data Set

SourcedK

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence

Version 1.0

TIER 3 Process Models

Data Input Instructions:

115

↑ or

115

115

1. Enter value directly....or
2. Calculate by filling in blue cells. Press Enter, then hit "Calculate"
3. Value calculated by model. (Don't enter any data.)

METHOD 1: DISSOLVED PHASE CONSTITUENTS

Original Constituent Concentration C_o (mg/L)

Desired Cleanup Level C_t (mg/L)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Groundwater Seepage Velocity V_x (ft/yr)

Retardation Factor R (-)
↑ or

Soil Bulk Density Rho (kg/L)

Partition Coefficient K_{oc} (L/kg)

Fraction Organic Carbon f_{oc} (-)

Effective Porosity n_e (-)

Calculate R

Create Graph

HELP

METHOD 2: NAPL ZONE CONSTITUENTS

Type of Media

Initial Aqueous-Phase Concentration in Source Zone Under Natural Flow Conditions C_s (mg/L)

Desired Cleanup Concentration C_t (mg/L)

Density of NAPL Fluid Rho (g/mL)

Initial NAPL Saturation in Porous Media S_o (%)

Uncertainty in NAPL Saturation \pm Factor of

Natural Groundwater Seepage Velocity V_s (ft/yr)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Is This a Pumping Scenario?

Site Location: Site 17 DP-27

Constituent: TCE to SCL

METHOD 2: Continued

What is the Typical Groundwater Seepage Velocity While Pumping? (ft/yr)

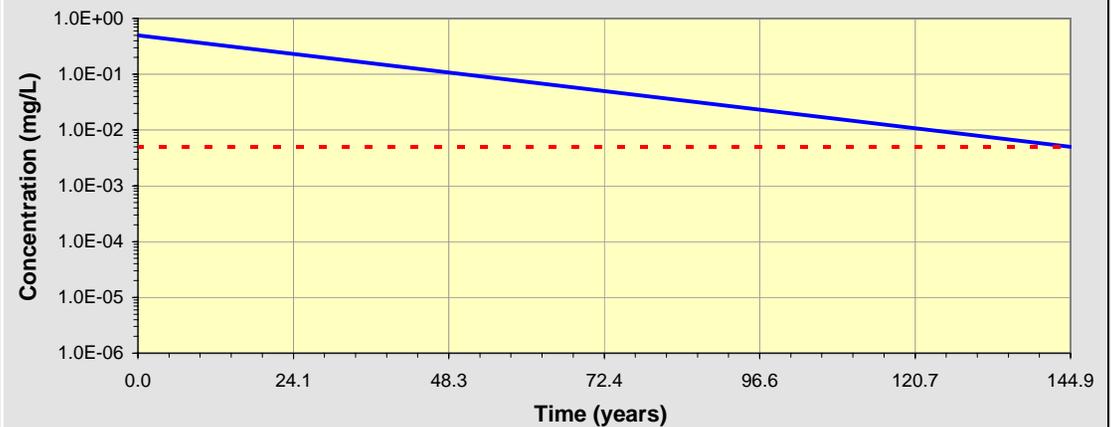
Concentration in Produced Groundwater as a Result of Mass Transfer Effects is (mg/L)

Create Graph

HELP

OUTPUT GRAPH

--- Cleanup Level



RESULTS

- 1) The Number of Pore Volumes Required to Reach Desired Cleanup Level **1.04E+02** (-)
- 2) Time to Flush Out Constituents and Achieve Desired Cleanup Level **1.45E+02** (yrs)

Return to Main Screen

New Site/Clear Screen

Paste Example Data Set

SourcedK

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence

Version 1.0

TIER 3 Process Models

Data Input Instructions:

115

↑ or

115

115

1. Enter value directly...or
2. Calculate by filling in blue cells. Press Enter, then hit "Calculate"
3. Value calculated by model. (Don't enter any data.)

METHOD 1: DISSOLVED PHASE CONSTITUENTS

Original Constituent Concentration C_o (mg/L)

Desired Cleanup Level C_t (mg/L)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Groundwater Seepage Velocity V_x (ft/yr)

Retardation Factor R (-)
↑ or

Soil Bulk Density Rho (kg/L)

Partition Coefficient K_{oc} (L/kg)

Fraction Organic Carbon f_{oc} (-)

Effective Porosity n_e (-)

Calculate R

Create Graph

HELP

METHOD 2: NAPL ZONE CONSTITUENTS

Type of Media

Initial Aqueous-Phase Concentration in Source Zone Under Natural Flow Conditions C_s (mg/L)

Desired Cleanup Concentration C_t (mg/L)

Density of NAPL Fluid Rho (g/mL)

Initial NAPL Saturation in Porous Media S_o (%)

Uncertainty in NAPL Saturation \pm Factor of

Natural Groundwater Seepage Velocity V_s (ft/yr)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Is This a Pumping Scenario?

Site Location: Site 17 DP-27

Constituent: TCE to SCL

METHOD 2: Continued

What is the Typical Groundwater Seepage Velocity While Pumping? (ft/yr)

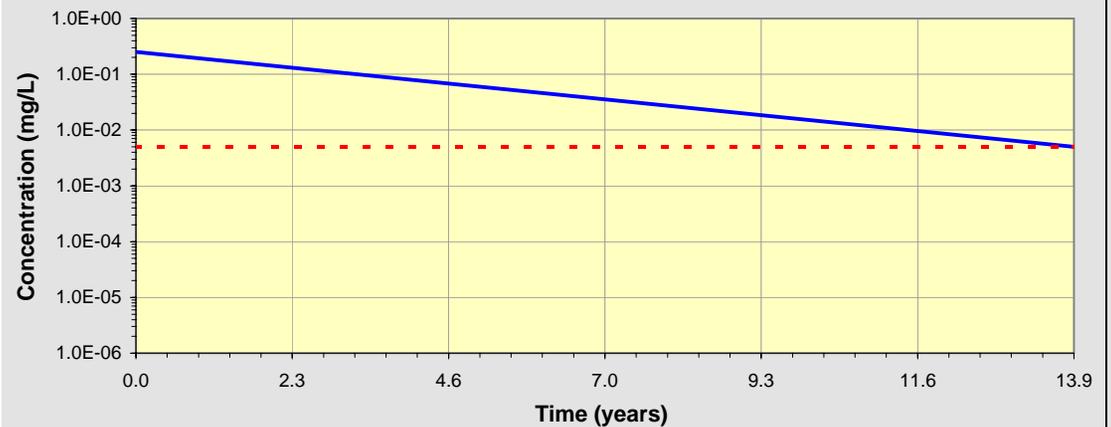
Concentration in Produced Groundwater as a Result of Mass Transfer Effects is (mg/L)

Create Graph

HELP

OUTPUT GRAPH

--- Cleanup Level



RESULTS

- 1) The Number of Pore Volumes Required to Reach Desired Cleanup Level **9.27E+01** (-)
- 2) Time to Flush Out Constituents and Achieve Desired Cleanup Level **1.39E+01** (yrs)

Return to Main Screen

New Site/Clear Screen

Paste Example Data Set

SourcedK

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence

Version 1.0

TIER 3 Process Models

Data Input Instructions:

115

↑ or

115

115

1. Enter value directly...or

2. Calculate by filling in blue cells. Press Enter, then hit "Calculate"

3. Value calculated by model. (Don't enter any data.)

METHOD 1: DISSOLVED PHASE CONSTITUENTS

Original Constituent Concentration C_o (mg/L)

Desired Cleanup Level C_t (mg/L)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Groundwater Seepage Velocity V_x (ft/yr)

Retardation Factor R (-)
↑ or

Soil Bulk Density Rho (kg/L)

Partition Coefficient K_{oc} (L/kg)

Fraction Organic Carbon f_{oc} (-)

Effective Porosity n_e (-)

Calculate R

Create Graph

HELP

METHOD 2: NAPL ZONE CONSTITUENTS

Type of Media

Initial Aqueous-Phase Concentration in Source Zone Under Natural Flow Conditions C_s (mg/L)

Desired Cleanup Concentration C_t (mg/L)

Density of NAPL Fluid Rho (g/mL)

Initial NAPL Saturation in Porous Media S_o (%)

Uncertainty in NAPL Saturation \pm Factor of

Natural Groundwater Seepage Velocity V_s (ft/yr)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Is This a Pumping Scenario?

Site Location: Site 17 DP-27

Constituent: TCE to SCL

METHOD 2: Continued

What is the Typical Groundwater Seepage Velocity While Pumping? (ft/yr)

Concentration in Produced Groundwater as a Result of Mass Transfer Effects is (mg/L)

Create Graph

HELP

OUTPUT GRAPH

--- Cleanup Level



RESULTS

- 1) The Number of Pore Volumes Required to Reach Desired Cleanup Level **9.27E+01** (-)
- 2) Time to Flush Out Constituents and Achieve Desired Cleanup Level **2.50E+01** (yrs)

Return to Main Screen

New Site/Clear Screen

Paste Example Data Set

SourcedK

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence

Version 1.0

TIER 3 Process Models

Data Input Instructions:

115

↑ or

115

115

1. Enter value directly...or
2. Calculate by filling in blue cells. Press Enter, then hit "Calculate"
3. Value calculated by model. (Don't enter any data.)

METHOD 1: DISSOLVED PHASE CONSTITUENTS

Original Constituent Concentration C_o (mg/L)

Desired Cleanup Level C_t (mg/L)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Groundwater Seepage Velocity V_x (ft/yr)

Retardation Factor R (-)
↑ or

Soil Bulk Density Rho (kg/L)

Partition Coefficient K_{oc} (L/kg)

Fraction Organic Carbon f_{oc} (-)

Effective Porosity n_e (-)

Calculate R

Create Graph

HELP

METHOD 2: NAPL ZONE CONSTITUENTS

Type of Media

Initial Aqueous-Phase Concentration in Source Zone Under Natural Flow Conditions C_s (mg/L)

Desired Cleanup Concentration C_t (mg/L)

Density of NAPL Fluid Rho (g/mL)

Initial NAPL Saturation in Porous Media S_o (%)

Uncertainty in NAPL Saturation \pm Factor of

Natural Groundwater Seepage Velocity V_s (ft/yr)

Length of Source Zone Parallel to Groundwater Flow L (ft)

Is This a Pumping Scenario?

Site Location: Site 17 DP-27

Constituent: TCE to SCL

METHOD 2: Continued

What is the Typical Groundwater Seepage Velocity While Pumping? (ft/yr)

Concentration in Produced Groundwater as a Result of Mass Transfer Effects is (mg/L)

Create Graph

HELP

OUTPUT GRAPH

--- Cleanup Level



RESULTS

- 1) The Number of Pore Volumes Required to Reach Desired Cleanup Level **9.27E+01** (-)
- 2) Time to Flush Out Constituents and Achieve Desired Cleanup Level **1.29E+02** (yrs)

Return to Main Screen

New Site/Clear Screen

Paste Example Data Set

**SourceDK Tier 2 Results
High Hydraulic Conductivity and Various
Biodegradation Rates**

SourceDK

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence

Version 1.0

TIER 2 Box Model

Site Location and I.D.: Site 17 NSF-IH Shallow Groundwater

Constituent of Interest: TCE; 1,000 to 5 ppb; High K;

1. HYDROGEOLOGY

Darcy Velocity V_d (ft/yr)
 Hydraulic Conductivity K ft/d
 Hydraulic Gradient i (ft/ft)

2. SOURCE CHARACTERISTICS

Key Assumption:
 Source Represented as Box Model



Average Source Groundwater Concentration at Time = 0 C_{gwo} ug/L
 Source Length S_l (ft)
 Source Width S_w (ft)
 Source Thickness S_t (ft)
 Enter Value for Specific Discharge Q (ft³/yr)

3. SOURCE DECAY CONSTANT

Enter Directly k_s (1/yr)
 Calculate Source Decay Constant Using Sections 3A and 3B k_s (1/yr)

3A. SOURCE MASS

Source Mass at Time = 0 M_o (kg)
Select Method for Calculating Source Mass
 Method 1: Enter Source Mass Directly
 Method 2: Simple Volume X Concentration Calculation
 Method 3: Detailed Volume X Concentration Calculation
 Method 4: Estimated From NAPL Relationships

3B. SOURCE ZONE BIODEGRADATION

No Biodegradation
 Assume Biodegradation Occurs in "Box" in Dissolved Phase Only
 Select Method 1:
 Biodegradation Rate Constant λ (per yr)
 Select Method 2:
 Biodegradation Rate Derived From Electron Acceptor By-Product Data.
 (Applies Only to Petroleum Hydrocarbon Sites)
 a) Biodegradation Capacity BC (mg/L)
 or
 Delta Oxygen DO (mg/L)
 Delta Nitrate NO_3 (mg/L)
 Observed Ferrous Iron Fe^{2+} (mg/L)
 Delta Sulfate SO_4 (mg/L)
 Observed Methane CH_4 (mg/L)
 and
 b) Percentage of Biodegradation Capacity Applied to This Constituent (%)

4. TIME FOR OUTPUT

a) Number of Years Over Which to Plot Data (yr) (Required)
 b) Time in Years at Which Decay Starts (yr) (Optional)

5. UNCERTAINTY RANGE FOR MASS ESTIMATE ± Factor of

6. FIELD DATA FOR COMPARISON

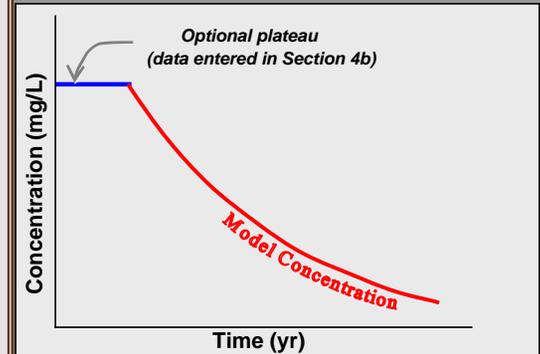
Year From Time = 0 (yr)	<input type="text" value="0"/>	<input type="text"/>								
Concentration (ug/L)	<input type="text" value="1000"/>	<input type="text"/>								

7. CHOOSE OUTPUT TO VIEW

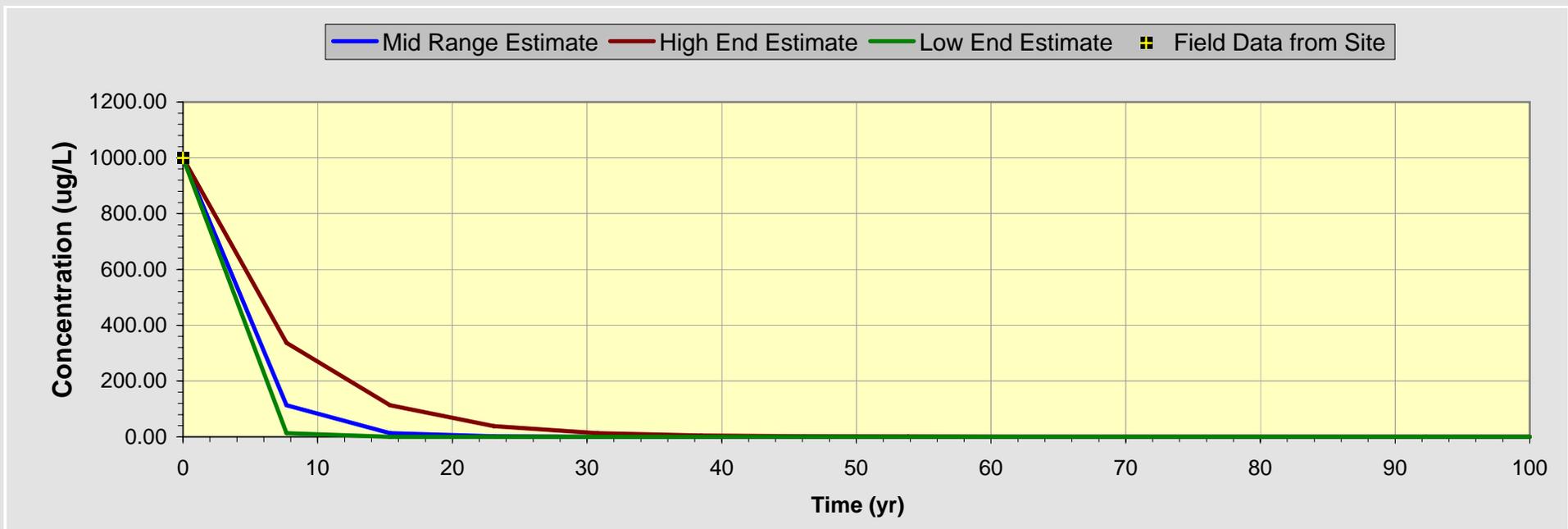
Data Input Instructions:

- 1. Enter value directly ... or
 → 2. Calculate by filling in blue cells. Press Enter, then hit "Calculate" button.
 → 3. Value calculated by model. (Do not enter any data.)

SourceDK OUTPUT SHOWS THIS:



TYPE OF MODEL	Time (yr)														
	0.00	7.69	15.38	23.08	30.77	38.46	46.15	53.85	61.54	69.23	76.92	84.62	92.31	100.00	
Model Conc. (ug/L)	1000.000	113.614	12.908	1.467	0.167	0.019	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	
Actual Conc. (ug/L)	1000.000														
Mass Discharge (kg/yr)	2.8E+00	3.2E-01	3.7E-02	4.1E-03	4.7E-04	5.4E-05	2.8E-05								



1. Display Concentration Vs. Time Chart
 or
 Display Source Mass Vs. Time Chart
2. Number of Years Over Which to Plot Graph (yr)
 (Press "Calculate Current Sheet" button after changing value.)

Log Linear

Concentration/Time Mini-Calculator

(yr) →

High End Conc Estimate	<input type="text" value=""/> (ug/L)
Mid Range Conc Estimate	<input type="text" value=""/> (ug/L)
Low End Conc Estimate	<input type="text" value=""/> (ug/L)

Concentration (ug/L) →

High End Time Estimate	<input type="text" value="37"/> (yr)
Mid Range Time Estimate	<input type="text" value="19"/> (yr)
Low End Time Estimate	<input type="text" value="9"/> (yr)

Return To Input

Calculate Current Sheet

HELP

SourceDK

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence

Version 1.0

TIER 2 Box Model

Site Location and I.D.: Site 17 NSF-IH Shallow Groundwater

Constituent of Interest: TCE; 1,000 to 5 ppb; High K_d

1. HYDROGEOLOGY

Darcy Velocity V_d (ft/yr)
 Hydraulic Conductivity K ft/d
 Hydraulic Gradient i (ft/ft)

2. SOURCE CHARACTERISTICS



Average Source Groundwater Concentration at Time = 0 C_{gwo} ug/L
 Source Length S_l (ft)
 Source Width S_w (ft)
 Source Thickness S_t (ft)
 Enter Value for Specific Discharge Q (ft³/yr)

3. SOURCE DECAY CONSTANT

Enter Directly k_s (1/yr)
 Calculate Source Decay Constant Using Sections 3A and 3B k_s (1/yr)

3A. SOURCE MASS

Source Mass at Time = 0 M_o (kg)
Select Method for Calculating Source Mass
 Method 1: Enter Source Mass Directly
 Method 2: Simple Volume X Concentration Calculation
 Method 3: Detailed Volume X Concentration Calculation
 Method 4: Estimated From NAPL Relationships

3B. SOURCE ZONE BIODEGRADATION

No Biodegradation
 ↓ or
 Assume Biodegradation Occurs in "Box" in Dissolved Phase Only
 Select Method 1:
 Biodegradation Rate Constant λ (per yr)
 ↓ or
 Select Method 2:
 Biodegradation Rate Derived From Electron Acceptor By-Product Data.
 (Applies Only to Petroleum Hydrocarbon Sites)
 a) Biodegradation Capacity BC (mg/L)
 or
 Delta Oxygen DO (mg/L)
 Delta Nitrate NO_3 (mg/L)
 Observed Ferrous Iron Fe^{2+} (mg/L)
 Delta Sulfate SO_4 (mg/L)
 Observed Methane CH_4 (mg/L)
 and
 b) Percentage of Biodegradation Capacity Applied to This Constituent (%)

4. TIME FOR OUTPUT

a) Number of Years Over Which to Plot Data (yr) (Required)
 b) Time in Years at Which Decay Starts (yr) (Optional)

5. UNCERTAINTY RANGE FOR MASS ESTIMATE ± Factor of

6. FIELD DATA FOR COMPARISON

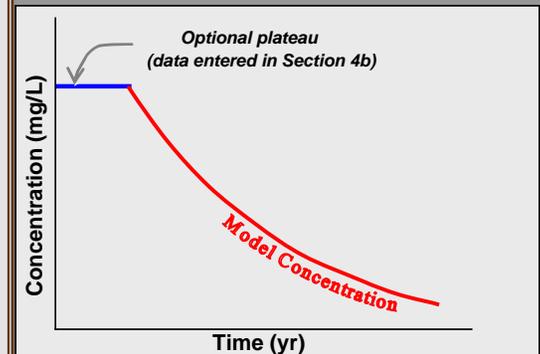
Year From Time = 0 (yr)	<input type="text" value="0"/>	<input type="text"/>								
Concentration (ug/L)	<input type="text" value="1000"/>	<input type="text"/>								

7. CHOOSE OUTPUT TO VIEW

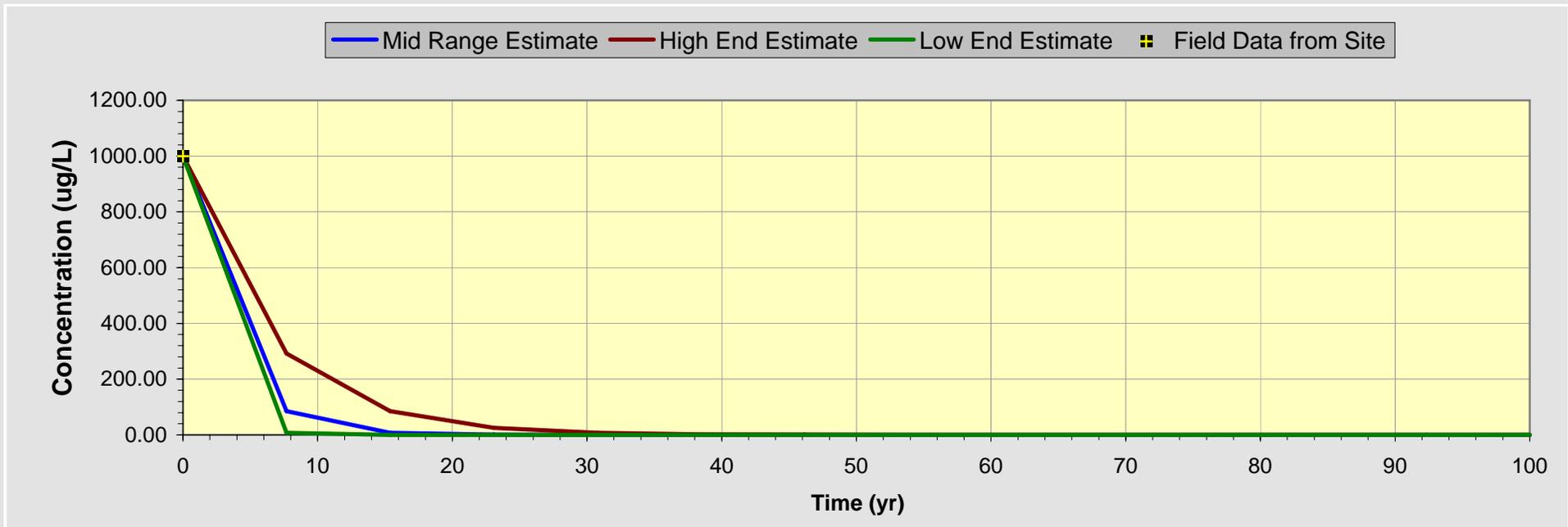
Data Input Instructions:

- 115** → 1. Enter value directly ... or
115 → 2. Calculate by filling in blue cells. Press Enter, then hit "Calculate" button.
115 → 3. Value calculated by model. (Do not enter any data.)

SourceDK OUTPUT SHOWS THIS:



TYPE OF MODEL	Time (yr)													
	0.00	7.69	15.38	23.08	30.77	38.46	46.15	53.85	61.54	69.23	76.92	84.62	92.31	100.00
Model Conc. (ug/L)	1000.000	85.064	7.236	0.616	0.052	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Actual Conc. (ug/L)	1000.000													
Mass Discharge (kg/yr)	2.8E+00	2.4E-01	2.0E-02	1.7E-03	1.5E-04	2.8E-05								



1. Display Concentration Vs. Time Chart
 or
 Display Source Mass Vs. Time Chart

2. Number of Years Over Which to Plot Graph (yr)
 (Press "Calculate Current Sheet" button after changing value.)

Log Linear

Concentration/Time Mini-Calculator

Time (yr) → High End Conc Estimate (ug/L)
 Mid Range Conc Estimate (ug/L)
 Low End Conc Estimate (ug/L)

Concentration (ug/L) → High End Time Estimate (yr)
 Mid Range Time Estimate (yr)
 Low End Time Estimate (yr)

Return To Input

Calculate Current Sheet

HELP

Appendix K
Detailed Cost Estimate

Remediation Cost Summary
 Site 17 Groundwater Feasibility Study
 NSF-IH, Indian Head Maryland

Remedial Alternative	Description	Construction Time (weeks)	Operation Time (years)	Capital Cost	2008 Lifetime O&M Cost	PW Lifetime O&M Cost	Total PW Cost
1	No Action	NA	NA	\$0	\$0	\$0	\$0
2	MNA and ICs	Minimal	100	\$24,300	\$1,004,400	\$460,600	\$484,900
3	Source Treatment Using ISCO, MNA, and ICs (One time mixing at TCE>1,000 ug/L area)	8.2	30	\$1,526,200	\$522,800	\$348,200	\$1,874,400
4	Source Zone Treatment Using ISCR, MNA, and ICs (One time mixing at TCE>1,000 ug/L area)	9.0	30	\$1,394,700	\$522,800	\$348,200	\$1,742,900
5	Source Zone Removal, Off-site Disposal, MNA, and ICs	3	30	\$2,866,400	\$399,000	\$348,200	\$3,214,600

REMEDIAL ALTERNATIVE 2 MNA and ICs	LOCATION: Site 17, Disposed Metal Parts Along Shoreline	MEDIA:	Construction time: minimal
	NSF-IH, Indian Head, Maryland	Groundwater	Operation time: 100 years
			Post Remediation Monitoring: included in the operation time

DESCRIPTION OF ALTERNATIVE:

1) MNA monitoring at semiannually for 3 years, annually for 5 years, and 5-year intervals for the remaining years until 30th year.

2) Installation of 4 additional groundwater monitoring wells, one in the center of South Plume, one in the center of North Plume, and two immediately downgradient of the South Plume.

3) For each sampling event samples are collected from all existing and new groundwater monitoring wells and three locations of surface water sample from the shoreline of the Creek within Site 17.

4) Groundwater samples will be analyzed for TCL VOCs; TOC; MNA parameters including sulfate, nitrate, chloride, methane, ethane, and ethene; alkalinity; iron (II); and, field parameters including DO, ORP, pH, and temperature. Surface water samples will be analyzed for VOCs. The methods will not be specified because within a 30-year timeframe, current methods may not be valid.

5) Data interpretation and report would be prepared following a sampling event.

6) Five-year reviews would be performed throughout the duration of the remediation for up to 40 years and a site closure report would be developed.

Cost Component	Qty	Unit	Cost Source	Estimated Activity Duration (day)	Labor Unit Cost	Labor Total Cost	Equipment Unit Cost	Equipment Total Cost	Material Unit Cost	Material Total Cost	Subcontractor	Total Cost
CAPITAL COSTS												
Institutional Controls/Planning												\$5,000.00
Site-Specific LUC	1	lump sum	Professional Judgment		\$5,000.00	\$5,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$5,000.00
Permitting, Planning, and Reporting												\$8,500.00
GW Drilling Permits	1	lump sum	Professional Judgment		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,000.00	\$1,000.00
Health and Safety Plan	1	lump sum	Professional Judgment		\$2,500.00	\$2,500.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2,500.00
FSP, QAPP, and DQOs	1	lump sum	Professional Judgment		\$5,000.00	\$5,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$5,000.00
Site Preparation				3								\$1,244.77
Site Clearing (very minimal - only for 3 GW MW drillings - by hand)	0.1	acre	M 022030 200 0100	1	\$1,725.00	\$172.50	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$172.50
Survey (for locations of 3 GW wells - 2 man crew)	1	lump sum	E 9924 1201	1	\$617.50	\$617.50	\$204.77	\$204.77	\$0.00	\$0.00	\$0.00	\$822.27
Personnel and Equipment Decon	1	lump sum	Professional Judgment	1	\$250.00	\$250.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$250.00
Remediation Activities				3								\$3,000.00
Installation of MWs	4	wells	Redox Tech Quote	3	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$3,000.00	\$3,000.00
Construction Oversight												\$2,004.00
Geologist	1.2	weeks	E 99 11 0203		\$1,670.00	\$2,004.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2,004.00

REMEDIAL ALTERNATIVE 2 MNA and ICs	LOCATION: Site 17, Disposed Metal Parts Along Shoreline NSF-IH, Indian Head, Maryland						MEDIA: Groundwater		Construction time: minimal				
									Operation time: 100 years				
									Post Remediation Monitoring: included in the operation time				
Mob/Demob													\$424.48
Assume 10% of total field activities	1	lump sum	Professional Judgment		\$424.48	\$424.48	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$424.48
SUBTOTAL CAPITAL COST						\$15,968.48		\$204.77		\$0.00	\$4,000.00		\$20,173.25
Scope Contingency	10%												\$2,017.32
Bid Contingency	10%												\$2,017.32
TOTAL CAPITAL COST													\$24,207.90
OPERATION & MAINTENANCE AND PERIODIC ACTIVITIES - PER EVENT COST													
Sampling and Analysis													
Sample Collection													\$4,056.54
Sample collection - 2 crew, 10 hrs/day, \$50/hr	3	days	Professional Judgment		\$1,000.00	\$3,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$3,000.00
Disposable and decon materials per sample (including QA/QC)	15	samples	E 33 02 0401, 33 02 0402, 33 02 0561		\$0.00	\$0.00	\$0.00	\$0.00	\$24.90	\$373.50	\$0.00	\$0.00	\$373.50
Equipment Rental	3	days	E 33 02 0573, 33 02 0578		\$0.00	\$0.00	\$227.68	\$683.04	\$0.00	\$0.00	\$0.00	\$0.00	\$683.04
Lab Analysis													\$12,853.00
Metals	21	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$3,297.00	\$0.00	\$3,297.00
VOCs (groundwater and surface)	15	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,680.00	\$0.00	\$1,680.00
TOC	7	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$280.00	\$0.00	\$280.00
Chloride, nitrite/nitrate, sulfate, sulfide, permanganate	11	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$715.00	\$0.00	\$715.00
Methane, ethane, ethene	11	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$6,776.00	\$0.00	\$6,776.00
Alkalinity	7	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$105.00	\$0.00	\$105.00
Data Interpretation													\$7,500.00
Report	1	lump sum	Professional Judgment		\$7,500.00	\$7,500.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$7,500.00
Five-Year Review													\$7,000.00
Report	1	lump sum	Professional Judgment		\$5,000.00	\$5,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$5,000.00
Field Inspection	1	lump sum	Professional Judgment		\$2,000.00	\$2,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2,000.00
Site Closure													\$25,000.00
Report development	1	lump sum	Professional Judgment		\$25,000.00	\$25,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$25,000.00

PRESENT WORTH CALCULATION					
REMEDIAL ALTERNATIVE 2		MNA and ICs			
Location:	Site 17, Disposed Metal Parts Along Shoreline	Construction time:	minimal		
Media:	Shallow Groundwater	Operation time:	100 years		
		Discount Rate:	5.2%		
		O&M Contingency:	20%		
Year	Real Cost Incurred	Cost Description	Cost Type	Discount Factor	Present Worth
0	\$24,208	Cost associated with ICs, planning, and installation of 3 GW wells installation	Capital	1.00	\$24,208
1	\$117,166	Four events of MNA quarterly samplings	O&M	1.05	\$111,374
2	\$117,166	Four events of MNA quarterly samplings	O&M	1.11	\$105,869
3	\$58,583	Two events of MNA semiannual samplings	O&M	1.16	\$50,318
4	\$29,291	Annual MNA sampling	O&M	1.22	\$23,915
5	\$37,691	Annual MNA sampling and five-year review	O&M, Periodic	1.29	\$29,253
6	\$29,291	Annual MNA sampling	O&M	1.36	\$21,610
7	\$29,291	Annual MNA sampling	O&M	1.43	\$20,541
8	\$29,291	Annual MNA sampling	O&M	1.50	\$19,526
9	\$0			1.58	\$0
10	\$29,291	MNA Sampling and five-year review	O&M	1.66	\$17,643
15	\$29,291	MNA Sampling and five-year review	O&M	2.14	\$13,693
20	\$29,291	MNA Sampling and five-year review	O&M	2.76	\$10,627
25	\$29,291	MNA Sampling and five-year review	O&M	3.55	\$8,248
30	\$29,291	MNA Sampling and five-year review	O&M	4.58	\$6,401
35	\$29,291	MNA Sampling and five-year review	O&M	5.90	\$4,968
40	\$29,291	MNA Sampling and five-year review	O&M	7.60	\$3,856
45	\$29,291	MNA Sampling and five-year review	O&M	9.79	\$2,992
50	\$29,291	MNA Sampling and five-year review	O&M	12.61	\$2,322

PRESENT WORTH CALCULATION						
REMEDIAL ALTERNATIVE 2		MNA and ICs				
Location:	Site 17, Disposed Metal Parts Along Shoreline	Construction time:	minimal			
Media:	Shallow Groundwater	Operation time:	100 years			
		Discount Rate:	5.2%			
		O&M Contingency:	20%			
Year	Real Cost Incurred	Cost Description	Cost Type	Discount Factor	Present Worth	
55	\$29,291	MNA Sampling and five-year review	O&M	16.25	\$1,802	
60	\$29,291	MNA Sampling and five-year review	O&M	20.94	\$1,399	
65	\$29,291	MNA Sampling and five-year review	O&M	26.98	\$1,086	
70	\$29,291	MNA Sampling and five-year review	O&M	34.76	\$843	
75	\$29,291	MNA Sampling and five-year review	O&M	44.79	\$654	
80	\$29,291	MNA Sampling and five-year review	O&M	57.71	\$508	
85	\$29,291	MNA Sampling and five-year review	O&M	74.36	\$394	
90	\$29,291	MNA Sampling and five-year review	O&M	95.81	\$306	
95	\$29,291	MNA Sampling and five-year review	O&M	123.45	\$237	
100	\$29,291	MNA Sampling and five-year review	O&M	159.06	\$184	
CAPITAL COST	\$24,208					
2006 Dollar LIFETIME O&M	\$1,004,309	Lifetime Present Worth O&M			\$460,571	
TOTAL IMPLEMENTATION COST	\$1,028,517	TOTAL PRESENT WORTH			\$484,779	

REMEDIAL ALTERNATIVE 3 Source Treatment Using ISCO, MNA, and ICs (One time mixing at TCE>1,000 ug/L area)	LOCATION:				MEDIA: Groundwater	Construction time:	8.2 weeks
	Site 17, Disposed Metal Parts Along Shoreline					Operation time:	30 years
	NSF-IH, Indian Head, Maryland					Post Remediation Monitoring:	included in the operation time

DESCRIPTION OF ALTERNATIVE:

1) ISCO treatment area (TCE> 1,000 ppb) with 10% escalation factor: 3,885 SF

2) Thickness of: Top 8 ft: 8 ft

Contamination interval thickness: 10 ft

3) MEC clearance will be conducted during the excavation activities of the first 8-foot. Cost and duration escalation factor to facilitate MEC clearance: 100%

4) 6-Foot Diameter crane-mounted auger is assumed for the soil mixing.

5) For the purpose of long-term monitoring, a total of 5 permanent MWs will be installed; 3 during the baseline and 2 at approximately 12 months after soil mixing.

6) The short-term performance sampling is assumed to consist of: baseline, 6-, 9-, and 12-month post-mixing monitoring events. Assumed analytical requirements are described in Section 5.1.3.

7) The long-term monitoring would consist of quarterly events for 2 years, biannual events for 1 year, annual events for the remaining years until 5 years, and every 5-year intervals for the remaining years. Assumed requirements are described in Section 5.1.3.

9) Five-year reviews would be performed throughout the duration of the remediation for up to 30 years and a site closure report would be developed.

Cost Component	Qty	Unit	Cost Source	Estimated Activity Duration (days)	Labor Unit Cost	Labor Total Cost	Equipment Unit Cost	Equipment Total Cost	Material Unit Cost	Material Total Cost	Subcontractor	Total Cost
CAPITAL COSTS												
Institutional Controls/Planning												\$5,000.00
Site-Specific LUC	1	lump sum	Professional Judgment		\$5,000.00	\$5,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$5,000.00
Site Preparation				2								\$2,200.00
Site Clearing (very minimal - by hand)	0.5	acre	CCI, 2008	1	\$2,000.00	\$1,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,000.00
Survey (for locations of injection points and GW wells - 2 man crew)	1	day	CCI, 2008	1	\$1,200.00	\$1,200.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,200.00
Shallow Soil (0 - 8 ft bgs) Handling				17								\$137,407.76
Dewatering - assume onsite treatment and disposal	1	lump sum	MTS, 2008.		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$87,479.20	\$87,479.20
Excavation of top 8 feet (include 100% escalation factor for MEC clearance) Dozer 80 HP, 150', clay	2302	CY of soil	RMS 31 23 16.46.2240	12	\$6.76	\$15,563.82	\$5.68	\$13,077.30	\$0.00	\$0.00	\$0.00	\$28,641.12
Temporary staging/stockpiling (+ 15% swelling factor) Front end loader, wheel-mounted, 1.5 CY	2648	CY of soil	CH2M HILL Rate (modified from RMS 31 23 23.15 6040 with 300% escalation factor)	12	\$1.53	\$4,050.97	\$1.02	\$2,700.65	\$0.00	\$0.00	\$0.00	\$6,751.61
Backfill - 80 HP 150', clay	2648	CY of soil	CH2M HILL Rate (modified from RMS 31 23 23.14 2240 with 300% escalation factor)	5	\$2.97	\$7,863.64	\$2.52	\$6,672.18	\$0.00	\$0.00	\$0.00	\$14,535.83
Soil Mixing Activities				18								\$286,862.79
Installation of MWs	5	wells	BOA rates	3	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$6,750.00	\$6,750.00
Reagent (sodium persulfate, ferrous sulfate, and citric acid, include shipping cost)	1	lump sum	See Table 5-2.		\$0.00	\$0.00	\$0.00	\$0.00	\$123,291.99	\$123,291.99	\$0.00	\$123,291.99

REMEDIAL ALTERNATIVE 3 Source Treatment Using ISCO, MNA, and ICs (One time mixing at TCE>1,000 ug/L area)	LOCATION: Site 17, Disposed Metal Parts Along Shoreline NSF-IH, Indian Head, Maryland				MEDIA: Groundwater	Construction time: 8.2 weeks
						Operation time: 30 years
						Post Remediation Monitoring: included in the operation time

DESCRIPTION OF ALTERNATIVE:

1) ISCO treatment area (TCE> 1,000 ppb) with 10% escalation factor: 3,885 SF

2) Thickness of: Top 8 ft: 8 ft
Contamination interval thickness: 10 ft

3) MEC clearance will be conducted during the excavation activities of the first 8-foot. Cost and duration escalation factor to facilitate MEC clearance: 100%

4) 6-Foot Diameter crane-mounted auger is assumed for the soil mixing.

5) For the purpose of long-term monitoring, a total of 5 permanent MWs will be installed; 3 during the baseline and 2 at approximately 12 months after soil mixing.

6) The short-term performance sampling is assumed to consist of: baseline, 6-, 9-, and 12-month post-mixing monitoring events. Assumed analytical requirements are described in Section 5.1.3.

7) The long-term monitoring would consist of quarterly events for 2 years, biannual events for 1 year, annual events for the remaining years until 5 years, and every 5-year intervals for the remaining years. Assumed requirements are described in Section 5.1.3.

9) Five-year reviews would be performed throughout the duration of the remediation for up to 30 years and a site closure report would be developed.

Cost Component	Qty	Unit	Cost Source	Estimated Activity Duration (days)	Labor Unit Cost	Labor Total Cost	Equipment Unit Cost	Equipment Total Cost	Material Unit Cost	Material Total Cost	Subcontractor	Total Cost
Iron-activated persulfate soil mixing - 6 ft diameter auger	1300	CY of soil	See Table 5-2.	15	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$156,820.80	\$156,820.80
Site Restoration				4								\$5,754.17
Compaction - riding sheepfoot, 6" lifts, 3 passes	2648	CY of soil	RMS 31 23 23.23 5620	2	\$0.24	\$635.45	\$0.79	\$2,091.68	\$0.00	\$0.00	\$0.00	\$2,727.12
Top soil, 6" layer	72	CY of soil	CCI, 2008	1	\$0.00	\$0.00	\$0.00	\$0.00	\$30.00	\$2,160.00	\$0.00	\$2,160.00
Fine grading and seeding, inc. lime, fertilizer & seed	144	SY	RMS 32 91 19.13 1000	1	\$1.46	\$210.24	\$0.24	\$34.56	\$0.35	\$50.40	\$865.00	\$867.05
MEC Clearance Support (only during the top 8-foot soil excavation activities and does not include cost for MEC handling and management)												\$93,596.00
Mob/Demob	4	person	CH2M HILL Rates		\$2,000.00	\$8,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$8,000.00
MEC Clearance (\$100/hr; 10 hrs/day; 4 persons)	17	days/4 crew	CH2M HILL Rates		\$4,000.00	\$68,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$68,000.00
OE Clearance Report												
OE Clearance Plan (Draft and Final)	1	each	CH2M HILL Rates		\$3,500.00	\$3,500.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$3,500.00
Health and Safety Plan (including briefing)	1	each	CH2M HILL Rates		\$2,500.00	\$2,500.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2,500.00
After Action Report	1	each	CH2M HILL Rates		\$1,600.00	\$1,600.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,600.00
Lodging and Per diem	17	days/4 crews			\$0.00	\$0.00	\$0.00	\$0.00	\$588.00	\$9,996.00	\$0.00	\$9,996.00
Construction Oversight												\$114,906.60
Field Superintendent	8.2	weeks	CH2M HILL Rate	c	\$3,444.00	\$28,240.80	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$28,240.80
Safety Engineer	8.2	weeks	CH2M HILL Rate	c	\$3,936.00	\$32,275.20	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$32,275.20
Site Project Manager	8.2	weeks	CH2M HILL Rate	c	\$4,428.00	\$36,309.60	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$36,309.60
Lodging and Per diem	123	day/3 persons			\$0.00	\$0.00	\$0.00	\$0.00	\$147.00	\$18,081.00	\$0.00	\$18,081.00
Preconstruction Submittals												\$124,391.35
ESS (draft, draft final, final)	1	lump sum	10% of total construction cost		\$49,756.54	\$49,756.54	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$49,756.54
Preconstruction survey, design basis, pre-draft, draft, and final design, specifications, and H&S plans	1	lump sum	15% of total construction cost		\$74,634.81	\$74,634.81	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$74,634.81

REMEDIAL ALTERNATIVE 3 Source Treatment Using ISCO, MNA, and ICs (One time mixing at TCE>1,000 ug/L area)	LOCATION: Site 17, Disposed Metal Parts Along Shoreline NSF-IH, Indian Head, Maryland				MEDIA: Groundwater	Construction time: 8.2 weeks
						Operation time: 30 years
						Post Remediation Monitoring: included in the operation time

DESCRIPTION OF ALTERNATIVE:

1) ISCO treatment area (TCE> 1,000 ppb) with 10% escalation factor: 3,885 SF

2) Thickness of: Top 8 ft: 8 ft
Contamination interval thickness: 10 ft

3) MEC clearance will be conducted during the excavation activities of the first 8-foot. Cost and duration escalation factor to facilitate MEC clearance: 100%

4) 6-Foot Diameter crane-mounted auger is assumed for the soil mixing.

5) For the purpose of long-term monitoring, a total of 5 permanent MWs will be installed; 3 during the baseline and 2 at approximately 12 months after soil mixing.

6) The short-term performance sampling is assumed to consist of: baseline, 6-, 9-, and 12-month post-mixing monitoring events. Assumed analytical requirements are described in Section 5.1.3.

7) The long-term monitoring would consist of quarterly events for 2 years, biannual events for 1 year, annual events for the remaining years until 5 years, and every 5-year intervals for the remaining years. Assumed requirements are described in Section 5.1.3.

9) Five-year reviews would be performed throughout the duration of the remediation for up to 30 years and a site closure report would be developed.

Cost Component	Qty	Unit	Cost Source	Estimated Activity Duration (days)	Labor Unit Cost	Labor Total Cost	Equipment Unit Cost	Equipment Total Cost	Material Unit Cost	Material Total Cost	Subcontractor	Total Cost
Permitting												\$4,975.65
GW MW permits	1	lump sum	1% of total construction cost		\$4,975.65	\$4,975.65	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$4,975.65
General Conditions												\$49,756.54
Decontamination, temp. facilities, sed. & erosion control, temp. fence, etc.	1	lump sum	10% of total construction cost		\$49,756.54	\$49,756.54	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$49,756.54
Contractor Overhead and Profit												\$74,634.81
Home office cost, etc.	1	lump sum	15% of total construction cost		\$74,634.81	\$74,634.81	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$74,634.81
Mob/Demob												\$74,634.81
Assume 10% of total field activities	1	lump sum	15% of total construction cost, excludes mixing subcontractor cost		\$74,634.81	\$74,634.81	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$74,634.81
SUBTOTAL CAPITAL COST						\$544,342.88		\$24,576.36		\$153,579.39	\$251,915.00	\$974,120.48
Scope Contingency	40%											\$389,648.19
Bid Contingency	10%											\$97,412.05
TOTAL CAPITAL COST												\$1,461,180.73

OPERATION & MAINTENANCE AND PERIODIC ACTIVITIES - PER EVENT COST												
Sampling and Analysis - Groundwater and Surface water												
Sample Collection												\$4,205.94
Sample collection - 2 crew, 10 hrs/day, \$50/hr	3	days	Professional Judgment		\$1,000.00	\$3,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$3,000.00
Disposable and decon materials per sample	21	samples	E 33 02 0401, 33 02 0402, 33 02 0561		\$0.00	\$0.00	\$0.00	\$0.00	\$24.90	\$522.90	\$0.00	\$522.90
Equipment Rental	3	days	E 33 02 0573, 33 02 0578		\$0.00	\$0.00	\$227.68	\$683.04	\$0.00	\$0.00	\$0.00	\$683.04
Lab Analysis (including QA/QC samples)												\$5,713.68
TAL Metals by CLP (ILM04) (filtered)	12	samples	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,643.04	\$1,643.04
TAL Metals by CLP (ILM04) (unfiltered)	12	samples	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,643.04	\$1,643.04

REMEDIAL ALTERNATIVE 3 Source Treatment Using ISCO, MNA, and ICs (One time mixing at TCE>1,000 ug/L area)	LOCATION: Site 17, Disposed Metal Parts Along Shoreline NSF-IH, Indian Head, Maryland		MEDIA: Groundwater	Construction time: 8.2 weeks
				Operation time: 30 years
				Post Remediation Monitoring: included in the operation time

DESCRIPTION OF ALTERNATIVE:

1) ISCO treatment area (TCE> 1,000 ppb) with 10% escalation factor: 3,885 SF

2) Thickness of: Top 8 ft: 8 ft
Contamination interval thickness: 10 ft

3) MEC clearance will be conducted during the excavation activities of the first 8-foot. Cost and duration escalation factor to facilitate MEC clearance: 100%

4) 6-Foot Diameter crane-mounted auger is assumed for the soil mixing.

5) For the purpose of long-term monitoring, a total of 5 permanent MWs will be installed; 3 during the baseline and 2 at approximately 12 months after soil mixing.

6) The short-term performance sampling is assumed to consist of: baseline, 6-, 9-, and 12-month post-mixing monitoring events. Assumed analytical requirements are described in Section 5.1.3.

7) The long-term monitoring would consist of quarterly events for 2 years, biannual events for 1 year, annual events for the remaining years until 5 years, and every 5-year intervals for the remaining years. Assumed requirements are described in Section 5.1.3.

9) Five-year reviews would be performed throughout the duration of the remediation for up to 30 years and a site closure report would be developed.

Cost Component	Qty	Unit	Cost Source	Estimated Activity Duration (days)	Labor Unit Cost	Labor Total Cost	Equipment Unit Cost	Equipment Total Cost	Material Unit Cost	Material Total Cost	Subcontractor	Total Cost
TCL Volatiles by CLP (OLM04) for groundwater and surface water	17	samples	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,615.00	\$1,615.00
Chloride, nitrite/nitrate, sulfate (300.0)	12	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$585.84	\$585.84
TOC	8	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$320.00	\$320.00
Methane, ethane, ethene (RSK-175)	12	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,213.08	\$1,213.08
Alkalinity (310.1)	8	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$105.44	\$105.44
Ferrous Iron (Iron[II])	8	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$231.28	\$231.28
Sampling and Analysis - Saturated Soil; Only for Baseline, 6- and 9-month Post-Soil Mixing												
Sample Collection												\$6,554.96
DPT drilling (mob, daily rates, consumables) - 4 locations	2	days	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$4,000.00	\$4,000.00
Sample collection - 2 crew, 10 hrs/day, \$50/hr	2	days	Professional Judgment		\$1,000.00	\$2,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2,000.00
Disposable and decon materials per sample	4	samples	E 33 02 0401, 33 02 0402, 33 02 0561		\$0.00	\$0.00	\$0.00	\$0.00	\$24.90	\$99.60	\$0.00	\$99.60
Equipment Rental	2	days	E 33 02 0573, 33 02 0578		\$0.00	\$0.00	\$227.68	\$455.36	\$0.00	\$0.00	\$0.00	\$455.36
Lab Analysis (including QA/QC samples)												\$1,855.36
TAL Metals	8	samples	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,095.36	\$1,095.36
TCL Volatiles	8	samples	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$760.00	\$760.00
Data Interpretation												\$10,000.00
Report	1	lump sum	Professional Judgment		\$10,000.00	\$10,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$10,000.00
Five-Year Review												\$12,000.00
Report (draft and final)	1	lump sum	Professional Judgment		\$10,000.00	\$10,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$10,000.00
Field Inspection	1	lump sum	Professional Judgment		\$2,000.00	\$2,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2,000.00

REMEDIAL ALTERNATIVE 3 Source Treatment Using ISCO, MNA, and ICs (One time mixing at TCE>1,000 ug/L area)	LOCATION:		MEDIA: Groundwater	Construction time:	8.2 weeks
	Site 17, Disposed Metal Parts Along Shoreline			Operation time:	30 years
	NSF-IH, Indian Head, Maryland			Post Remediation Monitoring:	included in the operation time

DESCRIPTION OF ALTERNATIVE:

1) ISCO treatment area (TCE> 1,000 ppb) with 10% escalation factor: 3,885 SF

2) Thickness of: Top 8 ft: 8 ft

Contamination interval thickness: 10 ft

3) MEC clearance will be conducted during the excavation activities of the first 8-foot. Cost and duration escalation factor to facilitate MEC clearance: 100%

4) 6-Foot Diameter crane-mounted auger is assumed for the soil mixing.

5) For the purpose of long-term monitoring, a total of 5 permanent MWs will be installed; 3 during the baseline and 2 at approximately 12 months after soil mixing.

6) The short-term performance sampling is assumed to consist of: baseline, 6-, 9-, and 12-month post-mixing monitoring events. Assumed analytical requirements are described in Section 5.1.3.

7) The long-term monitoring would consist of quarterly events for 2 years, biannual events for 1 year, annual events for the remaining years until 5 years, and every 5-year intervals for the remaining years. Assumed requirements are described in Section 5.1.3.

9) Five-year reviews would be performed throughout the duration of the remediation for up to 30 years and a site closure report would be developed.

Cost Component	Qty	Unit	Cost Source	Estimated Activity Duration (days)	Labor Unit Cost	Labor Total Cost	Equipment Unit Cost	Equipment Total Cost	Material Unit Cost	Material Total Cost	Subcontractor	Total Cost
Site Closure												\$25,000.00
Report development	1	lump sum	Professional Judgment		\$25,000.00	\$25,000.00	\$0.00		\$0.00	\$0.00	\$0.00	\$25,000.00

PRESENT WORTH CALCULATION					
REMEDIAL ALTERNATIVE 3		Source Treatment Using ISCO, MNA, and ICs (One time mixing at TCE>1,000 ug/L area)			
Location:	Site 17, Disposed Metal Parts Along Shoreline	Construction time:	8 weeks		
Media:	Shallow Groundwater	Operation time:	30 years		
		Discount Rate:	5.2%		
		O&M Contingency:	20%		
Year	Real Cost Incurred	Cost Description	Cost Type	Discount Factor	Present Worth
0	\$1,526,171	Capital Cost + Baseline + 6-month + 9-month post-soil mixing sampling events	Capital	1.00	\$1,526,171
1	\$95,614	4 quarterly sampling events	O&M	1.05	\$90,888
2	\$95,614	4 quarterly sampling events	O&M	1.11	\$86,395
3	\$47,807	2 biannual sampling events	O&M	1.16	\$41,062
4	\$23,904	annual sampling	O&M	1.22	\$19,516
5	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	1.29	\$29,728
6	\$0			1.36	\$0
7	\$0			1.43	\$0
8	\$0			1.50	\$0
9	\$0			1.58	\$0
10	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	1.66	\$23,072
11	\$0			1.75	\$0
12	\$0			1.84	\$0
13	\$0			1.93	\$0
14	\$0			2.03	\$0
15	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	2.14	\$17,906
16	\$0			2.25	\$0
17	\$0			2.37	\$0
18	\$0			2.49	\$0
19	\$0			2.62	\$0
20	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	2.76	\$13,897
21	\$0			2.90	\$0
22	\$0			3.05	\$0
23	\$0			3.21	\$0
24	\$0			3.38	\$0
25	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	3.55	\$10,786
26	\$0			3.74	\$0
27	\$0			3.93	\$0
28	\$0			4.13	\$0
29	\$0			4.35	\$0
30	\$68,304	Closure sampling and Closure Report	O&M, Periodic	4.58	\$14,927
CAPITAL COST	\$1,526,171				
2008 Dollar LIFETIME O&M	\$522,760		Lifetime Present Worth O&M		\$348,178
TOTAL IMPLEMENTATION COST	\$2,048,931		TOTAL PRESENT WORTH		\$1,874,348

REMEDIAL ALTERNATIVE 4 Source Treatment Using ISCR, MNA, and ICs (One time mixing at TCE>1,000 ug/L area)	LOCATION:				MEDIA: Groundwater	Construction time: 9 weeks	
	Site 17, Disposed Metal Parts Along Shoreline					Operation time: 30 years	
	NSF-IH, Indian Head, Maryland					Post Remediation Monitoring: included in the operation time	
DESCRIPTION OF ALTERNATIVE:							
1) ISCR treatment area (TCE> 1,000 ppb) with 10% escalation factor:		3,885 SF		5) For the purpose of long-term monitoring, a total of 5 permanent MWs will be installed; 3 during the baseline and 2 at approximately 12 months after soil mixing.			
2) Thickness of: Top 8 ft:		8 ft		6) The short-term performance sampling is assumed to consist of: baseline, 6-, 9-, and 12-month post-mixing monitoring events. Assumed analytical requirements are described in Section 5.1.4.			
Contamination interval thickness:		10 ft		7) The long-term monitoring would consist of quarterly events for 2 years, biannual events for 1 year, annual events for the remaining years until 5 years, and every 5-year intervals for the remaining years. Assumed requirements are described in Section 5.1.4.			
3) MEC clearance will be conducted during the excavation activities of the first 8-foot. Cost and duration escalation factor to facilitate MEC clearance:		100%		9) Five-year reviews would be performed throughout the duration of the remediation for up to 30 years and a site closure report would be developed.			
4) 6-Foot Diameter crane-mounted auger is assumed for the soil mixing.							

Cost Component	Qty	Unit	Cost Source	Estimated Activity Duration (day)	Labor Unit Cost	Labor Total Cost	Equipment Unit Cost	Equipment Total Cost	Material Unit Cost	Material Total Cost	Subcontractor	Total Cost
CAPITAL COSTS												
Institutional Controls/Planning												\$5,000.00
Site-Specific LUC	1	lump sum	Professional Judgment		\$5,000.00	\$5,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$5,000.00
Site Preparation				2								\$2,200.00
Site Clearing (very minimal - by hand)	0.5	acre	CCI, 2008	1	\$2,000.00	\$1,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,000.00
Survey (for locations of injection points and GW wells - 2 man crew)	1	day	CCI, 2008	1	\$1,200.00	\$1,200.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,200.00
Shallow Soil (0 - 8 ft bgs) Handling				17								\$123,216.13
Dewatering - assume onsite treatment and disposal	1	lump sum	MTS, 2008.		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$87,479.20	\$87,479.20
Excavation of top 8 feet (include 100% escalation factor for MEC clearance) Dozer 80 HP, 150', clay	2302	CY of soil	RMS 31 23 16.46.2240	12	\$6.76	\$15,563.82	\$5.68	\$13,077.30	\$0.00	\$0.00	\$0.00	\$28,641.12
Temporary staging/stockpiling (+ 15% swelling factor) Front end loader, wheel-mounted, 1.5 CY	2648	CY of soil	RMS 31 23 23.15 6040	12	\$0.51	\$1,350.32	\$0.34	\$900.22	\$0.00	\$0.00	\$0.00	\$2,250.54
Backfill - 80 HP 150', clay	2648	CY of soil	RMS 31 23 23.14 2240	5	\$0.99	\$2,621.21	\$0.84	\$2,224.06	\$0.00	\$0.00	\$0.00	\$4,845.28
Soil Mixing Activities (No MEC support is required)				22								\$188,813.00
Installation of MWs	5	wells	BOA rates	3	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$6,750.00	\$6,750.00
Reagent (Granular peerless ZVI + shipping)	36,000	lbs	See Table 5-3		\$0.00	\$0.00	\$0.00	\$0.00	\$0.47	\$16,900.00	\$0.00	\$16,900.00
Technology Royalti	1309	CY of soil	7% per cubic yard of treated soil	4	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$9,163.00	\$9,163.00
ZVI soil mixing	1300	CY of soil	See Table 5-3	15	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$156,000.00	\$156,000.00
Site Restoration				4								\$5,754.17
Compaction - riding sheepfoot, 6" lifts, 3 passes	2648	CY of soil	RMS 31 23 23.23 5620	2	\$0.24	\$635.45	\$0.79	\$2,091.68	\$0.00	\$0.00	\$0.00	\$2,727.12

REMEDIAL ALTERNATIVE 4 Source Treatment Using ISCR, MNA, and ICs (One time mixing at TCE>1,000 ug/L area)	LOCATION:		MEDIA: Groundwater	Construction time:	9 weeks
	Site 17, Disposed Metal Parts Along Shoreline			Operation time:	30 years
	NSF-IH, Indian Head, Maryland			Post Remediation Monitoring:	included in the operation time

DESCRIPTION OF ALTERNATIVE:

1) ISCR treatment area (TCE> 1,000 ppb) with 10% escalation factor:
 2) Thickness of: Top 8 ft: 3,885 SF
 Contamination interval thickness: 8 ft
 10 ft
 3) MEC clearance will be conducted during the excavation activities of the first 8-foot.
 Cost and duration escalation factor to facilitate MEC clearance: 100%
 4) 6-Foot Diameter crane-mounted auger is assumed for the soil mixing.

5) For the purpose of long-term monitoring, a total of 5 permanent MWs will be installed; 3 during the baseline and 2 at approximately 12 months after soil mixing.
 6) The short-term performance sampling is assumed to consist of: baseline, 6-, 9-, and 12-month post-mixing monitoring events. Assumed analytical requirements are described in Section 5.1.4.
 7) The long-term monitoring would consist of quarterly events for 2 years, biannual events for 1 year, annual events for the remaining years until 5 years, and every 5-year intervals for the remaining years. Assumed requirements are described in Section 5.1.4.
 9) Five-year reviews would be performed throughout the duration of the remediation for up to 30 years and a site closure report would be developed.

Cost Component	Qty	Unit	Cost Source	Estimated Activity Duration (day)	Labor Unit Cost	Labor Total Cost	Equipment Unit Cost	Equipment Total Cost	Material Unit Cost	Material Total Cost	Subcontractor	Total Cost
Top soil, 6" layer	72	CY of soil	CCI, 2008	1	\$0.00	\$0.00	\$0.00	\$0.00	\$30.00	\$2,160.00	\$0.00	\$2,160.00
Fine grading and seeding, inc. lime, fertilizer & seed	144	SY	RMS 32 91 19.13 1000	1	\$1.46	\$210.24	\$0.24	\$34.56	\$0.35	\$50.40	\$865.00	\$867.05
MEC Clearance Support (only during the top 8-foot soil excavation activities and does not include cost for MEC handling and management)												\$93,596.00
Mob/Demob	4	person	CH2M HILL Rates		\$2,000.00	\$8,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$8,000.00
MEC Clearance (\$100/hr; 10 hrs/day; 4 persons)	17	days/4 crew	CH2M HILL Rates		\$4,000.00	\$68,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$68,000.00
OE Clearance Report												
OE Clearance Plan (Draft and Final)	1	each	CH2M HILL Rates		\$3,500.00	\$3,500.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$3,500.00
Health and Safety Plan (including briefing)	1	each	CH2M HILL Rates		\$2,500.00	\$2,500.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2,500.00
After Action Report	1	each	CH2M HILL Rates		\$1,600.00	\$1,600.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,600.00
Lodging and Per diem	17	days/4 crews			\$0.00	\$0.00	\$0.00	\$0.00	\$588.00	\$9,996.00	\$0.00	\$9,996.00
Construction Oversight												\$126,117.00
Field Superintendent	9.0	weeks	CH2M HILL Rate	c	\$3,444.00	\$30,996.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$30,996.00
Safety Engineer	9.0	weeks	CH2M HILL Rate	c	\$3,936.00	\$35,424.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$35,424.00
Site Project Manager	9.0	weeks	CH2M HILL Rate	c	\$4,428.00	\$39,852.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$39,852.00
Lodging and Per diem (3 persons)	135	days			\$0.00	\$0.00	\$0.00	\$0.00	\$147.00	\$19,845.00	\$0.00	\$19,845.00
Preconstruction Submittals												\$144,164.38
Preconstruction survey, design basis, pre-draft, draft, and final design, specifications, and H&S plans	1	lump sum	15% of total construction cost		\$80,091.32	\$80,091.32	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$80,091.32
ESS (draft, draft final, final)	1	lump sum	12% of total construction cost		\$64,073.06	\$64,073.06	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$64,073.06
Permitting												\$10,678.84
GW MW permits	1	lump sum	1% of total construction cost		\$10,678.84	\$10,678.84	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$10,678.84
General Conditions												\$53,394.21
Decontamination, temp. facilities, sed. & erosion control, temp. fence, etc.	1	lump sum	10% of total construction cost		\$53,394.21	\$53,394.21	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$53,394.21

REMEDIAL ALTERNATIVE 4 Source Treatment Using ISCR, MNA, and ICs (One time mixing at TCE>1,000 ug/L area)	LOCATION:				MEDIA: Groundwater	Construction time:	9 weeks
	Site 17, Disposed Metal Parts Along Shoreline					Operation time:	30 years
	NSF-IH, Indian Head, Maryland					Post Remediation Monitoring:	included in the operation time

DESCRIPTION OF ALTERNATIVE:

1) ISCR treatment area (TCE > 1,000 ppb) with 10% escalation factor: 3,885 SF

2) Thickness of: Top 8 ft: 8 ft
Contamination interval thickness: 10 ft

3) MEC clearance will be conducted during the excavation activities of the first 8-foot. Cost and duration escalation factor to facilitate MEC clearance: 100%

4) 6-Foot Diameter crane-mounted auger is assumed for the soil mixing.

5) For the purpose of long-term monitoring, a total of 5 permanent MWs will be installed; 3 during the baseline and 2 at approximately 12 months after soil mixing.

6) The short-term performance sampling is assumed to consist of: baseline, 6-, 9-, and 12-month post-mixing monitoring events. Assumed analytical requirements are described in Section 5.1.4.

7) The long-term monitoring would consist of quarterly events for 2 years, biannual events for 1 year, annual events for the remaining years until 5 years, and every 5-year intervals for the remaining years. Assumed requirements are described in Section 5.1.4.

9) Five-year reviews would be performed throughout the duration of the remediation for up to 30 years and a site closure report would be developed.

Cost Component	Qty	Unit	Cost Source	Estimated Activity Duration (day)	Labor Unit Cost	Labor Total Cost	Equipment Unit Cost	Equipment Total Cost	Material Unit Cost	Material Total Cost	Subcontractor	Total Cost
Contractor Overhead and Profit												\$80,091.32
Home office cost, etc.	1	lump sum	15% of total construction cost		\$80,091.32	\$80,091.32	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$80,091.32
Mob/Demob												\$53,394.21
Assume 10% of total field activities	1	lump sum	Professional Judgment, excludes mixing subcontractor cost		\$53,394.21	\$53,394.21	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$53,394.21
SUBTOTAL CAPITAL COST						\$559,176.01		\$18,327.81		\$48,951.40	\$260,257.20	\$886,419.27
Scope Contingency	40%											\$354,567.71
Bid Contingency	10%											\$88,641.93
TOTAL CAPITAL COST												\$1,329,628.91

OPERATION & MAINTENANCE AND PERIODIC ACTIVITIES - PER EVENT COST												
Sampling and Analysis - Groundwater and Surface Water												
Sample Collection												\$4,205.94
Sample collection - 2 crew, 10 hrs/day, \$50/hr	3	days	Professional Judgment		\$1,000.00	\$3,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$3,000.00
Disposable and decon materials per sample	21	samples	E 33 02 0401, 33 02 0402, 33 02 0561		\$0.00	\$0.00	\$0.00	\$0.00	\$24.90	\$522.90	\$0.00	\$522.90
Equipment Rental	3	days	E 33 02 0573, 33 02 0578		\$0.00	\$0.00	\$227.68	\$683.04	\$0.00	\$0.00	\$0.00	\$683.04
Lab Analysis (including QA/QC samples)												\$5,713.68
TAL Metals by CLP (ILM04) (filtered)	12	samples	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,643.04	\$1,643.04
TAL Metals by CLP (ILM04) (unfiltered)	12	samples	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,643.04	\$1,643.04
TCL Volatiles by CLP (OLM04) for groundwater and surface water	17	samples	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,615.00	\$1,615.00
Chloride, nitrite/nitrate, sulfate (300.0)	12	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$585.84	\$585.84
TOC	8	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$320.00	\$320.00

REMEDIAL ALTERNATIVE 4 Source Treatment Using ISCR, MNA, and ICs (One time mixing at TCE>1,000 ug/L area)	LOCATION:		MEDIA: Groundwater	Construction time:	9 weeks
	Site 17, Disposed Metal Parts Along Shoreline			Operation time:	30 years
	NSF-IH, Indian Head, Maryland			Post Remediation Monitoring:	included in the operation time

DESCRIPTION OF ALTERNATIVE:

1) ISCR treatment area (TCE> 1,000 ppb) with 10% escalation factor: 3,885 SF

2) Thickness of: 8 ft

Top 8 ft:

Contamination interval thickness: 10 ft

3) MEC clearance will be conducted during the excavation activities of the first 8-foot. Cost and duration escalation factor to facilitate MEC clearance: 100%

4) 6-Foot Diameter crane-mounted auger is assumed for the soil mixing.

5) For the purpose of long-term monitoring, a total of 5 permanent MWs will be installed; 3 during the baseline and 2 at approximately 12 months after soil mixing.

6) The short-term performance sampling is assumed to consist of: baseline, 6-, 9-, and 12-month post-mixing monitoring events. Assumed analytical requirements are described in Section 5.1.4.

7) The long-term monitoring would consist of quarterly events for 2 years, biannual events for 1 year, annual events for the remaining years until 5 years, and every 5-year intervals for the remaining years. Assumed requirements are described in Section 5.1.4.

9) Five-year reviews would be performed throughout the duration of the remediation for up to 30 years and a site closure report would be developed.

Cost Component	Qty	Unit	Cost Source	Estimated Activity Duration (day)	Labor Unit Cost	Labor Total Cost	Equipment Unit Cost	Equipment Total Cost	Material Unit Cost	Material Total Cost	Subcontractor	Total Cost
Methane, ethane, ethene (RSK-175)	12	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,213.08	\$1,213.08
Alkalinity (310.1)	8	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$105.44	\$105.44
Ferrous Iron (Iron[II])	8	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$231.28	\$231.28
Sampling and Analysis - Saturated Soil; Only for Baseline, 6- and 9-month Post-Soil Mixing												
Sample Collection												\$6,554.96
DPT drilling (mob, daily rates, consumables) - 4 locations	2	days	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$4,000.00	\$4,000.00
Sample collection - 2 crew, 10 hrs/day, \$50/hr	2	days	Professional Judgment		\$1,000.00	\$2,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2,000.00
Disposable and decon materials per sample	4	samples	E 33 02 0401, 33 02 0402, 33 02 0561		\$0.00	\$0.00	\$0.00	\$0.00	\$24.90	\$99.60	\$0.00	\$99.60
Equipment Rental	2	days	E 33 02 0573, 33 02 0578		\$0.00	\$0.00	\$227.68	\$455.36	\$0.00	\$0.00	\$0.00	\$455.36
Lab Analysis (including QA/QC samples)												\$1,855.36
TAL Metals	8	samples	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,095.36	\$1,095.36
TCL Volatiles	8	samples	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$760.00	\$760.00
Data Interpretation												\$10,000.00
Report (draft and final)	1	lump sum	Professional Judgment		\$10,000.00	\$10,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$10,000.00
Five-Year Review												\$12,000.00
Report (draft and final)	1	lump sum	Professional Judgment		\$10,000.00	\$10,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$10,000.00
Field Inspection	1	lump sum	Professional Judgment		\$2,000.00	\$2,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2,000.00
Site Closure												\$25,000.00
Report development	1	lump sum	Professional Judgment		\$25,000.00	\$25,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$25,000.00

PRESENT WORTH CALCULATION					
REMEDIAL ALTERNATIVE 4		Source Treatment Using ISCR, MNA, and ICs (One time mixing at TCE>1,000 ug/L area)			
Location:	Site 17, Disposed Metal Parts Along Shoreline	Construction time:	9 weeks		
Media:	Shallow Groundwater	Operation time:	30 years		
		Discount Rate:	5.2%		
		O&M Contingency:	20%		
Year	Real Cost Incurred	Cost Description	Cost Type	Discount Factor	Present Worth
0	\$1,394,619	Capital Cost + Baseline + 6-month + 9-month post-mixing sampling events + data evaluation report	Capital	1.00	\$1,394,619
1	\$95,614	4 quarterly sampling events	O&M	1.05	\$90,888
2	\$95,614	4 quarterly sampling events	O&M	1.11	\$86,395
3	\$47,807	2 biannual sampling events	O&M	1.16	\$41,062
4	\$23,904	annual sampling	O&M	1.22	\$19,516
5	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	1.29	\$29,728
6	\$0			1.36	\$0
7	\$0			1.43	\$0
8	\$0			1.50	\$0
9	\$0			1.58	\$0
10	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	1.66	\$23,072
11	\$0			1.75	\$0
12	\$0			1.84	\$0
13	\$0			1.93	\$0
14	\$0			2.03	\$0
15	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	2.14	\$17,906
16	\$0			2.25	\$0
17	\$0			2.37	\$0
18	\$0			2.49	\$0
19	\$0			2.62	\$0
20	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	2.76	\$13,897
21	\$0			2.90	\$0
22	\$0			3.05	\$0
23	\$0			3.21	\$0
24	\$0			3.38	\$0
25	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	3.55	\$10,786
26	\$0			3.74	\$0
27	\$0			3.93	\$0
28	\$0			4.13	\$0
29	\$0			4.35	\$0
30	\$68,304	Closure sampling and Closure Report	O&M, Periodic	4.58	\$14,927
CAPITAL COST	\$1,394,619				
2008 Dollar LIFETIME O&M	\$522,760		Lifetime Present Worth O&M		\$348,178
TOTAL IMPLEMENTATION COST	\$1,917,379		TOTAL PRESENT WORTH		\$1,742,796

REMEDIAL ALTERNATIVE 5		LOCATION:				MEDIA:		Construction time:		3 weeks		
Source Zone Removal, Off-site Disposal, MNA, and ICs		Site 17, Disposed Metal Parts Along Shoreline				Shallow Groundwater		Operation time:		30 years		
		NSF-IH, Indian Head, Maryland						Post Remediation Monitoring:		Included in the operation time		
DESCRIPTION OF ALTERNATIVE:												
Excavation of soil area of attainment containing surface and buried metal debris, buried non metal debris, and contaminated soil; off-site disposal of the excavated material to a permitted landfill; and, creation of wetland.												
ASSUMPTIONS:												
1) Excavation Area (=source zone from Figure 3-1 with 10% escalation factor)	3885 SF	0.09 acres	6) Swelling factor:	15%								
2) Total Depth of Excavation	18 ft		7) Installation of	3	additional groundwater monitoring wells.							
3) Volume of excavation in place	2590 CY or	4,056 tons	8) The long-term monitoring would consist of quarterly events for 2 years, biannual events for 1 year, annual events for the remaining years until 5 years, and every 5-year intervals for the remaining years. Assumed requirements are described in Section 5.1.5.									
4) Depth to contaminated zone (Conservative Assumption)	8 ft bgs		9) All samples would be analyzed for TCL VOCs (CLP Method OLM03.2), total organic carbon (TOC; EPA Method 415.1), sulfate (EPA Method 300.0), nitrate (EPA Method 300.0), chloride (EPA Method 300.0), methane, ethane and ethene (SW-846 Method RSK 175), TAL Met									
5) Disposal Volume (Assumed interval from 6 to 18 ft bgs)	1439 CY or		Field measurements such as DO, ORP, pH, and temperature would also be collected. In addition to the above parameters, groundwater samples will be analyzed for TAL metals. Surface water samples will be analyzed for VOCs and metals.									
6) Clean reuseable volume:	1151 CY		10) Data interpretation and report would be prepared following a sampling event.									
7) Total imported backfill:	1,439 CY or	2254 tons	11) Five-year reviews would be performed throughout the duration of the remediation for up to 30 years and a site closure report would be developed.									
8) Total volume of top soil (6")	72 CY		12) Sources of costs are 2004/2007 RS Means Site Work & Landscape Cost Data, RS Means Environmental Remediation Cost Data - Unit Price, vendor quotes, CCI cost data, and professional judgment based on similar projects.									
Cost Component	Qty	Unit	Cost Source	Estimated Activity Duration (day)	Labor Unit Cost	Labor Total Cost	Equipment Unit Cost	Equipment Total Cost	Material Unit Cost	Material Total Cost	Subcontractor	Total Cost
CAPITAL COSTS												
Site Preparation				1.09								\$1,380.00
Site clearing (dozer light)	0.09	acre	CCI, 2008	0.09	\$2,000.00	\$180.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$180.00
Survey	1	day	CCI, 2008	1	\$1,200.00	\$1,200.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,200.00
Dewatering												\$499,050.00
Sheet Pile System Installation - including pump system	1	lump sum	CH2M HILL, 2008.		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$237,600.00	\$237,600.00
Sheet Pile	4320	SF	CCI		\$0.00	\$0.00	\$60.00	\$259,200.00	\$0.00	\$0.00	\$0.00	\$259,200.00
Disposal of Water Offsite (assume hazardous)	250	gallon	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2,250.00	\$2,250.00
Excavation and Backfill				6								\$80,644.88
Excavation, bulk, dozer, piled, 300 HP 50' haul common earth	2,590	CY	M 31 23 16 42 5020 adjusted (4.0 multiplier per CCI)	2	\$1.24	\$3,211.60	\$3.68	\$9,531.20	\$0.00	\$0.00	\$0.00	\$12,742.80
Dewatering of excavated material	2,303		CH2M HILL Estimate (Stockpile passive dewatering, mix dry & wet, no free liquids)		\$5.75	\$13,242.25	\$7.50	\$17,272.50	\$4.00	\$9,212.00	\$0.00	\$39,726.75
Borrow, loading, and spreading - common earth, shovel, 1CY bucket	1,439	CY	CH2M HILL Rates	2	\$2.50	\$3,597.50	\$2.50	\$3,597.50	\$12.00	\$17,268.00	\$0.00	\$24,463.00

REMEDIAL ALTERNATIVE 5		LOCATION:					MEDIA:		Construction time: 3 weeks				
Source Zone Removal, Off-site Disposal, MNA, and ICs		Site 17, Disposed Metal Parts Along Shoreline					Shallow Groundwater		Operation time: 30 years				
		NSF-IH, Indian Head, Maryland							Post Remediation Monitoring: Included in the operation time				
Borrow, loading, and spreading - top soil, shovel, 1CY bucket (6" thick)	72	CY	M 02055 150 0800	1	\$1.33	\$95.69	\$3.03	\$217.99	\$20.00	\$1,438.89	\$0.00	\$1,752.57	
Grading - large area	432	SY	M 02300 100 0100	1	\$0.24	\$103.60	\$0.22	\$94.97	\$0.00	\$0.00	\$0.00	\$198.57	
Compaction - sheepsfoot, 12" lifts, 4 passes	2,590	CY	M 31 23 23 23 5720	2	\$0.19	\$492.10	\$0.49	\$1,269.10	\$0.00	\$0.00	\$0.00	\$1,761.20	
MEC Clearance Support (during soil excavation activities and does not include cost for MEC handling and management)												\$89,008.00	
Mob/Demob	4	person	CH2M HILL Rates		\$2,000.00	\$8,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$8,000.00	
MEC Clearance (\$100/hr; 10 hrs/day, 4 persons)	16	days/4 crew	CH2M HILL Rates		\$4,000.00	\$64,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$64,000.00	
OE Clearance Report													
OE Clearance Plan (Draft and Final)	1	each	CH2M HILL Rates		\$3,500.00	\$3,500.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$3,500.00	
Health and Safety Plan (including briefing)	1	each	CH2M HILL Rates		\$2,500.00	\$2,500.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2,500.00	
After Action Report	1	each	CH2M HILL Rates		\$1,600.00	\$1,600.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,600.00	
Lodging and Per diem	16	days/4 crews			\$0.00	\$0.00	\$0.00	\$0.00	\$588.00	\$9,408.00	\$0.00	\$9,408.00	
Off-site Transportation and Disposal												\$570,171.84	
Landfill Fees	2,254	tons	Clean Harbors (direct landfill to RCRA C)		\$0.00	\$0.00	\$0.00	\$0.00	\$200.00	\$450,800.00	\$0.00	\$450,800.00	
Transportation Cost	2,254	tons	Clean Harbors		\$0.00	\$0.00	\$0.00	\$0.00	\$50.00	\$112,700.00	\$0.00	\$112,700.00	
Loading soil into truck	2,979	CY	E 33 19 0150		\$0.77	\$2,293.45	\$1.47	\$4,378.40	\$0.00	\$0.00	\$0.00	\$6,671.84	
Site Restoration												\$5,505.72	
Hydroseeding	90	M.SF	M 02920 320 2400	2	\$11.65	\$1,045.84	\$6.82	\$612.25	\$42.86	\$3,847.63	\$0.00	\$5,505.72	
Monitoring Wells Installation												\$6,750.00	
Installation of MWs	3	wells	BOA rates	3	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$6,750.00	\$6,750.00	
Construction Oversight												\$16,877.28	
Engineer (P2)	2	weeks	Professional Judgement	11	\$2,450.00	\$5,145.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$5,145.00	
Site Health and Safety (P2)	2	weeks	Professional Judgement	11	\$2,450.00	\$5,145.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$5,145.00	
Superintendent (P3)	2	weeks	Professional Judgement	11	\$3,136.80	\$6,587.28	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$6,587.28	
Lodging and Per diem (3 persons)	63	days			\$0.00	\$0.00	\$0.00	\$0.00	\$147.00	\$9,261.00	\$0.00	\$9,261.00	
Preconstruction Submittals												\$186,032.82	
Preconstruction survey, design basis, pre-draft, draft, and final design, specifications, and H&S plans	1	lump sum	15% of total construction cost		\$103,351.57	\$103,351.57	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$103,351.57	
ESS (draft, draft final, final)	1	lump sum	12% of total construction cost		\$82,681.25	\$82,681.25	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$82,681.25	
General Conditions												\$68,901.04	
Decontamination, temp. facilities, sed. & erosion control, temp. fence, etc.	1	lump sum	10% of total construction cost		\$68,901.04	\$68,901.04	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$68,901.04	
Contractor Overhead and Profit												\$103,351.57	
Home office cost, etc.	1	lump sum	15% of total construction cost		\$103,351.57	\$103,351.57	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$103,351.57	

REMEDIAL ALTERNATIVE 5		LOCATION:					MEDIA:		Construction time: 3 weeks				
Source Zone Removal, Off-site Disposal, MNA, and ICs		Site 17, Disposed Metal Parts Along Shoreline					Shallow Groundwater		Operation time: 30 years				
		NSF-IH, Indian Head, Maryland							Post Remediation Monitoring: Included in the operation time				
Mob/Demob													\$68,901.04
Mob & demob of equip & personnel	1	lump sum	10% of total construction cost		\$68,901.04	\$68,901.04	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$68,901.04
SUBTOTAL CAPITAL COST						\$549,125.78		\$296,173.90		\$613,935.52	\$246,600.00		\$2,204,885.19
Scope Contingency	20%												\$440,977.04
Bid Contingency	10%												\$220,488.52
TOTAL CAPITAL COST													\$2,866,350.75
OPERATION & MAINTENANCE AND PERIODIC ACTIVITIES - PER EVENT COST													
Sampling and Analysis - Groundwater and Surface Water													
Sample Collection													\$4,031.64
Sample collection - 2 crew, 10 hrs/day, \$50/hr	3	days	Professional Judgment		\$1,000.00	\$3,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$3,000.00
Disposable and decon materials per sample	14	samples	E 33 02 0401, 33 02 0402, 33 02 0561		\$0.00	\$0.00	\$0.00	\$0.00	\$24.90	\$348.60	\$0.00	\$0.00	\$348.60
Equipment Rental	3	days	E 33 02 0573, 33 02 0578		\$0.00	\$0.00	\$227.68	\$683.04	\$0.00	\$0.00	\$0.00	\$0.00	\$683.04
Lab Analysis													\$4,443.55
TAL Metals/Cyanide by CLP (ILM04) (filtered)	9	samples	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,232.28	\$0.00	\$1,232.28
TAL Metals/Cyanide by CLP (ILM04) (unfiltered)	9	samples	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,232.28	\$0.00	\$1,232.28
TCL Volatiles by CLP (OLM04) (only pre & post injection) for groundwater and surface water	14	samples	BOA rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,330.00	\$0.00	\$1,330.00
Chloride, nitrite/nitrate, sulfate (300.0)	9	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$439.38	\$0.00	\$439.38
TOC	6	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$240.00	\$0.00	\$240.00
Methane, ethane, ethene (RSK-175)	9	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$909.81	\$0.00	\$909.81
Alkalinity (310.1)	9	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$118.62	\$0.00	\$118.62
Ferrous Iron (Iron(II))	6	samples	BOA Rates		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$173.46	\$0.00	\$173.46
Data Interpretation													\$10,000.00
Report	1	lump sum	Professional Judgment		\$10,000.00	\$10,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$10,000.00
Five-Year Review													\$7,000.00
Report	1	lump sum	Professional Judgment		\$5,000.00	\$5,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$5,000.00
Field Inspection	1	lump sum	Professional Judgment		\$2,000.00	\$2,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2,000.00
Site Closure													\$25,000.00
Report development	1	lump sum	Professional Judgment		\$25,000.00	\$25,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$25,000.00

PRESENT WORTH CALCULATION					
REMEDIAL ALTERNATIVE 5		Source Zone Removal, Off-site Disposal, MNA, and ICs			
Location:	Site 17, Disposed Metal Parts Along Shoreline	Construction time:	6 weeks		
Media:	Shallow Groundwater	Operation time:	30 years		
		Discount Rate:	5.2%		
		O&M Contingency:	20%		
Year	Real Cost Incurred	Cost Description	Cost Type	Discount Factor	Present Worth
0	\$2,866,351	Excavation, Off-site Disposal	Capital	1.00	\$2,866,351
1	\$95,614	4 quarterly sampling events	O&M	1.05	\$90,888
2	\$95,614	4 quarterly sampling events	O&M	1.11	\$86,395
3	\$47,807	2 biannual sampling events	O&M	1.16	\$41,062
4	\$23,904	annual sampling	O&M	1.22	\$19,516
5	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	1.29	\$29,728
6	\$0			1.36	\$0
7	\$0			1.43	\$0
8	\$0			1.50	\$0
9	\$0			1.58	\$0
10	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	1.66	\$23,072
11	\$0			1.75	\$0
12	\$0			1.84	\$0
13	\$0			1.93	\$0
14	\$0			2.03	\$0
15	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	2.14	\$17,906
16	\$0			2.25	\$0
17	\$0			2.37	\$0
18	\$0			2.49	\$0
19	\$0			2.62	\$0
20	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	2.76	\$13,897
21	\$0			2.90	\$0
22	\$0			3.05	\$0
23	\$0			3.21	\$0
24	\$0			3.38	\$0
25	\$38,304	5-Year groundwater sampling, and five-year review	O&M, Periodic	3.55	\$10,786
26	\$0			3.74	\$0
27	\$0			3.93	\$0
28	\$0			4.13	\$0
29	\$0			4.35	\$0
30	\$68,304	Closure sampling and Closure Report	O&M, Periodic	4.58	\$14,927
CAPITAL COST	\$2,866,351				

PRESENT WORTH CALCULATION					
REMEDIAL ALTERNATIVE 5		Source Zone Removal, Off-site Disposal, MNA, and ICs			
Location:	Site 17, Disposed Metal Parts Along Shoreline	Construction time:	6 weeks		
Media:	Shallow Groundwater	Operation time:	30 years		
		Discount Rate:	5.2%		
		O&M Contingency:	20%		
Year	Real Cost Incurred	Cost Description	Cost Type	Discount Factor	Present Worth
2008 Dollar LIFETIME O&M	\$522,760		Lifetime Present Worth O&M		\$348,178
TOTAL IMPLEMENTATION COST	\$3,389,111		TOTAL PRESENT WORTH		\$3,214,528